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The effect of preseason sport camp on strength and speed abilities in youth swimmers

El efecto del campamento deportivo de pretemporada en las capacidades de fuerza y velocidad de los nadadores juveniles

O efeito do acampamento esportivo de pré-temporada nas habilidades de força e velocidade em nadadores jovens

Grzegorz Bielec[1], Daniel Jurak[2] & Marek Rejman[3]

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1 Gdansk University of Physical Education and Sport, Faculty of Physical Culture, Gdansk, Poland. grzegorz.bielec@awf.gda.pl https://orcid.org/0000-0003-4606-4045
2 Center for Mental Health Rehabilitation, Beroun, Czech Republic. jurak@nember.cz https://orcid.org/0000-0001-6219-4072
3 Wroclaw University of Health and Sport Sciences, Faculty of Physical Education and Sport, Wroclaw, Poland. marek.rejman@awf.wroc.pl 0000-0003-3857-6999

ABSTRACT

Introduction: Regular assessment of anthropometric variables and motor fitness of young athletes is an integral part of the training process. However, the physiological effects of seasonal sport camps on youth athletes have not been investigated thoroughly. **Objective:** The aim of the current study is to assess the changes in strength and speed performance in youth swimmers resulting from a short-term preseason camp. **Methods**: Eleven swimmers aged 13-14 years participated in an 8-day camp. The camp programme included nine training sessions in the swimming pool, five general fitness training sessions in the athletics stadium, and two strength circuit training sessions. Participants were interviewed to determine the amount of physical activity undertaken in summer vacation. Fitness tests were conducted on the 1st day and were repeated on the 8th day of camp. Participants performed the following motor tests: a 50-m dash, bent-arm hang, a handgrip test, and a 100-m front crawl trial. **Results:** Participants improved their swimming speed ($p<0.001$) but worsened their handgrip strength ($p=0.04$). No significant changes were noted in the results of the 50-m dash test ($p=0.90$) and the bent-arm hang test ($p=0.30$). Anthropometric variables were not correlated substantially with any result of motor performance. Participation in physical activity during summer break was negatively correlated with swimming performance ($r=-0.66$; $p<0.05$) and positively correlated with handgrip strength ($r=0.70$; $p<0.05$). **Conclusions:** Improvement in swimming speed was the most important outcome of the preseason camp for youth athletes. Endurance-oriented training loads may have caused the lack in improvement of muscular strength. The amount of physical activity undertaken during summer vacation had an impact on motor performance in age-group swimmers.

Key words: swimming, youth, training, muscle strength, speed

RESUMEN

Introducción: La evaluación periódica de las variables antropométricas y de la aptitud motriz de los jóvenes atletas forma parte integral del proceso de entrenamiento. Sin embargo, no se han investigado a fondo los efectos fisiológicos de los campamentos deportivos estacionales en los atletas jóvenes. **Objetivo:**evaluar los cambios en el rendimiento de fuerza y velocidad en nadadores juveniles resultantes de un campamento de pretemporada de corta duración. **Métodos:** Once nadadores de 13-14 años participaron en un campamento de ocho días. El programa incluía nueve sesiones de entrenamiento en la piscina, cinco de físico general en el estadio de atletismo y dos de fuerza en circuito. Se entrevistó a los participantes para determinar la cantidad de actividad física realizada en las vacaciones de verano. Se realizaron pruebas de aptitud física el primer día y se repitieron el octavo día del campamento. Los participantes realizaron las siguientes pruebas motrices: carrera de 50 metros lisos, suspensión de brazos flexionados, prueba de agarre de manos y prueba de 100 metros de crol frontal. **Resultados:** Los participantes mejoraron su velocidad de nado ($p<0.001$), pero empeoraron su fuerza de agarre ($p=0.04$). No se observaron cambios significativos en los resultados de la prueba de 50 metros lisos (p=0.90) y la prueba de suspensión con brazos flexionados ($p=0.30$). Las variables antropométricas no se correlacionaron sustancialmente con ningún resultado del rendimiento motor. La participación en actividades físicas durante las vacaciones de verano se correlacionó negativamente con el rendimiento en natación ($r=-0.66$; $p<0.05$) y positivamente con la fuerza de agarre ($r=0.70$; $p<0.05$). **Conclusiones:** La mejora en la velocidad de nado fue el resultado más importante del campamento de pretemporada para los atletas juveniles. Las cargas de entrenamiento

