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Original Article

Results of a five-year test program to develop the swimming skills and physical abilities of freshman pedagogy students in Nitra

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Abstract
As of the 2010-2011 academic year, the Faculty of Central European Studies at the Constantine the Philosopher University in Nitra has annually examined the development of swimming skills and general physical stamina of freshmen pedagogy students over the course of their first semester. In the past five academic years, 97 such students have been tested with an aim to study the impact of an educational development program composed primarily of aquatic exercises.
The results of this analysis have shown significant development of basic swimming skills ($p < 0.05$), as well as breaststroke and backstroke techniques over a distance of 25m ($p < 0.001$). The conditional and coordination levels of the group were significantly improved in nearly every test ($p < 0.05$) excepting the static vestibular system. Assessments performed at the beginning and close of the period revealed many significant relationships between body measurements, basic swimming skills, and physical abilities ($p < 0.05$).
Keywords: swimming skills, physical abilities, coordination skills, research program, 19-20 year old students

Introduction

Although swimming is one of the most important sports in Slovakia, not enough attention is paid to further develop a student's skills following certain levels of education. Our present research was motivated by the intention to improve our college freshmen's poor swimming skills and overall low physical ability levels. In order to accomplish this, we created an exercise program focused on these concerns, and each year (beginning with the 2010-2011 academic year) we assessed the students' development at the end of their first semester. In our university, and specifically for students studying to become kindergarten teachers, swimming is a mandatory course taken at this time, and as such is the only physical education course they much attend. Therefore, such an exercise program is the only means by which to positively impact the student's physical abilities.

Given previous research results obtained by studying various age groups, here too we have examined the correlation between swimming level and measured physical ability, though it was a difficult task to ensure the validity of the test system and apply the various test methods to measure skills versus abilities correctly (Baráth, Benčuriková and Viczay, 2007; Viczay, Kontra and Macejková, 2007; Benčuriková, 2009, 2010; Macejková and Viczayová, 2008, 2010; Macejková, Viczayová and Masaryková, 2008; Viczay, 2011; Viczay, Kontra and Baráth, 2014; Viczay and Kontra, 2015). In addition, we could not find any relevant or comparable resources by which to analyse the data – there is no domestic or foreign literature which focuses on the development of swimming skills during the first year of college for those studying to become kindergarten teachers. In Slovakia, any similar research was primarily focused on the results of the physical education entrance exams, or on comparisons of different groups at the end of the selected semester (Bence, 2007; Nitrai, 2003; Macejková, Masaryková and Čepová, 2005; Macejková, Kalečík and Hrubiznová, 2014).

Furthermore, we have found very little empirical data on the correlation between swimming skills and physical abilities. Such studies have been conducted largely on preschoolers and school children, and thus do not match our results on account of the difference in age (Benčuriková et all., 2011; Viczay and Kontra 2008, 2015; Macejková and Viczayová, 2008, 2010; Macejková, Viczayová and Masaryková, 2008; Viczayová, 2011).

We propose that the development of physical abilities in these students is important on account of future problems which may arise from poor swimming abilities should the students become qualified as kindergarten teachers, or, later, elementary school physical education teachers. For this reason, the training is evaluated on a scale of practical marks, the components of which are: (1) standard water safety practices, (2) 25m breaststroke performance, and (3) education methodology basics.

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The main aim of our research was to discern how the aquatic exercise program we compiled might develop the swimming skills and physical abilities of students studying to become kindergarten teachers, and to explore any major correlations therein. We propose that our development program works effectively. Furthermore, we submit that there is a relationship between anthropometric indicators, swimming skills, and physical abilities.

Material & methods

The five-year research program of the Faculty of Central European Studies at the Constantine the Philosopher in Nitra included 97 female students studying to become kindergarten teachers. Over a period of twelve weeks, the students attended weekly, 90-minute lessons during which we applied an aquatic exercise program based on literature concerning the swimming skills of beginning students (Karissa, 2002; Tóth, 2002; Benčuriková, et al., 2011).

The program was based on easy to understand instructions, logically interdependent coordination and conditional exercises, natural movements in the water, exercises to improve technique, and water games. The first two lessons were focused on basic swimming skills: breathing while swimming, diving and underwater orientation, floating on the stomach and back, gliding on the stomach and back, and jumping into the water. The order of the selected sample of students was not changed during the training, and in order to move on to the next skill, each student had to demonstrate a flawless execution of the previous one.

