Original Article

Assessment of basic aquatic skills in children: inter-rater reliability of coaches, teachers, students and parents

TOBIAS VOGT^{1,2}, ILKA STAUB¹

¹German Sport University Cologne, Institute of Professional Sport Education and Sport Qualifications, GERMANY

²Waseda University, Faculty of Sport Sciences, JAPAN

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Abstract:

The process of learn-to-swim pursues the goal of comprehensive aquatic education. This results in extensive learning contents, even before a first in-water locomotion is possible. While there are different ways to quantify performance in swimming (e.g. time tracking), assessing basic aquatic skills solely refers to the teachers' or coaches' experience, if not gut instinct. Therefore, this study aimed to develop an easy-to-apply assessment tool that quantifies basic aquatic skills to help estimating the stages of development in children. To capture basic aquatic skills, 22 (pre)school children (non-swimmers) performed 19 developed consecutive tasks according to physical in-water characteristics. Performances were video recorded and rated by four peer groups (i.e., coaches, teachers, students, parents) using standardized evaluation sheets. Peers (total n=809) comprised different levels of swim teaching qualification and experience. Using the peer groups' ratings, inter-rater reliability was computed. Findings revealed that the presented easy-to-apply assessment of basic aquatic skills (ABAS) is reliable according to substantial agreement between the peer groups' ratings. Thus, ABAS has benefit for educational concepts and learning-to-swim classes.

KeyWords: Skill acquisition, Motoric development, Movement learning, Physical education, Learn-to-swim, Drowning prevention

Introduction

Within the process of learning to swim four stages have to be mastered for a comprehensive aquatic education. First and foremost, children have to get (1) familiarized with the element water. After passing this initial phase of habituation, (2) basic aquatic skills have to be learned. In concrete terms, this includes being able to fully submerge, learn a rhythmic and steady breathing pattern with the added pressure of water, being able to float prone and supine using buoyancy, glide with reduced drag and dive safely into the water (Bissig & Gröbli, 2004b; Rheker, 2011; Wilke & Daniel, 2007). Subsequently, it is possible to learn (3) elementary water locomotion (dsv-jugend, 2015). Based on a first unspecific locomotion in the water, the well-known (4) Olympic swimming techniques can then be learned. The comprehensive aquatic education leading to water literacy opens a wide range of aquatic sports and therefore, lifelong sport activities (Rheker, 2011). It is possible to learn a swimming technique without basic aquatic skills. However, such reduction minimizes other possible succeeding applications and, above all, restricts water safety (Brenner, Moran, Stallman, Gilchrist & McVan, 2006). To achieve a more inclusive drowning prevention, a wide range of motor and cognitive competencies is required as suggested in a recently published fundamental framework on water safety competencies (Stallman et al., 2017). While there are different ways to quantify performance in swimming (e.g. time tracking, measurement of energetics, biomechanical analyses), evaluating basic aquatic skills often refers to the teachers' or coaches' experience, if not their gut instinct.

The concept of testing basic motor skills is well developed (Cools, De Martelaer, Samaey & Andries, 2009). In addition to comprehensive literature on the construction of such procedures (Bös, 2017), numerous tests for different motor skills and age groups already exist (e.g. Hendersen, Sugden & Barnett, 2007; Herrmann, Gerlach & Seelig, 2015; Kiphard & Schilling, 2007; Zimmer & Volkamer, 1987). However, each of these tests only provides dry-land motor assessment. In the late 1970th, a first in-water assessment was found reliable to test swimming skills of preschool children using 90 consecutive tasks within 9 subcategories (i.e., jumping, locomotion front and back, breathing, kicking, diving, ring pick-up in shallow and deep water as well as orientation during underwater swimming; Erbaugh, 1978). To date and following on from this, many countries established their assessment and badge systems (i.e., German examination regulations are provided by DLRG; 2015); however, none has been tested for validity, objectivity or reliability to date (Bissig & Gröbli, 2004a; Lepore, Columba & Friedlander, 2015; Reischle, Buchner & Rudolph, 2011).

