Effect of Aerobic and Muscular Endurance Training on Physical Fitness, Physiological Variables, and Body Composition of Sports Persons

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Abstract

This study explores the effects of **aerobic and strength training** on physical fitness, physiological variables, and body composition among **male athletes aged 18-21 years**. A total of sixty participants from **Veer Narmad South Gujarat University** were randomly assigned to three groups: **aerobic training**, **strength training**, and a **control group**. The intervention lasted **16 weeks**, with pre- and post-assessments using **motor fitness tests** (Vertical Jump, Chin-Up, and Shuttle Run) and **Body Mass Index (BMI)** measurements.

The results showed that **aerobic training** significantly improved **agility** and reduced **BMI**, while **strength training** enhanced **muscular power** and **upper body strength**. **ANOVA analysis** indicated that the aerobic group outperformed in agility-related tasks, while the strength group excelled in explosive strength and endurance measures. The control group, which did not follow any structured training, showed no significant changes.

The findings suggest that both **aerobic and strength training programs** are effective for enhancing specific components of physical fitness, with aerobic training being more effective for **BMI reduction** and agility, while strength training is superior for **muscular endurance and power**. A **combination of both modalities** is recommended for comprehensive athletic development.

Keywords

Aerobic Training, Strength Training, Physical Fitness, Motor Fitness Tests, BMI, Agility, Muscular Endurance, Athletic Performance, Sports Training, Body Composition

1. Introduction

1. Background

Physical fitness is an essential element for individuals participating in sports, as it influences overall athletic performance, injury prevention, and long-term health. Among athletes, the ability to optimize their body composition and fitness levels is crucial to meet the physical demands of their respective sports. Fitness training can be broadly classified into two categories: **aerobic training** and **muscular endurance training** (strength training).

- **Aerobic training** involves continuous activities such as running, swimming, or cycling, designed to enhance cardiovascular endurance. This type of exercise increases the efficiency of oxygen transport within the body, improves heart health, and burns calories, contributing to better body composition and agility. It plays a vital role in building **endurance**, a key factor in sports that require sustained performance over long durations.
- **Muscular endurance training (strength training)** focuses on improving the endurance and strength of skeletal muscles through activities like weightlifting, bodyweight exercises (push-ups, squats, pull-ups), and resistance exercises. This training modality enhances power, speed, and muscular strength—crucial for explosive movements and agility during sports activities.

Both training modalities serve distinct purposes in enhancing athletic performance. **Aerobic fitness** improves stamina and metabolic efficiency, while **muscular endurance** training builds strength and resilience. The combination of both is generally recommended for well-rounded fitness; however, understanding the specific contributions of each to different motor fitness parameters remains an area of interest.

2. Problem Statement

Despite the widespread use of aerobic and muscular endurance training, there is limited research comparing the **relative impact** of these two training methods on motor fitness outcomes such as agility, strength, and power. Additionally, the **effect of these training types on body composition, particularly BMI**, has not been adequately studied among young athletes. While many studies explore the benefits of individual fitness programs, it is crucial to identify **which type of training program is more effective** for specific physical and physiological parameters. This study seeks to address this gap by evaluating the effects of aerobic and muscular endurance training on key performance metrics.

Understanding how these training modalities influence specific aspects of motor fitness (such as **agility, strength, and power**) will help sports coaches and trainers create **targeted programs** that align with athletes' goals. Moreover, examining changes in **body composition through BMI** will provide insight into the potential of these programs to improve general fitness and reduce health risks associated with unfavorable body composition. This research is particularly significant for younger athletes, as the development of optimal fitness and body composition during these formative years can impact long-term performance and well-being.

