ORIGINAL ARTICLE

Validity and reliability of an assessment instrument of track start in swimming

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Abstract

Background and Study Aim The development and validation of assessment instruments are essential procedures for any professional intervention, including in physical education and sports contexts. This study aimed to provide a component-based assessment instrument for track start in swimming. It refers to the act of starting the competitive swim by diving into the water from a raised block (platform) at the edge of the pool.

Material and Methods The content validity involved the participation of sixty-three experienced swimming coaches. They completed a questionnaire about their degree of agreement (Likert scale) with the initial position, impulsion, flight, and entry into the water as the track start's components. Reliability and construct validity involved the participation of seven experienced swimming coaches. The first was verified through test-retest (intrarater) and reproducibility (interrater) procedures. The latter was tested by considering the instrument's ability to assess different track start performances.

Results The concordant answers (strongly agree and agree) ranged from 63% to 95%, with most components above 80%. The Intraclass Correlation Coefficients (ICC) results show from good to excellent interrater and intrarater reliabilities. Specifically, the interrater correlations in the test and intrarater correlations in track start 1 were revealed excellent. In addition, the interrater correlations in the retest and intrarater correlations in track start 2 were revealed good.

Conclusions The obtained validities and reliabilities made possible a component-based assessment instrument that allows: (i) a clear and standardized structure of track start in swimming involving the initial position, impulsion, flight, and entry into the water; (ii) accessing to the practitioners' states in relation to desired start performance; and (iii) a reference for coaches and teachers to provide instruction and feedback for learning and performance improvement.

Keywords: content validity, construct validity, sport of swim, types of starting, performance evaluation.

Introduction

In the last few years, the swimming start has increasingly been focus of concern for researchers, sports coaches and physical education teachers. It refers to the act of starting the competitive swim by diving into the water from a raised block (platform) at the edge of the pool. The basic function of the swimming start is to transfer the speed from diving to swim [1, 2]. Indeed, there seems to be some recognition that an efficient start implies a significant contribution to the reduction of the total time of the swim [2, 3, 4, 5].

Similar to the swimming styles (e.g., butterfly, backstroke, breaststroke, and front-crawl stroke), the start has evolved over time, the main ones being grab and track starts. Other ones (e.g., swing, handle, rear-weighted track, and front-weighted starts) have been conceived as variations of these two [6, 7, 8, 9]. Investigations on swimming start have been developed based on different concerns, mainly to understand the kinematic and kinetic variables of the foregoing start styles [6, 9, 10, 11]. For instance, studies have shown that (i) grab start involves greater flight displacement [12] and smaller reaction [13, 14] than track start; (ii) reduced block time depends on the increase in the vertical and horizontal velocities in the grab and track starts, respectively [15]; (iii) effective starts are related to the higher peaks of force [16, 17]; and (iv) training improves the peak horizontal force, velocity of take-off, and block and flight times [18, 19]. Currently, the track start has been seen as a more efficient than grab start [20].

This study sought to add to the existing body of knowledge about the biomechanical structure of swimming start by providing a component-based assessment instrument of track start. An important assumption here is that the movement

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behaviors of the interacting components need to be considered, not only because they are the ones that give rise to these previous biomechanical aspects [10], but also because they constitute the focus of instruction and feedback for learning and performance improvement. Although there is widespread recognition that swimming start unfolds by performing sequential components (e.g., phases), there has also been some distinction as to what they are and how they occur [21]. For example, while Maglischo [5] proposes that it involves preparatory position, pull, block impulsion, flight, entry, and slide, Matúš et al. [8] suggest the phases of block, flight, and underwater.

Over the last few years, several assessment instruments in swimming have been built and validated. For example, Madureira et al. [22] proposed an assessment instrument of beginners' front-crawl stroke efficiency that included ten component items (recovery and entrance; release; stroke synchronization; breathing; stroke and breathing synchronization; 6-downsweep, in-sweep, and upsweep; body positioning; kicking; kick and breathing synchronization; kick and stroke synchronization). On the other hand, Monteiro et al. [23] validated an assessment instrument of pedagogical knowledge in swimming, which comprised the task nature, practice schedule, and feedback regimes. Other instruments have been concerned mainly with children's aquatic readiness. This is the case of Erbaugh [24], who proposed an assessment instrument for the swimming performance of children aged between 2 and 6 years. This instrument comprised the following components: entry by jump; front and back locomotion; breathing; kicking; diving; ring pick-up and retrieval; and hoop obstacle course. In a similar vein, a recent study by Valentini et al. [25] published an instrument that evaluates the aquatic readiness (Aquatic Readiness Assessment - ARA) based on the following components: water orientation and adjustment, water entry, breath control, body position, arm propulsion action, arm recovery action, leg action, and combined movement. Although some of the foregoing instruments have considered entering the water through diving [e.g., 24, 26], to the best of our knowledge, they have focused on readiness, fundamental skills, or adaptation to the aquatic environment.

