







Systematic observation in the technical evaluation of canoe paddling: design of an observational tool

La observación sistemática en la evaluación técnica del paleo en canoa: diseño de una herramienta observacional

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Abstract

Technical precision during the paddling gesture is a fundamental element for sports performance in canoeing. Therefore, its evaluation and analysis are a primary objective for athletes in this discipline. Given the scarcity of existing instruments to explore this technical gesture, the objective of the present study was to design and validate an observation tool to evaluate the canoe paddling technique in canoeing, specifically in the canoe modality. The tool was designed *ad hoc* using a mixed system of field format and exhaustive and mutually exclusive category systems. The tool consists of 20 criteria and 56 categories and was validated based on the visualization of the training of three male and three female paddlers of the Real Círculo de Labradores de Sevilla (Spain) during the 2021-2022 season. The results of the Data Quality and Generalizability analysis showed high correlation and inter- and intra-observer concordance indexes, both being close to 1 and higher than 0.85. In addition, the results obtained in the Generalizability analysis were also adequate, resulting in relative G and absolute G coefficients with values above 0.81. The study suggests that the observational tool developed is suitable to evaluate the canoe paddling technique.

Keywords: observational methodology; data quality; generalizability; canoeing.

Resumen

La precisión técnica durante el gesto de paleo es un elemento fundamental para el rendimiento deportivo en piragüismo. Por ello, su evaluación y análisis es un objetivo primordial para los deportistas en esta disciplina. Dada la escasez de instrumentos existentes para explorar este gesto técnico, el objetivo del presente estudio fue diseñar y validar una herramienta de observación para evaluar la técnica de paleo en piragüismo, específicamente en la modalidad de canoa. La herramienta fue diseñada *ad hoc* mediante un sistema mixto de formato de campo y sistemas de categorías exhaustivas y mutuamente excluyentes. La herramienta consta de 20 criterios y 56 categorías y fue validada a partir de la visualización del entrenamiento de tres palistas masculinos y tres femeninos del Real Círculo de Labradores de Sevilla (España) durante la temporada 2021-2022. Los resultados del análisis de la Calidad del Dato y de Generalizabilidad realizados mostraron elevados índices de correlación y concordancia inter e intraobservador, siendo en ambas próximos a 1 y superior a 0.85. Además, los resultados obtenidos en el análisis de Generalizabilidad fueron también adecuados, resultando unos coeficientes G relativo y G absoluto con valores superiores a 0.81. El estudio sugiere que la herramienta de observación desarrollada es adecuada para evaluar la técnica de paleo en canoa.

Palabras clave: metodología observacional; calidad del dato; generalizabilidad; canoa.

Introduction

Canoeing is a discipline with a great tradition, although it represents a minority sport that does not have much media repercussion beyond major sporting events such as the Olympics (Guevara-Pérez et al., 2022). Therefore, although it is a sport that requires great physical, psychological and technical preparation (Vives-Ribó & Costa-Sánchez, 2022) it has not received excessive attention from researchers. Although the existing literature provides information and strategies to improve the preparation of these athletes (e.g., Gavala-González et al., 2019; Guevara-Pérez et al., 2022; Liu et al., 2020), there is not such a large body of knowledge as in other sports such as soccer, basketball or handball. Moreover, if there is a need to consult scientific evidence on specific aspects, such as paleo technique, this paucity of publications makes the task even more difficult.

The technique in canoeing has a high importance for performance in this sport discipline, which has been the subject of study in previous research (Tilden et al., 2021). Thus, the analysis of the paddling in this sport requires a deep quantitative and qualitative analysis that identifies the different aspects that make it up, such as the aerial phase, traction or underwater (Alacid, 2009). Technical development in canoeing requires great precision, which must be employed at times when the athlete is making a great effort (Messias et al., 2014), which adds a greater degree of difficulty to their technical performance. In fact, an adequate development of the paddling technique allows a more efficient propulsion of the boat and greater control of its trajectory, decreasing the time spent to travel the required distance and increasing the chances of performing better (Messias et al., 2021; Wakeling et al., 2022).

