

# Autonomic Nervous System Adaptation: Impact on the Physical Performance of Martial Arts Athletes

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**Abstract** The autonomic nervous system (ANS) plays a critical role in maintaining homeostasis and optimizing athletic performance, particularly in martial arts, where physical and mental demands fluctuate rapidly. This study aims to evaluate the ANS adaptation in martial arts athletes and its impact on their physical performance. The analysis of the functional state of the ANS in 136 martial arts athletes revealed that 24.3% (33 athletes) exhibited ANS tension, leading to disturbances in vegetative homeostasis and a decreased regulatory-adaptive capacity of the body, which negatively influenced performance outcomes. Additionally, the predominance of sympathicotonic changes in 10.3% of cases was observed, reflecting impaired heart adaptability. However, the majority of athletes (64%) demonstrated adequate ANS adaptation, indicating well-maintained autonomic function and a high level of qualification. These findings emphasize the importance of monitoring autonomic function in martial arts athletes to assess their adaptive responses to physical loads and inform training regimens to optimize performance and prevent potential health risks.

**Keywords** Regulatory-adaptive capacity, Heart rate variability, Sports performance, Training adaptation, Cardiovascular function, Autonomic dysfunction, Sympathetic and parasympathetic balance, Sports medicine

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## 1. Relevance

Disturbances in vegetative regulation are often an early indicator of a decline in the body's adaptation to physical loads, which can result in decreased performance [1,6,8]. When the body's reserve capabilities are exhausted, dysregulatory disturbances in vegetative function at both suprasegmental and segmental levels can occur. These disturbances are frequently associated with the pathogenesis of cardiovascular diseases [1,4,9]. The autonomic nervous system (ANS) plays a critical role in maintaining homeostasis and regulating vital functions in the body, enabling athletes to perform under varying levels of stress and fatigue. As such, ANS disorders, especially those involving imbalances between the sympathetic and parasympathetic divisions, are significant markers of compromised physiological states in athletes [2,7].

The autonomic nervous system dysfunction in athletes, particularly in martial arts, can influence both physical endurance and mental resilience. Martial arts athletes, who are subjected to high-intensity, acyclic training involving both aerobic and anaerobic components, face substantial stress on the body. The body's capacity to adapt to these

varied and strenuous physical demands is determined in large part by the functional state of the ANS. The imbalance in autonomic regulation can thus lead to decreased ability to recover, increased injury susceptibility, and, ultimately, reduced performance [3,7].

Research has shown that proper autonomic regulation is essential for ensuring that athletes maintain optimal physiological balance during training and competition. When these autonomic processes are disturbed, athletes may experience symptoms such as increased fatigue, diminished endurance, altered cardiovascular responses, and heightened stress sensitivity. This highlights the importance of assessing the vegetative adaptation of martial arts athletes to physical loads and stress [5,10]. Given the unique physiological demands of martial arts, understanding the relationship between autonomic function and athletic performance is crucial for optimizing training regimens, enhancing performance, and reducing health risks.

## 2. Objective of the Study

The aim of this study is to assess the autonomic status of martial arts athletes and examine the impact of physical training on their vegetative adaptation.

### 3. Materials and Methods

The study was conducted at the base of the Research Institute of Sports Medicine and Rehabilitation. A total of 136 martial arts athletes participated in the research, including 85 men (62.5%) and 51 women (37.5%), aged between 18 and 33 years (mean age =  $25.5 \pm 2.6$  years). Martial arts, classified as acyclic sports, are distinguished by their emphasis on speed and strength during training, involving variable intensity loads during competition [2]. Of the athletes examined, 23 practiced taekwondo, 48 participated in boxing, 29 practiced Greco-Roman wrestling, and 36 were judo athletes.