A component-based assessment instrument will contribute to swimming coaching/teaching processes by making possible: (i) a clear and standardized structure of motor skill (track start); (ii) the access to the practitioners' states in relation to desired start performance; (iii) insights for the elaboration of instructions and feedbacks; (iv) references for practitioners and coaches maintain or modify their expectancies and planning [27, 28, 29, 30].

Materials and Methods

Participants

The content validation involved the voluntary participation of sixty-three swimming coaches, with an average age of 43.3 years (± 12.9) and an average time of professional practice of 20.3 years (±13.0). The participants of the reliability and construct validation were seven swimming coaches, with an average age of 38.7 years (± 10.3) and an average time of professional practice of 17.7 years (± 8.1). Participation required the volunteers' written consent, and the experimental protocol was given ethical approval by the local Institutional Review Board.

Research Design

Regarding the content validity procedures, participants were invited to answer via a Google Forms link a questionnaire about the track start composed of two parts: (1) participants' characteristics without identification of name or any document number; (2) motor skill characteristics. Regarding the first, participants reported the date of birth; gender; time of professional practice with swimming; whether they worked with swimming in the health promotion, education, leisure, or competition dimensions (amateur or professional); whether they worked with babies, children, adolescents, adults, or elderly individuals; and if they worked in a club, academy, school, public agency, private company, or other.

The second part began with the following statement and instructions for filling out: "the track start is efficient when (mark X in the column that represents your degree of agreement)". Therefore, the participant was given the possibility to (i) totally disagree, (ii) disagree, (iii) neither agree nor disagree, (iv) agree, and (v) totally agree with the components of the track start related to the initial position, impulsion, flight, and entry into the water (Table 1). In this part, participant also had the opportunity to provide suggestions about the content or wording of the analysed item.

As for reliability and construct validity, participants were asked to rate two track swimming starts. To do this, they had to access a Google Forms link that contained two videos whose performances differed in relation to the performance errors. The videos were run at 25% of the real velocity. On the right side of the videos was the foregoing assessment instrument. Thus, participants were able to fill the instrument by recording "observed" or "not observed" for each component item while watching the videos. The performer was one of the experimenters who was an expert swimmer and coach who was not identified during performances.

To characterise a test-retest design, these procedures occurred twice with a time interval of one week and in reverse order. It allowed accessing

Table 1. Components of the track start swimming.

Item	Component
1	**INITIAL POSITION**
1.1	One foot pulls the front edge of the block with the toes, while the other supports the back with the front of the sole of the foot.
1.2	The knees are semi flexed
1.3	The trunk flexes over the thigh and the hip remains higher than the head
1.4	Hands grasp the front edge of the block, close to the side
1.5	The head is down
2	**IMPUSION**
2.1	The block is pushed back with the hands and feet so that the trunk, hip, and knee are extended.
2.2	Trunk moves forward accompanied by raising the head above the hips and looking forward
3	**FLIGHT**
3.1	The arms are extended forward so the head is between them; hands overlapping and pointing down
3.2	The legs, initially apart, are joined in an extended position with the feet in plantar flexion.
3.3	There is alignment of the hips with the head and arms, which may be followed by a pike position
4	**ENTRY INTO WATER**
4.1	The overlapping hands enter the water with the elbows extended; the head is between the arms
4.2	The rest of the body enters the water aligned in the same place as the hands
4.3	Feet remain in plantar flexion and legs together and knees extended
4.4	There is hyperextension of the trunk after entering the water

the reliability of the assessment by the same evaluator (test-retest intrarater reliability) and the reproducibility of the evaluation by different evaluators (objectivity or interrater reliability) [31].

