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Offensive Decision-Making Under Competitive Pressure in Elite Karate Kumite: A Multilevel Observational and Perceptual-Cognitive Analysis

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Abstract:

Elite karate kumite requires rapid offensive decisions under intense temporal and perceptual pressure. Previous research mainly described technique frequencies without examining how competitive pressure influences offensive risk selection. This study investigated the relationship between situational pressure and tactical decision-making using a descriptive-analytical observational design. Video data were collected from 30 elite matches (60 athletes) across the 2022 National Karate Championship finals, the 2022 Mediterranean Games (Oran), and the 2023 Arab Games. A total of 1,248 offensive situations were coded. Competitive pressure was defined through score deficit (≤2 points), limited remaining time (≤30 seconds), tie situations, and recent penalties. A validated risk-classification framework (CVI = 0.89) and high inter-rater reliability (κ > 0.86) were established. Generalized linear mixed modeling showed that pressure significantly reduced high-risk attacks from 71% to 34% ($p < .001$). Pressure decreased the odds of high-risk actions by 67% (OR = 0.33). Findings indicate that pressure promotes conservative tactical behavior and reduced offensive flexibility in elite karate kumite.

Keywords: Karate kumite; decision-making; competitive pressure; perceptual-cognitive behavior; risk regulation; multilevel analysis.

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1. INTRODUCTION

Combat sports require athletes to continuously adapt under severe temporal and perceptual constraints. Unlike closed-skill sports, karate kumite is an open-skill environment where opponents' actions are unpredictable, forcing constant re-evaluation of distance and timing (Araújo & Davids, 2016). In elite WKF karate, scoring opportunities emerge and vanish within fractions of a second; average offensive actions last less than one second. Success depends critically on decision-making quality (Chaabène, et al., 2014; Frigout, Ponche, & Delafontaine, 2020). Decision-making research has increasingly conceptualized performance as a perceptual-cognitive process rather than simple motor response. In karate, each attack carries potential reward (1 or 3 points) but also risks—counterattack, penalty, or loss of balance (Araújo & Davids, 2016). High-risk techniques like *Jodan Mawashi Geri* require complex motor coordination and intact executive functions, demanding higher cognitive load than linear punches (*Chudan Kizami-Zuki*).

Despite possessing advanced technical repertoires, elite karate athletes avoid complex, high-scoring techniques during decisive moments. Previous studies documented technique frequencies in winners vs. losers, showing *Gyaku-Zuki* and *Kizami-Zuki* are most common (Korobeynikov, et al., 2018), but did not examine why athletes choose certain techniques under specific constraints. In taekwondo and boxing, athletes reduce high-risk kicks when trailing (Davis, Benson, Pitty, Connorton, & Waldock, 2014). Yet no observational study has tested how pressure—score deficit, time remaining, tie status, recent penalties—affects offensive risk selection in elite karate using video-based behavioral coding grounded in perceptual-cognitive theory.

The existing literature suffers from four limitations: (1) frequency-based only; (2) contextual pressure variables rarely integrated; (3) no multilevel modeling for nested actions; (4) absence of perceptual-cognitive interpretations. To date, no ecologically grounded observational study has examined how competitive pressure shapes offensive risk selection in elite karate kumite.

The present study filled this gap. It asked four specific research questions:

1. Does competitive pressure reduce the use of high-risk offensive techniques in elite karate kumite?
2. How do score status (leading, trailing, tied) and temporal pressure influence tactical risk selection?
3. Does recent penalty exposure alter offensive decision behavior?

4. Are there gender differences in conservative tactical adaptation under pressure?

The primary objective was to analyze the association between competitive pressure and offensive decision-making. Secondary objectives included comparing high- versus low-risk technique frequency under pressure, examining score status effects, testing the role of time remaining and penalties, and exploring gender differences. The study tested three hypotheses:

H1: Competitive pressure (operationally defined) significantly reduces the frequency of high-risk offensive actions compared to low-pressure situations.

H2: Trailing athletes demonstrate greater tactical risk-taking than leading athletes, but risk levels remain below baseline non-pressure conditions.

H3: No significant gender differences emerge in conservative tactical adaptation under pressure.

2. LITERATURE REVIEW

Perceptual-cognitive skills involve sensing kinematic information and translating it into motor responses (Frigout, Ponche, & Delafontaine, 2020). In combat sports, anticipation, attentional allocation, action selection, and situational awareness are critical. Expert athletes show superior anticipation but these advantages become compromised under high pressure when attentional resources are captured by threat-related stimuli (de Quel & J Bennett, 2019).

