BMC Sports Science, Medicine and Rehabilitation

RESEARCH

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Sensitivity to rewards and punishments in karate athletes: an examination of the temperamental characteristics and profile of karate competitors according to the revised reinforcement sensitivity theory

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Abstract

Background The revised Reinforcement Sensitivity Theory (rRST) assumes the existence of three systems controlling motivation and behavior: the behavioral activation system (BAS), the behavioral inhibition system (BIS), and the fight-flight-freeze system (FFFS). This study aims to examine for the first time the features of BAS, BIS, and FFFS among karate players in comparison with athletes representing other sports disciplines (physical education students) and physically inactive people. The specific configuration of temperament traits and profiles characterizing karate players will also be found.

Methods The cross-sectional study was performed among male karate athletes and control groups (physically active and inactive men). The study used the modified Reinforcement Sensitivity Questionnaire (rRSQ) to measure BAS, BIS, and FFFS.

Results The ANOVA showed that both karate competitors KS and KK scored significantly higher in BAS than the sample of PI participants. In addition, KK athletes scored significantly lower in Freeze than in PI and KS groups. Research also suggests that KK athletes presented significantly lower overall scores in FFFS than PI individuals. Furthermore, the results of K-means cluster analysis indicated the existence of two distinct patterns of temperamental traits: (1) Cluster 1 suggests avoidance tendencies (high Flight and Freeze, and low BAS, BIS, and Fight levels); while (2) the Cluster 2 describes approach tendencies (high BIS, BAS and Fight scores, and low levels of Flight and Freeze). Significantly more KK athletes were included in Cluster 2 than in Cluster 1, compared to PI, PA, and KS samples.

Conclusions The research indicates that individuals engaged in karate, particularly those practicing Kyokushin karate, tend to exhibit a heightened sensitivity to rewards (high BAS). This finding holds significance for coaches and sports instructors, suggesting that motivating karate athletes through incentives is more effective, while the use of punishment should be minimized during training. Additionally, the study proposes that the practice of Kyokushin

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karate has the potential to significantly diminish the freezing response in threatening situations and enhance overall fear management by reducing levels of the Fight-Flight-Freeze System (FFFS). Consequently, the Kyokushin karate style may be considered more advantageous than the Karate Shotokan (KS) style in these aspects, despite both styles contributing to the improvement of BAS. Given that a higher BAS is linked to positive emotions, optimism, and happiness, karate training emerges as a form of health intervention, acting as a preventive measure against mental disorders and promoting overall well-being.

Keywords Approach-avoidance motivation, Behavioral activation system, Behavioral inhibition system, Fight-flight-freeze system, Physical activity, Karate Kyokushin, Karate Shotokan, Revised reinforcement sensitivity theory, Temperamental traits

Introduction

Main assumptions of the revised reinforcement sensitivity theory

Gray's [1–4] revised reinforcement sensitivity theory (rRST) posits the existence of three distinct biologically based motivational systems influencing individuals' behavioral tendencies: (1) the behavioral approach system (BAS) responds to rewards and the cessation of punishment, triggering emotions like hope and happiness that promote approach behaviors; (2) the fight-flight-freeze system (FFFS) responds to immediate punishment or threats, activating emotions like panic, fear, and rage that initiate escape, avoidance, or fight behaviors; and (3) the behavioral inhibition system (BIS) is responsible for resolving goal conflicts, such as those between BAS (approach) and FFFS (avoidance), or within each of these systems.

The BAS system operates as a reward system, managing responses to all pleasurable stimuli [3, 5]. McNaughton and Corr [4] showed that FFFS behavior should be considered defensive avoidance, and BIS behavior should be considered defensive approach. The FFFS system is regarded as a component of the threat response, overseeing the emotion of fear and propelling escape and avoidance behaviors [5]. The BIS system serves as the foundation for the emotion of anxiety and is conceptualized as a mechanism for detecting and resolving conflicts [6]. Furthermore, Berkman [7] provides empirical validation for the revised RST, showing that the behavioral activation system (BAS) is sensitive to both conditioned and unconditioned incentives, and the behavioral inhibition system (BIS) is sensitive to conflicting incentives. The rRST provides a unique link between the brain and behavior and has implications for understanding individual differences in personality, emotion, motivation, and learning [6, 8]. The three distinct traits of temperament BAS, FFFS, and BIS were confirmed in a large longitudinal study [8], showing age and gender invariance.

Application of the reinforcement sensitivity theory to physical activity and sport

Although RTS can be crucial to understanding exercise behavior in athletes, the BIS-BAS reinforcement theory has rarely been explored in the context of sports and physical activity (PA). Research has shown that the BIS and BAS can influence individual differences in approach and avoidance motivation in sports and physical activities [9–12]. Some studies have examined the relationship between BIS and physical fitness, its affective response to exercise, and its role as a personality correlate of physical activity [13, 14]. The BIS exhibited a negative correlation with cardiovascular fitness and the ability to tolerate high-intensity exercise among adolescents [13]. Adolescents with elevated BIS scores reported more negative Feelings Scale (FS) responses to exercise at both moderate and intense levels. On the other hand, the BAS showed a positive correlation with exercise enjoyment. Adolescents with high BAS scores reported more positive emotions and higher energetic arousal during moderate exercise. However, the connection between BAS and affect was less pronounced during the challenging exercise task [13].

Studies showed that PA is positively related to BAS [12, 15, 16] but unrelated to BIS [16]. Wilson et al. [14] evidenced that BIS predicted objectively measured PA (positive association), while BAS was positively related to self-reported PA in college women. Furthermore, studies have shown that BAS sensitivity is positively related to participation in high-risk sports, while BIS sensitivity is negatively related [11]. Research suggests that BIS and BAS sensitivity can be related to sports levels. In particular, athletes in downhill sports scored significantly higher on Reward Sensitivity (BAS) than beginners and non-participants. In addition, proficient participants scored significantly lower on Punishment Sensitivity (FFFS and BIS) compared to beginners and non-participants [11]. In contrast, another study showed that the sample of elite athletes in speed skating exhibited lower results in the BAS compared to the sample of physical education students [17]. In another study [9, 10], both BIS and BAS have been correlated positively with response inhibition, which is relevant in sports performance and expertise. However, no differences were found in response inhibition between athletes experienced in intercept sports (biathlon and alpine skiing) and non-athletes. These studies showed inconsistency in relation to levels of sports

participation. Therefore, more studies are required to explain the contribution of RTS in sports and PA.

