ORIGINAL ARTICLE

https://doi.org/10.6063/motricidade.24096

Effects of age and experience on the development of aquatic competence in children aged 36 to 72 months

Efeitos da idade e da experiência no desenvolvimento da competência aquática em crianças de 36 a 72 meses

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ABSTRACT

Considering age and experience as possible constraints to the development of aquatic skills, this study sought to analyse the effect of both on the aquatic competence of 368 children aged between 36 and 72 months using the Erbaugh Scale. Children were categorised according to age and previous aquatic experience in swimming lessons. The results of the two-factor ANOVA indicate that aquatic competence values increase from the lowest to the highest age group and the values found for the different levels of experience in swimming lessons. A regression model was applied and proved to be significant. According to the model, age and previous aquatic experience together were responsible for explaining 46% of the variance in aquatic competence. When applied in each group, the regression analysis indicated that age starts to exert less influence and the experience a greater influence on aquatic competence the older the age groups become. In addition, as the experience increases, the difference in aquatic competence increases between older and younger children. Therefore, the analysis of the contribution of these variables allows professionals to be guided in planning teaching strategies for the development of aquatic competence.
KEYWORDS: constraints; children; aquatic competence.

INTRODUCTION

To move in the aquatic environment, a child needs to coordinate a set of complex multi-articular actions in an environment that strongly restricts body movements (Guignard et al., 2017). Water is approximately 830 times denser than air, 829 times heavier and 55 times more viscous (Mackay, Shiu, Ma, & Lee, 2006; Castro, Correia, & Wizer, 2016). Due to the physical properties of water, to move in a competent way in this environment, to just generate propulsion is not enough, it is also necessary to minimise the drag forces produced by the environment in response to the body movements in the water. Looking at it in this way, it is possible to understand this interaction as a dynamic system.

The term "competence", when related to the aquatic environment, refers to a set of skills, behaviour and knowledge that expand the relationship between humans and the aquatic environment and help to reduce the risk of drowning (Moran et al., 2012; Langendorfer, 2015; Quan, Ramos, Harvey, Kublick, & Langendorfer, 2015). Nonetheless, there is still no consensus on the concept and the skills that comprise the aquatic competence construct. Langendorfer (2011) applied the Model of Constraints by Newell (1986) to the development of aquatic competence. According to Langendorfer (2011), the degree of aquatic competence is dependent on the relationship between the characteristics of the individual, the characteristics of the environment in which the task will be performed and the task. To enable new patterns of movement to emerge, changes must occur in at least one of the elements of the organism–environment–task triad (Newell, 1986). In this case, the system needs to adapt to the new conditions imposed by the constraints in a process called "self-organisation." This new state of behavioural organisation, revealed from the process of self-organisation, arises as older forms of behaviour lose stability (Kamm, Thelen, & Jensen, 1990). This loss of stability is, in humans, influenced by the individual's constraints, the environment and the task.

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Conflict of interest: nothing to declare. Funding: nothing to declare.
Reveived: 03/29/2021. Accpted: 06/09/2021.

Age, understood in this study as a constraint of the individual and related to maturation, has been questioned as to its importance in the acquisition of aquatic abilities. Langendorfer and Bruya (1995) proposed the concept of aquatic readiness, relating the age of children to the characteristics of the process of acquiring aquatic skills. As to the relevance of age in this process, Franklin et al. (2015) sought to identify the main factors that impact the learning process of swimming in children aged 5 to 12 years. The study showed that there is a linear increase in the level of aquatic abilities with increasing age. A similar result was found by Michielon, Scurati, Roione, and Invernizzi (2006), which also showed that age seems to be an important factor in the development of aquatic skills in children aged 4 to 36 months. Langendorfer (1987) participated in the discussion, emphasising that if the development sequence depended only on maturation, then all adults would reach advanced levels of ability; however, there is evidence indicating that without proper stimulation, it is not possible to achieve a mature level of performance (Halverson, Roberton, & Langendorfer, 1982).

