Original Article

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Determinants of kicking force in taekwon-do: a pilot study on the role of aggression, sex, and age

Jacek Wąsik [1ACD], Cezary Kuśnierz [2ADE], Kamil Radecki [1B], Dariusz Mosler [1D]

[1] Institute of Physical Culture Sciences, Jan Dlugosz University in Częstochowa, Poland
[2] Faculty of Physical Education and Physiotherapy, Opole University of Technology, Opole, Poland

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Abstract: *Introduction:* The ability to generate high kicking force is a key determinant of performance in taekwondo. While the biomechanical aspects of kicking techniques have been extensively investigated, the potential role of psychological traits, such as aggression, in force generation remains insufficiently explored. The aim of the study was to assess the relationship between aggression levels and the ability to generate kicking force in taekwondo athletes, taking into account the role of sex and age. *Materials and Methods:* Thirty taekwondo athletes (6 women and 24 men; mean age 27.07 ± 6.42 years) participated in the study. Under laboratory conditions, maximal impact force of three kicking techniques (front, roundhouse, and side kick) performed with both legs was recorded using a force plate. Aggression was assessed using the Buss–Perry Aggression Questionnaire (BPAQ). Descriptive statistics, correlation analyses, independent-samples t-tests, and multiple linear regression were applied ($p < 0.05$). *Results:* In the regression model explaining total kicking force ($R^2 = 0.53$; $p < 0.001$), sex and age were significant predictors, whereas aggression was not statistically significant. Men generated significantly greater kicking force than women (large effect size), whereas no significant differences in aggression levels were observed between sexes. *Conclusions:* The findings indicate that the relationship between aggression and kicking force in taekwondo athletes is limited and technique-specific. Overall force-generation capacity appears to be determined primarily by somatic and biomechanical factors rather than by dispositional aggression. Future studies should include larger samples and additional biomechanical and psychophysiological variables.

Keywords: taekwondo; kicking force; aggression; biomechanics; combat sports; force plate; performance predictors

Corresponding author: Cezary Kuśnierz, c.kusnierz@po.edu.pl

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INTRODUCTION

Taekwondo is a martial art in which the effectiveness of kicking techniques is a key element of sporting success [1, 2]. Generating high force in a short time requires the complex integration of biomechanical, neuromotor, and psychological factors [3]. Previous studies have focused mainly on the analysis of kinetic and kinematic parameters of kicks [4–6], such as segment velocity, effective mass, and energy transfer, pointing to the important role of muscle strength, inter-segmental coordination, and level of training [7]. However, the importance of personality factors in the context of the ability to generate force in combat sports has been analyzed much less frequently.

Aggression, understood as a relatively stable personality disposition encompassing physical and verbal components, as well as anger and hostility, may play a significant role in contact sports [8,9]. From a psychophysiological perspective, a higher level of aggression may be associated with increased activation of the sympathetic nervous system and the mobilization of motor resources [10], which may potentially facilitate the generation of greater power output and maximal force under task conditions [11]. On the other hand, aggression as a dispositional trait does not necessarily directly determine biomechanical parameters, which depend to a greater extent on somatic, structural, and training-related factors [12]. The literature on combat sports indicates that the impact of training on aggression levels is not unequivocal. Regular and long-term training may lead to a reduction in aggression [13,14], particularly in systems grounded in values of self-control and discipline [15]. At the same time, higher levels of aggression have been reported in full-contact sports compared to non-contact disciplines [16]. This suggests that the level of aggression may be modulated by the specific characteristics of a given discipline and the nature of competitive engagement.

The literature also emphasizes the importance of emotion regulation, arousal control, and an optimal level of activation for effective technical performance [17]. Nevertheless, empirical data concerning the direct relationship between the level of aggression and kick force parameters remain limited, particularly in disciplines based predominantly on kicking techniques, such as taekwondo [5,18].

