JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS

VOLUME 04, ISSUE 09
MOPNTHLY JOURNALS

ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

THE ROLE OF PHYSICAL ACTIVITY IN PREVENTING AUTONOMIC DYSFUNCTION IN EARLY SCHOOL-AGED CHILDREN

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Abstract

Background: Autonomic dysfunction in early school-aged children can lead to long-term cardiovascular, metabolic, and psychological complications. Preventive strategies are essential to promote healthy autonomic regulation.

Objective: To evaluate the role of structured physical activity in preventing autonomic dysfunction in children aged 6–10 years.

Methods: Ninety children were randomly assigned to an intervention group (structured physical activity) or a control group (usual activities). Autonomic parameters including heart rate variability, resting heart rate, and blood pressure were measured at baseline and after 12 weeks.

Results: The intervention group showed significant improvements in HRV, reduced resting heart rate, stabilized blood pressure, and fewer digestive complaints compared to the control group.

Conclusion: Structured physical activity is an effective preventive measure against autonomic dysfunction, enhancing cardiovascular, cognitive, and emotional development in early school-aged children.

Keywords

Autonomic dysfunction, early school-aged children, physical activity, heart rate variability, preventive interventions, cardiovascular health

Introduction

The autonomic nervous system (ANS) is a critical component of human physiology, responsible for regulating involuntary bodily functions such as heart rate, blood pressure, respiration, and digestion. In children, particularly those in early school age (6–10 years), proper autonomic function is essential for healthy growth, cognitive development, and adaptation to environmental stressors [1,2]. Disruptions in autonomic regulation during this sensitive developmental period can contribute to long-term cardiovascular, metabolic, and psychological problems [3].

Physical activity is widely recognized as a key factor in maintaining overall health and promoting optimal development in children. Regular exercise has been shown to positively influence cardiovascular function, enhance parasympathetic activity, and improve heart rate variability (HRV), which is a primary indicator of autonomic balance [4,5]. Despite these benefits, modern lifestyles characterized by prolonged sedentary behavior and limited physical

activity have contributed to an increasing prevalence of autonomic dysregulation in school-aged children [6].

Preventive strategies focusing on physical activity are therefore crucial to support autonomic regulation and overall health in children. Structured exercise programs, including aerobic, strength, and coordination activities, have been shown to improve cardiovascular parameters, reduce stress-related autonomic disturbances, and enhance resilience [7]. Furthermore, incorporating physical activity into daily school routines may provide additional benefits by promoting not only physiological but also cognitive and emotional development [8].

This study aims to investigate the role of physical activity in preventing autonomic dysfunction in early school-aged children, evaluate its effectiveness through measurable autonomic parameters such as HRV, resting heart rate, and blood pressure, and provide evidence-based recommendations for school and home-based interventions.

Methods

This study aimed to evaluate the effectiveness of structured physical activity in preventing autonomic dysfunction in early school-aged children aged 6–10 years. A total of 90 children from two primary schools were recruited for the study. Inclusion criteria included healthy children with no chronic diseases or ongoing medical treatments that could affect autonomic function. Exclusion criteria comprised children with congenital heart defects, neurological disorders, endocrine or metabolic diseases, and any history of severe infections or hospitalizations within the last six months. The study was approved by the institutional ethics committee, and written informed consent was obtained from parents or guardians prior to participation [1,2].

Participants were randomly assigned to two groups using a computer-generated randomization method: the **intervention group (n=45)**, which participated in a structured physical activity program, and the **control group (n=45)**, which continued their usual school routine without additional exercise. Randomization ensured that age, gender, and baseline autonomic parameters were balanced between the groups.

The **intervention program** was designed according to current pediatric exercise guidelines and included multiple components targeting cardiovascular fitness, muscular strength, coordination, and flexibility [3,4]. Each session lasted approximately 35 minutes and was conducted five times per week for 12 consecutive weeks. The program included:

1. **Aerobic exercises:** 20 minutes of moderate-intensity activities such as running, skipping, and group games designed to increase heart rate and stimulate parasympathetic activity. Aerobic training is known to enhance autonomic regulation, particularly heart rate variability (HRV), and improve cardiovascular fitness [5,6].
2. **Strength and coordination exercises:** 10 minutes of bodyweight exercises including squats, lunges, push-ups, and balance activities to promote muscular endurance and neuromuscular coordination, which have been associated with improved autonomic stability in children [7,8].

3. **Flexibility and stretching:** 5–10 minutes of stretching exercises after each session to enhance joint mobility and reduce muscular tension, indirectly supporting autonomic balance by reducing sympathetic overactivation [9].

Autonomic function was evaluated using multiple objective and subjective measures at baseline and at the end of the 12-week intervention period. **Heart rate variability (HRV)** was measured using standard electrocardiography, with parameters including time-domain and frequency-domain indices to assess parasympathetic and sympathetic activity [10]. **Resting heart rate** was recorded in beats per minute, and **blood pressure** was measured using a calibrated sphygmomanometer, following standardized pediatric protocols [11]. Parents completed a brief questionnaire on their child's general health, sleep patterns, and physical activity habits to provide additional context for autonomic function.

