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ORIGINAL

ANALYSIS OF THE MISTAKES IN XUANFENGJIAO AND TENGKONG WAIBAITUI JUMPS IN WUSHU. A PILOT STUDY

ANÁLISIS DEL ERROR EN LOS SALTOS XUANFENGJIAO Y TENGKONG WAIBAITUI EN WUSHU. UN ESTUDIO PILOTO

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ABSTRACT

The objective of this research is to identify and analyze T-Patterns and polar coordinates and the technical and behavioral sequential mistakes that occur in two jumps with a rotation of 540 degrees integrated in the forms and routines of wushu competition (taolu). We analyzed 47 forms of an international senior men's competition: 43 Xuanfengjiao jumps and 33 *Tengkong-Waibaitui* jumps. We use observational methodology. The analysis has been performed by employing traditional statistic tests, T-Pattern detection and polar coordinate analysis. The most frequent mistakes are the insufficient degree of rotation and the lack of height of the kick at shoulder level. The mistake sequences affect the

attack of the jump (taking more than four steps), aerial development (with lack of height of the kick at the level of the shoulders and with the non-extension of the leg), landing on the floor (with the insufficient degree of rotation and without both feet) and the reception and imbalances (with no direct entry into position and with the movement of the feet or compensatory rebound to avoid losing balance). Wushu instructors, referees and coaches can use these results to improve the training and development of the competition and to improve the trainer's techniques by providing more accurate feedbacks.

KEYWORDS: wushu, jump, error, Observational methodology, T-pattern

RESUMEN

El objetivo de esta investigación es detectar y analizar mediante T-Patterns y coordenadas polares los errores técnicos y las secuencias conductuales que se producen en dos saltos con rotación de 540 grados integrados en las formas o rutinas de competición de wushu (taolu). Analizamos 47 formas de competición masculina sénior de ámbito internacional: 43 saltos *Xuanfengjiao* y 33 saltos *Tengkong-Waibaitui*. Los errores más frecuentes son el insuficiente grado de giro y la falta de altura de la patada a nivel de los hombros. Las secuencias de errores afectan al ataque del salto, al desarrollo aéreo, a la toma de suelo, y a la recepción y desequilibrios. Los técnicos, árbitros y entrenadores de wushu pueden utilizar estos resultados para mejorar el entrenamiento y desarrollo de la competición y perfeccionar la tarea de los docentes proporcionando feedbacks más precisos.

PALABRAS CLAVE: wushu, salto, error, Metodología observacional, T-Pattern.

INTRODUCTION

The present research focuses on wushu, specifically on the modality of forms (taolu). This competition with free routines contains specific evaluation and reduction criteria (International Wushu Federation -IWUF-, 2005). Depending on the quality of the movements, the general presentation and the difficulty coefficient, the form or routine presented will have a pre-established score. It is similar to rhythmic gymnastics where the athlete knows the score in advance to which they aspire with his routine, being the maximum score with which the competitor begins their routine. The score is then reduced as the competitor makes mistakes.

Since the taolu (IWUF, 2005) forms competition system was modified, the scoring criterion corresponding to "degree of difficulty" was introduced. This involved the design of an ideal technical model and the codification of techniques that imply that the reductions applied to the score of the competitors are based on the mistakes made. Based on the rules of refereeing and the penalty criteria established by IWUF (2005), any discrepancy with the established ideal technical model will be considered a mistake.

This way, there is evidence that the prior knowledge of the most common mistakes reduces the fear of failing (Zubiaur González & Gutiérrez Santiago, 2003). The research in wushu has focused on the modality of sanda (Ju, 2017; Zhang & Gu, 2014) and on the biomechanical analysis of some jumps in wushu routines (Benouaich et al., 2015; Wang et al., 2017). In spite of this, until now, research on the technical mistakes in wushu was nonexistent, although it has been studied in other disciplines such as judo (i.e., Gutiérrez-Santiago et al., 2013; Prieto-Lage et al., 2020), or in individual sports such as rhythmic gymnastics or swimming (Rejman, 2013; Veličković et al., 2016). Due to this absence, wushu teachers have relied on their own professional experience or on the indications of international technical manuals for their teaching technique (Bangjun & Alpanseque, 2007; Perez & Woodman, 2017; Wu, 2007).