Additionally, when analyzing the relationship between aggression and the ability to generate force, demographic variables such as sex and age should be considered. Sex differences in maximal strength and muscular power are well documented and result from variations in body composition and physiological parameters [19,20]. Age, in turn, may influence the level of training adaptation and the extent of sport-specific experience. Although the biomechanical determinants of kick force in taekwondo have been extensively described [21], considerably less attention has been devoted to the role of psychological dispositions in the context of force generation [22]. There is a lack of studies examining the direct relationship between the level of aggression and objectively measured kinetic parameters of a kick (e.g., maximal impact force expressed in N). It also remains unclear whether aggression constitutes an independent predictor of force-generation capacity after controlling for sex and age, and whether its potential influence is global in nature or specific to particular techniques.

The aim of the present study was to assess the relationship between the level of aggression and the ability to generate kick force in taekwondo athletes, taking into account the role of sex and age. The following research questions were formulated: Is the level of aggression associated with kick force? Does aggression constitute a significant predictor of total kick force after controlling for sex and age? Do sex and age differentiate the level of aggression and the ability to generate kick force?

To the best of our knowledge, no previous studies have directly examined the relationship between dispositional aggression and objectively measured kicking force in taekwondo athletes. Therefore, the present study provides preliminary

evidence on the potential role of psychological traits in force generation during kicking techniques.

MATERIAL AND METHODS

Study Group

The study involved 30 taekwondo athletes affiliated with the International Taekwon-do Federation (ITF), with a mean age of 27.07 ± 6.42 years. The sample consisted of 6 women (body mass: 66.83 ± 11.69 kg; body height: 165.83 ± 8.95 cm) and 24 men (body mass: 80.88 ± 12.35 kg; body height: 179.54 ± 5.96 cm). All participants represented a high competitive level, including athletes holding master-class ranks and competitors regularly participating in national and international tournaments.

The athletes had substantial sport-specific experience. The mean training experience was 11.73 ± 7.53 years (Me = 11 years; range: 2–30 years), indicating considerable variability in the duration of taekwondo practice within the study group.

The inclusion criteria were: a minimum of two years of taekwondo training experience, age of at least 18 years, written informed consent to participate in the study, and the absence of medical contraindications to maximal physical effort.

For comparative analyses, participants were stratified according to sex and age. Age grouping was performed using the median split method (Me = 25.5 years), resulting in two groups: younger athletes (≤ 25.5 years, n = 15) and older athletes (> 25.5 years, n = 15).

All participants were healthy at the time of testing and reported no musculoskeletal injuries in the period preceding the measurements. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Research Ethics Committee of Jan Długosz University in Częstochowa (Resolution No. KE-U/80/2022, 16 November 2022). All athletes provided written informed consent prior to participation.

Study Protocol

The study was conducted under laboratory conditions. Each participant performed five repetitions of three kicking techniques characteristic of taekwondo: the front kick, the roundhouse kick, and the side kick, executed with both the left and the right leg. Prior to the main measurements, the athletes completed a standardized warm-up consisting of general-purpose exercises and sport-specific technical elements. All trials were performed with maximal intensity, with short recovery intervals between successive kicks in order to minimize the influence of fatigue on performance outcomes.

During each trial, the maximal force generated at the moment of contact (N) was recorded. For further analyses, the mean maximal values from five repetitions were calculated for each technique. Additionally, an overall kick force index (Force_total) was computed as the mean value across all analyzed techniques.

Research Tools

Kick force was recorded using a measurement system based on a force plate positioned at the target impact location. A AMTI MC12-2K force plate from the 2000 series (AMTI, Watertown, MA, USA) was used to measure impact force. The plate was mounted to a rigid support structure and covered with a training pad to protect participants from direct contact with the measurement surface. The aluminum force plate dimensions were 305 × 406 × 79 mm. Its maximum load capacity was 4450 N for the Fx and Fy components and 8900 N for the Fz component. The force plate was synchronized temporally and spatially with the Noraxon MR 3.18 system (Noraxon, Scottsdale, AZ, USA).

The level of aggression was assessed using the Buss–Perry Aggression Questionnaire (BPAQ), which consists of 29 items rated on a 1–5 Likert scale. The instrument measures four components of aggression: physical aggression, verbal aggression, anger, and hostility. The total score (BPAQ_total) was calculated as the sum of all items, with reverse scoring applied to items 9 and 16 [23].

