Revista de Artes Marciales Asiáticas
Volume 16(1), 1-11 ~ January-June 2021
DOI: 10.18002/rama.v16i1.6330
http://revpubli.unileon.es/ojs/index.php/artesmarciales

RAMA
I.S.S.N. 2174-0747

Time-motion analysis in elite female wushu sanda athletes according to competitive phases and weight categories

Breno Berny VASCONCELOS*(A,B,C,D,E,F), & Fabrício Boscolo del VECCHIO(A,D,E,F)

Physical Education College, Federal University of Pelotas, Pelotas, Rio Grande do Sul (Brazil)

Received: 24/09/2020; Accepted: 04/02/2021; Published: 09/02/2021.

ORIGINAL PAPER

Abstract

Introduction: Wushu Sanda is a Chinese combat sport. *Objective:* To measure the time-motion structure of elite female wushu sanda athletes during the 13th World Wushu Championships in different weight divisions (light, middle, and heavy categories) and competition phases (eliminatory, quarterfinals, semifinals and finals). *Material and methods:* Fifty-five female athletes from 31 countries participated in 46 matches during the competition. All 46 matches, accounting 95 rounds, 35 in light, 25 in middle and 35 in heavyweight divisions, took part in the study. Matches were analyzed using the software Kinovea™. Each match was reproduced in slow motion (50%) twice; therefore, one athlete was observed each time to ensure that all activities would be registered, totalizing 92 observations (46 matches, 2 observations per match). We registered the time in observation, preparation, interaction, effort, pause, high-intensity and low-intensity activities. *Results:* Descriptive data showed an effort:pause ratio of 2.2:1, a high:low intensity efforts ratio of 1:1.3, and mean observation-preparation-interaction times of 4.5-1.2-4.2 seconds. When comparing by weight category, heavyweight categories had higher total fighting time per round than the light and middle categories. Also, heavyweight categories had longer preparation and interaction mean-time; and referee interruption time frequency, total and mean times than the light and middle categories. Total pause time was also higher for heavyweights. According to the competitive phase, semifinal matches had shorter observation times than eliminatory and final matches. Also, semifinal matches had lower low-intensity time than quarterfinals and finals. *Conclusions:* Wushu sanda is an intermittent combat sport, and female athletes present some time-motion differences according to weight division and competitive phase.

Keywords: Wushu sanda; kung fu; time-motion analysis; martial arts; combat sports.

Análisis de tiempo-movimiento en atletas femeninas de élite de wushu sanda según fases competitivas y categorías de peso

Resumen

Introducción: El Wushu Sanda es un deporte de combate chino. *Objetivo*: Medir la estructura de tiempo-movimiento de atletas femeninas de élite de wushu sanda durante el 13er Campeonato Mundial de Wushu en diferentes categorías de peso (ligera, media y pesada) y fases de competición (eliminatorias, cuartos de final, semifinales y finales). *Material y métodos*: Cincuenta y cinco atletas de 31 países participaron en 46 combates en el campeonato. Todos ellos, que sumaron 95 asaltos, 35 en peso ligero, 25 en medio y 35 en pesado, se incluyeron en el estudio. Los combates se analizaron mediante el software Kinovea™. Cada combate se reprodujo a cámara lenta (50%) dos veces; así, cada vez se observó a un atleta para asegurar que se registrasen todas las actividades, totalizando 92 observaciones (46 combates, 2 observaciones/combate). Se registró el tiempo de observación, preparación, interacción, esfuerzo, pausa, actividades de alta y baja intensidad. *Resultados*: Los datos descriptivos mostraron una ratio esfuerzo:pausa de 2,2:1, una relación de esfuerzos de alta:baja intensidad de 1:1,3 y tiempos medios de observación-preparación-interacción de 4,5-1,2-4,2

Análise de tempo-movimento em lutas femininas de elite de wushu sanda de acordo com fases competitivas e categorias de peso

Resumo

Introdução: Wushu Sanda é uma modalidade esportiva de combate chinesa. *Objetivo:* Medir a estrutura de tempo-movimento de atletas de elite de wushu sanda durante o 13º Campeonato Mundial de Wushu em diferentes divisões de peso (categorias leve, médio e pesado) e fases de competição (eliminatórias, quartas de final, semifinais e finais). *Materiais e Métodos:* Cinquenta e cinco atletas de 31 países participaram de 46 lutas durante a competição. Todas as 46 lutas, contabilizando 95 rounds, 35 nas categorias leves, 25 nas médias e 35 nas pesadas, participaram do estudo. As lutas foram analisadas usando o software Kinovea™. Cada luta foi reproduzida em câmera lenta (50%) duas vezes; portanto, um atleta foi observado a cada vez para garantir que todas as atividades fossem registradas, totalizando 92 observações (46 lutas, 2 observações por luta). Foram registrados os tempos em atividades de observação, preparação, interação, esforço, pausa, alta intensidade e baixa intensidade. *Resultados:* Os dados descritivos mostraram uma relação esforço: pausa de 2,2:1, uma relação de esforços de alta: baixa intensidade de 1:1,3 e tempos médios de observação-

* *Corresponding author*: Breno Berny Vasconcelos (brenobvasc@gmail.com)

Contributions: (A) Study design. (B) Literature review. (C) Data collection. (D) Statistical / Data analysis. (E) Data interpretation. (F) Manuscript preparation.