Therefore, through T-Patterns and polar coordinates, the objective of the present research is to identify and analyze the technical errors and the most frequent behavioral sequencing that take place in 540º nanquan jumps (*Xuanfengjiao* and *Tengkong-Waibaitui*), carried out in the forms or free routines of the senior male wushu competition (taolu).

METHOD

Design

Observational methodology allowed us to analyze the jumps in the forms of wushu. The observation was systematic, open and non-participating (Anguera, Blanco-Villaseñor, Losada, & Portell, 2018).

The observational design was nomothetic (several subjects that execute the same technique), monitoring (determining the stability of the technique in the different jumps), and multidimensional (the dimensions correspond to the criteria of the observation instrument). A series of decisions about the participants, the instruments and the procedure come from this design (Anguera et al., 2011).

Participants

We used a convenience sample of 47 forms of the international senior men's competition. The established measurement units in this study were *Xuanfengjiao* (n = 43) and *Tengkong-Waibaitui* (n = 33) jumps. The jumps were analyzed using public domain audio-visual material.

Instruments

The observational instrument developed ad hoc for this study is called the "540º Wushu Jumping Observation Instrument" I.O.SALTOS540-WUSHU (see Table 1). It combines the field format with the category system. This type of combination has been used in multiple studies (Aguado-Méndez et al., 2020; Álvarez-Kurogi, 2020; Lasierrra et al., 2020; Sabio Lago et al., 2018). It is formed by a set of criteria that allows us to determine the technical mistakes of

the jumps that are studied. It fits the observational design and meets the conditions of thoroughness and mutual exclusivity (Anguera et al., 2018).

The ideal technical models used to elaborate the observation instrument are part of the wushu refereeing and competition regulation established by IWUF (2005). The development of this observation tool was based on everything that did not match the ideal technical model of the IWUF (2005), and it was considered a mistake and, therefore, was part of the observation instrument. The two jumps researched are part of the techniques codified in the regulations such as *Xuanfengjiao* (XFJ, code-323A) and *Tengkong waibaitui* (TKWBT, code-324A). They are movements of difficulty "B" whose value is +0.3. The skills that make up the structure of these jumps are based on specific motor patterns of wushu discipline but executed as gymnastic elements.

Table 1. Observational Instrument I.O. SALTOS540-WUSHU

CRITERION	CODE	CATEGORY DESCRIPTION
Beginning/End	SF	Start of the form. The competitor makes the greeting that indicates the beginning of the form.
	EF	End of the form. The competitor makes the greeting indicating the end of the form.
Type of Jump	XFJ	*Xuanfengjiao*. *Xuanfengjiao* Jump.
	TKWBT	*Tengkong waibaitui*. *Tengkong waibaitui* Jump.
Jump Attack	ES4	It exceeds four steps. The athlete takes more than four steps before performing the jump impulse.
Air Development	LHUSL	Leg height under shoulder level. The elevation of the leg in the execution of the kick is below the level of the shoulders, based on technical qualification.
	HLLHL	Height leg lower than hip level. The leg elevation in the execution of the kick is below the level of the horizontal (hip), requirement to validate the degree of difficulty.
	LE	Leg extension. The kicking action is not executed with the knee fully extended.
	APX	Absence of pat. At the highest altitude reached with the leg, the foot does not hit the palm of the opposite hand. Exclusive to the *xuanfengjiao* jump.
Floor taking 1	IDR	Insufficient degree of rotation. The athlete does not manage to perform the necessary rotation to reach 540 degrees of rotation, delimited by the position of the feet at the moment of starting the momentum and the position of the feet immediately after landing on the ground.
Floor taking 2	NSF	No simultaneous feet. The competitor does not land on the floor impacting it with both feet simultaneously.
Reception	ADEP	Absence of a direct entry to position. The position in fall is not defined instantaneously. It does not "nail" the position.
	AER	Absence of extended reception. The position is not maintained for at least two seconds to demonstrate the correct stability.
Imbalances	PM	Prolonged Movements. Movements, mainly from the upper zone, aimed to alleviate the imbalances.
	DP	Deformity of position. Movements of knee flexion or hip instability that alter a correct position.
	CM	Compensatory movements. Compensatory movements of the feet to counter the imbalance.
	REB	Rebounds The athlete gives small jumps to achieve the lost stability.
	AS	Additional support. Support of any other part of the body other than the feet.
	FALL	Falls. The athlete falls to the ground.
Suit	SB	Suit breaks. Any part of the suit is broken or is broken during the development of the jump.
	SH	Suit hooks. The suit is rolled or hooked on any part of the body.
	FS	Footwear suit. The athletic shoe escapes or is barefoot.
Other	OUT	Out of area. The competitor leaves the area defined for the exhibition of the form.
	FGT	Forgotten. The competitor forgets or omits to execute the jump.

