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School-based swimming lessons enhance specific skills and motor coordination in children: the comparison between two interventions

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ABSTRACT

This study aimed to verify the impact of two learn-to-swim programs, implemented for 12 weeks, in age school Brazilian children's aquatic readiness and motor coordination. Thirty-one children aged 7-9 years old (mean± SD 8.00± 0.86 years) were randomly divided into two different experimental groups. One was submitted to lessons mainly focused on basic skills development (BS), and the other was mainly focused on the formal skills of swimming techniques (FS). The aquatic readiness (17 skills) and the motor coordination (Körperkoordinationstest Für Kinder test) were evaluated before and after the interventions. After 12 weeks, the total score of the swimming skills was different between groups (F= 24.19, p< 0.01, η_p^2= 0.46), changing from 34.35± 9.22 to 50.18± 8.49 points (p< 0.01, d= 2.60) in the BS and from 36.00± 5.86 to 42.64± 7.46 points in the FS (p< 0.01, d= 1.88). Leg kicking with breath control at ventral and dorsal body position, feet-first entry and deep-water immersion were significantly higher after the training in the BS. The motor coordination scores increased in both the BS (135.57± 37.45 to 172.64± 33.17, p< 0.01, d= 2.11) and FS (130.18± 37.71 to 162.71± 40.40, p< 0.01, d= 1.41). These results showed that both swimming practices improved aquatic readiness and motor coordination, with higher aquatic competence after the lessons that mainly focused on basic skills development.

KEYWORDS: motor development; aquatic skills; swimming; child.

INTRODUCTION

Swimming lessons have been gaining importance worldwide as a practice to promote age-appropriate motor experiences and to develop physical activity among young children (Campaniço, Costa, Garrido, & Silva, 2019; Langendorfer, 2019). For these reasons, swimming has been included in the school curriculum in several countries (Cardon, Verstraete, Clercq, & Bourdeaudhuij, 2004; Stloukalová & Roztoci, 2015), and has been recognised as important for safety reasons (Campaniço et al., 2019), in addition to providing beneficial consequences in physiological and psychological variables, and contributing to long-term healthy lifestyle habits (Cardon et al., 2004; Costa, Barbosa, Ramos, & Marinho, 2016).

Previous research suggested that children improved aquatic competence in several aquatic skills after six months of swimming practices (Costa et al., 2012; Rocha, Marinho, Garrido, Morgado, & Costa, 2018). Moreover, the swimming lessons stimulated the acquisition of new motor patterns necessary to move in the aquatic environment and thus contributing to a wide motor repertoire of the child's movements (Langendorfer & Bruya, 1995). In fact, previous findings suggested that children between 5 and 10 years of age participating regularly in swimming lessons revealed great gross motor development (Moura, Neiva, Faíl, Morais, & Marinho, 2021). Although there is evidence that swimming instruction can build aquatic skills and contribute to the increase of children's motor development (Bem, Cabelguen, Ekeberg,

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& Grillner, 2003; Martins, Silva, Marinho, & Costa, 2015; Moura et al., 2021), there is still lack of evidence about the effect of specific intervention contexts, such as those provided by schools in daily routines.

In swimming, each individual must acquire the abilities to perform the appropriate actions to move in the water, achieving the required balance, breathing, and propulsion (Barbosa & Queirós, 2004; Barbosa, Costa, Marinho, Silva, & Queirós, 2012; Langendorfer, 2014). There are several constraints, such as balance and breathing, typical of an aquatic environment, and it is mandatory to develop specific skills to overcome these issues (Barbosa & Queirós, 2004; Barbosa et al., 2012). The ability to swim requires a previous condition of autonomy and confidence in the new environment that should be achieved in a gradual acquisition of aquatic skills (Catteau & Garoff, 1990; Navarro, 1995; Campaniço & Silva, 1998; Moreno & Sanmartín, 1998; Barbosa et al., 2012). First, there is a need to develop fundamentals of adaptation to the aquatic environment (i.e., familiarization, balance, breathing, propulsion, jump/diving, manipulations), followed by the acquisition of basic aquatic skills (i.e., different levels of dynamic balance, breathing, propulsion, jumping, manipulation), and then specific swimming skills (i.e., front crawl, backstroke, breaststroke, and butterfly, starts, turns and arrivals) (Swimming for All Swimming for Life, 2013). Therefore, learning to swim should be based on the progressive and sequential learning of movement patterns in a dynamic interaction with the water (Langendorfer, 2014).