Funding: The authors received no funding for this work.

segundos. Al comparar categorías de peso, el peso pesado tuvo un mayor tiempo total de lucha por asalto que el ligero y medio. Además, la categoría de peso pesado tuvo un tiempo medio de preparación e interacción más largo, así como una mayor frecuencia interrupción por parte del árbitro, y tiempos totales y medios mayores que las categorías ligera y media. El tiempo total de pausa también fue mayor en esta categoría. Según la fase competitiva, los combates de semifinales tuvieron tiempos de observación más cortos que las rondas eliminatorias y las finales. Además, la ronde de semifinales tuvo menos tiempo de baja intensidad que los de cuartos de final y finales. *Conclusiones*: El wushu sanda es un deporte de combate intermitente, y las atletas femeninas presentan algunas diferencias en tiempo-movimiento según la categoría de peso y la fase competitiva.

Palabras clave: Wushu sanda; kung fu; análisis de tiempo-movimiento; artes marciales; deportes de combate.

preparação-interação de 4,5-1,2-4,2 segundos. Ao comparar por categoria de peso, as categorias de peso pesadas tiveram maior tempo total de luta por round do que as categorias leves e médias. Além disso, as categorias pesadas tiveram maior tempo médio de preparação e interação; e frequência do tempo de interrupção do árbitro, tempos totais e médios do que as categorias leves e médias. O tempo total de pausa também foi maior para as pesadas. De acordo com a fase competitiva, as lutas da semifinal tiveram menor tempo de observação do que as eliminatórias e as finais. Além disso, as lutas das semifinais tiveram menor tempo de baixa intensidade do que as quartas de final e as finais. *Conclusões:* Wushu sanda é um esporte de combate intermitente, e as atletas do sexo feminino apresentam algumas diferenças de tempo-movimento de acordo com a divisão de peso e fase competitiva.

Palavras-chave: Wushu sanda; kung fu; análise de tempo-movimento; artes marciais; desportos de combate.

1. Introduction

Wushu, also known as *kung-fu*, is the Chinese martial arts. Wushu evolved from a traditional martial art with distinct styles to several modern competitive sports, such as Wushu Taolu and Wushu Sanda (International Wushu Federation, 2014). Wushu sanda is a combat sport with both striking and grappling motor actions, which means athletes can target each other with punches, kicks, and also throws (Vasconcelos & Del Vecchio, 2017).

A typical wushu sanda bout has three rounds of two minutes each with one-minute intervals in between. The matches are held in an elevated squared platform called *leitai*. The leitai has eight by eight meters area and is 80 centimetres high above the ground. Additionally, the leitai has no lateral barriers, and surrounding the leitai there is on the ground a 30 cm height and 2 meters width protective cushion, which means athletes can be thrown off the leitai. Athletes compete using mouthguard, head, torso and underwear protection, as well as boxing gloves. Athletes can utilize all wushu punching, kicking and throwing techniques, and the valid striking and scoring areas are head, torso (chest, abdomen, waist and back) and thighs. Strikes on the back of the head, neck and crotch are prohibited. A match can be won by winning two of the three rounds or by technical knock-out. There are eleven weight categories, from under 48kg until over 90kg at the Senior's Weight Division (18 to 40 years old). There are also seven categories at the Children's Weight Division (12 to 14 years old), and eight weight categories at the Junior's Weight Division (15 to 17 years old). Children and Junior categories have some different and extras rules to guarantee athletes' safety (International Wushu Federation, 2017).

A minimal number of studies investigated wushu sanda athletes, especially during competitions (Artioli et al., 2009). Although investigations in combat sports to examine physiological measurements are restricted, since their invasive approach may disturb competition flow, time-motion and technical-tactical analysis, both non-invasive methods, have been widely used to provide information about physical demands during competitions (Del Vecchio, Hirata, & Franchini, 2011). The time-motion analysis has been used to quantify matches' timing structure and activity phases, enhancing training processes since they can be planned based on modality's specific demands (Del Vecchio et al., 2011; Hughes & Franks, 2007). This approach has been used to quantify time structure of several combat sports such as judo (Miarka et al., 2012), taekwondo (Del Vecchio, Antunez, & Bartel, 2016), Brazilian jiu-jitsu (Andreato et al., 2015), karate (Tabben et al., 2015), kickboxing (Ouergui et al., 2014), and mixed martial arts (Del Vecchio et al., 2011), however, to date, no investigations on wushu sanda athletes were conducted.