The validity of the construct of the observation instrument was done by its coherence with the theoretical framework (González-Prado et al., 2015) and by consulting six wushu experts that reached a degree of agreement of 95% in response to a questionnaire about the observation instrument, analyzing its suitability for the actual competition and by following the same procedure as others studies (Prieto-Lage, Louzao-Neira, et al., 2020). The six experts were provided with a comprehensive description of the observation instrument, the objectives of the investigation and instructions for answering the questionnaire. The questionnaire consisted of five items (with a Likert scale of five levels) about its suitability to the object of study, compliance with the criteria of completeness and mutual exclusivity, clarity in the wording of the categories and the degree of objectivity that allows the data collection to be unified by various observers.

All the mistakes of the jumps object of study were codified and registered by LINCE v.1.2.1 software (Gabin et al., 2012), which has been used in numerous studies (Álvarez Medina et al., 2018; Ramón-Llin et al., 2021; Valldecabres et al., 2019).

Procedure

Being an observational study in a natural environment with public videos that do not involve experimentation, it was not necessary to obtain informed consent from the competitors (American Psychological Association, 2002).

After designing the observation instrument, the validity of its development was made through its coherence with the theoretical framework and through a consultation of 6 experts in wushu (international referees as well as coaches), who had to show their degree of agreement with the instrument, reaching 95%.

After an adequate training in the use of the observational instrument, the data was recorded by two expert wushu observers. The quality of the data (Anguera & Hernández-Mendo, 2013) was obtained by making a single record by two observers who discussed among themselves which category each behavior was assigned to, with an agreement between the two observers before each entry.

After the recording the data, we obtained an Excel file with the sequence of all the codes of the recorded behaviors. The versatility of this file allowed us to make successive transformations for the different analysis.

Data Analysis

The statistical analysis was carried out using the IBM Statistical Package for the Social Sciences, version 20.0 (IBM-SPSS Inc., Chicago, IL, USA). The relation among the different studied categories was calculated using the chi-square test ($\chi 2$). The statistical significance was assumed to be $p < 0.05$.

To identify the mistake sequences, we calculated the T-Patterns with Theme v.5.0. (Magnusson et al., 2016) with a significance level of 0.005 (the percentage of accepting a critical interval due to chance is 0.5%). We set a minimum number of occurrences to three, not discarding patterns of occurrence equal to or greater than three. This software reveals hidden structures and unobservable aspects of sports techniques, being extremely effective in sports sciences (Magnusson et al., 2016). Its graphic representation shows the studied behaviors, showing the existing links between the different technical mistakes in the jumps. It consists of two parts. The left quadrant represents the relation between behaviors. It should be read as a tree diagram, from top to bottom. The right quadrant tells us how many times this relation occurs through lines that go from the top to the bottom.

The polar coordinates were calculated with the HOISAN program (Hernández-Mendo et al., 2012), using the analytical technique of Sackett (1980) in the genuine retrospective variant (Gorospe & Anguera, 2000) used in numerous research (Tarragó et al., 2017). The construction of the polar coordinates was carried out by determining the modules of the vectors (they are considered significant when they are greater than 1.96) and the angle of the vector, which will indicate the nature of relationship of the behaviors depending on the quadrant where it and the radius are located. A detailed explanation of the polar coordination technique is shown in previous publications (Castellano Paulis & Hernández Mendo, 2003).

RESULTS

Statistical Descriptive Analysis

Table 2 shows the frequency and percentage of the mistakes in *Xuanfengjiao* (XFJ) and *Tengkong waibaitui* (TKWBT) jumps jointly and individually, as well as the identified mistake patterns.