Reliability analysis demonstrated high internal consistency of the applied instruments. For the BPAQ, $\alpha = 0.89$ and $\omega = 0.90$. The BIS/BAS scales achieved α coefficients ranging from 0.70 to 0.85, with the highest reliability observed for the FFFS scale ($\alpha = 0.85$). In the case of the ERQ-S, α values were 0.83 for cognitive reinterpretation and 0.76 for expressive suppression. These results indicate good to very good reliability of the instruments used.

The study was conducted by a research team with experience in sport biomechanics and sport psychology. Force measurements were carried out by personnel trained in the operation of the measurement system, while the questionnaire procedure was supervised by a researcher experienced in the use of psychometric instruments.

To ensure procedural standardization, all researchers followed homogeneous instructions for participants and monitored the correct execution of the techniques.

Statistical Analysis

Descriptive statistics were calculated for all variables and are presented as mean values and standard deviations (M ± SD). The normality of data distribution was assessed using the Shapiro–Wilk test, which is recommended for relatively small sample sizes.

Group differences in aggression levels and total kicking force were examined using independent-samples t-tests. Due to unequal group sizes, particularly between male and female athletes, Welch's t-test was applied. Effect sizes for between-group differences were calculated using Cohen's d and interpreted as small (0.2), medium (0.5), and large (0.8).

To identify predictors of kicking force, a multiple linear regression analysis was conducted. The dependent variable was the total kicking force index (Force_total), calculated as the mean value across six kicking techniques (left and right front, roundhouse, and side kicks). The predictors included aggression level (BPAQ_total), sex, age, and training experience (years). Prior to regression analysis, predictor variables were standardized (z-scores) to obtain standardized regression coefficients (β).

Regression results are reported as standardized β coefficients with 95% confidence intervals (95% CI). Model fit was evaluated using the coefficient of determination (R^2) and adjusted R^2, while the overall significance of the model was assessed using the F statistic.

In addition, a post-hoc statistical power analysis was conducted based on the observed effect size in the regression model. The standardized regression coefficient for sex ($\beta = 0.49$) indicated a large effect according to Cohen's criteria. Using this observed effect size, a significance level of $\alpha = 0.05$ and a sample size of $N = 30$, the estimated statistical power exceeded 0.80, indicating sufficient power to detect the strongest effect observed in the model. However, the power to detect small or moderate effects was likely limited.

All statistical tests were two-tailed, and the level of statistical significance was set at $p < 0.05$. Statistical analyses were performed using Python statistical packages (SciPy, Statsmodels).

RESULTS

Descriptive statistics for aggression levels and kicking force parameters across sex, age, and training experience groups are presented in Table 1. The mean aggression score for the entire sample was 60.03 ± 11.44 points. With respect to kicking force, the highest mean values were observed for the right side kick (4123.18 ± 1924.74 N) and right roundhouse kick (3882.59 ± 1707.94 N), whereas the lowest values were recorded for the left front kick (2744.20 ± 1280.96 N). Men generated substantially higher kicking force than women across all techniques. For example, the mean total kicking force was 4010.77 ± 1083.82 N in men compared with 2298.42 ± 609.83 N in women. In contrast, aggression scores were relatively similar between sexes (61.12 ± 11.82 in men vs. 55.67 ± 8.62 in women). Older athletes and those with greater training experience tended to demonstrate higher mean kicking force values. The mean total kicking force was 4098.99 ± 1443.54 N in older athletes compared with 3237.61 ± 765.92 N in younger athletes, and 4113.95 ± 1260.23 N in more experienced athletes compared with 3327.51 ± 1099.34 N in less experienced athletes.

