REVIEW ARTICLE

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Measurement of aquatic competence in toddlers, infants, and children between 6 months and 14 years: a systematic review

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ABSTRACT

The aim of this study was to carry out a systematic review of the literature on tools for measuring aquatic competence in toddlers, infants, and children between the ages of 6 months to 14 years old. A systematic review was carried out following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement. Six of the eight studies selected obtained high valuations based on the Downs and Black Quality Assessment checklist. The studies were classified into three categories, one that proposed tools that measured actual aquatic competence (*n*= 6), the other one that measured perceived aquatic competence (*n*= 1), and the other that measured both (*n*= 1). Five studies measured emotional, social, cognitive, and communicative skills apart from motor skills. Most of the studies focused the proposed assessment tool on a specific age group, while two looked at a broader age group. In conclusion, eight instruments have been developed and validated in recent years for measuring aquatic competence for children between 6 months and 14 years of age from a multipurpose perspective. These have tools designed to facilitate and improve teacher assessment and determine children's perception of their own aquatic competence.

KEYWORDS: motor development; swimming skills; water skills; assessment.

INTRODUCTION

The term aquatic competence (Langendorfer & Bruya, 1995) includes the knowledge of swimming and the readiness and ability to enter the water and submerge completely, to surface and stay afloat for at least 1 minute, to make a 360° turn, to propel oneself forward or backwards a minimum distance of 22 meters and to be able to exit the water autonomously (American Red Cross, 2014). Thus, aquatic competence is considered a combination of physical and cognitive abilities necessary to enjoy the different aquatic environments or to solve problems in them (Moreno-Murcia and Ruiz-Pérez, 2019).

Aquatic competence helps humans not only to avoid risks and save their lives (Brenner et al., 2003; Rubio et al., 2015) but also to support the integral development (cognitive, socio-affective, and motor) of the individual (Fragala-Pinkham, Haley, & O'Neil, 2008; Sigmundsson & Hopkins, 2010; Font-Ribera et al., 2011; Burac, 2015) as shown by some studies focused on young children (Terzidis et al., 2007; Brenner et al., 2009). Moreover, a good aquatic competence can make learning more advanced/specialised forms of these skills easier (Clark & Metcalfe, 2002; Hulteen, Morgan, Barnett, Stodden, & Lubans, 2018).

The familiarisation with the aquatic environment should be done early to avoid developing fears and promote a positive environment (Becker, Nascimento, Rossignaud, Maia, & Santos, 2017; Moreno-Murcia & Ruiz-Pérez, 2019). Moreover, this can benefit the adaptation to the aquatic environment since mastering a water sport that requires complex coordination skills (of arms, legs, and breathing) along with specific water sport skills requires, as a precondition, autonomy, confidence, and satisfaction in the aquatic environment (Hulteen et al., 2018). This preparation period is located in the early childhood stage (4-6 years) (Blanksby, Parker, Bradley,

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& Ong, 1995; Parker & Blanksby, 1997; Gallahue, 2008). It is assumed that before being able to master the aquatic environment, it is necessary to acquire the basic and minimum skills necessary for safety and survival in the aquatic environment. But it is not the same to consider aquatic motor skills in an isolated manner (Moreno-Murcia & Albarracín, 2017) as all of them together in the aquatic environment in order to ascertain the acquisition of skill (Moreno-Murcia & Ruiz-Pérez, 2019).

The measurement of aquatic competence provides objective information on which to base decisions about learners, monitor progress, and gain insight into children's level of water safety. It becomes the first step that any aquatic educator needs to take before diagnosing and evaluating an intervention later. It should be emphasised that having an effective, standardised tool for the assessment of aquatic competence is very important as it provides accurate information about the level of each person, thus enabling the setting of objectives and planning of activities with the least margin of error.

