International Journal of Sport Studies for Health, 2026, VOL. 9, NO. 3, 1-12

International Journal of Sport Studies for Health

Journal Homepage

Psychophysiological Responses to Competitive Anxiety, Stress Biomarkers (sCort and sAA), and Performance in Elite Female Basketball Players

Amir Hossien. Mehrsafar[1*], Behrouz. Golmohammadi[1], Parisa. Gazerani[2**]

[1] Division of Sport Psychology, Department of Sports Sciences, Faculty of Humanities, Semnan University, Semnan, Iran.
[2] Department of Life Sciences and Health, Faculty of Health Sciences, Oslo Met, Oslo, Norway.

*** Corresponding author email address**: a.mehrsafar@semnan.ac.ir
**** Corresponding author email address**: parisaga@oslomet.no

Article Info

Article type:
Original Research

How to cite this article:
Mehrsafar, A. H., Golmohammadi, B., & Gazerani, P. (2026). Psychophysiological Responses to Competitive Anxiety, Stress Biomarkers (sCort and sAA), and Performance in Elite Female Basketball Players. *International Journal of Sport Studies for Health*, *9*(3), 1-12.
http://dx.doi.org/10.61838/kman.intjssh.5162

ABSTRACT

Objective: This study examined the associations between competitive anxiety, self-confidence, salivary cortisol (sCort), salivary alpha-amylase (sAA), and performance outcomes in elite female basketball players.

Methods and Materials: In this observational cross-sectional study, 30 elite female basketball players (mean age = 16.4 ± 0.9 years) competing at national and international levels were included. Psychological states were assessed using the Persian version of the Competitive State Anxiety Inventory-2 Revised (CSAI-2R) approximately 1 hour prior to competition. Saliva samples were collected 30 minutes before competition to measure sCort and sAA. Pearson correlation and multiple regression analyses were performed to examine associations and exploratory multivariable relationships.

Findings: Higher levels of cognitive and somatic anxiety were significantly associated with lower free-throw and field-goal percentages and with more turnovers, whereas self-confidence showed the opposite pattern. Pre-competition sCort and sAA were positively associated with anxiety and negatively associated with self-confidence. In exploratory multivariable analyses, overall regression models were significant for several performance indicators, although individual predictors in enter models were not significant, suggesting substantial shared variance among predictors. In backward exploratory models, sAA, self-confidence, and cognitive anxiety/sCort combinations were retained in models of selected performance outcomes.

Conclusion: These findings highlight the importance of integrated psychophysiological monitoring in elite sport. Combined psychological and physiological assessments may support coaches and practitioners in optimizing performance and managing competitive stress in high-level athletes.

Keywords: Competitive anxiety, Cortisol, Alpha Amylase, Basketball, Performance.

Article history:
Received 28 March 2026
Revised 01 April 2026
Accepted 09 May 2026
Initial Publication 10 June 2026
Final Publication 01 July 2026

1. Introduction

Basketball is a fast-paced team sport that involves short bursts of high-intensity activity. It places significant demands on athletes' cognitive, perceptual, and motor skills. Players must engage in repeated high-intensity efforts while also processing information quickly, making decisions, and coordinating complex movements—all under time pressure (1). This combination of physiological load and cognitive demand makes basketball a suitable model for examining psychophysiological stress responses, particularly in elite athletes exposed to high-pressure competitive environments (2). In this context, regulating anxiety and stress responses is crucial for maintaining consistent performance. Competitive anxiety is widely recognized as a major psychological factor that affects athletic performance. It is defined as a negative emotional state marked by cognitive worry, heightened physiological arousal, attentional disruption, and a threat-based appraisal of competitive situations (3). Competitive anxiety is understood through the multidimensional anxiety theory, which identifies its manifestation across three domains: cognitive (e.g., intrusive thoughts, concerns about performance), somatic (e.g., increased heart rate, muscle tension), and behavioral (e.g., irritability, impulsive reactions, disruption of pre-performance routines). When these responses are not properly managed, they can hinder emotional control and diminish the athlete's ability to perform optimally under pressure (4). The interaction between these factors has been framed within theoretical models that describe how increases in physiological arousal and cognitive anxiety together influence performance outcomes. This relationship is often explained through the catastrophe model (5). This model suggests that performance is influenced by the interaction between cognitive anxiety and physiological arousal. When cognitive anxiety is high, even small increases in arousal can lead to sudden and significant declines in performance, rather than gradual decreases (6). These non-linear effects are especially relevant in basketball, where performance outcomes are highly sensitive to momentary changes in attention, precision, and decision-making (7). Consistent with this framework, systematic reviews have identified competitive anxiety as one of the most significant psychological factors affecting basketball performance at all levels of competition (8). Empirical studies show that poorly managed anxiety can impair attentional control, decision-making, and fine motor skills, particularly in high-pressure situations like free-throw shooting (9). Furthermore, recent evidence indicates that anxiety responses in basketball players are influenced by factors such as age, competitive experience, and contextual demands, along with activation of physiological stress systems (10, 11).

In competitive settings, competitive stress, conceptualized as a biopsychosocial phenomenon (12), rapidly activates neural threat-processing networks, whereby the amygdala, hypothalamus, and monoaminergic brainstem structures play central roles in initiating stress responses that involve both the hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic–adrenal–medullary (SAM) system. Activation of the HPA axis leads to cortisol secretion, with salivary cortisol (sCort) serving as a valid and non-invasive indicator of HPA activity and hormonal stress regulation (13). In parallel, activation of the SAM system results in rapid increases in salivary alpha-amylase (sAA), a sensitive marker of sympathetic nervous system activity that responds almost immediately to psychosocial stressors (14). The distinct temporal dynamics of these biomarkers indicate that sAA reflects an immediate stress response, whereas sCort represents a delayed and more sustained activation (15). Accordingly, the sampling protocol was standardized within the pre-competition period to capture the fast-reacting sympathetic response indexed by sAA alongside the relatively slower HPA-axis response reflected by sCort, thereby allowing both biomarkers to be interpreted within the same anticipatory stress context.

