Research on Optimizing the Motor Capacity of Middle School Students by Combining Physical Exercises with Consumption Natural Products

Dan Cristian STOICESCU[1]
Virgil TUDOR[2]
Daniel CONSTANTINESCU[3]

Abstract

This research aims to contribute to the optimization of physical education lessons in middle school by implementing internationally recognized strategic sports games and assessing their effectiveness. Additionally, it seeks to enhance physical fitness and promote a healthy lifestyle among students.

The choice of this topic stems from the desire to explore the scientific complexity of the field and to contribute through the proposed research to improving physical education lessons in middle school, thereby enhancing students' physical condition and fostering a healthy lifestyle among adolescents.

This study aims to identify the effectiveness of physical well-being programs in parallel with the use of natural plant-based products. The objective of the research is to analyze statistical data obtained from ergometric bicycle evaluations of middle school students before and after the administration of natural products in correlation with the results of sports performance tests.

The statistical analysis suggests that the treatment had a measurable impact on key physiological parameters, particularly those related to ventilation efficiency, CO_2 exchange, and carbohydrate metabolism, while oxygen per pulse remained unchanged

Keywords: *middle school students, natural products, healthy lifestyle, Aeroscan device.*

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1. Introduction

A healthy lifestyle provides insights into the behaviors that contribute to well-being in both adolescents and adults, as well as how these behaviors are positively or negatively influenced by nutrition, physical exercise, sleep patterns, and psychological balance. A healthy lifestyle is reflected not only through

[1] National University of Physical Education and Sport, Faculty of Physical Education and Sport, Bucharest, Romania, bausu_dan38@yahoo.com
[2] National University of Physical Education and Sport, Faculty of Physical Education and Sport, Bucharest, Romania, virgiltro@yahoo.com
[3] Baia Elementary School, Tulcea, scoala_baia@yahoo.com

observable actions and behaviors but also through psychological processes and experiences that can be assessed using scientific methods. It encompasses individual actions, group decisions, organizational strategies, and external factors that influence these decisions, including social changes, health-related policies, and programs aimed at improving quality of life.

Within the framework of this research, both theoretically and practically, we aim to compare the outcomes of traditional physical education programs with those incorporating both physical and mental education strategies. The applicability of play-based activities in children's motor development has been well established, highlighting the importance of dynamic movement-based games and the enjoyment they bring to participants.

This topic holds significant interest for me, as I believe I can contribute to the improvement of the physical education system in middle school education. Since my admission to doctoral studies, I have gained a deeper understanding of the scientific complexity of this field and realized my potential to enhance the optimization of physical education lessons through the implementation of internationally recognized strategic games. Through this research, we seek to demonstrate that engaging in such structured play allows students to develop various cognitive skills, improve their ability to question and reflect, take on greater responsibility, adopt a healthier lifestyle, and enhance their socialization skills. Integrating elements from the International Baccalaureate Physical Education curriculum is expected to improve students' physical condition as well as their cognitive and emotional capabilities.

We consider it necessary to diversify the school curriculum by incorporating internationally recognized strategic games, which will enhance lesson density, increase student engagement, and modernize physical education classes. Modernizing physical education lessons involves revising instructional methods and techniques to improve the teaching process and facilitate student learning at the middle school level. Modern didactics, which focus on student-centered learning, are grounded in research on learning processes that have led to the development of contemporary educational theories.

In this context, we will attempt a novel approach to physical education, incorporating both qualitative and quantitative perspectives to ensure a more technical and strategic fulfillment of the educational objectives in middle school sports programs. The foundation of our research is the improvement of educational quality through the optimization of physical education lessons. The enjoyment of physical activity is a critical psychological factor influencing children's attitudes toward exercise. Alongside enjoyment, a child's sense of competence and confidence in their physical abilities plays an essential role in fostering a positive attitude toward physical activity.

A review of the literature, combined with my experience teaching physical education in middle schools, has led me to pursue this study, as I believe it can contribute to improving the quality of life for students. To prevent and combat childhood overweight and obesity from an early age—starting from primary school (ages 6-11) there should be structured programs in every school to educate students, parents, and teachers about the risks associated with these health conditions. One of the primary causes of childhood obesity is the lack of physical activity, coupled with unhealthy dietary habits. Through this study, we aim to present a comprehensive program for preventing and managing excess weight in middle school students.