Among the strategies to accurately analyze sport behavior, Observational Methodology (OM) is one of the most appropriate; therefore, when faced with the need to explore the technique of canoe paddling, it is advisable to approach it. In fact, the use of OM has made an exceptional contribution to scientific research in the field of physical activity and sport (Vázquez-Diz et al., 2019) and is considered the most suitable for the study of the behaviors of athletes in their usual context, competition (Anguera & Hernández-Mendo, 2013, 2014). In its scientific procedure, highly flexible and rigorous, it studies the perceptible behaviors directly and/or indirectly occurring in their natural context (Anguera & Hernández-Mendo, 2013, 2014, 2015). And it can be considered a Mixed Method in itself, since it includes a first qualitative phase that, after obtaining parameters from observational records, is transformed into a quantitative phase (Anguera & Hernández-Mendo, 2014, 2016).

The notable impact of OM in sports science research and the progress of computer programs (Sánchez-Izquierdo et al., 2021) facilitate the design and validation of ad hoc observation tools; examples can be found in individual, combat or team sports for both technical and tactical analysis of the game. Examples of this are the studies on the evaluation of trotting posture in dressage (Morillo-Baro et al., 2022), the analysis of behaviors in judo (García-Heredia et al., 2019) or the studies conducted in futsal (Morcillo et al., 2019; Vázquez-Diz et al., 2022), basketball (Pastrana-Brincones et al., 2021), handball (Jiménez-Salas & Hernández-Mendo, 2016; Quiñones et al., 2019), soccer (Morillo-Baro et al., 2021) rugby (Villarejo et al., 2014) and water polo (Santos et al., 2014) among others.

However, there is hardly any scientific evidence that has analyzed biomechanical and technical elements in canoeing. Only a few works have shown studies on technique, but from different approaches and disciplines, such as those carried out by Alacid et al. (2005) on child kayakers, Caubet (1999) on the study of the kinematic parameters of the technique in canoeing or those of Alacid (2009) and Cárceles (2009) on the analysis of the technique of canoeing in still water. However, in canoeing, no studies have been found that present systematic observation tools with the aim of coding the technical gesture of paddling, which represents an important gap and its development is considered of interest. There are studies that highlight the most relevant aspects to be taken into account when analyzing this movement (Valcarce & Gómez, 2005; Gavala, 2020a, 2020b), which generates an adequate theoretical support on which to design an exhaustive instrument to observe this technical gesture.

Given the existence of a sufficient theoretical basis on which to propose the design of a tool to observe the technique of canoe paddling, and due to the importance of this skill in the development of the competition, it is proposed to develop

a tool that allows its observation. In addition, taking into account previous research that has highlighted how OM can solve the need to provide instruments through which to explore technical aspects in other sports, it is suggested that this type of procedure could help to advance technical knowledge in this sport. Therefore, the objectives of the present work were, firstly, to design an observational tool for canoe technique, which would allow coding the different parts of the technical gesture and serve as an evaluation tool for coaches in their process of improving sport performance. Also, to ensure that the tool was valid and reliable, providing data that could be generalizable, it was proposed to carry out analyses of the quality of the data obtained and generalizability analysis.

Materials and Methods

The design of this study is punctual, nomothetic and multidimensional (P/N/M), so it is located in quadrant III of the observational designs proposed by Anguera et al. (2011). Coding was carried out in an "empirical-inductive" manner and an observational tool was constructed using a mixed system of field format and exhaustive and mutually exclusive category systems (Anguera et al., 2011).

Participants

To perform the data quality and generalizability analyses, the paddling technique of canoeists from the Real Círculo de Labradores de Sevilla team (2021) was observed. Specifically, the actions of 6 different paddlers were recorded, 3 men and 3 women of the under 18 and adult categories. All of them with a high level of performance, a minimum experience of 5 years in the sport and having participated in national or international competition.