The learn-to-swim programs in the school context usually focus on teaching to perform formal swimming techniques, such as front crawl, backstroke, breaststroke, and butterfly. These swimming techniques involve complex movement patterns that require a lot of practice to be effectively learnt and preceded by proper aquatic environment adaptation (Swimming for All Swimming for Life, 2013). Although there is a general consensus on the skills to be taught to children, there is a lack of research on the effect of different learning programs in water competency and how to optimize specific swimming skills in order to increase aquatic readiness and prevent drowning (Button, McGuire, Cotter, & Jackson, 2017).

It is generally accepted that learning to swim should be taught in sequential format, ultimately leading to traditional swimming strokes, using a "bottom-up" approach, from the least to the most complex skills (Kelly, 1989; Block, 1994; Barbosa et al., 2012). Skills are often taught in a progression, assuming that every skill is a prerequisite of the next, regardless of whether or not that skill is fundamental. Likewise, there is a lack of evidence of the learn-to-swim programs, and particularly, in specific real contexts with several constraints (i.e., number of lessons per week), such as those found in some Brazilian schools. Thus, the main purpose of the current study was to verify the effect of two swimming programs developed in the school context on aquatic readiness and motor coordination in children. It was hypothesised that both swimming lessons improved aquatic readiness and motor coordination, but specific adaptations would exist to each swimming program.

METHODS

Participants

Children from 7 to 9 years of age of both genders, enrolled in a Brazilian state school in the city of Itumbiara-GO, were randomly selected to participate in the current study. The study included participants who were healthy and attending school regular classes and swimming classes provided by the school curriculum. Children were excluded if they had a health problem, were not authorised by their guardians, if they participated in a swimming training program and/or other sport as a complement of the school lessons, or if they miss more than one swimming lesson. Thirty-one volunteers (15 females, 16 males; mean± SD= 8.00± 0.86 years old, 29.36± 9.09 kg of body mass, 1.28± 0.08 m of height, and 17.59± 3.66 kg/m^2 of body mass index) were randomly divided into two different experimental groups. One experimental group was submitted to a swimming program mainly focused on basic skills development (BS; n= 17, 8.00± 0.87 years old, 30.60± 9.70 kg, 1.29± 0.08 m, 18.23± 3.89 kg/m^2) and the other was mainly focused on the formal development of swimming techniques (FS; n= 14, 8.00± 0.88 years old, 27.86± 8.40 kg, 1.28± 0.08 m, 16.81± 3.32 kg/m^2). The participants guaranteed that no other training program or sport was performed during the experimental period. All participants attended all the swimming lessons and so, no one was excluded from the analysis. All children and parents or guardians were informed about the experimental procedures of the study and, after acceptance, the informed consent was signed. Data confidentiality was guaranteed, as well as their anonymity during the treatment process and analysis. The local swimming school board and the University of Beira Interior Review Board approved the study procedures in accordance with the Declaration of Helsinki.

Procedures

The current study was implemented during the 2018-2019 school year in a Brazilian state school. The participants were evaluated twice for their aquatic readiness and motor coordination, specifically before and after the swimming program. The swimming lessons were implemented for twelve weeks, once a week, in both groups.