The decision to pursue this research aligns with my professional experience in teaching physical education to middle school children, assessing their motor abilities, and maintaining a balance between physical and mental activity. The applicability of play-based approaches in children's motor activities has been demonstrated, particularly through dynamic movement games that bring enjoyment to participants.

The Role of Natural Products in Supporting a Healthy Lifestyle

In today's society, which places increasing emphasis on health and physical performance, the use of natural products has gained considerable attention, particularly among students and athletes. A well-balanced diet is essential for the healthy development of children and adolescents, and natural supplements rich in vitamins, minerals, proteins, and amino acids serve as an effective means of supporting these crucial processes. As modern life accelerates and academic and athletic demands intensify, requiring sustained energy and concentration, natural products have become essential for maintaining a healthy lifestyle.

Students are in a critical developmental stage, undergoing complex biological and physiological transformations that require proper nutrition to support growth, immunity, and cognitive performance. Natural products help compensate for potential nutritional deficiencies, particularly for students engaged in intense physical activities or those following restrictive diets. A study conducted by Ackerman et al. (2020) found that student athletes frequently use natural products to sustain their energy levels and combat fatigue. Similarly, research by Firmasyah & Prasetya (2021) demonstrated that natural products are often used to address nutritional deficiencies caused by diet or rigorous training regimens.

Essential vitamins and minerals such as vitamin D, calcium, magnesium, and zinc play a crucial role in strengthening the skeletal system, reducing the risk of fractures, and ensuring harmonious physical development. Additionally, an optimal intake of proteins and amino acids promotes muscle synthesis, which is particularly important for student-athletes requiring rapid recovery after intense training sessions (Burke et al., 2020).

Beyond their effects on physical health, natural supplements significantly impact cognitive performance and emotional well-being. Certain B-complex vitamins and Omega-3 fatty acids have been linked to enhanced memory, improved concentration, and reduced stress—key factors for students facing demanding academic schedules and exams (Kathryn et al., 2020). For athletes of all ages, natural products have been shown to have a positive influence on endurance, physical performance, and recovery. Plant-based extracts and antioxidants help reduce muscle inflammation, while essential amino acids and proteins derived from natural sources contribute to tissue regeneration, optimizing post-exercise recovery (Ficarra et al., 2022).

The benefits of natural products extend beyond sports and physical education, offering significant implications for overall health and longevity. By maintaining metabolic balance, strengthening the immune system, and supporting cognitive functions, natural products contribute to the development of healthy adults capable of effectively managing the challenges of modern life. Studies indicate that the intelligent use of natural products supports younger generations in reaching their full potential, thus contributing to the formation of a healthier and more resilient society (Desbrow et al., 2020).

Metabolic Analysis Using the Aeroscan Device

An ergometer is a type of exercise machine that allows users to simulate movements they would naturally perform outside of the machine. It can take various forms, such as:

- Treadmill, which replicates walking or running.
- Cycle ergometer, which mimics cycling.
- Elliptical trainer.
- Rowing machine, which simulates rowing.

Ergometers are used for athletic training, physical fitness improvement, and stress testing in sports medicine. They are also beneficial when outdoor conditions are unfavorable (extreme temperatures, rain, winter, wind) to prevent injuries or for personal reasons such as convenience, cost, safety, and accessibility. To ensure optimal conditions, the ergometer should be placed in a well-ventilated room (with windows, a fan, or air conditioning). However, since they lack external environmental factors such as landscape variations, wind resistance, or terrain diversity, ergometers may feel monotonous for some users.

Typically, ergometers are equipped with sensors that measure user performance in real time, displaying data on a small screen. Many models offer adjustable resistance, allowing users to control workout intensity.

The Aeroscan Test: The Gold Standard for Energy Metabolism Analysis

The Aeroscan test is considered the "gold standard" for diagnosing energy metabolism during physical activity. It provides real-time data on the type of energy substrate the body is utilizing at any given moment, specifically the proportion of fats and carbohydrates burned.

