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Impact of Resistance Training on Physical Fitness Parameters: A Study of Body Composition and Energy Balance

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Abstract

This study aims to analyze the impact of resistance training on physical fitness parameters, especially on body composition and energy balance. The subjects in this study were students of the Department of Physical Education, Health and Recreation (PEHR), Universitas Negeri Makassar (UNM) who participated in a resistance training program for eight weeks, with a training frequency of three times per week. The method used was a quasi-experiment with a single group pretest-posttest design. Body composition measurements were carried out through analysis of body fat percentage, muscle mass, and body mass index (BMI), while energy balance was calculated based on estimates of daily energy intake and energy expenditure. The results showed a significant increase in muscle mass and a decrease in body fat percentage after resistance training intervention ($p < 0.05$). In addition, there was an improvement in energy balance, which was indicated by dietary adjustments and increased energy expenditure due to physical activity. These findings indicate that resistance training contributes positively to improving body composition and managing energy balance, which are important indicators of physical fitness. This study recommends the integration of resistance training into student fitness programs as a strategy to improve health and physical performance.

Keywords: *Endurance Training, Body Composition, Energy Balance, Physical Fitness.*

INTRODUCTION

Physical Fitness is one of the important aspects in supporting physical performance, endurance, and individual productivity, especially for students of PEHR UNM who are required to have prime physical condition as a form of representation of the profession and sports competence they are pursuing. However, in reality, some students still face challenges in maintaining optimal physical fitness due to the density of academic activities, lack of structured exercise patterns, and a less active lifestyle. In addition, the lack of intrinsic motivation to exercise regularly, as well as social and psychological pressures are also factors that weaken physical fitness.

Two important indicators that represent the physiological status of physical fitness are body composition and energy balance. Body composition includes the proportion of muscle mass to body fat. Research shows that ideal body composition, which is characterized by a high proportion of muscle mass and low body fat levels, contributes significantly to physical performance and endurance. For example, research by Kochman

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et al. showed that the relationship between physical fitness and muscle mass is indicated by higher levels of fat-free mass in individuals with better fitness, as well as a balanced ratio in body composition (Kochman et al., 2022). In addition, Ali and Sarkar emphasized the importance of body composition in measuring physical fitness, showing significant differences in physical fitness and body composition among college students (Ali & Sarkar, 2024).

Energy balance, which is the ratio between energy intake from food and energy expenditure through activity, is also an important factor in maintaining overall health. Persistent energy imbalance can lead to various health problems, including increased body fat or decreased muscle mass. Good energy balance is positively associated with physical fitness, especially in children with varying degrees of obesity (Lee et al., 2022). Poor energy balance, on the other hand, can result in the risk of obesity and other health conditions, as discussed in a study by Liao et al., which showed that obesity was closely associated with low physical fitness among adolescents (Liao et al., 2013).

Body composition and energy balance serve as key indicators in assessing and maintaining physical fitness. Maintaining an optimal body composition ratio and proper energy balance is essential for long-term health and improving quality of life. Therefore, it is important to educate the public on ways to achieve and maintain a healthy physical condition obtained through a balanced diet and adequate physical activity (Ardi et al., 2023). Resistance training has been shown to be significantly effective in improving body composition and supporting energy balance regulation. The inclusion of resistance training in a fitness program can result in increased muscle mass and decreased body fat proportions, both of which contribute to increased basal energy expenditure (Strasser et al., 2012) With increased muscle mass, individuals not only gain a better physical appearance but also a more active body metabolism, which plays an important role in maintaining a healthy energy balance (Kelley et al., 2023). The right balance between healthy body composition and optimal energy balance will support PEHR students in achieving physical fitness, better learning capacity, and maximum performance in sports activities.

Research shows that resistance training has positive effects not only on body composition, but also on overall physical fitness parameters. In the context of patients with various health conditions, resistance training has shown significant improvements in muscle strength and balance, which also have a positive impact on their quality of life (Chung et al., 2016; Corcos et al., 2013; Schlenstedt et al., 2015). A study by Corcos et al. showed that resistance training interventions can improve muscle strength and movement speed, as well as reduce the risk of falls in individuals with Parkinson's (Corcos et al., 2013).

A study by Kelley et al. emphasized that although resistance training does not always change body weight directly, the changes in body composition that occur, namely increased muscle mass, have a major impact on health risks associated with obesity and metabolic diseases (Kelley et al., 2023). In addition, resistance training can also contribute to improved sports performance, where better muscle strength is associated with higher athletic ability, given the positive interaction between strength and other fitness components (Li et al., 2023). Therefore, training programs should systematically consider the integration of resistance training to achieve optimal results. Research shows that an integrated approach will increase the efficiency of training programs and allow individuals to achieve desired health and fitness outcomes in a more effective and efficient manner (Mahoney et al., 2023; Xiao et al., 2021).