In terms of the importance of experience in the development of aquatic skills, Erbaugh (1986a) evaluated the aquatic competence of children with different levels of experience. Those with previous experience in swimming classes maintained higher scores in all evaluations during an eight-month period than children without previous experience in swimming lessons. Zelazo and Weiss (2006) and Olaisen, Flocke, and Love (2018) also evidenced the strong influence of experience in improving the organisation of aquatic skills in children of different ages. Considering the high degree of complexity required to move in the aquatic environment and the factors of age and experience as possible constraints to the development of aquatic abilities, the aim of this study was to identify and understand the contribution of both (age and experience) to the aquatic competence of children aged between 36 and 72 months.

METHODS

Participants

The study included 368 children participating in swimming classes, aged between 36 and 72 months of both genders. The sample size was based on an adequate number that guarantees statistical procedures, the availability of the population (children aged from 36 to 72 months, all swimming practitioners) and on the result of the F test for four groups (calculations performed using the GPower 3.1 application). Thus, a sample number of 180 children per sex was reached, totalling 360 individuals. Data on the children participating in the study, such as age and previous aquatic experience (PAE), were obtained through a form completed by the parents/guardians of the children and were categorised as shown in Table 1.

This research project was duly submitted for evaluation by the Research Ethics Committee of UFRGS (RS, Brazil) and approved under opinion number 2.532.306; in addition, it follows the determinations of resolution 466/2012 of the National Health Council (Brazil). Anonymity and confidentiality of data were guaranteed.

Procedure

Data collection took place between March 2018 and September 2019 in swimming schools, clubs and condominiums with swimming pools at a time previously agreed with those responsible and with the educational establishments. For this, prior contact was made with the establishments to inform the objectives and procedures of the research. Upon obtaining the consent of each educational establishment, each child's parents were informed about the purpose of the research and the activities that would be carried out. When parents agreed to participate, they signed the Free and Informed Consent Form they had been given. In addition to parental consent, the child's verbal consent was obtained.

The Erbaugh Scale was used to assess the children's aquatic competence (AC) in the study. The Erbaugh Scale was previously validated (article in preparation) for Brazilian children to assess their AC accurately. The Erbaugh Scale is an ordinal scale composed of 47 items, which are subdivided into 6 tasks. The Scale tasks correspond to the skills required in the aquatic environment and include details of the distance covered, body position, and movement of arms and legs (Erbaugh, 1981). Items are organised and numbered in order

Table 1. Characterisation of the sample.

Age range (months)	Previous aquatic experience (months)	n
I (36–47)	I (< 1)	21
	II (1–6)	17
	II (6–12)	11
	IV (> 12)	26
II (48–59)	I (< 1)	28
	II (1–6)	42
	III (6–12)	24
	IV (> 12)	44
III (60–72)	I (< 1)	21
	II (1–6 months)	36
	III (6–12 months)	35
	IV (> months)	63

of difficulty. Thus, for the first task of the Scale corresponding to the "Entry: Jump Tasks" in the water, there are 5 items. The first, and the simplest, receives a score of 1, while the last and most difficult item receives a score of 5. In addition to this, the following tasks are evaluated by the Scale: Locomotion: Tasks in the prone position (10 items), Locomotion: Tasks in the supine position (10 items), Locomotion: Leg movement (9 items), Diving tasks (6 items) and Tasks of searching for objects at the bottom of the pool (7 items). The score on the Erbaugh Scale ranges from 0 to 47.

Regarding aquatic competence, the differential of this scale lies in the fact that it considers the distance travelled by the child and the characteristics of the performed movement. This aspect highlights the author's concern with aquatic safety. Therefore, the instrument is able to provide information about the characteristics of the movement pattern, as well as how much the child can sustain this movement pattern over the distance covered.

For the application of the Erbaugh Scale, 2 evaluators were needed. One of them, who had experience teaching aquatic skills to children, remained in the pool and was responsible for applying the instrument to each child. The other evaluator remained on the edge and was responsible for operating a video camera to obtain the images for each test applied. All evaluations were recorded for later analysis.