More importantly, other than assessing swimming skills, an instrument to measure basic aquatic skills before an initial locomotion in the water is even possible does not yet exist.

Therefore, this study aimed to develop an easy-to-apply assessment tool that quantifies the evaluation of basic aquatic skills to help swim teaching peers estimating different stages of development. Using the peers' evaluation, inter-rater reliability of basic aquatic skills have been tested, hypothesizing the assessment tool's reliability irrespective of the different swim teaching experiences in peers (i.e., coaches, teachers, students and parents).

Material & methods

Test battery

According to physical in-water characteristics, the test battery consists of 19 consecutive tasks (please refer to table 1 for details). Suitable for children, tasks were developed to assess basic aquatic skills (figure 1A) that referred to five levels of competency (LOC; figure 1B): (1) submerging by holding breath, (2) submerging with adapted exhalation, (3) floating with one additional skill, (4) floating with two additional skills and (5) jumping into the water. Each task was assigned to one or more levels of competency and could be rated as either passed or failed, referring to pre-defined evaluation criteria (table 1). Tasks were interlinked; however, succeeding in a previous task was not a precondition to possibly succeed in subsequent tasks.

Figure 1: Basic aquatic skills (A) and assigned test battery tasks (B; light to darker grey water drops, respectively), referring to in-water or dry-land levels of competency (LOC1-5).

Table 1: Test battery tasks including description and evaluation criteria to assess the level of competency in basic aquatic skills

No.	Name of the task	Description	Evaluation criteria	Basic aquatic skill(s)
1	Wash your face	Splash water in your face.	→ Allows water in the face. → Face is relaxed.	Submerge
2	Washbowl	Submerge your face fully into the water.	→ Face is submerged (hairline to chin).	Submerge
3	Blow your nose	Generate bubbles by exhaling through your nose and/or mouth.	→ Nose and/or mouth generate clear visible bubbles.	Submerge, breath
4	Diver	Fully submerge your body and head.	→ Whole body is fully submerged.	Submerge
5	Fisheye	Fully submerge and open your eyes under water.	→ Opening eyes under water with confidence/without struggling.	Submerge
6	Deep diver	Submerge and pick up a ring.	→ Picking up a ring from the ground. → Picking up a ring from the ground (by hand). → Without holding on to the edge.	Submerge
7	Whirlpool	Submerge and exhale as long as possible. Generate big bubbles.	→ Face is fully submerged (hairline to chin). → Bubbles are clearly visible by exhaling air through nose and/or mouth.	Submerge, breath
8	Air pump	Inhale for only a short period of time, then submerge to exhale for a long period of time and repeat.	→ Short inhale. → Long exhale (under water). → Clear visible bubbles are generated through nose and/or mouth.	Submerge, breath

9	Towboat	Hold on to the ring with both hands and stay calm with your face submerged while the instructor is dragging you through the water.	→ Arms are straight above the head and cover the ears (hands are together). → Face (hairline to chin) is submerged (lifting the head for breathing is accepted). → Able to float in a relaxed body position. → No visible driving motion of legs.	Submerge, float
10	Starfish	Float on the surface with your face into the water.	→ Floating on the surface. → Body is in a relaxed position.	Submerge, float
11	Screw	Float on your front (prone position) on the surface and try to turn without touching the ground.	→ Turns body from prone to supine and back to prone position. → In final prone position, face (hairline to chin) is submerged. → Remains relaxed and stable in final prone position.	Submerge, float
12	Catapult	Float on the surface with your face fully into the water. The instructor will push you. Stay calm in the floating position.	→ Face (hairline to chin) is submerged. → Remains relaxed after being pushed off by the instructor.	Submerge, float, glide
13	Torpedo	Push off the wall and glide calmly.	→ Pushes off the wall. → Face (hairline to chin) is submerged. → Glides relaxed without any driving motion by arms and/or legs.	Submerge, float, glide
14	Arrow on the back	Push off the wall and glide in a streamlined position on your back (supine position). Your head should lie in the water.	→ Pushes off the wall. → Body is in a streamlined position. → Back of the head (ears) is submerged. → Glides relaxed without driving motions.	Float, glide
15	Arrow on the front	Push off the wall and glide in a streamlined position on your front (prone position). Your face should lie in the water.	→ Pushes off the wall. → Arms are extended straight above the head. → Face (hairline to chin) is submerged. → Glides relaxed without driving motions.	Submerge, float, glide
16	Jump like a frog 1	Jump into shallow water.	→ The jump takes place without contact to the instructor. → The jump takes place without contact to the wall. → There is a jump-off visible.	Jump
17	Jump like a frog 2	Jump into deep water with help.	→ The jump takes place with help or contact by the instructor. → There is a jump-off visible.	Jump
18	Jump like a frog 3	Jump into deep water and swim back to the edge independently.	→ The jump takes place without help or contact by the instructor. → There is a jump-off visible. → Return to the edge takes place independently without contact to the skipped obstacle.	Jump
19	Jump like a penguin	Dive into the water.	→ The entry into the water has to be headfirst.	Jump