RESUMO

Introdução: A avaliação regular das variáveis antropométricas e da aptidão motora de jovens atletas é uma parte integrante do processo de treinamento. No entanto, os efeitos fisiológicos dos acampamentos esportivos sazonais em atletas jovens ainda não foram investigados de forma aprofundada. **Objetivo:** Avaliar as mudanças no desempenho de força e velocidade em nadadores jovens resultantes de um acampamento de pré-temporada de curta duração. **Métodos:** Onze nadadores com idades entre 13 e 14 anos participaram de um acampamento de 8 dias. O programa do acampamento incluiu nove sessões de treinamento na piscina, cinco sessões de condicionamento físico geral no estádio de atletismo e duas sessões de treinamento em circuito de força. Os participantes foram entrevistados para determinar a quantidade de atividade física realizada durante as férias de verão. Os testes de aptidão física foram realizados no primeiro e no oitavo dia do acampamento. Os participantes realizaram os seguintes testes motores: corrida de 50 m, suspensão com os braços flexionados, teste de preensão manual e prova de nado crawl de 100 m. **Resultados:** Os participantes melhoraram sua velocidade de nado (p<0,001), mas apresentaram piora na força de preensão manual (p=0,04). Não foram observadas mudanças significativas nos resultados do teste de corrida de 50 m (p=0,90) e no teste de suspensão com os braços flexionados (p=0,30). As variáveis antropométricas não apresentaram correlação substancial com nenhum resultado de desempenho motor. A participação em atividades físicas durante as férias de verão apresentou correlação negativa com o desempenho na natação (r=-0,66; p<0,05) e correlação positiva com a força de preensão manual (r=0,70; p<0,05). **Conclusões:** A melhora na velocidade de nado foi o resultado mais importante do acampamento de pré-temporada para jovens atletas. As cargas de treinamento orientadas a la resistencia pueden haber causado la falta de mejora de la fuerza muscular. La cantidad de actividad física realizada durante las vacaciones de verano influyó en el rendimiento motor de los nadadores juveniles.

Palabras clave: natación, jóvenes, entrenamiento, fuerza muscular, velocidad

voltadas à resistência podem ter contribuído para a ausência de melhora na força muscular. A quantidade de atividade física realizada durante as férias de verão teve impacto no desempenho motor de nadadores jovens por faixa etária.

Palavras-chave: natação, juventude, treinamento, força muscular, velocidade.

INTRODUCTION

In recent decades, youth swimming has come to the forefront of interest for scientific experts, who emphasized the importance of early identification of the level of certain conditions and skills that could determine the talent for competitive swimming (Morais *et al*., 2017). As young swimmers progress from one level of performance to the next, coaches should consistently assess their swimming technique, anthropometrics, and their strength and speed capabilities (Bond *et al*., 2015; Ferraz *et al*., 2020). Common international fitness test batteries (e.g. Eurofit) are used to assess motor performance in youth swimmers. The relationships between motor abilities and swim performance are evident (Yol & Sunay, 2023) Although anthropometric data alone is not the only predictor of swimming success, it nevertheless provides crucial information. When this data is integrated with other factors of swimming performance, such as swimming speed, training and the swimmer's mindset, it can significantly improve the performance of an athlete (Moura *et al*., 2014). Certain anthropometric characteristics, such as arm span or body length, have been associated with better swimming performance. For instance, a longer arm span relative to body height can provide a swimmer with a mechanical advantage in the water (Geladas *et al*., 2005; Schnitzler *et al*., 2007; Toussaint & Truijens, 2005). Hand's dimensions (e.g. length and width) also have an impact on swim propulsion, particularly during the front crawl swim (Rejman *et al*., 2023). Anthropometric data allows coaches to tailor training plans to fit each swimmer's unique physical characteristics. For example, a swimmer with a compact body composition and shorter limbs could benefit more from strength-focused exercises and sprints. In contrast, swimmers with limbs of a considerable length may find longer distance events more advantageous (Bond *et al*., 2015). Knowing the precise body dimensions of the swimmer can aid in choosing the correct equipment, like paddle size or fin length. Furthermore, technique adjustments can be made based on the swimmer's body proportions (Chusaini *et al*., 2020).