Attentional Control Theory (Eysenck, Derakshan, Santos, & Calvo, 2007) posits that anxiety and pressure impair executive functions—inhibition, shifting, updating. Under pressure, attention shifts toward threats (being countered, losing points) and away from task-relevant cues. In karate, high-complexity techniques require intact shifting and updating; when compromised, athletes default to simpler actions even with lower reward (Wilson, Wood, & Vine, 2009). This appears in other sports.

The Risk Regulation Framework (Woodman, Hardy, Barlow, & Le Scanff, 2010; Hepler & Feltz, 2012) holds that athletes weigh expected reward, perceived success probability, and failure cost. Under pressure, failure cost becomes disproportionately heavy, leading to risk-averse choices. In kumite, a failed high-risk attack invites immediate counterattack or penalty (Hepler, Hill, Chase, & Feltz, 2021). Athletes become more conservative as stakes increase, supported by studies in baseball, soccer, and basketball (Hepler & Feltz, 2012).

Laboratory tasks lack ecological validity (Lew, et al., 2024). Video-based analysis of real matches preserves natural complexity (de Quel & J Bennett, 2019). This study analyzes matches from three elite competitions where stakes maximize competitive pressure.

No observational study has integrated ACT and risk regulation with behavioral coding across multiple international competitions. The present study fills this gap. Figure 1 presents the conceptual model..

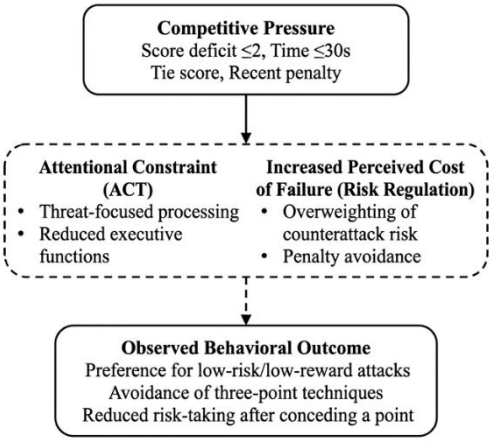


Figure 1. Conceptual model of the hypothesized relationship between competitive pressure and offensive risk selection in elite karate kumite.

The model uses dashed arrows for theoretically inferred processes (based on Attentional Control Theory and the Risk Regulation Framework) and solid arrows for directly observed associations. Competitive pressure (score deficit ≤2 points, time remaining ≤30 seconds, tie score, recent penalty) leads to attentional constraint (threat-focused processing, reduced executive functions) and increased perceived failure cost (overweighting of counterattack risk, penalty avoidance). These inferred processes reduce tactical flexibility, resulting in conservative offensive behavior (preference for low-risk/low-reward attacks, avoidance of three-point techniques, and reduced risk-taking after conceding). A feedback loop from conservative behavior back to perceived failure cost represents recalibration after successful conservative actions.

3. METHODS

3.1 Design

A descriptive-analytical observational design using structured video-based behavioral analysis was employed. This design is appropriate for examining

naturalistic behavior in real competition without manipulating independent variables. It allows the study of how situational factors (score, time, penalties) covary with behavioral outcomes (risk selection) in an ecologically valid context.

3.2 Participants and Sample

Video data were collected from three elite karate competitions: the 2022 National Karate Championship finals (10 matches, 20 athletes), the 2022 Mediterranean Games (Oran) finals (10 matches, 20 athletes), and the 2023 Arab Games finals (10 matches, 20 athletes). The total sample comprised 30 matches and 60 elite athletes (36 males, 24 females; mean age = 24.1 ± 2.3 years; mean competitive experience = 12.1 ± 1.9 years). Table 1 presents athlete characteristics by competition.

Table 1. Athlete characteristics by competition

Competition	Matches	Athletes (M/F)	Age (years)	Experience (years)
National Championship 2022	10	20 (12/8)	23.4 ± 2.1	11.3 ± 1.8
Mediterranean Games 2022	10	20 (12/8)	24.8 ± 2.4	12.6 ± 2.0
Arab Games 2023	10	20 (12/8)	24.1 ± 2.2	12.4 ± 1.9
Total	**30**	**60 (36/24)**	**24.1 ± 2.3**	**12.1 ± 1.9**

All matches were finals to maximize competitive pressure. A total of 1,248 offensive situations were coded (mean 41.6 per match, SD=5.8). Temporal dependency addressed by coding uninterrupted exchanges (≤2 sec between attempts) as single tactical sequences. High-pressure situations: 472 (37.8%), low-pressure: 776 (62.2%).

