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EFFECTS OF HEAD POSITION ON THE DURATION OF BREASTSTROKE SWIMMING IN PRESCHOOL SWIMMING BEGINNERS

VPLIV POLOŽAJA GLAVE MED PRSNIM NA PLAVALNO ZMOGLJIVOST PREDŠOLSKIH ZAČETNIKOV

ABSTRACT

The purpose of this study was to determine swimming duration during breaststroke swimming at a fixed distance swim or if the fixed distance could not be completed, time to exhaustion in swimming beginners with three different head positions: (a) with the head held above the water throughout the stroke cycle; (b) breathing normally in line with breaststroke stroke coordination; and (c) with the face submerged, and breathing occurring *ad libitum* via a snorkel. Thirteen preschool swimming beginners (5 girls; ages 6 years ± 8 months, height 120 ± 6 cm, body mass 24 ± 5 kg) were asked to swim breaststroke as long as possible in three different conditions. Swimming duration was evaluated by converting swim time to a score on an eleven-point scale. Swimming duration scores were higher when swimming with the face submerged and breathing through a snorkel compared with either holding the head above the water or with normal breaststroke breathing. However, due to similar stroke lengths swimming efficiency did not differ between the trials with the different head positions.. It could be concluded that head position significantly influenced breaststroke swimming duration in swimming beginners. Children were able to swim for longer and hence had a higher swimming score when the face was submerged and breathing occurred ad libitum through a snorkel compared with holding the head above water or when breathing in time with breaststroke. However, swimming efficiency was unaffected by the three head positions.

Keywords: Learning; Teaching; Body position; Children; Swimming

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IZVLEČEK

Pri plavalnih začetnikih smo želeli ugotoviti zmogljivost plavanja prsnega z glavo v treh različnih položajih, kot so: (a) glavo so imeli med plavanjem ves čas dvignjeno, (b) glavo so dvigovali in spuščali usklajeno z zaveslaji in (c) plavali so s potopljeno glavo in dihali skozi dihalko. Trinajst predšolskih plavalnih začetnikov (od tega pet deklet; starost 6 let ± 8 mesecev, višina 120 ± 6 cm, teža 24 ± 5 kg) je trikrat plavalo prsno kar se da dolgo, vsakič z glavo v drugem položaju. Trajanje njihovih plavanj smo s pomočjo enajst stopenjske lestvice pretvorili v točke. Plavalni začetniki so dosegli statistično pomembno višje točke, ko so plavali s potopljeno glavo tako v primerjavi z usklajenim gibanjem glave, kot tudi v primerjavi z dvignjeno glavo. Dolžina zaveslaj se med plavanji z različnimi položaji glave ni spreminjala. Glede na dobljene rezultate lahko zaključimo, da je položaj glave značilno vplival na plavalno zmogljivost plavalnih začetnikov. Otroci so bili sposobni plavati najdlje, ko so imeli glavo potopljeno in so dihali skozi dihalko. Glede na podobne dolžine zaveslajev, različni položaji glave niso različno učinkovali na učinkovitost plavanja.

Ključne besede: učenje, poučevanje, položaj telesa, otroci, plavanje

INTRODUCTION

Well-developed swimming skills are not only essential for drowning prevention, but also contribute to the development, and maintenance of overall fitness. It is therefore not surprising that swimming learning programs for both beginners, and advanced swimmers form part of physical education curriculums at different levels of education in many European countries (Jurgec, Kapus, & Majerič, 2016). Despite disagreement amongst swimming learning experts about the best stroke to teach beginners, European countries, and Japan typically begin with breaststroke, whereas North America, Australia, and New Zealand have a long tradition of teaching front crawl (Langendorfer, 2013): although it could be argued that both strokes are poorly suited as a first technique (Langendorfer, 2013; Stallman, 2014). The breaststroke is the oldest known swimming stroke (Maglischo, 2003), and as stated above, is often the first stroke attempted by beginners. It is also a very popular stroke for recreational, and leisure swimming due to the stability of the body position, and the opportunity to keep the head out of the water for a large portion of the stroke cycle (Maglischo, 2003). Breathing in breaststroke usually occurs in time with the natural stroke-induced body lift, providing a natural breathing point during each arm stroke. Specifically, inhalation takes place at the end of the insweep, and the head should be lifted enough for the mouth to clear the surface, and inhale. The head then returns to the water to exhale as the arms stretch forward to begin their recovery phase (Maglischo, 2003). Breathing could be simplified further by holding the head constantly above the water. With this modification, swimmers could breathe continuously, and could maintain a forward-looking head position for a larger proportion of the swim. However, a head up position during breaststroke may displace the center of gravity further backward from the center of buoyancy (Gagnon & Montpetit, 1981; McLean, & Hinrichs, 2000). Moreover, Haugen, and Blixt (1994) described the impact that anxiety can have on a child in the water: a high head position will reduce buoyancy, and place the body in a diagonal position, which will reduce forward motion, and produce short, rapid strokes, as well as incomplete breathing, and rapid fatigue. Indeed, in a survival situation this could be problematic as a higher resistance to movement is energetically more demanding, and may shorten swim time to exhaustion (Stallman, Major, Hemmer, & Haavaag, 2010). Nevertheless, a head-up position might help a beginner swimmer initially as the need to coordinate breathing with stroke cycle would be removed. A counter argument would be that the increased resistance would make it more energetically demanding and therefore, produce faster exhaustion. In a survival setting, the later will result in swim failure and drowning. Therefore correct body position in the water is important for an efficiency point of view, but also when breaststroke is used as a survival stroke. Thus, the use of a head up position during breaststroke is questionable.