In tasks that required control of the distances covered, coloured E.V.A. bands, measuring 0.5 m, were used side by side until reaching 6 m at the side edge of the pool. The E.V.A. bands colour differences enabled the visualisation of the distance travelled by the child during the observation of the videos. It was decided to add 1 meter between the place where the child started the test and the beginning of the E.V.A. bands. The objective was to disregard the child's height and minimise the edge impulse's effects at the beginning of the task. Subsequently, the evaluator analysed the images obtained and scored the child's performance in each Erbaugh Scale task.

Data analysis

Means, standard deviations and 95% confidence interval limits were calculated. Two-factor ANOVA was applied to the data to compare the AC of children of different age groups (36 to 47 months, 48 to 59 months and 60 to 72 months) and with different PAE (up to 1 month of experience, up to 6 months of experience, 6 months to 12 months of experience and more than 12 months of experience). Blanca, Alarcón, Arnau, Bono, and Bendayan (2017) showed that the robustness of ANOVA is maintained even in conditions of non-normal data. Levene's test was used to verify the homoscedasticity of the data. Tukey's post hoc test was applied to locate the differences between the clusters. The age and experience effect sizes were identified, respectively, by the η^2 statistic (small: ≤ 0.02, medium: > 0.02 and ≤ 0.08 or large: > 0.08) (Cohen, 1988).

Multiple regression analysis was applied to verify the predictor behaviour of age (in months) and PAE (in months) on AC. This procedure was performed with the whole study sample. Later, to deepen the results, the sample was divided by age groups and PAE, then the multiple regression analysis was applied to the groups in isolation. The objective of this procedure was to compare the predictor behaviour of independent variables in different age ranges and with different PAE.

Among the methods of entry of independent variables in the multiple regression model, the present study opted for the stepwise method. Tabachnick and Fidell (2013) point out that the methods differ from each other in relation to what occurs with the shared variance between the variables and how the order in which the variables enter the equation is determined. The stepwise method allows each variable to be considered for inclusion before developing the equation, and the independent variable with the highest contribution is added first (Hair, Black, Babin, & Anderson, 2014). It is important to highlight that the child's age in months was used for regression analysis, while the PAE was categorised as shown in Table 1. The data were analysed using SPSS version 21.0, and a significance level of 0.05 was adopted.

RESULTS

Figure 1 shows the AC means and standard deviations for each age group. AC values increased from the lowest to the highest age group [$F(2,356) = 73.99$; $p < 0.001$; $\eta^2 = 0.29$, large effect size]. The mean values and limits of confidence for each age group were: (I) 17.4 [15.3 to 19.4], (II) 24.6 [23.0 to 26.2], (III) 32.9 [31.5 to 34.3] points.

Figure 2 shows the AC means and standard deviations for the groups by PAE. AC values increased as the experience increased [$F(3,356) = 27.90$; $p < 0.001$; $\eta^2 = 0.19$, large effect size]. However, Group III (6 to 12 months of experience) showed no difference when compared to Group II (up to 6 months of experience) ($p = 0.185$) and when compared to Group IV (more than 12 months of experience) ($p = 0.190$). The mean values and limits of confidence for each group by PAE were: (I) 17.8 [15.6 to 20.0], (II) 25.3 [23.2 to 27.5], (III) 28.4 [26.2 to 30.6], (IV) 31.3 [29.6 to 32.9] points. There was no interaction between age groups and experience levels [$F(6,356) = 1.47$; $p = 0.185$; $\eta^2 = 0.02$, small effect size].

Multiple linear regressions were used to verify whether age and PAE in swimming classes (independent variables) could predict the AC of the child (dependent variable).

Both age and PAE showed a positive and significant correlation with AC (age= 0.57; *p*< 0.001 and PAE= 0.43; *p*< 0.001). The analysis resulted in a statistically significant model [F(2,365)= 155.61; *p*< 0.001; R2= 0.46] and age and PAE were responsible for explaining 46% of the variance of AC. According to the model, both age (ß= 0.52; t= 13.52; *p*< 0.001) and PAE (ß= 0.36; t= 9.43; *p*< 0.001) can be considered predictor variables of AC. Even if a positive and significant correlation was found between age and PAE (r= 0.13; *p*< 0.001), both variables entered the model.