The purpose of the current study

The studies mentioned above suggest that the BIS-BAS theory can offer insights into individual differences in approach and avoidance motivation in the context of sports and physical activity and may have implications for understanding sports expertise and performance. Current research suggests differences in particular levels of temperamental traits across sports disciplines. However, to the best of our knowledge, rRST has never been explored among karate athletes. The present study fills this gap and aims to explore for the first time the BAS, BIS, and FFFS traits among karate competitors in comparison to athletes representing other sports disciplines (physical education students) and inactive physical people. Furthermore, it is interesting whether temperamental traits are incorporated in a specific pattern for karate athletes, distinguishing them from people who are physically active and inactive. Therefore, the specific configuration of temperamental traits within the profile characterizing karate athletes will be explored in this study using explorative cluster analysis. K-means clustering is a profile statistical analysis that can consider both the relationships between variables and the categorization of individuals into groups based on similarities and differences between individuals. In this way, we will explore whether there are specific temperamental profiles for karatekas, representing two basic styles of fight: Kyokushin and Shotokan. Understanding individual differences in temperamental traits in people representing different sports disciplines is important for the sports psychology area and can be used in sports selection and targeted support for athletes. In this preliminary study, we want to understand the temperamental traits of karate athletes in order to develop better master programs for individual athletes, sports psychologists, and coaches in the future.

While there is no direct evidence specific to karate, insights from related studies can provide some understanding of the potential influence of BIS/BAS temperament on karate athletes. Previous findings suggest that personality traits and psychological factors may play a role in the context of martial arts performance. Studies have shown that BAS sensitivity is positively related to participation in high-risk sports, possibly due to their approach-oriented motivation and sensitivity to reward cues [11], which are positively related to high sensation seeking [18], extroversion, and impulsivity [1, 19]. On the other hand, individuals with higher BIS sensitivity, which is associated with avoidance motivation, may be less inclined to engage in high-risk sports. Although not specific to karate, this finding suggests that individuals with higher BAS sensitivity may be more inclined to participate in physically demanding and challenging sports, which could potentially include karate. The following hypotheses about intergroup differences in temperamental traits will be verified using analysis of variance (ANOVA):

H1 Because of participating in aggressive and high-risk sports, karate athletes demonstrate higher levels of BAS than people who are physically active and inactive [11].

H2 Due to the constant need to make decisions about using defensive or offensive strategies in the interaction with the rival's behavior during a sports fight, BIS levels are higher in karate competitors compared to other groups of physically active and inactive individuals [9, 10].

H3 Karate competitors score higher in Fights than the other groups because of their frequent participation in combat.

H4 The levels of Flight and Freeze, as well as FFFS, are lower in karate athletes than in non-karate groups [11].

Methods

Study design and procedure

The cross-sectional study was conducted in Poland from 1 October 2022 to 18 May 2023. The study protocol was approved by the University Research Ethics Committee of Opole University of Technology (9 July 2022; No. 2/2022). The study was anonymous and voluntary, and all participants provided their informed consent to participate in this study. Since karate is a more common sports discipline among men than women in Poland, we decided to examine only males to avoid potential sources of bias related to unequal and unrepresentative gender samples. The study aims to find a specific pattern of temperamental traits in karate athletes. Therefore, we selected three distinguished groups to research: (1) karate athletes, (2) non-karate athletes, and (3) non-athletes. Deliberately, two different styles of karate were selected, one involving full-contact fighting (Kyokushin) and the other without direct contact (Shotokan). Therefore, the inclusion criteria comprised a minimum age of 16 years and male gender. In addition, at least one year of participation in karate training in Shotokan or Kyokushin karate style was required from the sample of karate athletes. The a priori power analysis showed that the total sample of 180 people is required to perform the ANOVA test for four groups (non-athletes, athletes, Shotokan karate athletes, and Kyokushin karate athletes), assuming a minimal power of 0.80 ($1 - \beta$), $p = 0.05$ (α), and medium effect size $f = 0.25$ [20].

A paper-and-pencil questionnaire was administered to karate athletes during the Winter grouping of the

national team WKF Shotokan in Spała 2023, at the Gliwice Kyokushin Karate Club, and the grouping of black belts Shinkyoukushin in Stara Wieś. Trainers invited eligible students to participate during training sessions, and those meeting the inclusion criteria and providing written consent voluntarily joined the research. While 119 karatekas responded to the invitation, one declined; seven were below 16 years of age, and 30 were female, leading to their exclusion from further statistical analyses. The final sample included 81 male karate athletes. The other two groups of non-karate athletes and non-athletes participated in the online survey. Academic instructors teaching physical education classes at the Opole University of Technology (Poland) encouraged their students to take part in the research. The study's invitation was distributed via the university's email list. Initially, 190 university students expressed interest, but 15 declined, and 10 did not meet the inclusion criteria (specifically, being male), resulting in a final sample of 165 non-karateka participants forming the control group. The total sample of 246 participants is appropriate for the ANOVA test, with a power of 0.92, as suggested in post-hoc power analysis [20].

Measurement

The revised Reinforcement Sensitivity Questionnaire (rRSQ) was developed by Jackson [21] as a 30-item self-report measure of five dimensions of the rRST (six items each): BAS (e.g., "I actively look for new experiences"), BIS (e.g., "I want to avoid looking bad"), and FFFS, represented by Fight (e.g., "When provoked, I easily get into a fight"), Flight (e.g., "I am likely to run if harassed by a stranger in an unfamiliar place"), and Freeze (e.g., "If I got scared in my bed at night, I would remain motionless"). Participants respond to each item using a 5-point Likert scale (from 1 = "I completely disagree" to 5 = "I completely agree"). The reliability scores assessed in current research using McDonald's ω were 0.78, 0.52, 0.74, 0.63, 0.72, and 0.62 for the BAS, BIS, Fight, Flight, Freeze, and FFFS, respectively. We translated the RSQ into Polish using a bilingual expert and then back-translated it into English, as recommended by Beaton et al. [22]. The confirmatory factor analysis (CFA) showed that there is acceptable factor structure for five-factor model (for BAS, BIS, Fight, Flight, and Freeze as factors), with the following fit indices: $\chi^2=660.51$, $df=314$, $p<0.001$, $\chi^2/df=2.10$, CFI=0.79, SRMR=0.075, RMSEA=0.067, 95% confidence interval (CI=0.060, 0.074). When the hierarchical structure was assumed, including BIS, BAS, and FFFS as a second-order bi-factor for Fight, Flight, and Freeze systems, fit indices improved, $\chi^2=554.79$, $df=297$, $p<0.001$, $\chi^2/df=1.87$, CFI=0.84, SRMR=0.063, RMSEA=0.059, 95% confidence interval (CI=0.052, 0.067), which means that the Polish version of the rRSQ is valid instrument for temperamental traits measurement, due to the rRST.