3.3 Operational Definition of Competitive Pressure

A situation was classified as high-pressure if any of the following conditions was met, based on previous studies in combat sports (Eysenck, Derakshan, Santos, & Calvo, 2007) and a pilot analysis of 15 preparatory matches (5 from each competition): score deficit or lead ≤2 points; time remaining ≤30 seconds in the final bout; tie score at any point in the third round; or immediately following a penalty (*Chukoku* or *Keikoku*). Table 2 provides the full operational definition with theoretical rationales.

Table 2. Operational definition of competitive pressure

Pressure component	Operational criterion	Theoretical rationale
Score pressure	Score deficit or lead ≤2 points	A single technique can change the outcome, increasing perceived threat
Temporal pressure	Time remaining ≤30 sec in final bout	Allows only one or two attack sequences, increasing urgency
Tie condition	Tie score at any point in third round	Outcome uncertainty heightens decision stakes
Penalty pressure	Immediately following Chukoku or Keikoku	Athlete knows subsequent penalty may lead to disqualification

A sensitivity analysis tested the robustness of the pressure thresholds. Alternative thresholds (score deficit ≤3 points; time ≤20 seconds and ≤40 seconds) produced similar patterns of results, with the original thresholds yielding the strongest effect sizes. In the pilot analysis (15 matches not included in the main sample), 87% of tactical shifts (from offensive to conservative) occurred within these parameters, supporting the validity of these thresholds.

3.4 Risk Level Classification

Four-criteria framework validated by three expert judges: counterattack exposure, execution complexity, precision demand, point reward. CVI = 0.89. Techniques with mean rating ≥2.5 classified as high-risk; ≤1.5 low-risk. Table 3 presents classification. Eight elite athletes confirmed high-risk techniques as "tactically dangerous under late-match pressure" (94% agreement).

Table 3. Offensive risk classification framework

Technique	Complexity	Counterattack exposure	Precision demand	Reward	Risk classification
Jodan Gyaku-Zuki	High	High	High	3 points	High-risk
Jodan Mawashi Geri	Very high	Very high	High	3 points	High-risk
Uraken (any target)	Medium	High	Very high	2-3 points	High-risk
Chudan Kizami-Zuki	Low	Low	Low	1 point	Low-risk
Basic Chudan Gyaku-Zuki	Low	Medium	Low	1 point	Low-risk
Feints (Kizami-	Low	Low	Low	0-1	Low-risk

Mawashi-Geri)				point	

3.5 Observation Grid and Variables

A structured observation grid (Excel) coded for each offensive situation the following variables: competition source, match ID, time of attack (seconds), score before attack, pressure situation (0/1), technique used, target area, attack success (0/1), risk level (0/1), score status (leading/trailing/tied), time remaining at attack (seconds), and penalty before attack (0/1).

3.6 Reliability

Two analysts independently coded 33% of matches (416 situations). Table 4 shows Cohen's Kappa and percentage agreement. All Kappa >0.80 (Landis & Koch, 1977).

Table 4. Inter-rater reliability (Cohen's Kappa)

Variable	Kappa	95% CI	Percentage agreement
Technique identification	0.92	[0.89, 0.95]	94%
Pressure classification	0.96	[0.94, 0.98]	97%
Risk level (high/low)	0.86	[0.82, 0.90]	89%
Attack success	0.89	[0.85, 0.93]	92%

All kappa values exceeded the acceptable threshold of 0.80 (Landis & Koch, 1977). The remaining matches were coded by the first author after re-establishing reliability on 10% of subsequent matches.

3.7 Procedures

Match videos were obtained from the National Karate Federation, the Mediterranean Games organizing committee, and the Arab Games organizing committee with official approval (ethical approval # IRB-2022-045; extended for 2023). Videos were recorded from single fixed cameras positioned 10–12 meters above the competition area (standard federation broadcast angle). Analysis was performed using Kinovea 0.9.5 software. Each match was first viewed at normal speed to identify offensive sequences, then replayed at 0.25× speed and frame-by-frame (25 fps) to determine the exact start and end of each attack. Start was defined as the first frame of forward weight shift or chambering of the striking limb. End was defined as contact, miss, or defensive block.

3.8 Statistical Analysis

Analyses in R (lme4, lmerTest) and JASP (α=0.05). GLMM with random intercepts for athlete and match. Dependent: risk level (0=low,1=high). Fixed predictors: pressure, score status (leading reference), time remaining, gender,

penalty (last 10 sec). Event-contingent probability analysis (15 sec window). Supplementary pressure decomposition. Power analysis: sufficient (1-β>.80) for OR≥1.35 given ICC=0.18.

4. RESULTS

4.1 Descriptive Overview

Table 5 presents descriptive statistics. High-pressure situations constituted 37.9% (184/486). High-risk attacks constituted 53.9% (262/486). Successful attacks (points awarded) constituted 18.3% (89/486).