Aquatic readiness

The evaluation of aquatic readiness was completed using an observation checklist of 17 specific aquatic skills commonly used in swimming research (Langendorfer & Bruya, 1995; Costa et al., 2012; Rocha et al., 2018). The assessed aquatic skills were: water entry (Sk1); water orientation and adjustment at vertical position (Sk2); breath control — immersion of the face and eye-opening (Sk3); horizontal buoyancy (Sk4); body position at ventral gliding (Sk5); body position at dorsal gliding (Sk6); body position at longitudinal rotation in gliding (Sk7); body position at front and back somersaults (Sk8); leg kicking with breath control at ventral body position, with flutter boards (Sk9); and without any flutter device (Sk10); leg kicking with breath control at dorsal body position with flutter boards (Sk11); and without any flutter device (Sk12); feet-first entry (Sk13); head-first entry (Sk14); autonomy in a deep pool (legs and arms displacement) (Sk15); vertical buoyancy at deep water (Sk16); deep water immersion (Sk17). Each skill comprised different levels of complexity that defined the level of mastery of the child (Langendorfer & Bruya, 1995). The scores ranged from level 1 (minimum) to 3 (maximum) for Sk1, Sk2, Sk7, Sk13, Sk14, and Sk15; from level 1 to 4 for Sk4, Sk5, Sk6, Sk8, Sk9, Sk10, Sk11, Sk12, and Sk17; and from level 1 to 5 for Sk3 and Sk16. Before evaluation, each exercise was explained and exemplified by the teacher and then replicated three times by each participant. The assessment of these skills was performed by the main researcher. When unable to perform any of the tries, it was settled as stage one. Two cameras (Canon EOS Rebel T6i+ EF-S 18-55mm f / 3.5-5.6 IS STM, Tokyo, Japan) were used, one frontally and the other laterally to the performed skill, and the evaluation was confirmed by video analysis.

Motor coordination

The motor coordination was assessed using the *Körperkoordinationstest Für Kinder* test (KTK), developed by Kiphard and Schilling (1974) and applied to children since then (e.g. Lopes, Rodrigues, Maia, & Malina, 2011; Moreira et al., 2019). Each child was evaluated in specific tasks, such as walking backwards along a balance beam with decreasing width, 6 cm, 4.5 cm, and 3 cm (WB); two-legged jumping from side to side for 15 s (JS); moving sideways on wooden boards for 20 s (MS); and one-legged hopping for height (HH) over a foam obstacle with in-creasing height in consecutive steps of 5 cm, according to the guidelines (Kiphard & Schilling, 1974; Rudd et al., 2016). The purpose of these tasks was to evaluate balance, rhythm, strength, laterality, speed and agility (Scordella et al., 2015). The sum of raw scores of the subtests was calculated for further analysis. Each evaluation was performed individually by the main researcher and then confirmed by video analysis (Canon EOS Rebel T6i+ EF-S 18-55mm f / 3.5-5.6 IS STM, Tokyo, Japan).

Swimming practice

The swimming lessons took place in a 20 m swimming pool with the water temperature set at 28°C. Both the BS and the FS experimental groups were submitted to a swimming program implemented for twelve weeks, once a week, in sessions that lasted for 50 min. The lessons in the BS were mainly focused on basic swimming skills development and in the FS were mainly focused on the formal development of swimming techniques. Both learn-to-swim programs were developed by the swimming teachers in cooperation with the research team. The swimming lessons were carried out by two swimming teachers, and the teaching methods developed in each class were similar, according to the literature guidelines (Swimming for All Swimming for Life, 2013). The students mainly performed analytical tasks for development purposes; however, ludic tasks were also included. The specific skills developed in both interventions are presented in Table 1.

Statistical analysis

Standard statistical procedures were selected to calculate means, standard deviations (SDs) and median values. The normality of data distribution was assessed by the Kolmogorov-Smirnov test. The Wilcoxon signed-ranks tests were used to compare initial values *vs.* final values in each swimming skill (non-parametric), in each group. The paired-samples t-test was used to assess the differences between evaluation moments in *KTK* data results (normally distributed), in each group. The values of the swimming skills assessed before and after the swimming program were compared between groups using the Mann-Whitney U-test. The independent T-test was used to compare the initial values of motor coordination results and the comparison between the post-training results between groups was performed by a one-way analysis of covariance, adjusted for the pre-training values (covariates). The effect size was computed to analyse the differences between pre and post-intervention, and between groups for each variable. Cohen *d* and partial eta squared (η_p^2) for normally distributed variables were determined using IBM SPSS Statistics software. A specific effect size calculator for non-parametric tests was used to determine eta squared and then these values were converted into Cohen *d* values (Lenhard & Lenhard, 2016). A *d* value< 0.2 was considered a trivial effect, 0.2 to 0.6 a small effect, 0.6 to 1.2 a moderate effect, 1.2 to 2.0 a large effect, 2.0 to 4.0 a very large effect, and ≥ 4.0 an extremely large effect (Hopkins, Marshall, Batterham, & Hanin, 2009). For η_p^2, cut-off values were interpreted as 0.01 for small, 0.09 for moderate and 0.25 for large (Cohen, 1992). The criterion for significance was set at an alpha level of $p< 0.05$. The software IBM SPSS Statistics for Windows (version 27.0., IBM Corp., Armonk, NY, USA) was used for all statistical analyses.