Statistical analysis

As a preliminary analysis, descriptive statistics were performed, including minimal (min.) and maximal (max.) score in each rRST scale, mean (*M*), standard deviation (*SD*), skewness, and kurtosis, as well as McDonald's ω for reliability coefficient. Missing data (less than 10%) were replaced using the full information maximum likelihood (FIML) imputation method. Confirmatory factor analysis (CFA) was performed to check the factor structure and validity of the rRST in Polish. Construct validity was evaluated also using several goodness-of-fit criteria [23, 24], including ML χ2, df and *p*-value (the ratio χ2/df<2 is considered very good fit, between 2 and 3 – good, and acceptable<5), standardized root mean squared residual (SRMR≤0.08 is acceptable), root mean square error of approximation (RMSEA; acceptable fit if≤0.08, adequate fit if<0.06, and good if 0.04), and comparative fit index (CFI is acceptable if≥0.90, and good if>0.95). A one-way ANOVA was performed to examine differences between four groups of participants (KS, KK, PA, and PI) in the following rRST scales: BIS, BAS, Fight, Flight, Freeze, and FFFL. The Bonferroni post-hoc test was performed to examine the difference between particular groups. The partial eta-square coefficient (η^2_p) was applied to examine effect size. A value of 0.01 can be interpreted as weak, 0.06 as average, and 0.14 as strong. Also, the Pearson's χ^2 test of independence was conducted for categorical data as a sensitivity analysis. The Cramer's V or ϕ statistics were used to assess effect size for Pearson's χ^2 test. Finally, the K-means cluster analysis was performed to examine the temperamental profile of participants, using the Hartigan-Wong algorithm for cluster extraction. The independent samples Student's *t*-test was conducted to test differences in temperamental traits between clusters, with Cohen's *d* as an effect size (additional sensitivity analysis). All statistical analyses were performed using the software JAMOVI, ver. 2.3.28 for Windows.

Results

Participants characteristics

The study involved a sample of 246 male participants aged 16 to 60 ($M=24.72$, $SD=8.51$). This sample comprised 72 individuals self-reporting as physically inactive (PI; 29.27%), 93 indicating physical activity (PA; 37.81%), and 81 karate athletes divided into two styles and groups: Shotokan practitioners (KS; $n=39$, 15.85%) and Kyokushin practitioners (KK; $n=42$, 17.07%). Within the karateka sample, the average duration of the training experience was 12 years ($M=11.80$, $SD=8.63$, ranging from 1 to 43 years). On average, karatekas engaged in training four days per week ($M=3.72$, $SD=1.56$), with

20 athletes training two days a week (24.69%), 25 individuals practicing three days a week (30.86%), 12 participants exercising four days a week (14.82%), and 24 men (29.63%) declaring training five days or more. The average duration of a typical training session was 6 h (M=6.22±3.58). Among the karatekas, two individuals did not specify any kyu or dan ranks. Kyu ranks were distributed as follows: four people at 8 kyu (4.94%), two athletes at 7 kyu (2.47%), one person each at 6 and 5 kyu (1.24%), ten individuals at 4 kyu (12.35%), 11 participants at 3 kyu (12.58%), nine individuals at 2 kyu (11.11%), and 18 karatekas at 1 kyu (22.22%). Regarding dan ranks, 16 karateka athletes held 1 dan (19.75%), four individuals held 2 dan (4.94%), and one person each held 4, 5, and 6 dan (1.24%). In terms of disciplines, 50 karateka athletes (61.73%) specialized in Kumite, while 34 athletes (13.82%) focused on kata. In the karateka group, 39 individuals participated at the regional level of competition (48.15%), 36 at the national level (44.44%), 19 at the European level (23.46%), and 15 competed in world championships (18.52%).

In the total sample, 18 participants (7.32%) had completed primary education, 5 (2.03%) had secondary education, 153 (62.20%) had high school education, and 70 (28.46%) held a Master's degree or higher. Regarding relationship status, 116 individuals (47.15%) were in a relationship, while 130 (52.85%) were single. Economic status varied, with 15 respondents (6.10%) reporting unsatisfactory status, 58 (23.58%) indicating average status, 112 (45.53%) reporting good status, 54 (21.95%) stating very good status, and 7 individuals (2.85%) reporting excellent economic status.

Descriptive statistics

Descriptive statistics were examined for the rRST scales, including BIS, BAS, and FFFS, to check whether a parametric test can be performed (Table 1). Since the total sample is large (N=246) and skewness and kurtosis ranged between −1 and +1 for all variables (besides the FFFS scale for the PA sample), we decided that the parametric test would be performed in the following steps.

Table 1 Descriptive statistics for the revised reinforcement sensitivity theory (rRST) scales of temperament: behavioral activation system (BAS), behavioral inhibition system (BIS), and fight-Flight-Freeze System (FFFS), stratified by type of physical activity

