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The Influence of Explosive Strength, Isokinetic Potential, and Stability on the Performance Success of the Uchi-mata Throw Technique in Students

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Abstract: *The aim of this study was to determine the influence of explosive strength, isokinetic muscle potential, and stability on the success of performing the Uchi-mata throwing technique in students (n = 57) from the Faculty of Sport and Physical Education, University of Sarajevo, who were systematically introduced to judo for the first time through the teaching process. The predictor variables included indicators of explosive strength (countermovement jump—CMJ, squat jump—SJ, and countermovement jump with arm swing—CMJFA), isokinetic peak torque of relevant muscle groups at 30°/s and 60°/s, and stability indices (overall stability index—BOSI, anteroposterior stability index—BAPSI, and mediolateral stability index—BMLSI). The criterion variable was defined as the first principal component extracted from the ratings of three expert evaluators. Hierarchical regression analysis showed that explosive strength alone was not a statistically significant predictor ($R^2 = .093$, $p = .155$), whereas the full model (explosive strength + isokinetic potential + stability) explained 62.4% of the variance in performance success ($R = .79$, $R^2 = .624$, $p = .007$). Significant partial predictors were peak torque of plantar flexion in the dominant ankle ($\beta = -1.044$, $p < .001$), elbow extension of the dominant arm ($\beta = -0.668$, $p = .007$), and the overall stability index (BOSI). These findings indicate that technical proficiency in Uchi-mata among novice students is not determined by general explosive strength, but rather by the functional integration of specific maximal force and postural stability within a properly acquired biomechanical movement pattern. The results have practical implications for planning and programming judo instruction in the initial stages of learning, with an emphasis on developing specific isokinetic strength and stability.*

Key words: *combat sports, teaching, learning, performance, new technologies*

Introduction

In terms of movement structure, judo belongs to polystructural acyclic activities, whose primary objective is to disrupt the opponent's balance within clearly defined rules (Dukarić, Šupljika Gabelica, and Rajković Vuletić, 2023; Perković, 2022). As an Olympic and Paralympic sport, judo is among the most widespread combat sports worldwide (International Olympic Committee [IOC], 2023; International Paralympic Committee [IPC], 2023). The specificity of judo combat is reflected in its high dynamics, frequent changes in intensity, and short explosive actions lasting approximately 20–30 s, interspersed with brief rest intervals (5–10 s). In this context, anaerobic energy supply predominates, while aerobic capacity remains important for recovery between bouts and repeated high-intensity efforts (Franchini, de Moraes Bertuzzi, Takito, and Kiss, 2009; Franchini, Del Vecchio, Matsushigue, and Artioli, 2011; Marcon, Franchini, Vieira, and Barros Neto, 2007; Van Malderen, Jacobs, Ramon, Zinzen, Deriemaeker, and Clarys, 2006).

Within the repertoire of judo techniques, throwing techniques (nage-waza) represent a core component of both the competitive and instructional process. Structurally, judo includes elements of stance, movement, falling techniques, gripping, as well as throwing and control techniques, where the quality of throw execution depends on efficient energy transfer through the kinetic chain of the arms–trunk–hips–legs–feet (Kajmović, Rađo, and Mekić, 2011; Mikić, 2000). Uchi-mata (ashi-waza) is among the most distinctive and effective throwing techniques, and biomechanically it is based on the action of two forces: one force vector is generated by the tori's arms, while the other results from the lifting/"sweeping" action of the leg, accompanied by simultaneous destabilization and control of the center of mass (Sacripanti, 1989). Biomechanical analyses further indicate that execution time, optimal joint angles, and body center-of-mass positioning are key determinants of Uchi-mata effectiveness (Kim, Yoon, Kim, and Chung, 2005), whereas three-dimensional assessments confirm that techniques such as Uchi-mata achieve maximal

effectiveness when they are biomechanically optimized and when force transmission through the kinetic chain is precise and timely (Sterkowicz, Sacripanti, and Sterkowicz-Przybycien, 2013).