The objective of competitive swimming is to complete a specified distance in the shortest possible time, making speed the primary predictor of success. Velocity is the direct measure of a swimmer's performance in races (Smith, Norris, & Hogg, 2002). Maintaining the planned speed over longer distances requires proper swimming technique that allows swimmers to maximize speed without expending unnecessary energy (Zamparo, Cortesi, & Gatta, 2020). Moreover, well-trained speed abilities allow the swimmer to maintain an adequate velocity in subsequent swimming strokes (Pinto *et al.*, 2023). Also, the speed of starts and turns can significantly influence a swimmer's overall time in races that involve multiple laps (Morais *et al.*, 2012). Some studies show a relationship between running speed on short distances and sprint-swimming performance among youth athletes (Pardos-Mainer *et al.*, 2015; Tolstopyatov *et al.*, 2023).

In the context of maximizing swimming speed, muscle strength is the dominant component in various aspects of swimming performance. For example, a swimmer's strength determines how much force they can exert against the water with each stroke, making it essential for propelling the swimmer forward (Morais *et al.*, 2018; Prado *et al.*, 2022). Upper body and leg strength help swimmers maintain a streamlined position in the water, reducing drag and making their propulsion more efficient (Huxel Bliven, & Anderson, 2013; Khiyami *et al.*, 2022; Ozcadirci *et al.*, 2021). The results of some studies show a moderate to strong correlation between handgrip strength and swimming speed (Price *et al.* 2024). Stronger muscles can better handle the repetitive motions and stresses of swimming (Aspenes *et al.*, 2009). Finally, muscle strength plays a role in how effectively swimmers can push off the walls during turns. Short-distance races require a single, dynamic turn putting swimmers with stronger muscles at an advantage (Keiner *et al.*, 2015). Assuming that swimming speed is determined by individual body characteristics, muscle strength and anthropometric measures, these variables were taken into consideration in this study.

Summer holidays are a time for rest from school duties and regular sports training. Many research demonstrate that physical activity levels decrease during summertime, and excessive weight gain occurs among schoolchildren (Park & Lee, 2015; Weaver *et al*. 2019). Thus, preseason summer camps are organized for youth athletes to prepare them physiologically and mentally for training loads applied in the forthcoming season. However, the impact of summer camps on adolescents' motor skills is not clearly defined. For example, adolescents participating in summer camps of various sports (soccer, basketball, taekwondo) improved their abilities in leg muscle strength and balance, but did not improve running speed and handgrip strength compared to the control group (Yilmaz & Cakmakci, 2023). Nevertheless, data collected from the preseason camp (e.g. motor fitness tests) are useful in assessing athlete's motor potential. This knowledge can help the coach with planning training loads in the new training season (Di Felice & Powell, 2021; Ruf *et al.*, 2022). Due to our best knowledge, no studies have explored the effect of a preseason sport camp among youth swimmers so far.

The aim of the study assessed the following: (i) the individual fitness level in age-group swimmers after the summer break; (ii) the effect of an 8-day preseason sport camp on their speed and strength abilities; and (iii) the relationship between their physical activity during summertime and their actual fitness level.

MATERIAL AND METHODS

Participants

The studied group consisted of eleven primary school students (3 female and 8 male) aged 13-14 years (mean age 13.6±0.4 years). All of the students were members of the same swimming club and have been practicing swimming for 4 years. During the school year they attended nine swim training sessions and one dry-land training session per week. The average distance covered in the last macrocycle before the summer break (April-June) was 3.5±0.7 km per session. Additionally, during the school year they also took part in four physical education classes per week. Students and their parents were informed about the purpose and tasks involved in the study before the camp. The written informed consent was obtained from students and their parents. The study protocol was accepted by the local Institutional Review Board in accordance with the Declaration of Helsinki (decision KB-24/23). Anthropomorphic characteristics of the participants is presented in Table 1.

