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Sport Performance Indicators of the *Miluh-chagi* Taekwondo Kick Technical System

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Abstract: Taekwondo masters and coaches believe that they have a kind of "eagle eye" and that is why they feel comfortable to analyze athletes' skills without using essential tools. The aim of this study was to analyze the athletes' technical indicators during performance of the Miluh-chagi kick. To analyze the reliability and precision of the cycle of ten kicks (n = 120), performed by 5 women and 7 men senior athletes, we used an expert panel and a previously published observational tool. The coefficient of variation was calculated to verify precision. The intraclass correlation coefficient was calculated to confirm the reliability among the evaluators. Student's t-test was used for group-to-group analysis. Correlation analyses were accessed using Spearman's rho. The data quality sample reliability results, for group, intra- and inter-rater were excellent and good respectively. Statistically significant differences, with a large effect size, were found in the foot take-off, knee up and start leg flexion observational moments. The values showed a small and negative to moderate correlation between the conducts and aggregates criteria. Perfect correlation values were found between support leg foot and contact leg position. These findings meet the measurement requirements of athletes' technical indicators to analyze motor behavior, development and performance of this technique.

Keywords: taekwondo; miluh-chagi; motor behavior; motor development; observational methodology

1. Introduction

Taekwondo is a Korean martial art and combat sport, that has been an Olympic discipline since the Sidney (2000) Olympic Games, where kicking skills are crucial for a high motor performance. This combat sport originated in medieval or similar cultures, and today it is primarily a combat activity conditioned by safety rules [1]. ***Miluh-chagi*** is a Taekwondo kicking technique, and can be directed at the opponent's middle and higher zone. It is a typical Taekwondo push kick but can also score like any other kick. The trajectory follows a linear movement. The foot contact zone, with the target, can be made by the tip of the foot with flexion of the toe, the outside of the foot, and the sole of the foot. Elite athletes successfully use this kick with the front leg and change the target zone, correct the trajectory, needing less time relative to speed for foot motor control, and adjust the foot trajectory earlier than other athletes; and no bilateral difference was found in any of the variables on the knee flexion and extension assessment [2,3,4]. The authors Kim et al., [5] identified four phases for kicks: Start (A), Toe off (B), Maximum Knee Flexion (C), and Impact (D); and three moments: Push, Lift, and Strike. The authors [6] identified three phases and six moments: Foot take-off, knee up, contact moment, start leg extension, start leg flexion and thigh extension. The authors Gavacan & Sayers [7] also describe four phases in the analysis of the kick technical process. The preparation phase was defined as occurring from toe down of the support leg until toe off of the kicking leg. The

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chamber phase started at the end of the preparation phase and continued until the beginning of knee extension in the kicking leg. The extension phase followed and continued until contact with the target pad. The studies presented by Gavacan et al. (2007) and Barnamehei, et al. (2007) [7,8] assert that all this movement must be executed at a high velocity by rapid pelvic axial rotation, hip abduction, hip flexion and knee extension, combined with rapid movements of the center of mass towards the target. In the Taekwondo combat sport, the sporting outcome depends for the most part on the technical perfection of the kick. The athletes' kicking skills execution is essential for a good performance, seeking a masterly presentation of the martial art [6].

Taekwondo coaches believe that they have a kind of "eagle eye" and that is why they feel comfortable to analyze athletes' skills without using essential observational tools. In contrast, O'Donoghue argued that the role of the performance analyst working with coaches and athletes is to help enhance performance through a cycle of observation, analysis, reflection, planning and action. The coach observes the athlete performing the skill and this observation is evaluated by comparing it with the theoretical ideal performance [9]. The use of fundamental indicators to model performance and establish performance profiling has provided the basis with high applicability for coaching staff to manage performance during training and competition [10]. Gomez-Ruano et al., (mention Hughes and Franks, 2007) say that the development and implementation of new measurement technologies (e.g., observational video analysis systems) with multiple practical applications have intensified the focus of performance analysis in sport [10]. Researchers have shown that human observation and memory are not reliable enough to provide accurate and objective information for high-performance athletes. So objective measuring tools using technology are necessary to enable the feedback process [11].

The aim of this study was to analyze the athletes' technical indicators during the technical skill implementation of "a cycle of ten kicks" performing one Taekwondo technique namely - *Miluh-chagi*. This study used a previously designed, validated and published observation tool, the Observation System for Technical Performance Indicators - Chagi (OSTIP-C) Sousa et al. [1].

2. Materials and Methods

2.1. *Study Design*

The present study is a part of the quantitative empirical studies. An arbitrary observation code was used in a natural environment [12].

2.2. *Observation moments*

To achieve the study goal, we used the observation instrument designed, validated and published by Sousa et al. [1] called the *Observation System for Technical Performance Indicators - Chagi (OSTPI-C)* to characterize the observation moments for analysis of the Miluh-chagi technique performance cycle and, from these, create the behavioral events of the athletes for data analysis in Taekwondo (observation criteria). Thus, we followed the procedure recommended by Sousa et al. [1] which includes three phases with six moments of observation. To evaluate the athletes' performances the variables were measured by a panel of evaluators at six observation moments through a cycle of ten technical gestures.

2.3. *Study variables, criteria and alphanumeric codes*

The variables took the form of characteristic conduits subdivided into: conduct criteria and aggregate criteria.

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Table 1. Alphanumeric codes of conduct criteria and aggregate criteria by contact leg, support leg, head, trunk, left arm and right arm. An upgrade from Sousa et al., (2022) [1].

Variables	Criteria		Alphanumeric Codes
(V1) -Foot take-off (V2) -Knee lift (V3) -Start of leg extension (V4) -Contact moment (V5) -Start of leg flexion (V6) -Thigh extension	**Conducts criteria**	Contact leg (CL)	1CL1 - In trunk extension; 1CL2 - Back; 1CL3 - Facing front; 1CL4 - Facing forward; 1CL5 - Facing out up to 45º; 1CL6 - Facing out up to 90º; 1CL7 - Straight flexion of the thigh and leg; 1CL8 - Acute flexion of the thigh and leg; 1CL9 - Obtuse flexion of the thigh and leg; 1CL10 - Foot extension; 1CL11 - Neutral; 1CL12 - Foot flexion. 2CL1 - Straight leg flexion; 2CL2 - Acute flexion of the leg; 2CL3 - Obtuse flexion of the leg; 2CL4 - Facing forward; 2CL5 - Facing backward; 2CL6 - Facing in; 2CL7 - Facing out; 2CL8 - Obtuse flexion; 2CL9 - Extension; 2CL10 - Hyper-extension; 2CL11 – Tip of the foot with flexion of toe; 2CL12 - Dorsum of the foot; 2CL13 - Inner part of the foot; 2CL14 - Outside of the foot; 2CL15 - Sole of the foot; 2CL16 - Heel of the foot. 3CL1 - Facing horizontal; 3CL2 - Facing vertical; 3CL3 - Facing diagonal; 3CL4 -Facing up and in extension; 3CL5 - Facing up and in flexion; 3CL6 - Facing in and in extension; 3CL7 - Facing in and in flexion; 3CL8 - Facing forward; 3CL11 - Facing in up to 45º; 3CL12 - Facing in up to 90º; 3CL13 - Facing in up to 180º.

			1SL1 - With obtuse flexion; 1SL2 - In extension; 1SL3 - Facing out; 1SL4 - Facing forward; 1SL5 - Facing in; 1SL6 - Extension; 1SL7 - Obtuse flexion; 1SL8 - Facing forward; 1SL9 - Facing out less than 90º; 1SL10 - Facing out more than 90º; 1SL11 - Facing forward; 1SL12 - Facing out less than 90; 1SL13 - Facing out more than 90.
			2SL1 - Obtuse flexion; 2SL2 - In extension; 2SL3 - Hyper-extension; 2SL4 - Facing out in external rotation less than 45º; 2SL5 - Facing out in external rotation less than 90º; 2SL6 - Facing out in external rotation less than 135º; 2SL7 - Extension; 2SL8 - Obtuse flexion; 2SL9 - Hyper-extension; 2SL10 - On tiptoe in external rotation less than 90º; 2SL11 - On tiptoe in external rotation less than 135º; 2SL12 - On tiptoe in external rotation less than 180º; 2SL13 - On the sole in external rotation less than 90º; 2SL14 - On the sole in external rotation less than 135º; 2SL15 - On the sole in external rotation less than 180º.
		Support leg (SL)	3SL1 - Obtuse flexion; 3SL2 - In extension; 3SL3 - In hyper-extension; 3SL4 - Facing out in external rotation up to 45º; 3SL5 - Facing out in external rotation up to 90º; 3SL6 - Facing out in external rotation up to 180º; 3SL7 - Obtuse flexion; 3SL8 - In extension; 3SL9 - Hyper-extension; 3SL10 - Facing forward; 3SL11 - Facing out up to 45º; 3SL9 - Facing out up to 90º.
			1H1 - Extension; 1H2 - Neutral; 1H3 - Flexion; 1H4 - Extension; 1H5 - Neutral; 1H6 - Flexion.
			2H1 - Extension; 2H2 - Neutral; 2H3 - Flexion; 2H4 - Extension; 2H5 - Neutral, 2H6 - Flexion.
	Aggregates criteria	Head (H)	3H1 - Extension; 3H2 - Neutral; 3H3 - Flexion; 3H4 - Extension; 3H5 - Neutral; 3H6 - Flexion.