The combined analysis of both jumps reveals that the most frequent mistakes are: the lack of height of the leg at shoulder level (LHUSL), the insufficiency on the degree of rotation (IDR) and the absence of direct entry into position (ADEP). We highlight the absence of mistakes in categories of penalization cataloged by the IWUF (2005), such as, for example, track exits (OUT) or neglects (FGT).

The individual analysis of the XFJ jump indicates that the predominant mistakes are the insufficiency of the degree of rotation (IDR), the absence of direct entry into position (ADEP) and the lack of simultaneous feet (NSF). Two other mistakes also stand out, such as foot movements in imbalances (CM) and insufficient leg extension in air development (LE). In the TKWBT jump, the predominant mistake, without a doubt, is the deficient height of the kick to reach the height of the shoulder level (LHUSL). Rebound mistakes (REB) and insufficient degree of rotation (IDR) are also relevant.

Table 2. Descriptive statistics and T-Patterns identified from the technical mistakes in XFJ and TKWBT

DESCRIPTIVE MEASURES							
		XFJ and TKWBT		XFJ		TKWBT	
	Error	Fr.	%	Fr.	%	Fr.	%
Jump Attack	ES4	7	9.2	5	11.6	2	6.1
Air Development	LHUSL	23	30.3	1	2.3	22	66.7
	LE	8	10.5	6	13.9	2	6.1
Floor 1	IDR	25	32.9	18	41.9	7	21.2
Floor 2	NSF	12	15.8	10	23.3	2	6.1
Reception	ADEP	19	25	15	34.9	4	12.1
	AER	2	2.6	1	2.3	1	3
Imbalances	PM	2	2.6	2	4.6	0	0
	CM	14	18.4	9	20.9	5	15.1
	REB	9	11.8	1	2.3	8	24.2
	AS	3	3.9	2	4.6	1	3

T-PATTERNS OF THE SEQUENCES OF ERRORS			
Jump	T-Pattern	O	I
Generic	((SF TKWBT) (XFJ EF))	18	1
XFJ	(IDR (ADEP CM))	3	2
	(LE (IDR ADEP))	3	3
	(NSF (IDR ADEP)	3	4
TKWBT	(LHUSL) (IDR CM))	3	5
	(LHUSL (IDR REB))	3	6
XFJ and TKWBT	(ES4 (IDR CM))	3	7
	(ES4 (ADEP CM))	3	8
	(ES4 (IDR ADEP))	3	9

Fr. = Frequency; O = Occurrence; I = Identifier

Detection of Temporal Patterns and Polar Coordinates

The pattern of Figure 1A shows the internal logic of execution of the jumps within the form. In 18 of the 47 analyzed forms, the same execution sequence is repeated. At the beginning of the form (SF), first there is a 540º jump *Tengkong waibaitui* (TKWBT), followed by another *Xuanfengjiao* jump (XFJ) to end the form (EF). A total of 43, 540º Xuangfengjiao jumps and 33, 540º *Tengkong waibaitui* jumps are observed, both being executed at the beginning of the form.

The individual analysis of each jump provides chains of specific mistakes for each of them. In the XFJ jump, we identify the behavioral patterns (mistakes) shown in Table 2 (I.2 to 4), in the TKWBT jump the one shown in Table 2 (I.5-6).

Table 3 shows the results of the analysis of the polar coordinates in jumps XFJ and TKWBT jointly and individually, taking into account that the focal category of the analysis has been the IDR error.

The pattern of the XFJ jump (IDR (ADEP CM)) indicates that an insufficient degree of rotation at the time of reception of the jump greatly hinders the direct entry into position and causes imbalances with foot movements (Table 2, I.2).

The jump pattern XFJ (LE (IDR ADEP)) shows that not fully extending the leg makes it difficult to reach the appropriate degree of rotation, and therefore does not enter directly into the final position of the jump properly (Figure 1B). This is also indicated in the polar coordinate of Figure 1E1. It is evident that on 12 occasions the insufficient degree of rotation included the absence of direct entry into position (IDR ADEP), being a statistically significant relation ($\chi 2 = 13.768$, $p < 0.001$).