RESULTS

The results of the skills evaluated before and after the swimming lessons for each swimming program intervention are shown in Table 2. No differences were found between the initial values of the participants in the BS and the FS groups. However, the swimming skills 10, 11, 12, 13 and 17 were significantly different after the training, with higher values obtained in the BS group. The changes caused by the swimming program performed by the BS group were found to be large or very large in skills 2 to 16. A smaller amount of skills were improved in the swimming program implemented in the FS, and no significant changes were found in skills 1, 2, 3, 5, 11, 13, 15, 16, and 17. The sum of the swimming skills scores after the intervention was different between groups ($F= 24.19$, $p< 0.01$, $\eta_p^2= 0.46$), changing from 34.35± 9.22 to 50.18± 8.49 ($p< 0.01$, $d= 2.60$) in the BS and from 36.00± 5.86 to 42.64± 7.46 ($p< 0.01$, $d= 1.88$) in the FS.

The motor coordination was significantly improved in both swimming lessons. The sum of scores in the motor coordination assessment increased from 130.18± 37.71 to 162.71± 40.40 ($p< 0.01$, $d= 1.41$) and from 135.57± 37.45 to 172.64± 33.17 ($p< 0.01$, $d= 2.11$) in the BS and the FS, respectively. An overview of the raw scores of the subtests is presented in Figure 1 (BS) and Figure 2 (FS). When comparing the post- training values (considering pre-training variables as covariate), no differences were found between the groups in WB ($F= 0.04$, $p= 0.84$, $\eta_p^2< 0.01$), JS ($F= 0.83$, $p= 0.37$, $\eta_p^2= 0.03$), MS ($F< 0.01$, $p= 0.93$, $\eta_p^2< 0.01$) and HH ($F= 1.32$, $p= 0.26$, $\eta_p^2= 0.04$). Likewise, no differences were found in the sum of the scores in the motor coordination values after the intervention ($F= 0.37$, $p= 0.55$, $\eta_p^2= 0.01$).

DISCUSSION

The current study aimed to understand the impact of two different learning-to-swim programs in aquatic readiness

Table 1. Characteristics of swimming lessons in BS and FS groups.

Skills	Week											
	1	2	3	4	5	6	7	8	9	10	11	12
Sk1	↑ / +	↑	↔									
Sk2	↑ / +	↑ / +	↔	↑	↑	↔						
Sk3	↑ / +	↑ / +	↔	↑	↑	↔						
Sk4	↑ / +	↑	↔	↑	↑	↔						
Sk5				↑	↑	↔	↑	↑	↔			
Sk6				↑	↑	↔	↑	↑	↔			
Sk7							↑	↑	↔	↑	↑	↔
Sk8												
Sk9		+	+	+	+			↑	+ / ↔	+ / ↑	= / ↑	= / ↔
Sk10		+	+	+	+				+	+ / ↑	= / ↑	= / ↔
Sk11	+	+	+	+	+	+	+	+	+	+ / ↑	= / ↑	= / ↔
Sk12	+	+	+	+	+	+	+	+	+	+ / ↑	= / ↑	= / ↔
Sk13					↑	+	+ / ↑	+ / ↑	↔	+	=	=
Sk14						+	+	+		+	=	=