Table 1.
Anthropometric and body composition parameters in tested swimmers (n=11). Data is presented as mean value ± standard deviation.

Body height [m]	Body mass [kg]	Body mass index [kg/m^2]	Body fat [%]	Arm span [m]	Hand length [cm]	Hand width [cm]
1.73±6.4	62.1±11.9	20.5±2.9	20.6±5.0	1.75±7.9	19.4±0.7	8.4±0.5

Study design

The study was carried out during an 8-day summer camp preceding the new training season. The camp schedule included:

- eleven swim training sessions in the swimming pool (average mileage 2.53 ± 0.61 km per session),
- six general fitness training sessions in an outdoor track-and-field stadium (slow-pace running, accelerated running, core muscle exercises, stretching exercises),
- two strength training sessions in an indoor gym (circuit training with 50-60 percent of maximal load).

Additionally, students participated in recreational activities: walking in the forest (two times, ca 7 km each time) and kayaking (once, ca 6 km). Each training session lasted 70-90 minutes. Low-to-moderate training loads were applied during the camp. The measurements and fitness tests were conducted on the 1st day of the camp, and repeated on the 8th day of the camp. Anthropomorphic measurements and swimming speed tests were performed in the morning, while running speed tests and strength measurements were completed in the afternoon the same day.

Measurements

Anthropomorphic measurements

Anthropomorphic measurements were taken at 8:30-9:00 AM in a separate room in the indoor swimming pool. During the measurements students wore T-shirts and shorts. Body height was measured with a Seca 216 stadiometer (Seca GmbH, Germany) to one decimal place (0.1 cm). Body mass index (BMI), body mass, and body fat percentage were assessed using a Tanita BC 418 MA analyser (Tanita Corp., Japan).

A series of anthropometric measurements were taken for each swimmer. One trained anthropologist and an assistant performed all of the measurement in accordance with the standards developed by the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones *et al.* 2012). Testing was carried out using the proper instruments after their calibration. Hand length was measured with sliding caliper from the tip of the middle finger to the midline of the distal wrist crease. Hand width was measured as the distance from the radial side of the second metacarpal joint to the ulnar side of the fifth metacarpal joint Arm span was measured with a flexible steel tape from the tip of the middle finger of one hand to the tip of the middle finger of the opposite hand. During the measurement the participants stood with their back to the wall, with both arms raised and extended to the sides. The measurements were taken twice, and the coefficient of variation (CV) was calculated for each pair of measurements. The range of CV values was from 2.3 to 3.4.

Swimming speed test

Before the test students performed a 15-min dry-land warm-up and a 1000-meter warm-up in the water. The warm-up in the water included easy-pace swimming, short-distance accelerations, and 3-4 starts from the starting blocks. The 100-m freestyle trial was performed according to the World Aquatics rules. The swimming speed test was conducted in an indoor 25-meter, six-lane swimming pool. The air temperature, and water temperature were 28°C and 27°C, respectively. The participants were instructed to swim a 100-m freestyle at maximum speed. To create a competitive environment and encourage maximal effort, participants were paired up voluntarily. Time was measured by two researchers with Finis 3X300M stopwatches (Finis Inc., USA). The mean value of two measures was recorded (Lopes *et al.*, 2021)

50-m dash test

The running speed test was conducted in an outdoor track-and-field stadium. Before the test students performed a warm-up that consisted 800-m jogging, three sets of intervals over 10-15 meters, and ten minutes of stretching exercises. The students started from a stationary standing position with one foot in front of the other. When the commands were given ("get set" then "go") the student had to run 50 meters with maximum speed. The time was measured by two researchers with Finis 3X300M stopwatches (Finis Inc., USA). The average time of two measurements was recorded.