The main part of the exercise program consisted of backstroke instruction (40 minutes) followed by improvement of breaststroke technique (20 minutes). At first, the students practiced the arm and leg work of both strokes on dry land so as to better feel and master the correct movement; this was followed by the use of various devices as training aids (floats, swim boards, noodles, and pull buoys). During backstroke instruction, we carefully monitored the body's position in the water in order to maintain correct hip placement. The last ten minutes of each lesson were focused on jumping into the water, diving, and basic water rescue methods. The main aim of the exercise program was such that at the end of the course, each student would be able to swim, correctly and without stopping, a distance of 25m. To measure the swimming skills and selected physical abilities, we used two test modules based on relevant literature (Kiricsi, 2002; Tóth, 2002; Moravec, Kampmiller and Sedláček et al., 2002; Macejková et al, 2005; Benčuriková, 2009).

Swimming skills (Si): [S1] diving, [S2] floating on the stomach, [S3] floating on the back (end results only), [S4] gliding on the stomach, [S5] gliding on the back (end results only), [S6] 25m breaststroke, [S7] 25m backstroke (end results only).

Physical abilities (Pi): [P1] Jacík test, [P2] sit-up test, [P3] standing long, or broad, jump test, [P4] static vestibular system with eyes open (Flamingo test), [P5] static vestibular system with eyes closed (Flamingo test).
In our analysis of the data, in addition to applying descriptive statistics, we examined the changes within a group by means of the one-sample t-test. To explore the relationships between variables, Pearson's correlation coefficient was used. Data was considered significant at a 0.05% level.

Results and discussion

Changes in the levels of swimming skills

In terms of physical size, the average height, weight, and body mass index was essentially the same at both the beginning and end of the course ($p > 0.05$); further, given the average body mass index, the students were classified as within normal range at the time of both assessments.
As can be seen in Table 1, our aquatic exercise program had a positive effect on the development of S1, S2, and S4 basic swimming skills ($p < 0.05$). Because the students were initially unable to swim on their backs, S3 (floating on the back) and S5 (gliding on the back) could only be tested at the end of the program; entry times for these skills are therefore blank. On the other hand, because the face is held above the water in these tests, the students were able to master them in a relatively short time – at the end of the program, the average value for S3 was 37.4 seconds, and for S5 7.2m.

The high standard of deviation in Table 1 indicates significant performance differences among the students. The reason behind the high deviation in values for the S2 (flotation) and S4 (gliding) tests at the conclusion of the program may be that not all students were able to learn the breathing technique which is so key to these skills. In addition, some students visibly struggled with effectively starting a glide and maintaining its rhythm, whose range is also largely determined by lower limb strength; we believe that the combined effect of these factors may have caused the differences within the group's results for S4. As for the average results for S6 (25m breaststroke), the end time of 35.5 seconds is significantly better than the 38.5 seconds noted at the beginning of the course ($p < 0.001$). Given the smaller standard deviation measured at the end of the program, it can be said that the group became more homogeneous over time. We propose, also, that the improved performance can be explained by the acquisition of basic swimming skills and the application of exercises to improve overall technique. As for S7 (25m backstroke), by the end of the program more than 80% of the students had mastered the technique and could successfully cover the 25m distance, though for some the correct execution of arm work, the overall harmony of arms and legs, and hip sinking, respectively, continued to pose issues. The latter is most problematic given that excessive hip sinking increases frontal resistance, and so requires more power from the swimmer in order to implement the motion cycle; this can lead to a significant speed reduction in beginners. In summary, however, our aquatic exercise program resulted in a significant improvement of basic swimming skills and swimming performance level.

Table 1: Test results of basic swimming skills (n = 97)

Test/Variable	Testing	Mean	SD	Min.	Max.	t-value
S1 (s) **Diving test**	entry	19.0	10.90	5.3	56.1	**-2.758****
	exit	23.2	9.05	7.7	41.7	
S2 (s) **Floating on the stomach test**	entry	14.4	7.18	5.6	31.7	**-7.877*****
	exit	25.3	12.33	5.1	64.0	
S4 (m) **Gliding on the stomach test**	entry	6.5	1.92	3.1	11.3	**-9.185*****
	exit	9.2	2.11	5.0	14.6	

Changes in the level of physical ability

As seen in Table 2, with the exception of the static vestibular system (P4, where $p > 0.05$), the conditional and coordination performance of the group improved significantly during the study.