↑ Aquatic skill developed in BS group; + Aquatic skill developed in FS group; ↔ Aquatic skill consolidation in BS group; = Aquatic skill consolidation in FS group; Sk1: Water entry; Sk2: water orientation and adjustment at vertical position; Sk3: breath control - immersion of the face and eye opening; Sk4: horizontal buoyancy; Sk5: body position at ventral gliding; Sk6: body position at dorsal gliding; Sk7: body position at longitudinal rotation in gliding; Sk8: body position at front and back somersaults; Sk9: leg kick with breath control at ventral body position, with flutter boards; Sk10: and without any flutter device; Sk11: leg kick with breath control at dorsal body position with flutter boards; Sk12: and without any flutter device; Sk13: feet-first entry; Sk14: head-first entry; Sk15: Autonomous in deep pool (legs and arms displacement); Sk16: vertical buoyancy at deep water; Sk17: deep water immersion.

and motor coordination of 7-9 years old children. The difference between the interventions was that the BS program was mainly focused on the development of basic swimming skills and the FS on formal swimming skills. Results showed that participants in the BS obtained higher gains in Sk10, Sk11, Sk12, Sk13 and Sk17 (i.e., leg kicking with breath control at ventral body position without any flutter device; leg kicking with breath control at dorsal body position with and without any flutter device; feet-first entry; deep water immersion). Moreover, the total aquatic competence after the

Table 2. Mean± standard deviation (SD) and median values of swimming skills before (pre) and after swimming lessons (post) in BS and FS groups. P-value and effect size (d) are also presented.

Skills	Group	Pre		Post		Pre vs. Post	
		Mean± SD	Median	Mean± SD	Median	*p*-value	*d*
Skill 1	BS	3.00± 0.00	3	3.00± 0.00	3	1.00	0.00
	FS	2.93± 0.27	3	3.00± 0.00	3	0.32	0.55
Skill 2	BS	2.35± 0.49	2	2.76± 0.44	3	< 0.01**	1.67
	FS	2.29± 0.47	2	2.43± 0.51	2	0.32	0.55
Skill 3	BS	3.24± 1.20	3	4.18± 0.95	5	0.01**	1.57
	FS	3.79± 1.19	3.5	4.07± 1.07	4.5	0.33	0.53
Skill 4	BS	2.00± 1.17	2	3.18± 0.85	4	< 0.01**	2.57
	FS	1.93± 1.00	2	2.50± 1.02	3	0.03*	1.38
Skill 5	BS	1.88± 1.11	1	3.18± 1.01	4	< 0.01**	2.91
	FS	2.14± 0.95	2	2.93± 1.33	4	0.06	1.18
Skill 6	BS	1.47± 0.87	1	2.47± 1.01	2	< 0.01**	2.40
	FS	1.36± 0.50	1	1.79± 0.70	2	0.03*	1.38
Skill 7	BS	1.47± 0.51	1	2.35± 0.49	2	< 0.01**	3.75
	FS	1.71± 0.61	2	2.07± 0.62	2	0.03*	1.49
Skill 8	BS	1.24± 0.56	1	2.12± 0.78	2	< 0.01**	3.75
	FS	1.36± 0.75	1	1.93± 1.14	1.5	0.04*	1.32
Skill 9	BS	2.29± 1.05	2	3.06± 1.03	3	< 0.01**	1.78
	FS	2.07± 0.48	2	2.79± 0.98	2	0.02*	1.71
Skill 10#	BS	2.06± 0.97	2	3.12± 0.93	3	< 0.01**	2.64
	FS	1.86± 0.54	2	2.36± 0.93	2	0.04*	1.33
Skill 11#	BS	1.88± 0.17	1	3.00± 0.94	3	< 0.01**	2.68
	FS	1.79± 0.43	2	2.29± 0.99	2	0.06	1.17
Skill 12#	BS	1.65± 1.00	1	2.76± 0.90	2	< 0.01**	2.61
	FS	1.64± 0.50	2	2.07± 0.73	2	0.03*	1.38
Skill 13#	BS	2.06± 0.43	2	2.65± 0.49	3	< 0.01**	2.39
	FS	1.86± 0.54	2	2.14± 0.36	2	0.19	0.74
Skill 14	BS	1.47± 0.51	1	2.35± 0.61	2	< 0.01**	2.97
	FS	1.64± 0.50	2	2.29± 0.73	2	0.02*	1.51
Skill 15	BS	1.47± 0.51	1	2.00± 0.50	2	< 0.01**	2.12
	FS	1.64± 0.63	2	1.79± 0.70	1	0.16	0.82
Skill 16	BS	3.12± 1.65	4	4.76± 0.44	5	< 0.01**	1.89
	FS	4.21± 0.05	4	4.29± 1.07	4	0.32	0.56
Skill 17#	BS	1.71± 1.16	1	3.24± 1.09	4	< 0.01**	2.51
	FS	1.79± 1.25	1	1.93± 1.39	1	0.32	0.56

