Original Article

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Does technical training increase the effectiveness of swimming at the initial stage of training in girls and boys?

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Abstract: *Background:* The aim of study was to determine the influence of an experimental programme for grasping an effective swimming technique on the results of active swimming among youth swimmers at their initial stage of training. *Methods:* The subjects were 90 children of both sex aged 9–11 year and split into two groups: a) an experimental group (n = 45; girls: n = 18, boys: n = 27) that underwent the original programme and b) a controlled group (n = 45; girls: n = 18, boys: n = 27) that underwent a standard programme. The observation spanned 12 weeks, during which both groups had 24 training sessions. Swimming speed and effectiveness were assessed according to the following variants: A (full style), B (upper limbs), and C (lower limbs). *Results:* The intervention improved results for A (full style) among girls in the experimental group (F(2,68) = 6.37, p = 0.003; η_p^2 = 0.16) and B (upper limbs) (F(2,68) = 7.78, p = 0. 001; η_p^2 = 0.19). Among the boys in the experimental group, a trend towards significance (F(2,104) = 2.45, p = 0.091; η_p^2 = 0.05) was observed regarding variant B. Regarding variant C (lower limbs), among girls, significant changes were noted in the relationship term*group (F(2,68) = 5.19, p = 0.008; η_p^2 = 0.13) and in boys, among terms (F(2,104) = 8.71, p = 0.000; η_p^2 = 0.14). No significant changes were noted in the control groups. *Conclusions*: The applied training improved performance in the experimental group, confirming the validity of introducing exercises to improve swimming technique at the initial stages of training.

Keywords: training optimisation, kids and youth, water sports, motor learning, educability

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INTRODUCTION

The comprehensive training stage, the aim of which is to comprehensively improve the body for sports activity, falls in early school age (8–10 years). In swimming, the main objective at this stage is to technically prepare athletes, fully familiarise them with the water, introduce the elements of sporting competition, and increase the body's aerobic capacity [1]. Additionally, physical, technical, and mental efficiencies, which are interconnected, play a key role in training sessions [2]. Swimming is a strictly technical discipline, and correct technique as well as general fitness should be soundly developed during biological development because they condition the level of sports engagement in the future and are connected with optimal energy expenditure according to individual needs [3]. The principles of economical swimming, referred to as the ability to 'swim fast and without much trouble' [4,5], are used to prepare contestants before sports competitions. It is not only fitness and strength training that impact the level of preparedness but also technical training, which, as Bompa and Haff [6] have claimed, allows contestants to learn the movements, remember them lastingly, and automate them fully.

Boomer and Nelms [7] reported that in swimming, economisation is expressed in the effectiveness of competitors' upper-limb strokes. To achieve optimal swimming ergonomics, coaches should draw swimmers' attention to correct body posture in the water to avoid redundant resistance and ensure that the work on upper- and lower-limb propulsion is correct and effective. Salo and Riewald [8] expressed the same opinion, claiming that the effectiveness of swimming depends mainly on the technical efficiency of propulsion movements, muscle strength, joint flexibility, correct body posture in the water, the level of training, and the swimmer's physical build. They also claimed that swimming technique has an enormous influence at the developmental age and that technical training in this period should account for up to 80% of the total training time.

To perfect their swimming technique, contestants should not only focus on high speed but also control the so-called swimming step, which means 'the number of strokes needed to cover a distance' [9]. Neglecting swimming technique control may negatively impact swimmers' ability to perform at their best during swimming competitions. The two above-mentioned values should be specially shaped while training young swimmers and refined at subsequent training stages [3,10]. An optimal swimming technique is a perfectly mastered movement habit that enables the achievement of the best athletic score. However, it should be remembered that as a swimmer, a growing organism is not just a 'miniature of an adult'; hence, the loads used should be determined according to individuals' developmental features, that is, meticulously selected to suit each specific contestant [6,11-13]. Recent findings also confirm that long-term swimming training induces measurable somatic adaptations in children, which underlines the importance of tailoring loads to biological age rather than chronological age [14,15].

Despite many indications and recommendations regarding the meaning of 'swimming technique', there is still insufficient research concerning the comprehensive training stage as the basis for subsequent sport championships. The aim of this research was to ascertain the influence of an original technique programme for improving the effectiveness of swimming on the results of active swimming among swimmers in the early stages of training.