Successful execution of complex throws such as Uchi-mata depends on the interaction between motor abilities and the quality of the acquired technical movement pattern. A particularly important component is the ability to generate and control force in functionally relevant joints, which can be objectively assessed using isokinetic diagnostics (Desnica-Bakrač, 2003). The strength profile of upper-extremity joints—especially the elbow and shoulder—has been shown to be relevant in sports characterized by grip control and directing the opponent during projection (Ruivo, Pezarat-Correia, and Carita, 2012). However, in novice populations (students), maximal muscle potential does not necessarily translate automatically into technical efficiency, because performance is strongly conditioned by coordination, timing, and stabilization of the trunk segment.

Stability and balance abilities provide the foundation for efficient force transfer and body control throughout all phases of a throw, particularly during the initial phase of disrupting the opponent's balance and during the transition into body positioning for projection. In judo, dynamic stability is especially important because technique execution occurs under conditions of contact, rotation, and changes of support, and balance-control strategies differ across athletes with different levels of experience (Lien and Tang, 2003). Furthermore, postural control and balance have been shown to be associated with specific characteristics of an athlete's motor profile (Metikoš, Kovač, Čović, and Mekić, 2014), suggesting that stability may play a mediating role in the realization of complex movement structures.

In the context of university instruction, an additional specificity lies in the fact that students often encounter judo as a sport systematically for the first time precisely through the teaching process at the faculty. Under such conditions, technique learning occurs within a limited time frame, and students are in the initial phases of acquiring motor structures, where typical errors, suboptimal timing, and insufficient trunk stabilization are common. Research focusing on the analysis of technical errors in beginners emphasizes that mistakes in foot throwing techniques occur in recognizable sequences and that their timely identification enables targeted exercise programming and faster technique acquisition (Gutiérrez-Santiago, Prieto, Camerino, and Anguera, 2013; Lage, Gutiérrez-Santiago, Foguet, and Argilaga, 2013).

Accordingly, the aim of this study was to examine the influence of explosive strength, isokinetic muscular potential, and stability on the performance success of the Uchi-mata throwing technique in students who encounter judo for the first time through university instruction, and to identify the partial predictors that contribute most to execution quality. The findings may have direct practical application in planning instructional content, selecting diagnostic procedures, and designing specific exercise programs.

Methods

Participants

The study was conducted on a sample of 57 male students (n = 57) from the Faculty of Sport and Physical Education, University of Sarajevo. Participants were 20–22 years old and were full-time students attending the Judo course. Inclusion criteria were: regular class attendance, absence of acute musculoskeletal injuries, medical fitness to perform maximal motor tests, and signed informed consent. Testing was carried out in the combat sports hall and in the motor abilities assessment laboratory of the Faculty of Sport and Physical Education.

Variables and Measures

The set of variables included predictor variables from three domains and one criterion variable. Lower-limb explosive power was assessed using the Countermovement Jump (CMJ), Squat Jump (SJ), and Countermovement Jump with arm swing (CMJFA) tests. Postural stability was evaluated using the Overall Stability Index (BOSI), Anteroposterior Stability Index (BAPSI), and Mediolateral Stability Index (BMLSI). Maximal muscular capacity was assessed through isokinetic parameters (peak torque) of the relevant muscle groups: plantar and dorsiflexion of the ankle (dominant and non-dominant leg), knee flexion and extension, elbow flexion and extension, and shoulder adduction.

The criterion variable was performance in executing the Uchi-mata throwing technique, evaluated by three expert raters using a 1–5 scale. The raters were licensed judo coaches with at least five years of coaching and competitive experience. Inter-rater reliability was determined using Cohen's kappa coefficient. Based on the raters' scores, factor analysis was performed and the first principal component was extracted and used as a latent criterion variable.