Therefore, the regression equation that predicts the AC (points), based on the age (months) and PAE (months), is:

AC= -15.34+ (0.577× age)+ (3.46× PAE)

Regression analyses were also applied to the data when separated by age ranges and PAE. Significance levels and correlation values between independent and dependent variables for each age range and PAE are shown in Table 2 and Table 3.

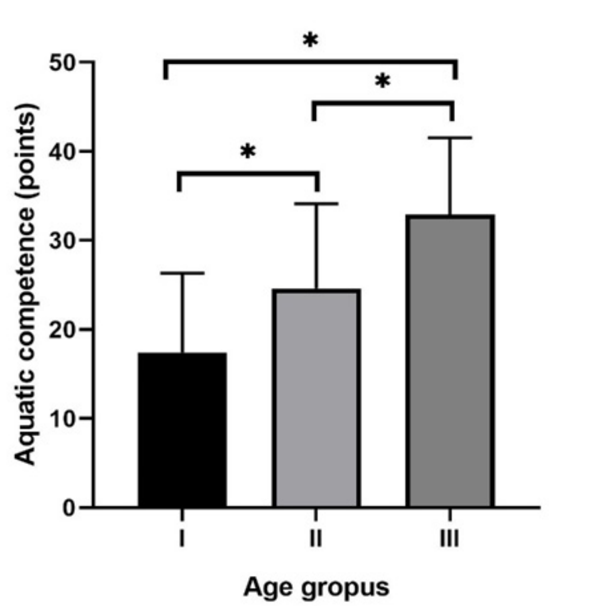
All analyses performed for the different clusters (age and PAE) resulted in a statistically significant model. According to the resulting models, both age and PAE were considered predictors of AC, except for Group II, per age group (48 to 59 months). Regression analysis for this grouping resulted in a model in which only PAE was considered a predictor of AC. Table 4 presents the values of R^2, the results of ANOVA, and ß and T-test values for the regression models resulting from age groupings, with the significance levels.

Table 5 shows the values of R^2, the result of ANOVA, as well as ß and T-test values for the regression models resulting from clusters by PAE, with the significance levels.

DISCUSSION

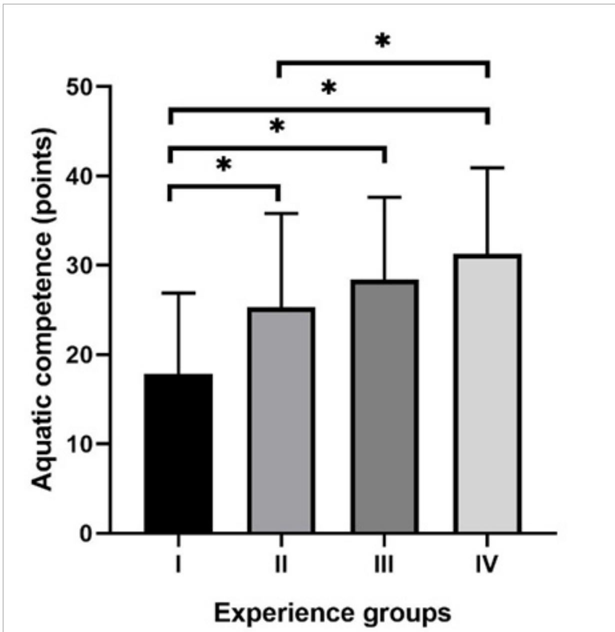
Considering the high degree of complexity required to move in the aquatic environment, this study sought to understand the effect of age and experience in the development of AC in children aged between 36 and 72 months, as well as to investigate the predictive character of these two variables in relation to AC. In general, both age and PAE were able to distinguish the AC of children from 36 to 72 months of age; thus, both were predictors of AC. Together, age and PAE were responsible for explaining up to 46% of the AC variance.