Historically, the design of instruments to measure the teaching of swimming as a sport has been one of the main concerns of specialists (Navarro & Juarez, 2017). Currently, the study on the measurement of aquatic competence is generating more interest in the scientific field, creating new tools with an easy application and greater rigor, that soon can provide objective data and advances in the knowledge of this area of research. But many of these proposed test instruments or assessment tools have not presented psychometric measures of validity and reliability even though different aquatic centres use them. Since the error is inherent to measurement, it is necessary to evaluate the quality of the measuring instruments, determining whether or not they meet the metric quality criteria that every instrument must satisfy to be used with guarantees. Therefore, to measure and to do it through standardised tests is a necessity. Reviewing the tools currently available to measure aquatic competence can be very useful to optimise the aim of improving the design, methodology, and organisation of the teaching-learning process of aquatic competence and the further development of standardised and validated tools. Therefore, the aim of this study was to carry out a systematic review of the literature on tools for measuring aquatic competence in -toddlers, infants, and children between the ages of 6 months to 14 years old. This review can show the scientific evidence in this regard, which can serve to know what validated measurement instruments can be used by the teachers and coaches. Also, this review can inform if there is a need to investigate even more in this context for the adequacy of the teaching-learning process of aquatic competence.

METHODS

Design

A systematic review was carried out following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Moher, Liberati, Tetzlaff, Altman, & The Prisma Group, 2009). This guide, which has a checklist of items, was designed to improve the report integrity of systematic reviews and meta-analyses. PRISMA may also be useful for critical appraisal of published systematic reviews (Moher et al., 2009).

Procedure

For this review, an initial search strategy was conducted to find scientific literature related to measuring aquatic competence in toddlers, infants, and children (between 6 months and 14 years of age). The following search terms were used: 'aquatic skill'; 'water competence'; 'aquatic competence'; 'swimming competence', 'test', 'evaluation'; 'assessment', 'measurement', 'swimming', & 'readiness'. Different combinations of these search terms were carried out using the Boolean search method (including OR/AND) in the Web of Science, Scopus, Pubmed, Dialnet, SportDiscus, and Google Scholar databases. The search was carried out from April 1st to April 30th of 2020. To identify additional studies, reference lists of any relevant reviews and original studies were reviewed to ensure an exhaustive search for all evidence associated with swimming competence in infants and primary school children.

Eligibility criteria

Studies were included in the review if they: (a) targeted toddlers, infants, and children between 6 months and 14 years of age; (b) were original research articles in English or Spanish languages, testing the eligibility of tests that measured aquatic competence; (c) objectively measured the validity of the aquatic competence test. Articles were excluded if they (a) also included data of adolescents or adults; (b) did not detail the protocol or the age of the participants; (c) was oriented towards swimming styles or organisational aspects; (d) were specifically aimed at populations with pathologies or disabilities; (e) unavailability of the full text.

Quality assessment

The quality of the articles selected was evaluated on the Downs and Black Quality Assessment Checklist (Downs & Black, 1998). The checklist is used in systematic reviews to rate articles with different research designs, and a higher score on the scale corresponds to a better quality of the article.

The original Downs and Black Quality Assessment Checklist was used with a couple of modifications. For questions 9-12 and 14-26, an additional option of "not applicable" was included. Question 27 was scored with "Yes" (1 point — statistical significance reached), "No" (1 point — statistical significance not reached), or "Not applicable". In answering questions 5 and 25, age and sex were determined as the core confounders, whereas body weight, height, and aquatic experience were defined as other confounders. Questions scored as 'Not applicable' were not considered when calculating the final quality score of an article, which was expressed as a percentage (Equation 1):

$$(\text{total number of points/total number of applicable points}) \times 100\% \quad (1)$$

No article was excluded based on its quality score or study design. The studies were rated as follows: low, with a score ≤ 50%; (ii) good, with a score between 51% and 75%, and (iii) excellent, with a score > 75% (Sarmento et al., 2018; Santos, Marinho, Neiva, & Costa, 2021). The quality assessment was done by Archit Navandar, as this author did not participate in the other parts of the article selection process.

Data extraction and synthesis

From the eight articles selected, the study aims, population, age, type of study, mode of observation, instruments, evaluation characteristics, grading system, and conclusions were extracted. Data extraction was performed by the same two reviewers who performed the initial search, and the data validation was done by the author that performed the quality appraisal. Data were managed and analysed using Microsoft Excel® 2016 (Microsoft Corporation, Redmont, WA, USA).