		Trunk (T)	1T1 - Front; 1T2 - Diagonal; 1T3 - Lateral; 1T4 - Front; 1T5 - Diagonal; 1T6 - Lateral. 2T1 - Front; 2T2 - Diagonal; 2T3 - Lateral; 2T4 - Front; 2T5 - Diagonal; 2T6 - Lateral. 3T1 - Front; 3T2 - Diagonal; 3T3 - Lateral; 3T4 - Front; 3T5 - Diagonal; 2T6 - Lateral.
		Left arm (La)	1La1 - Arm and forearm in extension; 1La2 - Arm and forearm in obtuse flexion; 1La3 - Arm and forearm in acute flexion; 1La4 - Arm and forearm in extension; 1La5 - Arm and forearm in obtuse flexion; 1La6 - Arm and forearm in acute flexion. 2La1 - Arm and forearm in trunk prolongation; 2La2 - Arm in trunk prolongation and forearm flexion; 2La3 - Arm in hyper-extension and forearm extension; 2La4 - Arm and forearm in trunk prolongation; 2La5 - Arm in trunk prolongation and forearm flexion; 2La6 - Arm in hyper-extension and forearm extension. 3La1 - Arm and forearm in trunk prolongation; 3La2 - Arm in trunk prolongation and forearm flexion; 3La3 - Arm in hyper-extension and forearm extension; 3La4 - Arm and forearm in trunk prolongation; 3La5 - Arm in trunk prolongation and forearm flexion; 3La6 - Arm in hyper-extension and forearm extension.

		Right arm (Ra)	1Ra1 - Arm and forearm in extension; 1Ra2 - Arm and forearm in obtuse flexion; 1Ra3 - Arm and forearm in acute flexion; 1Ra4 - Arm and forearm in extension; 1Ra5 - Arm and forearm in obtuse flexion; 1Ra6 - Arm and forearm in acute flexion. 2Ra1 - Arm and forearm in trunk prolongation; 2Ra2 - Arm in trunk prolongation and forearm flexion; 2Ra3 - Arm in hyper-extension and forearm extension; 2Ra4 - Arm and forearm in trunk prolongation; 2Ra5 - Arm in trunk prolongation and forearm flexion; 2Ra6 - Arm in hyper-extension and forearm extension. 3Ra1 - Arm and forearm in trunk prolongation; 3Ra2 - Arm in trunk prolongation and forearm flexion; 3Ra3 - Arm in hyper-extension and forearm extension; 3Ra4 -Arm in trunk prolongation and forearm flexion; 3Ra5 - Arm in trunk prolongation and forearm flexion; 3Ra6 - Arm in hyper-extension and forearm extension.

V1 … V2: Variables

2.4. *Data on a cycle of ten kicks and athletes' sample of practitioners*

The sample consisted of a technical cycle of ten kicks (*n* = 120), performed by 5 senior women (*n* = 50) and 7 senior men (*n* = 70) Portuguese Taekwondo athletes in the Olympic combat discipline. The whole sample of athletes: S_{age} = 22.5 ± 2.6; S_{height} = 170.3 ± 6.4; S_{weight} = 65.3 ± 9.5; $S_{practice\ years}$ = 7.3 ± 1.3. The women's weight categories were Under 53kg (*n* = 1), Under 57kg (*n* = 2), Under 62kg (*n* = 1), and Under 67kg (*n* = 1). The men's weight categories were Under 58Kg (*n* = 1), Under 68kg (*n* = 2), Under 74kg (*n* = 2), Under 80kg (*n* = 1), and U87kg (*n* = 1). Regarding the Taekwondo Black Belt DAN degree (1º DAN - *n* = 3; 2º DAN - *n* = 6 and 3º DAN - *n* = 3). The athletes had been members of the Portuguese national team at least once. The study followed the ethical guidelines outlined in the Declaration of Helsinki and the research study project was approved by a scientific committee of the University of Extremadura, Cáceres, Spain. Before their participation all the athletes were informed of the procedures, use, nature, and purpose of the study and filled out an informed consent form.

2.5. *Evaluator panel*

All the evaluators received prior and strict observation training according to recommendations by several authors [13-19]. When a person is invited to be an observer, he/she must learn "to see what they are really asked to see" [16-20]. Carrying out the training of the evaluators, we followed the methodological recommendations upgrade proposed by Medina & Delgado and Escobar-Pérez & Cuervo-Martínez [20,21]. The expert panel (evaluator panel) consisted of five evaluators one being an international expert (evaluator 1) with more than 30 years' experience, a national coach level of G3, a world coach level and 7th DAN Black Belt Taekwondo degree. The other four evaluators had:

25 years' experience, a European coach level and 6th DAN Black Belt Taekwondo degree (evaluator 2), two had 20 years' experience, a national coach's level of G3 and 5th DAN Black Belt Taekwondo degree (evaluators 3 and 4), and one had 15 years' experience, a national coach level of G2 and 4th DAN Black Belt Taekwondo degree (evaluator 5). DAN is a term that characterizes an advanced martial arts rank indicating greater knowledge and skills.

2.6. *Procedure*

The data collection was conducted in one single day at Rio Maior City, Portugal. In the first step the athletes were informed of the procedures and purpose of the study lineup. Then, they filled out an informed consent form. Thereafter they received a briefing session on the conditions under which the protocol was to be performed, the objectives of the study and the measurements that would be taken.

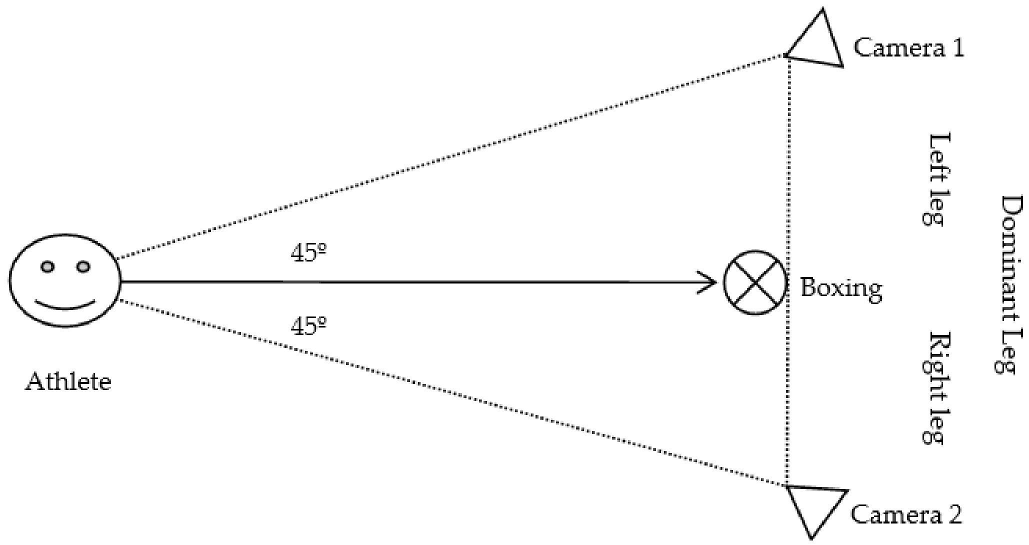

Figure 1. Representation of image collection, authors' creation.

The condition of execution of the athlete's technical gesture consisted of a cycle of ten kicks at maximum speed without an oral or whistle command. For data collection, the camcorder was positioned diagonally 45º to the right, relative to the action of the athletes and 350cm from the beginning of the gesture. The athletes performed ten kicks against a boxing bag and they were all requested to perform the action with their dominant leg. The use of this system for technical movement analysis in Taekwondo followed a set of procedures: - The observer is placed perpendicular to the punching bag on the contact leg side, and the image covers the entire area of intervention and technical execution of the athlete. For image/video recording we used a Casio ZR200 camcorder with 10x Optical Zoom. To make and capture digital images we used Match Vision Software and viewing in AVI format. After collecting images of ten kick cycles executed by the athletes, the training phase of the observers began [6].