Variable	Group	*N*	*M*	*SD*	Min.	Max.	Skewness	Kurtosis
BAS	Total sample	246	21.80	4.65	6	30	-0.71	0.51
	Physically Inactive	72	20.17	5.19	6	30	-0.75	0.65
	Physically Active	93	21.98	4.43	10	30	-0.51	-0.31
	Karate Shotokan	39	22.64	3.92	15	30	-0.10	-1.02
	Karate Kyokushin	42	23.43	4.04	12	29	-0.79	0.29
BIS	Total sample	246	19.33	3.36	10	30	0.00	0.38
	Physically Inactive	72	19.32	3.61	11	29	0.02	0.49
	Physically Active	93	19.27	3.65	10	30	0.08	0.18
	Karate Shotokan	39	18.97	2.96	13	27	-0.03	0.30
	Karate Kyokushin	42	19.83	2.57	13	25	-0.29	0.08
Fight	Total sample	246	17.81	4.50	8	30	0.13	-0.39
	Physically Inactive	72	17.90	4.49	8	30	0.27	-0.16
	Physically Active	93	17.45	4.24	9	29	0.31	-0.10
	Karate Shotokan	39	18.28	4.67	10	27	-0.02	-0.59
	Karate Kyokushin	42	18.00	4.99	8	27	-0.28	-0.65
Flight	Total sample	246	14.78	4.08	6	28	0.64	0.62
	Physically Inactive	72	15.33	3.70	6	26	0.21	0.19
	Physically Active	93	14.58	4.27	6	28	0.69	0.99
	Karate Shotokan	39	15.18	4.35	9	26	1.01	0.89
	Karate Kyokushin	42	13.91	3.94	8	26	0.91	0.79
Freeze	Total sample	246	14.81	4.92	6	29	0.38	-0.47
	Physically Inactive	72	15.82	4.89	6	26	0.09	-0.83
	Physically Active	93	14.80	4.92	6	29	0.57	0.28
	Karate Shotokan	39	15.56	4.71	8	25	0.29	-1.07
	Karate Kyokushin	42	12.43	4.47	6	22	0.68	-0.33
FFFS	Total sample	246	47.40	8.66	27	86	0.58	1.26
	Physically Inactive	72	49.06	7.65	31	64	-0.22	-0.69
	Physically Active	93	46.83	8.78	32	86	1.25	3.51
	Karate Shotokan	39	49.03	8.44	34	75	0.56	0.89
	Karate Kyokushin	42	44.33	9.50	27	71	0.69	1.10

Table 2 The one-way ANOVA for the revised reinforcement sensitivity theory (rRST) scales as dependent variable and type of physical activity (four groups of participants: physically inactive, physically active, Karate Shotokan, and Karate Kyokushin)

Variable	*SS*	*MS*	*F* (3, 242)	*p*	η^2_p
Behavioral Activation System	334.02	111.34	5.42	0.001	0.063
Behavioral Inhibition System	15.93	5.31	0.47	0.705	0.006
Fight	22.77	7.59	0.37	0.773	0.005
Flight	64.14	21.38	1.29	0.278	0.016
Freeze	333.75	111.25	4.82	0.003	0.056
Fight-Flight-Freeze System	725.83	241.94	3.32	0.021	0.040

Analysis of variance for the revised reinforcement sensitivity theory scales of temperament and types of physical activity

The results of one-way ANOVA are presented in Table 2; Fig. 1. Significant differences were found in BAS, Freeze, and FFFS between four groups of participants: Physically Inactive (PI), Physically Active (PA), Karate Shotokan (KS), and Karate Kyokushin (KK). The Bonferroni post-hoc test showed that the PI sample scored significantly lower in BAS than Karate competitors: KS ($p=0.039$, Cohen's d = -0.55) and KK ($p=0.002$, Cohen's d = -0.72). Furthermore, the KK sample scored significantly lower in Freeze than PI ($p=0.002$, Cohen's $d=0.71$) and KS groups ($p=0.022$, Cohen's $d=0.65$). Also, KK athletes presented significantly lower FFFS scores than PI participants ($p=0.029$, Cohen's $d=0.55$).

Temperamental profiles of athletes

The results of the K-means cluster analysis (visualized in Fig. 2) showed that two distinct patterns of temperamental traits (BAS, BIS, Fight, Flight, and Freeze) are presented in the sample ($N=246$). In the first cluster ($n=111$), participants scored low in BAS, BIS, and Fight scales, while they scored high in Flight and Freeze. In contrast, people in the second cluster ($n=135$) scored high in BAS, BIS, and Fight, but they presented low levels of Flight and Freeze (Fig. 2). Principal component analysis (PCA) enables the condensation and visualization of information within a dataset comprising individuals or observations characterized by multiple correlated quantitative variables. Each variable can be viewed as a distinct dimension in this context (see Fig. 3). The first cluster explains 36.7% of temperament variance and describes Approach-Avoidance motivational tendencies (see Fig. 3). In the approach, the motivational dimensions include BAS and Fight (associated with positive emotions and optimism), while Flight and Freeze constitute the avoidance tendencies (related to fear). The second cluster explains 28.6% of temperament variance and is related to high BIS scores (responsible for anxiety level).