Participants and rating peers

All classified as non-swimmers, 22 children (6.95 ± 1.03 years, male $n = 12$, female $n = 10$) were recruited to voluntarily perform the developed tasks. Performances were video recorded from standardized frontal (above and under surface) as well as lateral perspectives, resulting in to-be rated task videos. Prior to each children's participation, the parent or guardian provided written informed consent and the study protocol had been approved by the German Sport University's Ethics Committee.

Pre-defined swim teaching peers that act or have acted as coaches, teachers, students and parents (total of 809 raters; please refer to table 2 for details) participated in an online survey to rate the task videos.

Coaches' experience ranged from learn-to-swim to national and international levels, including some coaching Olympic swim-athletes. Teachers teach or have taught physical education in German primary schools, including swim lessons. At the time of participating in the online survey, students were enrolled studying physical education or sport and exercise science aiming to become teachers, coaches, or both; however, the students' main sport was not exclusively swimming. Parents have or had at least one child in the respective learn-to-swim age, participating or having participated in learn-to-swim and, at least partly, advanced swimming

lessons with or without the respective parents observing these lessons. If applicable, rating peers were assigned to more than one peer group (e.g. teachers having children are also parents).

Each participant provided informed consent prior to entering the present study's online survey.

Table 2: Participants and peers

Peer	n(m, f)	Age (mean ± SD)	Education [%]		Experience [%]	
All	809 (m 243, f 566)	38.12 ± 12.02	HS:	36.46		
			UG:	8.65		
			G:	23.36		
			SE:	28.43		
			none:	3.09		
Coaches	440 (m 150, f 290)	39.45 ± 13.17	SE:	25.00	<i>Coaching degree</i>	
			G:	22.73	Elite A:	9.97
			UG:	8.86	Elite B:	22.29
			HS:	38.86	Elite-C:	47.51
			none:	4.55	Basic-B:	3.81
					Basic-C:	33.43
Teachers	205 (m 32, f 173)	42.49 ± 11.16	SE:	73.30	<i>Years taught swimming</i>	
			G:	12.68	< 6:	35.84
			UG:	3.90	6-10:	15.61
			HS:	8.29	11-15:	13.29
			none:	1.46	16-20:	17.92
					> 20:	17.34
Students	154 (m 59, f 95)	23.94 ± 5.13	SE:	2.60	<i>Perceived preparedness</i>	
			G:	5.84	+++:	26.09
			UG:	19.48	++:	39.13
			HS:	72.08	+::	26.09
			none:	0.00	-:	8.70
					--:	0.00
					---:	0.00
Parents	483 (m 122, f 361)	44.51 ± 8.87	SE:	34.58	<i>Children swimming</i>	
			G:	28.99	1:	24.84
			UG:	5.80	2:	54.87
			HS:	26.71	3:	16.56
			none:	3.93	4:	3.31
					> 4:	0.42

Participants (n) of each peer, including double entries, male (m) and female (f), with mean values ± standard deviation (SD) for age (in years), highest level of education (in %; SE = teachers' state examination or PhD, G = graduate master level, UG = undergraduate bachelor level, HS = high school, or none), and experience (in %; coaches: level of coaching degree; teachers: years of swim-teaching in schools; students: perceived preparedness ranging from 'very well = +++' to 'very poor = ---'; parents: number of children that participate or have participated in learn-to-swim lessons).