Statistical Analysis

Content validity was analysed considering the relative frequency of occurrences of each level of agreement in each assessment item. Concerning the reliability and construct validity, although for single checklist items the Fleiss' Kappa reliability test [17, 32] could be used, we are interested in evaluating the track start performance by considering each component (initial position, impulsion, flight, and entry into water), and how reliable the results could be for multiple raters (evaluators). For this purpose, each component was considered in terms of the number of observed items and subsequently analysed through Intraclass Correlation Coefficients (ICC). In this case, ICC2k (average random raters) was run to verify the interrater reliability, and ICC3k (average fixed raters) was used to analyse the intrarater reliability [33, 34, 35, 36]. These statistical procedures allow us to infer the following categorical levels of correlation [37]: poor = less than 0.5; moderate = between 0.5 and 0.75; good = 0.75 and 0.9; and excellent = greater than 0.90.

Finally, construct validity was tested considering the instrument's ability to assess different performances [31, 38, 39, 40]. For this purpose, the number of observed items was considered the dependent variable in relation to each component and the overall performance of the track start (sum of all observed items). Since the swimming start results from the sequential interaction between four components (initial position, impulse, flight, entry into water), each component was also analysed considering a weight of 25% through the following calculation: C% = (Nio x 25) ÷Ni, where C refers to the component, Nio is the number of observed items, and Ni is the number of items. This procedure allowed accessing each component in terms of relative performance to global performance (100%), in addition to providing subsidies for proposing performance categories (e.g., poor, moderate, good, and excellent). A multivariate analysis of variance (MANOVA) was run to compare starts (1 and 2) x performances (initial position, impulsion, flight, entry into water, and overall) in both measures. The observed significant effects were followed up using $Tukey_{HSD}$ test.

Results

Content validity

Regarding the participants' characteristics, Table 2 shows that most of them (63%) worked with swimming combining health with education, leisure, and competition. It is also possible to note that a significant part of them (81%) worked with babies, children, adolescents, adults, and elderly individuals, with the main places of work being clubs and gyms (65%).

Table 2. Relative frequency of responses related to the swimming professionals' characteristics.

Item	**(%)**
Swimming dimensions	
Health	6
Education	5
Leisure	5
Competition	16
Health + others	63
Education + others	5
Athletes/Students	
Adolescents	6
Adults	13
Babies, Children, Adolescents, Adults, and Elderly	81
Local	
Private Company	10
Public agency	19
Personal trainer	5
School	2
Club and Academy	65

Table 3 presents the relative frequency of responses in each agreement level and track start component. It shows that "I totally disagree" obtained below 5% of the answers and that "I disagree" was below 10%, except for component 3.3, which obtained 13%. The frequencies obtained in relation to neutrality were also low, ranging from 2% to 22%. The highest relative frequencies of responses were observed in "strongly agree", which ranged from 32% to 65%. In turn, the relative frequencies of "agree" ranged from 25% to 37%. When considering the sum of discordant answers (strongly disagree and disagree) and concordant answers (strongly agree and agree), a significant relative frequency is observed in the latter. These frequencies ranged from 63% to 95%, with most components above 80%. It is interesting to note that component 3.3 was once again highlighted with a value of 63%, which was one of the comments made.

Regarding the comments, they were related to the following components: 1.1 (*support foot between the hands*); 1.2 (*knees close together, hips pointing up and head down*); 1.5 (*head between arms*); 3.3 (*not necessarily pike position*); 4.2 (*where the hands enter the rest of the body. Keep your legs together and extended. Keep the body in streamlined position after entering the water [this is the end of the exit!]*).

The analysis of these comments in conjunction with the percentage results made it possible to verify that they were already clearly included in the instrument. Regarding the item 3.3, it was modified to: "there is alignment of the hips with the head and arms, which may involve the pike position". In addition, item 2.2 was changed to: "the trunk moves forward accompanied by the elevation of the head and looking forward".

Reliability and construct validity

The ICC results show significant interrater and intrarater reliabilities (Table 4). Specifically, the interrater correlations in the test and intrarater

Table 3. Relative frequency (%) of responses at each level of agreement (strongly disagree; disagree; neither agree nor disagree; agree; and strongly agree) in each component of the track start.