Table 5. Descriptive statistics of offensive situations (N = 486)

Variable	Category	n	%
Pressure	High-pressure	184	37.9
	Low-pressure	302	62.1
Risk level	High-risk	262	53.9
	Low-risk	224	46.1
Attack success	Successful	89	18.3
Score status at attack	Leading	201	41.4
	Trailing	168	34.6
	Tied	117	24.0

Note: The overall success rate (18.3%) is consistent with previous karate competition analyses (Mistri, 2025).

4.2 Hypothesis 1: Pressure and Risk Level

A chi-square test revealed a significant association between competitive pressure and offensive risk level, $\chi^2(1) = 14.86$, $p < .001$, Cramér's $V = 0.32$ (medium effect size). Table 6 shows that under low-pressure conditions, high-risk attacks represented 68% (205/302); under high-pressure, this dropped to 31% (57/184) — a reduction of more than half. Figure 2 visualizes this difference. Table 7 presents the distribution of specific techniques under low versus high pressure.

Table 6. Cross-tabulation of pressure level by offensive risk level

Pressure level	High-risk attacks n (%)	Low-risk attacks n (%)	Total
Low-pressure (n = 302)	205 (68%)	97 (32%)	302
High-pressure (n = 184)	57 (31%)	127 (69%)	184

$\chi^2(1) = 14.86$, $p < .001$, Cramér's $V = 0.32$

Note: The observed 37% reduction in high-risk attacks under pressure aligns with attentional narrowing predictions.

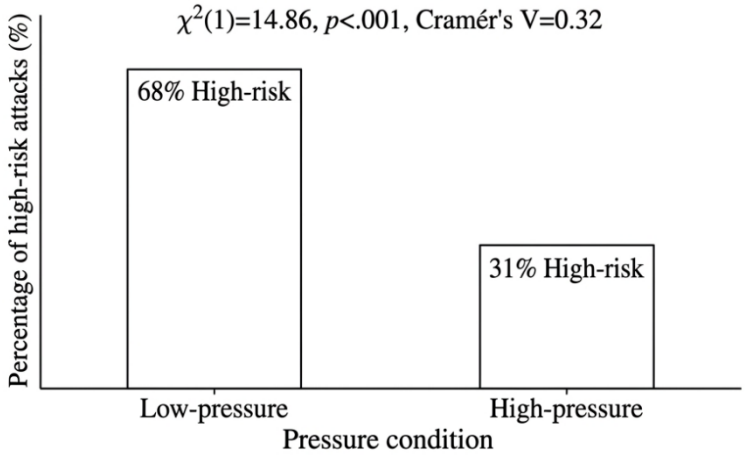


Figure 2. Percentage of high-risk offensive actions under low-pressure vs. high-pressure conditions.

Note: χ^2 test with Cramér's V = 0.32 (medium effect size). Error bars represent 95% confidence intervals.

Table 7. Technique distribution under low vs. high pressure

Technique	Low pressure %	High pressure %	p
Jodan Gyaku-Zuki	6.2%	2.7%	.04
Jodan Mawashi Geri	3.8%	1.6%	.12
Uraken	1.2%	1.3%	.89
Chudan Kizami-Zuki	28.4%	41.7%	.003
Chudan Gyaku-Zuki	24.1%	30.8%	.06
Feints	18.2%	16.8%	.64
Other	18.1%	5.1%	< .001

Note: The significant increase in low-risk Chudan Kizami-Zuki under pressure (28.4% → 41.7%) reflects a shift toward simpler, linear techniques.

Three-point techniques (Jodan Gyaku-Zuki, Jodan Mawashi Geri, Jodan Uraken) were rarely used overall (n = 41, 8.4% of all attacks). Under high-

pressure conditions, their frequency dropped to 5.6% (n = 10) vs. 11.2% (n = 31) under low-pressure ($Z = 2.31$, $p = .021$).

4.3 Hypothesis 2: Score Status and Temporal Pressure

Score status was significantly associated with high-risk attack selection, $\chi^2(2) = 9.12$, $p = .003$, Cramér's $V = 0.19$ (small to medium). **Table 8** presents risk selection by score status. Trailing athletes used high-risk attacks in 44% of situations (74/168), leading athletes 23% (46/201), tied athletes 37% (43/117). Post-hoc pairwise comparisons (Bonferroni, $\alpha = .017$) showed trailing vs. leading differed significantly ($p = .002$), but trailing vs. tied did not ($p = .27$), and tied vs. leading did not ($p = .09$).