Previous research has shown that increases in competitive anxiety are commonly accompanied by elevations in both sCort and sAA, and that these responses are associated with impaired sport performance (8, 16, 17). Studies conducted in basketball contexts largely support this pattern. For instance, Madrigal & Wilson (2017) reported significant pre-competition increases in sCort among female basketball players, with higher cognitive anxiety associated with greater cortisol concentrations (18). Similarly, Tabassum et al., (2021) found that pre-competition contextual stressors (e.g., away games) increased anxiety levels, elevated sCort, and reduced self-confidence in basketball players, which coincided with subsequent performance declines (19). Despite these findings, empirical evidence in female basketball players remains limited. The few available studies suggest that competitive stress elicits meaningful physiological responses in female athletes (20), yet integrated examinations combining psychological and physiological markers across these temporal phases are scarce. A recent systematic review by Kamarauskas &

Conte, (2022) concluded that official basketball competitions consistently induce increases in both sCort and sAA. Importantly, researchers emphasized that the existing evidence is almost exclusively derived from male samples and that controlled investigations focusing on elite female basketball players are largely absent (10). Given established sex-related differences in emotion regulation and physiological stress reactivity, potentially driven by hormonal fluctuations (e.g., estrogen and progesterone), as well as differences in HPA-axis activity and sympathetic nervous system responses**,** this lack of female-specific evidence represents a significant limitation in the current literature. However, no study to date has simultaneously investigated psychological (anxiety and self-confidence) and physiological (sCort and sAA) responses in relation to performance outcomes in elite female basketball players under competitive conditions. Therefore, the aim of the present study was to examine the associations between competitive anxiety and self-confidence with sCort and sAA levels in elite female basketball players during the pre-competition period. In line with the cross-sectional design, the study was limited to examining associations rather than causal relationships. It was hypothesized that cognitive and somatic anxiety would be positively associated with sCort and sAA, whereas self-confidence would be negatively associated with these biomarkers**.** Furthermore, higher levels of anxiety and physiological stress responses were expected to be associated with poorer performance outcomes, whereas higher self-confidence was expected to be associated with better performance.

2. Methods and Materials

2.1 Participants

A sensitivity power analysis was performed using G*Power (version 3.1.9.7) to determine the minimum detectable effect size given the study sample. For a multiple linear regression model with five predictors (cognitive anxiety, somatic anxiety, self-confidence, sCort, and sAA), assuming a significance level of $\alpha = 0.05$ and statistical power of 0.80, a total sample size of 30 participants was sufficient to detect a large effect size ($f^2 = 0.54$). This a priori analysis ensures that the study was adequately powered to detect large effects, minimizing the risk of Type II errors. However, smaller effects might not have been reliably identified with the current sample size. The chosen effect size threshold ($f^2 = 0.54$) reflects practical significance, ensuring that meaningful relationships between predictors and outcomes were captured. (21). Participants were selected from the Iranian women's national basketball team training camp and represented the highest competitive level, including national and international-level athletes (mean age: 16.4 ± 0.9 years; height: 178.0 ± 10.1cm; body mass index: 21.3 ± 1.3 kg·m^{-2}; weekly training volume: 18.93 ± 2.48 hours). Participants were non-smokers and in good general health, with no history of neurological, psychiatric, endocrine, or musculoskeletal disorders that could influence psychological or physiological responses. Eligibility was confirmed via self-report and medical record review. Participants were also instructed to maintain consistent sleep and dietary routines prior to testing to minimize variability in physiological measures. Participants were instructed to abstain from caffeine consumption for at least 12 hours prior to sampling. Menstrual cycle phase and hormonal status were not controlled or recorded. This study was approved by the Committee of Research Ethics at the Sport Sciences Research Institute of Iran and conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent prior to participation and received no financial or material compensation.

2.2 Measures

2.2.1 Psychological assessments

The revised Persian version of the Competitive State Anxiety Inventory-2 (CSAI-2R) was employed to assess the multidimensional components of competitive anxiety (3). The instrument consists of 16 items distributed across three subscales: somatic anxiety (6 items; e.g., "My body feels tense"), cognitive anxiety (5 items; e.g., "I am concerned about this competition"), and self-confidence (5 items; e.g., "I am confident that I can meet the challenge"). Items are rated on a 4-point Likert scale ranging from 1 ("Not at all") to 4 ("Very much so"), with higher scores reflecting greater intensity of the respective psychological constructs. Scores for each subscale were summed across the items, with possible total score ranges from 6 to 24 for each subscale. The Persian version of the CSAI-2R has been validated in Iranian athlete populations, demonstrating satisfactory reliability and factorial validity (22). In the present study, the questionnaire was administered in paper-based format approximately 1 hour prior to competition.

2.2.2 Physiological assessments

Salivary samples were collected to assess physiological stress responses, specifically sCort and sAA. Whole saliva was obtained using the passive drool technique while participants were seated in a relaxed position. Participants were instructed to allow saliva to accumulate naturally for approximately 2 minutes before expelling it into sterile polypropylene tubes. Each participant provided approximately 2 mL of saliva, which met the minimum required volume for reliable biochemical analysis of sCort and sAA levels. To ensure the integrity of the samples, a standardized waiting period of 30 seconds was imposed following mouth rinsing with water. This interval was included to minimize potential dilution effects and guarantee the optimal quality of the samples**.** Participants were instructed to refrain from eating or drinking for at least one hour and to avoid tooth brushing for 30 minutes prior to sample collection to reduce the risk of contamination. Immediately before sampling, participants rinsed their mouths with water to remove residual debris, following standard procedures in salivary biomarker research (23). Samples were stored at −20 °C until analysis. Samples were processed in batches to control for potential variability across measurements. Prior to biochemical assessment, samples were thawed and centrifuged at 3000 rpm for 10 minutes to obtain clear supernatant. The centrifugation was performed at room temperature to prevent any temperature-related inconsistencies that could affect the sample integrity. sCort concentrations were determined using a commercially available enzyme-linked immunosorbent assay (ELISA) kit (Zellbio™, Germany; sensitivity = 0.1 nmol/L; intra- and inter-assay CVs < 8%). sAA activity was determined using a commercially available kinetic enzyme assay kit (Salimetrics, USA; sensitivity = 0.5 U/mL; intra- and inter-assay CVs < 9%), with enzyme activity expressed in U/mL.