This result was expected since studies conducted over the years have shown the relevance of age and experience in the development of motor skills in childhood (Halverson et al., 1982; Cleland & Gallahue, 1993; Saraiva, Rodrigues, Cordovil, & Barreiros, 2013), but it is unprecedented to show these effects over different age groups and experience levels early in swimming. Malina (2004) highlighted that development and motor proficiency occur due to the relationship between the experience of an individual and the growth and



*p< 0.001. I: 36 to 47 months (n= 75), II: 48 to 59 months (n= 138); III: 48 to 59 months (n= 155).

Figure 1. Aquatic competence values for age groups.



*p< 0.001. I: up to 1 month (n= 70), II: 1 to 6 months (n= 95); III: 6 to 12 months (n= 70), IV: more than 12 months (n= 133).

Figure 2. Aquatic competence values for age groups.

Table 2. Correlation between age and previous aquatic experience and the aquatic competence for different age groups.

Age range		AC r (*p*)
I (n= 75)	Age	0.33 (*p*= 0.002)
	PAE	0.36 (*p*= 0.001)
II (n= 138)	Age	0.14 (*p*= 0.043)
	PAE	0.46 (*p*< 0.001)
III (n= 155)	Age	0.17 (*p*= 0.014)
	PAE	0.46 (*p*< 0.001)

AC: aquatic competence; PAE: previous aquatic experience.

Table 3. Correlation between age and the aquatic competence for different clusters of previous aquatic experience.

PAE		AC r (*p*)
I (n= 70)	Age	0.52 (*p*< 0.001)
II (n= 95)		0.52 (*p*< 0.001)
III (n= 70)		0.58 (*p*< 0.001)
IV (n= 133)		0.64 (*p*< 0.001)

AC: aquatic competence; PAE: previous aquatic experience.

Table 4. Regression analyse results for age ranges 1, 2 and 3.

Age range	Regression model	Coefficient
I	[F(2,72)= 9.59; *p*< 0.001; R^2= 0.21]	Age (ß= 0.28; t= 2.68; *p*= 0.009)
		PAE (ß= 0.32; t= 3.04; *p*= 0.003)
II	[F(1,136)= 37.79; *p*< 0.001; R^2= 0.21]	Age -
		PAE (ß= 0.46; t= 6.14; *p*< 0.001)
III	[F(2,152)= 25.62; *p*< 0.001; R^2= 0.25]	Age (ß= 0.19; t= 2.76; *p*= 0.006)
		PAE (ß= 0.47; t= 6.70; *p*< 0.001)

AC: aquatic competence; PAE: previous aquatic experience; t: T test; ß: value.

maturation process, which in the present study is represented by the child's age. Olaisen et al. (2018) evaluated the effects of an intervention in the aquatic environment and the influence of age and number of classes on the aquatic abilities of 149 children aged 3 to 14 years. To perform the evaluation, the authors used the instrument entitled "The Hoover Curriculum Checklist". The authors found significant effects from the intervention, and the differences between groups

Table 5. Regression analyse results for different clusters of previous aquatic experience.

PAE	Regression model	Coefficient
I	[F(1,68)= 25.84; *p*< 0.001; R^2= 0.27]	Age (ß= 0.52; t= 5.08; *p*< 0.001)
II	[F(1,93)= 35.07; *p*< 0.001; R^2= 0.27]	Age (ß= 0.52; t= 5.92; *p*< 0.001)
III	[F(1,68)= 34.39; *p*< 0.001; R^2= 0.33]	Age (ß= 0.58; t= 5.86; *p*< 0.001)
IV	[F(1,131)= 91.68; *p*< 0.001; R^2= 0.41]	Age (ß= 0.64; t= 9.57; *p*< 0.001)

AC: aquatic competence; PAE: previous aquatic experience; t: T test; ß: value.

of different ages and with different amounts of experience in aquatic environments were also significant.