Females' participation in combat sports competition is growing in the last twenty years; however, it is still lower than males due to numerous reasons, manly cultural (Pasque, 2009). Boxing, for example, is in the Olympics since 1904, and only in 2012 female athletes were authorized to compete in three weight categories, while there are ten for male athletes (International Olympic Committee, 2015a). Judo is in the Olympics since 1964, but female categories were included only in 1992 (International Olympic Committee, 2015b). The freestyle wrestling is in the Olympics since 1904, and only in 2004, a hundred years later, female athletes were able to compete (International Olympic Committee, 2015c). The Greco-Roman wrestling is in the Olympics since 1896 and, to date, has no female categories (International Olympic Committee, 2015d). Wushu sanda is not in the Olympics, but female athletes have similar conditions to the previously cited Olympic combat sports. In the World Wushu Championships, the biggest and most important wushu competition held every two years since 1991, there are eleven weight categories for male athletes and only seven for females (International Wushu Federation, 2015b). Due to female's participation growth, there is an urge to increase studies on female combat sports athletes, since female athletes present distinct physical, physiological and technical-tactical demands (Miarka, Marques, & Franchini, 2011).

The technical-tactical aspects of female wushu sanda athletes were recently explored (Vasconcelos & Del Vecchio, 2017). However, no data about their time structure is available. Therefore, this study aimed to measure the time-motion structure of elite female wushu sanda athletes during the 13th World Wushu Championships in different weight divisions (light, middle, and heavy categories) and competition phases (eliminatory, quarterfinals, semifinals and finals).

2. Materials and methods

2.1. Experimental approach

To evaluate elite female wushu sanda athletes, matches from the 13th World Wushu Championships (held in Jakarta, Indonesia, in 2015), the first aired World Wushu Championship, were downloaded from the official International Wushu Federation platform, WushuTV.

Athletes from the seven female weight categories were grouped in “light” (<48kg and <52kg), “middle” (<56kg and <60kg) and “heavy” (<65kg, <70kg and <75kg) weight divisions, as previous suggested by Chang (2013).

The time-motion process and the time structure variables selection were based on previous studies (Miarka et al., 2014; Ouergui et al., 2014; Tabben et al., 2015), and are displayed in Table 1. The primary time-motion variables were directly measured (frequency: number of times that it happened during the round, total time: the total amount of time expended on it during the round; mean-time: the mean of time expended each time it happened during the round) in each round of each match. The secondary time-motion variables were calculated using the primary variables' values (Del Vecchio et al., 2011; Silva, Del Vecchio, Picanço, Takito, & Franchini, 2011). Since matches were professionally recorded, filming sometimes stopped focusing on matches to film corners, crowd, the arena, or quick advertisements. To ensure that most parts of the matches were analyzed, the control variable Lost filming time was directly measured (occurrence, total, and mean-time) in each round of each match.

2.2. Participants

Fifty-five female athletes from 31 countries participated in 46 matches during the 13th World Wushu Championships. All 46 matches, accounting 95 rounds, 35 in light, 25 in middle and 35 in heavyweight divisions, took part in the study. All athletes were between 18 and 35 years old, according to the competition regulations (International Wushu Federation, 2015b). As previously pointed (Miarka et al., 2012), this study ensured anonymity and confidentiality by replacing athletes' identification by codes. Moreover, there are no ethical issues in analyzing or interpreting data obtained at public events.

2.3. Procedures

All matches were analyzed using the software Kinovea™. Each match was reproduced in slow motion (50%) twice, totalizing 92 observations; therefore, one athlete was observed each time to ensure that all activities would be registered (Silva et al., 2011; Vasconcelos & Del Vecchio, 2017). To avoid inter-observer variability, a single investigator highly experienced in wushu sanda competitions analyzed all matches to determine the duration of each variable. In order to verify the analysis reliability, ten matches (20 rounds) were randomly chosen and reanalyzed. Reliability was verified using intraclass correlation coefficients (ICCs). Most of the variables had excellent reliability (0.90 – 1.0). Only three variables had no excellent reliability. Two of them had good reliability (Preparation time frequency: 0.75; Preparation time total time: 0.77), and one had bad reliability (Preparation time mean-time: 0.16).

Table 1. Time motion variables in the notational analysis of wushu sanda matches.

Primary time-motion variables	
Microstructural variables	
• Observation time	Standing or active movements with no physical contact, such as steps, bounces or slides
• Preparation time	Feints, distance-measuring, and isolated strikes
• Interaction time	Successive striking exchanges involving sets of punches, kicks, and throws, or clinches. Considered when 1 foot/hand moved to initiate the attack. Finished when a foot/hand-delivered the last strike, when a throw was successful/unsuccessful concluded or when a clinch position was ended
• Referee interruption time	Referee interruptions due to falls, throws, clinches longer than 2s, penalties, and injuries. Considered by referee"s vocal ("ting") and gestural signal to stop fighting. Finished by referee's vocal ("kaishi") and gestural signal to restart fighting
Macrostructural variables	
• Round duration	Total fighting time per round. Measured from referee's vocal ("kaishi") and gestural signal to start fighting to referee's vocal ("ting") and gestural signal to end each round
• Break time	The interval between rounds. Measured from referees vocal ("ting") and gestural signal to end the current round to referee's vocal ("kaishi") and gestural signal to start the next round.
Secondary time-motion variables	
Effort time	Sum of observation, preparation, and interaction times of the round
Pause time	Sum of all referee interruption times of the round
High-intensity time	Sum of all interaction times of the round
Low-intensity time	Sum of all observation and preparation times of the round
Quality control variables	
Lost filming time	When filming lost focus on the match to show corners, crowd, referees, the arena or else