2.2.3 Performance assessment

Basketball performance was assessed using objective competition-based indicators derived from official competition statistics. The selected variables included free-throw percentage, field goal percentage, turnovers, assist-to-turnover ratio, and competition outcome (win/loss), all of which are commonly used metrics in basketball performance analysis and are directly linked to cognitive control and motor precision, which are known to be disrupted by anxiety and stress in high-pressure situations (24). Free-throw percentage was calculated as the number of successful free throws divided by the total number of free-throws attempts during the competition and expressed as a percentage. Only players with at least one free-throw attempt were included in the analysis. Field goal percentage was computed as the ratio of successful two- and three-point field goals to the total number of field goal attempts. Similarly, inclusion required at least one field goal attempt. Turnovers were recorded as the total number of possessions lost due to errors in ball handling, passing, or rule violations, as documented in the official competition statistics. The assist-to-turnover ratio was calculated by dividing the total number of assists by the total number of turnovers, providing an index of offensive efficiency based on standard performance analysis conventions (25). Competition outcome was recorded dichotomously as win or loss. All performance variables were obtained from official statistics collected by the competition's technical staff in accordance with established basketball data recording procedures. The data collectors were independent of the research team and were not informed about the study hypotheses. Data extraction and verification were conducted following standard protocols (25). Performance metrics were not normalized per playing time, as all athletes played a comparable amount of time during the competition.

2.3 Procedure

The study was performed during an internal selection competition for the Iranian women's national basketball team, providing an ecologically valid, high-pressure competitive environment. All competitive activities were carried out in accordance with official International Basketball Federation (FIBA) regulations. One week prior to the competition, baseline saliva samples (approximately 2.5 mL) were collected from all athletes under non-competitive, low-stress conditions. To ensure comparability, baseline sampling was conducted at the same time of day as competition sampling, thereby controlling for circadian fluctuations in cortisol secretion. On the day of competition, participants completed the CSAI-2R approximately 1 hour before the start of the competition (around 09:00 h). Saliva samples for the assessment of sCort and sAA were collected 30 minutes later (around 09:30 h). Participants remained seated and refrained from any physical activity during the interval between questionnaire completion and saliva sampling to avoid acute influences on physiological stress markers. Following sample collection, athletes performed their standardized pre-competition warm-up routines, and the official competition commenced at approximately 10:00 h. A schematic overview of the study timeline is shown in Figure 1.

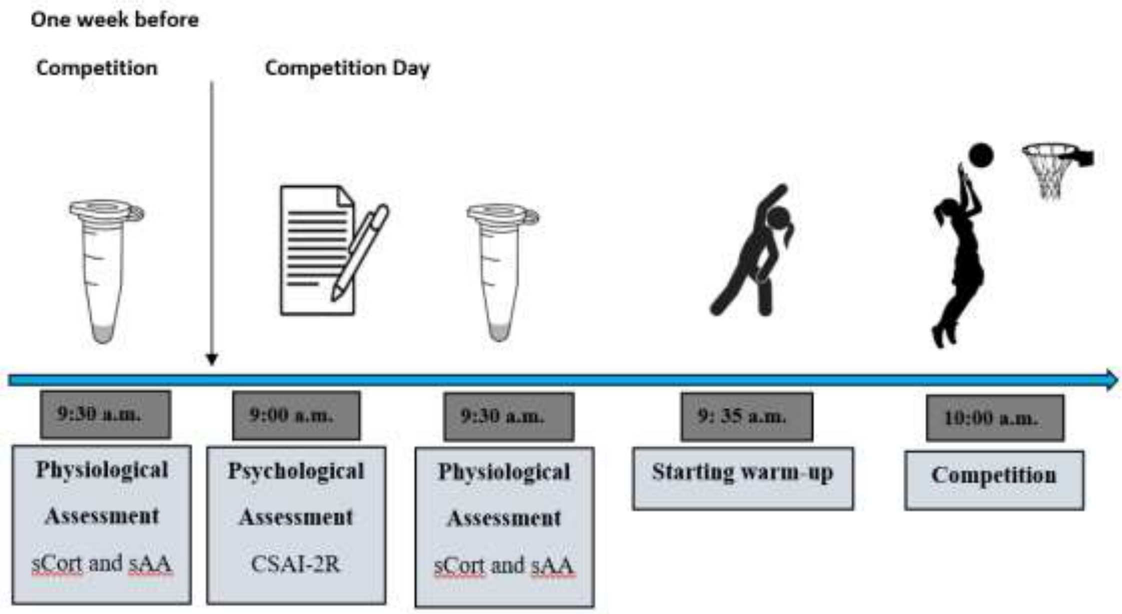

Figure 1. Schematic overview of the study timeline. Baseline saliva samples were collected one week before competition under non-competitive conditions at the same time of day as competition sampling. On the competition day, participants completed the CSAI-2R approximately 60 minutes before the start of the game (around 09:00 h), followed by saliva collection for sCort and sAA approximately 30 minutes before competition (around 09:30 h). The official competition began at approximately 10:00 h. CSAI-2R = Competitive State Anxiety Inventory-2 Revised; sCort = salivary cortisol; sAA = salivary alpha-amylase.

2.4 Statistical analysis

All variables were initially screened for normality and outliers. Outliers were identified using standardized z-scores (±3.0) and were winsorized to the nearest acceptable value to reduce their influence. Distributional assumptions were evaluated using the Shapiro–Wilk test, confirming the suitability of parametric analyses. These results were further supported by visual inspection of Q–Q plots and histograms, which indicated no substantial deviations from normality. Paired-samples t-tests were conducted to compare sCort and sAA levels between baseline and competition conditions. Pearson correlation coefficients were used to examine associations among psychological variables (cognitive anxiety, somatic anxiety, and self-confidence), physiological stress markers (sCort and sAA), and basketball performance indicators. Given the exploratory nature of the study, no correction for multiple comparisons was applied; therefore, the findings should be interpreted with appropriate caution. Point–biserial correlations were additionally performed to assess relationships between competition outcome (win/loss) and continuous physiological and performance variables. To investigate associations, multiple linear regression analyses using the enter method were conducted to examine the extent to which psychological and physiological variables were associated with physiological markers and performance outcomes. Multicollinearity diagnostics were performed using variance inflation factor (VIF) and tolerance statistics, indicating no evidence of problematic multicollinearity among predictors (VIF < 5; tolerance > 0.20). In addition, backward stepwise regression procedures were applied to identify the most parsimonious set of predictors. Because of the limited sample size and the intercorrelation among predictors, the regression analyses were treated as exploratory. Backward stepwise procedures were used only as a secondary exploratory approach to identify parsimonious variable sets; however, these models are susceptible to overfitting, unstable variable selection, and inflated Type I error, particularly in small samples. Accordingly, stepwise results were interpreted cautiously and regarded as hypothesis-generating. A binary logistic regression analysis was performed to examine factors associated with competition outcome, with psychological variables, physiological markers, and performance indicators entered as predictors. Both enter and backward stepwise approaches were used to evaluate model stability. Given the limited number of wins (n = 12), the binary logistic regression analysis was especially vulnerable to overfitting and unstable parameter estimates; therefore, these results were considered exploratory only. Effect sizes for correlation analyses were interpreted according to Cohen's conventions (small: r = 0.10, medium: r = 0.30, large: r = 0.50). Effect sizes were calculated using Cohen's *d* for dependent samples and interpreted based on conventional thresholds (small = 0.20–0.49, medium = 0.50–0.79, large ≥ 0.80). Statistical significance was set at $p < 0.05$, with all tests being two-tailed. All analyses were conducted using IBM SPSS Statistics (version 27).