2.7. *Statistical analysis*

The results are presented as Mean ± Standard Deviation (SD). The Intraclass Correlation Coefficient (ICC) between observers to measure the evaluators' reliability was used with values varying between variables in six observation moments. The reference values for the ICC were <0.5 (Poor), 0.5-0.75 (Moderate), 0.75-0.90 (Good), and ≥0.90 (Excellent) [22,23,24]. The Coefficient of

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Variation (CV) is the ratio of the standard deviation to the mean, and shows the extent of variability in relation to the mean of the population. The CV was expressed as a percentage [CV = (SD/Ẋ).100] and used to verify precision [23,24,25]. Student´s *t*-test was used to compare the maximum values of the variables: take-off of the foot, knee up, start leg extension, contact moment, start leg flexion, and thigh extension in the women and men Taekwondo athletes. The effect size (Cohen's d) was calculated and rated according to Cohen and Lakens [26,27,28] as ǀ d ǀ < 0.20 (Trivial), ǀ d ǀ = 0.20 - 0.49 (Small), ǀ d ǀ = 0.50 - 0.79 (Moderate), and ǀ d ǀ > 0.79 (Large). Correlation analysis was carried out calculating Spearman's rho. The criteria indicated by Hopkins et al. [24] were used to assess the strength of correlation such as: 0-0.30 (Small), 0.31-0.49 (Moderate), 0.50-0.69 (Large), 0.70-0.89 (Very large), and 0.90-1 (Almost perfect). The results are presented as Mean ± Standard Deviation (SD). Statistical significance was set at the ** $p < 0.01$ and * $p < 0.05$ for all analyses in this study. Correlation coefficient analysis was carried out using the non-parametric test of Spearman's rho, because the Kolmogorov-Smirnov test of distribution of the data on the continuous variables did not meet the assumption of normality. For that reason, Spearman's rho test was used to analyze the association between each of the six variables. The Spearman's rho results of the six variables are shown in the tables below. The values of the correlation coefficient for all variables did not exceed 0.85, which means that there was no problem of multicollinearity [23,24,29]. All the data analysis was performed using IBM SPSS 24.0 software, and figures were created by Excel spreadsheet for Windows.

3. Results

Valid and complete results were obtained throughout a technical cycle of ten kicks (n = 120) performed by 12 athletes (41.7% women and 58.3% men). Table 2 displays the main characteristics of the Taekwondo athletes which were not significantly different in terms of age and Taekwondo practice years. The men showed statistically significant differences in terms of height (taller +3.4cm) and weight (heavier +2.1kg) compared to the women. The effect sizes shown as moderate in height and small in weight variables.

Table 2. - Taekwondo women and men athletes' characteristics. Mean ± Standard Deviation (SD) and Student´s *t*-test.

Variables	Women (n = 5)		Men (n = 7)		*t*-Value	*p*-Value	ES
	Mean	SD	Mean	SD			
Age (years)	23.0	2.3	22.1	2.9	0.535	0.604	0.028
Height (cm)	164.6	1.8	174.3	5.2	3.958	0.003	0.610
Weight (kg)	58.0	5.9	70.6	8.0	2.950	0.015	0.465
Taekwondo Practice (years)	7.4	1.3	7.1	1.3	0.327	0.751	0.011

SD: Standard Deviation; ES: Effect Size

To determine the quality of the data studied, the coefficient of variation, and intraclass correlation coefficient were calculated to confirm the reliability of the evaluators' panel. To evaluate the panel's reliability, they analyzed the 6^{th} and 7^{th} cycle of ten kicks, executed by athlete #9 (woman), and athlete #5 (man) respectively. Table 3 displays the CV results showing that the men's group revealed less variation than the women's group. Through the ICC the evaluators' reliability results for both groups (women and men) were shown to be good ($p < 0.05$).

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Table 3. - Intraclass correlation coefficient (ICC) reliability of evaluators, and coefficient of variation (CV) after analyzing the 6th and 7th cycle of the whole cycle of ten kicks (n = 120).

Observation moments (a cycle of ten kicks)		Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Evaluator 5
Women	Evaluator 1 (expert)	0.956	0.813	0.821	0.875	0.827
	Inter- ICC			0.946*		
	CV (%)	39.6	43.6	42.7	39.6	39.9
Men	Evaluator 1 (expert)	0.977	0.845	0.878	0.859	0.884
	Inter- ICC			0.958*		
	CV (%)	42.9	43.1	43.8	41.8	42.6

E1, ... E5: Evaluator 1, ... Evaluator 5; CV: Coefficient of Variation; ICC: Intraclass Correlation Coefficient; * p<0,001

The foot take-off indices are reported in Table 4. The alphanumeric codes associated with the conducts criteria which presented the highest mean percent value were 1CL2 (64.0) in the women and 1CL4 (68.6) in the men; and the alphanumeric code linked to the aggregates criteria was for both group 1T1 (72.0) and (68.6) women and men respectively. The CL1, CL2, SL1, SL2 conducts criteria, and H1 aggregates criteria was higher in women and the T1, La1, and Ra2 aggregates criteria in the men's group. Only the CL2 conducts criteria showed a statistically significantly difference in the women and men. The CL2 and H1 criteria indicated a large effect size.

Table 4. - Foot take-off, in the women and men (%). Mean ± standard deviation (SD), Student's t-test and Effect size for the whole a cycle of ten kicks (n = 120).

Variable 1 ǀ **Foot Take-off**	Kick cycle women (n = 50) Mean	SD	Kick cycle men (n = 70) Mean	SD	t-Value	p-Value	ES
Conducts and aggregates criteria / Alphanumeric codes (%)							
CL1 – Contact leg position	2.20	0.571	2.17	0.613	0.259	0.796	0.149
1CL1 – Back in short distance	8.0		11.4				
1CL2 – Back in medium distance	64.0		60.0				
1CL3 – Back in long distance	28.0		28.6				
CL2 – Contact leg foot position	1.80	0.639	1.31	0.468	4.811	<0.001	2.777
1CL4 – Facing forward	32.0		68.6				
1CL5 – Facing out up to 45º	56.0		31.4				
1CL6 – Facing out up to 90º	12.0		0.0				
SL1 – Support leg position	1.40	0.646	1.34	0.654	0.636	0.526	0.164
1SL1 – No action	56.0		60.0				
1SL2 – Short forward action	36.0		31.4				
1SL3 – Medium forward action	8.0		8.6				
1SL4 – Long forward action	0.0		0.0				
SL2 – Support leg foot position	1.56	0.644	1.43	0.498	1.260	0.210	0.727
1SL5 – Facing forward	52.8		57.1				
1SL6 – Facing out up to 45º	39.2		42.9				
1SL7 – Facing out up to 90º	8.0		0.0				
H1 – Head position	1.56	0.644	1.37	0.487	1.827	0.070	1.054
1H1 – Extension	52.0		62.9				
1H2 – Neutral	40.0		37.1				
1H3 – Flexion	8.0		0.0				
T1 – Trunk position	1.28	0.454	1.31	0.468	0.401	0.689	0.231
1T1 – Front	72.0		68.6				

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1T2 – Diagonal	28.0		31.4				
1T3 - Lateral	0.0		0.0				
La1 – Left arm and forearm position	1.44	0.501	1.49	0.503	0.491	0.624	0.283
1La1 – Arm and forearm in extension	56.0		51.4				
1La2 – Arm and forearm in obtuse flexion	44.0		48.6				
1La3 – Arm and forearm in acute flexion	0.0		0.0				
Ra1 – Right arm and forearm position	1.44	0.501	1.51	0.503	0.798	0.426	0.460
1Ra1 – Arm and forearm in extension	56.0		48.6				
1Ra2 – Arm and forearm in obtuse flexion	44.0		51.4				
1Ra3 – Arm and forearm in acute flexion	0.0		0.0				

SD: Standard deviation; %: percentage; ES: Effect size

The knee up indices are reported in Table 5. The alphanumeric codes associated with the conducts criteria which presented the highest percent mean value were 1SL8 (52.0) in the women and 1CL8 (60.0) in the men; and the alphanumeric codes linked to the aggregates criteria were for both groups 1La5 (72.0) and (68.6) women and men respectively. The CL3, CL4, SL4, H2, T2, and La2 aggregates criteria were higher in the women, and the SL3, SL4 and Ra2 aggregates criteria in the men's group. The CL4 aggregates criteria showed a statistically significant difference in the women and men. The CL4, H2 and Ra2 conducts criteria indicated a very large effect size.