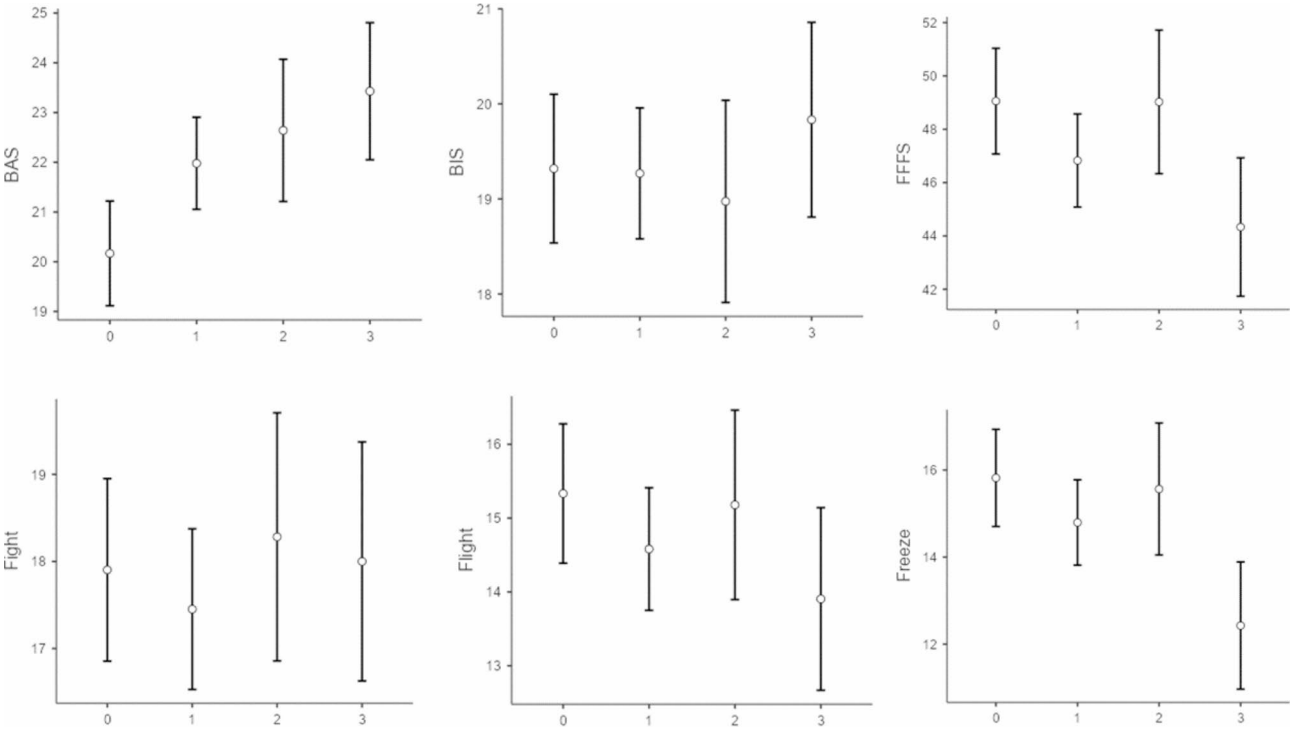

Fig. 1 Mean values and 95% confidence intervals in the revised Reinforcement Sensitivity Theory (rRST) scales of temperament: Behavioral Activation System (BAS), Behavioral Inhibition System (BIS), and Fight-Flight-Freeze System (FFFS), for four groups of participants: Physically Inactive (group 0 on horizontal axis), Physically Active (group 1), Karate Shotokan (group 2), and Karate Kyokushin (group 3)

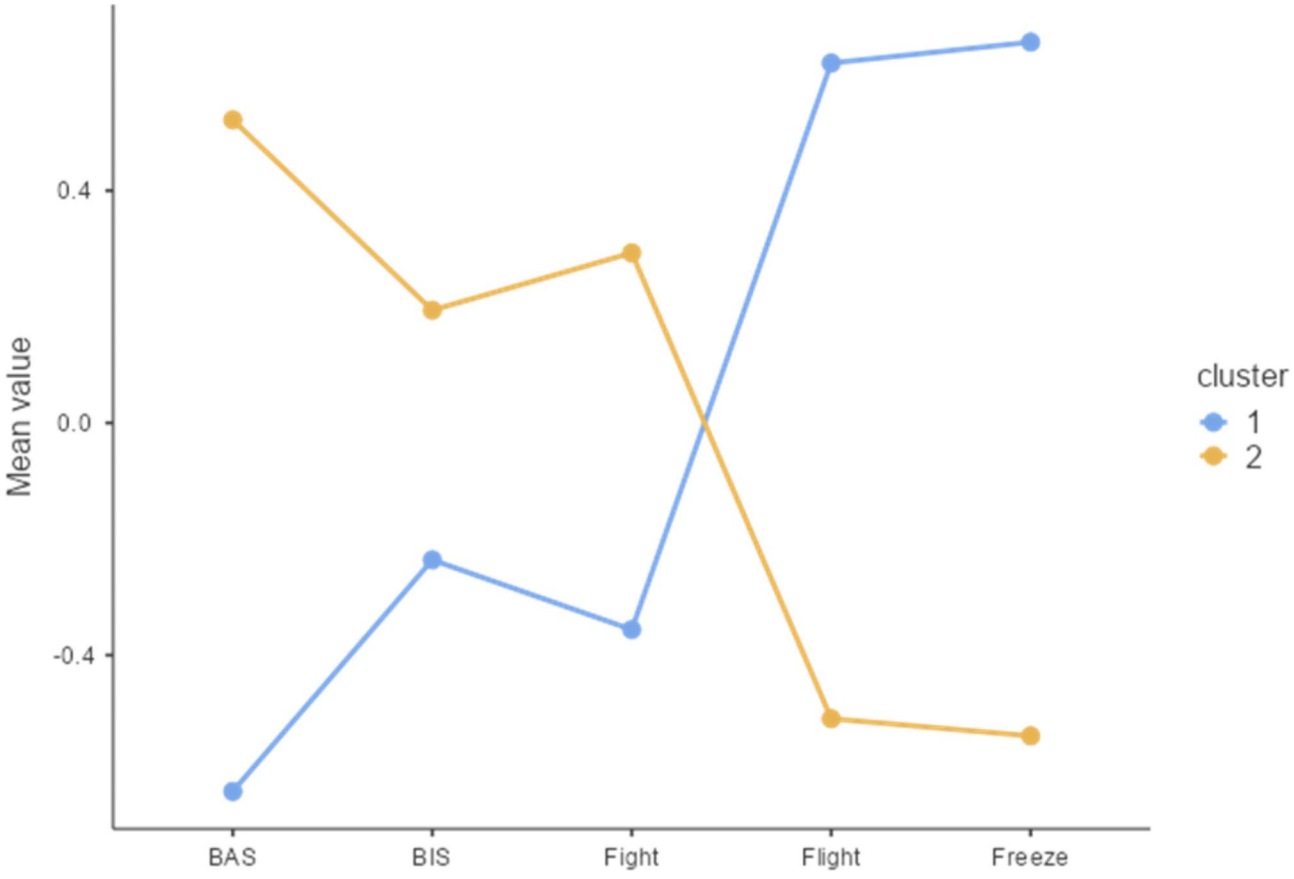

Fig. 2 Mean values in Cluster 1 ($n = 111$) and Cluster 2 ($n = 135$) samples in particular scales of the revised Reinforcement Sensitivity Theory of temperament: Behavioral Activation System (BAS), Behavioral Inhibition System (BIS), Fight, Flight and Freeze Systems