Data collection

The online survey was set up using a standard scientific online survey platform (QuestBack; www.unipark.com). Links were distributed to potential raters, including all Kindergartens (parents) and preschools (teachers) within Germany's federal state North Rhine-Westphalia, the German Sport University (students), the German swimming federation [Deutscher Schwimmverband] as well as all federal state swimming bases (coaches).

The online survey was accessible over a period of 12 weeks.

Statistical analysis

Statistical analyses were performed using IBM SPSS for windows (version 25.0). Interrater reliability (IRR) for swim teaching peers (i.e., coaches, teachers, students and parents) and basic aquatics skills (i.e., submerge, breath, float, glide; characterizing jumping tasks as dry-land motor skill, respective tasks were excluded from further analyses) was assessed using Krippendorff's α (K α ; Hayes & Krippendorff, 2007). K α serves as a reliability measure in larger numbers of raters while correctly handling missing data (Krippendorff, 2012; Shultz, Anderson, Matheson, Marcello & Besier, 2013; Zapf, Castell, Morawietz & Karch, 2016). IRR was accepted to indicate moderate (0.41-0.60) or substantial agreement (0.61-0.80; Hallgren, 2012; Landis & Koch, 1977).

Results

Inter-rater reliability

IRR over peers referring to combined basic aquatic skills indicate substantial agreement (over all peers K α = 0.63; over peer groups K α ≥ 0.62; table 3).

IRR over basic aquatic skills referring to all peers as well as to peer groups indicate moderate to substantial agreement (0.52 ≤ K α ≤ 0.71, except parents' rating for breath; table 4).

Table 3: IRR over peers

Peer	n	K α	low-up CI	F
All	809	0.63	0.52-0.73	0.31
Coaches	440	0.63	0.51-0.74	0.25
Teachers	205	0.65	0.54-0.74	0.18
Students	154	0.66	0.53-0.76	0.18
Parents	483	0.62	0.51-0.72	0.39

Inter-rater reliability (IRR) over all peers (all) as well as each respective peer group (i.e., coaches, teachers, students, parents) referring to combined basic aquatic skills with the valid numbers of raters (n, including double entries for coaches, teachers, students, parents), Krippendorff's alpha (K α), lower (low) and upper (up) limits of confidence intervals (CI, 95%) as well as error (F).

Table 4: IRR over basic aquatic skills

Skill	Peer	K α	low-up CI	F
Submerge	All	0.59	0.48-0.70	0.05
	Coaches	0.60	0.48-0.71	0.43
	Teachers	0.61	0.49-0.72	0.43
	Students	0.62	0.50-0.73	0.35
	Parents	0.58	0.46-0.69	0.08
Breath	All	0.53	0.41-0.64	0.35
	Coaches	0.53	0.40-0.64	0.33
	Teachers	0.52	0.39-0.63	0.36
	Students	0.55	0.38-0.71	0.25
	Parents	0.39	0.39-0.63	0.39
Float	All	0.61	0.51-0.72	0.38
	Coaches	0.62	0.51-0.73	0.34
	Teachers	0.64	0.53-0.73	0.23
	Students	0.63	0.52-0.74	0.26
	Parents	0.61	0.50-0.71	0.44
Glide	All	0.68	0.58-0.78	0.39
	Coaches	0.69	0.54-0.83	0.37
	Teachers	0.71	0.62-0.81	0.33
	Students	0.71	0.55-0.85	0.50
	Parents	0.67	0.57-0.77	0.45

Inter-rater reliability (IRR) over each defined basic aquatic skill (i.e., submerge, breath, float, glide) referring to all peers (all) and each respective peer group (i.e., coaches, teachers, students, parents) with Krippendorff's alpha (K α), lower (low) and upper (up) limits of confidence intervals (CI, 95%) as well as error (F).