Table 5. - Knee up (%), in the women and men. Mean ± Standard Deviation (SD), Student's *t*-test and Effect Size for the whole cycle of ten kicks (n = 120).

Variable 2 ǀ **Knee up**	Kick cycle women (n = 50)		Kick cycle men (n = 70)		t-Value	p-Value	ES
	Mean	SD	Mean	SD			
Conducts and aggregates criteria Alphanumeric codes (%)							
CL3 – Contact leg position	2.04	0.781	2.00	0.637	0.308	0.758	0.177
1CL7 – Straight flexion of the thigh and leg	28.0		20.0				
1CL8 - Acute flexion of the thigh and leg	40.0		60.0				
1CL9 - Obtuse flexion of the thigh and leg	32.0		20.0				
CL4 – Contact leg foot position	2.16	0.792	1.54	0.774	4.264	<0.001	2.461
1CL10 - Foot extension	24.0		62.9				
1CL11 - Neutral	36.0		20.0				
1CL12 - Foot flexion	40.0		17.1				
SL3 – Support leg position	1.48	0.505	1.50	0.504	0.214	0.831	0.123
1SL8 - Obtuse flexion	52.0		50.0				
1SL9 - In extension	48.0		50.0				
1SL10 - Hyper-extension	0.0		0.0				
SL4 – Support leg foot position	1.56	0.644	1.74	0.695	1.464	0.146	0.845
1SL11 - Facing forward	48.0		40.0				
1SL12 - Facing out less than 90º	40.0		45.7				
1SL13 - Facing out more than 90º	10.0		14.3				
H2 – Head position	1.86	0.729	1.63	0.641	1.841	0.068	1.062
1H4 - Extension	34.0		45.7				
1H5 - Neutral	46.0		45.7				
1H6 - Flexion	20.0		8.6				
T2 – Trunk position	1.56	0.705	1.37	0.594	1.586	0.115	0.915
1T4 - Front	56.0		68.6				

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1T5 - Diagonal	32.0		25.7				
1T6 - Lateral	12.0		5.7				
La2 – Left arm and forearm position	1.72	0.454	1.69	0.468	0.401	0.689	0.231
1La4 - Arm and forearm in extension	28.0		31.4				
1La5 - Arm and forearm in obtuse flexion	72.0		68.6				
1La6 - Arm and forearm in acute flexion	0.0		0.0				
Ra2 – Right arm and forearm position	1.48	0.505	1.66	0.478	1.955	0.053	1.128
1Ra4 - Arm and forearm in extension	52.0		34.3				
1Ra5 - Arm and forearm in obtuse flexion	48.0		65.7				
1Ra6 - Arm and forearm in acute flexion	0.0		0.0				

SD: Standard deviation; %: percentage; ES: Effect size

The start leg extension indices are reported in Table 6. The alphanumeric codes associated with the conducts criteria which presented the highest mean percent value were 2SL4 (64.0) in the women and 2SL2 (65.7) in the men. The alphanumeric codes linked to the aggregates criteria which showed highest percent mean values was 2La2 and 2Ra2 (60.0) in the women, and 2La2 (71.4) in the men. The CL5 conducts criteria, and Ra3 aggregates criteria were higher in the women and CL5, SL5, SL6 conducts criteria, H3, T3, and La3 aggregates criteria in the men's group. No one aggregates criterion revealed a statistically significant different in the women and men. Only the CL5 conducts criteria indicated a large effect size.

Table 6. - Start leg extension (%), in the women and men. Mean ± Standard Deviation (SD), Student's *t*-test and Effect Size for the whole cycle of ten kicks (*n* = 120).

Variable 3 ǀ **Start leg extension**	Kick cycle women (n = 50)		Kick cycle men (n = 70)		t-Value	p-Value	ES
	Mean	SD	Mean	SD			
Conducts and aggregates criteria Alphanumeric codes (%)							
CL5 – Contact leg position	2.44	0.644	2.26	0.695	1.464	0.146	0.845
2CL1 - Straight leg flexion	8.0		14.3				
1CL2 - Acute leg flexion	40.0		45.7				
1CL3 - Obtuse leg flexion	52.0		40.0				
CL6 – Contact leg foot position	2.24	0.916	2.26	0.912	0.101	0.919	0.058
2CL4 - Facing forward	32.0		31.4				
2CL5 -Facing backward	12.0		11.4				
2CL6 - Facing inside	56.0		57.1				
2CL7 - Facing out	0.0		0.0				
SL5 – Support leg position	1.60	0.495	1.66	0.478	0.636	0.526	0.367
2SL1 - Obtuse flexion	40.0		34.3				
2SL2 - In extension	60.0		65.7				
2SL3 - Hyper-extension	0.0		0.0				
SL6 – Support leg foot position	1.44	0.644	1.46	0.502	0.164	0.870	0.094
2SL4 - Facing out in external rotation less than 45º	64.0		54.3				
2SL5 - Facing out in external rotation less than 90º	28.0		45.7				
2SL6 - Facing out in external rotation less	8.0		0.0				

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than 135º							
H3 – Head position	2.00	0.857	2.06	0.899	0.350	0.727	0.202
2H1 - Extension	36.0		37.1				
2H2 - Neutral	28.0		20.0				
2H3 - Flexion	36.0		42.9				
T3 – Trunk position	2.52	0.580	2.63	0.594	0.997	0.321	0.575
2T1 - Front	4.0		5.7				
2T2 - Diagonal	40.0		25.7				
2T3 - Lateral	56.0		68.6				
La3 – Left arm and forearm position	2.00	0.639	2.00	0.538	0.000	1.000	0.000
2La1 - Arm and forearm in trunk prolongation	20.0		14.3				
2La2 - Arm in trunk prolongation and forearm flexion	60.0		71.4				
2La3 - Arm in hyper-extension and forearm extension	20.0		14.3				
Ra3 – Right arm and forearm position	1.48	0.646	1.46	0.557	0.207	0.836	0.119
2Ra1 - Arm and forearm in trunk prolongation	60.0		57.1				
2Ra2 - Arm in trunk prolongation and forearm flexion	32.0		40.0				
2Ra3 - Arm in hyper-extension and forearm extension	8.0		2.9				

SD: Standard deviation; %: percentage; ES: Effect size

The contact moment indices are reported in Table 7. The alphanumeric codes associated with conducts criteria which present the highest mean percent value were 2SL8 (56.0) in the women and 2CL11, and 2SL8 (54.3) in the men. The alphanumeric codes linked to aggregates criteria showing the highest percent values was 2La5 (84.0) in the women, and (77.1) in the men. In this variable all conducts and aggregates criteria were higher in the women than in the men except for SL8 - support leg foot position. No one conducts criteria revealed a statistically significant difference in the women and the men. The SL8 and La4 conducts criteria indicated a large effect size.

Table 7. - Contact moment (%), in women and men. Mean ± Standard Deviation (SD), Student's *t*-test and Effect Size for the whole cycle of ten kicks (n = 120).

Variable 4 ∣ **Contact moment**	Kick cycle women (n = 50)		Kick cycle men (n = 70)		t-Value	p-Value	ES
	Mean	SD	Mean	SD			
Conducts and aggregates criteria							
Alphanumeric codes (%)							
CL7 – Contact leg position	1.68	0.683	1.60	0.600	0.680	0.498	0.392
2CL8 - Obtuse flexion	44.0		45.7				
2CL9 - Extension	44.0		48.6				
2CL10 - Hyper-extension	12.0		5.7				
CL8 – Contact leg foot zone	3.04	2.166	2.80	2.054	0.617	0.539	0.356
2CL11 – Tip of the foot with flexion of toe	52.0		54.3				
2CL12 - Dorsum of the foot	0.0		0.0				
2CL13 - Inner part of the foot	0.0		5.7				
2CL14 - Outside of the foot	35.2		31.4				
2CL15 - Sole of the foot	12.8		8.6				