2.3. Statistical analyses

All statistical tests were conducted with software IBM SPSS Statistics, version 20.0. After Shapiro-Wilk's normality test, descriptive statistics were applied to quantify means, standard deviations, and confidence intervals of each variable by round, weight category, and competitive phase. In order to compare each variable by competitive phase and weight division, a one-way ANOVA was conducted with Bonferroni's post hoc. Effort activity, pause activity, high-intensity activity, and low-intensity activity were considered dependent variables. Weight division, competitive phase, round, active moments (observation, preparation, and interaction activities) and non-active moments (pause referee) were considered independent variables.

3. Results

3.1. Descriptive analysis

Table 2 shows the frequency, total, and mean-duration of all time-motion variables per round.

3.2. Comparisons by weight category

Table 3 displays time-motion variables compared by weight categories. There were differences between categories for Total fighting time per round ($F(2,88)=4.68$; $p=0.012$; $\eta 2p=0.096$), and the post hoc test identified that heavyweight group showed higher duration than light ($p=0.004$) and middle ($p=0.019$) categories.

Table 2. Frequency and duration of time-motion variables by round on elite female wushu sanda matches (*n*=92 observations).

Variables	Round 1		Round 2		Round 3	
	M±SD	**CI95%**	***M±SD***	**CI95%**	***M±SD***	**CI95%**
Round duration	158.4±49.8	(148.3;168.6)	163.0±48.1	(153.1;172.8)	167.0±53.7	(156.0;178.0)
Break time	72.3±16.7	(68.9;75.7)	70.8±3.2	(70.1;71.5)	-	-
Observation time						
Frequency (blocks)	13.5±4.0	(12.7;14.3)	13.7±3.9	(12.9;14.5)	12.1±4.0	(11.3;12.9)
Total time	59.3±18.0	(55.6;62.9)	59.2±17.7	(55.6;62.8)	50.6±15.4	(47.5;53.7)
Mean-time	4.5±1.6	(4.2;4.9)	4.6±1.5	(4.2;4.9)	4.3±0.7	(4.2;4.5)
Preparation time						
Frequency (blocks)	3.6±2.6	(3.0;4.1)	3.5±2.7	(3.0;4.1)	2.9±2.1	(2.5;3.3)
Total time	4.2±3.3	(3.5;4.8)	4.1±3.0	(3.4;4.7)	3.4±3.1	(2.8;4.1)
Mean-time	1.2±0.3	(1.1;1.2)	1.2±0.3	(1.1;1.2)	1.1±0.2	(1.1;1.1)
Interaction time						
Frequency (blocks)	11.5±3.6	(10.8;12.3)	11.8±3.7	(11.1;12.6)	11.5±4.0	(10.7;12.3)
Total time	47.2±17.5	(43.6;50.8)	49.7±18.3	(46.0;53.4)	48.5±14.4	(45.6;51.4)
Mean-time	4.1±0.9	(3.9;4.2)	4.2±1.1	(4.0:4.4)	4.3±0.7	(4.2;4.5)
Referee interruption time						
Frequency (blocks)	8.6±4.0	(7.8;9.5)	9.0±3.5	(8.3;9.7)	9.8±4.4	(8.9;10.7)
Total time	48.3±35.6	(41.0;55.5)	51.4±35.5	(44.1;58.6)	64.2±30.2	(58.0;70.4)
Mean-time	5.7±3.6	(5.0;6.5)	5.4±2.0	(5.0;5.8)	6.6±2.2	(6.1;7.1)
Low-intensity time	63.0±19.1	(59.1;66.9)	62.6±18.9	(58.8;66.5)	53.7±16.0	(50.4;57.0)
High-intensity time	47.2±17.5	(43.6;50.8)	49.7±18.3	(46.0;53.4)	48.5±14.4	(45.6;51.4)
Effort time	110.2±25.4	(105.0;115.4)	112.4±21.5	(108.0;116.7)	101.7±27.5	(96.1;107.3)
Pause time	48.3±35.6	(41.0;55.5)	51.4±35.5	(44.1;58.6)	64.2±30.2	(58.0;70.4)

CI95% = 95% confidence interval. All variables are presented in seconds (s)

Table 3. Frequency and duration of time-motion variables by weight category on elite female wushu sanda matches (*n*=92 observations).