In contrast, submerging the face, and/or the head during breaststroke would have some positive biomechanical effects (Stallman, et al., 2010) thereby allowing beginners to swim more easily. A concern with this approach however is swimmers' ability to breathe, and see where they are going. These limitations can be overcome by use of a mask/goggles, and a snorkel. Indeed, the use of a snorkel would permit swimmers to breathe *ad libitum,* similar to the head-up approach, but would not induce the same negative effects on body alignment (Gagnon & Montpetit, 1981; McLean & Hinrichs, 2000). Whether one of these two approaches is better than the other at facilitating swimming duration, and technical efficiency, and in-turn is better than 'normal' breaststroke breathing in beginner swimmers remains to be seen.

The purpose of this study was to determine swimming duration during breaststroke swimming at a fixed distance swim or if the fixed distance could not be completed, time to exhaustion in swimming beginners with three different head positions: (a) with the head held above the water throughout the stroke cycle; (b) breathing normally in line with breaststroke stroke coordination; and (c) with the face submerged, and breathing occurring *ad libitum* via a snorkel. It was hypothesized that swimmers would be able to swim for longer, and therefore be more likely to complete the fixed distance with the face submerged, and breathing occurring *ad libitum* via the snorkel compared with the other two conditions. Additionally, as participants were swimming beginners, it was hypothesized that swimming with the normal stroke coordinated breathing pattern would be the shortest trial.

MATERIALS AND METHODS

Participants

13 children (8 boys, 5 girls) participated in the study (ages 6 years ± 8 months, height 120 ± 6 cm, body mass 24 ± 5 kg). Their general swimming performance assessed by two qualified swimming teachers was classified as “beginner” or “non-swimmer”, and they had no previous experience of formal swimming lessons. Prior to testing they attended a water familiarization course during which they became familiar with wearing a mask, and snorkel. The standard diving mask and snorkel adapted for children were used. The mask enclosed the nose, which meant that participants needed to breathe exclusively through mouth during the swimming. The familiarization course lasted 16 hours in two weeks i.e. eight two-hour exercises sessions. It included the water adaptation exercises (water entry, putting the head under the water, watching under the water, exhalation into the water, floating on the back and gliding) and learning breaststroke. The course started by using the mask and snorkel, however, later in the course these aids were gradually removed from the exercises. Thus, the participants practiced all three experimental breaststroke-swimming conditions. Beside the familiarization course, they were not enrolled on any other swimming programs during the testing period. Prior to starting the study, all children gave an assent. Moreover, all parents were informed of the purpose of the study, and testing procedures before giving written consent for their child’s participation. Local institutional ethical approval was obtained from the University of Ljubljana, Faculty of Sport before the start of the study. All procedures conformed to the Declaration of Helsinki.

Procedures and Measures

Each participant completed three tests in a randomized order. In one test participants swam with their head above water, in another with their face submerged using a snorkel to breathe and wearing a mask, and in the final condition, they adopted the ‘normal’ stroke-induced breathing pattern: participants only used a snorkel, and goggles/mask during the submerged face trial. All tests were completed on a single day with 30 minutes of rest separating each bout: no warm-up was administered. Each test was conducted in the same 25 m swimming pool (water, and air temperature 32°C and 28°C, respectively), and was initiated from a push start. Children were asked to swim breaststroke for as long as they could without the use of floating aids. The test was terminated when they were unable to continue, and grabbed a support line to stop, or after completing the fixed distance of 25 m, whichever was sooner.