Instruments

To conduct this research, an observation tool was designed *ad hoc*, using a combination of field format and exhaustive and mutually exclusive category systems (Anguera & Hernández-Mendo, 2013). The tool is constituted by 20 criteria and 56 categories, which correspond to the complete motor action of the shoveling gesture (Valcarce & Gómez, 2005; Gavala, 2020a, 2020b). Chronologically, it begins with the aquatic phase, which refers to the moment when the paddle comes into contact with the water, and concludes when the paddle leaves the water and ceases to have contact with it. The objective of this phase is to obtain sufficient momentum to move the boat, which requires the technical gesture to be precise and efficient.

This phase is divided into three sub-phases: (a) attack, (b) pull and (c) output. Attack begins when the blade first touches the water and ends when the blade is completely in the water. The pull begins when the paddle blade is completely submerged and moves into the water from a position distant from the athlete until the paddle exceeds the canoeist's steering leg. The exit begins when the paddle has finished the traction phase and is ready to exit the water in an upright position in order to start the paddling cycle again and obtain new propulsive force to move the canoe (Figure 1).

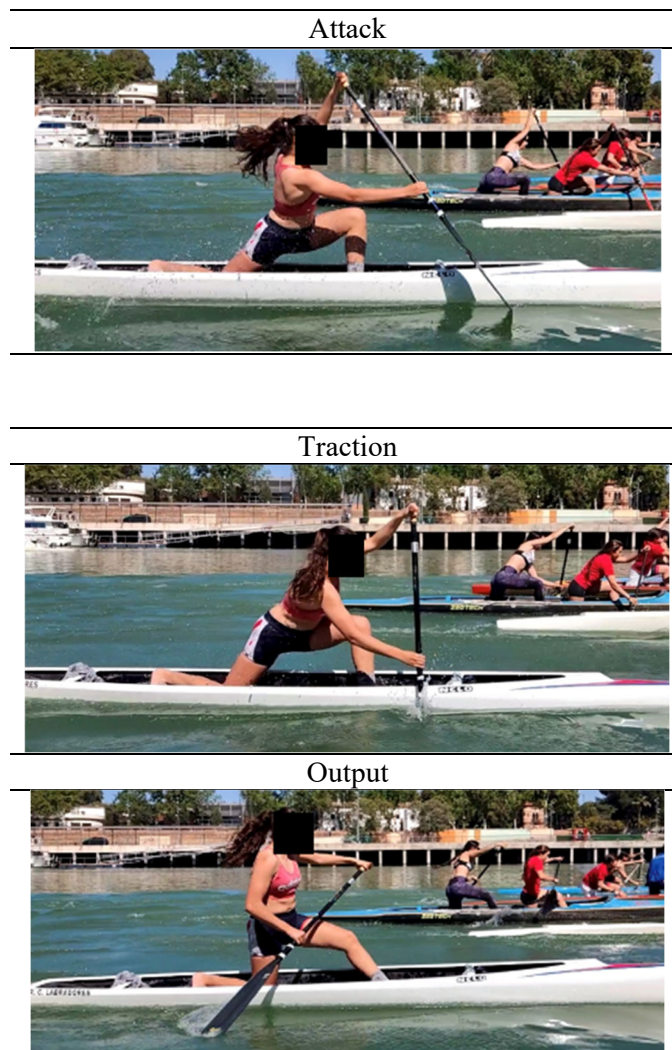


Figure 1. Example of the three subphases of the aquatic phase: attack, traction and output.

Table 1 shows the criteria of the proposed observation tool and the categories that make up each one of them:

Table 1. List of categories corresponding to each criterion and coding system.