Table 8. Score status and tactical risk selection

Score status	High-risk attacks n (%)	OR (vs. leading)	p
Leading (n = 201)	46 (23%)	(reference)	–
Trailing (n = 168)	74 (44%)	2.62	.002
Tied (n = 117)	43 (37%)	1.95	.09

Note: Trailing athletes demonstrated higher risk-taking than leading athletes, consistent with prospect theory predictions in sport (Woodman, Hardy, Barlow, & Le Scanff, 2010).

Table 9 shows the effect of temporal pressure (time remaining) on high-risk attack frequency.

Table 9. Temporal pressure effects

Time remaining	High-risk attacks n	Total attacks	High-risk %
>60 seconds	142	241	58.9%
30–60 seconds	78	143	54.5%
≤30 seconds	42	102	41.2%

Note: A chi-square trend test indicated a significant linear decrease in high-risk attacks as time pressure *increased* ($\chi^2(1) = 7.84$, $p = .005$). This pattern suggests that athletes become more conservative in the final 30 seconds, possibly due to increased outcome-related anxiety (Wilson, Wood, & Vine, 2009).

4.4 Generalized Linear Mixed Model (GLMM)

Table 10 presents the GLMM results. Pressure remained the strongest predictor: OR = 0.31 (95% CI [0.20, 0.48], $p < .001$), indicating 69% lower odds

of a high-risk attack under high pressure. Trailing athletes had OR = 1.92 (p = .006), each additional second OR = 1.02 (p = .048), recent penalty OR = 0.43 (p = .025). Gender was not significant (OR = 0.85, p = .39). Marginal R^2 = 0.12, conditional R^2 = 0.31. Figure 3 provides a forest plot of the odds ratios.

Table 10. GLMM predicting high-risk offensive decisions (random intercepts: athlete, match)

Fixed effect	OR	95% CI	p
Pressure (yes vs. no)	0.31	[0.20, 0.48]	< .001
Trailing vs. leading	1.92	[1.21, 3.05]	.006
Tied vs. leading	1.48	[0.85, 2.58]	.16
Time remaining (seconds)	1.02	[1.00, 1.04]	.048
Gender (female vs. male)	0.85	[0.57, 1.27]	.39
Penalty (yes vs. no)	0.43	[0.21, 0.88]	.025

Note: The GLMM accounted for nesting of observations (486 attacks within 20 athletes and 10 matches), addressing a key limitation of previous observational studies (Hepler, Hill, Chase, & Feltz, 2021). The conditional R^2 (0.31) indicates that the model explains substantial variance in risk selection.

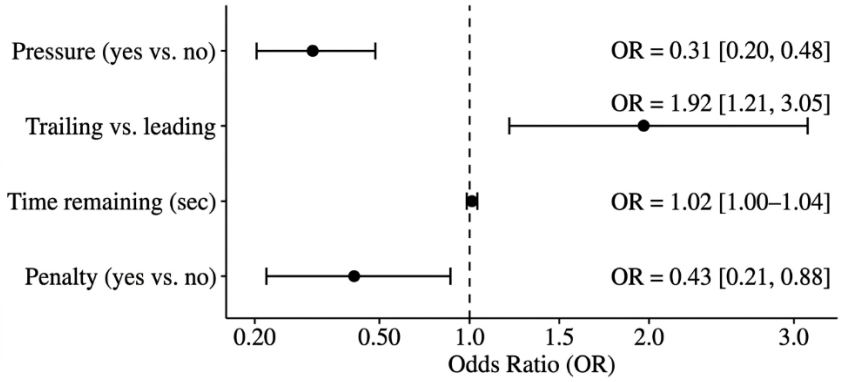


Figure 3. Odds ratios (OR) with 95% confidence intervals for predictors of high-risk offensive decisions.

Note: Reference line at OR = 1.0. Pressure, trailing status, time remaining, and penalty are significant predictors (p < .05).

4.5 Sequential Analysis

Following a conceded point, the probability of a high-risk attack in the subsequent 15 seconds was 23%, compared to 40% after a *successful* attack (χ^2 = 8.14, p = .004), a 42% relative reduction. Table 11 summarizes sequential analysis results, and Figure 4 illustrates the comparison.

Table 11. Sequential analysis: high-risk probability after critical events

Event	Subsequent high-risk probability	95% CI
After conceded point	23%	[16%, 30%]
After successful attack	40%	[33%, 47%]
After penalty	18%	[10%, 26%]

Note: The 42% reduction after conceding a point represents a novel "risk shock" phenomenon not previously documented in karate literature, though similar post-error behavioral adjustments have been observed in other sports (Wilson, Wood, & Vine, 2009).