3. Results

Descriptive statistics and Pearson correlation coefficients among the psychological, physiological, and performance variables are presented in Table 1.

Table 1. Descriptive statistics, bivariate correlations (Pearson's r), point-biserial correlations (rpb) among the psychological, physiological, and performance variables

Variable	Mean (SD)/ n (%)	1 r [95 % CI]	2 r [95 % CI]	3 r [95 % CI]	4 r [95 % CI]	5 r [95 % CI]	6 r [95 % CI]	7 r [95 % CI]	8 r [95 % CI]	9 r [95 % CI]	10 rpb [95 % CI]
1. Cognitive Anxiety	15.86 (2.77)	-									
2. Somatic Anxiety	15.14 (2.36)	0.65** [0.38, 0.81]	-								
3. Self-confidence	20.31 (2.93)	-0.70** [-0.85, -0.46]	-0.59** [-078, -0.29]	-							
4. sCort before Competition (nmol/L)	12.96 (2.84)	0.52** [0.20, 0.74]	0.55** [0.24, 0.76]	-0.70** [-0.84, -0.46]	-						
5. sAA before Competition (U/mL)	73.79 (16.33)	0.59** [0.30, 0.78]	0.63** [0.35, 0.81]	-0.71** [-0.85, -0.48]	0.77** [0.58, 0.88]	-					
6. Free-throw %	71.95 (6.28)	-0.58** [-0.77, -0.26]	-0.60** [-0.79, -0.39]	0.59** [0.30, 0.78]	-0.66** [-0.82, -0.38]	-0.71** [-0.85, -0.47]	-				
7. Field goal %	43.30 (5.28)	-0.59** [-0.78, -0.29]	-0.40* [-0.66, -0.05]	0.62** [0.34, 0.80]	-0.45* [-0.69, -0.10]	-0.56** [-0.76, -0.25]	-0.75** [-0.87, -0.54]	-			
8. Turnovers	3.76 (1.40)	0.64 [0.36, 0.81]	0.62** [0.34, 0.80]	-0.59** [-0.78, -0.30]	-0.62** [-0.33, -0.80]	0.65** [-0.38, -0.82]	-0.38* [-0.87, -0.54]	-0.53** [-0.74, -0.20]	-		
9.Assist/Turnover Ratio	1.55 (0.50)	-0.50** [-0.73, -0.17]	-0.61** [-0.79, -0.32]	0.65** [0.39, 0.82]	-0.69** [-0.84, -0.45]	-0.75** [-0.87, -0.54]	-0.62** [-0.80, -0.33]	0.54** [0.22, 0.75]	0.68** [-0.83, -0.42]	-	
10. Competition Outcome (rpb)	Win = 12 (40 %) Loss = 18 (60 %)	-0.32 [-0.61, 0.44]	-0.20 [-0.52, 0.17]	0.11 [-0.25, 0.45]	-0.29 [-0.58, 0.07]	-0.34 [-0.62, 0.17]	0.27 [-0.09, 0.57]	0.32 [0.08, 0.58]	-0.13 [-0.47, 0.23]	-0.08 [-0.28, 0.43]	-

*p < 0.05, **p < 0.01, n= 30.

Paired-samples t-tests revealed that physiological stress markers increased significantly from the baseline assessment to the competition condition. Specifically, sCort levels increased from baseline (M = 7.64, SD = 1.69) to competition (M = 12.97, SD = 2.84), reflecting a substantial elevation under competitive conditions ($t_{(29)} = 9.45$, $p < 0.01$, Cohen's d = 1.72). A similar pattern was observed for sAA, which rose from baseline (M = 42.27, SD = 8.04) to competition (M = 73.80, SD = 16.34), indicating a marked rise in response to competition ($t_{(29)} = 9.91$, $p < 0.01$, Cohen's d = 1.81). Overall, both biomarkers showed significant increases from baseline to competition, with large effect sizes.

Pearson correlation analyses revealed several significant associations among psychological, physiological, and performance variables. Cognitive anxiety was strongly and positively associated with somatic anxiety ($r = 0.65$, $p < 0.01$), while both were strongly negatively associated with self-confidence (cognitive: $r = -0.71$; somatic: $r = -0.59$, ps < 0.01). Pre-competition sCort and sAA were positively associated with both cognitive and somatic anxiety (rs ≈ 0.53–0.64, ps < 0.01) and negatively associated with self-confidence (rs ≈ −0.70 to −0.72, ps < 0.01), indicating moderate-to-large associations. Performance indicators showed a consistent pattern. Free-throw and field-goal percentages were negatively associated with both anxiety dimensions (rs ≈ −0.41 to −0.60, ps < 0.05) and positively associated with self-confidence (rs ≈ 0.60–0.63, ps < 0.01). In contrast, turnovers were positively associated with anxiety (rs ≈ 0.63–0.64, ps < 0.01) and negatively associated with self-confidence ($r = -0.60$, $p < 0.01$), whereas the assist-to-turnover ratio showed the opposite pattern (anxiety: rs ≈ −0.51 to −0.61; self-confidence: $r = 0.66$, $p < 0.01$). Competition outcome was not significantly associated with any psychological, physiological, or performance variables (all ps > 0.05). Results from the enter and backward stepwise regression models (multiple linear and binary logistic) are presented in Table 2A, B.

Table 2. Results of multiple linear and binary logistic regression analyses examining predictors of basketball performance and competition outcome.