Strength measurements

Strength measurements were conducted in a gym. Students wore T-shirts, shorts and sports shoes. Before the measurements, students performed a 20-minute warm up including isometric and stretching exercises. Handgrip strength was assessed by the Smedley Hand Dynamometer, (Gima S.p.A., Italy), in accordance with the standards developed by ISAK. Students stood upright with their arms lowered freely alongside the torso. The dominant hand holding the dynamometer was positioned so that it was not touching the body. After being given a signal from the researcher, the student squeezed the dynamometer as strongly as possible. After a 10-second pause, the student performed the maneuver again. Then the better of the two results was recorded.

Muscular strength was assessed by a bent arm hang test. The students stood on a stool and grasped a bar suspended 2 meters from the ground with both of their hands. While the bar was being gripped, the student's chin had to be above the bar. Students were not allowed to rest their chins on the bar. When given a signal from the researcher, the stool was pulled away from under the student and the timer was started. The test was performed until the student let go of the bar, or when his/her eyes reached the point below the bar (Venckunas *et al*., 2018).

Physical activity assessment

Students were verbally interviewed to ask how much time they spent on moderate physical activity and on vigorous physical activity during their seven week summer holiday. The interview was based on the Global Physical Activity Questionnaire (Bergier *et al.*, 2019). An example question was: how much time during a typical summertime day did you partake in sport or other physical activity of moderate intensity? Students gave examples of their physical activities (playing football, riding bicycle, kayaking, etc.) and stated the time that was devoted to these activities. The amount of physical activity was expressed in minutes. The total minutes of proclaimed physical activities were summed up separately for moderate and intense efforts.

Statistical calculations

Statistical calculations were performed with the Statistica 13.0 software (TIBCO Software Inc., Palo Alto, CA, USA). The data demonstrated a normal distribution in the Shapiro-Wilk test. Differences between fitness test results measured on the 1st and the last day of the camp were assessed by the Students' t-test for dependent samples. Cohen's *d* for the paired t-test was used to calculate the effect size. The relationship between fitness test results and anthropomorphic variables was determined based on the Pearson's product-moment correlation coefficient. The strength of correlation was assessed as follows: $r<0.1$ – negligible correlation; $0.1<r\leq0.3$ – weak correlation; $0.3<r\leq0.5$ – moderate correlation; $0.5<r\leq0.7$ – strong correlation; $0.7<r\leq0.9$ – very strong correlation; $r>0.9$, near-perfect correlation. Statistical significance was set at $p<0.05$.

RESULTS

According to the interview, students devoted on average 2848.6 ± 2065.5 minutes on moderate physical activity during summer vacation. They also stated that they spent on average 207.7 ± 127.3 minutes on vigorous physical activity during the summertime.

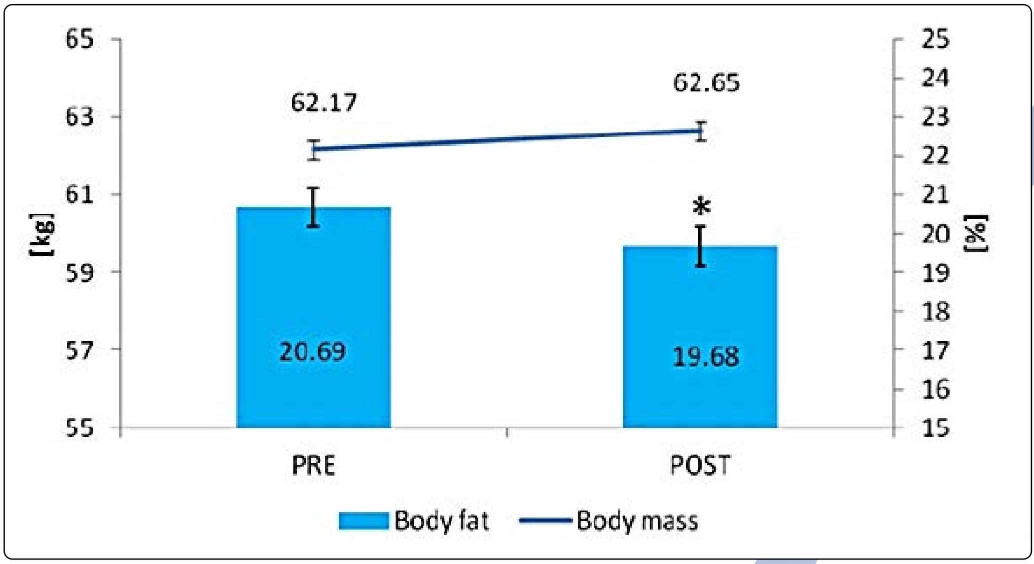
Table 2 displays the results of the fitness tests obtained on the first and last day of summer camp. Students improved markedly in their 100-m swimming performance. No significant differences were noted in the 50-m run test and in the muscular strength test. Students outcomes were worse in the follow-up handgrip strength test.