Resistance training is an important element in training programs that contributes to changes in body composition, including increased muscle mass. Resistance training does not always significantly change body weight, changes in body composition that occur can reduce health risks related to obesity and metabolic diseases and weight loss is not always immediately visible, the results of increased muscle mass have positive implications for long-term health (Haider et al., 2018; Zdzieblik et al., 2015). Resistance training has also been shown to optimize sports performance. In a study conducted by Granacher and Behm, it was found that better muscle strength due to resistance training is closely related to improvements in other athletic abilities, thanks to the positive interaction between strength and fitness components such as coordination, agility, and endurance (Granacher & Behm, 2023).

Physiological impact on muscle metabolism, specifically regarding the stimulation of muscle protein synthesis via the mechanistic target of rapamycin (mTOR) signaling pathway. This activation causes muscle hypertrophy and contributes to increased lean body mass. Increased muscle mass has been shown to increase basal metabolic rate (BMR), allowing for increased caloric expenditure even at rest, which is essential for maintaining a healthy body composition without requiring significant weight loss (Larson-Meyer et al., 2010).

In addition, the benefits of resistance training go beyond muscle growth. Resistance training has been shown to improve insulin sensitivity and aid in glycemic regulation, which plays a key role in the prevention of metabolic diseases such as type 2 diabetes (Buxton et al., 2012; Yagi et al., 2014). Increased insulin sensitivity can be associated with increased muscle mass, which serves as a major site of glucose disposal. The resulting improvement in glucose metabolism is particularly important given the increasing prevalence of metabolic syndrome globally (Scudiero et al., 2020).

However, studies that specifically examine the impact of resistance training on physical fitness parameters, especially those involving physiological variables such as body composition and energy balance, are still limited. Therefore, this study aims to evaluate the impact of resistance training programs on changes in body composition and energy balance as physical fitness parameters in the Department of PEHR UNM. The results of this study can be used as a basis for developing scientific-based training programs that are relevant to the needs and characteristics of sports students.

METHODS

This study used a quantitative approach with a quasi-experimental method and a one-group pretest-posttest design. This design was chosen to observe changes that occurred before and after resistance training interventions on students' physical fitness parameters.

Research Subjects

The subjects of the study were active students from the Department of PEHR at UNM who met the inclusion criteria: aged 18–22 years, in good health, not participating in any other intensive training programs, and willing to follow the prescribed training program for eight weeks. In addition, participants were required to have a moderate level of physical fitness and basic experience in physical exercise, ensuring familiarity with movement techniques and reducing injury risk during resistance training. A total of 20 subjects were selected using purposive sampling, a method chosen to ensure that participants possessed specific characteristics relevant to the study’s objectives. This sampling approach was intended to control variability, target individuals with appropriate

training backgrounds, and enhance the internal validity of the intervention by selecting participants most likely to respond consistently to the resistance training protocol.

Research Procedure

The study was conducted over a period of 8 weeks, with a training frequency of 3 sessions per week. The resistance training program consisted of bodyweight exercises, resistance bands, and dumbbells, incorporating variations such as squats, push-ups, lunges, planks, and rows. Each training session lasted approximately 45–60 minutes, including a 10-minute dynamic warm-up and a 5–10-minute cool-down with static stretching. The main session was structured using moderate intensity, set at 60–70% of one-repetition maximum (1-RM) or corresponding to a Rate of Perceived Exertion (RPE) of 6–7 on a 10-point scale. Each exercise was performed in 3 sets of 10–15 repetitions. Rest periods were standardized to 60–90 seconds between sets and 90–120 seconds between different exercises to allow partial recovery while maintaining cardiovascular and muscular engagement.

Data Collection Instruments and Techniques

1. Body Composition: The composition of the body, including body fat percentage, muscle mass, and body mass index (BMI), was measured using a bioelectrical impedance analysis (BIA) device.
2. Energy Balance: Energy balance was assessed by calculating the difference between estimated daily energy intake and total energy expenditure.
   a. *Energy intake* was estimated using a 24-hour food recall conducted over three consecutive days (including one weekend day) and analyzed using NutriSurvey 2007 software to determine daily caloric and macronutrient intake.
   b. *Energy expenditure* was calculated by combining estimated Basal Metabolic Rate (BMR)—derived using the Harris-Benedict Equation—with activity-related energy expenditure. Physical activity levels were assessed using a daily activity log and checklist, adapted from the Compendium of Physical Activities (Ainsworth et al., 2011) which includes estimated MET values (Metabolic Equivalent of Task) for various daily and exercise-related activities.
   c. A Physical Activity Level (PAL) multiplier was applied to BMR to estimate Total Energy Expenditure (TEE). Based on participants' reported activity patterns, a moderate activity level (PAL = 1.6–1.75) was used for most individuals.