RESULTS

Based on the keywords input, a total of 689 articles were found after removing duplicates. The articles were then screened based on the title and abstracts, leading to the elimination of 576 articles. From the remaining 113 articles, 95 were eliminated based on the inclusion criteria, and 10 were eliminated based on the exclusion criteria. Finally, 8 articles were included in the review (Figure 1).

All the studies on the measurement of aquatic competence included in this review were published in the last fifteen years, with a majority being in the last five years. The studies encompassed groups in Spain (n= 6), Germany (n= 1) and China (n= 1).

Six of the eight studies obtained excellent valuations (above 75%) based on the Downs and Black Quality Assessment, and the others obtained a good score (Table 1). Data extracted from the studies are presented in Tables 2 and 3.

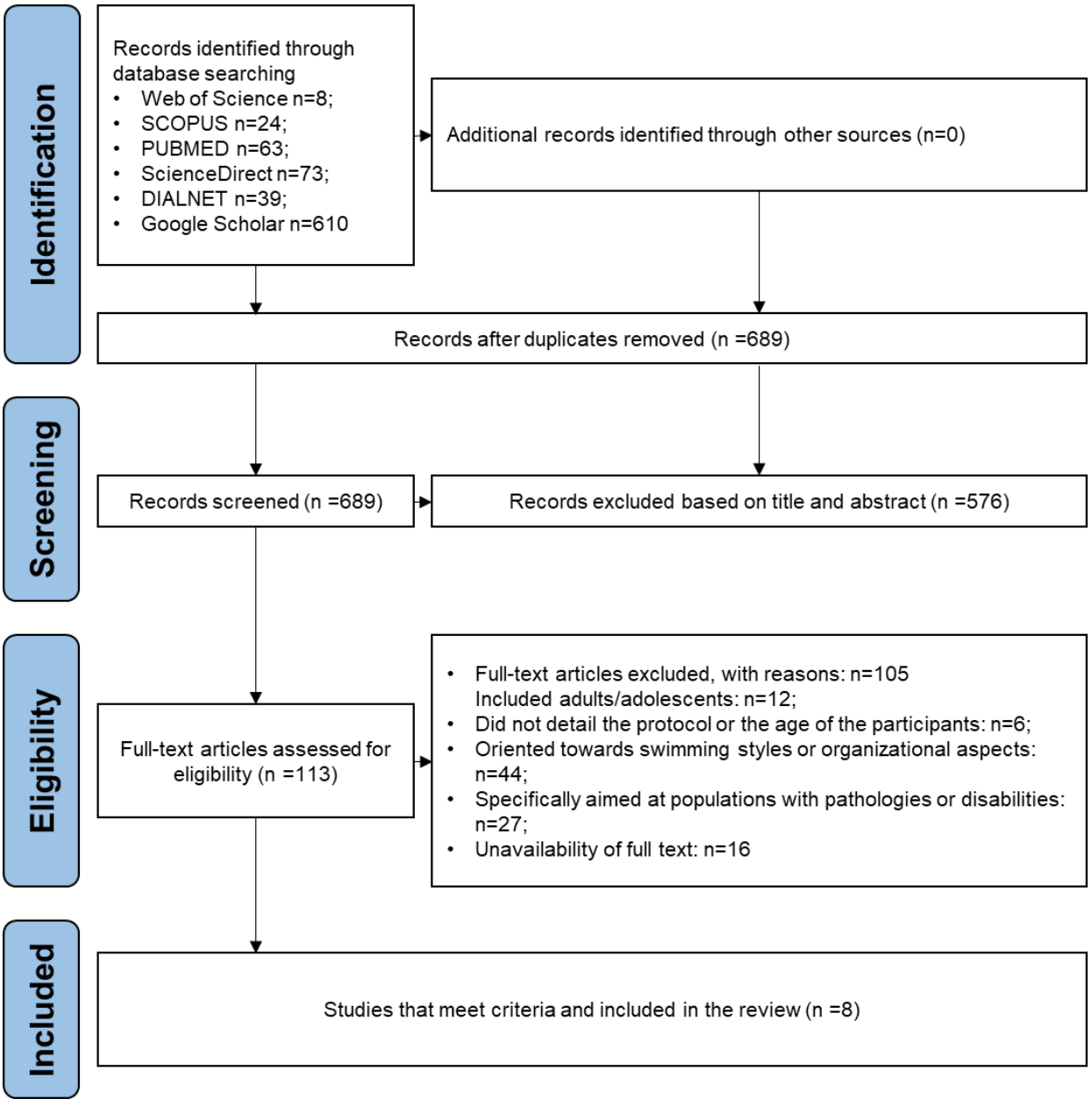
The studies can broadly be classified into three groups, one with those that propose a tool for measuring actual aquatic competence (Moreno-Murcia, 2005; Gómez-Mármol, López-Rodríguez, & Sánchez-Alcaraz Martínez, 2015; de Paula-Borges & Moreno-Murcia, 2018; Salar-Andreu, Moreno-Murcia, & Ruiz-Pérez et al., 2018; Moreno-Murcia, de Paula-Borges, & Huéscar Hernández, 2020; Vogt & Staub, 2020), and those that propose instruments to measure perceived aquatic competence in the other (Moreno-Murcia & Ruiz-Pérez, 2008). Chan, Lee, Macfarlane, Hagger, & Hamilton (2020) validated a measurement instrument that, although fundamentally measures the perceived aquatic competence, can also be used to measure the actual aquatic competence.

