



# The Effects of Resistance Training Interventions on Weight, Body Mass Index, Body Fat Percentage, and Flexibility in College Students: A Comparison Between Sports and Non-Sports Students

Gallant Pamungkas<sup>1ABCDE</sup>, Cerika Rismayanthi<sup>1AB</sup>,  
Ahmad Nasrulloh<sup>1BC</sup> and Fatkurahman Arjuna<sup>1BDE</sup>

<sup>1</sup>Universitas Negeri Yogyakarta

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Corresponding Author: Gallant Pamungkas, E-mail: [gallantpamungkas.2022@student.uny.ac.id](mailto:gallantpamungkas.2022@student.uny.ac.id)

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## Abstract

**Background.** Resistance training is an effective form of exercise that promotes healthy body weight regulation and enhances flexibility. However, discrepancies exist regarding the varying impacts of resistance training based on individuals' training status across different fitness components, such as body composition and flexibility.

**Objectives.** The primary objective of this study is to assess whether there are significant differences in the outcomes of resistance training responses between trained and untrained groups concerning body composition and flexibility.

**Materials and methods.** This experimental resistance training study involved 60 male students (age = 20.83 ± 0.85 years old) from the same university. The participants were divided into two groups based on their training status: a trained group (S; n = 30) and an untrained group (NS; n = 30). Both groups underwent an identical training regimen, consisting of three sessions per week over a total of four weeks or 12 training sessions.

**Results.** Significant differences were observed in the paired sample T-test analysis between pre-test and post-test results in the untrained group for body weight ( $t_{(29)} = 7.940$ ,  $p < 0.001$ ,  $d = 1.45$ ), body mass index ( $t_{(29)} = 7.579$ ,  $p < 0.001$ ,  $d = 1.38$ ), body fat percentage ( $t_{(29)} = 9.733$ ,  $p < 0.001$ ,  $d = 1.77$ ), and sit-and-reach flexibility ( $t_{(29)} = -7.714$ ,  $p < 0.001$ ,  $d = -1.40$ ). Similarly, the trained group showed significant changes in body weight ( $t_{(29)} = 2.644$ ,  $p = 0.013$ ,  $d = 0.483$ ), body fat ( $t_{(29)} = 2.561$ ,  $p = 0.016$ ,  $d = 0.351$ ), and flexibility ( $t_{(29)} = -2.543$ ,  $p = 0.017$ ,  $d = 0.351$ ), while no substantial difference was found in body mass index ( $t_{(29)} = 1.925$ ,  $p = 0.064$ ,  $d = -0.464$ ).

**Conclusion.** The study found that using resistance training protocols targeting weight reduction with 60-70% of 1 Repetition Maximum (RM) over a one-month intervention period, without stringent calorie restriction, significantly decreased weight and BMI while enhancing flexibility. Notably, regardless of training status disparities, the untrained group demonstrated more expressed improvements compared to the trained group, indicating the influence of training status on response variations to training stimuli.

**Keywords:** resistance training, body composition, flexibility, training status.

## Introduction

In 2022, global obesity rates have surged dramatically, surpassing triple the figures recorded in 1975 (Di Cesare et al., 2016). Presently, more than 650 million adults, 340 million teenagers, and 39 million children worldwide are grappling with obesity (World Health Organization, 2021). with projections indicating a continual rise in these

numbers annually. According to forecasts from the World Obesity Federation, the prevalence of obesity among children and adolescents is anticipated to soar to 206 million individuals by 2025 and further to 254 million by 2030 (Lobstein & Brinsden, 2019). This issue holds significant global importance due to the strong correlation between adolescent obesity and the heightened risk of obesity-related complications and premature mortality in adulthood (Nicolucci & Maffei, 2022). Moreover, obesity is linked to an array of health concerns, including cardiovascular diseases (Powell-Wiley et al., 2021), diabetes type 2 (Al-Talabany et al., 2018), cancer (Pati, Irfan, Jameel, Ahmed,

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& Shahid, 2023), osteoarthritis (Nedunchezhiyan et al., 2022), respiratory issues (Cortes-Telles, Ortiz-Farias, Pou-Aguilar, Almeida-de-la-Cruz, & Perez-Padilla, 2021), endocrine (Ylli, Sidhu, Parikh, & Burman, 2022), depression (Fu et al., 2023), and reduced quality of life (Stephenson, Smith, Kearns, Haywood, & Bissell, 2021). Hence, urgent measures are imperative to curb the escalating growth rate of overweight or obese adolescents globally.

Flexibility, defined as the capacity to move throughout the full range of motion (ROM) at joints (Afonso, Olivares-Jabalera, & Andrade, 2021), offers a plethora of health advantages that contribute to enhancing daily life quality by averting injuries, back pain, and balance issues (Pate, Oria, & Pillsbury, 2012; Pfeifer, Ross, Weber, Sui, & Blair, 2022). Extensive research indicates that body weight factors can significantly impact flexibility levels. Studies by Pate, Oria, & Pillsbury (2012) highlight that rising obesity rates among adolescents lead to decreased flexibility and overall fitness, consequently impairing postural control and triggering various musculoskeletal health issues. Maintaining a healthy weight and optimal flexibility is imperative for overall well-being. Encouraging the cultivation of these attributes among teenagers can be achieved through engaging in resistance training activities.