Each test was filmed from poolside using a video camera (DCR-TRV 410E, PAL standard recorder, Sony, Tokyo, Japan) operating at 25 Hz. The footage was used to determine swimming time, and the number of stroke cycles. The latter was subsequently used to determine stroke rate (per minute), and stroke length, which are measures of technical efficacy (Craig & Pendergast, 1979; Kjendlie, Ingjer, Stallman, & Stray-Gunderson, 2004). Stroke rate was calculated by multiplying stroke cycles by 60, and dividing this by swim time (seconds). Stroke length was calculated by dividing swim distance (meters), and number of stroke cycles.

The duration of swimming was evaluated by converting swim time in seconds to a score on a bespoke 11-point scale. A score of 0 denoted a total lack of ability to swim i.e. not able to swim a particular trial at all, whereas a score of 10 was used when a swimmer was able to swim the 25 m unaided. Table 1 depicts the swim time, and its corresponding score.

Table 1. Table depicting how swim time was converted to swimming score.

SWIM TIME	SCORE
the participant was no able to swim	0
the participant swam from 1 to 6 seconds	1
the participant swam from 7 to 12 seconds	2
the participant swam from 13 to 18 seconds	3
the participant swam from 19 to 24 seconds	4
the participant swam from 25 to 30 seconds	5
the participant swam from 31 to 36 seconds	6
the participant swam from 37 to 42 seconds	7
the participant swam from 43 to 48 seconds	8
the participant swam from 49 to 54 seconds	9
the participant was able to swim 25 meters and longer	10

Statistical Analyses

Due to the ordinal nature of the swimming score data, and the lack of normal distribution in stroke rate, and stroke length, all variables were expressed as the median (interquartile range (IQR)), and analyzed using the Friedman Repeated Measures ANOVA on Ranks. Where a significant difference was observed, pairwise comparisons (Wilcoxon signed-rank post hoc test) were performed. Statistical significance was accepted at the $p \leq .05$ level. Effect sizes were obtained per pair of swim trials using r, whereby r is the z score divided by the square root of the total number of observations. A value of .1 is deemed small, .3 medium, .5, and above large (Field, 2013). All statistical parameters were calculated using the statistics package SPSS (version 15.0, SPSS Inc., Chicago, USA).

RESULTS

All participants attempted to swim breaststroke with the head held above water, and with the face submerged. However, three participants (two boys and one girl) did not even attempt the swimming trial with normal breathing i.e. coordinated with stroke cycle. In the trial where the head was held above the water, four participants completed the 25 m distance, and therefore did not stop due to exhaustion. When the face was submerged, and breathing occurred *ad libitum* via a snorkel, nine swimmers were able to complete the 25 m distance indicating that this was easiest trial. In all three trials, participants used breaststroke pattern (i.e. breaststroke arm strokes and kicks) without arm strokes, which are typical for underwater swimming. Moreover, regardless to breathing conditions they used more or less continuous stroking pattern without significant gliding phase. The swimming scores, the stroke rates, and stroke length for each participant per trial are presented in Table 2.

Table 2. Swimming scores, stroke rates, and stroke lengths of beginner swimmers swimming breaststroke with the head in different positions.

Participant	Breaststroke with the head above the water			Breaststroke with the normal breathing			Breaststroke with the face submerged and breathing via a snorkel		
	Swimming score	Stroke rate (min-1)	Stroke length (m)	Swimming score	Stroke rate (min-1)	Stroke length (m)	Swimming score	Stroke rate (min-1)	Stroke length (m)
1	6	68	0.35	0	0	0	6	45	0.46
2	1	72	0.43	0	0	0	10	58	0.42
3	1	50	0.25	0	0	0	9	32	0.25
4	10	54	0.29	4	35	0.64	10	37	0.45
5	10	46	0.38	2	40	1.01	10	38	0.64
6	10	52	0.26	2	40	0.5	10	52	0.39
7	10	69	0.31	3	46	0.57	10	53	0.51
8	8	31	0.42	2	43	0.32	9	25	0.47
9	5	79	0.26	1	24	2.2	10	52	0.45
10	5	40	0.43	1	30	0.77	10	39	0.56
11	3	50	0.29	3	42	0.51	10	28	0.6
12	3	32	0.73	2	36	0.63	4	23	0.88
13	4	65	0.25	2	23	0.73	10	47	0.38

Swimming scores were affected by the head position (Friedman's $Q = 23.5$; $p < .01$). Specifically, swimming score was significantly higher with the face submerged compared to swimming with the head held above the water ($z = 2.527$; $p < .01$; effect size $r = .5$; see Figure 1), and swimming with normal breathing ($z = 3.192$; $p < .01$; effect size r = .6). Additionally, swimming with the head above the water resulted in a greater swimming score compared with the normal breathing trial ($z = 3.071$; $p < 0.01$; effect size $r = .6$; see Figure 1).