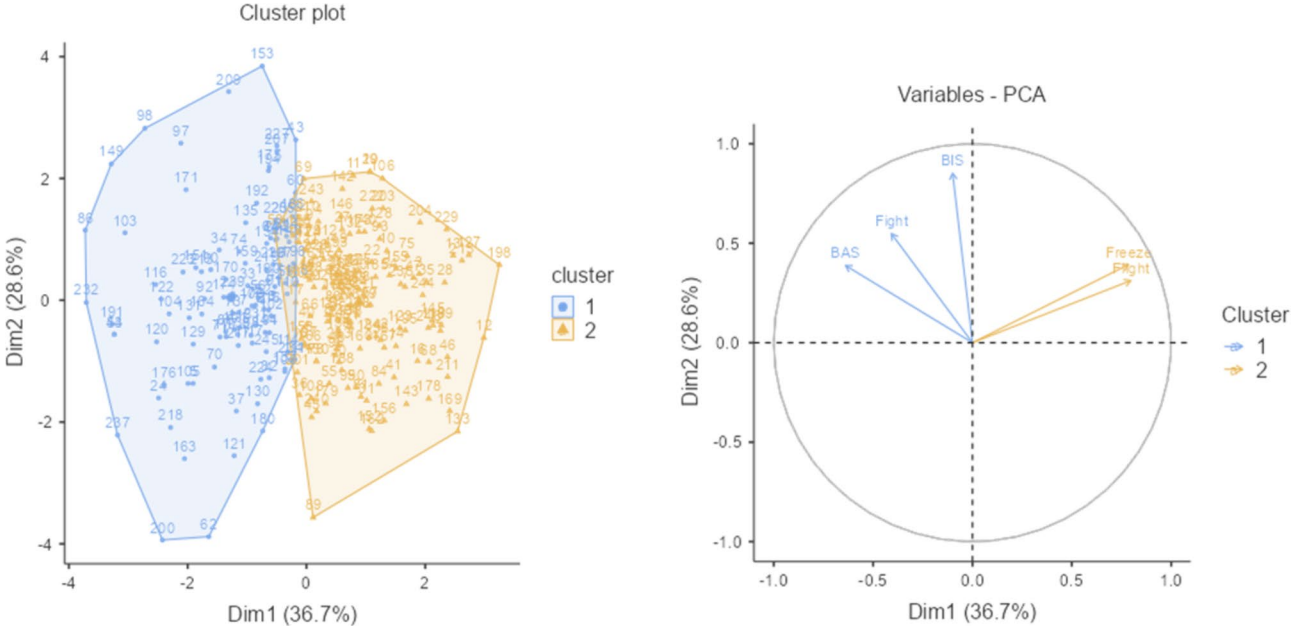

Fig. 3 Cluster plot and Principal Component Analysis (PCA) for Behavioral Activation System (BAS), Behavioral Inhibition System (BIS), Fight, Flight and Freeze Systems in the total sample ($N = 246$)

Table 3 Distribution of participants representing four types of physical activity (physically inactive, physically active, Karate Shotokan, and Karate Kyokushin) in the first and second cluster

Samples	Cluster 1 ($n=111$)		Cluster 2 ($n=135$)	
	n	%	*n*	%
Physically Inactive	41	56.9	31	43.1
Physically Active	44	47.3	49	52.7
Karate Shotokan	18	46.2	21	53.8
Karate Kyokushin	8	19.0	34	81.0

Note. Percentages represents proportion in rows

We examined the distribution of participants representing four types of physical activity (PI, PA, KS, and KK) in each cluster, using Pearson's χ^2 test of independence (Table 3). The differences were significant, $\chi^2(3)=15.79$, $p<0.001$, Cramer's $V=0.25$. In particular, among KK athletes prevailed those who represent Cluster 2 (81% vs. 19%), while in the other samples (KS, PA, and PI), the frequencies in Cluster 1 and Cluster 2 were almost equally distributed (Table 3). As a sensitivity analysis, we examined the particular differences between the two groups using Pearson's χ^2 test of independence. Significantly more KK athletes are included in Cluster 2 than in Cluster 1, compared to the PI sample [$\chi^2(1)=15.55$, $p<0.001$, $\phi=0.37$], PA group [$\chi^2(1)=9.76$, $p=0.002$, $\phi=0.27$], and KS [$\chi^2(1)=6.82$, $p=0.009$, $\phi=0.29$]. PI does not differ significantly from PA and KS samples, as well as PA from the KS group in the distribution of participants in Cluster 1 and Cluster 2.

Furthermore, as a sensitivity analysis, the Student's *t*-test was conducted to examine significant differences in temperamental traits between clusters (Table 4). Participants included in Cluster 2 scored higher than those in Cluster 1 in BAS, BIS, and Fight and lower in Flight, Freeze, and FFFS. The absolute value of Cohen's *d* ranged between 0.44 and 1.49, indicating a medium to large effect size for these comparisons.

Discussion

The present study explored the rRST temperamental traits in karate athletes. Although the BIS/BAS temperament, which is part of the Reinforcement Sensitivity Theory (RST), has been studied in various contexts, specific research on its application to martial arts, such as karate, was limited. For the first time, we provide direct evidence on the BIS/BAS temperamental traits in karate athletes, compared to non-karate athletes and people who are physically inactive. The study partially confirmed our hypotheses. We assumed that participation in an aggressive combat sport is related to higher levels of BAS (H1), BIS (H2), and Fight (H3), whereas lower levels of FFFS, Flight, and Freeze (H4). Both karate athletes in Kyokushin and Shotokan styles scored higher in BAS than physically inactive participants, but they did not differ from people engaged in PA. Therefore, the H1 was confirmed partially. Hypotheses H2 and H3, which state that BIS and Fight, respectively, are higher among karate athletes than other groups, were not confirmed in this study since no significant intergroup differences were found in BIS and Fight scales. Hypothesis H4 was partially confirmed since individuals practicing karate Kyokushin showed lower scores in Freeze compared to physically inactive people and karate Shotokan athletes. Furthermore, lower FFFS levels were found in karate Kyokushin athletes than in the physically inactive sample. Furthermore, two clusters were identified in this study, showing two opposite patterns of temperament: Cluster 1 with avoidance tendencies (high Flight and Freeze, while low BAS, BIS, and Fight) and Cluster 2 with approach attitude (high BAS, BIS, and Fight, while low Flight and Freeze). The current research provides insights into the potential influence of temperament and psychological factors on sports participation and performance in karate discipline. The current results will be discussed based on scientific literature.