The athletes underwent a neuropsychological assessment using several scales, including:

- Asthenic State Scale (ASS)
- Kerdo Autonomic Index (AI)
- Hospital Anxiety and Depression Scale (HADS)
- Mental Stress Scale (PSM-25)

An express diagnostic evaluation of the asthenic condition was performed using the Asthenic State Scale, which consists of 30 questions. The results were interpreted as follows:

- Less than 50 points: No asthenia
- 51-75 points: Mild asthenia
- 76-100 points: Moderate asthenia
- 101-120 points: Severe asthenia

The Kerdo Autonomic Index (AI) was used to assess the balance between the sympathetic and parasympathetic divisions of the autonomic nervous system. The AI is calculated using the following formula:

$$AI = (1 - \text{Diastolic Pressure} / \text{Pulse}) \times 100$$

The interpretation of the data is as follows:

- Sympathicotonia: +16 to +30
- Pronounced sympathicotonia:  $\geq +31$
- Parasympathicotonia: -16 to -30
- Pronounced parasympathicotonia:  $\leq -30$
- Sympathetic-parasympathetic balance: -15 to +15

Statistical analysis was performed using Microsoft Excel 2016, utilizing built-in statistical functions.

### 4. Results of the Study

During the objective examination of 136 martial arts athletes, 24.3% (33 out of 136) were diagnosed with autonomic dysfunction. The following symptoms were observed among athletes with autonomic dysfunction:

- Hyperhidrosis (excessive sweating) of the feet and palms: 77.2% (25 out of 33 athletes)
- Stabbing pain in the heart area: 48.5% (16 out of 33 athletes)
- Meteorological sensitivity (sensitivity to weather changes): 42.6% (14 out of 33 athletes)
- Emotional lability (frequent mood swings): 33.1% (11 out of 33 athletes)

- Intolerance to stuffy rooms: 30.1% (10 out of 33 athletes)
- Allergic reactions (various types of allergic symptoms): 25.0% (8 out of 33 athletes)

The following symptoms were observed less frequently:

- Sleep disturbances: 16.1% (5 out of 33 athletes)
- Loss of appetite: 14.7% (5 out of 33 athletes)
- Nausea: 5.1% (2 out of 33 athletes)
- Irritability: 14.7% (5 out of 33 athletes)
- Dizziness: 10.3% (3 out of 33 athletes)
- Headaches: 5.1% (2 out of 33 athletes)

These symptoms reflect a range of autonomic dysfunction indicators that could impact the performance and well-being of martial arts athletes. The frequency of symptoms such as hyperhidrosis, heart-related pain, and meteorological sensitivity suggests that athletes may experience significant physiological and emotional stress that warrants further examination and possible intervention.

The data collected are presented in Table 1 for a clearer understanding of the prevalence of symptoms associated with autonomic dysfunction.

**Table 1.** Frequency of Symptoms of Autonomic Dysfunction (n=136)

Symptoms	Number of athletes	
	Absolute	%
Hyperhidrosis of the feet and palms	105	77,2
Stabbing pain in the heart area	66	48,5
Meteorological sensitivity	58	42,6
Emotional lability	45	33,1
Intolerance to stuffy rooms	41	30,1
Allergic reactions	34	25,0
Sleep disturbances	22	16,1
Loss of appetite	20	14,7
Nausea	7	5,1
Irritability	20	14,7
Dizziness	14	10,3
Headaches	7	5,1

The autonomic nervous system was evaluated using the Scale of Asthenic State and the Kerdo Index.