Subphase	Segments	Criteria	Categories	Code
Attack	Governing arm in attack	1. Elbow angle	<90	AGA89
			90-135	AGA90
			>135	AGA135
	Trailing arm in attack	2. Angle with respect to the trunk	< 0	AGT-
			0 a 45	AGT+
			>45	AGT++
	Trailing arm in attack	3. Elbow angle	<90	AAA89
			90-135	AAA90
			>135	AAA135
	Trunk in attack	4. Position	Parallel to the water	AAP
			Non-parallel	AAPN
			Yes	ATR
	Government leg in attack	5. Rotation	No	ATRN
			<0	ATA-
0			ATA0	
Support leg in attack	6. Angle with respect to the support knee	>0	ATA+	
		<90	APG89	
		90	APG90	
Support leg in attack	7. Knee angle	>90	APG91	
		<90	APA89	
		90	APA90	
Support leg in attack	8. Knee angle	>90	APA91	
		<90	TGA89	
		90-135	TGA90	
Steering arm in traction	9. Elbow angle	>135	TGA135	
		<0	TGT-	
		0 a 45	TGT+	
Traction trailing arm in traction	10. Angle with respect to the trunk	>45	TGT++	
		<90	TAA89	
		90-135	TAA90	
Trunk in traction	11. Elbow angle	>135	TAA135	
		Yes	TTR	
		No	TTRN	
Steering leg in traction	12. Rotation	<90	TPG89	
		90	TPG90	
		>90	TPG91	
Support leg in traction	13. Knee angle	<90	TPA89	
		90	TPA90	
		>90	TPA91	
Outgoing steering arm	14. Knee Angle	<90	SGA89	
		90-135	SGA90	
		>135	SGA135	
Trailing arm at outlet	15. Elbow angle	Yes	SGV	
		No	SGVN	
		<90	SAA89	
Outgoing trunk	16. Cuff height view	90-135	SAA90	
		>135	SAA135	
		<0	STA-	
Steering leg at outlet	17. Elbow angle	0	STA0	
		>0	STA+	
		<90	SPG89	
Support leg on exit	18. Angle of the trunk with respect to the knee support	90	SPG90	
		>90	SPG91	
		<90	SPA89	
Support leg on exit	19. Knee angle	90	SPA90	
		>90	SPA91	
		>90	SPA91	

The criteria that make up the tool are ordered by the different segments that can be evaluated within each subphase. Thus, it is considered interesting to analyze the steering arm, trailing arm, trunk, steering leg and support leg. In turn, each of them may be composed of one or more criteria for further study.

The attack subphase was composed of criteria one through eight. The first criterion refers to the angle of the elbow of the steering arm, i.e., the angle formed by the two segments of the upper arm in the attack. There are three categories: an angle less than 90 degrees (AGA89), an angle between 90 and 135 degrees (AGA90) and an angle greater than 135 degrees (AGA135). The second criterion refers to the angle formed by the arm with respect to the trunk in the attack. Assuming that the trunk line is 0, the arm to the left of this line will be negative angles (AGT-) and to the right will be positive, dividing into two other categories, from 0 to 45 degrees (AGT+) and more than 45 degrees (AGT++). The third criterion is the angle of the trailing arm elbow in the attack. There are three categories: an angle less than 90 degrees (AAA89), an angle between 90 to 135 degrees (AAA90) and angle greater than 135 degrees (AAA135). The fourth criterion is the relative position of the trailing arm with respect to the water. It is differentiated whether it is parallel or not parallel to the water surface (AAP and AAPN respectively). The fifth criterion is the existence or not of trunk rotation in the attack, giving rise to the two categories ATR and ATRN respectively. The sixth criterion is the angle formed by the trunk with respect to the supporting knee during the attack. Assuming that the line of the supporting leg is 0, the trunk to the left of this line will be negative angles (ATA-), right on the line will be 0 degrees (ATA0) and to the right will be positive, more than 0 degrees (ATA+). The seventh and eighth criteria correspond to the knee angles of the steering leg and the supporting leg respectively. Three categories fall into each of the criteria: an angle less than 90 degrees, an angle exactly 90 degrees and an angle greater than 90 degrees.