Testing Protocol and Data Collection

All testing was conducted under controlled conditions and preceded by a standardized warm-up lasting 10–15 minutes. Explosive power tests were performed in three trials per test, with a 60-second rest interval between trials; the best achieved value was recorded as the final result. Postural stability was assessed using a stabilometric platform in a standardized barefoot standing position, with each trial lasting 20 seconds. Isokinetic testing was conducted according to a standardized protocol with submaximal warm-up, after which participants performed maximal repetitions at 60°/s and 30°/s; the highest peak torque value was accepted as the valid result. Technical performance was evaluated under standardized conditions: students performed the Uchi-mata technique while the raters independently assessed the quality of execution.

Research Ethics

The study was conducted in accordance with the ethical principles of scientific research. All participants provided written informed consent; participation was voluntary, data anonymity was ensured, and participants retained the right to withdraw from the study at any time without consequences.

Data Processing and Statistical Analysis

Data were processed using descriptive statistics (mean, standard deviation, minimum and maximum values, skewness and kurtosis coefficients). Associations between predictor variables and the criterion variable were examined using Pearson's correlation coefficient (r). To determine the contribution of predictor sets in explaining performance in executing the technique, hierarchical regression analysis was applied, with predictors entered in blocks (explosive power, isokinetic potential, stability), and R, R^2, ΔR^2, and significance levels (p) reported. Factor analysis of the raters' scores was performed to form a latent criterion variable by extracting the first principal component. Inter-rater agreement was assessed using Cohen's kappa coefficient. Statistical analyses were performed using IBM SPSS Statistics, version 21.0 (IBM Corp., Armonk, NY, USA). The level of statistical significance was set at $p < .05$.

Results

Table 1. *Descriptive Statistical Indicators of the Study Variables (N = 57)*

Variable	M	SD	Min	Max	Skew	Kurt
CMJ (cm)	34.21	5.12	24.00	46.00	0.21	-0.48
SJ (cm)	31.87	4.76	22.00	42.00	0.18	-0.55
CMJFA (cm)	38.14	5.89	26.00	50.00	0.25	-0.41
Plantar flexion (Nm)	132.45	21.33	96.00	178.00	-0.36	0.27
Elbow extension (Nm)	78.62	14.11	52.00	104.00	-0.28	-0.19
BOSI	2.41	0.53	1.48	3.62	0.44	-0.22
Uchi-mata	7.62	1.04	5.00	9.50	-0.31	-0.11

M = mean; SD = standard deviation; Skew = skewness coefficient; Kurt = kurtosis coefficient.

From the descriptive statistics presented in **Table 1**, it can be observed that all variables show a relatively homogeneous distribution, with skewness and kurtosis values within acceptable limits for a normal distribution. The mean CMJ value was 34.21 cm, whereas CMJFA showed slightly higher values (38.14 cm), indicating the expected difference between jumps performed with and without an arm swing. The peak plantar flexion torque (M = 132.45 Nm) showed greater variability compared with the other variables, while the mean performance score for the Uchi-mata technique was 7.62, suggesting a relatively good level of technical execution in the examined sample.

Table 2. *Association Between Predictor Variables and Uchi-mata Throw Performance*

Variable	r	p
CMJ	0.21	.118
SJ	0.18	.164
CMJFA	0.24	.092
Plantar flexion (Nm)	-0.69	.000

Elbow extension (Nm)	-0.52	.003
BOSI	-0.41	.012

r – Pearson correlation coefficient; p – level of statistical significance

The correlation analysis presented in **Table 2** indicates that the explosive power variables (CMJ, SJ, CMJFA) were not significantly associated with throwing performance ($p > .05$). In contrast, the peak plantar flexion torque showed a strong and statistically significant negative correlation ($r = -0.69$, $p < .001$), while elbow extension demonstrated a moderate negative association ($r = -0.52$, $p = .003$). Postural stability (BOSI) was also significantly related to the criterion variable ($r = -0.41$, $p = .012$), confirming its functional importance in throw execution.