Discussion

This study aimed for an easy-to-apply assessment tool that quantifies the evaluation of basic aquatic skills. The developed test battery tasks were verified computing inter-rater reliability in peer groups that have been identified as relevant swim teaching peers (i.e., coaches, teachers, students, parents).

Peer groups

When recruiting each peer group, individuals were defined upon having a direct or indirect impact on a learn-to-swim process and eventually swimming. Herein, the level of (swim teaching) education as well as the level of (swim teaching) experience have been considered as important factors in each peer group. Underlining evident differences in the peer groups' swim teaching qualification, coaches on the one end had received a well-founded qualification (i.e., licensed by the swimming federation), whereas experiences of rating parents on the other end referred primarily to accompanying their own child(ren) to swimming lessons or to having shared experiences with their child(ren) in the water. As recently reported, teachers and parents assessed differences in elementary school childrens' academic, artistic and (dry-land) athletic competencies (Racz et al., 2019). Accordingly, it seems reasonable to note that in the present study's findings the coaches (K α 0.63, licensed swim teaching qualification) as well as the parents (K α 0.62, accompanying swim teaching) revealed the lowest inter-rater reliability among all peers. With this, one may argue that the criteria to rate a presented task video may have been either under- (i.e., coaches) or over-classified (i.e., parents) with respect to each peer groups' swim teaching education or experience.

However, the present study's findings also revealed ratings of substantial agreement (Hallgren, 2012) not only in each peer group but also over all peers. Additionally, the present study serves previous suggestions to have e.g. skills and competences assessed by a large(r) variety of relevant peer groups (i.e., not only parents and teachers but also coaches and students in the present study) to result in a multi-informat approach (De Los Reyes et al., 2015; Racz et al., 2019).

Aquatic skills

The test objectives were based on the learning contents of the first two phases of aquatic education, addressing both the familiarisation with the water as well as basic aquatic skills. These basic aquatic skills of submerging, breathing, floating and gliding (jumping had been excluded as dry-land motor skill) were differentiated into consecutive tasks. Except the parents' rating for breathing (K α 0.39), all findings of the present study indicate moderate to substantial agreement over all peers as well as in each peer group rating basic

aquatic skills separately. With this, it seems reasonable to note that breathing as a separated basic aquatic skill has been rated rather inconsistent among the peer groups (lowest $K\alpha$ values). Previously suggested as a key element in a learn-to-swim process (American Red Cross, 2014), breathing is considered to be the most important and fundamental skill (Stallman et al., 2017). However, the importance of breathing in the process of learn-to-swim may be reversed with respect to its difficulty of detecting a correct (safe) exhalation under water; e.g. conscious calm exhalation under water challenges the accurate visual observation of bubbles on the surface of the water. Following this line of thought, the present study's findings further underline an importance to keep tackling this prominent difficulty in the future, in particular when being asked to rate a breathing skill without presumably being properly educated to do so. Consequently, this limitation needs to be considered before applying the suggested assessment of basic aquatic skills, possibly by (even more) carefully wording the respective breathing criteria.

Overall the present study's assessment of basic aquatic skills may be considered as reliable among peer groups with different swim teaching qualifications and experiences.

Conclusions

The presented tool may serve an easy-to-apply assessment of basic aquatic skills (ABAS), particularly in children. Used among swim teaching peers, a prior evaluation of essential stages of development within a comprehensive aquatic education not only tests basic aquatic skills but sustainably supports a first in-water locomotion to eventually achieve water competency (Stallman et al., 2017) and may lead to an aquatic literacy in the context of sports literacy (Hulteen et al., 2015; Pill, 2011).

Conflicts of interest -The authors declare that there are no conflicts of interest.

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