Table 2: Test results for conditional and coordination skills (n = 97)

Test/Variable	Testing	Mean	SD	Min.	Max.	t-value
P1 **Jacík test**	entry	60.9	11.21	39.0	92.0	**-6.018*****
	exit	66.1	10.47	34.0	99.0	
P2 **Sit up test**	entry	29.9	8.29	16.0	50.0	**-4.677*****
	exit	32.3	9.36	18.0	50.0	
P3 **Broad jump test**	entry	148.0	22.33	99.0	204.0	**-4.081*****
	exit	154.8	23.86	111.0	219.0	
P4 **Flamingo test – open eyes**	entry	165.5	104.20	18.0	360.0	**-1.914**
	exit	188.5	111.07	11.1	528.0	
P5 **Flamingo test – closed eyes**	entry	10.2	15.962	1.0	76.0	**-2.830****
	exit	15.5	16.079	1.2	70.0	

The high standard of deviation in all of these tests indicates that the performance differences amongst the students had not decreased by the end of the study. More specifically, the high standard of deviation in the case of the two balance tests (P4 and P5, both Flamingo tests), can be attributed to the extremely poor performance of some students, as well as to the different developmental and functional statuses of the vestibular apparatus. Due to the development and sensitivity of the vestibular system, several authors have measured similar performance fluctuations when applying these tests to different age groups (Baráth, Benčuriková and Viczay, 2007; Benčuriková, 2009, 2010). A developmental experiment conducted by Farmosi (1992) among first-year university students likewise showed the high degree of variability in balancing performance indicated by the high standard deviation values. Our results of the balance tests are, further, also in accordance with the arguments of other researchers that the development of coordination skills is closely related to the development of the nervous system, and as such is determined by the dynamics of the latter's development. Therefore, the quality depends mainly on the state of the vestibular apparatus and the development of the central nervous system (Benčuriková, et all., 2011). It is very likely that the reason for the poor performance can be linked to insufficient skill development during the primary school age. Per our data, we have been able to only partially confirm that the effect of our aquatic exercise program improves each of the selected physical abilities in our study group, as there was no significant difference between the initial and final results for P4 (Flamingo test with eyes open). We believe that the results are influenced, collectively and respectively, by developmental differences, the status of movement development, and the genetic basics of the vestibular apparatus.

Exploring relationships between test variables

In this section of the study, we will describe the relationships we found among physical measurements, physical abilities, and swimming skills.

Body measurements as related to basic swimming skills, 25m breaststroke, 25m backstroke, and physical abilities

Per Table 3, during the initial stage of swimming instruction, body measurements can play a key role in learning swimming skills. More specifically, body mass and body composition (BMI) are directly related to gliding on the stomach and back. This is further underscored by the results of Kiricsi (1999), who, by applying factor analysis, found that body measurements and body composition directly influence the process of learning to swim.

Table 3: Body measurements as related to basic swimming skills, 25m breaststroke, 25m backstroke, and physical abilities (the correlation coefficients)

Test/Variable	Body height		Body weight		BMI	
	entry	exit	entry	exit	entry	exit
S1 (s) Diving test	0.189	**0.372***	0.160	0.235	0.103	**0.107**
S2 (s) Floating on the stomach test	**0.357***	**0.315***	0.065	0.177	-0.069	0.055
S4 (s) Gliding on the stomach test	**0.362***	0.245	**0.432*****	**0.548*****	**0.313***	**0.490*****
S5 (s) Gliding on the back test	---	-0.044	---	**0.426*****	---	**0.481*****
S6 (s) 25m breaststroke test	- 0.088	-0.146	**-0.217***	-0.143	-0.173	-0.113
P1 Jacík test	-0.210	-0.182	**-0.237***	**-0.307***	-0.163	-0.207

The significant relationship between body mass and the 25m breaststroke skill can be easily explained: at the beginning of the program, the students' technique was inadequate, which naturally required greater exertion. As a result of exercises to improve this technique, their progress in the water became easier, and was no longer as significantly impacted by body weight. The general level of fitness (P1) is clearly influenced by weight, as for more overweight students this task proved more difficult.

Basic swimming skills as related to 25m breaststroke and 25m backstroke

The results of our correlation analysis reaffirm the fact that swimming skills are key factors in the teaching and acquiring of different swimming styles. Per Table 4, the proper implementation of diving, floating, and gliding skills can significantly determine overall performance. For example, backstroke mastery would not have been possible if the neuromuscular system had not previously adapted to the uncommon movement of gliding on the back.

Table 4: The correlation coefficients of basic swimming skills and swimming performances

Test/Variable	S6 25-meter breaststroke		S7 25-meter backstroke
	entry	exit	exit
S1 (s) Diving test	-0.281	**-0.345***	**-0.411*****
S2 (s) Floating on the stomach test	**-0.465*****	-0.302	**-0.437*****
S4 (s) Gliding on the stomach test	**-0.550*****	-0.245	**-0.461*****
S5 (s) Gliding on the back test	---	**-0.351***	**-0.316***

In accordance with other researchers, our findings also prove that it is highly ineffective to begin swimming instruction until students are able to properly blow air into water, dive, and glide.