Concerning the dimensions to be measured with the proposed instruments, the articles study are differentiated into two groups: those studies in which the measurement is referred to the motor skills exclusively (Moreno-Murcia, 2005; Chan et al., 2020; Vogt and Staub, 2020), and those others that involve motor skills along with others, such as the emotional, social, cognitive and communicative skills (Moreno-Murcia & Ruiz-Pérez, 2008; Gómez-Mármol et al., 2015; de Paula-Borges & Moreno-Murcia, 2018; Salar-Andreu et al., 2018; Moreno-Murcia et al., 2020).

The included studies present measurement instruments for different ages up to 14 years old. Most of the studies focused on a specific age group: babies from 6 to 12 months (Salar-Andreu et al., 2018); children from 4 to 5 years old (Moreno-Murcia & Ruiz-Pérez, 2008), or 6 to 7 years old (de Paula-Borges & Moreno-Murcia, 2018; Vogt and Staub, 2020). Some studies looked at children across different ages, such as between 3 – 6 years (Gómez-Mármol et al., 2015; Moreno-Murcia et al., 2020); 4 – 8 years (De Sousa Morgado et al., 2020); 4 – 11 years (Moreno-Murcia, 2005); and 5 – 14 years (Chan et al., 2020).

DISCUSSION

Among the main objectives of measurement are: determining whether children master a particular concept or skill; informing children and families of what they know and what they can do; indicating to children where to focus for improvement; determining how to group learners; identifying individuals with special needs; and comparing the performance of groups of children locally, nationally, or internationally. Attending to the needs of the evaluation of aquatic competence, and considering the importance of this competence in childhood and adolescence, this study aimed to analyse



Source: Moher et al. (2009).

Figure 1. PRISMA flow diagram.

all the validated measurement instruments of aquatic competence at the infant and primary stage.

In this sense, the carried out review found 8 scientific publications that present the validation and proposal of an instrument to measure aquatic competence in toddlers, infants, and children.

Some of them are designed for the measurement of real aquatic competence in the first months of life (Salar-Andreu et al., 2018); some others for the infant stage (Gómez-Mármol et al., 2015; Moreno-Murcia et al., 2020); while for the 6 to 12-year stage some instruments have been designed in a more specific way (Moreno-Murcia, 2005; De Paula-Borges & Moreno-Murcia, 2018; Chan et al., 2020). On the other hand, the research of Moreno and Ruiz-Pérez (2008) and Vogt and Staub (2020) focused on the measurement of perceived aquatic competence. In general, the orientation of all validations is focused on the measurement of aquatic competence in a global way, but the studies of Salar-Andreu

Table 1. The Downs and Black Checklist scores for the articles selected.