The test can be performed on any cardio machine, depending on the type of training effort. It is commonly conducted on:

- Treadmills (for athletes, football players).
- Cycle ergometers (for cyclists).
- Both treadmill and cycle ergometer, depending on the study requirements.

This is a submaximal test, meaning it does not require the test subject to reach physical exhaustion. The testing duration is 15–20 minutes.

- Target Groups for the Aeroscan Test
- Individuals looking to lose weight – determines the optimal cardio intensity for maximum fat burning.
- Athletes – establish the precise training intensity based on individual goals, such as improving aerobic endurance, increasing tolerance in the mixed aerobic-anaerobic zone, or enhancing anaerobic training.
- Nutritionists – help professionals prescribe personalized diets based on clients' metabolic rates, both at rest and during exercise.
- Anyone seeking to optimize fat metabolism, which is essential for maintaining cardiovascular health.
- Endurance athletes – provides a scientific approach to structuring high-performance cardio training.
- Real-time substrate consumption data determines the exact percentage of lipids and carbohydrates burned during exercise.
- Precise caloric intake calculations for athletes – enable athletes to replace energy losses and maintain peak performance throughout an event.
- Optimized cardio workout planning helps athletes tailor the duration and intensity of their training sessions based on specific objectives.
- Eliminates inefficient training sessions – ensures that all exercise routines contribute positively to performance and health.
- Aeroscan Measurement Device

The Aeroscan device is commonly used for weight loss, cellulite reduction, and skin rejuvenation. Exercising with this equipment is comfortable and does not require excessive effort.

Its main benefits include:

- Fat tissue and muscle warming, which stimulates metabolism and improves blood circulation.
- Enhanced calorie burning during physical activity, promoting weight loss.
- Experimental Group Testing Procedure (40 Students)

For our study, the experimental group was tested using the following procedure:

1. Each student was fitted with a heart rate monitoring belt to track real-time cardiac activity.
2. Students pedaled at a constant speed of at least 24 km/h.
3. The device displayed the following parameters:
    - Oxygen consumption
    - Metabolic rate
    - Heart rate

This data was used to assess the impact of natural product supplementation on physical performance and metabolic efficiency.

Aggregated Effort Levels Statistics

In this study, data obtained from the Aeroscan® apparatus measurements were analyzed. This device consists of an exercise bike, an air tube inserted into the subject's mouth, and a heartbeat sensor. The apparatus allows for different levels of difficulty by adjusting pedaling resistance.

During testing, the subject exchanges respiratory gases (O_2 and CO_2) through the air tube, enabling the measurement of both individual gas volumes and total air exchange. Below are the key physiological parameters recorded by the device, classified into primary and derived indicators:

Primary Parameters

1. Respiratory rate (breaths/min) – Measures the volume of air inhaled or exhaled per minute, a key indicator of pulmonary function during exercise.
2. Heart rate (beats/min) – The number of heart beats per minute (bpm).
3. Ventilation (l/min) – Minute ventilation, representing the total volume of air exchanged in one minute.
4. O_2 intake (l/min) – The amount of oxygen consumed per minute, an indicator of aerobic capacity.
5. CO_2 expired (l/min) – The volume of carbon dioxide exhaled per minute, reflecting metabolic activity.

Derived Parameters

6. Relative O_2 intake (ml/kg/min) – Oxygen consumption relative to body weight, commonly used to compare individual fitness levels.
7. Relative CO_2 expired (ml/kg/min) – The amount of CO_2 exhaled per kilogram of body weight.
8. Respiratory exchange ratio (RER) – The ratio of CO_2 production (VCO_2) to O_2 consumption (VO_2), indicating the predominant energy source (carbohydrates vs. fat).
9. Ventilation oxygen equivalent (l) – The ratio of ventilation volume to oxygen intake (ventilation/O_2 intake), indicating breathing efficiency.
10. O_2 per pulse (l) – The amount of oxygen consumed per heartbeat (VO_2/heart rate), an indicator of cardiovascular efficiency.
11. Fat energy (kcal/h) – The amount of energy expended from fat during exercise.
12. Carbohydrates energy (kcal/h) – The amount of energy expended from carbohydrates during exercise.
13. Fat energy % – The percentage of total energy derived from fat.
14. Carbohydrates energy % – The percentage of total energy derived from carbohydrates.
15. Total energy (kcal/h) – The overall energy expenditure per hour.
16. Metabolic equivalent of task (MET, 3.5 ml/kg/min) – A measure of the energy cost of physical activities based on oxygen consumption. One MET is defined as 3.5 ml of O_2 per kilogram of body weight per minute, corresponding to resting metabolic rate.