The traction subphase was composed of six criteria, from 9 to 14. The ninth criterion, and where the traction phase begins, is the angle of the steering arm elbow, i.e. the angle formed by the two segments of the upper arm in traction. Three categories are defined: an angle less than 90 degrees (TGA89), an angle between 90 and 135 degrees (TGA90) and an angle greater than 135 degrees (TGA135). The tenth criterion is the angle of the steering arm relative to the trunk in traction. Assuming that the trunk line is 0, the arm to the left of this line will be negative angles (TGT-) and to the right will be positive, dividing into two other categories, from 0 to 45 degrees (TGT+) and more than 45 degrees (TGT++). Criterion number 11 is the angle of the trailing arm elbow in traction. It is also divided into three categories: an angle less than 90 degrees (TAA89), an angle between 90 to 135 degrees (TAA90) and an angle greater than 135 degrees (TAA135). Criterion number 12 defines the existence or not of trunk rotation in traction, giving rise to the two categories TTR and TTRN respectively. Number 13 and 14 are the knee angles of the steering leg and the supporting leg in traction respectively. There are also three categories in each of the criteria: an angle less than 90 degrees, an angle exactly 90 and angle greater than 90 degrees.

The output subphase was composed of six criteria, from fifteen to twenty. Criterion number 15 establishes the start of the exit subphase, and is the angle of the elbow of the steering arm in this subphase; that is, the angle formed by the two segments of the upper arm at the exit. As in previous criteria, three categories are also defined: an angle less than 90 degrees (SGA89), an angle between 90 to 135 degrees (SGA90) and angle greater than 135 degrees (SGA135). Criterion number 16 refers to the relative position of the steering arm handle, i.e., whether it is at the height of the line of sight. It is divided into two categories: if it is in the correct position (SGV) or if it is not (SGVN). Criterion number 17 establishes the angle of the trailing arm elbow at the start. Three categories define it: an angle less than 90 degrees (SAA89), an angle between 90 to 135 degrees (SAA90) and an angle greater than 135 degrees (SAA135). Criterion number 18 defines the angle of the trunk with respect to the supporting knee. Assuming that the line of the supporting leg is 0, the trunk to the left of this line will be negative angles (STA-), right on the line will be 0 degrees (STA0) and to the right will be positive, more than 0 degrees (STA+). Criteria 19 and 20 are those concerning the knee angles of the steering leg and the supporting leg respectively in this subphase. Three categories are distinguished in each of the criteria: an angle less than 90 degrees, an angle exactly 90 degrees and an angle greater than 90 degrees.

Overall, the criteria and categories were defined by a categorical core and its level of plasticity or degree of openness (Anguera, 1990).

Procedure

To carry out the study, the researchers contacted the Real Círculo de Labradores de Sevilla to request the participation of its canoeing section. After obtaining the required permission, informed consent was requested from the athletes to take part in the research and to cede the images taken for research purposes. Likewise, the guidelines of the Declaration of Helsinki and the Belmont Report were respected at all times.

After collecting the data, as in similar studies, it is necessary for the observer to have the necessary assurance about its recording (Sánchez-Izquierdo et al., 2021; Morillo-Baro et al., 2021). For this purpose, the consensus concordance (Anguera, 1990) has been used as a qualitative perspective; and from a quantitative point of view by obtaining the different correlation coefficients of Pearson, Spearman and Kendall's Tau-B. In addition, Cohen's Kappa index was used to calculate the concordance index. The HOISAN computer software (Hernández-Mendo et al., 2012) was used to perform all these analyses.

Agreements were established between the observers (experts in this sport discipline) at the time of recording and they were trained until it was considered that they had a good control of the tool to record the data. The interobserver reliability was calculated with the data of a session recorded by two observers, in the same way as in studies developed with the OM (e.g. Sabarit et al., 2022); then one of the observers recorded the data of the technique of one of the paddlers, after fifteen days the same observation was recorded again and the results of the intraobserver concordance were obtained. The recordings of the technical executions were made from a lateral plane.