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2CL16 - Heel of the foot	0.0		0.0				
SL7 – Support leg position	1.56	0.501	1.54	0.502	0.185	0.854	0.106
2SL7 - Extension	44.0		45.7				
2SL8 - Obtuse flexion	56.0		54.3				
2SL9 - Hyper-extension	0.0		0.0				
SL8 – Support leg foot position	2.60	1.485	3.00	1.465	1.467	0.145	0.846
2SL10 - On tiptoe in external rotation less than 90º	20.0		14.3				
2SL11 - On the tiptoe in external rotation less than135º	52.0		40.0				
2SL12 - On the tiptoe in external rotation less than 180º	0.0		0.0				
2SL13 - On the sole in external rotation less than 90º	4.0		22.9				
2SL14 - On the sole in external rotation less than 135º	24.0		22.9				
2SL15 - On the sole in external rotation less than 180º	0.0		0.0				
H4 – Head position	1.96	0.832	1.94	0.866	0-109	0.914	0.062
2H4 - Extension	35.7		40.0				
2H5 - Neutral	31.6		25.7				
2H6 - Flexion	32.7		34.3				
T4 – Trunk position	2.64	0.485	2.51	0.608	1.212	0.228	0.699
2T4 - Front	0.0		5.7				
2T5 - Diagonal	36.0		37.2				
2T6 - Lateral	64.0		57.1				
La4 – Left arm and forearm position	2.08	0.396	1.94	0.478	1.661	0.099	0.958
2La4 - Arm and forearm in trunk prolongation	4.0		14.3				
2La5 - Arm in trunk prolongation and forearm flexion	84.0		77.1				
2La6 - Arm in hyper-extension and forearm extension	12.0		8.6				
Ra4 – Right arm and forearm position	1.64	0.898	1.57	0.650	0.485	0.628	0.280
2Ra4 - Arm and forearm in trunk prolongation	64.0		51.4				
2Ra5 - Arm in trunk prolongation and forearm flexion	8.0		40.0				
2Ra6 - Arm in hyper-extension and forearm extension	28.0		8.6				

SD: Standard deviation; %: percentage; ES: Effect size

The start leg flexion indices are reported in Table 8. The alphanumeric codes associated with the conducts criteria which present the highest percent values were 3SL5 (68.0) in women and 3CL5 (62.9) in the men. The alphanumeric codes linked to the aggregates criteria showing the highest percent values were 3Ra1 (60.0) in the women, and (80.0) in the men. The mean value of the conducts criteria was higher in the men than in the women except for SL10. The H5 and Ra5 aggregates criteria were higher in the women, and the T5 and La5 aggregates criteria in the men's group. Only the SL10 conducts criteria revealed a statistically significant difference in the women and the men. The SL10 conducts criteria, and H5 and Ra5 aggregates criteria indicated a large effect size.

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Table 8. - Start leg flexion (%), in women and men. Mean ± Standard Deviation (SD), Student's *t*-test and Effect Size for the whole cycle of ten kicks (*n* = 120).

Variable 5 I Start leg flexion	Kick cycle women (n = 50)		Kick cycle men (n = 70)		t-Value	p-Value	ES
	Mean	SD	Mean	SD			
Conducts and aggregates criteria Alphanumeric codes (%)							
CL9 – Contact leg position	1.96	0.925	1.97	0.916	0.067	0.947	0.038
3CL1 - Facing horizontal	44.0		42.9				
3CL2 - Facing vertical	16.2		17.1				
3CL3 - Facing diagonal	39.8		40.0				
CL10 – Contact leg foot position	2.64	0.985	2.54	0.973	0.536	0.593	0.309
3CL4 - Facing up and in extension	4.0		5.7				
3CL5 - Facing up and in flexion	60.		62.9				
3CL6 - Facing in and in extension	4.0		2.9				
3CL7 - Facing in and in flexion	32.0		28.6				
SL9 – Support leg position	1.60	0.571	1.74	0.606	1.303	0.195	0.752
3SL1 - Obtuse flexion	44.6		34.3				
3SL2 - In extension	51.4		57.1				
3SL3 - Hyper-extension	4.0		8.6				
SL10 – Support leg foot position	2.00	0.571	1.63	0.641	3.272	<0.001	1.889
3SL4 - Facing out in external rotation up to 45º	16.0		45.7				
3SL5 - Facing out in external rotation up to 90º	68.0		45.7				
3SL6 - Facing out in external rotation up to 180º	16.0		8.6				
H5 – Head position	2.16	0.889	1.86	0.905	1.820	0.071	1.050
3H1 - Extension	32.0		48.6				
3H2 - Neutral	20.0		17.1				
3H3 - Flexion	48.0		34.3				
T5 – Trunk position	2.48	0.580	2.49	0.608	0.052	0.959	0.030
3T1 - Front	4.4		5.7				
3T2 - Diagonal	43.6		40.0				
3T3 - Lateral	52.0		54.3				
La5 – Left arm and forearm position	1.88	0.918	1.91	0.608	0.246	0.806	0.052
3La1 - Arm and forearm in trunk prolongation	48.0		22.9				
3La2 - Arm in trunk prolongation and forearm flexion	16.0		62.9				
3La3 - Arm in hyper-extension and forearm extension	36.0		14.3				
Ra5 – Right arm and forearm position	1.56	0.812	1.29	0.617	2.102	0.038	1.213
3Ra1 - Arm and forearm in trunk prolongation	64.0		80.0				
3Ra2 - Arm in trunk prolongation and forearm flexion	16.0		11.4				
3Ra3 - Arm in hyper-extension and forearm extension	20.0		8.6				

SD: Standard deviation; %: percentage; ES: Effect size

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The thigh extension indices are reported in Table 9. The alphanumeric codes associated with the conducts criteria which presented the highest percent values were 3CL8 (64.0) in women and 3SL7 (61.4) in the men. The alphanumeric codes linked to the aggregates criteria showing the highest percent values were 3La4 (64.0) in the women, and 3Ra6 (62.9) in the men. The mean value of the conducts criteria was higher in the men than the women except for SL11, and all the aggregates criteria were higher in the men's group than the women's group except for Ra6. No one conducts criteria showed a statistically significant difference in the women and the men. The T6, La6 and Ra6 aggregates criteria indicated a moderate effect size.

Table 9. - Thigh extension (%), in the women and the men. Mean ± Standard Deviation (SD), Student's *t*-test and Effect Size for the whole cycle of ten kicks (*n* = 120).

Variable 6 ∣ **Thigh extension**	Kick cycle women (n = 50)		Kick cycle men (n = 70)		t-Value	p-Value	ES
	Mean	SD	Mean	SD			
Conducts and aggregates criteria Alphanumeric codes (%)							
CL11 – Contact leg position	1.44	0.644	1.51	0.558	0.674	0.502	0.389
3CL8 - Obtuse flexion	64.0		51.4				
3CL9 - In extension	28.0		45.7				
3CL10 - In hyper-extension	8.0		2.9				
CL11 – Contact leg foot position	1.96	0.669	2.00	0.637	0.332	0.740	0.191
3CL11 - Facing in up to 45º	24.0		20.0				
3CL12 - Facing in up to 90º	56.0		60.0				
3CL13 - Facing in up to 180º	20.0		20.0				
SL11 – Support leg position	1.46	0.613	1.40	0522	0.577	0.565	0.333
3SL7 - Obtuse flexion	60.0		61.4				
3SL8 - In extension	34.0		37.1				
3SL9 - Hyper-extension	6.0		1.4				
SL12 – Support leg foot position	1.96	0.669	2.00	0.637	0.332	0.740	0.191
3SL10 - Facing forward	24.0		20.0				
3SL11 - Facing out up to 45º	56.0		60.0				
3SL12 - Facing out up to 90º	20.0		20.0				
H6 – Head position	1.84	0.889	1.97	0.916	0.784	0.434	0.452
3H4 - Extension	48.0		42.9				
3H5 - Neutral	19.8		17.1				
3H6 - Flexion	32.2		40.0				
T6 – Trunk position	2.16	0.738	2.29	0.663	0.977	0.331	0.564
3T4 - Front	20.0		11.4				
3T5 - Diagonal	44.0		48.6				
3T6 - Lateral	36.0		40.0				
La5 – Left arm and forearm position	1.44	0.644	1.57	0.714	1.035	0.303	0.597
3La4 - Arm and forearm in trunk prolongation	64.0		55.7				
3La5 - Arm in trunk prolongation and forearm flexion	28.0		31.4				
3La6 - Arm in hyper-extension and forearm extension	8.0		12.9				
Ra5 – Right arm and forearm position	1.76	0.960	1.63	0.871	0.781	0.436	0.502
3Ra4 - Arm and forearm in trunk prolongation	60.2		25.7				

3Ra5 - Arm in trunk prolongation and forearm flexion	4.0	11.4
3Ra6 - Arm in hyper-extension and forearm extension	35.8	62.9

SD: Standard deviation; %: percentage; ES: Effect size

The Figure 3 shows the observation moment of contact of the foot with the boxing bag. The contact leg and support leg are in obtuse flexion, the support leg foot is on tiptoe in external rotation less than 135º and the contact leg foot is on sole of the foot.