Study Design and Testing Protocol

The study included 39 subjects, who were tested on the Aeroscan apparatus before and after the treatment. Initially, 40 subjects were enrolled, but one participant was excluded due to missing post-treatment data.

Each subject was tested at three effort levels, corresponding to different resistance settings on the device, measured in watts (W):

- Level 1: 50 W
- Level 2: 75 W
- Level 3: 100 W

Respiratory Exchange Ratio (RER) and Energy Source Utilization

A crucial parameter in this study is the Respiratory Exchange Ratio (RER), which is defined as the ratio of CO_2 production (VCO_2) to O_2 consumption (VO_2). The RER provides insights into which type of fuel—carbohydrates or fats—is predominantly used during exercise.

RER Value Interpretation

1. RER ≥ 1.0
   - Indicates predominant carbohydrate utilization.
   - Typically occurs during high-intensity exercise or anaerobic metabolism, where energy demands are met quickly by carbohydrates, leading to higher CO_2 production.
2. $0.7 \leq$ RER < 1.0
   - Suggests a mixed fuel utilization (carbohydrates and fats in equal proportions).
   - Commonly observed during moderate-intensity exercise, where the body efficiently utilizes both fuel sources.
3. RER < 0.7
   - Indicates a greater reliance on fat metabolism.
   - Typically seen during low- to moderate-intensity exercise or prolonged endurance activities, especially when glycogen stores become depleted.

A Respiratory Exchange Ratio (RER) value lower than approximately 0.7 suggests a greater reliance on fat metabolism for energy. While 0.7 is the approximate RER for palmitic acid, different fatty acids may exhibit slightly varying RER values depending on their chain length and oxidation characteristics.

Lower RER values are typically observed during low- to moderate-intensity exercise, where the body efficiently utilizes fat as the primary energy source through aerobic metabolism. This occurs particularly during prolonged exercise when glycogen stores become depleted, prompting the body to shift toward fat oxidation for sustained energy production.

By analyzing these physiological responses, this study aims to determine how different training intensities and natural supplementation influence energy metabolism and exercise efficiency in middle school students.

2. Methodology

Scope

This research section aims to conduct a statistical evaluation of middle school students' performance using an ergometric bicycle, both before and after the administration of natural supplements, in parallel with sports performance tests.

To compare the initial and final results, the following statistical methods were applied:

- Dependent t-test to assess significant differences between pre- and post-intervention data.
- Shapiro-Wilk test to verify the normality of data distribution.

Participants

The research was conducted in three rural secondary schools, involving students from middle school classes in rural areas.

The study group consisted of 40 healthy volunteers, both boys and girls, aged 11 and 12 years. The distribution of participants was as follows:

- 24 students from Baia Elementary School,
- 16 students from Jurilovca Elementary School, Tulcea County

The study duration was 12 months. During this period, students in the experimental group were administered one 500 mg Spirulina capsule and one Safflower Oil capsule daily for three months, followed by a one-month break (Cherian et al., 2020).

The study included two groups of students:

1. Experimental group – received natural products.
2. Control group – did not receive any natural products, but their data were measured at the same time intervals as the experimental group.

This study design allowed for a comparative analysis of physical and metabolic performance changes between the two groups.

Instruments

- Aeroscan Device and Ergometric Bicycle – Used to analyze energy metabolism through exhaled gases.
- Statistical Analyses:
  - ✓ Descriptive statistics
  - ✓ Shapiro-Wilk test

Procedure

- Written informed consent was obtained from all participating students.
- Participants had the option to withdraw from the study at any time.
- Measures were taken to ensure data confidentiality and comply with ethical research standards.