A Multiple regression (Enter Method)	Basketball Performance Indicators: Free-throw %				Field goal %				Turnovers				Assist/Turnover Ratio			
Variable	B	β	t	p	B	β	t	p	B	β	t	p	B	β	t	p
Somatic Anxiety	-0.38	-0.16	-0.81	0.42	-0.59	-0.31	-1.35	0.18	0.15	0.30	1.43	0.16	0.01	0.09	0.49	0.62
Cognitive Anxiety	-0.41	-0.15	-0.80	0.42	0.28	0.12	0.59	0.56	0.11	0.19	1.01	0.31	-0.04	-0.20	-1.12	0.27
Self-Confidence	-0.05	-0.02	-0.11	0.91	0.64	0.35	1.36	0.18	0.01	0.02	0.11	0.91	0.03	0.17	0.82	0.41
sCort before Competition (nmol/L)	-0.44	-0.20	-0.89	0.37	0.23	0.12	0.50	0.61	0.10	0.20	0.92	0.36	-0.03	-0.19	-0.93	0.35
sAA before Competition (U/mL)	-0.14	-0.37	-1.57	0.12	-0.09	-0.30	-1.11	0.27	0.01	0.20	0.85	0.40	-0.01	-0.40	-1.82	0.08
Backward Stepwise	Step: 5 sAA before Competition				Step: 5 Self-Confidence				Step: 4 Cognitive Anxiety sCort before Competition				Step: 5 sAA before Competition			
	-0.27	-0.71	-5.40	0.01	1.13	0.62	4.26	0.01	0.22	0.43	2.81	0.01	-0.02	-0.75	-6.11	0.01
									0.19	0.38	2.49	0.01				

B Logistic regression	Competition Outcome (Win/Loss): Enter Method					Backward Stepwise Step: 6				
Variable	B	Wald Statistic	p	Odds Ratio (OR)	[95 % CI]	B	Wald Statistic	p	Odds Ratio (OR)	[95 % CI]
Somatic Anxiety	-0.39	1.36	0.24	0.67	[0.34, 1.30]					
Cognitive Anxiety	-0.06	0.03	0.86	0.93	[0.45, 1.95]					
Self-Confidence	-1.02	3.28	0.07	0.35	[0.11, 1.08]					
sCort before Competition (nmol/L)	-0.44	1.92	0.16	0.63	[0.33, 1.20]					
sAA before Competition (U/mL)	-0.11	1.77	0.18	0.89	[0.75, 1.05]	-0.14	4.34	0.03	0.86	[0.75, 0.99]
Free-throw %	0.07	0.24	0.62	1.07	[0.80, 1.45]					
Field goal %	0.43	4.46	0.03	1.54	[1.03, 2.32]	0.34	5.29	0.02	1.41	[1.05, 1.90]
Turnovers	0.63	0.79	0.37	1.88	[0.46, 2.29]					
Assist/Turnover Ratio	-3.24	2.04	0.15	0.03	[0.02, 1.33]					

Note: B: unstandardized beta; β: standardized regression weight; *p < 0.05, **p < 0.01, n= 30.

Exploratory multiple linear regression analyses were conducted to examine multivariable associations between psychological and physiological variables and basketball performance indicators. The model for free-throw percentage was statistically significant, $F_{(5, 24)} = 6.56$, $p = 0.01$, accounting for 57.7% of the variance ($R^2 = 0.58$, adjusted $R^2 = 0.49$). However, none of the individual variables reached statistical significance (all $p > 0.05$). In the exploratory backward regression model, sAA was the only variable reaching statistical significance ($F_{(1, 28)} = 29.23$, $p < 0.01$, $R^2 = 0.51$). A similar pattern was observed for field-goal percentage. Although the overall model was significant, $F_{(5, 24)} = 4.24$, $p = 0.01$, $R^2 = 0.47$, no individual variables reached statistical significance (all $p > 0.05$). The final exploratory backward model retained self-confidence as the only variable reaching statistical significance ($F_{(1, 28)} = 18.19$, $p < 0.01$, $R^2 = 0.39$). Turnovers were also significantly explained by the model, $F_{(5, 24)} = 6.29$, $p = 0.01$, $R^2 = 0.57$, although no variables demonstrated unique effects. The exploratory backward model indicated that cognitive anxiety and sCort were jointly associated with turnovers ($F_{(2, 27)} = 14.87$, $p < 0.01$, $R^2 = 0.44$). The model for assist-to-turnover ratio was likewise significant, $F_{(5, 24)} = 8.35$, $p < 0.01$, $R^2 = 0.64$, with no individual variables reaching statistical significance. In contrast, the exploratory backward model identified sAA as the only variable reaching statistical significance ($F_{(1, 28)} = 37.42$, $p < 0.01$, $R^2 = 0.57$).

An exploratory binary logistic regression analysis was conducted to examine associations between study variables and competition outcome (win/loss). In the enter model, field-goal percentage was the only variable reaching statistical significance (B = 0.43, Wald = 4.46, p = 0.03, OR = 1.55). The backward stepwise logistic regression yielded a more parsimonious model including sAA and field-goal percentage. sAA showed a negative association with competition outcome in the exploratory backward model (B = -0.14, Wald = 4.34, p = 0.03, OR = 0.86), whereas field-goal percentage remained positively associated with competition outcome (B = 0.34, Wald = 5.29, p = 0.02, OR = 1.42).

4. Discussion and Conclusion

The present study provides an integrated psychophysiological examination of competitive anxiety, self-confidence, salivary stress biomarkers, and performance in elite female basketball players, addressing the limited availability of integrated psychophysiological investigations in elite female athletes, as previous research has largely focused on male samples or assessed psychological and physiological responses separately. By simultaneously assessing psychological states alongside indices of both HPA-axis (sCort) and SAM-system (sAA) activation, this study addresses a notable gap in basketball research, particularly in elite female basketball players, where psychophysiological responses remain underexplored and have been predominantly investigated in male samples (10). Competition was associated with marked elevations in both sAA and sCort, indicating that basketball represents a potent psychosocial stressor, although these responses should be interpreted with consideration of sampling timing, as well as circadian and contextual factors that may influence biomarker levels. These responses are consistent with evidence indicating that competitive settings trigger coordinated activation of endocrine and autonomic systems (23, 26). The magnitude of these increases aligns with previous basketball-specific findings demonstrating substantial stress-related biomarker changes across competitive contexts (10, 27).