Once this step of the research was completed, the Generalizability analysis was performed using the SAGT computer software (Hernández-Mendo et al., 2012, 2016) to determine the intra- and inter-observer reliability, determine the homogeneity of the categories (validity) and carry out a decision study on the sample size with the aim of being able to generalize accurately. These analyses complement the Data Quality analyses.

Data analysis

The HOISAN software (Hernández-Mendo et al., 2012) was used for coding and recording the observations, as well as for carrying out the different correlations necessary to evaluate the quality of the data. The SAGT v1.0 computer software (Hernández-Mendo et al., 2012, 2016) was used to perform the Generalizability analysis, to determine the interobserver and intraobserver agreement, and to assess the homogeneity of the categories in order to finally determine the minimum number of sessions to be visualized to generalize accurately.

Results

Data Quality Analysis

The results of the calculation of the different correlation coefficients and concordance index are shown in Table 2.

Table 2. Data quality analysis: correlation coefficients and concordance index.

Correlation coefficients		
Coefficient	Intra observer	Inter observer
Pearson	0.92	0.82
Sperman	0.88	0.84
Tau de kendall	0.91	0.88
Matching index		
Index	Intraobserver	Interobserver
Kappa de cohen	0.87	0.82

As can be seen, the value of the correlation coefficients and Cohen's Kappa index for this research exceed 0.80 for both intraobserver reliability (0.87) and interobserver reliability (0.82). Due to these results, high reliability is considered to exist, according to the values proposed by Gelfand and Hartmann (1975) and Landis and Koch (1977).

Generalizability Analysis

To determine intraobserver and interobserver reliability, a two-facet design, categories and observers (C/O), was used. The results of the intraobserver reliability analysis indicate that almost all the variability is associated with the categories facet (91.41%), with 0% for the observers' facet and 8.58% for the interaction of the categories/observers facets. The generalizability coefficients in this design structure determine results of 0.95, both for the relative G coefficient and for the absolute G coefficient, which are excellent results. For the determination of interobserver reliability, the results indicate that almost all the variability is associated with the categories facet (84.67%), with 0% for the observers' facet and 15.32% for the interaction of the categories/observers facets. The result obtained for both generalizability coefficients, relative G and absolute G, is 0.91, which is equally adequate.

To estimate the homogeneity of the categories, a two-facet crossover design, observers and categories (O/C), was used. The generalization coefficients for this design are practically null (0.14 and 0.03) and therefore satisfactory in the sense of differentiators (Blanco-Villaseñor et al., 2014); being associated to the facet categories 77.69% of the variance, to the relationship between categories and observers 22.30% and being 0% for the category observers.

Table 3 below shows the results of the generalizability analysis for these first three objectives: intraobserver reliability, interobserver reliability and determination of the homogeneity of the categories.

Table 3. Generalizability Analysis.

Generalizability Analysis	Facets	Relative G Coefficient	Absolute G Coefficient
Intraobserver reliability C/O	C= 91.41% O= 0% C/O= 8.58%	0.96	0.96
Interobserver reliability C/O	C= 84.67% O= 0% C/O= 15.32%	0.92	0.92
Homogeneity O/C	C= 77.69% O= 0% O/C= 22.30%	0.14	0.03

Note: C (Categories), O (Observers).

In order to estimate the minimum number of sessions necessary to generalize accurately, a two-facet design has been used, categories and observation sessions (C/P). An overall analysis of the generalizability indices according to this design structure shows that excellent results can be obtained after 6 observations, since a relative and absolute G coefficient of 0.94 would be obtained.

Table 4 below shows a measurement study of the results obtained as a function of the number of observations.

Table 4. Results of the coefficients obtained according to the number of observations.