Although both variables (age and PAE) entered the model as predictors of AC, the regression analysis indicated that age (ß= 0.52) was the highest predictor when compared to the PAE (ß= 0.36). The influence of age is related to several changes in the body, both from the structural and functional point of view, especially when it comes to children. Increased age is associated with changes resulting from maturation of executive function, working memory and speed of information processing (Luna, Garver, Urban, Lazar, & Sweeney, 2004; Best & Miller, 2010). These functions, when combined, lead to faster reaction times, improved dexterity, increased speed and precision of movement, and lower movement variability (Savion-Lemieux, Bailey, & Penhune, 2009). These factors optimise the performance of motor skills and increase the relevance of age in the acquisition of AC.

It is important to bear in mind that, although the "status" of the central nervous system has been overvalued as a constraint of the individual, other characteristics also interfere with development (Newell, 1986). Structural changes related to height, body mass and relative size of body parts also represent constraints for an individual and have repercussions on the process of acquiring motor competence. According to Newell (1986), these changes in body size lead to changes in the biomechanical constraints of the system. Although age offers a possibility for representing the maturational state of a child, Erbaugh (1986b) pointed out that characteristics such as the child's body mass have greater potential for predicting aquatic abilities.

Erbaugh (1986b) analysed two aquatic abilities of 117 children aged three to six years old: displacement in (i) prone and (ii) in supine positions. In addition, other information was collected, such as age, height, body mass and aquatic experience. Multiple regression analysis was applied to the data, and the child's body mass was the best predictor of their ability in the aquatic environment. Age was also important, however, in the absence of information on body mass. Both variables showed a high correlation (r= 0.73) with each other. In regard to these results, it is possible to infer that body mass can be a variable used to predict AC, possibly due to its relationship with the maturational state of the child. Then, the correlation values between age and body mass, as well as the importance attributed to age in the absence of body mass information presented in Erbaugh's study (Erbaugh, 1986b), suggest that age can also be used as being indicative of the maturational state of the child.

The results of the regression also showed a positive correlation between age and PAE. Although the value was low (r= 0.13), the correlation was significant ($p< 0.001$), suggesting a tendency that the older the child, the higher the experience concerning the aquatic environment. In other words, age is able to reflect not only the biological and neurological maturity of the child but also the accumulated effects of environmental stimuli, reflecting on the quality of the movement performed (Saraiva et al., 2013).

For Langendorfer (1987) and Savion-Lemieux et al. (2009), if the acquisition of motor skills were dependent only on age or maturational processes, then all adults would reach advanced levels of any motor skills. However, evidence indicates that without adequate and practical stimulation, it is not possible to reach a mature level of performance (Halverson et al., 1982). Moreover, although the younger child has biological limitations, which make it challenging to perform high-complexity motor actions, the experience gained in swimming lessons greatly contributes to the acquisition of AC, albeit to a lesser degree in terms of complexity of movements.

To assess the influence of experience in the acquisition of aquatic skills, Erbaugh (1986a) evaluated the AC of children with different levels of experience. Those with previous experience in swimming lessons maintained higher AC values in all evaluations over an eight-month period than children from the group without previous experience in swimming lessons, and even without considering age, this result points to, in line with the results of the present study, the relevance of experience in the development of AC. The role of experience in the acquisition of motor skills was also investigated by Logan, Robinson, Wilson, and Lucas (2011). The authors sought, through a meta-analysis, to analyse the effectiveness of motor intervention programs in children. The study provided evidence that the implementation of motor intervention programs is an effective strategy to develop fundamental motor skills in children.

It is important to mention another result from the present study concerning the non-distinction between groups with close PAE. As in the case of the group of children with 6 to 12 months of experience who did not present any difference when compared to the group of children with up to 6 months of experience (= 0.185), and when compared to the group of children with more than 12 months of experience (= 0.190). It is known that AC is related to other variables that are capable of interfering in the process of acquiring aquatic skills, such as fear of water, motor experiences in general, motor experiences in the aquatic environment and characteristics of the classroom environment (Anderson & Rodriguez, 2014). Consequently, a more substantial difference between the groups was necessary for the PAE to assume significant relevance in the development of AC, differentiating the groups even under the influence of other factors.