Table 2.
Fitness test results of examined swimmers (n=11) achieved on the 1st day (PRE) and on the 8th day (POST) of the camp. Data is presented as mean values ± standard deviation.

	PRE	POST	*p* value	Cohen's *d* effect size
100-m swim [sec]	74.6±8.9	71.3±7.4	<0.001	0.34
50-m dash [sec]	8.1±0.8	8.1±0.7	0.90	-0.02
Bent arm hang test [sec]	20.9±18.1	19.3±15.0	0.30	0.07
Grip strength test [kg]	23.9±8.2	21.3±8.4	0.04	0.31

Figure 1 shows changes in the body composition of the participants. No changes occurred in body mass, whereas body fat percentage decreased markedly.

Figure 1.
Body composition parameters assessed on the 1st day (PRE) and on the 8th day (POST) of the camp in examined swimmers (n=11). Data is presented as mean values.



* *p*<0.05

Anthropometric variables and body composition parameters were not correlated significantly with any results of the fitness tests. However, the amount of physical activity during summer vacations was correlated substantially with the 100-m swim results (both PRE and POST) and grip strength (POST) (Table 3).

Table 3.
Pearson's correlation between fitness tests results and amount of declared physical activity during summertime in examined swimmers (n=11).

	100-m swim PRE [sec]	100-m swim POST [sec]	50-m dash PRE [sec]	50-m dash POST [sec]	Bent arm hang PRE [sec]	Bent arm hang POST [sec]	Grip strength PRE [kg]	Grip strength POST [kg]
Moderate PA [min]	-0.72*	-0.66*	-0.59	-0.57	0.40	0.26	0.54	0.70*
Vigorous PA [min]	-0.43	-0.54	-0.11	0.05	0.27	0.24	0.58	0.43

* $p<0.05$

PRE - 1st day of the camp POST - 8th day of the camp PA - Physical Activity

Swimming performance was positively correlated with the results of the 50-m dash test, and negatively correlated with the bent arm hang, and handgrip strength tests during the first day of camp. At the end of the camp a significant, negative correlation was noted between swimming performance and handgrip strength.

Table 4.
Pearson's correlation between 100-m swim trial and fitness tests results in examined swimmers (n=11)

	50-m dash PRE [sec]	50-m dash POST [sec]	Bent arm hang PRE [sec]	Bent arm hang POST [sec]	Grip strength PRE [kg]	Grip strength POST [kg]
100-m swim PRE [sec]	0.64*	-	-0.61*	-	-0.75*	-
100-m swim POST [sec]	-	0.59	-	-0.55	-	0.89*

* $p<0.05$ PRE - 1st day of the camp POST - 8th day of the camp

DISCUSSION

The present study revealed a significant increase in swimming speed and a decrease in grip strength among youth participants of the preseason 8-day swim camp. Data is limited in the literature concerning the effects of preseason sports camps among youth athletes. Hydren *et al*. (2013) reported substantial improvements in sit-and-reach, countermovement jumps, and push-ups performance in eleven 13-years-old ski racers as an effect of a 6-day high-altitude training. On the other hand, Selmi *et al.* (2022) observed a decrease in countermovement jump performance among 15 youth male soccer players who participated in a two-week preseason training camp. Similarly, countermovement jump performance as well as mean power output decreased significantly in six 15-year-old competitive cyclists who took part in a six-day preseason sports camp (Wahl *et al.*, 2021). During these camps, they performed moderate and intense efforts during their training sessions. Selmi *et al.* (2022) suggested that decrease of leg muscle power (countermovement jump) may have been affected by an imbalance in neuromuscular status of youth football players. In their study, variation of neuromuscular status was probably caused by persistent fatigue and insufficient recovery time during the camp.