Behavioral approach system (BAS) in karate athletes

We found that karate competitors scored significantly higher in BAS than physically inactive participants. Although these differences were not presented between karate athletes and physically active people, our first hypothesis (H1) was partially confirmed. Furthermore, Fight was not significantly higher in karate athletes than in other control groups. The present results suggest that participation in any physical activity or sport can increase

Table 4 Student's *t*-test to examine differences between clusters in temperamental traits

Variable	Cluster 1 $n=111$		Cluster 2 $n=135$		*t*(244)	*p*	d
	M	*SD*	*M*	*SD*			
Behavioral Activation System	18.85	4.45	24.23	3.19	−11.03	< 0.001	−1.41
Behavioral Inhibition System	18.54	3.68	19.99	2.92	−3.43	< 0.001	−0.44
Fight	16.21	4.10	19.13	4.40	−5.34	< 0.001	−0.68
Flight	17.31	3.90	12.70	2.87	10.64	< 0.001	1.36
Freeze	18.04	4.26	12.16	3.68	11.59	< 0.001	1.49
Fight-Flight-Freeze System	51.55	8.81	43.99	6.88	7.55	< 0.001	0.97

levels of BAS. Zhu et al. [12] showed that exercise has been shown to enhance the midbrain-striatal dopamine (DA) system and improve the brain reward function in adolescents, which is strongly associated with BAS. Also, the rRST suggests shorter response latencies in specific tasks, which is related to BAS [25].

Overall, as a critical component of Gray's RST, BAS is associated with sensitivity to reward and motivation to approach goal-oriented outcomes [26–29]. BAS is an appetitive-motivational system that is activated by reward consumption and conditioned signals of reward or non-punishment, triggering approach behavior [30]. Behavioral activation aims to increase pleasurable feelings and create a sense of meaning by deliberately practicing certain behaviors. Physical activity is a central part of behavioral activation, which improves mental health and well-being. Therefore, the differences between karate athletes and physically active men were not shown in BAS. The present results suggest that the practice of any PA and sport may be equally related to higher BAS. The results indicate that approach attitude and reward-driven motivation could be generally used to improve both PA and sports levels.

Behavioral inhibition system (BIS) in karate athletes

Hypothesis H2 was not confirmed in the present study, suggesting that karate training is not related to BIS levels. No difference in BIS was found between karate and non-karate athletes, as well as between athletes and physically inactive participants. We assumed that constant consideration between the choice of approach and avoidance techniques during a karate fight leads to heightened BIS. BIS is engaged in resolving goal conflicts between approach-avoidance (e.g., BAS and Flight, or Fight and Freeze), approach-approach (e.g., BAS and Fight), and avoidance-avoidance (e.g., Freeze or Flight). Unlike the hasty approach motivated by BAS and active avoidance prompted by FFFS, behavioral inhibition allows for a cautious approach or passive avoidance of perceived threats. When conflicts arise, the BIS induces anxiety to inhibit ongoing behaviors, focus attention on the threat, and motivate a controlled assessment of the situation [31].

Response inhibition, which is linked directly to the BIS, has been proposed as a cognitive mechanism important for improving performance in sports [9, 10]. Hoverer, response inhibition did not differentiate athletes from non-athletes in the previous study [10], which seems to be consistent with current findings. On the other hand, BIS sensitivity is negatively related to participation in high-risk sports [11], which can explain why karate athletes do not outperform other athletes and non-athletes in BIS in our study.

BIS is related to avoidance behaviors and response inhibition, which may negatively influence an athlete's motivation to exercise and their performance in sports [15]. Indeed, previous studies found a negative relationship between BIS and affective response to exercise and, as a consequence, engagement in physical activity [10, 15]. High activity of the BIS has been linked to high levels of anxiety, depression, and somatic disorders, which also may impact an athlete's motivation to engage in physical activity [32]. The study suggests that higher BIS levels may make athlete adolescents more vulnerable to stressful experiences and situations, indicating its potential impact on mental well-being [33]. Previous studies have shown a greater difficulty in suppressing anger among athletes under anger-provoking conditions, indicating a lower activation of the BIS and a higher activation of the BAS [34]. However, the relationship between BIS and physical activity is an area of ongoing research. Further studies may provide additional insights into the role of the BIS in the context of physical activity and sport.

Feight, flight, and freeze systems (FFFS) in karate competitors

The present study suggests that training in combat sports, like karate, seems not to be related positively to fight tendencies, which is inconsistent with hypothesis H3. Although a successful fight is the primary goal of karate training and competition, the level of the Fight scale was similar in karate athletes to that of the other groups. Previous studies have shown that aggression levels are higher in athletes representing contact sports and low competitive levels [35]. Additionally, higher levels of aggression were associated with worse executive functions and reduced inhibition control [36, 37]. However, athletes usually demonstrate better behavioral inhibition than non-athletes [38]. The results of the study by Xia et al. [34] indicated that implicit anger (as a component of aggression) significantly reduced behavioral inhibition in contact athletes but not in non-athletes. Furthermore, numerous research studies have evidenced that engagement in martial arts and combat sports has a positive impact on reducing aggression [39–46].

Summarizing the studies mentioned above, although aggressive behavior can play a crucial role in contact sports, little is known about the mechanism that reduces aggression in people engaged in martial arts training. The role of behavioral approach and avoidance motivation systems can be helpful in explaining the reduction of levels of aggressive behavior among martial arts competitors. Therefore, further study should examine a mediating role of the rRST traits on the relationship between aggression and sports success in karate. It is suggested that long-term practice in both aggressive and defensive behaviors during karate training reduces fight tendencies and aggressive behavior. However, longitudinal research could be helpful in confirming this speculation.

The study also showed that Freeze differs the KK sample from the KS and PI samples (but not from the PA group). As assumed, KK athletes scored significantly lower than PI and even the KS group. In addition, the total score of FFFL (composed of summarized scores in Fight, Flight, and Freeze) was significantly lower in KK than in non-athletes. Therefore, the hypothesis H4 was also partially confirmed. Karate athletes must fight with fear during training and competitions. It is possible that training in KK is an excellent opportunity to cope with Freeze and Flight reactions. Repeated practice can lead to mastery in controlling negative emotions (such as anger and frustration) and better coping with stress. Karate is based on a specific scoring system (points and penalties) during training and competition, which involves punches, swinging legs, and kicks to the face and body. Karate athletes can use different tactics, such as offensive, defensive, or counter-attacking, depending on the current and dynamic situation. Karatekas must rely on predetermined strategy and initiative when making decisions, such as taking risks to gain points and penalties or deciding whether they should expose or protect themselves. Therefore, self-control, emotion regulation, and cognitive processing during decision-making are crucial to achieving success in the Karate discipline [47, 48].