Table 1. Descriptive statistics and between-group differences for aggression and averaged kicking techniques

Variable	Total (N=30) M±SD	Women (n=6) M±SD	Men (n=24) M±SD	Younger (n=15) M±SD	Older (n=15) M±SD	Less experienced (n=17) M±SD	More experienced (n=13) M±SD
BPAQ_total	60.03 ± 11.44	55.67 ± 8.62	61.12 ± 11.82	59.47 ± 9.50	60.60 ± 13.24	58.41 ± 9.27	62.15 ± 13.69
Left front kick (N)	2744.20 ± 1280.96	1625.58 ± 284.15	3023.86 ± 1258.44	2331.44 ± 709.85	3156.97 ± 1513.11	2467.12 ± 957.44	3151.41 ± 1407.31
Left roundhouse (N)	3596.44 ± 1684.19	2164.63 ± 357.19	3941.45 ± 1625.71	3308.34 ± 1155.46	4458.21 ± 2018.16	3352.75 ± 1374.52	4466.23 ± 1963.11
Left side kick (N)	3985.47 ± 1983.54	3000.59 ± 1570.24	4214.13 ± 1931.87	3584.22 ± 1299.25	4323.11 ± 2195.41	3597.61 ± 1425.26	4487.52 ± 2221.08
Right front kick (N)	3009.57 ± 1348.88	1719.29 ± 283.79	3319.64 ± 1304.26	2453.42 ± 851.76	3545.86 ± 1508.26	2584.13 ± 960.34	3778.55 ± 1464.39
Right roundhouse (N)	3882.59 ± 1707.94	2395.97 ± 406.11	4253.86 ± 1715.46	3343.63 ± 1234.86	4421.01 ± 1989.94	3473.22 ± 1317.43	4515.81 ± 2005.36
Right side kick (N)	4123.18 ± 1924.74	2781.47 ± 1595.21	4458.61 ± 2043.76	3917.36 ± 1534.95	4330.96 ± 2330.32	3722.25 ± 1677.41	4684.94 ± 2160.53
Total kick force (N)	3668.30 ± 1208.67	2298.42 ± 609.83	4010.77 ± 1083.82	3237.61 ± 765.92	4098.99 ± 1443.54	3327.51 ± 1099.34	4113.95 ± 1260.23

Group differences in aggression and total kicking force are presented in Table 2. No statistically significant differences in aggression were observed with respect to sex, age, or training experience ($p > 0.05$). The effect sizes ranged from trivial to medium (Cohen's $d = 0.10–0.48$). In contrast, total kicking force differed significantly between men and women ($t = 5.14$, $p < 0.001$), with a very large effect size ($d = 1.69$), indicating substantially greater force generation among male athletes. Differences related to age ($t = −2.04$, $p = 0.054$) and training experience ($t = −1.79$, $p = 0.086$) did not reach statistical significance but demonstrated moderate-to-large effect sizes, suggesting a potential tendency toward greater kicking force among older and more experienced athletes.

Table 2. Group differences in aggression and total kicking force

Variable	Grouping variable	t	p	Cohen's d	Interpretation
Aggression	Sex	1.28	0.229	0.48	medium
	Age	-0.27	0.79	0.1	trivial
	Training experience	-0.85	0.407	0.33	small
Total kick force	Sex	5.14	<0.001	1.69	very large
	Age	-2.04	0.054	0.75	medium–large (trend)
	Training experience	-1.79	0.086	0.67	medium (trend)