In our study different motor fitness tests were utilized in the assessment of swimmers' fitness levels. Our intention was to use the tests that are easy to perform in camp conditions, and that are related to swimming performance. We chose a 50-m dash as it is correlated to a 100-m front crawl in regard to performance within age-group swimmers (Rogowska, Bujak & Zarzeczny, 2023). Handgrip strength is also correlated with 100-m front crawl performance (Seffrin *et al.*, 2022) and 50-m front crawl performance (Gomez-Burton *et al.*, 2016) in youth swimmers. Finally, upper extremity muscle strength, and back muscle strength affect freestyle performance on short and middle distances in youth swimmers (Ozeker *et al.*, 2020). Our study confirmed the findings of the aforementioned papers. We revealed significant correlations between the results of the 100-m swim trail, and the results of utilized fitness tests, namely the 50-m dash, bent arm hang test, and the handgrip strength test.

The significant improvement in the 100m front crawl result may have been due -paradoxically- to the moderate training loads applied during the eleven sessions in the pool. Our swimmers were not fatigued by the excessive training volume, so they were able to concentrate harder on the technical correctness of the stroke. Matos *et al.*, (2022) noted that in adolescent swimmers, the result of a sprint race is related, among other factors, to kinematic variables, such as the stroke length and the turning time. Thus, a biomechanical analysis of a 100-m front crawl performance would provide more valuable information on why the results improved.

In our study the grip strength of youth swimmers decreased markedly even though training loads were not strenuous during the camp. We suppose that the prevalence of aerobic training sessions over alternate training modalities may have influenced the grip strength of our swimmers. This is due to the fact that the physiological effect of endurance training is different from the effect of strength training. The main difference is that there is an inverse relationship between the muscle fiber cross-sectional area and mitochondrial oxidative capacity (Huiberts *et al.*, 2024). An alternate explanation of hindered grip strength performance at the end of the camp may relate to the adaptation of sarcomeres in the flexors of the hand and digits. Water resistance tends to stretch these muscles during swimming (Kudo *et al.*, 2013). Thus, the flexors become adapted to delivering force at greater muscle lengths, resulting in more sarcomeres in series within these muscles. However, such adaptations may not be beneficial in squeezing maneuvers. We believe that the conducted swimming training sessions had an adaptive effect on sarcomeres of shoulder and elbow flexors as these muscles are mainly responsible for generating the velocity in front-crawl swimming (Gola *et al.*, 2014). The results of our study confirm the insights of Odabas and Altan's study (2025) in which handgrip strength in 36 adolescent swimmers decreased after 8 weeks of moderate-intensity endurance training. Perhaps the use of other training modalities, especially during land-based activities, would strengthen the forearm and hand muscles in our swimmers. It seems that training with elastic bands would be the right solution in this case. The effect of such training has been found in adolescent handball players (Salas *et al.*, 2025).

The lack of differences in running speed is probably due to the small amount of running exercises during the camp. During the camp, there were six training sessions devoted to running short distances with accelerations. A study by Angulo-Gomez *et al.*, (2022) show that training based on eccentric contractions significantly increased running speed over a 20m distance in adolescents. However, the camp program described in this paper did not introduce strength training to enhance running speed.

The muscular strength of our swimmers, evaluated with bent-arm hang, was classified in the 80th percentile in the report of Tomkinson *et al.* (2018). The outstanding muscular strength of swimmers can be explained by the long-term involvement of shoulder, chest, and back muscles in swimming movements. We did not note significant changes in muscular strength of our swimmers at the end of the preseason camp. It is plausible that low-to-moderate training loads applied during the camp were not a strong enough stimulus to induce changes in muscular strength. The level of muscular strength of our swimmers was lower than observed in Spanish (Saavedra *et al*., 2010) and Croatian (Pavić *et al*., 2008) swimmers at the same age. We suppose that the time of measurement may have affected the results. Our swimmers were examined at the end of summer break, whereas muscular strength of Spanish swimmers was assessed at the end of a competitive season. In that time, just a few days after the main competitions, the activation of their muscles probably remained consistently high. Although the muscular strength of Croatian swimmers was assessed at the beginning of a new school year, they participated in regular swim training sessions during summertime. Thus, their muscles were more activated when compared to our swimmers, who were not engaged in regular training for six weeks.