A coherent psychophysiological pattern emerged across variables. While these findings suggest associations between anxiety and self-confidence, it is essential to emphasize that they do not establish causal relationships. Cognitive and somatic anxiety were strongly interrelated and both inversely associated with self-confidence, suggesting potential overlap in psychological variance among these constructs, consistent with recent basketball evidence linking heightened anxiety to reduced confidence and poorer perceived performance (4, 28). Importantly, both anxiety dimensions showed moderate-to-large positive associations with sCort and sAA, whereas self-confidence was strongly negatively associated with these biomarkers. These findings support a convergence between subjective stress and physiological activation, reflecting integrated neurobiological processes in which threat appraisal is associated with activation of limbic–hypothalamic pathways and coordinated HPA and SAM responses (29).

Performance outcomes followed a consistent and theoretically grounded pattern. Higher anxiety and elevated pre-competition stress biomarkers were associated with reduced shooting efficiency (free-throw and field-goal percentages), increased turnovers, and lower assist-to-turnover ratios. These performance indicators represent distinct domains, with shooting accuracy reflecting technical precision, whereas turnovers and assist-to-turnover ratio reflect decision-making and execution efficiency under competitive pressure. These findings are consistent with literature suggesting that pressure and competitive anxiety may disrupt attentional control and motor execution in basketball tasks, particularly in precision-based actions such as free-throw shooting. They are also consistent with the catastrophe model and attentional disruption frameworks, which propose that elevated anxiety may compromise both motor precision and cognitive control, thereby increasing the likelihood of performance errors under stress (30, 31). It should be noted that attentional and motor control processes were not directly measured in the present study; therefore, these interpretations remain inferential. From a performance-analytics perspective, these associations are also consistent with evidence identifying shooting efficiency and ball security as primary determinants of success in basketball (32, 33). Importantly, the observed associations were strongest for performance efficiency indicators (i.e., shooting accuracy, turnovers, and assist-to-turnover ratio) rather than overall team success or competition outcomes, suggesting a greater influence on individual execution and decision-making under pressure rather than broader team-level performance outcomes. The observed pattern can be interpreted within a neurocognitive–physiological framework; however, such mechanisms were not directly measured in the present study and therefore remain theoretical. Competitive anxiety likely reflects heightened threat appraisal, may be associated with increased limbic reactivity and shifts processing away from goal-directed control (34). This is accompanied by activation of both the HPA axis and SAM system, resulting in elevated cortisol and arousal. Acute stress responses have been shown to impair working memory and executive functioning while increasing motor variability and attentional instability (35, 36). In basketball contexts, such disruptions may manifest as decreased shooting precision and increased decision errors, particularly under time pressure and dynamic play conditions. Future work should aim to test these mechanisms directly, using process-level measures such as neurocognitive and neural assessments, rather than relying on inferred interpretations.

Within this framework, self-confidence demonstrated strong negative associations with both anxiety and physiological stress markers, alongside positive associations with performance indicators. These findings suggest that self-confidence may function as a key regulatory resource, modulating cognitive appraisal processes and attenuating maladaptive stress responses (37). Athletes with higher self-confidence may be more likely to interpret competitive demands as challenges rather than threats, representing a potential explanatory pathway for reduced physiological reactivity and enhanced performance efficiency (28, 38). From a neurocognitive perspective, this pattern may reflect more effective prefrontal regulation of limbic activity, facilitating adaptive control over stress responses (29). This interpretation is consistent with emerging evidence in basketball contexts indicating that self-confidence is positively associated with performance outcomes and may buffer the detrimental effects of competitive anxiety (28).

The regression analyses provided additional insight into the structure of these relationships. Multicollinearity among predictors likely contributed to significant overall models while limiting the identification of unique individual effects, suggesting substantial shared variance among psychological and physiological variables (39). This pattern indicates that these constructs may operate as an integrated system rather than independent predictors. In contrast, stepwise models identified more parsimonious predictors, with sAA consistently associated with performance indicators and sCort contributing to turnovers. While this pattern is theoretically interpretable, it should be interpreted cautiously due to the instability and overfitting risks associated with stepwise procedures in small samples (40). Accordingly, these findings should be considered exploratory and hypothesis-generating rather than confirmatory, and require validation in larger samples to establish their robustness and generalizability (41).

Competition outcome was not significantly associated with individual variables at the correlational level, which is consistent with the multifactorial nature of basketball performance. It should be noted that win/loss represents a team-level outcome that is only partially determined by individual pre-competition psychological and physiological states. However, logistic regression analyses indicated that field-goal percentage was positively associated with win probability, whereas pre-competition sAA showed a negative association. The direction of these findings aligns with performance analytics literature identifying shooting efficiency as a key determinant of success (32, 33). Nevertheless, these findings should be interpreted with caution due to the limited number of outcome events relative to predictors, which may compromise model stability and increase the risk of overfitting (39, 41).

4.1 *Practical Implications*

The findings highlight the importance of integrating psychological and physiological monitoring in elite basketball settings. The combined assessment of competitive anxiety and salivary biomarkers may provide a practical framework for identifying athletes at risk of performance disruption under pressure (10, 26). This framework can be particularly useful for coaches, sports psychologists, medical staff, and performance analysts**,** offering insights into an athlete's stress reactivity and overall psychological state.

Interventions should target both cognitive appraisal and physiological regulation. Evidence-based approaches such as psychological skills training—including imagery, self-talk, and breathing techniques—may help reduce maladaptive stress responses and improve performance consistency (42). Additionally, incorporating pressure-based training scenarios, particularly for shooting tasks, may enhance athletes' ability to maintain attentional control and motor stability under competitive stress (30). Strengthening self-confidence may further support performance by buffering stress-related disruptions (28).

However, practical constraints such as feasibility, cost, and timing of saliva-based monitoring must be considered in real elite settings. Importantly, the biomarker measurements in the present study primarily reflect anticipatory pre-competition stress rather than in-competition responses, which should be taken into account when interpreting their practical applicability. While biomarker monitoring is valuable, it should complement, rather than replace, traditional performance metrics and psychological assessments. These biomarkers provide insight into an athlete's physiological state and stress reactivity but are not intended as standalone tools for decision-making. Future research should explore the feasibility of integrating these measures into regular practice routines while accounting for constraints related to cost, time, and equipment availability.

4.2 Limitations and Future Directions

Several limitations should be considered. The relatively small sample size, combined with the high intercorrelation among predictors, may have reduced statistical power and compromised the stability of regression estimates, particularly in stepwise models (39). Moreover, the small sample size limits the generalizability of the findings to broader populations. This pattern suggests potential multicollinearity, which can obscure the unique contribution of individual predictors and inflate standard errors. In addition, sensitivity analysis indicated that the present sample size was adequately powered to detect only large effects, and therefore smaller effects may not have been reliably identified. The logistic regression analysis was further constrained by a limited number of outcome events, increasing the risk of overfitting and unstable parameter estimates (41). This issue is especially problematic for binary outcome models, where a high number of predictors relative to outcome events can lead to biased or unreliable results. Future research should employ larger sample sizes, adopt multilevel or repeated-measures designs to better capture within- and between-athlete variability, and consider the use of parsimonious or penalized regression approaches with appropriate validation procedures.