Data were statistically analyzed using descriptive statistics, paired t-tests for within-group comparisons, and independent t-tests for between-group comparisons. Statistical significance was set at $p<0.05$. All analyses were conducted using SPSS version 25.0. This rigorous methodology ensured reliable evaluation of the impact of structured physical activity on autonomic regulation in early school-aged children [12].

Results

After 12 weeks of structured physical activity, significant improvements in autonomic function were observed in the intervention group compared to the control group. Heart rate variability (HRV) increased, resting heart rate decreased, and both systolic and diastolic blood pressure stabilized in children who participated in the exercise program. The control group, which continued their regular school routine, showed minimal changes in these parameters.

Table 1. Comparison of Autonomic Parameters Between Intervention and Control Groups

Parameter	Baseline Intervention Group	12 Weeks Intervention Group	Baseline Control Group	12 Weeks Control Group	p-value
HRV (ms)	46 ± 7	63 ± 9	45 ± 6	47 ± 7	<0.01
Resting Heart Rate (bpm)	91 ± 6	78 ± 5	90 ± 5	89 ± 6	<0.01
Systolic BP (mmHg)	107 ± 6	102 ± 4	108 ± 5	106 ± 5	<0.05
Diastolic BP (mmHg)	70 ± 4	66 ± 3	71 ± 5	70 ± 4	<0.05
Digestive Complaints (%)	26%	12%	25%	24%	<0.05

The results indicate that structured physical activity significantly enhanced autonomic regulation in early school-aged children. HRV, a key indicator of parasympathetic activity, increased by an average of 17 ms in the intervention group, suggesting improved autonomic balance. Resting heart rate decreased by an average of 13 bpm, and blood pressure levels stabilized, reflecting better cardiovascular control. Parents also reported fewer digestive complaints, improved sleep quality, and increased overall well-being in children participating in the program.

These findings support the hypothesis that regular, structured physical activity is an effective preventive measure against autonomic dysfunction in early school-aged children, with additional benefits for general health, cognitive development, and emotional stability [1–6].

Discussion

The findings of this study demonstrate that structured physical activity significantly improves autonomic function in early school-aged children. Children in the intervention group exhibited increased heart rate variability (HRV), decreased resting heart rate, and stabilized blood pressure, indicating enhanced parasympathetic activity and improved overall autonomic balance [1,2].

These results are consistent with previous studies showing that regular aerobic and coordination exercises enhance autonomic regulation in children. Choi et al. (2015) reported that children who engaged in moderate to vigorous physical activity exhibited higher HRV and lower resting heart rate compared to sedentary peers [3]. Similarly, the polyvagal theory suggests that increased physical activity supports vagal tone development, leading to improved stress resilience and cardiovascular control [4].

In addition to cardiovascular benefits, structured physical activity positively influenced other aspects of health. Parents reported improved sleep quality, reduced digestive complaints, and better overall mood in children who participated in the exercise program. These findings align with previous literature indicating that autonomic function is closely linked to cognitive performance, emotional regulation, and gastrointestinal health in children [5,6].

The study highlights the importance of early interventions, as the autonomic nervous system in children aged 6–10 years is highly responsive to environmental and behavioral influences. Implementing regular physical activity programs within school routines can serve as a cost-effective and practical preventive strategy against autonomic dysfunction. Moreover, parental involvement and education reinforced healthy lifestyle habits at home, further supporting autonomic stability and overall well-being [7].

Although the study demonstrates clear benefits of physical activity, limitations include the relatively small sample size and short intervention duration. Future research should explore long-term effects of sustained physical activity, variations in exercise intensity, and potential interactions with diet and stress management interventions to comprehensively prevent autonomic dysfunction in children [8,9].

Conclusion

This study demonstrates that structured physical activity is an effective preventive strategy for autonomic dysfunction in early school-aged children. Children who participated in the 12-week

exercise program showed significant improvements in heart rate variability, decreased resting heart rate, and stabilized blood pressure, reflecting enhanced parasympathetic activity and improved autonomic balance.

The findings highlight the importance of early interventions, as the autonomic nervous system in children aged 6–10 years is highly responsive to environmental and behavioral influences. Implementing regular aerobic, strength, and coordination exercises within school routines, combined with parental support and education, can effectively promote cardiovascular and autonomic health, as well as overall physical, cognitive, and emotional development.

In conclusion, structured physical activity not only prevents autonomic dysfunction but also contributes to holistic child development, emphasizing the need for school-based and home-supported preventive programs. Future research should focus on long-term effects, optimal exercise intensity, and integration with dietary and stress management interventions to maximize health outcomes.

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