Table 3. Results of the Polar Coordinate Analysis for the focal conduct IDR

Jump and CB	Pro. X	Ret. Y	Quadrant	Radius	Ratio /Radius	Initial Angle	Transformed Angle
XFJ y TKWBT							
ES4	-2.45	2	II	3.16 (*)	0.63	39	140.85
LHUSL	-2.89	2.89	II	4.08 (*)	0.71	45	135
LE	-1.03	-0.73	III	1.26	-0.58	35	215.29
NSF	-0.72	-1.17	III	1.37	-0.85	58	238.46
ADEP	3.32	-2.89	IV	4.4 (*)	-0.66	41	318.99
AER	1.4	0	I	1.4	0	0	0
PM	0.35	0	I	0.35	0	0	0
CM	2.75	-2.16	IV	3.5 (*)	-0.62	38	321.9
REB	-0.22	0	I	0.22	0	0	0
AS	1.84	-0.31	IV	1.86	-0.17	10	350.36
XFJ							
ES4	0	1.37	I	1.37	1	90	90
LHUSL	0	-0.57	III	0.57	-1	90	270
LE	-1.2	2.77	II	3.02 (*)	0.92	67	113.43
NSF	-0.28	0.92	II	0.97	0.96	74	107.03
ADEP	2.86	-2.17	IV	3.59 (*)	-0.6	37	322.78
AER	0.41	0	I	0.41	0	0	0
PM	0.06	0	I	0.06	0	0	0
CM	0.84	-0.62	IV	1.04	-0.59	36	323.58
REB	-0.8	0	I	0.8	0	0	0
AS	0.61	0	I	0.61	0	0	0
TKWBT							
ES4	0	0.96	I	0.96	1	90	90
LHUSL	-2.6	2.31	II	3.48 (*)	0.66	41	138.37
LE	-1.03	-0.73	III	1.26	-0.58	35	215.29
NSF	-0.72	-1.17	III	1.37	-0.85	58	238.46
ADEP	-0.43	-2.05	III	2.09	-0.98	79	258.07
AER	1.4	0	I	1.4	0	0	0
CM	2.75	-2.16	IV	3.5 (*)	-0.62	38	321.9
REB	3.32	-2.31	IV	4.04 (*)	-0.57	35	325.18
AS	1.93	-0.72	IV	2.06	-0.35	20	339.69

CB = Conditioned Behavior; Pro. X = Zsum prospective (X); Ret. Y = Zsum retrospective (Y)
(*) In polar coordinates indicates a significant relationship ($p < .05$) between behaviors when the length of the vector is higher 1.96 (Radius> 1.96)

The pattern of the jump XFJ (NSF (IDR ADEP) indicates that when the athlete does not fall with both feet simultaneously, the degree of rotation is incorrect and the direct entry to position is done in a difficult way and not directly (Table 2, I.4).

The jump pattern TKWBT (LHUSL) (IDR CM)) indicates that the lack of height in the jump kick above the shoulder level results in not performing the full turn

(540º) which causes a compensatory foot movement to avoid balance loss in the reception (Table 2, I.5), a relation that is identified in the polar coordinate of Figure 1E2. The link between LHUSL and IDR is significant ($\chi 2 = 4.442$, $p = 0.035$) and also between IDR and CM ($\chi 2 = 5.305$, $p = 0.021$).

The pattern of the jump TKWBT (LHUSL (IDR REB)) warns us that the lack of height in the kick of the jump above the level of the shoulders results in not making the complete turn (540º), causing a compensatory rebound movement to avoid losing balance or performing some kind of additional support or falling in the reception (Figure 1C). This aspect is also shown in the polar coordinate of Figure 1E2.

The combined analysis of both jumps provides several mistake patterns. The pattern (ES4 (IDR CM)) reveals that when the competitor exceeds the steps established by the regulations (more than four), they get confused through causing a loss of strength at the boost level of the legs, which means that they do not reach the level of predetermined rotation and give an unbalanced reception that causes compensatory foot movement to avoid loss of position (Figure 1D). The relation is indicated in the polar coordinate of Figure 1E3. The link between IDR and CM is significant ($\chi 2 = 4.571$, $p = 0.033$).