MATERIAL AND METHODS

Participants

The research subjects were 90 children aged 9–11 years (10.9±0.67 years) attending swimming sessions (females: n = 36; males: n = 54). The experimental group (E) (total: n = 45; girls: n = 18; boys: n = 27) underwent the original programme in Club 1. The controlled group (K) (total: n = 45; girls: n = 18; boys: n = 27), from Club 2, underwent a standard Polish Swimming Association swimming programme. The groups were similar regarding age and the duration of swimming practice, which was approximately 2 years.

The main qualifying criterion was similar training loads. Additionally, all the swimmers were prepubescent.[12] All participants attended swimming classes regularly and showed a similar level of swimming skill defined by their performance of special exercises designed to test and qualify each child to the swimming classes. The intervention was conducted by the researcher who carried out the experiment.

The swimming skill test involved the following: Swim 100 m in alternating style; evaluate the level of initial swimming skill according to two variants, following the rule 'made the attempt or did not make the attempt'. To qualify for further examination, participants had to demonstrate the swimming technique in four swimming styles in the order of the alternating style.

Procedures

Swimming speed was measured over a distance of 25 m in three variants (A: full style, B: only upper limbs, C: lower limbs). The tested athlete entered the water on the track designed for performance of the test. At the height of the starting post, the athlete assumed a ready-to-take-off position (analogous to the position used for measuring thrust): squatting, with feet resting against the wall of the pool and one hand holding the body against the wall by holding on to the post bar, while the other hand extends forward in the direction in which the athlete will be swimming, with the head facing that hand, also pointing in the intended direction. After the start time, the test subject can begin swimming the distance at any time of their choosing. Manual timing, using a FINIS 3X-100M stopwatch (FINIS, Inc., USA), began at the moment the athlete's feet left the pool wall. When the test subject's hand touched the opposite wall (at the end of the prescribed distance), the time was stopped and recorded on the timing card. The timing method was in accordance with the Polish Swimming Federation's (PSF) regulations. To minimise error, measurement was always performed by the same well-trained and experienced people. When the test was conducted for assessment of variant C, that is, upper limbs only, the athlete held grey-blue ZOGGS (Camberley, UK) swimmers between their legs. When the test was conducted with the legs only, using the crawl technique, the test subject held a yellow ZOGGS (Camberley, UK) board in their hands and assumed an arrow position while lying on their chest. The equipment used gained the required approval and is standard during training and swimming classes with the observed groups. Swimming speed was converted into velocity using the basic formula $v = s/t$, where s is distance, and t is time; results were presented in m/s. Relative velocity expressed in m/s/kg was considered in the analyses to eliminate the possibility of the subjects' bodyweight influencing the results.

Measuring swimming effectiveness

Swimming effectiveness was measured during a 25-m swimming test in freestyle, front crawl style, and full style (variant A). The researcher recorded the number of upper-limb strokes. To verify score accuracy, the swim tests were recorded (GoPro Hero 6 Black, GoPro, Inc., USA), and the footage was compared with the scores the researcher assigned [14].

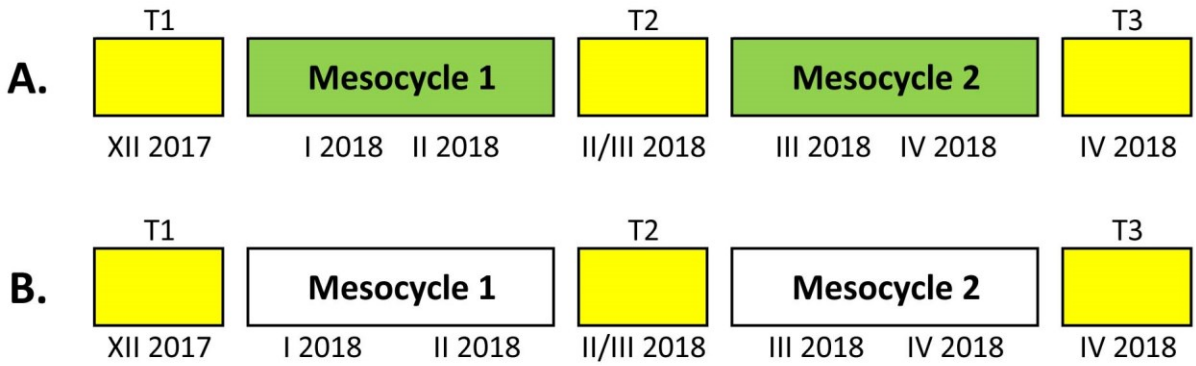

Figure 1. Experimental group (A) and Controlled group (B) training plan

Experimental structure

After two weeks of general swimming (comprising two 45-min swimming units per week), the project was launched to standardise the swimming level across both groups. The experimental variable was an original set of exercises, the aim of which was to have the swimmers perfect the front-crawl technique. The experimental exercises encompassed 12 out of 24 training units over a 12-week period from January 2018 to April 2018. They were then split into two basic stages that differed in terms of load intensity. Stage 1 covered 1,000 m and included technical exercises in every training unit. Stage 2 covered 1,500 m and aimed to have swimmers perfect the above-mentioned technical exercises in every training unit.