Temperamental profiles in participants

The K-means Clustering showed that participants in this study demonstrated two distinct patterns of temperamental traits. One temperamental configuration (Cluster 1) includes low BAS, BIS, and Fight scores and, at the same time, high Flight and Freeze. In other words, low approach and high avoidance tendencies are represented in Cluster 1. We can name this sample "sensitive to punishment" (STP). The systems of BAS, BIS, and Fight seem to play a crucial role in profiling participants and explain 28% of the variance in temperament. The opposite pattern of temperament consists of high BAS, BIS, and Fight levels and simultaneously low levels of Flight and Freeze (Cluster 2). As such, Cluster 2 characterizes people with a high approach and low avoidance motivations, named "sensitive to reward" (STR). Furthermore, these individual differences explain 37% of the variance in temperamental traits. Together, these two dimensions, STP and STR, explain 56% of temperamental variance. The present study fully supports Gray's rRST and clearly demonstrates evidence for two-dimensional approach-avoidance motivational tendencies [26, 27, 29, 49, 50].

Moreover, we found that the KK sample is represented predominantly by individuals sensitive to reward (Cluster 2). The KK sample differs from all three other samples because the PI, PA, and KS groups presented similarly to each other and had almost equal frequency distributions of STP and STR clusters. The present results suggest that only KK training can enhance approach tendencies. Parmigiani [51] examined the relationship between personality traits, endocrine response, and agonistic outcomes in karate athletes. The study found that karate athletes who lose fights demonstrate a higher level of harm avoidance and anxiety (suggesting high FFFS and BIS, respectively) as well as a lower level of novelty seeking (responded to BAS) than winning karate competitors. Harding (2004) examined the effects of reinforcement and extinction on response variability and stimulus generalization in martial arts training and found that students showed growth in a variety of techniques when reinforcement was provided. The rRST provides a more comprehensive understanding of responses to threat and punishment (FFFS) and sensitivity to avoidance motivation (BIS), as well as sensitivity to reward and approach motivation [7, 8].

Conclusions and practical implications of the study

The present study fully confirmed the rRST assumptions, evidencing the existence of two primary dimensions that guide human motivation, namely approach-avoidance behavioral tendencies. The rRST highlighted that both FFFS and BIS are associated with negative emotions, while high BAS is linked to positive emotions, which directly translates into avoidance or approach motivation, respectively [4, 25, 31, 52]. Heponiemi et al. [52, 53] found that individuals with high BIS sensitivity were more likely to experience unpleasant emotions during stressful situations, while those with high BAS sensitivity experienced increased pleasant emotions during rewarding tasks. The study indicates that karate athletes can be characterized as reward-sensitive persons (high BAS). This fact implies for coaches and sports instructors that karate athletes should be motivated by incentives, while punishment should be avoided during sports training.

Sports psychologists and coaches should utilize the current findings to improve sport selection and psychological support. It seems valuable to examine temperamental traits among adolescent athletes to save time and resources in a sports area. Successful sport profile seems to include people, presenting approach tendencies, and "sensitive to reward" patterns. On the other hand, sports psychologists can focus on improving BAS, BIS, and Fight and simultaneously on mitigating Flight and Freeze, as well as avoidant tendencies.

The study may also have implications for individual engagement in PA and any sport. Overall, behavioral activation can be used to improve motivation in sports by promoting engagement in activities that align with the individual's values and goals, leading to increased pleasure, joy, and a sense of accomplishment [54–56]. However, further research and comparative studies are needed to directly compare the effectiveness of behavioral activation with other interventions for increasing

physical activity in athletes. The ANOVA showed that Kyokushin karate athletes scored significantly lower on the Freeze scale than Shotokan karatekas. We speculate that Kyokushin karate practice can significantly reduce freeze reactions in threatening situations and generally improve coping with fear by reducing FFFS levels. Therefore, the KK style can be seen as more beneficial than the KS style, although both karate styles improve BAS. However, longitudinal research is required to verify the causal assumptions. Since BAS is related to positive emotions, optimism, and happiness, karate training can be considered as a health intervention that prevents mental disorders and promotes well-being.

The research failed to demonstrate that the BIS distinguishes karateka from control groups. It is proposed that psychological support should be directed at increasing BIS in karate athletes, which may contribute to enhancing their sporting accomplishments. Several techniques can potentially be considered to improve the BIS in athletes. Training programs that focus on cognitive mechanisms, such as response inhibition, executive functions, and cognitive flexibility, may be necessary for enhancing performance in sports and engagement in PA [57]. On the other hand, continued engagement in sports and athletic activities and maintaining a healthy lifestyle may contribute to the development and enhancement of inhibitory control and the BIS. Research has shown that physical activity can enhance the BIS and improve well-being [32]. Therefore, promoting an active lifestyle among athletes may indirectly influence the BIS. Individualized approaches that consider the unique characteristics and needs of athletes would be essential when sports psychologists and coaches implement such techniques.

Limitation of the study

Although the results of this study are significant for understanding the role of rRST in sports and PA participation, some limitations do not allow for generalization. The present study sample is not large and does not include women. Therefore, it is unclear whether gender has any effect on the rRST traits. Future studies should include a larger sample that is more representative of karate competitors of both genders. The self-report questionnaire (primarily online) can also be a source of measurement bias. Therefore, psychophysiological methods can be used in the future to examine BAS, BIS, and FFFS using more objective methods. Furthermore, it would be interesting to compare various martial arts disciplines in terms of temperament. Longitudinal studies could explain in the future to what extent temperament contributes to sport and PA and, conversely, how sport and PA determine the development of personality traits and adaptation to changes in the environment.

Author contributions
CK: Conceptualization, Methodology, Investigation; Project administration, Validation, Writing – original draft, Writing – review & editing. AMR: Conceptualization, Methodology, Formal Analysis, Resources, Validation, Visualization, Data curation; Writing – original draft, Writing – review & editing. KG: Validation, Writing – review & editing. PW: Investigation; Writing – review & editing.

Funding
Not applicable.

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The studies involving humans were approved by the University Research Ethics Committee of Opole University of Technology (9 July 2022; No. 2/2022). The studies were conducted in accordance with local legislation and institutional requirements. All participants provided their informed consent to participate in this study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 29 February 2024 / Accepted: 20 August 2024
Published online: 26 August 2024

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