Component	**Strongly disagree (%)**	**Disagree (%)**	**Neither agree nor disagree (%)**	**Agree (%)**	**Strongly agree (%)**	**Total disagreement (%)**	**Total Neutral (%)**	**Total agreement (%)**
1.1	3	5	6	30	56	8	6	86
1.2	2	3	3	35	57	5	3	92
1.3	2	6	6	32	54	8	6	86
1.4	3	5	17	35	40	8	17	75
1.5	2	3	11	37	48	5	11	84
2.1	3	10	6	37	44	13	6	81
2.2	5	8	17	35	35	13	17	70
3.1	2	6	8	37	48	8	8	84
3.2	0	6	19	25	49	6	19	75
3.3	2	13	22	32	32	14	22	63
4.1	2	0	3	33	62	2	3	95
4.2	2	0	3	30	65	2	3	95
4.3	2	6	2	32	59	8	2	90
4.4	3	0	17	38	41	3	17	79

correlations in track start 1 were revealed excellent. In addition, the interrater correlations in the retest and intrarater correlations in track start 2 were revealed good.

Regarding construct validity, MANOVA revealed significant effects for starts [Wilks' Lambda = 0.19, $F(4; 9) = 9.57$, $p = 0.002$, $\eta p^2 = 0.81$, observed power = 0.98]. The TukeyHSD test showed differences in the initial position ($p = 0.0001$) and overall performance ($p = 0.025$).

Discussion

How efficiently do swimmers perform the start? This is one of the questions often made by coaches to select practice tasks and provide feedback for improving swimming start performance. Notwithstanding the importance of this motor skill, swimming coaches have carried out assessments through nonsystematic observation based on criteria with subjective individual scales built based on common knowledge.

One could say that the validation of an instrument is a complex process as it involves several aspects, from the collection of information taken as true in the professional practice and/or academic environment (e.g., what and how to measure) to its experimental verification of the construct and reliability [41, 42]. This study first developed a content validation by reaching a significant level of relevance to and representativeness of the components of the assessment instrument of track start in swimming [38].

Some aspects were important for that: first, the study sampling allowed robustness to the findings because of its significant size (N = 63). Similar studies on the validation of assessment instruments, including in other sports, have used a significantly smaller sample size [22, 23, 25, 40, 43]. In addition, the robustness was also strengthened by the long and diversified professional experience. It is known that coaches keep building their knowledge about task requirements (e.g., sports of swimming) during their professional practices [30, 44, 45, 46]. As revealed in the method, the participating coaches had an average time of professional practice of 20.3 years and worked with swimming combining health with education, leisure, and competition purposes.

Second, there was significant agreement between the coaches in relation to the instrument's component items. One could say that the content validation has been completed through correction of those few items with low agreement and that had some suggestions for changes. Items 2.2 and 3.3 were modified to "the trunk moves forward accompanied by the elevation of the head and looking forward" and "there is alignment of the hips with the head and arms, which may involve the pike position", respectively.

Once the instrument structure was consolidated, it needed to pass a reliability check, that is, to determine if it could be used by the same and different evaluators. Acceptable agreement allows us to conclude that observed differences did not occur due to the way an evaluator applied the assessment instrument [47]. In this regard, good to excellent correlation values were found, which means that the assessment instrument of track start in swimming was able to be used for the same and different evaluators. These findings corroborate those from studies validating assessment instruments in swimming [22, 23, 24, 25].

Finally, construct validity was assessed as the degree to which an assessment instrument measured the targeted construct [38, 47]. It was made by analysing different performances, namely, *start 1* (superior performance) and *start 2* (inferior performance). The results revealed that these performances reached 57.9% and 34.0% of the optimal performance (100%), respectively. Therefore, the assessment instrument of track start made possible access to different performances. In addition, the instrument allowed us to identify that *starts1* and *2* differed significantly in relation to the initial position.

The analysis of the components in relative terms also makes it possible to identify the contribution of each one (25%) to the overall performance. From this, it is possible to infer the development of each one. For example, based on Figure 1, it could be said that the component of start 1 with the most need of instructional focus is the entry into the water, which has a score of 8.9%, that is, approximately 1/3 of the possible performance.

Finally, although most descriptions of the swimming start include sliding after entering the water, this was not considered in the present study. That is because this would no longer be part of the start, but rather the underwater

Table 4. Results of Intraclass Correlation Coefficients (ICC) for interrater and intrarater reliabilities.