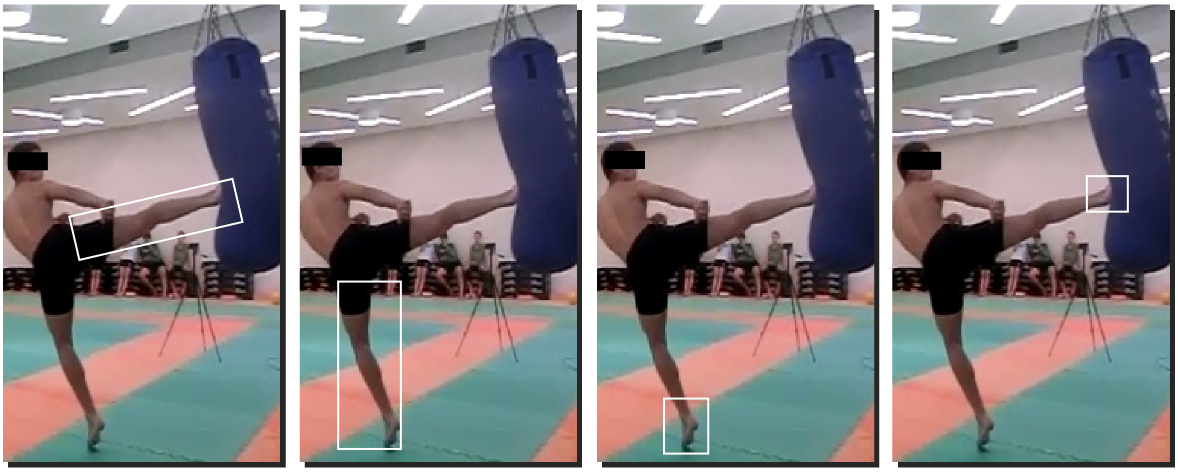

Figure 3. - Event configuration framework of V4: "contact moment".

In the foot take-off moment Spearman's correlation coefficient was statistically significant (Table 10) showing a moderate correlation between the conducts criteria |"support leg and contact leg position"| (p = 364; $p < 0.01$), and a small and negative correlation between the aggregates criteria |"left arm and forearm" and "head position"| (p = 236; $p < 0.01$).

Table 10. - The whole cycle of ten kicks (n = 120) correlation coefficient analysis results.

Spearman's rho Foot take-off	CL1	CL2	SL1	SL2	H1	T1	La1	Ra1
CL1 - Contact leg position	1,000							
CL2 - Contact leg foot position	-0.135	1,000						
SL1 - Support leg position	0.364**	0.000	1,000					
SL2 - Support leg foot position	0.068	0.092	0.021	1,000				
H1 - Head position	0.024	-0.142	-0.024	0.038	1,000			
T1 - Trunk position	0.035	-0.058	0.132	-0.096	0.173	1,000		
La1 - Left arm and forearm position	0.055	0.078	0.160	0.028	-0.236**	-0.211	1,000	
Ra1 - Right arm and forearm position	0.163	-0.234	0.039	-0.130	0.190	-0.197	-0.169	1,000

**. p<0.01 and *. p<0.05

In the knee up moment the correlation coefficient was statistically significant (Table 11) showing a small correlation between |"support leg foot" and "contact leg position"| (p = 241; p <

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0.05), between ǀ”head” and “contact leg position”ǀ ($p = 211$; $p < 0.05$), and ǀ”right arm and forearm” and “contact leg position”ǀ ($p = 189$; $p < 0.05$), ǀ”support leg foot position”ǀ ($p = 217$; $p < 0.05$), ǀ”head position”ǀ ($p = 216$; $p < 0.05$) and ǀ”left arm and forearm”ǀ ($p = 184$; $p < 0.05$) respectively.

Table 11. - The whole cycle of ten kicks ($n = 120$) correlation coefficient analysis results.

Spearman's rho Knee up	CL3	CL4	SL3	SL4	H2	T2	La2	Ra2
CL3 - Contact leg position	1,000							
CL4 - Contact leg foot position	0.090	1,000						
SL3 - Support leg position	0.047	-0.114	1,000					
SL4 - Support leg foot position	0.241**	-0.048	-0.004	1,000				
H12 - Head position	0.211*	-0.115	-0.032	0.020	1,000			
T2 - Trunk position	-0.008	0.071	-0.156	0.093	0.043	1,000		
La2 - Left arm and forearm position	-0.091	-0.077	0.171	-0.040	0.025	-0.082	1,000	
Ra2 - Right arm and forearm position	0.189*	-0.168	0.155	0.217*	0.216*	-0.038	0.184*	1,000

**. p<0.01 and *. p<0.05

In the start leg extension moment the correlation coefficients were statistically significant (Table 12) showing a small and negative correlation between ǀ”support leg foot and contact leg position”ǀ ($p = 276$; $p < 0.01$), between ǀ”head and support leg foot position”ǀ ($p = 241$; $p < 0.01$), between ǀ”left arm and forearm” and “support leg position”ǀ ($p = 180$; $p < 0.05$), and between ǀ”right arm and forearm” and “support leg position”ǀ ($p = 286$; $p < 0.01$); a small correlation between ǀ”support leg foot and support leg position”ǀ ($p = 272$; $p < 0.01$) and ǀ”trunk” and “contact leg foot position”ǀ ($p = 186$; $p < 0.01$); a moderate correlation between ǀ”head and contact leg position”ǀ ($p = 337$; $p < 0.01$), between ǀ”right arm and forearm”, and “head position”ǀ ($p = 330$; $p < 0.01$), and ǀ”right arm and forearm”ǀ, and ǀ”left arm and forearm”ǀ ($p = 298$; $p < 0.01$) respectively.

Table 12. - The whole cycle of ten kicks ($n = 120$) correlation coefficient analysis results.

Spearman's rho Start leg extension	CL5	CL6	SL5	SL6	H3	T3	La3	Ra3
CL5 - Contact leg position	1,000							
CL6 - Contact leg foot position	-0.162	1,000						
SL5 - Support leg position	0.054	-0.175	1,000					
SL6 - Support leg foot position	-0.276**	0.014	0.272**	1,000				
H3 - Head position	0.337**	0.125	-0.128	-0.241**	1,000			
T3 - Trunk position	0.147	0.186*	-0.007	-0.140	0.140	1,000		
La3 - Left arm and forearm position	0.146	0.093	-0.180*	-0.052	0.162	0.091	1,000	
Ra3 - Right arm and	-0.019	0.119	-0.286**	-0.063	0.330**	-0.017	0.298**	1,000

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forearm position

**. $p<0.01$ and *. $p<0.05$

In the contact moment correlation coefficients were statistically significant (Table 13) showing a small and negative correlation between |"head and support leg position"| (p = 208; p < 0.05); a moderate and negative correlation between |"support leg foot and contact leg foot position"| (p = 324; p < 0.01), and between |"head and contact leg position"| (p = 332; p < 0.01), and |"right arm and forearm and support leg position"| (p = 358; p < 0.01); and a small correlation between |"support leg and contact leg position"| (p = 190; p < 0.05), |"head and contact leg position"| (p = 181; p < 0.05), and |"trunk and support leg foot position"| (p = 238; p < 0.01).

Table 13. - The whole cycle of ten kicks (n = 120) correlation coefficient analysis results.

Spearman's rho Contact moment	CL7	CL8	SL7	SL8	H4	T4	La4	Ra4
CL7 - Contact leg position	1,000							
CL8 - Contact leg foot position	-0.056	1,000						
SL7 - Support leg position	-0.083	0.034	1,000					
SL8 - Support leg foot position	0.190*	-0.324**	-0.046	1,000				
H4 - Head position	-0.332**	0.181*	-0.208*	-0.108	1,000			
T4 - Trunk position	0.152	0.030	-0.023	0.238**	-0.158	1,000		
La4 - Left arm and forearm position	-0.171	-0.139	-0.150	0.136	0.088	0.103	1,000	
Ra4 - Right arm and forearm position	0.066	0.009	-0.358**	-0.006	0.002	0.030	0.123	1,000

**. $p<0.01$ and *. $p<0.05$

In the start leg flexion moment the correlation coefficients were statistically significant (Table 14) showing a small and negative correlation between |"trunk" and "contact leg"| (p = 214; p < 0.05), |"support leg"| (p = 228; p < 0.05), and |"support leg foot position"| (p = 274; p < 0.01) respectively; also a small and negative correlation between |"right arm and forearm" and "support leg position"| (p = 196; p < 0.05); a moderate and negative correlation between |"trunk and head position"| (p = 311; p < 0.01); a moderate correlation between |"support leg foot" and "contact leg foot position"| (p = 324; p < 0.01), between |"support leg foot" and "support leg position"| (p = 354; p < 0.01), between |"head and support leg position"| (p = 396; p < 0.01), and between |"head" and "support leg foot position"| (p = 326; p < 0.01).