3. Supporting Parameters: Height and weight were measured using a stadiometer and digital scales, recorded to the nearest 0.1 cm and 0.1 kg, respectively, to support calculations of BMI and validate BIA input accuracy.

Data Analysis

Data were analyzed using descriptive and inferential statistics with the help of IBM SPSS Statistics version 25. Normality tests were performed using the Shapiro-Wilk test. To determine the difference between pretest and posttest values, a paired sample t-test was used for normally distributed data, while the Wilcoxon signed-rank test was applied for non-normally distributed data. The significance level was set at $\alpha = 0.05$.

RESULTS

This study was conducted on 20 students from Department of PEHR UNM who participated in an 8-week endurance training program. Measurement data included body composition (percentage of body fat, muscle mass, and BMI) and energy balance before and after the training program. The complete results are presented as follows:

Body Composition

The results of the study showed that resistance training had a positive impact on students' body composition. There was a significant decrease in body fat percentage and body mass index (BMI), accompanied by a significant increase in muscle mass. More details can be seen in the following table:

Table 1. Average Body Composition Before and After Exercise

Variables	Pretest (Mean ± SD)	Posttest (Mean ± SD)	p-value
Body Fat (%)	20,5% ± 3,1	17,9% ± 2,8	0,000*
Muscle Mass (kg)	42,3 ± 4,5	44,1 ± 4,6	0,001*
Body Mass Index	23,7 ± 2,1	23,2 ± 2,0	0,021*

*Note: *p < 0.05 indicates significant difference

The results of the analysis showed a significant decrease in body fat percentage (p = 0.000) and body mass index (p = 0.021), as well as a significant increase in muscle mass (p = 0.001). This indicates that resistance training has a positive impact on the body composition of students. An asterisk (*) indicates a statistically significant difference (p < 0.05) between pre- and post-test measurements.

Energy Balance

The results showed that there were significant changes in body composition and energy balance of intervention participants. During the program, increased physical activity contributed significantly to the increase in daily energy expenditure (p = 0.000). These changes reflect the body's positive response to the intervention given, especially in terms of metabolic efficiency and energy regulation. More details can be seen in the following table:

Table 2. Average Energy Balance Before and After Exercise

Variables	Pretest (Mean ± SD)	Posttest (Mean ± SD)	p-value
Energy Intake (kcal/day)	2.550 ± 320	2.490 ± 310	0,312
Energy Expenditure (kcal/day)	2.230 ± 290	2.610 ± 280	0,000*
Energy Balance (kcal)	+320 ± 140	-120 ± 130	0,000*

There was a significant increase in daily energy expenditure (p = 0.000) due to increased physical activity, although energy intake was relatively stable. The difference between energy intake and expenditure changed from a surplus (+320 kcal) to a mild deficit (-120 kcal), indicating an improvement in energy balance that supports changes in body composition. The results showed that there were significant changes in body composition and energy balance in intervention participants. The percentage of body fat decreased by an average of 2.6%, while muscle mass increased by an average of 1.8 kg. In addition, there was a shift in energy balance from a positive condition to a controlled energy deficit. All of these changes showed statistical significance (p < 0.05), except for changes in energy intake which were not statistically significant (p > 0.05).

DISCUSSION

This study aims to evaluate the impact of resistance training on changes in body composition and energy balance in students from PEHR UNM. Based on the results obtained, it can be concluded that the resistance training program lasting 8 weeks has a significant impact on the physical fitness parameters measured, especially body composition and energy balance.

Changes in Body Composition

The results showed a significant decrease in body fat percentage and an increase in muscle mass in students who participated in the resistance training program. Specifically, the decrease in body fat percentage reached an average of 2.6%, which can be explained by increased physical activity and energy expenditure during the training period. Study states that resistance training, which includes various forms of weight training, can significantly help in increasing muscle mass and reducing body fat because this activity stimulates metabolism and calorie burning (Hariadi et al., 2022; Nurhadi et al., 2022). These findings have important practical implications for PEHR students. In addition to the health benefits and general improvement in physical fitness, more optimal body composition changes also support their ability to carry out professional roles in the field of physical education and sport. Students with healthy body composition, adequate muscle mass, and controlled body fat levels will have better physical capacity to teach, demonstrate sports movements, and actively engage in field practice activities. In addition, direct experience in undergoing and feeling the benefits of science-based exercise programs will also strengthen their competence in designing effective and safe exercise programs for students or athletes in the future.