At the beginning of the experiment, preliminary tests were conducted at T1 to determine the participants' starting swimming technique level. The experimental and controlled groups did the same number of weekly training units, with similar training loads.

The contestants in both groups (E and K) participated in three swimming units weekly and swam 1–2 km during every training session. During the training units in which swimmers from the experimental group performed special technical tasks (Mesocycles 1 and 2; Figure 1A), the children in the controlled group performed the trainers' and researchers' tasks (Mesocycles 1 and 2; Figure 1B), so that each group covered the same swimming distance without an overemphasis on swimming technique beyond the standard programme.

Mesocycle 1 concluded with a control test at T2 for both the experimental and controlled groups. After both groups of swimmers completed Mesocycle 2, another control test was administered at T3.

The experimental variable was the author's set of exercises to improve the front-crawl swimming technique, which involved 12 training units. Workouts with technical elements were scheduled for Tuesdays and Thursdays during the morning training unit. Group E contestants undertook the technical tasks with due diligence and commitment, and the trainers ensured optimal conditions for performance of the tasks through their methodologies. Specifically, the trainers' selection of exercises to improve the front-crawl technique considered body position in the water, proper water grip, and correct pulling and pushing in the water. Attention was also paid to appropriate coordination of the work of the upper and lower limbs and inhalation. To improve the technique, a video-assisted analysis of each athlete's movements was compiled.

Statistical Analysis

To verify the hypothesis on normality of the decomposition of the analysed variables, the Shapiro-Wilk test was used. The results were expressed as mean values (M), standard deviation (SD), minimum range (min), and maximum (max). Regarding meeting the sphericity conditions, checked using Mauchly's test, to compare the terms and groups simultaneously, classical analysis of variance (ANOVA) was used for repeated measurements with a post-hoc NIR Fisher test. For statistically significant differences in post hoc, effect size was calculated using Cohen's d. Based on the ANOVA results, interaction diagrams were compiled according to the main factors: GROUP*TERM.

All hypotheses were verified at a significance level of p = 0.05. The results were compiled using standard statistical methods. All data were analysed using STATISTICA 10 (data analysis software system, StatSoft, INC. 2010).

Ethics Statement

The study was approved by the Human Ethics Research Committee of Karol Marcinkowski Medical University in Poznań (Poland). After being informed of the procedures and potential benefits and risks associated with the research, the study was by participants and their parents or legal guardians also provided written informed consent for participation in the study. The research was conducted by faculty and staff of the Poznań University of Physical Education.

RESULTS

The speed test results as well as those of the swimming technique assessment are shown in figure 2, across the variants: A (full style), B (upper limbs), C (lower limbs) with division for sex for observed young swimmers.

The front-crawl swimming technique was assessed according to the number of strokes the swimmer took while covering the 25-m distance. To exclude the possible influence of the participants' body mass between observed groups, the relative speed results over 25 m are shown. Having followed the experimental programme, improved swimming results were observable in both male and female swimmers in the experimental group, with superior results noted for maximal swimming speed and the observed variants compared to the control group.

Relative maximal swimming speed and swimming technique in variant A (full style)

The subjects in the experimental group showed higher swimming speeds in variant A than those from the controlled group over the whole intervention period (Figure 2).

Detailed analysis of relative maximal full-style swimming speed revealed a noticeable simultaneous difference between the terms and groups ($F(2, 68) = 6.37$, $p = 0.003$, $\eta_p^2 = 0.16$) among the girls. Post hoc showed a statistical difference between the first and second term exclusively among girls in the experimental group ($p = 0.031$; d = 0.163), whereas there was no significant statistical difference among the boys ($F(2, 104) = 0.73$, $p = 0.482$, $\eta_p^2 = 0.01$) (Figure 2). Moreover, among all children from the experimental group, a reduction in the number of upper-limb strokes needed to cover 25 m in full style was observed. A significant statistical difference in the number of strokes was observed exclusively among the girls from the experimental group between the terms ($F(2,68) = 3.521$, p = 0.033, $\eta_p^2 = 0.06$). Post hoc analysis showed a significant difference between the first and second (p = 0.003, d = 0.405) and the first and third observation period (p=0,008, d = 0.587).