Table 14. - The whole cycle of ten kicks (n = 120) correlation coefficient analysis results.

Spearman's rho Start leg flexion	CL9	CL10	SL9	SL10	H5	T5	La5	Ra5
CL9 - Contact leg position	1,000							
CL10 - Contact leg foot position	0.129	1,000						
SL9 - Support leg position	-0.101	0.175	1,000					
SL10 - Support leg foot	-0.024	0.324**	0.354**	1,000				

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position								
H5 - Head position	-0.145	0.108	0.396**	0.326**	1,000			
T5 - Trunk position	0.121	-0.214*	-0.228*	-0.274**	-0.311**	1,000		
La5 - Left arm and forearm position	0.025	0.014	-0.114	-0.003	0.045	-0.129	1,000	
Ra5 - Right arm and forearm position	-0.117	0.049	-0.196*	0.048	0.103	-0.167	-0.149	1,000

**. p<0.01 and *. p<0.05

In the thigh extension moment the correlation coefficients were statistically significant (Table 15) showing a small and negative correlation between |”trunk and contact leg foot position”| (p = 227; $p < 0.05$), |”support leg foot position”| (p = 227; $p < 0.05$), and |”head position”| (p = 257; $p < 0.01$) respectively. There was also a small correlation between |”head and contact leg position”| (p = 273; $p < 0.01$), between |”left arm and forearm” and “contact leg position”| (p = 204; $p < 0.05$), between |”right arm and forearm” and “contact leg”| (p = 204; $p < 0.05$), and between |“right arm and forearm” and “support leg foot position”| (p = 204; $p < 0.05$). A moderate correlation was found between |”contact leg foot and contact leg position”| (p = 336; $p < 0.01$), between |”support leg and contact leg foot position”| (p = 329; $p < 0.01$), between |”support leg foot and contact leg position”| (p = 336; $p < 0.01$), and between |”support leg foot” and “support leg position”| (p = 329; $p < 0.01$) respectively. A perfect correlation was revealed between |”support leg foot and contact leg position”| (p = 1; $p < 0.01$).

Table 15. - The whole cycle of ten kicks (n = 120) correlation coefficient analysis results.

Spearman's rho Thigh extension	CL9	CL10	SL9	SL10	H5	T5	La5	Ra5
CL11 - Contact leg position	1,000							
CL12 - Contact leg foot position	0.336**	1,000						
SL11 - Support leg position	0.156	0.329**	1,000					
SL12 - Support leg foot position	0.336**	1,000**	0.329**	1,000				
H6 - Head position	0.273**	0.156	0.024	0.156	1,000			
T6 - Trunk position	0.036	-0.227*	-0.008	-0.227*	-0.257**	1,000		
La6 - Left arm and forearm position	0.204*	0.167	-0.014	0.167	-0.177	0.148	1,000	
Ra6 - Right arm and forearm position	0.126	0.204*	0.171	0.204*	0.039	-0.108	0.115	1,000

**. p<0.01 and *. p<0.05

4. Discussion

The main aim of the present study was to verify and analyze the athletes' technical indicators, during “a cycle of ten kicks” performed, in one usual combat Taekwondo technique, namely *Miluh-chagi*. All the participants were black belt Taekwondo practitioners. We used the published Observation System for Technical Performance Indicators - Chagi (OSTIP-C) [1] tool and a Taekwondo expert panel as evaluators. The results of our study suggest that OSTIP-C presents good reliability and precision to analyze motor behavior, motor development and motor performance [1]. The athletes' sample was composed of 5 women (41.7%) and 7 men (58.3%) Taekwondo practitioners who each performed “a cycle of ten kicks” (n = 120) of the Miluh-chagi technique. The Taekwondo athletes' characteristics were not statistically significant different in age and Taekwondo practice years (p>0.05). The men revealed a statistically significant different in height (t (10) = 3.958 ; p < 0.05) with a moderate effect size and weight (t (10) = 2.950 ; p < 0.05) with a small effect size. The effect size values findings in our study are in line those of Cohen and Lakens [26,27,28]. The men's group was, according to the mean, taller +3.4 cm and heavier +2.1 kg than women's group, coinciding with [2,3,4,30,31,32] where researchers conclude that the men's sample are taller and heavier than women's group.

The coefficient of variation was calculated to verify the precision among the evaluators. The results show very good values for the evaluators. The variation results show that the men presented less variation than the women's group. Our results are supported by various studies and in accordance with those of Hopkins (2000), Hopkins et al. (2009), and Reed et al. (2002) [23,24,25]. The intraclass correlation coefficient (ICC) statistical method was used to confirm the evaluators' reliability between variables at six observation moments. The reference values for the ICC were <0.5 (Poor), 0.5-0.75 (Moderate), 0.75-0.90 (Good), and ≥0.90 (Excellent) [22,23,24]. The evaluator group analyzed the 6th and 7th kick of a cycle of ten kicks, executed by athlete #9 (woman), and athlete #5 (man) respectively. The results (Table 3) confirm the reliability of the evaluators for both group (women and men). The women's group results presented for intra-rater reliability (evaluator 1 vs. evaluator 1) were excellent with 0.956 ($p < 0.01$) lower than Sousa et al., [6] who presented 0.994 ($p < 0.05$) with almost perfect conformity and Barrientos et al. with ICC = 0.99 that revealed excellent to perfect results [33]. The inter-rater results, among the expert evaluators, presented good values of more than 0.800 ($p < 0.01$) once again, lower than Sousa et al., who reported 0.968 ($p < 0.05$) [6]. Evaluator #2 was the one who presented the lowest inter-rater values (0.813) and evaluator #4 the highest 0.875 ($p < 0.01$). In the men's group the expert presented excellent intra-rater values of 0.977 ($p < 0.01$). The inter-rater results, between expert and evaluators, show good values more than 0.840 ($p < 0.01$). Again, the evaluator #2 showed lower values (0.845) between evaluators and expert, and evaluator #5 present good results 0.884 ($p < 0.01$). The findings in our study concerning the evaluators' reliability are supported by respective authors [18-21] who argue that good results are values above 0.800. On this issue, the strength of this study was that it used five evaluators, two more than the Ibáñez et al. and Barrientos et al. [30,33], and the same number as Sousa et al. [6]. All ICC results in this study using the OSTPI-C tool showed nearly perfect or excellent to perfect observers' agreement reliability [6,33]. Student´s *t*-test was used to compare the maximum values of the variables: foot take-off, knee up, start leg extension, contact moment, start leg flexion, and thigh extension in the women and men Taekwondo athletes.

Phase 1 has two observation moments: (1) The **Foot take-off** is composed of eight conducts and aggregates criteria (Table 4). The mean and standard deviation of the conducts criteria (CL1, CL2, SL1, SL2), aggregates criteria (H1) were higher in the women and aggregates criteria (T1, La1, Ra2) in the men's group. The alphanumeric codes associated with the conducts criteria which presented the highest mean percent value was 1CL2 (64.0) in the women and 1CL4 (68.6) in the men. The values found are in line with those Sousa et al. [6]. The alphanumeric codes linked to aggregates criteria which presented highest mean percent value were for both groups 1T1 (72.0) and (68.6) in the women and men respectively. Sousa et al. and Louro et al. [6,34] presented lower values than the findings in our study. Only the conducts criteria CL2, contact leg foot position, showed a statistically significant difference in means in the women's and men's groups (p < 0.01). Student's *t*-test show that in THE mean, the women athletes present statistically significant difference in the conducts criteria contact leg foot position (t (118) = 4.811; p < 0.01)) with a large effect size. In the men's group the contact leg foot position was 68.6% facing forward, and in the women's group the alphanumeric codes 1CL5, facing out up to 45º, presented a value of 56.0% and 1CL4, facing forward, presented 32.0%. These findings are related to those of Sousa et al. [6]. The aggregate criteria H1 and conduct criteria CL2 revealed a large effect size and no statistically significant difference (p > 0.05). (2) The **Knee up** indices are composed of eight conducts and aggregates criteria (Table 5). The mean and

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standard deviation of the conducts criteria (CL3, CL4) and the aggregates criteria (H2, T2, La2) were higher in the women. The conducts criteria (SL3, SL4) and aggregates criteria (Ra2) were higher in the men's group. The alphanumeric codes associated with the conducts criteria which presented the highest mean percent value was 1SL8 (52.0) in the women and 1CL8 (60.0) in the men. The alphanumeric codes linked to the aggregates criteria were for both group 1La5 (72.0) and (68.6) the women and the men respectively. The values are lower than those of Sousa et al. [6]. Only the conducts criteria CL4, contact leg foot position, presented a statistically significant difference in the means of the women's and men's groups ($p < 0.01$). Student's *t*-test shows that, in the means, the women athletes presented statistically significant differences in the conducts criteria contact leg foot position (t (118) = 4.264; $p < 0.01$)) with a large effect size. The alphanumeric codes of the contact leg foot position are 62.9% in the extension foot position for the men's group and 40.0% in the flexion foot position for the women's group. Sousa et al. [6] presented similar results to the values found in our study. The aggregates criteria H2, and Ra2 indicated a very large effect size but do not present a statistically significant difference ($p > 0.05$).