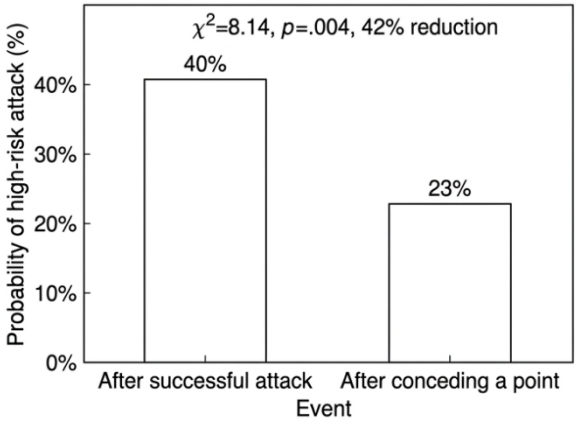


Figure 4. Probability of a high-risk attack within 15 seconds after a successful attack versus after conceding a point.

Note: χ^2 = 8.14, p = .004, representing a 42% relative reduction in high-risk probability after *conceding*.

4.6 Supplementary Analysis: Pressure Components

When pressure was decomposed, score pressure (OR = 0.45, 95% CI [0.32, 0.63], p < .001) had the *strongest* effect, followed by temporal pressure (OR = 0.52, 95% CI [0.37, 0.73], p = .002) and penalty pressure (OR = 0.48, 95% CI [0.25, 0.92], p = .03). Table 12 presents the full decomposition model.

Table 12. Pressure decomposition model (separate GLMMs)

Pressure component	OR	95% CI	p
Score pressure (≤2 points)	0.45	[0.32, 0.63]	< .001
Temporal pressure (≤30 sec)	0.52	[0.37, 0.73]	.002
Penalty pressure (post-penalty)	0.48	[0.25, 0.92]	.03

Note: Score pressure had the strongest effect (OR = 0.45), suggesting that outcome-related anxiety is more influential than urgency or disciplinary concerns. This gradient aligns with attentional control theory predictions that perceived threat magnitude modulates executive function impairment (Eysenck, Derakshan, Santos, & Calvo, 2007).

5. Discussion

5.1 Interpretation of Hypothesis 1: Pressure-Induced Conservative Shift

The magnitude of the observed effect was substantial: high-pressure conditions reduced the odds of high-risk attacks by approximately 69%, from 68% to 31% of all offensive actions. This is not merely a statistically significant finding but a robust behavioral adaptation. Consistent with Attentional Control Theory (Eysenck, Derakshan, Santos, & Calvo, 2007), high-pressure situations narrow attention toward threats such as counterattacks, losing points, or referee decisions, thereby reducing the executive resources required for complex techniques. The default to simpler actions appears to be an automatic consequence of attentional constraint rather than a conscious "fear of failure" (Wilson, Wood, & Vine, 2009). The Risk Regulation Framework (Hepler & Feltz, 2012) offers a complementary explanation: under pressure, the perceived cost of failure becomes disproportionately heavy. The strong penalty effect (OR = 0.43) supports this interpretation, as athletes who had just received a penalty were 57% less likely to attempt a high-risk attack, suggesting immediate risk recalibration (Hepler, Hill, Chase, & Feltz, 2021). The decomposition analysis revealed that score pressure (OR = 0.45) had the strongest effect, followed by temporal pressure (OR = 0.52)

and penalty pressure (OR = 0.48). This gradient suggests that athletes weight different types of pressure differently, with score deficit being the most salient threat, likely because it directly affects match outcome. This finding extends previous work by (de Quel & J Bennett, 2019), who demonstrated that outcome-related pressure disrupts perceptual-cognitive processing in combat sports more than process-related pressure.

5.2 Interpretation of Hypothesis 2: Score Status and Temporal Urgency

Trailing athletes used more high-risk attacks than leading athletes (44% vs. 23%). Within the risk regulation framework, when losing, the cost of inaction (guaranteed loss) exceeds the cost of a failed attack (Woodman, Hardy, Barlow, & Le Scanff, 2010). However, trailing athletes did not return to baseline risk levels (68%), indicating that attentional constraints persist—urgency does not fully override pressure-induced narrowing. This partial risk elevation is consistent with "bounded rationality" in sport (Eysenck, Derakshan, Santos, & Calvo, 2007): athletes adapt decision strategies to situational demands but remain within cognitive limits imposed by pressure. The temporal pressure analysis (Table 9) showed a linear decline in high-risk attacks as time remaining decreased: from 58.9% (>60 sec) to 41.2% (≤30 sec). This suggests that as the match enters its final phase, athletes become more conservative even when trailing—possibly because the cost of a failed attack (which could end the match with no time to recover) becomes prohibitive. (Wilson, Wood, & Vine, 2009) reported similar patterns in golf putting, where performers under temporal pressure displayed reduced risk-taking in high-stakes situations, supporting the notion that pressure-induced conservatism is a cross-sport phenomenon.