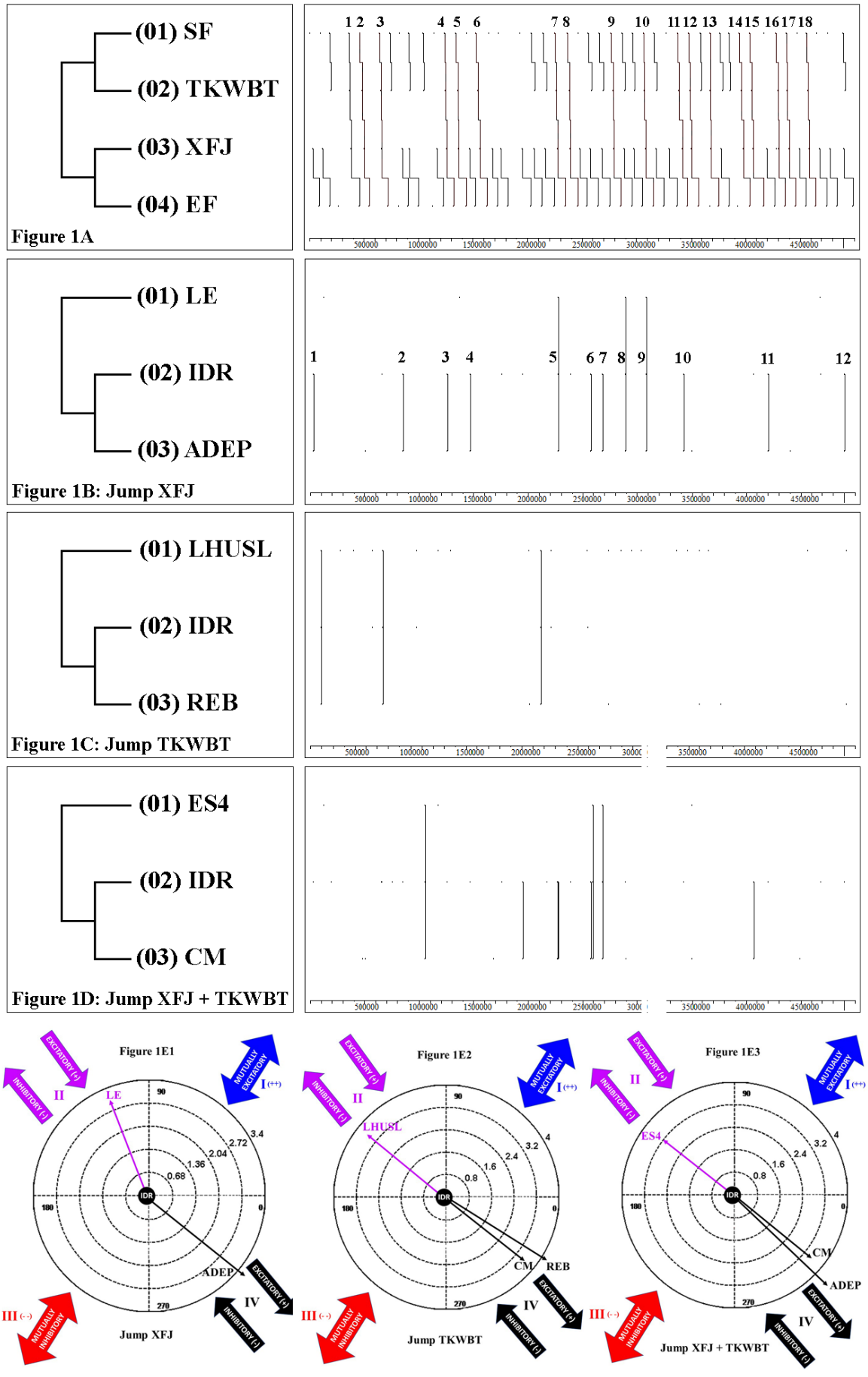

Figure 1. T-Patterns and polar coordinates of the jumps XFJ and TKWBT.

The pattern (ES4 (ADEP CM)) indicates that when the competitor performs more than four steps to have more momentum and thus be able to reach the degree of rotation, they get too much impulse, causing an indirect entry into position, and therefore a footwork movement for them to be able to get into position (Table 2, I.8). The relation between ES4 and ADEP is significant ($\chi 2 = 4.248$, $p = 0.039$) and also between ADEP and CM ($\chi 2 = 5.720$, $p = 0.017$).