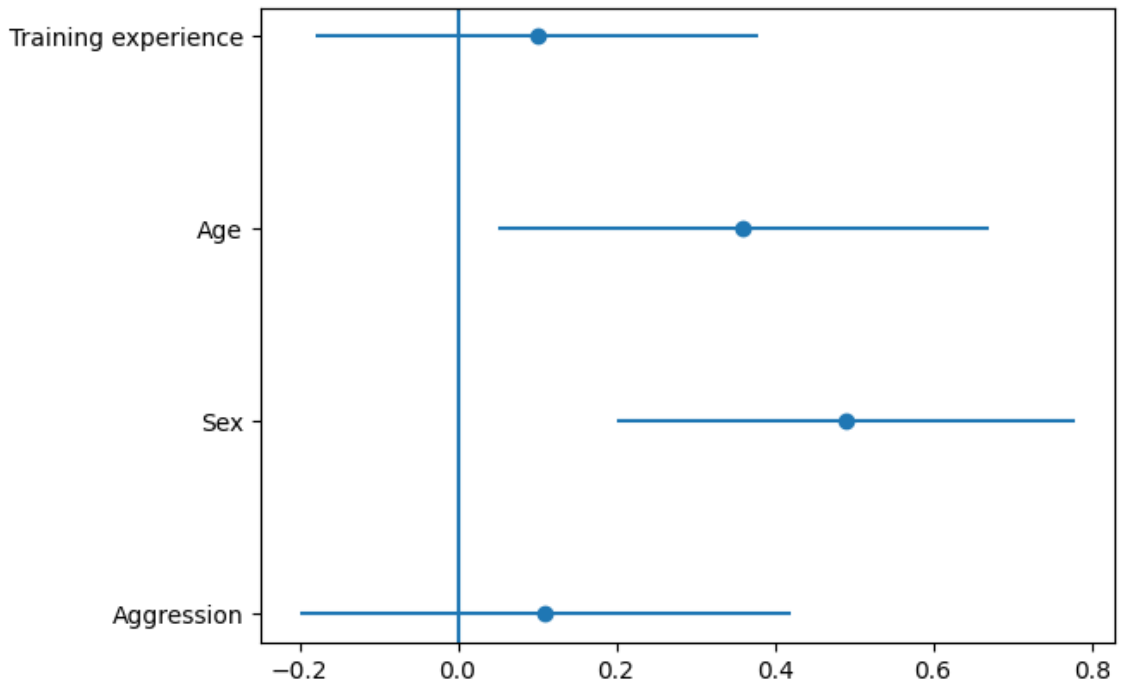

Figure 1. Standardized regression coefficients (β) with 95% confidence intervals for predictors of total kicking force (Force_total). The regression model included aggression level (BPAQ_total), sex, age, and training experience as predictors and explained 53% of the variance in total kicking force ($R^2 = 0.53$; $F(4,25) \approx 7.15$, $p < 0.001$). Sex showed the strongest positive association with kicking force ($\beta \approx 0.49$), followed by age ($\beta \approx 0.36$), whereas aggression ($\beta \approx 0.11$) and training experience ($\beta \approx 0.10$) were not statistically significant predictors. Error bars represent 95% confidence intervals.

To examine whether aggression predicts the ability to generate kicking force, a multiple linear regression analysis was performed with the total kicking force index (Force_total) as the dependent variable. Force_total was calculated as the mean value across six kicking techniques (left and right front, roundhouse, and side kicks). The predictors included aggression level (BPAQ_total), sex, age, and training experience. All variables were standardized prior to analysis in order to obtain standardized regression coefficients (β). The regression model was statistically significant, $F(4, 25) = 7.15$, $p < 0.001$, explaining 53% of the variance in total kicking force ($R^2 = 0.53$; adjusted $R^2 = 0.46$). Standardized regression coefficients with 95% confidence intervals are presented in Figure 1. Sex emerged as the strongest predictor of total kicking force (β = 0.49), indicating that male athletes generated substantially greater kicking force than female athletes. Age also showed a positive association with kicking force (β = 0.36). In contrast, aggression (β = 0.11) and training experience (β = 0.10) were not statistically significant predictors of total kicking force.

Overall, the regression analysis indicates that the ability to generate kicking force is primarily associated with demographic factors, particularly sex and age, whereas dispositional aggression and training experience do not significantly contribute to explaining variance in overall force-generation capacity.

DISCUSSION

The aim of the present study was to evaluate the relationship between dispositional aggression and the ability to generate kicking force in taekwondo athletes while considering the role of sex and age. The obtained results indicate that aggression does not appear to play a major role in determining the overall ability to generate force in taekwondo kicking techniques. Instead, demographic factors, particularly sex and age, demonstrated stronger associations with the capacity to produce high kicking force.