Basic swimming skills as related to physical abilities

As can be seen in Table 5, more significant relationships were found between basic swimming skills and the initial and final levels of physical ability. For example, the ability to balance (P4) correlates directly with the level of three important swimming skills: When diving under water (S1), it is vital that beginners are able to maintain their balance, as they may not otherwise be able to recover their lost vertical equilibrium within the new, foreign medium, which is itself moving. Further, floating (S2) and gliding (S4) exercises are done in a horizontal position – which is an unusual posture whose acquisition, initially, may cause an increased burden on the vestibular apparatus.

Table 5: The correlation coefficients of basic swimming skills and physical abilities

Test/Variable	P4 Flamingo test – open eyes		P2 Sit-up test		P3 Broad jump test	
	entry	exit	entry	exit	entry	Exit
S1 (s) Diving test	**0.412*****	**0.446*****	**0.549*****	**0.494*****	**0.447*****	**0.371***
S2 (s) Floating on the stomach test	**0.413****	**0.437****	**0.466****	**0.578****	**0.445****	**0.346***
S4 (s) Gliding on the stomach test	**0.440****	**0.326***	**0.420****	**0.471****	**0.367***	0.040
S5 (s) Gliding on the back test	---	0.052	---	0.041	---	**-0.389***

Gliding distance (S4) depends largely on two factors: correct technical implementation, and the strength of take-off. Thus, the dynamic power of a person's legs (P3) will play a large role here. For those students unable to acquire and/or carry out a proper take-off technique, the overall glide performance was weaker. As students were unable to swim on their backs at the beginning of the program, we were unable to measure an initial input value for gliding in this position. Otherwise, it is evident that diving, floating, and gliding all show a significant correlation with abdominal muscle power. We believe that there may be more as yet unknown, latent variables in the background of these relationships, which require further research to appropriately explore and interpret.

25m breaststroke and 25m backstroke as related to physical abilities

As can be seen in Table 6, with regards to physical abilities, dynamic leg power (P3) and the ability to balance (P5) correlated significantly with 25m breaststroke performance (S6). The first relationship is self-explanatory, as leg strength is the key factor in breaststroke performance (even more so than in other strokes); since in nearly all students the leg technique was incorrect at the beginning of the course, swimming the given distance meant a greater demand on those muscles, and the change in the relationship at the end of the program indicates significant improvement. The better a swimming technique is, the more economical the effort of an individual muscle group – in other words, with optimal technique, a swimmer can swim a given distance more quickly, and with less effort.

Table 6: The correlation coefficients of swimming performance and physical abilities

Test/Variable	**S6 25-meter breaststroke test**		**S7 25-meter backstroke test**
	entry	**exit**	**exit**
P2 Sit up test	-0.159	-0.215	**-0.340****
P3 Broad jump test	**-0.331***	-0.182	**-0.426****
P4 Flamingo test – open eyes	-0.217	-0.194	**-0.376****
P5 Flamingo test – closed eyes	**- 0.305***	-0.248	-0.059

According to the results of the exit assessment, 25m backstroke performance (S7) was closely related to: (1) abdominal muscle strength (P2), (2) dynamic leg strength (P3), and (3) vestibular system level (P4). The backstroke was taught as a new swimming style to the students, and is one in which progress is made in a different position when compared to other swimming styles; on account of this, most beginners struggle with keeping their balance while floating on their back. In addition, the moving and unstable (as such) water puts a further burden on the vestibular organs, so stimulation will increase performance until the motion becomes automatic. In addition to leg technique, backstroke performance is also affected by the strength of the leg and pelvic muscles.

Conclusions

For our research program, we set out to develop the swimming skills and physical abilities of freshmen studying to become teachers; summarizing our results, we can conclude that our exercise program and educational methodology significantly improved both basic swimming skills and swimming performance levels. When comparing the beginning and end performance results of the students, significant improvement in several physical abilities is evident. Specifically, these developments ($p < 0.05$) are as follows: general stamina (P1), the dynamic strength of abdominal muscles (P2) and lower limbs (P3), and the level of static balance detection with eyes closed (P5). On the other hand, there was no significant change ($p > 0.05$) in the level of static balance detection with eyes open (P4).

We assumed there would be significant correlations between body measurements, physical abilities, swimming skills, and 25m breaststroke and backstroke performance. We found, however, that there are relationships between the variables which are not as significant ($p > 0.05$). Nonetheless, the results of our study repeatedly confirm that in order to effectively teach a swimming stroke, swimming skills need to be focused on; furthermore, physical ability will determine the level of swimming skill and performance, particularly in the initial stages of swimming instruction.

The final results of our study indicate that by applying a properly crafted exercise program, students can adequately adapt to the aquatic environment and learn basic swimming skills, as well as the foundations for more complicated swimming styles. In light of our results, therefore, we propose further research – both more nuanced and multi-directional, and with a greater sample size – in order to study the remaining questions in this area.

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