The increase in muscle mass recorded at 1.8 kg also reflects the positive effects of resistance training on muscle development. This has a positive impact not only on the physical strength of the participants, but also on increasing the overall body metabolism rate (Nurhadi et al., 2022). A study conducted by Abdullah and Nur'Amalia noted that a systematic and regular exercise program greatly contributes to increasing the body's capacity to consume oxygen (VO_2 max) and significantly changing body composition (Abdullah & Nur'amalia, 2022). This is in line with research showing the relationship between exercise and better oxygen consumption, as evidenced by findings that resistance training stimulates physiological adaptations that are beneficial to metabolism (Susilo et al., 2024). These findings imply that resistance training programs are not only effective in reducing body fat percentage and increasing muscle mass, but can also play an important role in improving overall health, providing a powerful approach to weight management and physical health of students involved in this exercise activity.

Body Mass Index (BMI) is an important measure used to assess the proportion of body weight to height. A decrease in BMI from 23.7 to 23.2 indicates a shift in body composition, although it does not reflect significant weight loss. These changes can occur as a result of increased muscle mass and reduced body fat, which can result in decreased BMI even though body weight is relatively stable (Megawati et al., 2016; Nurkhopipah et al., 2018). Based on research conducted by Wairata et al., BMI is an important indicator in evaluating an individual's physical health, where the ideal BMI ranges between 21-23 kg/m^2 (Wairata et al., 2020). Other studies have shown that athletes must have a good balance between muscle mass and fat to achieve ideal body composition, which is also relevant for optimal metabolic health (Ananda et al., 2022; Hasan et al., 2017). A small decrease in BMI, even if it does not indicate significant weight loss, can reflect positive changes in body composition, such as increased muscle mass and decreased body fat.

These changes have major health implications, such as increasing metabolism because muscle burns more calories, even at rest.

Furthermore, research by Pringgadani et al. showed that BMI has a significant relationship with body fat mass and can also be used to predict the risk of falls in the elderly. This confirms that BMI is an important measure of health, more than just a number (Hermastuti & Isnawati, 2012; Pringgadani et al., 2020). The relationship between nutritional status, BMI, and physical performance has also been emphasized in several studies, which show the importance of good nutrition for muscle health and body composition (Dieny et al., 2020; Fitranti et al., 2022).

Measurable changes in BMI may reflect healthier adaptations in body composition, and support the importance of a more comprehensive evaluation involving measurements of fat and muscle mass. In-depth research on the interaction between eating habits, physical activity, and BMI shows that health status is not only determined by body weight numbers, but also by overall body composition (Ma'arif, 2022; Nurkhopipah et al., 2018).

Changes in Energy Balance

In terms of energy balance, this study found significant changes in energy expenditure and overall energy balance. The increased energy expenditure of 380 kcal per day (from 2,230 kcal to 2,610 kcal) could be attributed to the increase in exercise intensity and volume during the intervention period. This also explains why, despite the relatively constant energy intake of the students (around 2,490 kcal/day), they experienced a mild energy deficit that contributed to the reduction in body fat.

Research on energy balance in the context of energy expenditure and body fat reduction has shown that significant increases in energy expenditure can occur despite relatively stable energy intake. In a study by García-Hermoso et al., it was found that a physical intervention can produce changes in cardiovascular fitness that are directly related to the reduction of adiposity in overweight children and adolescents (García-Hermoso et al., 2020). In particular, the increase in oxygen consumption (VO2max) associated with an exercise program can help achieve significant body fat reduction, indicating a relationship between increased energy expenditure and decreased body fat percentage, although it should be noted that compensatory mechanisms in food intake still influence the results (García-Hermoso et al., 2018).

Energy balance also depends largely on the intensity of the exercise performed. Keating et al. highlighted that high interval training is more efficient in reducing adiposity compared to moderate intensity continuous training (Keating et al., 2017). Other studies also support the idea that despite the increase in total energy expenditure, compensatory mechanisms in food intake can influence the results seen in body fat reduction (Broskey et al., 2021). In addition, the combined method of aerobic and resistance training has been identified as an effective strategy in reducing body weight and body fat in obese populations (Pranoto et al., 2024).

The results of this study suggest that increasing energy expenditure through higher intensity and volume training may contribute to body fat reduction, although energy intake may not change significantly. Attention to dietary management aspects is also important during physical interventions to achieve optimal results in weight management (García-Hermoso et al., 2018; Lopez et al., 2022).