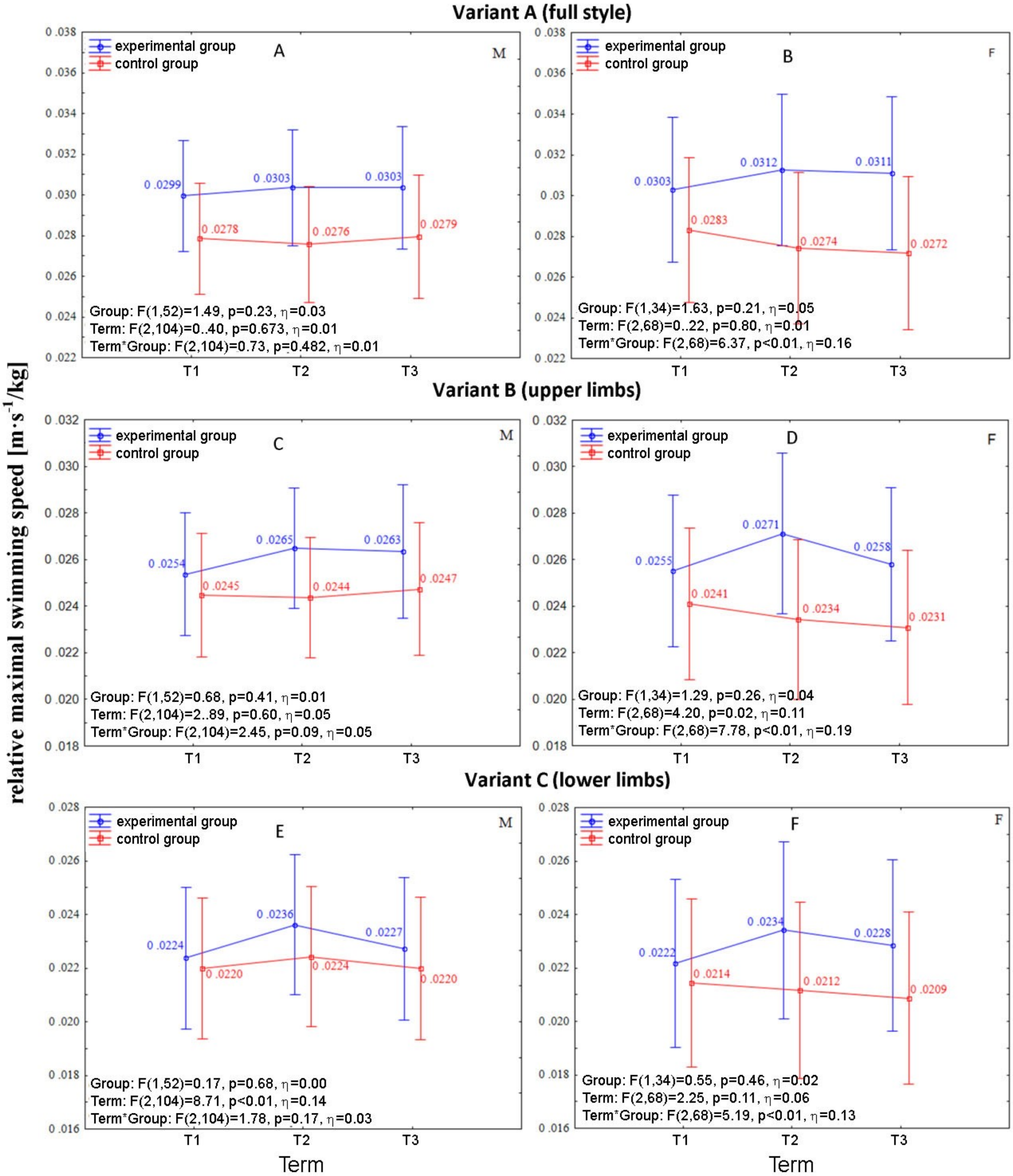

Figure 2. Characteristics of changes in boys' (M; A, C, E) and girls' (F; B, D,F) relative maximum swimming speed scores in variants: A (full style), B (upper limbs), C (lower limbs) over 25 m. [vertical bars represent 0.95 confidence intervals]

Relative maximal swimming speed and swimming technique in variant B (upper limbs)