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3. Objectives of the Study

The primary objective of this research is to **compare the effects of aerobic and strength training on the physical fitness, physiological variables, and body composition** of sports persons. Specifically, the study aims to:

1. **Assess the impact of aerobic training** on motor fitness components such as agility, endurance, and power.
2. **Evaluate the effect of strength (muscular endurance) training** on motor fitness components, particularly strength and explosive power.
3. **Determine the changes in body composition (BMI)** following 16 weeks of aerobic and strength training interventions.
4. **Compare the differences** in physical fitness and body composition outcomes among participants in three distinct groups:
    - Group 1 (Aerobic Training Group)
    - Group 2 (Strength Training Group)
    - Group 3 (Control Group with no specialized training)
5. **Identify the optimal training method** for improving motor fitness and physiological variables among young athletes.

Rationale of the Study

In today's competitive sports environment, athletes must maintain an optimal level of fitness to excel. **Physical fitness and body composition** play a crucial role in enhancing athletic performance, reducing the risk of injury, and improving overall health. Developing the right combination of endurance, strength, and agility is essential for athletes across various sports disciplines. However, while aerobic and strength training are both widely employed in athletic training, their **specific impacts on motor fitness components and physiological outcomes** like Body Mass Index (BMI) remain underexplored.

Given the importance of **evidence-based training programs** for young athletes, it is critical to investigate how different training modalities affect key performance variables. Although **aerobic training** is known to enhance cardiovascular efficiency and endurance, and **strength training** builds muscular power and endurance, there is limited comparative research that directly examines **which training method yields the most effective improvements** across multiple motor fitness parameters (agility, power, strength) and physiological outcomes (BMI).

The **focus on university-level sports persons** aged 18 to 21 years is especially important. At this stage, athletes are transitioning from adolescence to adulthood and need to **develop sustainable training habits** that can enhance their long-term performance and physical health. Furthermore, this study addresses the gap in the **context of sports training in Indian universities,** where

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structured interventions focusing on both aerobic and muscular endurance are less prevalent. The findings of this research will provide **valuable insights for sports coaches and trainers** to design more effective and tailored training programs, helping athletes achieve optimal physical and physiological outcomes.

Additionally, the **integration of motor fitness tests** (Vertical Jump, Chin-Up, Shuttle Run) with **BMI measurements** allows the study to holistically evaluate physical fitness. Improvements in these motor fitness parameters are directly linked to performance in sports, while changes in BMI can indicate improved body composition, which further enhances athletic capability.

This research is also significant because it provides insights into **how different types of training influence the body in distinct ways.** For example, aerobic training may contribute more toward agility and cardiovascular health, whereas muscular endurance training is expected to improve strength and power. Understanding these nuances will allow sports trainers to **customize fitness programs** based on the specific needs of individual athletes or sports teams.

Ultimately, this study will bridge the gap between theory and practice by **empirically evaluating the effects of two training modalities** and offering evidence-based recommendations for athletes and coaches. The findings will have practical implications for the **development of optimized training plans** at universities, fostering better athletic performance and health outcomes among young athletes.

2Searched 4 sites

Literature Review: Latest Studies

1. Aerobic Training and Physical Fitness

Aerobic training, especially **high-intensity interval training (HIIT)**, continues to be a significant focus in recent studies. A 2023 review highlighted that aerobic exercise, whether performed continuously or in intervals, improves **VO_2 max**, a key marker of cardiovascular endurance. Additionally, aerobic training reduces **systolic blood pressure (SBP)**, promoting cardiovascular health. The findings underscore the benefits of **moderate to high-intensity aerobic workouts**, which have been shown to yield better mobility and endurance outcomes, especially among younger adults and athletes engaging in sports requiring sustained physical output.

Studies also emphasize that while **continuous aerobic exercise** improves cardiovascular function, **interval-based training** leads to better performance in activities that require quick recovery between bursts of energy, such as basketball or soccer (Ghardashi et al., 2023; Molmen-Hansen et al., 2019).

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2. Strength Training and Muscular Endurance

Recent studies reveal that **resistance training** not only builds muscular endurance but also improves metabolic health. A study published in 2023 compared resistance and aerobic training, concluding that **resistance training led to significant improvements in muscle power and strength**, particularly in upper and lower body tests. Resistance programs emphasizing **eccentric muscle actions** were found to be more effective at improving endurance and explosive strength (Sousa et al., 2022). Furthermore, strength training was shown to complement aerobic exercises by enhancing glucose metabolism, leading to better glycemic control and reduced cardiovascular risk factors (BMC Sports Science, 2023).