Variables	Weight Category						*p*
	Light (-52kg)		Middle (-60kg)		Heavy (+60kg)		
	M±SD	**CI95%**	***M±SD***	**CI95%**	***M±SD***	**CI95%**	
Round duration	152.8±49.3	(138.5;167.1)	146.5±32.5	(129.0;164.1)	179.0±42.8‡	(163.6;194.5)	0.012
Break time	73.3±30.8	(66.0;80.6)	69.5±2.6	(60.6;78.5)	64±17.5	(56.1;71.8)	0.226
Observation time							
Frequency (blocks)	13.8±4.2	(12.7;15.0)	13.6±3.6	(12.2;15.1)	13.1±2.7	(11.9;14.4)	0.720
Total time	61.6±19.9	(56.2;66.9)	60.9±13.4	(54.4;67.4)	53.8±12.5	(48.0;59.5)	0.113
Mean-time	4.7±1.3	(4.2;5.1)	4.8±1.1	(4.2;5.3)	4.3±1.5	(3.8;4.7)	0.305
Preparation time							
Frequency (blocks)	3.4±2.5	(2.6;4.2)	3.2±2.1	(2.2;4.1)	3.5±2.5	(2.6;4.3)	0.872
Total time	3.8±2.8	(2.8;4.7)	3.3±2.1	(2.1;4.5)	4.7±3.4	(3.7;5.7)	0.194
Mean-time	1.0±0.3	(0.9;1.1)	1.0±0.3	(0.9;1.2)	1.3±0.3‡	(1.2;1.4)	<.001
Interaction time							
Frequency (blocks)	11.5±4.0	(10.4;12.6)	11.3±2.9	(9.9;12.6)	11.9±2.6	(10.7;13.1)	0.770
Total time	45.7±21.0	(40.3;51.2)	45.2±13.9	(38.5;51.9)	52.1±11.5	(46.2;58.0)	0.198
Mean-time	3.8±1.0	(3.5;4.1)	4.0±0.7	(3.7;4.4)	4.4±0.7†	(4.1;4.7)	0.015
Referee interruption time							
Frequency (blocks)	7.9±4.1	(6.8;9.0)	7.8±2.6	(6.4;9.1)	10.3±3.0‡	(9.1;11.5)	0.006
Total time	42.1±26.0	(32.9;51.3)	37.3±13.3	(26.0;48.5)	69.0±36.5‡	(59.1;78.9)	<.001
Mean-time	5.3±1.7	(4.3;6.0)	4.8±0.7	(3.9;5.7)	6.9±3.3‡	(6.1;7.7)	0.001
Low-intensity time	65.1±21.8	(59.4;70.7)	64.1±13.7	(57.2;71.0)	58.0±12.4	(51.9;64.0)	0.207
High-intensity time	45.7±21.0	(40.3;51.2)	45.2±13.9	(38.5;51.9)	52.1±11.5	(46.2;58.0)	0.198
Effort time	110.8±29.9	(103.0;118)6)	109.3±21.5	(99.7;118.8)	110.0±14.9	(101.6;118.4)	0.969
Pause time	42.1±26.0	(32.9;51.3)	37.3±13.3	(26.0;48.5)	69.0±36.5‡	(59.1;78.9)	<.001

† = different from Light groups (p<0.05). ‡ = different from other two groups (p<0.05). CI95% = 95% confidence interval. All variables are presented in seconds (s).

There were no differences for Interval between rounds ($F(2,88)=1.51$; $p=0.226$; $\eta 2p=0.033$) among weight categories.

For Observation time, were found no differences among categories on frequency ($F(2,88)=0.33$; $p=0.720$; $\eta 2p=0.007$), total time ($F(2,88)=2.24$; $p=0.113$; $\eta 2p=0.048$) and mean time ($F(2,88)=1.20$; $p=0.305$; $\eta 2p=0.027$).

For Preparation time, there were differences only for mean time ($F(2,88)=10.8$; $p<0.001$; $\eta 2p=0.197$), where heavy categories were higher than light ($p<0.001$) and middle ($p=0.002$) categories. There were no differences for frequency ($F(2,88)=0.14$; $p=0.872$; $\eta 2p=0.003$) and total time ($F(2,88)=1.67$; $p=0.194$; $\eta 2p=0.037$).

For Interaction time, the analysis showed differences only for mean time ($F(2,88)=4.41$; $p=0.015$; $\eta 2p=0.091$), and heavy were different from light group ($p=0.011$). No differences were pointed for frequency ($F(2,88)=0.14$; $p=0.872$; $\eta 2p=0.003$) and total time ($F(2,88)=1.65$; $p=0.198$; $\eta 2p=0.036$).

There were differences for Referee interruption time on frequency ($F(2,88)=5.51$; $p=0.006$; $\eta 2p=0.111$), total time ($F=2,88)=11.25$; $p<0.001$; $\eta 2p=0.204$) and mean time ($F(2,88)=7.12$; $p=0.001$; $\eta 2p=0.139$). On the frequency of occurrence, the heavy-group showed a higher number of Referee interruptions than light ($p=0.011$) and middle ($p=0.019$) categories. On total time, the heavy-group was higher than light ($p<0.001$) and middle ($p<0.001$) categories. On the mean-time, heavy were higher than light ($p=0.010$) and middle ($p=0.002$) groups.