Salivary biomarkers are sensitive to contextual and pre-analytical factors, including circadian rhythms and behavioral influences, such as caffeine intake, hydration status, oral health, and recent physical exertion, which were not fully controlled in the present study, and should be more rigorously standardized in future research (11, 23). In female samples, hormonal factors such as menstrual cycle phase should be considered, as they may influence physiological stress responses**.** The use of a single pre-competition sampling point limits insight into temporal stress dynamics and restricts the ability to interpret whether the observed values reflect anticipatory stress, competition readiness, or both (10). Future studies should incorporate multi-timepoint sampling designs and explore the effects of hormonal fluctuations to differentiate anticipatory from reactive stress responses more clearly. The observational design of the current study limits the ability to determine whether poorer expected performance increased anxiety or whether heightened anxiety led to reduced performance. Thus, causal inferences cannot be drawn from this design**.** Future research should combine experimental manipulations of competitive pressure with process-level measures (e.g., attentional control, gaze behavior, working memory) to directly test the underlying mechanisms (30, 36).

5. Conclusion

In this sample of elite female basketball players, higher competitive anxiety and lower self-confidence were associated with less favorable psychophysiological and performance profiles, while higher pre-competition stress biomarker levels were also associated with poorer performance indicators. These findings support the value of further investigating psychophysiological responses in elite female athletes, but should be interpreted as exploratory given the small sample and observational design.

Authors' Contributions

All authors equally contributed to this study.

Declaration

The authors declare that this manuscript is original, has not been published previously, and is not under consideration for publication elsewhere. All authors have approved the manuscript and agree with its submission to the journal.

Transparency Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments

Without the timely and efficient cooperation of the Basketball Federation, our coaches, and dedicated athletes, it would have been impossible to achieve the goals of this study. We appreciate all these individuals for their excellent collaboration. The authors gratefully acknowledge the use of language editing tools, including Grammarly, to improve the clarity and readability of the manuscript.

Declaration of Interest

The authors report no conflict of interest.

Funding

This study was supported by the Semnan University [grant numbers:14041205].

Ethical Considerations

This study was approved by the Committee of Research Ethics at the Sport Sciences Research Institute of Iran (ID: IR.SSRC.REC.1405.016) and was conducted as part of a research project approved by the Research Deputy of Semnan University. The study was carried out in accordance with the Declaration of Helsinki.

References

1. Scanlan AT, Dalbo VJ. Improving practice and performance in basketball. 2019;7:197. [PMID: 31461839] [PMCID: PMC6783966] [DOI]
2. Branquinho D, Ferraz R, Marinho DA, Neiva HP, Teixeira JE, Forte P, et al. The development of basketball players: current perspectives and future directions. Open Science Journal. 2022;7(3). [DOI]
3. Martens R, Vealey RS, Burton D. Competitive anxiety in sport1990.
4. Boas Junior MV, Ucha FG, Souza VHd, Manzini M, Corrêa MdF, Angelo DL, et al. The relationship between emotional regulation and sports performance: A systematic review. Journal of Physical Education. 2024;35:e3530. [DOI]
5. Shapiro JL, Bartlett M. Arousal, stress, and anxiety in sport, exercise, and performance: Concepts and management strategies. Sport, Exercise, and Performance Psychology: Routledge; 2018. p. 87-109. [DOI]
6. Janelle CM, Fawver BJ, Beatty GF. Emotion and sport performance. Handbook of sport psychology2020. p. 254-98. [DOI]
7. Lucia S, Bianco V, Di Russo F. Specific effect of a cognitive-motor dual-task training on sport performance and brain processing associated with decision-making in semi-elite basketball players. Psychology of Sport and Exercise. 2023;64:102302. [PMID: 37665802] [DOI]
8. Ayranci M, Aydin MK. The complex interplay between psychological factors and sports performance: A systematic review and meta-analysis. PloS one. 2025;20(8):e0330862. [PMID: 40857296] [PMCID: PMC12380335] [DOI]
9. Peng F, Zhang LW. The Relationship of Competitive Cognitive Anxiety and Motor Performance: Testing the Moderating Effects of Goal Orientations and Self-Efficacy Among Chinese Collegiate Basketball Players. Front Psychol. 2021;12:685649. [PMID: 34140921] [PMCID: PMC8203911] [DOI]
10. Kamarauskas P, Conte D. The effect of basketball matches on salivary markers: A systematic review. Biology of Sport. 2022;39(4):791-808. [PMID: 35959323] [PMCID: PMC9331335] [DOI]
11. Sánchez I, de la Rubia Ortí JE, Platero JL, Mariscal G, Barrios C. Modification of diurnal cortisol secretion in women's professional basketball. A pilot study. International Journal of Environmental Research and Public Health. 2021;18(17):8961. [PMID: 34501551] [PMCID: PMC8430658] [DOI]
12. Blascovich J. The biopsychosocial model of challenge and threat: Reflections, theoretical ubiquity, and new directions. Neuroscience of prejudice and intergroup relations: Psychology Press; 2013. p. 229-42.
13. Budala DG, Luchian I, Virvescu DI, Tudorici T, Constantin V, Surlari Z, et al. Salivary biomarkers as a predictive factor in anxiety, depression, and stress. Current Issues in Molecular Biology. 2025;47(7):488. [PMID: 40728957] [PMCID: PMC12293726] [DOI]
14. Arul QA, Debnath D. Salivary α-Amylase: A Reliable Stress Biomarker. European Dental Research and Biomaterials Journal. 2024;5(01/02):028-9. [DOI]
15. Ali N, Pruessner JC. The salivary alpha amylase over cortisol ratio as a marker to assess dysregulations of the stress systems. Physiology & behavior. 2012;106(1):65-72. [PMID: 22019784] [DOI]
16. Iwona GG, Wietrzyk A, Aleksandra T, Katarzyna PS, Agata H, Marek P. Salivary Alpha-Amylase and Cortisol Changes in Response to Basketball Training in Men and Women. Polish Journal of Sport and Tourism. 2025;32(4):3-10. [DOI]
17. Miguel-Ortega Á, Calleja-González J, Mielgo-Ayuso J. Interactions between stress levels and hormonal responses related to sports performance in pro women's basketball team. Journal of Functional Morphology and Kinesiology. 2024;9(3):133. [PMID: 39189218] [PMCID: PMC11348037] [DOI]
18. Madrigal LA, Wilson PB. Salivary hormone and anxiety responses to free-throw shooting competition in collegiate female basketball players. Journal of Clinical Sport Psychology. 2017;11(3):240-53. [DOI]
19. Tabassum Y, Sattar S, Iqbal MA, Butt MZI, Adnan MAJ, Roohi N. Effect of playing venue on pre-competition cortisol level and competitive state anxiety in university basketball players. Journal of Pharmaceutical Research International. 2021;33(43B):248-55. [DOI]