Phase 2 has two moments of observation: (3) The **Start leg extension** is composed of eight conducts and aggregates criteria (Table 6). The mean and standard deviation of the conducts criteria (CL5, CL6) and aggregates criteria (Ra3) was higher in the women. The conducts criteria (SL5, SL6) and aggregates criteria (H3, T3, La3) were higher in the men's group. The alphanumeric codes associated with the conducts criteria which presented highest mean percent value were 2SL4 (64.0) in the women and 2SL2 (65.7) in the men. The alphanumeric codes linked to the aggregates criteria which showed the highest mean percent values were 2La2 and 2Ra2 (60.0) in the women, and 2La2 (71.4) in the men's group. The authors Sousa et al. [6] also found a higher mean percent in this aggregate. Student's *t*-test shows that in mean, the women's and men's groups did not present statistically significant differences in any conducts or aggregate criteria, but a trivial to moderate effect size, and the CL5 conducts indicated a large effect size of 0.845, $| d | > 0.79$ (large). (4) The **Contact moment** is composed of eight conducts and aggregates criteria (Table 7). The mean and standard deviation of the conducts and aggregates criteria were higher in the women's group except in the conducts criteria SL8. The alphanumeric codes associated with the conducts criteria which presented the highest mean percent value were 2SL8 (56.0) in women and 2CL11, and 2SL8 (54.3) in the men. These results are not in agreement with Sousa et al. [6], regarding the contact area of the foot with the target, that has shown a greater stability index of 97%. The alphanumeric codes linked to the aggregates criteria which showed the highest mean percent values were 2La5 (84.0) in the women, and (77.1) in the men's group. Student's *t*-test shows that in mean, the women and men's groups did not present statistically significant differences in any conducts or aggregate criteria. The SL8 and La4 conducts criteria indicated a large effect size with 0.846 and 0.958 ($| d | > 0.79$) respectively. These findings are similar to those shown by Sousa et al. [6].

Phase 3 has two moments of observation: (5) The **start leg flexion** is composed of eight conducts and aggregates criteria (Table 8). The alphanumeric codes associated with the conducts criteria which presented the highest mean percent value were 3SL5 (68.0) in the women and 3CL5 (62.9) in the men's group. The alphanumeric code linked to the aggregates criteria showing the highest mean percent values was 3Ra1 (60.0) in the women, and (80.0) in the men's group. The mean and standard deviation of the conducts criteria were higher in the men than the women's group except for SL10. The H5 and Ra5 aggregates criteria were higher in the women, and T5 and La5 aggregates criteria in the men's group. These findings agree with those of Sousa et al. [6]. Student's *t*-test shows that in mean, the women's and men's groups presented statistically significant differences in the conducts criteria (SL10), contact leg foot position (t (118) = 3.272; $p < 0.01$)) with scale 1.889 corresponding to a large effect size ($| d | > 0.79$), which means the support leg foot position is 68% facing out in external rotation up to 90º for the women, and only 45.7% in the men's group. The aggregates criteria (H5 and Ra5) indicated a large effect size with 1.050 and 1.213 ($| d | > 0.79$) respectively. (6) The **thigh extension** is composed of eight conducts and aggregates criteria

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(Table 9). The mean and standard deviation of the conducts and aggregate criteria were higher in the men's than the women's group except for SL11 and Ra6. The alphanumeric codes associated with the conducts criteria which presented the highest mean percent value were 3CL8 (64.0) in the women and 3SL7 (61.4) in the men. These values are lower than those of Sousa et al. [6] who presented a stability index of more than 80.0%. The alphanumeric codes linked to the aggregates criteria which showed the highest mean percent values were 3La4 (64.0) in the women, and 3Ra6 (62.9) in the men's group. Student's *t*-test showed that in the mean, the women's and men's groups did not present statistically significant differences in any conducts or aggregate criteria. The T6, La6 and Ra6 conducts criteria indicated a moderate effect size with 0.564, 0.597 and 0.502 ($| d | = 0.50$ - 0.79) respectively.

The Correlation Coefficient analysis was carried out calculating Spearman's rho. The criteria indicated by Hopkins et al. [23,24] were used to assess the strength of correlation. Kwon, Kline, and Kline and Klammer [29,35,36] argued that it is difficult to measure the variables X and Y as separate latent constructs with a correlation of 0.90. The correlation coefficient values for all the variables did not exceed 0.85, which shows that there was no problem of multicollinearity [35]. Statistical significance was set at $p < 0.05$ for all the analyses in this study. A statistically significant correlation coefficient showing a small and negative correlation between two latent constructs was found as follows: In the foot take-off instant of observation between left arm and forearm and head position; in the start leg extension between support leg foot and contact leg position; between left arm and forearm, and support leg position; between support leg foot and contact leg position; in the contact moment between right arm and forearm, and support leg position; in the start leg flexion between trunk and contact leg, support leg and support leg foot position, and right arm and forearm and support leg position; and in the thigh extension between trunk and contact leg foot and support leg foot, and head position. A small correlation was found as follows: In the knee up, between support leg foot and contact leg position; between head and contact leg position; between right arm and forearm and contact leg position, support leg foot position, head position and left arm and forearm; in the start leg extension, between support leg foot and support leg position; between trunk and contact leg foot position; between right arm and forearm, and support leg position; in the contact moment, between trunk and support leg foot position; in the thigh extension, between head and contact leg position; between left arm and forearm and contact leg position; and between right arm and forearm and contact leg, and support leg foot position. These results are comparable to those reported by Sousa et al. [6].

A moderate and negative correlation was found as follows: In the contact moment, between support leg foot and contact leg foot position; between head, and contact leg position and support leg position respectively; and in the start leg flexion, between trunk and head position. A moderate correlation was found as follows: In the foot take-off, between contact leg foot and contact leg position; in the start leg extension, between head and contact leg position, between right arm and forearm and head, and left arm and forearm; in the start leg flexion, between support leg foot and contact leg foot position and support leg position, and between head and support leg position and support leg foot position; in the thigh extension, between contact leg foot and contact leg position, and between support leg and contact leg foot position. And, finally between support leg foot and contact leg position, and support leg position. Our study showed a perfect correlation ($\rho = 1$; $p < 0.01$), in the thigh extension instant of observation, between support leg foot and contact leg position. The Sousa et al. [6] study showed different results, they found a perfect stability index of 97% regarding the contact area of the foot.

5. Limitations

The limitations of our study relate to: (1) the sample size, (2) we did not measure leg length, and (3) the cycle of ten kicks was not contrasted with the weight categories for both groups. In future studies it would be interesting to use a bigger sample, and measure leg length. Finally, the authors believe that the results found respond to the premise of this study and will help, significantly, the observation of technical gesture cycles by coaches, physical trainers, athletes and practitioners.

6. Conclusions

The *Miluh-chagi* Taekwondo technique performed in a cycle of ten kicks (n = 120) using an observational methodology study has been able to verify if the athletes present a stable motor behavior, motor development and motor performance. The evaluators' intra- and inter-rater reliability results for both groups were excellent and good respectively. The foot take-off, knee up and start leg flexion observation moments presented statistically significant differences with a large effect size. On the other hand, the start leg extension, contact moment and thigh extension observation moments presented no statistically significant differences. The results showed small and negative to moderate correlations between the conducts criteria (contact leg, contact leg foot, support leg and support leg foot position) and aggregates criteria (head, trunk, left arm and forearm, and right arm and forearm). The principal finding of our study demonstrated a perfect correlation between support leg foot position and contact leg position.

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