In the regression model explaining total kicking force, sex emerged as the strongest predictor of performance. Male athletes generated significantly greater kicking force than female athletes, which is consistent with previous research demonstrating substantial sex differences in maximal strength and muscular power. These differences are commonly attributed to variations in muscle mass, muscle fiber cross-sectional area, and hormonal profiles, particularly the higher levels of anabolic hormones observed in men [24]. Similar sex-related differences in force generation during striking techniques have also been reported in biomechanical analyses of martial arts and combat sports [19]. The present findings therefore support the view that the ability to generate high impact forces during kicking techniques is largely determined by biological and physiological characteristics rather than by psychological traits.

Age also demonstrated a significant positive association with kicking force in the regression analysis, suggesting that older athletes may be capable of producing greater impact forces. This effect may reflect long-term neuromuscular adaptations and accumulated sport-specific experience resulting from prolonged participation in training and competition. Previous studies have shown that training experience and the development of neuromuscular coordination play an important role in the effective transfer of force during complex motor actions such as kicking techniques [7,21]. However, although age was identified as a significant predictor in the regression model, group comparisons between younger and older athletes did not reach statistical significance. This discrepancy may be explained by the relatively small sample size and the limited statistical power of the study.

In contrast, aggression did not emerge as a significant predictor of total kicking force. These findings suggest that psychological traits such as dispositional aggression play a limited role in determining the overall capacity to generate force in

taekwondo kicking techniques. From a theoretical perspective, aggression may be associated with increased arousal and activation of the sympathetic nervous system, which could potentially enhance short-term motor performance under competitive conditions [10,11]. Nevertheless, the present results indicate that such psychophysiological mechanisms are unlikely to substantially influence the maximal force generated during controlled laboratory measurements of kicking techniques.

At the same time, no statistically significant differences in aggression levels were observed between male and female athletes. This observation is consistent with previous literature indicating that sex differences in aggression are often moderate and strongly dependent on the context and type of aggressive behavior [25]. In the context of martial arts training, aggression may also be moderated by the philosophical and educational aspects of practice, which often emphasize discipline, emotional control, and respect for opponents [13–15]. Consequently, the absence of sex differences in aggression combined with clear differences in kicking force further supports the interpretation that biomechanical performance in striking techniques is determined primarily by somatic and physiological factors.

The results should also be considered within the broader context of research on aggression in combat sports. Previous studies have demonstrated that aggression levels vary across disciplines and may be influenced by the rules, philosophy, and training culture of a given martial art [26,27]. In disciplines such as taekwondo, where technical precision, speed, and controlled contact are emphasized, aggression may play a less prominent role in determining sport performance than in full-contact combat sports.

Taken together, the present findings suggest that the ability to generate high kicking force in taekwondo is influenced mainly by biological and training-related factors rather than by dispositional aggression. Psychological characteristics may contribute to momentary activation, motivation, or competitive readiness, but their influence appears to be relatively small when compared with biomechanical and physiological determinants of force production.

It should also be noted that the relatively small sample size and the unequal distribution of male and female participants may have limited the statistical power to detect smaller effects, particularly in regression analyses involving multiple predictors. Therefore, the present findings should be interpreted as preliminary and should be verified in future studies conducted on larger and more balanced samples.

Finally, the present study contributes to the growing body of literature on performance determinants in combat sports by integrating psychological and biomechanical perspectives. The results indicate that although psychological factors such as aggression may play a role in the broader context of sport performance, the capacity to generate high impact forces in taekwondo kicking techniques appears to depend primarily on structural, physiological, and training-related characteristics.

Study Limitations

The present study has several limitations that should be considered when interpreting the results. First, the sample size was relatively small, which may have limited the statistical power of the analyses, particularly in multiple regression models involving several predictors. In addition, the unequal distribution of male and female participants may have influenced the stability of parameter estimates and reduced the ability to fully assess potential sex-related differences.

Second, the study employed a cross-sectional design, which does not allow causal conclusions to be drawn regarding the relationship between aggression and the ability to generate kicking force. The relationships identified in the present study are correlational in nature and therefore should be interpreted with caution.

Third, aggression was assessed using a self-report questionnaire (BPAQ), which may be affected by response bias and social desirability. Although the questionnaire is widely used and demonstrates good psychometric properties, future

studies could benefit from including additional behavioral or physiological indicators of aggression and arousal.