The speed at which the participants covered 25 m using only their upper limbs was faster in the experimental group among both girls and boys. Detailed analysis of relative maximal swimming speed with the use of the upper limbs only revealed a noticeable statistical simultaneous difference between the terms and groups among girls ($F(2, 68) = 7.78$, $p=0.001$, $\eta_p^2 = 0.19$). Post hoc showed a statistical difference between the first and second as well as the second and third terms exclusively among girls in the experimental group ($p = 0.000$, d = 0.287; $p=0.002$, d = 0.237, respectively). Among the boys, a trend towards statistical significance was observed (F(2, 104) = 2.45, p = 0.091, η_p^2 = 0.05), possibly due to Type II statistical errors. Post hoc showed a statistical difference exclusively among the boys in the experimental group between the first and second (p = 0.005, d = 0.192) and first and third (p = 0.014, d = 0.166) observation terms (Figure 3).

Moreover, a reduction in the number of strokes needed to cover the 25-m distance in variant B was observed among the swimmers in the experimental group (F(2,68) = 6.812, p = 0.002, η_p^2 = 0.12). Post hoc analysis showed a significant difference between the first and third (p = 0.001, d = 0.065) and the second and third observation period (p=0,012, d = 0.773)

Relative maximal swimming speed in variant C (lower limbs)

Among the subjects in the experimental group, swimming speed with exclusive use of the lower limbs was faster than those in the controlled group. Detailed analysis of maximum swimming speed using only the legs revealed a statistically significant simultaneous difference between the terms and groups (p = 0.008) among girls. Among boys, a statistically significant difference between the terms was noted (p = 0.003). Statistically significant differences were only found in the experimental group. Among girls, regarding the relationship term*group (F(2, 68) = 5.19, p = 0.008, η_p^2 = 0.13), post hoc showed a significant difference between the first and second observation terms (p = 0.001; d = 0.226). Among the boys, significant differences among the first and second (p = 0.000; d = 0.202) as well as the second and third (p = 0.004; d = 0.054) observation terms were only noted in the experimental group, revealed post hoc. Other analyses showed no significant differences (Figure 4).

DISCUSSION

The most important finding of our study is that the key to progressing in terms of swimming performance at successive training stages is technical swimming style (e.g. front crawl) efficiency, mastery of which is directly related to the speed at which a swimmer can cover a specific distance. In the relatively rich scholarly literature concerning swimming training, insufficient attention has been paid to analysing the effectiveness of swimming technique teaching among swimmers at the initial stage of training in the age range of 9–11 years. To fill this research gap, the present study was conducted to ascertain the influence of an original programme for grasping an effective swimming technique on athletic scores in active swimming over 25 m among competitors of both genders at the initial stage of sports training.

Analysis of the study results indicated that the fewer arm strokes a swimmer makes, the faster they can cover 25 m. Furthermore, regarding upper-limb strokes, increased rotation was observed, thus intensifying the 'feeling of water'. Moreover, the inclusion of lower-limb work in the experiment strengthened participants' lower limbs, which increased the speed at which they covered 25 m in variant C. Morouco et al. [16] asserted that leg work is crucial in swimming, especially for short sprints in the range of 25–50 m. Those scholars have advised trainers to focus on improving swimmers' lower-body work in addition to upper-body work.

Furthermore, Jerszyński et al. [17] showed that children grasp new technical elements very easily in the early stages of training, which is in line with the premise of our investigation. Additionally, as training practice has shown, the exercises the trainer / teacher introduced during the experiment met with considerable interest and ease of acquisition on the part of the young swimmers, which led to improvement in the quality of their application of the technical elements and faster swimming speeds. Consequently, their degree of comfort with moving in the water was greater.

Wiesner and Rejman [18] have indicated that the benefits of acquiring swimming skills extend beyond athletics to bolster swimmers' sense of security, bring them joy, and boost their self-esteem; moreover, swimming skill translates into swimmers' willingness to take reasonable risks connected with overcoming the fear of water. However, swimmers maintain a healthy respect for hazardous activities. This combination may produce good results regarding the ability to move freely in water, which is necessary for swimmers to focus on the training elements without losing the energy needed to remain on the surface of the water.

In swimming, sports performance depends on athletes' ability to spend a minimal amount of time performing specific physical activities (at maximal speed), which requires a high level of strength. To perform a high-strength movement at maximal speed, the swimmer must overcome external resistance. Speed progress may be made thanks to the swimmer's increased 'strength provided we do it in the same movement in which we expect the increase [in] speed' [19].