Name of securities	Summary 1	Summary 2	Summary 3	Summary 4	Summary 5
P	2	6	8	10	(20)
C	56	56	56	56	56
Total observations	112	336	448	560	1120
Relative G coefficient	0.851	0.945	0.958	0.966	0.983
Absolute G coefficient	0.851	0.945	0.958	0.966	0.983
Relative error	1.668	0.556	0.417	0.334	0.167
Absolute error	1.670	0.557	0.417	0.334	0.167

Note: P (Observations), C (Categories).

Discussion

The objective of this research was to create and validate an observation tool to evaluate the canoe paddling technique in canoeing, specifically in the canoe modality. In addition, it was intended to obtain an instrument that would be useful and allow the codification of the technical gesture in this sport discipline, meeting the criteria of validity, accuracy and reliability required for this type of tool.

Firstly, the results obtained after the analyses performed have shown that it is a suitable tool for collecting and coding the paddling technique during the sport activity in canoeing. To ensure the correct design and validation of the tool, a procedure similar to that used in other validations of observation tools whose object was the analysis of the technical gesture in disciplines such as athletics (Lapresa et al., 2018), basketball (Garzón et al., 2011), beach handball (Vázquez-Diz et al., 2019) or dance (Sánchez-Izquierdo et al., 2021) has been followed. The analyses carried out have shown that it is an accurate, valid and generalizable tool, thus providing an appropriate resource in an underexplored area of research. Because it is a minority sport, the attention of researchers has not been very high. However, given the technical complexity of this sport, it is considered necessary to provide this type of instrument with the objective of reliably analyzing the technical gesture of paddling in this modality.

Secondly, this is a milestone in the literature related to this discipline, since it is the first instrument of these characteristics developed for the analysis of the canoe paddling technique, which provides an interesting resource in the preparation processes of the athletes who practice it. In fact, it has made it possible to code the different parts of the aquatic phase of the canoe paddling technique, which ensures an exhaustive analysis of this technical gesture and facilitates the understanding of its precision. In its development, and in order to explain the paddling technique in depth, a division by body segments within each sub-phase was required, which would allow the activity of each of them to be analyzed. In addition, although the technical gesture of the canoe is very rich, so we could delve more deeply into the action of each segment in the attack, traction and exit, but it would make the recording process difficult and would become impractical due to the large number of existing categories. For this reason, the actions or positions that are the pillar of the technique were selected, such as the angle of the trunk with respect to the knee in the attack or the angle of the steering arm with respect to the trunk.

Despite the limitations of the study, such as the sample size or the specific context of the participants, this study opens the door to other research on the technique of this sport discipline and to a deeper analysis of the athletes. For example, it would be possible to know the action of each segment in each phase of the stroke and its relationship with the speed of the boat or with the maximum stroke rate that the paddler can reach, which becomes an objective for future work. It would also be possible to analyze how the action of each segment affects the length of the stroke, which is interesting from a technical point of view in this discipline. In addition, with the help of other video angles, the tool could be completed by adding a new dimension to the movement. This would allow to know the movement of the paddler in the vertical axis, observing if there are lateral movements during the realization of the paddling technique. Finally, it could serve as a guide in the design of observation tools in similar disciplines, such as kayaking or create other specific tools to encode the aerial phase of the technical gesture.

Conclusions

Once again, the OM has proved to be effective for the analysis of the technical gesture of athletes in their usual context and has allowed the development of a suitable tool for analyzing the aquatic phase of the paddling. In addition, it opens a field of analysis in canoeing that is little explored in the literature, which is interesting for the advances that can be made in this discipline from a scientific point of view.

Practical applications

Video analysis is a frequently used means to improve the performance of athletes. Thanks to this instrument, coaches have at their disposal a reliable resource to better analyze the paddling and to be able to intervene in sports training processes. It would be of great interest to further explore this line of research in order to have more and more studies with which to discuss results.

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