Scale of Asthenic State:

The average score according to the Scale of Asthenic State was  $54.9 \pm 1.8$ . This scale assesses the level of asthenia (a state of fatigue and weakness). Among the martial arts athletes, the following results were observed:

- 15.4% (21 out of 136) had scores corresponding to the norm, meaning these athletes did not exhibit any signs of asthenic syndrome.
- 71.4% (97 out of 136) had mild manifestations of asthenic syndrome, indicating the presence of fatigue, weakness, and decreased physical endurance.
- 13.2% (18 out of 136) had moderate manifestations of asthenic syndrome, suggesting a more pronounced impact on physical and mental performance. (Fig. 1)

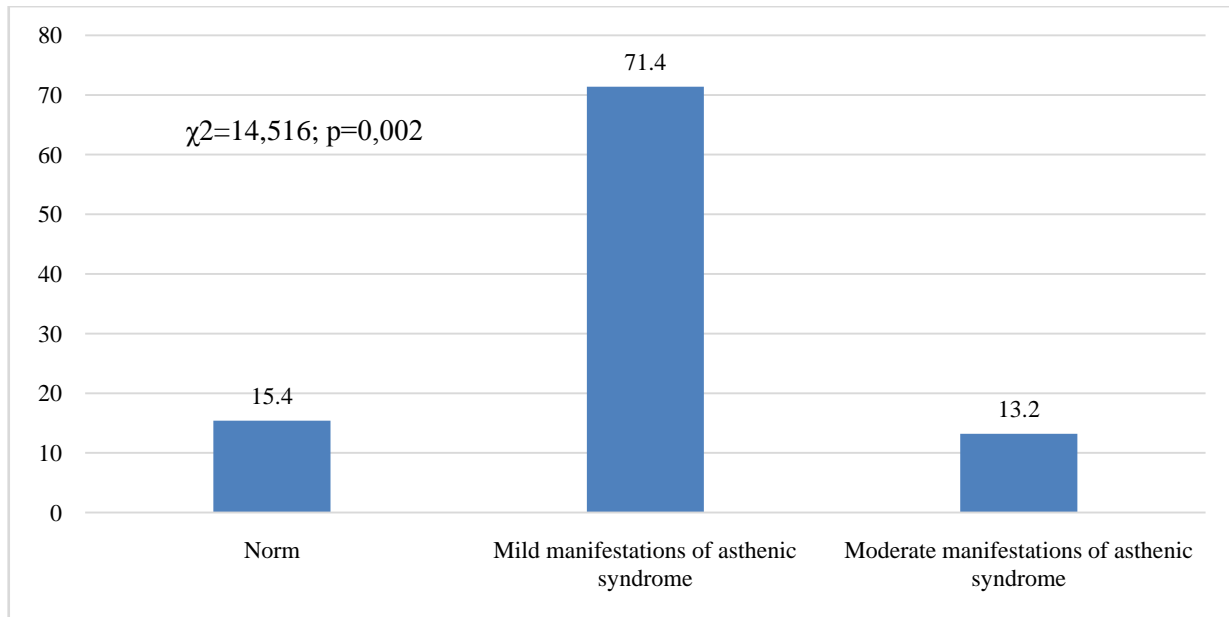


Figure 1. Scale of Asthenic State Scores Among the Examined Martial Arts Athletes

Kerdo Index Evaluation:

The Kerdo Index was used to assess the balance between the sympathetic and parasympathetic divisions of the autonomic nervous system. The following results were observed:

- 8.8% exhibited sympathicotonia, which is characterized by an overactivity of the sympathetic nervous system.
- 1.5% showed pronounced sympathicotonia, suggesting a more severe imbalance towards sympathetic activation.
- 19.9% had parasympatheticotonia, indicating overactivity of the parasympathetic nervous system.
- 5.9% had pronounced parasympatheticotonia, reflecting an extreme dominance of parasympathetic activity.
- In 64.0% of athletes, vagosympatheticotonia was observed, indicating a functional balance between the sympathetic and parasympathetic nervous systems, which is considered optimal for athletic performance.

These results provide insight into the autonomic regulation of martial arts athletes, highlighting the significant prevalence of mild asthenic symptoms and a balanced autonomic nervous system in the majority of athletes. However, a substantial number of athletes exhibited signs of sympathetic or parasympathetic dominance, which may affect their adaptability to training and recovery processes.