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	%
Moreno-Murcia (2005)	1	1	1	1	1	1	0	1	0	0	1	1	1	NA	NA	NA	1	0	1	1	1	1	NA	NA	1	0	1	77
Moreno & Ruiz-Pérez (2008)	1	1	0	1	0	1	1	0	NA	1	1	1	1	NA	1	NA	1	1	1	1	1	1	NA	NA	1	0	1	82
Gómez-Mármol et al. (2015)	1	1	0	1	0.5	1	1	0	0	0	1	1	1	NA	1	NA	NA	1	1	1	1	1	0	NA	0	0	1	67
Salar-Andreu et al. (2018)	1	1	1	1	1	1	1	0	0	1	1	1	1	NA	0	NA	1	1	1	1	1	1	0	0	1	0	1	76
De Paula-Borges and Moreno-Murcia (2018)	1	1	1	1	1	1	1	0	NA	1	1	1	1	1	0	NA	1	1	1	1	1	1	1	0	1	1	1	88
Vogt and Staub (2020)	1	1	1	1	0.5	1	1	1	NA	NA	1	0	0	NA	NA	NA	1	1	1	1	UC	UC	NA	NA	0	UC	1	68
Chan et al. (2020)	1	1	1	1	0	1	1	1	0	0	1	1	1	NA	NA	NA	1	1	1	1	1	1	NA	NA	0	NA	1	81
Moreno-Murcia et al. (2020)	1	1	1	1	0.5	1	1	0	NA	1	1	1	1	NA	0	NA	NA	1	1	1	NA	NA	NA	NA	NA	0	0	75

Table 2. Study characteristics of the articles included in the review.

	Study	Sample	Age	Study Type	Mode
1	Moreno (2005)	*n*= 645	3 – 11 years	Test	Direct Observation, 1 observer
2	Moreno & Ruiz-Pérez (2008)	*n*= 100	4.5± 0.67 years	Pilot Test-Retest	Individual, perception of each child
3	Gómez-Mármol et al. (2015)	*n*= 58	4.56± 1.15 years	Test-Retest	Direct Observation, 1 observer
4	Salar-Andreu et al. (2018)	Study 1: *n*= 211 Study 2: *n*= 831	8.6± 1.9 months 8.68± 2.27 months	Pilot test Test	Direct Observation, 1 observer
5	De Paula-Borges and Moreno-Murcia (2018)	*n*= 80	6 – 7 years	Control/intervention groups	Direct Observation, 2 observers
6	Vogt and Staub (2020)	*n*= 22	6.95± 1.03 years	Test	Filming in three planes, multiple observers
7	Chan et al. (2020)	Study 1: *n*= 4959 Study 2: *n*= 1614	8.63± 1.71 years 6.4± 0.52 years	Test-retest	Individual, perception of each child
8	Moreno-Murcia et al. (2020)	Study 1: *n*= 122 Study 2: *n*= 384 Study 3: *n*= 444	n/e 4.02± 0.82 years 4.45± 0.84 years	Pilot Test	Direct Observation, 1 observer

Table 3. Instruments used, characteristics of the evaluation, scoring, and conclusions of the studies selected.