Regarding the regression analysis performed for each age group, the results presented in Table 2 suggest a balance in the contribution of independent variables on AC in the age range I (36 to 47 months), which corresponds to the youngest children. In ranges II and III, the increased contribution of experience and the reduction of the contribution of age to AC are evident. The results presented in Table 4 also suggest that the child's age starts to exert less influence, while the PAE starts to exert a greater influence on the results of AC with the increase of age ranges. In this regard, Newell (1986) proposed that the younger the child, the more susceptible to individual restrictions they are, such as age, for example.

In the study conducted by Michielon et al. (2006), the authors analysed the effect of an aquatic motor intervention program consisting of spontaneous exploration movements in three groups of children of different ages: 4–12 months, 12–24 months and 24–36 months. No differences were found between the pre and post-test in each group; however, statistical differences were found in the comparison between groups of different ages, suggesting that the development of aquatic abilities in children in this age group (4–36 months) depends predominantly on age. The results found in the present study corroborate the results of Michielon et al. (1986) and show the greater relevance of age in the acquisition of AC in younger children.

As for the increase in the contribution of experience with the increase in age evidenced in the regression models by age range, it is important to highlight that in early childhood, the sequence of development of motor behaviours manifests itself more predictably (Newell, 1986). The influence of environmental and task constraints becomes more evident over time since the passage of time focuses on increasing the child's interactions with the surrounding environment and its influence on the development process.

The correlation results (Table 3) associated with the results of the regression analysis (Table 5) for each group of PAE indicate that with the increase in the experience, there is also an increase in the correlation between age and AC; that is, the more experience in the aquatic environment a child has, the greater the difference in the level of AC of that child when compared to another younger child with equal PAE. These results indicate the existence of an age-limiting aspect in the process of developing AC with the increase in the PAE. It is interesting to relate this result to the discussion about critical periods for swimming learning.

In terms of critical periods for swimming learning, Blanskby, Parker, Bradley, and Ong (1995) and Anderson and Rodriguez (2014) found that the later children are inserted into swimming programs, fewer classes are required to learn how to swim. So, variations in the pace of learning can happen due to the age of the child. Studies also suggest that the critical period for swimming learning occurs after five years of age. Although such evidence seems to challenge the importance of starting aquatic skills teaching programs before the age of five, Anderson and Rodriguez (2014) and Blanksby et al. (1995) also pointed out that children who started aquatic programs at early ages reached levels of proficiency established in the study at earlier ages. In addition, it is important to point out that in the present study, the effects of experience were perceived even in children under five years of age, suggesting that, regardless of the existence of critical periods for swimming learning, the evolution of AC levels occurs at all ages.

To exemplify the occurrence of learning aquatic skills before the age of five, it is important to mention the studies by Rocha, Marinho, Garrido, Morgado, and Costa (2018) and Wizer, Meira Júnior, and Castro (2016). Rocha et al. (2018) investigated the effect of aquatic intervention programs in shallow-pool and deep-pool environments, and Wizer et al. (2016) investigated the effects of the use of floats on the process of acquiring aquatic skills. Although the objectives of the studies were to compare the learning in environments with different characteristics, all described situations contributed positively to the process of acquiring aquatic skills in children under five years of age. A study by Zelazo and Weiss (2006) verified the effects of four months of intervention in infants on aquatic behaviour. According to the authors, babies evolved rapidly from disorganised movements to the acquisition of movements with a greater degree of organisation and complexity, further strengthening the role of experience in acquiring AC.

Despite the importance of experience in the aquatic skills acquisition process, it is important to highlight that the experience in the present study was evaluated only from the quantitative point of view. It was not possible to make inferences about the quality of the teaching programs experienced by the children in the study. Finally, we emphasise the importance of developing studies from the perspective of mapping other factors involved in the development of aquatic competence, such as the characteristics of swimming teaching programs.

CONCLUSIONS

Between age and PAE, age presented a greater potential for aquatic competence prediction than PAE because age includes not only part of the maturity of the individual but also the amount of experience acquired over time. In this case, it is suggested that there is an increased influence of environmental factors in the development process with increasing age. Therefore, the identification and level of contribution of the variables studied, age and experience, allow the professional to be guided in the planning and application of teaching strategies to develop aquatic competence.

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