The energy balance deficit recorded at -120 kcal, although relatively small, suggests that a resistance training program is able to create conditions that favor body fat reduction without causing starvation or metabolic disturbances. A moderate energy deficit plays an important role in gradually reducing body fat, especially since the risk of losing weight too quickly can disrupt metabolism and muscle mass. Research shows that drastic weight

loss is often accompanied by significant muscle mass loss, which can occur as a result of extreme calorie reduction. One study found that participants who underwent a strict calorie restriction experienced significantly higher lean body mass loss than those who did a moderate calorie restriction (Seimon et al., 2019).

The risk of muscle loss increases when an individual experiences a greater energy deficit. When individuals experience rapid weight loss, they lose not only fat, but also muscle mass, which contributes to a decrease in basal metabolic rate (Egan et al., 2022; Fothergill et al., 2016). This is important because muscle mass plays a role in regulating metabolism, so muscle loss can slow the body's overall metabolic processes (Doucet et al., 2018). In contrast, a moderate energy deficit is more likely to protect muscle mass, allowing for a sustained and stable decrease in body fat, which in turn may promote long-term success in weight management (Mero et al., 2010).

Implications of Resistance Training in the Context of Physical Fitness

The reduction in body fat and increase in muscle mass produced by resistance training are not only beneficial for improving physical fitness, but also for improving ideal body composition, which is very important in supporting physical performance. As a student studying sports science, having optimal physical condition is essential to support the ability to teach, train, and compete in sports. This study also shows that resistance training can be practically applied in students' lives without the need for complex equipment or a very long time. This opens up opportunities for students to integrate resistance training into their fitness routines, which in turn will improve their quality of life and overall health.

Resistance training has been shown to be a practical and effective method that can be integrated into students' routines without the need for complex equipment or excessive time. Studies have shown that students with physical exercise routines cope better with stress, anxiety, and depression than those who do not exercise (Antwi et al., 2022; Friedman et al., 2022) The importance of physical activity, especially in improving mental health, is the basis for students to consider investing time in resistance training. With easy access to simple exercises at home or outdoors, students can use their time more efficiently to do exercises without special equipment, thus optimizing the integration of this activity into their daily routine (Gentil et al., 2020). Physical activities such as resistance training not only improve physical health status but also contribute to the overall mental well-being of students. For example, studies have shown that students who engage in physical activity have better psychological levels and high resilience in facing challenges (Antwi et al., 2022; Friedman et al., 2022). Therefore, implementing resistance training that is easy and accessible at home or in the surrounding environment is a strategic step in improving their quality of life (Karlsen et al., 2017; Narici et al., 2021).

Resistance training has a significant impact on physical fitness, especially in changing body composition through increasing muscle mass and reducing body fat. Increasing muscle mass not only increases physical strength, but also contributes to sports that require explosive strength and muscular endurance, such as weightlifting and sprinting. Reducing body fat increases movement efficiency, speeds up reactions, and improves agility in sports such as basketball and tennis. In addition, increasing muscle mass also helps the body manage energy more efficiently, maintaining athlete performance in training and competition. Resistance training also increases muscular endurance, which is important in sports that require long-term strength, such as soccer and basketball. Finally, weight training improves posture and body balance, which supports performance in sports that involve fast or rotating movements, such as volleyball

or martial arts. Thus, resistance training plays an important role in the development of physical skills that support optimal performance in various sports disciplines.

Although this study provides significant findings, there are several limitations that need to be noted. First, the limited number of subjects only included students from Department of PEHR UNM, which may not be fully representative of the general student population. In addition, this study did not measure other variables that may affect physical fitness, such as psychological factors, sleep habits, and genetic factors. Further research is recommended to involve a larger sample and additional variables, as well as measure the long-term effects of resistance training on physical fitness.

CONCLUSION

The resistance training program implemented for 8 weeks had a positive impact on the physical fitness parameters of students from Department of PEHR UNM, especially in terms of body composition (decreased body fat and increased muscle mass) and energy balance. These findings support the importance of integrating resistance training into students' physical fitness programs, which can help improve health, physical performance, and overall quality of life.

Based on the results of the study, it is recommended that resistance training programs be systematically integrated into the physical fitness learning curriculum of students. In addition, periodic monitoring and evaluation are needed to ensure the effectiveness of the training and program adjustments according to individual needs and conditions. Further research is recommended to explore the long-term effects of resistance training on other aspects such as mental health, cardiovascular fitness, and academic performance. In addition, further research is needed to overcome the limitations of this study.

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