For children and teenagers, training is treated as a subsystem of competitive sport, justified by the fact that function and ability specifically shape every stage of ontogenesis flow; training should be adjusted to suit the abilities of each individual competitor [11,12], given the strict connection with biological development [12,13]. Moreover, this stage is an introduction to a complex championship formation process which, according to Ericsson at al., [20] may take 10 years or 10 000 hours, comprising not only training hours but also other forms of physical activity. At this stage, sports aptitudes are shaped in consonance with the swimmer's rising biological potential. It should therefore proceed harmoniously to avoid overly heavy training loads that could disturb the natural rhythm of swimmers' development, including puberty. In the absence of such precautions, training may lead to premature sporting specialisation, which could manifest in physical overload, injury, and burnout syndrome, potentially causing swimmers to resign from sports competition [21-23].

To prevent the above-mentioned negative outcomes, sports development should be pursued rationally and in an organised manner, which entails the coach formulating appropriate activities and aims. When training young competitors, carefully selected training loads that respect the rules of gradation with regard to championship development and biological development play a key role [12,13,21,24].

For children and teenagers at the preliminary training stage, fun and play should be prioritised alongside skilfully chosen technical exercises and training loads well suited to each youth's biological development [12,13,25,26]. Embodiment of the motto 'faster, higher, stronger' should be tempered by respect for the phases of children's training and youth. Trainers must be aware that unnatural acceleration of children's training or the overload of their psycho-physical abilities will not support high athletic scores when the trainees reach maturity [21,27].

In swimming, achieving desirable results is connected with the quality of early-stage training, especially regarding technical excellence, which is functional preparation for the stage with the highest training loads [11].

To guarantee the highest quality, the training should be scientifically-based, as relevant scientific knowledge offers excellent foundational support for trainers' decision making regarding training unit design, with consideration of swimmers' individual needs indicated by the findings of objective measurements for control and assessment, as well as the temporal structure of the training [6,28].

Observation of competitive swimmers has shown that contestants with a very good swimming technique and highly coordinated upper- and lower-limb strokes have an advantage, as these elements serve as a basis for successful swimming and are co-determinants in the ultimate sporting achievement [1].

To finish the training effectiveness assessment, systematic control of the quality of the technique for moving in the water should be checked by, for example, observing the changes in stroke frequency over a particular distance, that is, the number of movements necessary to cover a certain distance. Lack of control of the swimming technique limits swimmers' awareness of correct training methods, which may hinder outstanding performance in competition [1,9].

Referring to the rule of economical swimming, Bompa and Haff [6] asserted that in addition to endurance training, technical training also impacts improvement because, as Czajkowski [29] emphasised, the correct swimming technique is a 'movement habit that leads to perfection', which supports the achievement of the best possible results. This relates to the main premise of sports––competition––at every training level, with optimal conditions to meet each particular group's needs.

To reach this goal, trainers should bear in mind that youth training should not simply mirror training for top swimmers. Rather, youth training ought to be consciously designed, customised to a given swimmer at the initial training stage, and most importantly, implemented from the perspective of the swimmer's progress and keeping them at the specialist stage.

The above-mentioned research has some limitations. First, biological development was not considered, though its inclusion could reveal interesting information. Rather, the focus was on technical qualities and swimming specialisation, under the assumption that these elements would contribute the most information. Subsequent studies should incorporate biological development. Second, relative thrust values were shown due to between-group differences in physical build to eliminate the possibility of the subjects' body mass influencing the results. High absolute thrust values enable great power and strength with regard to the surroundings. Relative strength, on the other hand, 'decides on the effectiveness of the movements conducted by the whole body or its parts (for example, upper limbs)'. In sports that require individuals to develop great strength in relation to their body mass to perform technical tasks, relative strength should also be considered [30,31]. The relative thrust values are given in Newton per kilogram (N/kg) of gross mass.

CONCLUSION

A positive influence of the original technical training programme on swimming effectiveness in all researched variants in the experimental group was verified. The programme improved young swimmers' active swimming speed over 25 m.

At the initial stage of training, there is a relationship between swimming speed and effective swimming technique that may indicate that the training to improve young swimmers' swimming technique positively impacted overall swimming growth, compared to a standard training programme based on as much swimming as possible in every training session. Thanks to the introduction of technical training, increased upper-limb rotation was observed in the experimental group, which led to better water grip in the upper limbs hands.

Competing interests: The authors declare that they have no conflict of interest regarding the publication of the manuscript.

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