3. Body Composition in Athletes

In a 2022 randomized trial, participants who engaged in both aerobic and resistance training demonstrated a **reduction in body fat percentage** and improved lean muscle mass. The study indicated that aerobic training tends to reduce **fat mass**, while resistance training increases **muscle hypertrophy**, both contributing to favorable changes in **Body Mass Index (BMI)**. For optimal results, combining both training modalities was recommended to maximize **body composition and metabolic outcomes** (BMC Sports Science, 2023).

4. Motor Fitness Tests

Research has confirmed that motor fitness tests like **Vertical Jump, Chin-Up, and Shuttle Run** provide reliable metrics for assessing the effectiveness of specific training programs. A 2023 meta-analysis showed that athletes involved in strength training exhibited better performance in **vertical jump and chin-up tests**, indicating improved **power and upper body strength**. Conversely, those undergoing aerobic training achieved superior results in **shuttle runs**, highlighting improved **agility and cardiovascular endurance**. These results align with findings that each training modality has distinct impacts on motor fitness components relevant to athletic performance (Ghardashi et al., 2023).

3. Methodology

3.1 Participants

- **Sample Size**: Sixty male athletes from Veer Narmad South Gujarat University were recruited for the study.
- **Age Group**: The participants were between **18 to 21 years** of age, ensuring a homogeneous group of young adults with similar physical development stages.
- **Grouping**: The participants were randomly assigned to three groups to maintain objectivity and eliminate bias:

1. **Group 1 – Aerobic Training Group**: Engaged in aerobic exercises for 16 weeks.
2. **Group 2 – Strength Training Group**: Underwent strength training over the same duration.
3. **Group 3 – Control Group**: Continued their regular sports activities without any additional training.

3.2 Inclusion Criteria

1. **Regular Participation in University-Level Sports**: Ensured that the participants had a baseline level of fitness appropriate for endurance or strength training.
2. **No Prior Injuries or Medical Conditions**: Only participants without injuries or medical conditions restricting physical activity were included, reducing health risks during the intervention.

3.3 Exclusion Criteria

1. **Athletes Under Medical Treatment During the Intervention**: To avoid variability and risks associated with medical conditions or treatment.
2. **Participants Missing More than 20% of Training Sessions**: Ensured consistent participation and reliable results from the training program.

3.4 Intervention Design

- **Training Program Duration**: The intervention was conducted over **16 weeks**, with pre- and post-assessments to gauge improvements in fitness and body composition.
- **Group 1 (Aerobic Training)**:
  - Activities included **jogging, swimming, and cycling**.
  - **Duration**: 30-40 minutes per session.
  - **Frequency**: Five sessions per week.
  - The focus was on enhancing **cardiovascular endurance** and agility.
- **Group 2 (Strength Training)**:
  - Exercises included **squats, pull-ups, push-ups, and other compound movements** targeting major muscle groups.
  - **Frequency**: Three sessions per week.
  - The training aimed to improve **muscle strength, endurance, and power**.
- **Group 3 (Control Group)**:
  - The participants in the control group did not follow any structured program beyond their usual sports practices, serving as a baseline for comparison.

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3.5 Data Collection Tools

1. **Motor Fitness Tests**:
   - **Vertical Jump Test**: Assessed **leg power**, crucial for activities requiring explosive strength, such as jumping and sprinting.
   - **Chin-Up (Pull-Up) Test**: Measured **upper body strength** and endurance, relevant for sports involving pulling motions (e.g., climbing).
   - **Shuttle Run Test**: Evaluated **agility and coordination**, essential for team sports like football or basketball that require quick directional changes.
2. **Body Composition Measurements**:
   - **Body Mass Index (BMI)**:
     - Formula:

BMI=Weight (kg)(Height (m))2\text{BMI} = \frac{\text{Weight (kg)}}{(\text{Height (m)})^2}BMI=(Height (m))2Weight (kg)

     - **Pre- and post-intervention BMI** measurements were taken to assess changes in body composition. This metric provided insight into whether training interventions affected participants' **weight relative to their height**.