There were no differences for High Intensity time ($F(2,88)=1.65$; $p=0.198$; $\eta 2p=0.0036$) and Low Intensity time ($F(2,88)=1.61$; $p=0.207$; $\eta 2p=0.035$). Figure 1 displays effort and pause times among weight categories. No differences were found for Effort time ($F(2,88)=0.03$; $p=0.969$; $\eta 2p=0.001$). On Pause time, the heavy-group was higher than light ($p<0.001$) and middle ($F=2,88)=11.25$; $p<0.001$; $\eta 2p=0.204$) categories.

3.3 Comparisons by competitive phase

Table 4 displays time-motion variables considering competitive phase. There were no differences for total fighting time per round ($F(3,82)=0.33$; $p=0.807$; $\eta 2p=0.012$). Differences were noticed for interval between rounds ($F(3,82)=6.45$; $p=0.001$; $\eta 2p=0.191$), being eliminatory fights different from final fights ($p=0.001$).

On Observation time, there were no differences for frequency ($F(3,82)=1.82$; $p=0.150$; $\eta 2p=0.062$) and mean time ($F(3,82)=1.27$; $p=0.290$; $\eta 2p=0.044$), but differences were shown for total time ($F(3,82)=4.37$; $p=0.007$; $\eta 2p=0.138$), being semifinals different from quarterfinals ($p=0.031$) and finals ($p=0.038$).

There were no differences from Preparation time on frequency ($F(3,82)=1.39$; $p=0.252$; $\eta 2p=0.048$), total time ($F(3,82)=0.76$; $p=0.517$; $\eta 2p=0.027$) and mean time ($F(3,82)=1.25$; $p=0.297$; $\eta 2p=0.044$).

For Interaction time, no differences were noticed for frequency ($F(3,82)=0.87$; $p=0.462$; $\eta 2p=0.031$), total time ($F(3,82)=0.06$; $p=0.980$; $\eta 2p=0.002$) and mean time ($F(3,82)=1.00$; $p=0.397$; $\eta 2p=0.035$).

Also, no differences were found for Referee interruption time in frequency ($F(3,82)=0.47$; $p=0.707$; $\eta 2p=0.017$), total time ($F(3,82)=0.37$; $p=0.776$; $\eta 2p=0.013$), and mean time ($F(3,82)=0.24$; $p=0.870$; $\eta 2p=0.009$).

There were differences for Low Intensity time ($F(3,82)=4.44$; $p=0.006$; $\eta 2p=0.140$), being semifinals different from quarterfinals ($p=0.024$) and finals ($p=0.031$), while there were no differences for High Intensity time ($F(3,82)=0.06$; $p=0.980$; $\eta 2p=0.002$). Also there were no differences for Effort time ($F(3,82)=1.83$; $p=0.148$; $\eta 2p=0.063$) and Pause time ($F(3,82)=0.37$; $p=0.776$; $\eta 2p=0.013$).

Table4. Frequency and duration of time-motion variables by competitive phase on elite female wushu sanda matches (*n*=92 observations).

Variables	Competitive phase												*p*
	Eliminatory			Quarterfinals			Semifinals			Finals			
	M	*SD*	CI95%	*M*	*SD*	CI95%	*M*	*SD*	CI95%	*M*	*SD*	CI95%	
Round duration	151.9	54.4	(128.7;175.1)	161.5	33.9	(145.5;177.4)	158.2	62.1	(139.2;177.1)	168.8	25.6	(142.1;195.6)	0.807
Break time	87.6	35.3	(77.3;98.0)	68.9	2.7	(61.8;76.0)	63.8	20.0	(55.3;72.2)	55.5	26.1	(43.5;67.5)	0.001
Observation time													
Frequency (blocks)	12.9	4.3	(11.2;14.7)	14.7	3.1	(13.5;15.9)	12.7	4.1	(11.3;14.2)	14.0	2.2	(11.9;16.0)	0.150
Total time	52.7	22.4	(45.0;60.5)	63.0	12.4	(57.6;68.3)	51.3	16.6	(45.0;57.6)	66.3	9.7	(57.4;75.3)	0.007
Mean-time	4.1	1.5	(3.5;4.7)	4.4	0.9	(4.0;4.8)	4.5	1.5	(4.0;5.0)	5.0	1.3	(4.3;4.7)	0.290
Preparation time													
Frequency (blocks)	3.9	1.8	(2.8;5.1)	3.8	2.7	(3.0;4.6)	2.6	1.9	(1.7;3.6)	3.4	2.9	(2.0;4.7)	0.252
Total time	4.6	2.1	(3.1;6.1)	4.1	3.0	(3.1;5.1)	3.3	3.0	(2.1;4.5)	4.2	3.7	(2.5;5.8)	0.517
Mean-time	1.2	0.2	(1.0;1.3)	1.0	0.3	(0.9;1.1)	1.1	0.4	(1.0;1.3)	1.2	0.3	(1.0;1.4)	0.297
Interaction time													
Frequency (blocks)	10.5	3.7	(8.9;12.2)	12.2	2.3	(11.0;13.3)	11.7	4.6	(10.3;13.0)	11.9	1.9	(10.0;13.8)	0.462
Total time	47.8	19.9	(39.2;56.4)	47.9	15.1	(42.1;53.8)	48.7	21.4	(41.7;55.7)	46.1	7.1	(36.1;56.0)	0.980
Mean-time	4.4	1.1	(3.9;4.8)	3.9	0.9	(3.7;4.2)	4.0	0.8	(3.7;4.4)	3.9	0.5	(3.4;4.4)	0.397
Referee interruption time													
Frequency (blocks)	7.9	3.5	(6.1;9.8)	8.5	3.5	(7.2;9.7)	9.1	4.6	(7.6;10.6)	9.3	0.7	(7.2;11.3)	0.707
Total time	48.5	27.9	(32.7;64.4)	46.4	32.0	(35.5;67.3)	54.9	33.1	(42.0;67.9)	52.2	34.2	(33.8;70.5)	0.776
Mean-time	5.9	1.4	(4.7;7.1)	5.4	2.5	(4.6;6.3)	5.9	2.0	(4.9;6.9)	5.7	3.8	(4.3;7.1)	0.870
Low-intensity time	56.8	23.5	(48.6;64.9)	66.9	14.6	(61.3;72.5)	54.2	16.3	(47.5;60.9)	70.5	7.8	(61.1;79.9)	0.006
High-intensity time	47.8	19.9	(39.2;56.4)	47.9	15.1	(42.1;53.8)	48.7	21.4	(41.7;55.7)	46.1	7.1	(36.2;56.0)	0.980
Effort time	104.5	32.7	(92.8;116.1)	114.9	8.0	(106.9;122.9)	102.9	33.7	(93.4;112.4)	116.6	8.9	(103.1;130.1)	0.063
Pause time	48.5	27.9	(32.7;64.4)	46.4	32.0	(35.5;67.3)	54.9	33.1	(42.0;67.9)	52.2	34.2	(33.8;70.5)	0.776