Finally, the study focused exclusively on athletes practicing ITF taekwondo under a limited-contact competition format. Therefore, the results cannot be directly generalized to other combat sports or to full-contact disciplines, where the role of aggression in performance may be different. Future research should include larger and more diverse samples of athletes and incorporate additional biomechanical and psychophysiological variables.

Practical Implications

The findings of the present study provide several practical implications for training in taekwondo and other striking-based combat sports. First, the results indicate that the ability to generate high kicking force is primarily associated with somatic and physiological factors rather than with dispositional levels of aggression. Therefore, training programs aimed at improving kick performance should focus mainly on the development of muscular strength, power, and technical efficiency.

Second, the strong relationships observed between different kicking techniques and the overall force index suggest that general lower-limb strength and neuromuscular capacity may play an important role in force generation across multiple techniques. Consequently, strength and conditioning programs emphasizing lower-limb power development may contribute to improvements in overall kicking performance.

Finally, although aggression did not emerge as a significant predictor of total kicking force, its association with the force of the front kick suggests that psychological activation and arousal may influence performance in certain dynamic technical situations. Coaches should therefore consider psychological preparation and emotional regulation strategies as complementary elements of the training process, while recognizing that biomechanical and physical determinants remain the primary factors underlying force generation in taekwondo kicking techniques.

CONCLUSIONS

The results of the present study indicate that dispositional aggression does not constitute a significant determinant of the ability to generate kicking force in taekwondo athletes. In the regression model explaining total kicking force, demographic factors, particularly sex and age, emerged as significant predictors, whereas aggression did not contribute significantly to explaining variability in force-generation capacity.

These findings suggest that the ability to generate high kicking force in taekwondo is determined primarily by somatic and physiological characteristics as well as training-related factors rather than by dispositional levels of aggression. Although psychological traits may influence aspects of sport performance such as motivation, arousal, or competitive behavior, their role in determining maximal force output appears to be limited.

Future research should include larger and more balanced samples of athletes and incorporate additional biomechanical and psychophysiological measurements in order to further clarify the relationships between psychological characteristics and motor performance in combat sports.