*$p \leq 0.05$; **$p \leq 0.01$; #$p < 0.05$ between groups after intervention; 1 to 3 levels of complexity for skills 1, 2, 7, 13, 14, and 15; 1 to 4 levels of complexity for skills 4,5,6, 8, 9, 10, 11, 12, and 17; 1 to 5 levels of complexity for skills 3 and 16.

intervention was higher in the BS compared to the FS. Both the BS and the FS swimming lessons revealed great improvements in motor coordination scores and no differences were found between interventions. These results confirmed the researchers' hypotheses, demonstrating that both swimming practices improved aquatic readiness and motor coordination, although with different gains in aquatic competence.

The first sessions in the BS program were used to promote the children familiarisation with the aquatic environment, to build autonomy and create the basis for later acquisition of specific aquatic motor skills (Swimming for All Swimming for Life, 2013). By contrast, the FS lessons started with stimulation of formal swimming skills, such as leg kicking with breath control at ventral and dorsal body position. Interestingly, greater improvements in these specific skills (i.e., leg kicking with breath control at ventral and dorsal body position) were found in the BS lessons. Literature suggested that the practice and learning of higher complexity motor skills should only be performed after lower complexity motor skills consolidation (Gabbard, 2000). The current results confirmed that stimulation of basic swimming skills necessary for the adaptation to the aquatic environment (i.e., familiarisation, balance, breathing, jumping, and elementary propulsion) promote a higher and rapid increase of formal specific swimming skills. Furthermore, the greatest effect of the swimming lessons was found in the BS program, specifically in body position at longitudinal rotation, gliding, and front and back somersaults. These are skills particularly associated with balance and breathing, which constitute the basis for formal swimming techniques, such as front crawl, backstroke, or even turns (Barbosa & Queirós, 2004).

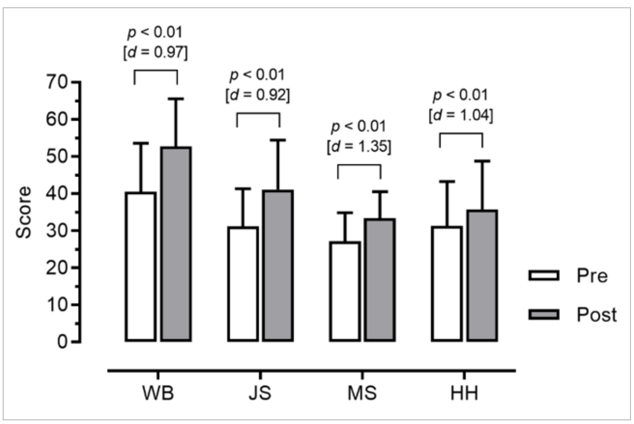

Figure 1. Mean values (and standard deviation) of subtests walking backwards (WB), jumping sideways (JS), moving sideways (MS), hoping for height (HH) before (Pre) and after (Post) intervention in participants in the program focused on basic swimming skills developments (BS). P-values and effect sizes (Cohen's d) are also presented.