CI95% = 95% confidence interval; All variables are presented in seconds (s)

3.4 *Effort:pause and High:low-intensity ratios*

Table 5 displays the effort:pause and high:low-intensity ratios of matches by rounds, weight categories, and competitive phases.

Table 5. Effort:pause and high:low intensity ratios on elite female wushu sanda athletes (*n*=92 observations)

Category	E:P	HI:LI
General	2.2:1	1:1.3
Match phases		
Round 1	2.3:1	1:1.3
Round 2	2.2:1	1:1.3
Round 3	1.6:1	1:1.1
Weight category		
Light (-52kg)	2.6:1	1:1.4
Medium (-60kg)	2.9:1	1:1.4
Heavy (+60kg)	1.6:1	1:1.1
Competitive phase		
Eliminatory	2.2:1	1:1.2
Quarterfinals	2.5:1	1:1.4
Semifinals	1.9:1	1:1.1
Finals	2.2:1	1:1.5

E:P = effort:pause ratio; HI:LI = high:low intensity ratio

4. Discussion

The purpose of the present study was to describe the time-motion characteristics of female wushu sanda matches from the 13th World Wushu Championships. We also compared these findings by weight category and competitive phase. Few studies investigated biodynamic aspects on wushu sanda (Artioli et al., 2009; Ribeiro, de Castro, Rosa, Baptista, & Oliveira, 2006), especially considering female athletes (Chang, 2013), and to the best of the author's knowledge, this is the first study to investigate time-motion characteristics on wushu sanda. As the main findings, we point the measuring of the E:P for international level female athletes, which is 2.2:1, and the H:L, which is 1:1.3. Additionally, we found and O-P-I of 4.5-1.2-4.2 seconds. This information may contribute to a better understanding of the profile of sanda matches.

Previously, Del Vecchio et al. (2011) explored temporal characteristics among male athletes on MMA, one of the most known mixed-orientation (contains both striking and grappling motor actions) modalities, and found an E:P of 6:1, 9:1 and 6:1 on the first, second and third rounds respectively, besides an H:L of 2:1. wushu sanda is also a mixed-orientation modality, and we found in this study, among female athletes, E:P of 2.3:1, 2.2:1 and 1.6:1 for first, second, and third rounds, respectively. Despite gender peculiarities, several differences can explain these results. Firstly, while a sanda match lasts until three rounds of 2 minutes each, an MMA match can last until five rounds of 5 minutes each (Miarka, dal Bello, Brito, & Amtmann, 2018). When it comes to rules, while MMA fighters are allowed to clinch and fight on the ground (Ultimate Fighting Championship, 2020), sanda fighters cannot clinch for more than 2 seconds, or the match is interrupted (International Wushu Federation, 2017). Athletes also cannot fight on the ground. Whenever an athlete falls to the ground or is thrown out of the leitai, the match is also interrupted (International Wushu Federation, 2017), while in MMA it is not possible to fall from the octagon and there are fewer interruptions provided by the rules (Ultimate Fighting Championship, 2020). The higher number of interruptions on sanda can be responsible for lower effort times and higher pause times durations, which affects the high and low-intensity efforts durations directly, and provides unique data to the training process.