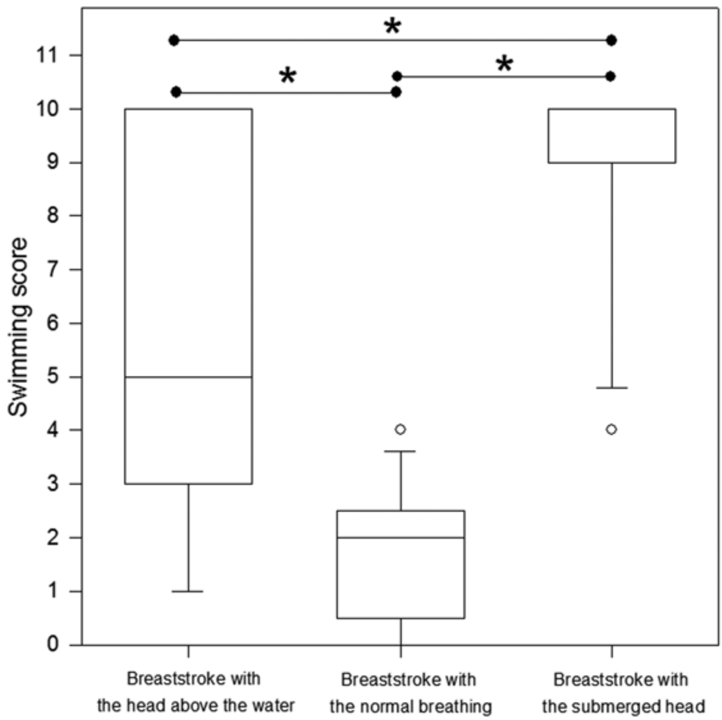

Figure 1. Comparison of swimming scores during breaststroke with different head positions. The swim score is derived from Table 1. Median (|), interquartile range and outliers (open circle) are displayed. * denote significant differences between swim trials (Wilcoxon signed-rank post hoc tests; p < .05).

Stroke rate also differed between the three swimming trials (Friedman's $Q = 13.4$; $p < .01$; see Figure 2). Specifically, stroke rate was higher when the head was held above the water ($z = 3.061$; $p < .01$; effect size $r = .6$) or when the face was submerged ($z = 2.726$; $p < .01$; effect size $r = .5$) compared to swimming with normal breathing. There was no difference in stroke rate between the submerged face trial, and the head above the water trial.

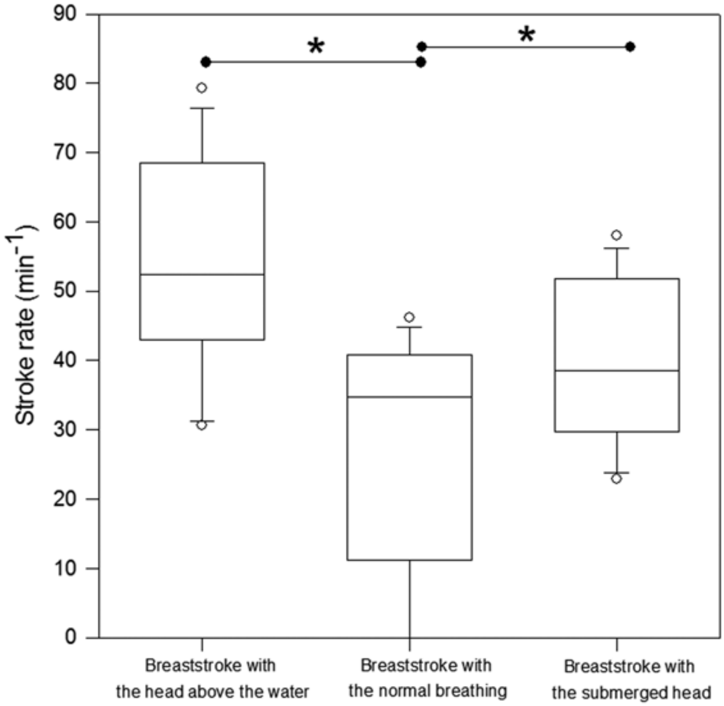

Figure 2. Comparison of stroke rate during breaststroke with three different head positions. Median (|), interquartile range and outliers (open circle) are displayed. * denote significant differences between swim trials (Wilcoxon signed-rank post hoc tests; $p < .05$).