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REFERENCES

1. Choi HH. Taekwon-Do: Koreańska sztuka samoobrony. Auckland: Międzynarodowa Federacja Taekwon-do; 1995.
2. Liu TT, Lin YC, Tang WT, Hamill J, Chang JS. Lower-limb kinematic characteristics of taekwondo kicks at different attack angles. Int J Perform Anal Sport. 2021; 21: 519–531.
3. McGill S. Core training: evidence translating to better performance and injury prevention. Strength Cond J. 2010; 32: 33–46. doi: 10.1519/SSC.0b013e3181df4521
4. Estevan I, Falco C. Mechanical analysis of the roundhouse kick according to height and distance in taekwondo. Biol Sport. 2013; 30: 275–279.
5. Falco C, Alvarez O, Castillo I, Estevan I, Martos J, Mugarra F, Iradi A. Influence of the distance in a roundhouse kick's execution time and impact force in taekwondo. J Biomech. 2009; 42: 242–248. doi: 10.1016/j.jbiomech.2008.10.041
6. Mosler D, Góra T, Kaczmarski J, Błaszczyszyn M, Chociaj M, Borysiuk Z. Target kinematic effect in kyokushin karate front kicks: an analysis of velocity, acceleration, and muscle activation patterns. Phys Act Rev. 2025; 13: 156–166. doi: 10.16926/par.2025.13.14
7. Bridge CA, Ferreira da Silva Santos J, Chaabène H, Pieter W, Franchini E. Physical and physiological profiles of taekwondo athletes. Sports Med. 2014; 44: 713–733. doi: 10.1007/s40279-014-0159-9
8. Anderson CA, Bushman BJ. Human aggression. Annu Rev Psychol. 2002; 53: 27–51. doi: 10.1146/annurev.psych.53.100901.135231
9. Kuśnierz C, Wosinek P, Marzec A. Variation in aggression levels in selected combat sports and martial arts. Phys Act Rev. 2025; 13: 92–102. doi: 10.16926/par.2025.13.23
10. Haller J. The neurobiology of abnormal manifestations of aggression: a review of hypothalamic mechanisms in cats, rodents, and humans. Brain Res Bull. 2013; 93: 97–109.
11. Cooke A, Kavussanu M, McIntyre D, Ring C. Effects of competition on endurance performance and the underlying psychological and physiological mechanisms. Biol Psychol. 2011; 86: 370–378. doi: 10.1016/j.biopsycho.2011.01.009
12. Franchini E, Del Vecchio FB, Matsushigue KA, Artioli GG. Physiological profiles of elite judo athletes. Sports Med. 2011; 41: 147–166.
13. Reynes E, Lorant J. Effect of traditional judo training on aggressiveness among young boys. Percept Mot Skills. 2002; 94: 21–25. doi: 10.2466/pms.2002.94.1.21
14. Kuśnierz C, Niewczas M, Cynarski WJ, Bielec G, Rogowska AM. Latent class analysis of aggression in martial arts and combat sports: a cross-sectional study. PLoS One. 2025; 20: e0328799. doi: 10.1371/journal.pone.0328799
15. Xu T, Li H, Rao G, Wang F. Exploring the impact of traditional Chinese martial arts and other martial arts on adolescent aggression: a comparative analysis of underlying mechanisms. BMC Psychol. 2025; 13: 352. doi: 10.1186/s40359-025-02657-5
16. Mazzanti M, Masini A, Sanmarchi F, Dallolio L, Mascherini G. Aggression and sport: a cross-sectional study on behavioral tendencies of athletes. J Bodyw Mov Ther. 2025; 42: 982–988. doi: 10.1016/j.jbmt.2025.03.001
17. Gross JJ, John OP. Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. J Pers Soc Psychol. 2003; 85: 348–362. doi: 10.1037/0022-3514.85.2.348
18. Wąsik J, Ortenburger D, Góra T. The kinematic effects of taekwondo strokes in various conditions of the outside environment: interpretation in the psychological aspect and perspective of application in sport, health-related training and survival abilities. Arch Budo. 2016; 12: 287–292.
19. Góra T, Mosler D, Ortenburger D, Wąsik J. Sex differences in utilizing effective mass among taekwon-do athletes performing turning and side kick. Phys Act Rev. 2024; 12: 70–77. doi: 10.16926/par.2024.12.23
20. Hunter SK. Sex differences in human fatigability: mechanisms and insight to physiological responses. Acta Physiol. 2014; 210: 768–789. doi: 10.1111/apha.12234
21. Gavagan CJ, Sayers MGL. A biomechanical analysis of the roundhouse kicking technique of expert practitioners: a comparison between the martial arts disciplines of Muay Thai, Karate, and Taekwondo. PLoS One. 2017; 12: e0182645. doi: 10.1371/journal.pone.0182645
22. Maxwell JP. Anger rumination: an antecedent of athlete aggression? Psychol Sport Exerc. 2004; 5: 279–289. doi: 10.1016/S1469-0292(03)00007-4
23. Buss AH, Perry M. The aggression questionnaire. J Pers Soc Psychol. 1992; 63: 452–459. doi: 10.1037/0022-3514.63.3.452

24. Handelsman DJ, Hirschberg AL, Bermon S. Circulating testosterone as the hormonal basis of sex differences in athletic performance. Endocr Rev. 2018; 39: 803–829. doi: 10.1210/er.2018-00020
25. Hyde JS. Gender similarities and differences. Annu Rev Psychol. 2014; 65: 373–398. doi: 10.1146/annurev-psych-010213-115057
26. Kuśnierz C, Cynarski WJ, Litwiniuk A. Comparison of aggressiveness levels in combat sports and martial arts male athletes to non-practising peers. Arch Budo. 2014; 10: 253–260.
27. Kuśnierz C, Rogowska A, Görner K. Emotional intelligence and aggression in kyokushin and shotokan karate athletes. Arch Budo. 2023; 19: 137–150.