The pattern (ES4 (IDR ADEP)) shows that performing more than four steps destabilizes the competitor, causing confusion as to the orientation needed to reach the degree of rotation, and therefore this results in an indirect reception in position (Table 2, I.9). This aspect is presented in the polar coordinate of Figure 1E3. The relation between IDR and ADEP is significant ($\chi 2 = 19.094$, $p < 0.001$).

DISCUSSION

The results of this research can be a valuable tool in the improvement of training, competition systems and methods, for instructors, referees and coaches, who will have reliable and objective data for the correction of mistakes and resources for technical improvement and evaluation, as well as a factor of improving instructing techniques.

The knowledge and understanding of the mistakes in the technique of sports execution is of great importance because they are a key element in the competition (Rejman, 2013; Veličković et al., 2016). There has not been an interest of the scientific community in generating this knowledge in wushu, focusing especially on biomechanical or performance aspects (Benouaich et al., 2015; Wang et al., 2017). Therefore, this knowledge can only be based on the traditional and personal experiences of the professionals of this sport. Analyzing the publications of the professionals of wushu (Bangjun & Alpanseque, 2007; Perez & Woodman, 2017; Wu, 2007) we observe that the important points, indicated by such, in the execution of the two jumps under study, coincide with the mistake type that has been obtained in this work.

Matching Aspects between 540º Jumps: Tengkong Waibaitui and Xuanfengjiao

The competition regulation of the IWUF (2005) defines both jumps with the qualification of "540 degrees", stating that this is the main difficulty of execution for athletes to overcome. This difficulty is precisely what complicates the execution of the other elements or requirements involved in the technique itself.

For this reason, it is interesting to highlight the appearance of the insufficient degree of rotation (IDR) as the most frequent mistake among the data obtained in the analysis and, consequently, it is the cause that would imply the invalidity of the largest number of jumps in competition (IWUF, 2005), with the loss of the score that encodes them (0.3). This is the reason why we decided to use this category (IDR) as the focal category for the polar coordinate analysis.

The competition regulation is also aware of the great difficulty involved in a jump with such a demand in rotation, being able to raise the leg to shoulder height, marking the jump as correctly executed if it reaches the height of the hip (IWUF, 2005) but penalizing it (LHUSL error) in the "technical" section (quality of movements). Thus, this study shows that performing a leg elevation at hip height is always achieved (no HLLHL mistake takes place), which is a circumstance that does not happen when we want to raise the leg to shoulder level (LHUSL mistake) and something that is not achieved by many competitors, making it the second most frequent mistake.

The competition system states the tremendous physical and coordination requirement that come with these jumps to achieve the established rotation and the height of the kick (IWUF, 2005). This circumstance, identified in the T-Pattern of Figure 1A, would explain why the competitors perform these jumps almost at the beginning of the form and under a pattern that first performs the *Tengkong Waibaitui* jump followed by *Xuanfengjiao*. That same pattern reveals that the number of TKWBT jumps is less than the number of XFJ jumps, so we can say that the TKWBT jumps are more complex in their execution for a greater number of athletes.

This study has revealed two mistakes (IDR and LHUSL) above the rest. Therefore, both competitors and coaches should pay special attention to them during their training.

Xuanfengjiao 540º Jumps

The two most frequent mistakes in this jump (IDR and ADEP) have been major components of the identified patterns with Theme v.5.0 Theme and the polar coordinate found with HOISAN. In this way, the pattern shows that up to 12 times, an insufficient degree of rotation (IDR) at the moment of jump reception greatly hinders a direct entry into position (ADEP). This same relation (IDR-ADEP) is reflected in the polar coordinate of the jump (Figure 1E1).

In addition, the identified patterns also show that this relation (IDR-ADEP) causes imbalances with foot movements (CM).

Also, the patterns indicate that this mistake ratio (IDR-ADEP) occurs because the athlete does not previously have the leg in full extension (LE) or because they do not fall simultaneously with both feet (NSF). A circumstance that is also evidenced is in the case of the LE category in the polar coordinate of this jump (Figure 1E1).