Table 3. *Hierarchical Regression Analysis of Predictors of Uchi-Mata Performance*

Model	Prediktori	R	R^2	ΔR^2	p
1	**Explosive strength**	0.305	0.093	0.093	.155
2	+ Isokinetic potential	0.736	0.541	0.448	.015
3	+ Stability	0.790	0.624	0.083	.007

R – multiple correlation coefficient; R^2 – coefficient of determination; ΔR^2 – change in the coefficient of determination relative to the previous model; p – model significance level ($p < .05$).

As shown in **Table 3**, explosive power alone explained 9.3% of the variance in Uchi-mata performance, but this contribution was not statistically significant ($p = .155$). With the inclusion of isokinetic muscle potential, the explained variance increased significantly to 54.1% ($p = .015$). The final model, which additionally included stability, accounted for 62.4% of the total variance in the criterion variable ($p = .007$), confirming the combined contribution of maximal strength and stability to the technical execution of the throw.

Table 4. *Standardized Regression Coefficients of the Final Model*

Predictor	Beta	t	p
Plantar flexion (dominant side)	-1.044	-4.87	.000
Elbow extension (dominant side)	-0.668	-2.89	.007
BOSI	-0.312	-2.11	.039

Beta – standardized regression coefficient; t – t-test value; p – statistical significance.

In the final regression model (**Table 4**), a statistically significant contribution was observed for the peak plantar-flexion torque ($p < .001$), dominant-arm elbow extension ($p = .007$), and overall stability (BOSI) ($p = .039$). Plantar flexion showed the strongest contribution, indicating a key role of the ankle joint in the projection phase of the throw. Elbow extension contributed significantly to final control and force direction, whereas stability facilitates effective force transfer without loss of balance.

Table 5. *Inter-Rater Agreement (Cohen's Kappa)*

a pair of judges	Kappa	p
1–2	0.448	.000
1–3	0.595	.000
2–3	0.656	.000

The obtained Cohen's kappa coefficients in **Table 5** indicate statistically significant agreement among all pairs of raters ($p < .001$). The highest level of agreement was observed between raters 2 and 3 ($\kappa = 0.656$), which can be interpreted as a high level of rating reliability. These results confirm that the criterion variable—performance success in executing the technique—was assessed with satisfactory inter-rater reliability.

Discussion

The results of the hierarchical regression analysis for the Uchi-mata technique in university students indicate that lower-limb explosive strength, assessed by the CMJ, SJ, and CMJFA tests, does not provide a statistically significant independent contribution to successful technique execution. This finding is consistent with previous research emphasizing that isolated indicators of vertical explosive power are insufficient to explain performance in complex combat-sport techniques (Franchini et al., 2011; Marcon et al., 2007). Judo combat and throwing techniques require a specific integration of strength, coordination, and tactical timing, which goes beyond the simple generation of maximal vertical force.

Although explosive strength is an important component of a judoka's motor profile, the technical execution of throws presupposes precise temporal coordination, inter- and intramuscular coordination, and biomechanical optimization of movement. Dapic Caput et al. (2013) note that motor abilities have predictive value in judo only when they are functionally integrated into sport-specific technical patterns. Otherwise, isolated strength measurements do not reflect the real demands of situational technique execution.

It is particularly important to emphasize that the participants in this study were students who were systematically exposed to judo for the first time through university coursework. They are therefore in the initial phase of motor learning, characterized by predominantly cognitive control of movement, increased muscle co-activation, and insufficient automatization of the technical structure. In such a phase, the production of maximal force is often not functionally aligned with the technical requirements, which may explain the absence of a significant contribution of explosive strength. In other words, students may possess a certain level of general motor ability, but still lack an efficient mechanism for transferring that force through the specific kinetic chain of the Uchi-mata technique.

With the inclusion of isokinetic variables, there is a substantial increase in the explained variance of performance success. In particular, the peak plantar-flexion torque of the dominant leg and the elbow-extension torque of the dominant arm emerged as prominent predictors. This finding supports the biomechanical structure of the technique, as the tsukuri and kake phases involve a vertical–rotational force component generated through the supporting limb, accompanied by final control of the projection through the upper extremity.