	Study	Instruments	Characteristics of the Evaluation	Scoring
1.	Moreno (2005)	Aquatic Motor Competence Scales	16 items [age: 4 – 5 years] 16 items [age: 6 – 7 years] 14 items [age: 8 – 9 years] 10 items [age: 10 – 11 years] Divided into two factors (familiarisation and immersion).	1 to 4
2.	Moreno and Ruiz-Pérez (2008)	Pictorial Scale of Perceived Aquatic Competence	10 items divided into two factors (perceived motor skills in water and attitude towards the water).	A, B & C
3.	Gómez-Mármol et al. (2015)	Observation Sheet for the Evaluation of Aquatic Psychomotor Assessment	22 items divided into five dimensions (familiarisation with the environment, balance, movement, manipulations, and social relations).	1 to 5
4.	Salar-Andreu et al. (2018)	Aquatic Developmental Aquatic Inventory	14 items divided into four areas (personal/social/emotional, communicative, cognitive, and aquatic motor skills).	1 to 4
5.	De Paula-Borges and Moreno-Murcia (2018)	Instrument for Measuring Knowledge, Ability, and Behavior in Aquatic Activities	11 items for the evaluation of knowledge. 35 items for the evaluation of ability. 16 items for the evaluation of knowing how to be.	Dichotomous
6.	Vogt and Staub (2020)	Assessment of Basic Aquatic Skills	19 consecutive tests	Dichotomous
7.	Chan et al. (2020)	Swimming Competence Questionnaire	11 items divided into two factors (distance and abilities)	Distance & dichotomous
8.	Moreno-Murcia et al. (2020)	Measurement Scale of Aquatic Competence in Infants Pictorial Scale of Perceived Aquatic Proficiency	23 items divided into three dimensions (socio-affective, cognitive, and motor). 6 items of the 'aquatic motor skills' factor.	1 to 5 A, B & C

et al. (2018) and Moreno-Murcia et al. (2020) have already begun to analyse aquatic competence in a more complete way (including the motor, cognitive and socio-affective domains).

The acquisition of technical skills can be gauged by designing an analysis specifically for it. It begins with the development of an analysis of the needs of the given population (Knudson, 2007). This helps identify an initial diagnosis, from which a specific course of action or intervention is determined. The process must always end with an assessment of the intervention carried out, which in turn involves measuring the effects of the intervention programs and making the corresponding decisions derived from this assessment. Measurement provides the information needed to design the best possible intervention strategy, and measurement also indicates to what extent this strategy has led to the desired results. Inadequate measurement of skills can lead to the acquisition and development of ineffective skills or a false sense of security (Di Paola, 2019), so validating the tools intended for skills verification is very important. From a scientific point of view, the validation of an instrument is a process that must be carried out to be able to recommend the use of a given measurement tool.

When developing aquatic competence tests, it is important to adapt these tests based on the age of the participants, making a clear identification of objectives that the children should acquire in each of these stages. In their report, De Martelaer and Soons (2014) established three different proposals to measure aquatic motor skills according to three different age groups: 6, 9, and 12 years old, where the distance of movements in the environment or the time spent in various horizontal or vertical positions increased based on age. This latter measuring instrument (De Martelaer & Soons, 2014) proposed skills in horizontal and vertical positions (displacements, floats, turns) to differentiate the competence in both positions. To this, entrance into the water through a jump was added, having aquatic security as a fundamental objective along with the measurement of the proposed skills. This gives a more holistic approach to measuring the overall motor development of the child. The authors of this paper are in favour of a broader measurement of aquatic competence, going beyond exclusively dealing with avoiding drowning as it gives an overall picture of skill acquisition in a stage when children are learning and also has an impact with regards to the transfer of skills from aquatic activities to others that they perform, thus favouring the integral development of the child.

This review has found that there is a shortage of validated measurement instruments to measure overall aquatic competence in infants and primary school. From this point of view, it would be interesting to continue to research the development and validation of instruments to measure aquatic competence, both at the elementary and primary stages, as well as in other ages, so that the teaching-learning process can be evaluated and optimised. Aquatic motor competence can be complemented with other specific instruments, such as the scale to measure perceived fear in the aquatic environment in children aged 3 to 6 years (Moreno-Murcia et al., 2020). This type of measurement can be a complement of great interest for measuring children's aquatic competence since it can provide valuable information regarding factors that may influence the actual aquatic competence itself.

CONCLUSION

The systematic review confirms that eight instruments have been developed and validated in recent years for measuring aquatic competence for children between 6 months and 14 years of age from a multipurpose perspective. These tools are designed to facilitate and improve teacher assessment, and determine children's perception of their own aquatic competence, both from the motor dimension and the emotional, social, cognitive, and communicative dimensions.

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