In the current study we did not note significant correlations between anthropomorphic variables and fitness tests results. However, substantial relationships between swimming performance and body fat percentage, arm span, hand length, and body height were discovered in age-group swimmers in other studies (Bond *et al*., 2015; Dos Santos *et al*., 2021; Ferraz *et al*., 2020). Moreover, Hogrel *et al*. (2012) revealed a distinct relationship between body height and muscle strength in schoolchildren. The lack of such relationships in our study may have been caused by a small sample size.

We noted a significant relationship between the amount of physical activity undertaken by our participants during the summertime and the results of the grip strength and 100-m swimming trials. According to Kharlova *et al.* (2020) higher temperatures and dry weather are associated with an increase of moderate-to-vigorous physical activity in children. This phenomenon is more pronounced in countries with variable climate, such as in central and northern Europe. Drenowatz *et al.* (2021) also revealed the impact of schoolchildren's unsupervised, spontaneous physical activity during summer break on their muscular fitness and cardio-respiratory endurance. Similarly, Augste and Kunzell (2014) observed better performance in speed, power, and endurance fitness tests among children examined in summer. Therefore, summertime physical activity of our swimmers may have affected their fitness tests results during the preseason camp.

We are aware of some limitations of the current study. Firstly, the power of statistical tests is not high due to the small sample size. In fact, our studied group consisted of all athletes aged 13-14 years who regularly attend swimming training. On the other hand, some other studies, cited in the current manuscript, also report a small number of participants (e.g. eleven participants in Hydren *et al*., 2013; six participants in Wahl *et al*., 2021). Secondly, physical activity data may have been subject to error due to possible inaccurate recall of activities performed by examined students during summertime. It is likely that the use of electronic physical activity monitoring devices (accelerometer or smart phone app) would allow a more reliable assessment of the level of physical activity of our study group during the summer break. Lastly, our students did not wear heart rate monitors during training sessions, therefore the actual cardiovascular response to the training loads could not have been assessed objectively. Despite limitations previously mentioned, we collected data from homogeneous group of youth athletes, who followed the same eating, sleeping, and training patterns during the camp. Thus, we provide reliable results from the field tests, that reflect actual motor fitness levels of youth swimmers participating in a preseason camp.

CONCLUSIONS

Participation in an eight-day preseason swim camp presented benefits in terms of improving swimming speed. Light-to-moderate training loads applied during the camp did not affect running speed and muscular strength in examined youth swimmers. This study can provide practical guidance for swim coaches in dispensing various training loads during preseason camp. In future studies, additional analyses would be advisable to gain a broader perspective on the effects of the preseason camp in youth swimmers. For example, a kinematic analysis of swim tests would assess whether the training loads applied during the camp contributed to improvements in swimming technique. It would also be advisable to consider modifying dry-land training to improve selected motor skills (e.g., handgrip strength, running speed). Studies involving larger groups of participants and presenting different activity levels are necessary to determine the actual physiological effect of a preseason camp.

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AUTHOR CONTRIBUTIONS

Grzegorz Bielec participated in the conceptualization, data curation, formal analysis (equal), investigation (equal), methodology (equal), resources (equal), writing-original draft preparation (equal). Daniel Jurak partcipated in the methodology (equal), resources (equal), writing-original draft preparation (equal). Marek Rejman participated in the supervision, formal analysis (equal), investigation (equal). All the authors participated equally in writing-review and editing. All the authors finally approved the manuscript.

DECLARATION OF INTEREST STATEMENT

The authors have no competing interests to declare that are relevant to the content of this paper.