3. Results

In the following tables and graphs, we present descriptive statistics for the tested parameters. Given the large amount of data collected, we will display the aggregated (averaged) effort levels data.

For each parameter, the descriptive statistics also include the results of the Shapiro-Wilk test for normality. The null hypothesis of the Shapiro-Wilk test states that the tested data follows a normal distribution.

- If the test statistic is above 0.94 (for our sample size of 40 subjects) and the p-value is below 0.05, we reject the null hypothesis, indicating that the data is not normally distributed.
- This test is used to validate the normality assumption required for t-tests. However, given our relatively large sample size (N=40), the t-tests remain robust, even when data deviates from normality.

Descriptive Statistics

Table 1

Statistic	Time	Respiratory rate (breaths/min)	Heart rate (beats/min)	Ventilation (l/min)	Ventilation oxygen equivalent (l)	O2 per pulse (l)
N (Sample size)		40	40	40	40	40
df (Degrees of freedom)		39	39	39	39	39
Mean	initial	32.96	144	33.69	31.26	7.40
	final	27.92	133	26.58	27.32	7.32
Standard deviation	initial	9.43	18.74	10.89	7.01	1.92
	final	7.47	18.34	8.12	4.37	1.48
Variance	initial	88.83	351	119	49.08	3.70
	final	55.74	336	65.96	19.13	2.19
Kurtosis	initial	1.92	-0.01	-0.85	1.09	3.10
	final	0.33	-0.53	0.40	-0.05	-0.30
Skewness	initial	0.84	0.24	0.21	1.03	1.03

Statistic	Time	Respiratory rate (breaths/min)	Heart rate (beats/min)	Ventilation (l/min)	Ventilation oxygen equivalent (l)	O2 per pulse (l)
	final	0.72	-0.18	0.76	0.26	-0.06
Shapiro statistic	initial	0.95	0.99	0.97	0.93	0.91
	final	0.95	0.99	0.96	0.98	0.98
Shapiro p-value	initial	0.097	0.97	0.28	0.013	0.006
	final	0.12	0.9	0.14	0.57	0.85

Descriptive Statistics

Table 2

Statistic	Time	O2 intake (l/min)	Relative O2 intake (ml/kg/min)	CO2 expired (l/min)	Relative CO2 expired (ml/kg/min)	Respiratory exchange ratio
N (Sample size)		40	40	40	40	40
df (Degrees of freedom)		39	39	39	39	39
Mean	initial	1.07	16.15	1.16	17.48	1.07
	final	0.97	14.61	0.97	14.62	1.00
Standard deviation	initial	0.27	3.98	0.33	4.81	0.15
	final	0.22	2.90	0.26	3.40	0.11
Variance	initial	0.08	15.86	0.11	23.15	0.02
	final	0.05	8.44	0.07	11.58	0.01
Kurtosis	initial	0.44	-0.68	-0.52	-0.93	0.29
	final	0.24	-0.47	-0.26	-0.79	0.08
Skewness	initial	0.54	0.33	0.16	0.10	0.03

Statistic	Time	O2 intake (l/min)	Relative O2 intake (ml/kg/min)	CO2 expired (l/min)	Relative CO2 expired (ml/kg/min)	Respiratory exchange ratio
	final	0.67	0.13	0.46	0.06	0.48
Shapiro statistic	initial	0.96	0.97	0.97	0.97	0.99
	final	0.95	0.99	0.98	0.98	0.97
Shapiro p-value	initial	0.16	0.48	0.42	0.27	0.99
	final	0.1	0.96	0.59	0.75	0.29

Descriptive Statistics

Table 3

Statistic	Time	Respiratory exchange ratio	Fat energy (kcal/h)	Carbo-hydrates energy (kcal/h)	Total energy (kcal/h)	Metabolic equivalent of task (3.5ml/kg/min)
N (Sample size)		40	40	40	40	40
df (Degrees of freedom)		39	39	39	39	39
Mean	initial	1.07	24.58	298	322	4.61
	final	1.00	43.68	247	291	4.17
Standard deviation	initial	0.15	38.9	97	84	1.14
	final	0.11	44.45	85.11	67.13	0.83
Variance	initial	0.02	1513	9479	6997	1.29
	final	0.01	1976	7244	4507	0.69
Kurtosis	initial	0.29	1.49	-0.06	0.44	-0.68
	final	0.08	-0.03	0.01	0.27	-0.47