Biomechanical analyses indicate that optimal joint angles, control of the center of mass, and appropriate timing are key determinants of Uchi-mata efficiency (Kim et al., 2005). In addition, three-dimensional motion analyses confirm that techniques such as Uchi-mata achieve maximal effectiveness when force transfer through the kinetic chain is biomechanically optimized (Sterkowicz et al., 2013). When coordination among the supporting leg, trunk, and arms is disrupted, mechanical advantage is lost.

The negative values of the standardized regression coefficients may be interpreted as an indicator of inadequate functional use of maximal force in beginners. In this population, greater isokinetic capacity does not necessarily imply superior technical performance, because force may be generated too early, in an incorrect direction, or without sufficient trunk stabilization. Ruivo et al. (2012) emphasize that the muscular strength profile must be aligned with the sport's specific demands, as isolated maximal strength without technical control can reduce precision and compromise stability.

Stability emerged as a significant factor in explaining performance success. Stability provides the foundation for efficient force transfer between the lower and upper extremities. During the kuzushi phase, the performer must control their own center of mass in order to effectively disrupt the opponent's balance. According to Kajmović et al. (2011), proper integration of the kuzushi–tsukuri–kake phases requires a stable base of support and precise movement coordination. In beginner students, insufficiently developed postural control may lead to increased sway and reduced efficiency of force transmission.

Previous research on technical errors in judo confirms that beginners' typical mistakes occur precisely during the phases of force transfer and trunk stabilization (Gutiérrez-Santiago et al., 2013; Lage et al., 2013). These authors highlight the importance of systematic motor learning and gradual error correction through specific motor tasks. In the context of the present study, students had a limited period for learning the technique, which further explains why maximal strength was not optimally integrated into the technical movement structure.

Mikić (2000) points out that energy transfer in throwing techniques is achieved through the arms, hips, legs, and feet, and that each link in the kinetic chain must be optimally coordinated. Among students encountering judo for the first time, this coordination has not yet been stabilized, resulting in partial utilization of muscular potential without full technical efficiency.

The findings are also consistent with contemporary approaches to judo training that emphasize the specificity of load and the functional application of strength (Franchini et al., 2009). Isolated explosive strength does not capture the complexity of situational technique execution in beginners, where the process of acquiring the motor structure predominates over performance optimization.

The total of 62.4% explained variance confirms that the combination of isokinetic muscular potential and stability plays a dominant role in the technical execution of Uchi-mata in beginner students. The remaining variance may be attributed to technical experience, the level of movement automatization, perceptual–cognitive abilities, and tactical understanding, which is consistent with the view of judo as a complex polystructural, acyclic activity (Dukarić et al., 2023; Perković, 2022). Overall, the results indicate that, in students encountering judo for the first time, technical success in Uchi-mata is not determined by general explosive power, but rather by the ability to functionally integrate maximal force and postural stability within a properly learned biomechanical movement pattern. Developing this integration represents a key instructional task during the early stages of learning judo techniques. It should be noted that the study was conducted on a relatively homogeneous sample of male beginner students, which limits the generalizability of the findings to female participants and those with higher levels of judo experience. Furthermore, technical success was assessed using judges' ratings rather than a detailed kinematic analysis, which could provide additional insight into the biomechanical mechanisms of force transfer.

Conclusion

Based on the present study, it can be concluded that successful technical execution of the Uchi-mata throw in beginner students primarily depends on functional movement control—namely, the ability to integrate specific strength and postural stability into a properly acquired biomechanical pattern. This supports the notion that, in the initial stages of learning, instruction should not rely on general indicators of explosiveness; instead, teaching content should be directed toward developing targeted strength in the relevant joints, improving stability, and refining motor learning through the correction of typical errors.

The limitations of this study include a beginner and homogeneous sample of male students, the assessment of a single technique, and the use of subjective performance ratings without detailed kinematic analysis. Future research should include both sexes, different experience levels, and objective biomechanical measures in order to more comprehensively explain the mechanisms underlying successful throw execution.

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