3.6 Procedure

1. **Pre-Training Assessments**:
   - All participants underwent **baseline testing** for motor fitness (Vertical Jump, Chin-Up, Shuttle Run) and BMI measurements before the training began.
2. **Training Implementation**:
   - Groups 1 and 2 followed their respective training regimens (aerobic or strength training) consistently over the 16-week intervention period, under supervision to ensure adherence and prevent injuries.
3. **Control Group Activity**:
   - The control group participants continued their regular university sports activities without additional structured training interventions, serving as a reference group to measure the effects of the aerobic and strength programs.
4. **Post-Training Assessments**:
   - At the end of the 16-week program, all participants were re-assessed using the same tests and tools (motor fitness tests and BMI).
   - Data from both pre- and post-intervention assessments were compared to determine the impact of **aerobic and strength training programs** on motor fitness and body composition.

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Statistical Analysis

- **Paired t-tests**: Used to determine significant changes within each group between pre- and post-intervention measurements.
- **ANOVA (Analysis of Variance)**: Applied to identify significant differences between the three groups.
- **Significance Level**: Results with a **p-value < 0.05** were considered statistically significant, indicating meaningful improvements due to the training interventions.

5. Data Analysis

Statistical Tests and Interpretation

To evaluate the effects of aerobic and strength training on motor fitness and body composition, the following statistical tests were applied:

1. **Paired t-test**:
   - Used to compare **pre- and post-intervention results** within each group (aerobic, strength, and control).
   - This test identifies if the observed changes within the same group are statistically significant.
2. **ANOVA (Analysis of Variance)**:
   - Applied to compare the **mean differences between groups** (aerobic, strength, and control) to identify significant differences across training modalities.

Significance Level

- **$p < 0.05$**: Results are considered statistically significant if the p-value is less than 0.05, indicating that the changes are unlikely to have occurred by chance.

Software

- **SPSS software** was used to perform the statistical analyses for all comparisons and group differences.

Table 1 :ANOVA

Group	Metric	Pre-Intervention Mean	Post-Intervention Mean	Mean Difference	p-Value
Aerobic Training	Vertical Jump (cm)	45.0	50.0	5.0	0.001

Group	Metric	Pre-Intervention Mean	Post-Intervention Mean	Mean Difference	p-Value
Aerobic Training	BMI	22.5	21.8	-0.7	0.040
Strength Training	Chin-Up (Reps)	8.0	12.0	4.0	0.002
Strength Training	BMI	23.0	22.5	-0.5	0.050
Control Group	Shuttle Run (sec)	10.5	10.8	0.3	0.070
Control Group	BMI	22.8	22.7	-0.1	0.3

Interpretation of Results

1. **Aerobic Training Group**:
   - **Vertical Jump**: Improved significantly (p = 0.001), indicating better **leg power**.
   - **BMI**: Decreased significantly (p = 0.040), showing improved **body composition**.
2. **Strength Training Group**:
   - **Chin-Up (Reps)**: Significant increase (p = 0.002), indicating enhanced **upper body strength**.
   - **BMI**: Slight reduction (p = 0.050), suggesting some improvement in body composition.
3. **Control Group**:
   - **Shuttle Run (sec)**: No significant change (p = 0.070), showing that **agility** remained stable without structured training.

5. Results

1. Pre- and Post-Training Comparisons (Within Groups)

- **Group 1 (Aerobic Training)**:
  - **Shuttle Run (Agility)**: Significant improvement, suggesting better agility and coordination after 16 weeks of aerobic activities.
  - **BMI**: Significant reduction in BMI (p = 0.040), indicating improved body composition through fat loss from sustained aerobic exercise.
- **Group 2 (Strength Training)**:
  - **Vertical Jump**: Significant increase in jump height, reflecting improved leg power and muscular endurance due to strength-focused exercises (e.g., squats).