20. Mazdarani FH, Khaledi N, Hedayati M. Effects of Official Basketball Competition on the Levels of Salivary Cortisol and Immunoglobulin (A) among female children. Journal of Childhood Obesity. 2016;3:12. [DOI]
21. Faul F, Erdfelder E, Lang AG, Buchner A. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior research methods. 2007;39(2):175-91. [PMID: 17695343] [DOI]
22. Mehrsafar AH, Khabiri M, Moghadamzadeh A. Factorial validity and reliability of Persian version of competitive state anxiety inventory-2 (CSAI-2) in intensity, direction and frequency dimensions. Journal of Sports and Motor Development and Learning. 2016;8(2):253-79.
23. Strahler J, Skoluda N, Kappert MB, Nater UM. Simultaneous measurement of salivary cortisol and alpha-amylase: application and recommendations. Neuroscience & Biobehavioral Reviews. 2017;83:657-77. [PMID: 28864234] [DOI]
24. Sarlis V, Tjortjis C. Sports analytics—Evaluation of basketball players and team performance. Information Systems. 2020;93:101562. [DOI]
25. Gál-Pottyondy A, Petró B, Czétényi A, Négyesi J, Nagatomi R, Kiss RM. Collection and advice on basketball field tests—A literature review. Applied Sciences. 2021;11(19):8855. [DOI]
26. Ali N, Nater UM. Salivary alpha-amylase as a biomarker of stress in behavioral medicine. International journal of behavioral medicine. 2020;27(3):337-42. [PMID: 31755033] [PMCID: PMC7239706] [DOI]
27. de Arruda AFS, Aoki MS, Paludo AC, Drago G, Moreira A. Competition stage influences perceived performance but does not affect rating of perceived exertion and salivary neuro-endocrine-immune markers in elite young basketball players. Physiology & behavior. 2018;188:151-6. [PMID: 29425971] [DOI]
28. Chun DR, Lee MY, Kim SW, Cho EY, Lee BH. The mediated effect of sports confidence on competitive state anxiety and perceived performance of basketball game. International Journal of Environmental Research and Public Health. 2022;20(1):334. [PMID: 36612655] [PMCID: PMC9819433] [DOI]
29. McEwen BS, Akil H. Revisiting the stress concept: implications for affective disorders. Journal of Neuroscience. 2020;40(1):12-21. [PMID: 31896560] [PMCID: PMC6939488] [DOI]
30. Giancamilli F, Galli F, Chirico A, Fegatelli D, Mallia L, Palombi T, et al. When the going gets tough, what happens to quiet eye? The role of time pressure and performance pressure during basketball free throws. Psychology of Sport and Exercise. 2022;58:102057. [DOI]
31. Mascret N, Vors O, Marqueste T, Cury F. Stress responses, competition, and free-throw performance: The predicting role of other-approach goals. Psychological reports. 2022;125(6):3049-68. [PMID: 34412542] [DOI]
32. Cabarkapa D, Cabarkapa DV, Fry AC. Game-related statistics that discriminate winning from losing in NCAA Division-I men's basketball. Frontiers in Sports and Active Living. 2024;6:1387918. [PMID: 38840953] [PMCID: PMC11150523] [DOI]
33. de Almeida MB, Canuto SC, Lima GS, Oliveira WG. Performance analysis in elite basketball differentiating game outcome and gender. European Journal of Human Movement. 2022;49. [DOI]
34. Kim EJ, Kim JJ. Neurocognitive effects of stress: a metaparadigm perspective. Molecular psychiatry. 2023;28(7):2750-63. [PMID: 36759545] [PMCID: PMC9909677] [DOI]
35. Harris D, Wilkinson S, Ellmers T. From fear of falling to choking under pressure: a predictive processing perspective of disrupted motor control under anxiety. Neuroscience & Biobehavioral Reviews. 2023;148:105115. [PMID: 36906243] [DOI]
36. Xin Z, Gu S, Yi L, Li H, Wang F. Acute exposure to the cold pressor stress impairs working memory functions: an electrophysiological study. Frontiers in Psychiatry. 2020;11:544540. [PMID: 33329085] [PMCID: PMC7719763] [DOI]
37. Wagstaff CR, Hings RF, Quartiroli A. Emotion regulation in sport contexts. Handbook of emotion regulation at work: Edward Elgar Publishing; 2025. p. 247-66. [DOI]
38. Lochbaum M, Sherburn M, Sisneros C, Cooper S, Lane AM, Terry PC. Revisiting the self-confidence and sport performance relationship: a systematic review with meta-analysis. International Journal of Environmental Research and Public Health. 2022;19(11):6381. [PMID: 35681963] [PMCID: PMC9180271] [DOI]
39. Riley RD, Snell KI, Ensor J, Burke DL, Harrell Jr FE, Moons KG, et al. Minimum sample size for developing a multivariable prediction model: PART II-binary and time-to-event outcomes. Statistics in medicine. 2019;38(7):1276-96. [PMID: 30357870] [PMCID: PMC6519266] [DOI]
40. Steyerberg EW. Clinical prediction models: Springer; 2019. [PMCID: PMC12468558] [DOI]
41. Van Smeden M, Moons KG, de Groot JA, Collins GS, Altman DG, Eijkemans MJ, et al. Sample size for binary logistic prediction models: beyond events per variable criteria. Statistical methods in medical research. 2019;28(8):2455-74. [PMID: 29966490] [PMCID: PMC6710621] [DOI]
42. Ong NC, Chua JH. Effects of psychological interventions on competitive anxiety in sport: A meta-analysis. Psychology of Sport and Exercise. 2021;52:101836. [DOI]