Test	ICC	*F*	df1	df2	*p*	Lower bound	Upper bound
Interrater: test	0.91	12.00	3	39	< 0.01	0.71	0.99
Interrater: retest	0.89	11.90	3	39	< 0.01	0.66	0.99
Intrarater: start 1	0.97	32.00	3	39	< 0.01	0.89	1.00
Intrarater: start 2	0.81	5.40	3	39	< 0.01	0.35	0.99

displacement. A recent study by Gonjo and Olstad [21] showed that there is no consensus on the start components, especially sliding. They point out that the underwater displacement through dolphins' movements decharacterises the start motor skill to characterize a form of underwater swimming.

Conclusions

The obtained validities and reliabilities made possible a component-based assessment instrument (Table 5) that allows: (i) a clear and standardized structure of track start in swimming involving the initial position, impulsion, flight, and entry

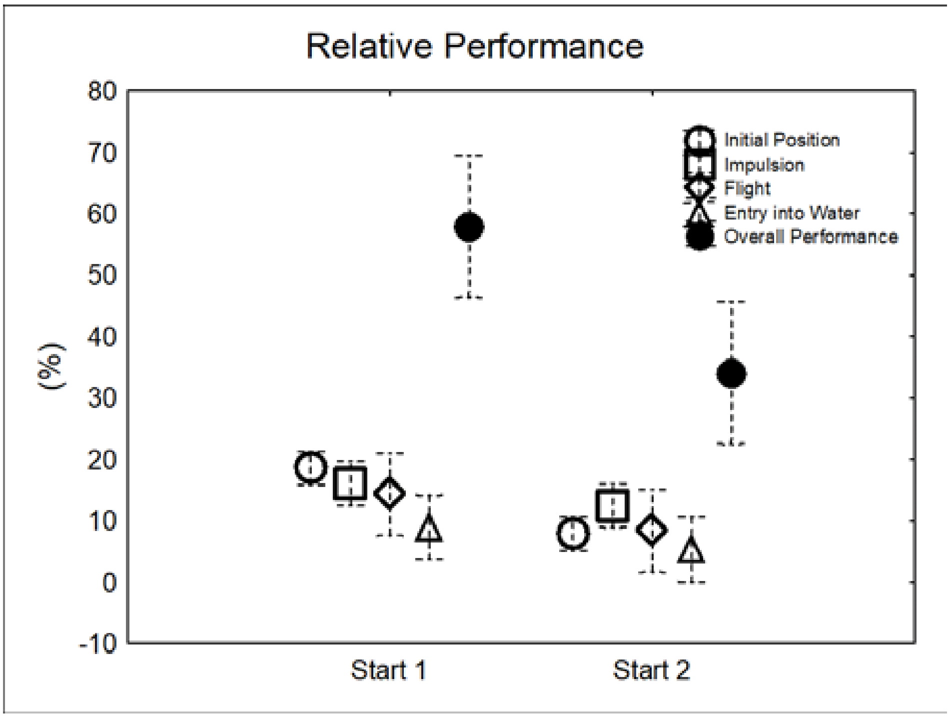

Figure 1. Relative performances of initial position, impulsion, flight, entry into water, and overall performance in track starts 1 and 2.

Table 5. Assessment Instrument of Track Start in Swimming.

Item	Component
1	**INITIAL POSITION**
1.1	One foot pulls the front edge of the block with the toes, while the other supports the back with the front of the sole of the foot.
1.2	The knees are semi flexed
1.3	The trunk flexes over the thigh and the hip remains higher than the head
1.4	Hands grasp the front edge of the block, close to the side
1.5	The head is down
2	**IMPUSION**
2.1	The block is pushed back with the hands and feet so that the trunk, hip, and knee are extended.
2.2	The trunk moves forward accompanied by the elevation of the head and looking forward
3	**FLIGHT**
3.1	The arms are extended forward so the head is between them; hands overlapping and pointing down
3.2	The legs, initially apart, are joined in an extended position with the feet in plantar flexion.
3.3	There is alignment of the hips with the head and arms, which may involve the pike position
4	**ENTRY INTO WATER**
4.1	The overlapping hands enter the water with the elbows extended; the head is between the arms
4.2	The rest of the body enters the water aligned in the same place as the hands
4.3	Feet remain in plantar flexion and legs together and knees extended
4.4	There is hyperextension of the trunk after entering the water

into the water; (ii) accessing to the practitioners' states in relation to desired start performance; and (iii) a reference for coaches and teachers to provide instruction and feedback for learning and performance improvement.

Conflict of interest

No potential conflict of interest was reported by the authors.

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