Statistic	Time	Respiratory exchange ratio	Fat energy (kcal/h)	Carbo-hydrates energy (kcal/h)	Total energy (kcal/h)	Metabolic equivalent of task (3.5ml/kg/min)
Skewness	initial	0.03	1.62	0.24	0.54	0.33
	final	0.48	0.94	0.17	0.68	0.13
Shapiro statistic	initial	0.99	0.69	0.98	0.96	0.97
	final	0.97	0.87	0.99	0.96	0.99
Shapiro p-value	initial	0.996	0	0.55	0.14	0.48
	final	0.29	0	0.95	0.14	0.96

Statistical Analysis: t-Tests for Treatment Effect Evaluation

To accurately quantify the differences between groups and test periods, we assessed the effect of treatment using t-tests.

Given that we anticipated both increases and decreases in the final measurements, we applied two-tailed t-tests at a significance level of 0.05.

- Paired (dependent) t-tests were conducted to compare pre-treatment and post-treatment measurements.
- A significant difference in these measurements would indicate a statistically significant effect of the treatment.

Levene's Test for Homogeneity of Variance

For each t-test, Levene’s test for equality of variances was performed as a reference measure. However, this test was not strictly necessary in our study because:

- Sample sizes are equal, making the t-tests robust, even in cases where variance differs significantly between groups.
- Levene's test assumes that the variances of the two compared groups are equal.
- If the Levene p-value is below 0.05, we reject the null hypothesis, indicating that the two groups have unequal variances.
- If the Levene p-value is above 0.05, we fail to reject the null hypothesis, suggesting equal variances between the groups.

This approach ensures a statistically sound evaluation of the treatment's impact on physical and metabolic performance.

t-Test Results

Table 4

	Respiratory rate (breaths/min)	Heart rate (beats/min)	Ventilation (l/min)
Significance level	0.05	0.05	0.05
Degrees of freedom	39	39	39
T critical (two-tailed)	2.02	2.02	2.02
T statistic	2.65	2.75	3.6
T test p-value (two-tailed)	0.012	0.009	0.001
Levene statistic	0.8	0	3.99
Levene p-value	0.37	0.96	0.049
Effect size (Cohen d)	0.59	0.58	0.74

t-Test Results

Table 5

	O2 intake (l/min)	Relative O2 intake (ml/kg/min)	CO2 expired (l/min)	Relative CO2 expired (ml/kg/min)
Significance level	0.05	0.05	0.05	0.05
Degrees of freedom	39	39	39	39
T critical (two-tailed)	2.02	2.02	2.02	2.02
T statistic	2.1	2.12	3.15	3.12
T test p-value (two-tailed)	0.042	0.041	0.003	0.003
Levene statistic	0.65	3.55	2.09	5.39
Levene p-value	0.42	0.06	0.15	0.02
Effect size (Cohen d)	0.4	0.44	0.63	0.69

t-Test Results

Table 6

	Respiratory exchange ratio	Ventilation oxygen equivalent (l)	O2 per pulse (l)
Significance level	0.05	0.05	0.05
Degrees of freedom	39	39	39
T critical (two-tailed)	2.02	2.02	2.02
T statistic	2.35	2.83	0.25
T test p-value (two-tailed)	0.024	0.007	0.804
Levene statistic	4.78	3.8	0.41
Levene p-value	0.03	0.055	0.53
Effect size (Cohen d)	0.55	0.67	0.05

t-Test Results

Table 7

	Fat energy (kcal/h)	Carbohydrates energy (kcal/h)	Total energy (kcal/h)	Metabolic equivalent of task (MET) (3.5ml/kg/min)
Significance level	0.05	0.05	0.05	0.05
Degrees of freedom	39	39	39	39
T critical (two-tailed)	2.02	2.02	2.02	2.02
T statistic	-2.07	2.67	2.18	2.12
T test p-value (two-tailed)	0.045	0.01	0.036	0.041
Levene statistic	1.47	0.4	0.64	3.55
Levene p-value	0.23	0.53	0.43	0.06
Effect size (Cohen d)	-0.46	0.56	0.42	0.44