The predominance of the sympathetic part of the autonomic nervous system in 10.3% of cases (15 athletes out of 136) indicates inadequate activation of the sympathetic-adrenal system, leading to functional desympathization. This suggests that these athletes may have impaired sympathetic regulation, which can affect their ability to efficiently respond to physical and mental stressors during training and competition.

Table 2. Kerdo Index Values in Martial Arts Athletes (n=136)

Interpretation:	Number of athletes	
	Absolute	%
Sympathicotonia (+16 to +30)	12	8,8
Pronounced sympathicotonia (+31 and above)	3	1,5
Functional balance between sympathicotonia and parasympatheticotonia (+15 to -15)	87	64,0
Parasympatheticotonia (-16 to -30)	27	19,9
Pronounced parasympatheticotonia (-31 and above)	8	5,9

Interpretation of Results:

- Sympathicotonia (+16 to +30): This is characterized by overactivation of the sympathetic nervous system, which prepares the body for "fight or flight" responses. The presence of 8.8% of athletes with sympathicotonia suggests that a portion of the athletes may be under chronic stress, leading to heightened readiness or an exaggerated response to stressors.
- Pronounced Sympatheticotonia ( $\geq +31$ ): Only 1.5% of athletes demonstrated pronounced sympathicotonia, indicating a more extreme and potentially problematic overactivation of the sympathetic nervous system. This condition may reduce the body's ability to recover and adapt effectively to physical loads.
- Parasympatheticotonia (-16 to -30): This indicates an overactivity of the parasympathetic nervous system, responsible for relaxation and recovery. 19.9% of athletes exhibited this condition, suggesting potential issues with recovery or an inability to regulate physical responses during intense activity.
- Pronounced Parasympatheticotonia ( $\leq -30$ ): 5.9% of athletes showed pronounced parasympatheticotonia,

which may lead to a sluggish recovery and reduced performance under high stress conditions.

- Vagosympatheticotonia (-15 to +15): 64.0% of the athletes had balanced autonomic nervous system activity, which is considered ideal for maintaining both recovery and performance under a range of conditions. This balance indicates an adaptive and flexible autonomic response, beneficial for high-performance athletes.

These findings underscore the diverse states of autonomic regulation in martial arts athletes and highlight the need for individualized training and recovery strategies to optimize performance and well-being. The predominance of vagosympatheticotonia in the majority of athletes reflects a well-regulated autonomic state, while those with more extreme autonomic imbalances may require targeted interventions.

In 25.7% of cases (35 out of 136), the predominance of the parasympathetic division of the autonomic nervous system (ANS) was observed. This indicates a state of overstrain and points to a deficiency in adaptive mechanisms, which may result in an inability to provide an optimal response to increased physical loads. In athletes exhibiting this pattern, the body's ability to properly adapt and manage stress during intense training or competition may be compromised, potentially leading to decreased performance and higher susceptibility to overtraining and fatigue.

#### Summary of Findings:

- 64.0% of athletes exhibited normotonia, meaning that the balance between the sympathetic and parasympathetic systems was functioning adequately, which is considered optimal for high-performance athletes. This balance allows for both effective physical exertion during training and efficient recovery post-exercise.
- 24.3% of athletes were diagnosed with autonomic dysfunction syndrome, indicating that some athletes are experiencing functional impairments in autonomic regulation, which could negatively affect their health and performance. These dysfunctions can manifest in various symptoms, as previously discussed, such as emotional lability, sleep disturbances, and physical discomfort.

These findings highlight the importance of monitoring autonomic nervous system function in martial arts athletes, as it plays a crucial role in adaptation to training loads and overall performance. It also emphasizes the need for individualized training regimens and recovery strategies to mitigate autonomic dysfunction and enhance both physical and psychological resilience in athletes.