In this way, it becomes clear that the most common mistake (IDR) of the *Xuanfengjiao* jump interrelates with other mistakes forming chains of mistakes. Either because this is altered by the failure of individual elements of the kinetic chain (LE) or because when the statutory turn is not reached, the competitor forces the reception (NSF), making body rotation movements to try to simulate

the correct entry into position (ADEP), and when this it is not controlled, it causes imbalances with the foot movement (CM).

Tengkong Waibaitui 540º Jumps

The score criteria for the quality of movements of the rules of the regulation in free routines (IWUF, 2005) establishes itself as a mistake, the leg of the kick being below the level of the shoulders and, in the results of this study, this mistake (LHUSL) prominently stands out from the others.

The detected patterns (Table 2, I.5-6) reflect the existence of a significant relation between the height of the leg under the shoulder level (LHUSL) and the inadequate degree of rotation (IDR) in the air phase of the jump, causing evident imbalances in the entrance to position that are manifested by compensatory movements of the feet (CM) or rebounds (REB). This same behavioral relationship shown in the two indicated patterns is also clearly evidenced in the polar coordinate of this jump (Figure 1E2).

The four steps that the regulation allows to make the sweep in the *Tengkong Waibaitui* jump do not favor the quantity of movements (which does happen in the *Xuanfengjiao* jump), so the strength of the turn completely depends on the impulse and makes lifting the leg up to the height of the shoulders at the time of execution of the kick much harder. So, the regulation of the *Tengkong Waibaitui* jump does not force to strike with the foot with the palm of the hand, as it demands in the *Xuanfengjiao* jump. In addition, although there is a reduction in the score, this failure does not invalidate the jump.

In any case, it continues to be verified that this technique, with the characteristics of a gymnastic element (540º of rotation), is affected by or affects each of the movements that it comprises, which are collected and codified according to the rules of the competition.

Study Limitations

There are certain methodological weaknesses, such as the small sample size, which justifies the pilot study nature of this research, or analyzes carried out to relate the different categories of the observation instrument (as they are small samples). Therefore, these limitations must be taken into account, since the interpretation and transfer of the results and conclusions presented must be considered with caution. On the other hand, we consider that the discussion of the results has been conditioned by the absence of scientific publications on the present field of study, this deriving from having carried out an unpublished investigation. However, this last aspect (unpublished study) must in turn be considered a strength, since it undoubtedly opens a line of original research for future studies on wushu.

CONCLUSIONS

It has become clear that the mistakes observed in this research match the parameters that athletes have to overcome when executing these jumps, those being the ones established in the competition regulations of the IWUF. The results of this study generate knowledge about the mistakes and their sequences in the 540º *Tengkong Waibaitui* and *Xuanfengjiao* jumps, which can be used by the wushu professionals to improve the training methods, the competition qualifications and to improve the task of teachers by providing more precise feedback.

The most frequent mistakes are the insufficient degree of rotation (IDR) and the lack of height of the kick at shoulder level (LHUSL). The IDR mistake is the most frequent in the 540º *Xuanfengjiao* jump as the LHUSL mistake is in the 540º *Tengkong waibaitui* jump.

The T-Patterns demonstrate the internal logic of the execution of the jumps within the form, first there is a *Tengkong waibaitui* jump and then a *Xuanfengjiao* jump, and both performed at the beginning of the form.

For most athletes, the *Tengkong waibaitui* jump has more complexity in its execution, so it is done less often. There are more mistakes when it is executed, and it is usually done before *Xuanfengjiao* at the beginning of the form.

Performing more than four steps in the beat of the jump produces a further chain of mistakes related to the insufficient degree of rotation, with no direct entry into position and with footwork movements,

The patterns detected in the *Xuanfengjiao* jump connect the insufficient degree of rotation with the absence of direct entry to position and three possible relations: foot movements (IDR-ADEP-CM), no leg extension (LE-IDR-ADEP), and non-simultaneous feet (NSF-IDR-ADEP).

In the *tengkong waibaitui* jumps, the significant relation between the height of the leg under the level of the shoulders with the insufficient degree of rotation is observed, which causes a footwork movement or compensatory rebound so as not to lose balance.

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