Figure 3 shows that there were no significant differences in stroke length between three swimming trials (Friedman's $Q = 5.2$; $p = .074$).

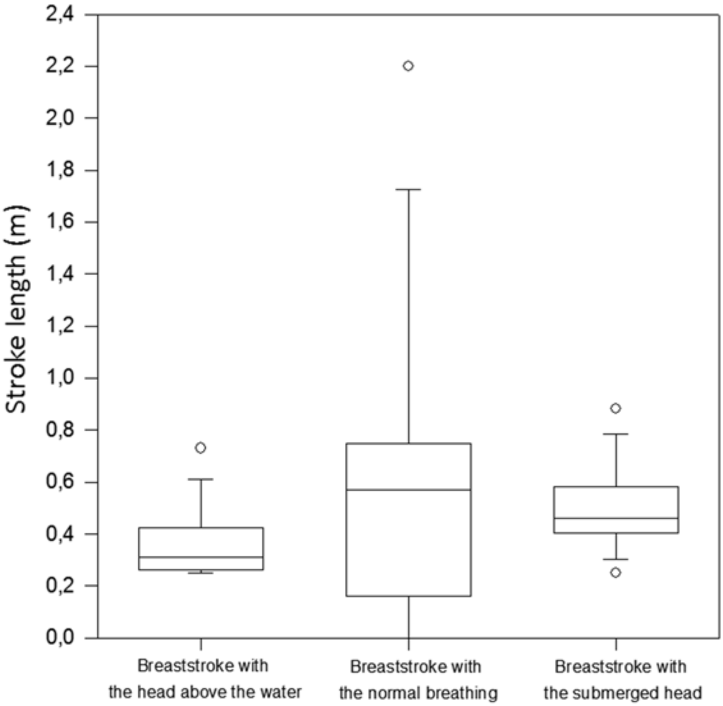

Figure 3. Comparison of stroke length during breaststroke with three different head positions. Median (|), interquartile range and outliers (open circle) are displayed.

DISCUSSION

The results of this study indicate that head position significantly influenced breaststroke swimming duration in beginner swimmers. Children were able to swim for longer, and hence had a higher swimming score when the face was submerged, and breathing occurred *ad libitum* through a snorkel compared with holding the head above water or when breathing in time with breaststroke.

It was expected that the swimming score would be the lowest when swimmers were required to coordinate their breathing with the stroke cycle, as participants were swimming beginners without appropriate acquisition of the fundamental aquatic skills (see Figure 1). Therefore, the ability to adequately coordinate breathing in time with the stroke (i.e. outward sweep, catch, into inward sweep) was likely too complex a task. Compared to the head above the water trial, submerging the face during breaststroke swimming resulted in a higher swimming score (see Figure 1). Submerging the face might have some positive biomechanical effects in beginner swimmers (e.g. increased buoyancy), which allowed the participants to swim more easily. For example, when a body part is lifted above the surface, the buoyancy force decreases. Harrison, Hillman, and Bulstrode (1992) calculated the percentage weight bearing of a stationary human body during partial immersions. Due to their conclusion that submerging to the seventh cervical vertebra decreased participant's weight for 85%, it could be estimated that the head above the water decreased the buoyancy force for 10-15% in comparison to full immersion. Therefore, holding the head above the water might result in less buoyancy when compared with submersion of the face. Furthermore, submerging the head might provide a better body position during breaststroke swimming. A swimmer's ability to float statically in a horizontal position is determined largely by the rotating effect resulting from their body weight, and buoyancy forces i.e. buoyant torque. In static floating, the center of buoyancy is generally closer to the head in comparison to the center of mass. Consequently, the buoyant torque acts to sink the legs (Gagnon & Montpetit, 1981; McLean & Hinrichs, 2000). Unfortunately, the impact that a 'head held above the surface' position has on the center of mass, and buoyancy has not been analyzed during surface gliding or swimming. However, it would be expected that differences in head position would affect resistance during swimming. For example, when the head is held above the water during gliding, passive drag is increased by 5.2% compared to gliding with the head submerged or gliding with the head on the surface (Cortesi & Gatta, 2015). Thus, it would not be unreasonable to propose that a 'head above the water position' during breaststroke would increase drag compared with a submerged face position or the normal cyclical breathing position (Chatard, Bourgaoi, & Lacour, 1990; Chatard, Lavoie, & Lacour, 1990) making breaststroke more metabolically taxing. In support of this, it has been shown in recreational adult swimmers that swimming breaststroke with the head above the water results in a higher energy cost, heart rate, and blood lactate accumulation, compared with normal breaststroke breathing (Stallman et al., 2010).