## 5. Discussion

The findings of this study emphasize the significant role of the autonomic nervous system (ANS) in the adaptation of martial arts athletes to physical loads and stressors. As shown in the results, 24.3% of athletes exhibited autonomic dysfunction, highlighting that a substantial portion of martial artists face challenges in maintaining proper vegetative

regulation under intense training and competition conditions. This dysfunction can disrupt homeostasis and compromise the athletes' regulatory-adaptive capacity, potentially leading to fatigue, reduced performance, and increased vulnerability to stress-related illnesses [1,3].

The study's results align with previous research suggesting that disturbances in the autonomic nervous system are common among athletes, particularly those engaged in high-intensity sports such as martial arts. The sympathicotonic shifts (10.3% of the athletes) observed in this study suggest an overactivation of the sympathetic-adrenal system, which could be linked to chronic stress, overtraining, or inadequate recovery. This condition, if persistent, could result in cardiovascular strain and immune system suppression, thus increasing the risk of injury or illness [2,4]. These findings are consistent with those of studies focusing on the relationship between sympathetic dominance and impaired cardiovascular adaptation in athletes [5].

Conversely, the parasympathetic predominance (25.7% of athletes) points to a state of overstrain and a deficiency in adaptive mechanisms, which suggests that some athletes may not be able to handle physical and mental stressors effectively. This could result in a reduced capacity for recovery, increasing the risk of overtraining syndrome. Parasympathetic predominance can also be indicative of an athlete's inability to optimally manage physical loads, which might contribute to suboptimal performance during competitions [6,7].

Interestingly, 64.0% of athletes exhibited normotonia, reflecting the fact that the majority of the martial arts athletes included in this study had well-balanced autonomic regulation. This observation suggests that martial arts training, which combines physical exertion, mental focus, and discipline, may help athletes achieve a healthy balance between sympathetic and parasympathetic activity. This balance is essential for sustained performance and optimal adaptation to training stress. It is particularly notable that normotonia was the most common finding, supporting the idea that martial arts athletes are generally well-prepared to manage physical and mental stress through effective regulation of their autonomic nervous system [8,9].

While most athletes displayed adequate autonomic adaptation, 24.3% of athletes with autonomic dysfunction might benefit from further attention to their training loads, recovery strategies, and psychological support. Monitoring and managing autonomic dysfunction in athletes is crucial, as it could potentially lead to suboptimal physical performance, delayed recovery, and a higher risk of developing chronic health issues [10].

In conclusion, this study highlights the importance of monitoring the autonomic nervous system in martial arts athletes to prevent overtraining, ensure effective adaptation, and maintain long-term health and performance. Future research could focus on interventions to help athletes with autonomic imbalances, including tailored training programs, psychological stress management techniques, and nutritional support to promote better autonomic regulation.

## 6. Conclusions

1. The analysis of the functional state of the autonomic nervous system (ANS) in martial arts athletes revealed that 24.3% (33 athletes) exhibited ANS tension, leading to disturbances in vegetative hemostasis and a reduction in the regulatory-adaptive capacity of the body. This dysfunction affects the athlete's ability to effectively adapt to physical and psychological stressors, which can negatively impact their performance and success in achieving sports accomplishments.
2. The predominance of sympathicotonic changes in 10.3% of athletes (15 out of 136) suggests poorer adaptive heart capacity, which may result in an excessive activation of the sympathetic-adrenal system. This finding highlights the potential for reduced cardiovascular efficiency and overall performance, as athletes in this group may experience difficulties in handling intense physical stress during competitions and training.
3. Based on the data obtained, the majority of martial arts athletes demonstrated adequate autonomic nervous system adaptation, as evidenced by the presence of normotonia in 64.0% of cases. This indicates a high level of qualification and the ability of these athletes to effectively manage both physical and emotional stress, thus optimizing their performance and reducing the risk of health-related issues associated with autonomic dysfunction.

In conclusion, while the majority of athletes exhibited proper autonomic adaptation, attention must be given to those with autonomic dysfunction, especially to manage the potential negative impacts on their training, health, and long-term performance.

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