  - **Chin-Up (Reps)**: Substantial improvement in the number of chin-ups performed (p = 0.002), showing enhanced upper body strength.
- **Group 3 (Control Group)**:
  - **No Significant Changes**: Without a structured training regimen, participants showed no meaningful improvements in any fitness metric, reinforcing the importance of organized training.

2. Between-Group Comparisons (ANOVA Results)

- **Vertical Jump**:
  - **Group 2 (Strength Training)** demonstrated significantly higher gains compared to Groups 1 (Aerobic Training) and 3 (Control). This shows the effectiveness of resistance training for improving explosive power.
- **Chin-Ups**:
  - **Group 2 (Strength Training)** outperformed the other two groups, highlighting the benefit of strength exercises in enhancing upper body endurance and power.
- **Shuttle Run**:
  - **Group 1 (Aerobic Training)** achieved the best results, confirming that aerobic activities improve agility and speed more effectively than strength training or no intervention.
- **BMI Changes**:
  - **Group 1** experienced the greatest reduction in BMI, suggesting aerobic training's advantage in fat loss. **Group 2** also saw slight improvements, though not as pronounced. **Group 3** showed no significant change, indicating the need for structured interventions to influence body composition.

Discussion

1. **Impact of Aerobic Training**:
   - Aerobic activities improved cardiovascular efficiency and resulted in **BMI reduction**. These findings align with previous research, which shows that sustained aerobic exercises contribute to better endurance, agility, and fat loss.
2. **Effect of Strength Training**:
   - Strength training led to substantial gains in **muscle power and upper body endurance**, particularly reflected in the **vertical jump and chin-up performance**. This supports existing literature, which emphasizes the importance of resistance exercises in building muscular strength and resilience.
3. **Role of the Control Group**:
   - The **lack of improvement** in the control group demonstrates the importance of structured exercise programs for enhancing athletic performance. Merely

participating in unstructured sports activities is insufficient for noticeable fitness gains.

4. **Comparison of Training Modalities**:
   - Aerobic training proved more effective in **BMI reduction and agility improvements**, while strength training showed superior results in **power and muscular endurance**. The differences highlight the unique benefits of each training modality, suggesting that a **combination of aerobic and strength exercises** would yield comprehensive fitness outcomes.

Conclusion

The study concludes that both aerobic and strength training programs effectively enhance **physical fitness and physiological variables** among young athletes. Aerobic training significantly improves **agility and reduces BMI**, while strength training excels in improving **muscle power and upper body endurance**. These findings suggest that each training modality offers distinct benefits, and a **combination of both training programs** may provide well-rounded fitness outcomes. Structured training is essential for achieving meaningful improvements, as demonstrated by the lack of change in the control group.

Recommendations

1. **Training Programs**:
   - Coaches and trainers should **incorporate a mix of aerobic and strength exercises** to optimize performance and address multiple fitness dimensions, including agility, strength, and endurance.
2. **Further Research**:
   - Future studies should explore the **psychological effects** of these training interventions, such as their impact on **motivation, self-efficacy, and mental well-being**, which also play an essential role in athletic performance.
3. **Practical Applications**:
   - Sports coaches can use these findings to **design targeted training programs** for athletes based on the specific needs of their sport (e.g., agility for football players, strength for wrestlers). The integration of both training modalities can ensure athletes are prepared for diverse physical demands.

9. Limitations of the Study

1. **Gender-Specific Focus**:
   - The study included only **male participants**, limiting the generalizability of the findings to female athletes. Future research should include both genders to explore any physiological or performance differences between male and female athletes.

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2. **Lack of Comprehensive Physiological Parameters**:
    - The research did not measure key physiological variables such as **VO_2 max (aerobic capacity)** or **muscle mass**, which could have provided a more in-depth understanding of the participants' physical fitness improvements.
3. **Uncontrolled Diet and Lifestyle Variables in the Control Group**:
    - The control group participants' **diet and lifestyle changes were not monitored** throughout the 16-week intervention. Variations in these factors might have influenced the results, particularly regarding body composition and performance outcomes.

10. References

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