Differences in resistance and buoyancy are not the only potential reasons why swimming scores were higher during the face-submerged trial. The fact that swimmers also wore a mask, and snorkel likely provided a significant swimming advantage. Specifically, vision will have been unobstructed as a result of the mask, and breathing would have occurred *ad libitum*. This will have made this trial easier for beginner swimmers who had an aversion to putting their face in the water, and had lower skill levels.

Besides the higher swimming scores when swimming with the face submerged, it could be expected that the less metabolically taxing trial would facilitate swimming efficiency i.e. swim with longer stroke length (Craig & Pendergast, 1979, Kjendlie, Ingjer, Stallman, & Stray-Gundersen, 2004). However, there were no significant differences in stroke length between the three trials (see Table 3), and there was no significant difference in stroke rate between the head above the water, and face submersion trials (see Table 2). This could simply be due to a lack of skill acquisition, and familiarization. Indeed, the three testing trials were the first attempts of surface swimming without any floating aids for most of the participants. Therefore, their main goal was to stay on the surface via kicking, and arm movements, and not to perform propulsive breaststroke movements. Moreover, swimming speed (which would impact stroke rate, and stroke length) was not a priority for them.

Our results indicate that the mask, and snorkel can be used as additional ergogenic aids supplementing those e.g. kick boards, pull-buoys, noodles etc. already in use. Specifically, they may assist buoyancy, and may help to increase a beginner's confidence allowing them to break contact with the bottom of the pool floor or the side of the pool. Moreover, they will help to place swimmers in the proper horizontal body position, thereby simplifying the complex coordination of arms, legs, and breathing (Parker, Blanksby, & Quek, 1999). This could give beginner swimmers additional motivation to try more challenging learning exercises. Furthermore, the mask, and snorkel could make learning in deep water less frightening, and more relaxing. With this in mind, it could be suggested that a learning program based on swimming with participants in a prone position, could be more effective by using a mask, and snorkel. However, we should emphasize it may also increase their dependency on those items which in turn would hinder the acquisition of correct technique and may in fact increase fear of swimming when the ergogenic aid was not available. Therefore, swimming breaststroke with a snorkel, and to a lesser extent a mask, should be viewed solely as an aid to teaching correct body position, and enhancing confidence. Being able to control breathing so that inhalation, breath hold, and exhalation occur in coordination with the correct phases of the arm strokes is an essential skill that beginner swimmers must master (Stallman, 2017). Indeed, Lanoue (1963) noted that people do not drown primarily because they cannot swim, but because they cannot get air into the lungs. Furthermore, beginners should be able to open their eyes under water so that they can better orientate themselves when swimming, and in the case of accidently falling into the water without mask/goggles.

We suggest that the findings of the current study be considered by swimming teachers, and parents of beginner swimmers when a mask, and snorkel be integrated into beginner swimmer teaching programs. The typical swimming learning curriculum in many European countries, particularly in Slovenia, follows an ordered pattern, with beginners progressing from water entry, opening their eyes under water, exhaling into the water, developing buoyancy, gliding, kicking, and finally arm stroke exercises (Jurgec, Kapus, & Majerič, 2016; Kapus et al., 2002). All of these take place without the use of a mask, and snorkel. This order could be reversed so that the mask, and snorkel are integrated, and introduced after water entry exercises. Familiarization with wearing the mask, and breathing through the snorkel could be continued during the exercises for improving buoyancy, gliding, kicking, and arm strokes. With this revised program, coordinating breathing with the natural stroke cycle, and opening the eyes under water would follow only once beginners master swimming with the face submerged while breathing *ad libitum* through a snorkel. The end goal would still be the same: to swim the desired stroke without the mask, and snorkel, with breathing integrated into the natural stroke cycle.

CONCLUSIONS

Our findings suggest that head position significantly influenced breaststroke swimming duration in beginner swimmers. Children were able to swim for longer and hence had a higher swimming score when the face was submerged and breathing occurred ad libitum through a snorkel compared with holding the head above water or when breathing in time with breaststroke. However, swimming efficiency was unaffected by the three head positions.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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