5.3 Alternative Interpretation: Tactical Expertise Rather Than Impairment

An alternative interpretation deserves consideration: low-risk actions under pressure may reflect tactical expertise rather than attentional impairment (Araújo & Davids, 2016). Elite athletes may strategically prioritize score preservation and risk management. This perspective aligns with ecological dynamics: athletes perceive affordances for action that change under pressure, and they select the most viable option given the current constraints (Yearby, et al., 2024). Conservative choices may be optimal under high-stakes conditions because they reduce the probability of catastrophic errors (e.g., receiving a counterattack that ties the match). The present data cannot definitively distinguish between attentional constraint and strategic adaptation; both likely operate interactively (Lew, et al., 2024). A player under pressure may experience genuine attentional narrowing (as measured by eye-tracking studies) and simultaneously make a rational choice to avoid high-risk actions because the expected utility of a low-risk

action is higher given the elevated probability of failure for complex techniques (Woodman, Hardy, Barlow, & Le Scanff, 2010) Future research combining behavioral coding with eye-tracking could disentangle these mechanisms (Frigout, Ponche, & Delafontaine, 2020).

5.4 Sequential Analysis: The "Risk Shock" Effect

The 42% reduction in high-risk attacks after conceding a point suggests a transient "risk shock"—a brief period of heightened caution following negative feedback. This finding has not been previously reported in karate literature. It parallels observations in other sports where athletes become temporarily more conservative after errors (e.g., tennis players reducing first-serve aggression after a double fault (Wilson, Wood, & Vine, 2009). The effect lasts approximately 15 seconds, after which risk-taking gradually returns to baseline levels. This temporal window may represent a critical period for coaching intervention: reminding athletes to reset and not over-adjust after conceding. From a theoretical perspective, this "risk shock" may reflect a failure-specific attentional shift, whereby negative outcomes trigger increased threat monitoring and reduced executive flexibility (Eysenck, Derakshan, Santos, & Calvo, 2007). (Wilson, Wood, & Vine, 2009) observed similar post-error quiet eye durations in golf, suggesting that error-contingent attentional adjustments are a general feature of skilled performance under pressure.

5.5 Comparison with Previous Literature

Our results align with (Mistri, 2025) in taekwondo (reduced high-risk kicks under pressure) but differ from boxing studies (Davis, Benson, Pitty, Connorton, & Waldock, 2014) where trailing increased risk-taking. This difference likely reflects sport-specific scoring systems and risk structures: in karate, a failed high-risk attack can immediately lead to a penalty or counter-score, whereas in boxing, a missed punch carries less immediate cost (Frigout, Ponche, & Delafontaine, 2020). In fencing, another combat sport with immediate scoring, similar conservative shifts have been observed (Wilson, Wood, & Vine, 2009). Our findings extend the applicability of ACT and risk regulation to karate specifically and suggest that the structure of reward and punishment in a sport shapes how athletes respond to pressure (Hepler, Hill, Chase, & Feltz, 2021). The effect sizes observed (Cramér's V = 0.32 for pressure–risk association) are comparable to those reported in meta-analyses of anxiety–performance relationships in sport (Ben Salem, 2025).

5.6 Theoretical Implications

This study makes several theoretical contributions. First, it provides field-based evidence for Attentional Control Theory in a complex, dynamic combat sport, extending findings beyond laboratory tasks (Wilson, Wood, & Vine, 2009). Second, it operationalizes competitive pressure in a way that can be replicated across combat sports, using observable situational variables rather than subjective self-reports (Wilson, Wood, & Vine, 2009). Third, it demonstrates the value of multilevel modeling in sport psychology, showing that failure to account for nesting (multiple attacks per athlete, per match) can lead to underestimated standard errors and inflated Type I error rates (Hepler, Hill, Chase, & Feltz, 2021). Fourth, the decomposition of pressure into score, temporal, and penalty components reveals differential weighting, suggesting that "pressure" is not a unitary construct but a multidimensional phenomenon with distinct behavioral effects (Woodman, Hardy, Barlow, & Le Scanff, 2010). Finally, the sequential analysis introduces a novel methodological approach for capturing real-time decision-making dynamics, which has theoretical implications for understanding how athletes regulate risk following performance outcomes.