Interpretation of t-Test Results

For respiratory rate, heart rate, and ventilation rate, the results of the t-tests indicate significant differences between pre- and post-treatment measurements:

- Respiratory rate and heart rate showed moderate effect sizes.
- The ventilation rate exhibited a larger effect size, suggesting a more substantial impact of the intervention on breathing efficiency.

For oxygen intake and relative oxygen intake, there were statistically significant differences, but these were close to the significance threshold and associated with small effect sizes.

The differences in exhaled carbon dioxide and relative exhaled carbon dioxide were more significant, with moderate effect sizes. This can be explained by:

1. A reduction in gas exchange requirements due to lower effort levels.
2. The shift from carbohydrate metabolism to fat metabolism, which produces less CO_2 per unit of oxygen consumed.

The respiratory exchange ratio (RER) and ventilation oxygen equivalent also showed statistically significant differences with moderate effect sizes. However, the oxygen per pulse parameter did not show a significant difference, suggesting no major impact on the cardiovascular efficiency per heartbeat.

For energy metabolism:

- Fat energy consumption, total energy consumption, and metabolic equivalent of task (MET) exhibited significant but borderline differences, each with small to moderate effect sizes.
- Carbohydrate energy consumption, however, showed a more significant difference, with a moderate but larger effect size, indicating a greater impact of the treatment on carbohydrate metabolism.

3. Conclusion

The statistical analysis suggests that the treatment had a measurable impact on key physiological parameters, particularly those related to ventilation efficiency, CO_2 exchange, and carbohydrate metabolism, while oxygen per pulse remained unchanged. The observed effects support the idea that natural products may influence energy metabolism and respiratory efficiency, but the magnitude of these effects varies across different physiological parameters.

The results indicate that for the three analyzed parameters (heart rate, respiratory exchange ratio, and carbohydrate consumption), there were significant differences between initial and final measurements after the use of natural products.

- The strongest effect was observed in heart rate ($F = 23.53$), where supplementation had a greater impact than effort level changes.
- Effort levels also showed significant differences, but these were close to the significance threshold, with much smaller variations between effort levels compared to the impact of supplements.
- The largest difference between effort levels was observed in the CO_2/O_2 ratio ($F = 5.057$, $p = 0.026$), indicating metabolic shifts between lipid and carbohydrate utilization. However, even in this case, the effect of natural products was stronger ($F = 13.386$, $p = 0.00035$).
- Interaction effects between treatment (natural products) and effort level were not significant.

Key Takeaways

- Natural products significantly improve endurance and energy metabolism efficiency.
- Energy resource utilization and adaptation to effort are more strongly influenced by natural products than by changes in effort level alone.

Metabolic Adaptations

The treatment had a visible and significant impact on Aeroscan measurement parameters, leading to:

1. Reduced effort and energy expenditure for the same physical tasks after supplementation.
2. More efficient gas exchange, particularly lower CO_2 exhalation, reflecting a shift toward better metabolic efficiency.
3. Respiratory Exchange Ratio (RER) improvements, demonstrating a transition from carbohydrate metabolism to fat metabolism, reducing reliance on rapid-burning carbohydrate energy.
4. Carbohydrate energy consumption serves as the most stable metabolic indicator, as it consistently remains non-zero, whereas fat energy consumption depends on RER values below 1.0.

Final Conclusion

The use of natural supplements significantly enhances exercise endurance and metabolic adaptation, leading to lower cardiovascular strain, optimized energy use, and improved respiratory efficiency. The findings suggest that natural products plays a more crucial role than effort level alone in enhancing performance and energy metabolism efficiency.

Informed Consent Statement: Written informed consent for the athletes' participation in the study was obtained.

Data Availability Statement: Data are available upon request from the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

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