Several differences were identified due to weight categories. We found that heavy category matches last longer than both light and middle categories, and differences in other variables can explain it. Heavy categories also have higher preparation and interaction mean-time, as well as pause time frequency, total, and mean-time durations, which directly affect match duration. It is probably justified by heavy athletes' behavior, who tend to clinch more than light and middle athletes, applying more throwing techniques from clinch positions (Chang, 2013), expending more time on interaction efforts. This behavior also justifies the higher number for interruptions, since clinching for more than 2 seconds causes an interruption, and also higher interruptions' duration, since interruptions last longer after a throw, once athletes need to get up and recompose themselves to back fighting. In this sense, for a more specific prescription according to weight categories, training sessions based on E:P should use a ratio of 1.5:1 for heavy categories and 2.5:1 to 3:1 for light and middle categories.

In international sanda competitions, female athletes need to win 2-3 matches to reach the final, usually round of 16, quarterfinals, and semifinals (International Wushu Federation, 2015a). There are few studies concerning time-motion analysis in CS considering competitive phases. In judo, male athletes' matches from the Olympic Games and International Championships have a very similar time-motion profile, with a small difference in groundwork duration (Miarka et al., 2016). Also, with male athletes, it was found that matches with lower-level show an E:P of 1:4, while state-level matches have an E:P of 1:8 (Del Vecchio et al., 2016). However, it worths highlighting that, at least in MMA, male and female matches have a different time-motion profile (Del Vecchio et al., 2015). In the present study, when comparing the time-motion variables by competitive phases, the intervals between rounds were longer in final matches, and low-Intensity time was lower on semifinals when compared to quarterfinal and final matches. Highlights that a champion athlete has to fight for consecutive days and may realize more than one match on the same day during an international championship. These results suggest that athletes tend to observe more their opponents before starting to attack them on eliminatory matches, once they do not know each other's fighting style, while on semifinal matches athletes and coaches already could observe all contestants, justifying lower observation periods (Ouergui et al., 2014). On final matches, observation time increase can be explained by athletes' precaution on decisive moments and, mainly, due to accumulated fatigue throughout the competition, as observed in wrestling (Barbas et al., 2011), judo (Branco et al., 2013), and Brazilian jiu-jitsu (Andreato et al., 2015).

As a practical application, we suggest exercises with a typical match duration (2 or 3 rounds of 2 minutes each with a 1-minute interval in between) using sequences of observation, preparation, and interaction stimuli (Del Vecchio et al., 2011). From our pioneer data, observation stimuli can last 4 to 5 seconds, and athletes should focus on realizing steps. Preparation stimuli can last 1 to 2 seconds, and athletes should focus on realizing isolated strikes (avoiding throws). Interaction stimuli can last 4 to 5 seconds, and athletes should focus on elaborated high speed striking sequences ending with a throwing technique. Every O-P-I cycle should last 9 to 12 seconds and be repeated 10 to 12 times per round.

Finally, the present study has two limitations. The first considering the data acquisition, since we used streamed combats. To minimize this bias, we calculated the lost time, which was responsible for 0.3% of all records (30 interruptions, totalizing 106 seconds among all matches), a meager percentage. Secondly, only one observer analyzed the matches from this study, and we tried to minimize this bias through an intra-rater reproducibility test considering frequency, total, and mean-time of each variable, which indicated excellent reproducibility for almost all of them (except one, preparation mean-time). Future studies should advance on time-motion analysis in sanda, relating motor and temporal aspects in an attempt to characterize different profiles through weight category, and competitive phase.

5. Conclusion

In conclusion, time-motion analysis of international level wushu sanda female matches showed an intermittent nature, with effort:pause ratio of 2.2:1, a high:low intensity efforts ratio of 1:1.3, and mean observation-preparation-interaction times of 4.5-1.2-4.2 seconds. Athletes presented distinct time-motion characteristics when compared by weight categories. Heavyweight categories had higher total fighting time per round than the light and middle categories. Also, heavyweight categories had longer preparation, interaction mean-time, and referee interruption time frequency, total and mean times than the light and middle categories. Total pause time was also higher for heavyweights. According to the competitive phase, semifinal matches had shorter observation times than eliminatory and final matches. Also, semifinal matches had lower low-intensity time than quarterfinals and finals. These findings suggest that athletes may have distinct physiological responses and may experience different efforts according to their weight category and each competition phase, which may be of interest of practitioners and coaches when programming athletes' training processes.

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Author's biographical data

Breno Berny Vasconcelos (Brazil). Physical Education Master's Degree student in the research line of Human Performance and Metabolism at ESEF/UFPel. Technical director of the Rio Grande do Sul state Wushu Taolu team (Brazil). Athlete of the Brazilian Wushu Taolu National Team (2014-2015). Member of the group of studies and research in sports training and human performance (GEPETED) in ESEF/UFPel. Black belt in Wushu. E-mail: brenobvasc@gmail.com

Fabrício Boscolo Del Vecchio (Brazil). PhD in Physical Education in FEF/UNICAMP, PhD advisor in ESEF/UFPel. Leader of the group of studies and research in sports training and human performance (GEPETED) in ESEF/UFPel. Black belt 2º dan in Judo. E-mail: fabricio_boscolo@uol.com.br