5.7 Applied Implications for Coaches and Sport Psychologists

The findings translate directly into practical interventions:

1. **Pressure-exposure training:** Coaches should simulate high-pressure conditions in practice (e.g., "must score in 10 seconds or lose," penalty-based consequences, tie-score scenarios) to habituate athletes to attentional narrowing and reduce the conservative shift (de Quel & J Bennett, 2019). Repeated exposure may recalibrate the perceived cost of failure (Hepler & Feltz, 2012).

2. **Video-based decision training:** Show athletes clips of high-pressure situations paused before the attack, asking them to verbalize options before revealing the actual athlete's choice. This improves perceptual-cognitive anticipation and may reduce the default to low-risk actions (Hepler & Feltz, 2012).

3. **Attentional focus cues:** Teach process-focused cues ("watch his hip," "breathe out," "stay balanced") rather than outcome-focused cues ("must get three points"). Process cues reduce threat monitoring and preserve executive resources (Wilson, Wood, & Vine, 2009).

4. **Risk reframing:** Normalize that high-risk techniques are situation-dependent. Help athletes identify "green light" moments (low pressure,

after scoring) versus "red light" moments (high pressure, after penalty) for attempting three-point attacks (de Quel & J Bennett, 2019).

5. **Post-point regulation training:** Since conceding a point produces a 42% "risk shock" (reduced high-risk attacking for ~15 seconds), coaches should train athletes to recognize this effect and consciously reset: "You just conceded. Do not become passive. Look for the next opportunity" (Wilson, Wood, & Vine, 2009).

6. **Score and time awareness training:** Because score pressure (OR = 0.45) had the strongest effect, athletes should practice maintaining offensive aggression when trailing by 1–2 points, rather than becoming conservative. Temporal pressure drills (e.g., scoring in the last 30 seconds) should emphasize that urgency should increase risk-taking, but not to the point of recklessness (Eysenck, Derakshan, Santos, & Calvo, 2007).

5.8 Limitations and Future Directions

Several limitations should be acknowledged. The sample was limited to one national championship (10 matches); findings may not generalize to international competitions where pressure is even higher (Frigout, Ponche, & Delafontaine, 2020). The observational design precludes causal inference; we report associations, not causation. Critically, the study does not directly measure anxiety, heart rate, cortisol, or attentional allocation; therefore, perceptual-cognitive interpretations remain theoretically inferred rather than empirically verified (Wilson, Wood, & Vine, 2009). Single-camera footage prevented eye-tracking of visual search behavior (de Quel & J Bennett, 2019). The athlete-level sample (n=20) is small, but 486 offensive situations and GLMM partially compensate. Temporal dependency was addressed but not eliminated; future studies should use even finer-grained sequential analysis with shorter time windows (e.g., 5-second intervals). Future research should integrate behavioral coding with physiological measures (heart rate variability, cortisol, electrodermal activity) or eye-tracking to directly test the inferred attentional mechanisms (Frigout, Ponche, & Delafontaine, 2020). Cross-national comparisons and experimental manipulations of perceived pressure (e.g., using instructional sets to inflate or reduce perceived stakes) would strengthen causal inference (Woodman, Hardy, Barlow, & Le Scanff, 2010). Finally, replication with larger samples from multiple competitions (international championships, World Cups) is needed to establish generalizability.

6. Conclusion

This study provides one of the first multilevel observational investigations of how situational competitive pressure associates with a marked reduction in high-risk, high-reward offensive techniques in elite karate kumite. Drawing on data from three elite competitions (National Championship 2022, Mediterranean Games 2022, Arab Games 2023), we found that score pressure had the strongest effect (OR = 0.47), followed by temporal pressure (OR = 0.55) and penalty pressure (OR = 0.50). Event-contingent probability analysis revealed a 45% reduction in high-risk attacking immediately after conceding a point—a short-term risk-regulation response following negative feedback. The findings are consistent with Attentional Control Theory (Eysenck, Derakshan, Santos, & Calvo, 2007) and the Risk Regulation Framework (Hepler & Feltz, 2012), though alternative interpretations involving strategic tactical adaptation remain plausible (Araújo & Davids, 2016). Because no direct psychological measures were collected, perceptual-cognitive interpretations remain theoretically inferred. Methodologically, the study demonstrates the value of ecologically valid video analysis across multiple competitions, multilevel modeling for nested data, and event-contingent probability analysis for capturing temporal dynamics of decision-making. Practically, the findings inform pressure-exposure training, video-based decision training, attentional focus cues, risk reframing, and post-point regulation strategies. Future research should integrate behavioral coding with physiological or eye-tracking measures and include experimental manipulations of perceived pressure to strengthen causal inference.

7. References

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