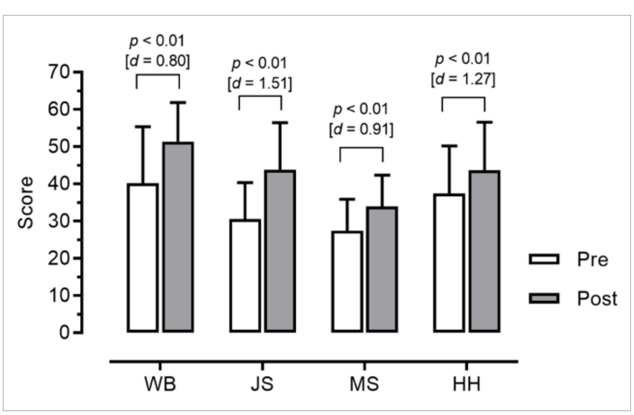

Figure 2. Mean values (and standard deviation) of subtests walking backwards (WB), jumping sideways (JS), moving sideways (MS), hoping for height (HH) before (Pre) and after (Post) intervention in participants in the program focused on formal swimming skills. P-values and effect sizes (Cohen's d) are also presented.

Both the BS and the FS learn-to-swim programs promoted an increase in aquatic readiness in children. Nevertheless, despite the high values recorded after the intervention, children did not attain mastery in these skills, which reveals that perhaps twelve lessons were not enough for the complete acquisition of basic skills (Gallahue & Ozmun, 2005). Possibly, for greater swimming proficiency, more sessions per week should be performed or longer interventions could be applied. The learning and acquisition of motor skills in swimming require repetition and systematisation (Campaniço et al., 2019). This was evident in previous studies that found an increase in aquatic readiness when implementing swimming programs that comprised two or three sessions per week, for a long period (Costa et al., 2012; Rocha et al., 2018). The current study results support the need to discuss some school curriculums that still provide a single swimming lesson per week and for limited-time periods (e.g., three months). Longer periods and more frequency of swimming lessons could help the children to attain mastery in specific swimming skills that could be fundamental for future success in learning swimming techniques and, most of all, to prevent drowning.

Previous research suggested that swimming instruction can build aquatic skills and contribute to increase children's motor development (Bem et al., 2003; Martins et al., 2015; Moura et al., 2021). In the current study, great improvement in motor coordination was found in both the BS and the FS program, which complies with previous evidence. Nevertheless, no differences were found between the BS and the FS interventions. This highlights that, at these ages, more than the specific learning process, children should be exposed to a wide range of experiences that stimulate their motor learning and contribute to a large motor development (Gallahue & Ozmun, 2005; Gallahue, Ozmun, & Goodway, 2013; Guignard, Button, Davids, & Seifert, 2020). Considering that the swimming lessons started at the beginning of the school year, and before that no systematic and regular activity was provided to the children, the increase in KTK subtest scores could be the result of an increase in physical activity (Lopes et al., 2011). The development of motor coordination is important since childhood (Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012) and it allows to learn and acquire more complex skills necessary to participate in physical activity, therefore contributing to engaging children in a healthy lifestyle (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006; Janssen & LeBlanc, 2010; Huotari, Nupponen, Mikkelsson, Laakso, & Kujala, 2011).

The researchers should be aware that the participants were not representative of the general population. The study included a limited number of Brazilian children engaged in a school-based swimming program, once a week, for twelve weeks. Moreover, the inclusion of a control group, without swimming lessons, could help researchers to further understand changes, particularly the motor coordination ones. Nevertheless, the researchers considered that the great impact that was verified has limited interference of confounding factors, such as the growing effect, because of the short period of intervention (i.e., 3 months). Despite these limitations, it is notable that both swimming programs were effective in improving aquatic readiness and motor coordination. In future studies, it should be interesting to find out the impact of different swimming programs in longer periods of intervention and further studies should be developed to understand the effect of different teaching styles, different learning contexts and dose-response issues.

CONCLUSION

The results showed that 12 weeks of swimming lessons, once per week, caused significant increases in aquatic readiness and in the motor coordination in Brazilian children aged 7-9 years old. The swimming lessons that focused on the development of basic swimming skills such as water orientation, breath control horizontal buoyancy, ventral and dorsal gliding, and horizontal rotations, resulted in greater aquatic readiness than the swimming lessons focused on formal swimming skills, such as leg kicking with breath control. Moreover, motor coordination was enhanced in both swimming programs, highlighting that swimming stimulates children's motor learning and contributes to a large motor development in 7-9 years old children. These results emphasise the need for a careful planning of swimming programs, even when limited to once a week in a school context, and perhaps raise the discussion about the need for more swimming lessons per week and for longer periods.

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