Resistance training is recognized for its remarkable effects on the body's metabolic system (Thyfault & Bergouignan, 2020), body weight management (Thyfault & Bergouignan, 2020; Wewege et al., 2022), and overall physical and mental well-being (Gordon et al., 2018; Thyfault & Bergouignan, 2020), consequently enhancing health-related quality of life (Bampton, Johnson, & Vallance, 2015). Furthermore, resistance training is acknowledged for its role in enhancing flexibility by elongating muscle fibers (Blazevich et al., 2014), reducing stiffness in tendons and muscles (Pate et al., 2012), and enhancing the effectiveness of the stretch-shortening cycle (Afonso, Ramirez-Campillo, et al., 2021; Kubo, Ishigaki, & Ikebukuro, 2017). Despite these benefits, research focusing on the impact of resistance training on flexibility remains limited compared to studies on its effects on strength, speed, and power. Given the outstanding advantages associated with resistance training, it comes as no surprise that this form of exercise has gained popularity across diverse age groups, backgrounds, and societal demographics.

While resistance training offers a range of benefits, its primary purpose is to facilitate muscle adaptation (Krzysztofik, Wilk, Wojdała, & Gołaś, 2019). Properly executed resistance training can optimize the adaptation of the musculoskeletal system, leading to enhanced strength in muscles, bones, joints, and tendons (Brumitt & Cuddeford, 2015). Moreover, the outcomes of resistance training adaptation are known to be diverse, influenced by factors such as the type and methodology of training, as well as the intricate interplay of complex training routines, alongside individual differences in age, genetics, and gender (Hughes, Ellefsen, & Baar, 2018). Additionally, various other elements, including one's training status, play a significant role in determining the results of adaptation from resistance training (Hughes et al., 2018).

Numerous studies have highlighted the variability in adaptation outcomes following resistance training, attributing this diversity to an individual's capacity to respond to training stimuli, commonly referred to as their training status. Wetmore et al. (2020) emphasized that

trained individuals often require more intense training to achieve notable muscle adaptations compared to their untrained counterparts. Conversely, untrained individuals exhibit heightened responsiveness to training stimuli, enabling them to undergo more substantial adaptations. This phenomenon, as elucidated by Kraemer & Ratamess (2004), is known as the ceiling theory, now popularly recognized as the "newbie gain" trend. This trend suggests that untrained individuals have the potential to experience more pronounced adaptations across various desired outcomes.

Existing research indicates a scarcity of direct comparisons regarding resistance training adaptations based on training status, particularly in experimental studies focusing on weight loss and enhanced flexibility. Therefore, the primary objective of this study is to investigate the impact of training status on the outcomes of resistance training among both untrained and trained groups, focusing on sports students and non-sports students lacking training experience. The findings from this research aim to shed light on prevailing trends and have the potential to inform strategies for promoting health and fitness effectively.

## Materials and Methods

### Study Participants

The study sample comprised 30 Non-Sports College Students (NS) and 30 Sports College Students (S), aged  $21.03 \pm 0.89$  years and  $20.63 \pm 0.76$  years, respectively. Participants were randomly selected from Yogyakarta State University and voluntarily agreed to take part until the conclusion of the exercise intervention. Inclusion criteria involved students majoring in sports and health sciences, who were categorized as the trained group, and those from non-sports disciplines, who were categorized as the untrained group. Each participant completed a questionnaire derived from the Muscle-Strengthening Exercise Questionnaire (MSEQ) to ascertain their regular exercise habits, particularly engagement in resistance training. The study thus featured two groups: NS (untrained) and S (trained). Body composition and flexibility data (pre-post-test) were collected for both groups to assess changes before and after the resistance training intervention, enabling the evaluation of intervention efficacy.

### Experimental Design

This research implemented a resistance training intervention spanning 12 sessions, each held three times a week for 1 to 1.5 hours, resulting in a total intervention period of one month. The primary objective was to investigate the impact of resistance training on body composition metrics (body weight, body mass index, and body fat percentage) and flexibility among both trained and untrained groups. Furthermore, the study aimed to identify which group, between the trained and untrained groups, demonstrated more significant adaptations in body composition and flexibility.

The intervention provided to all research participants aimed to facilitate weight loss through the circuit training method. Both the Standard (S) and Non-Standard (NS) groups adhered to a standardized training regimen,

maintaining consistent sets, rest periods, and the number of exercises, with the only variation being the intensity levels utilized. Throughout the study, the prescribed intensity followed the repetition maximum (RM) principle, with a range set at 60-70% of 1 RM, progressively increasing over the course of the intervention. This approach ensured that the weight was tailored to each participant's individual capabilities. Since we enrolled untrained participants and utilized various resistance training modalities, including gym machines, bodyweight exercises, and free weights, three fitness instructors were engaged to supervise and guide the training program, ensuring participants' safety and injury prevention. Their involvement was voluntary, and the intervention took place at the Health and Sport Center (HSC) Fitness Center, Yogyakarta State University. Details

of the training programs administered to the two groups are outlined in Table 1 below.

### Testing Procedure

The measurement sessions for each group took place simultaneously at the Fitness Center of HSC. Participants from both groups underwent measurements for body composition and flexibility at the commencement and conclusion of the exercise intervention (pre-post-test). The specifics of the body composition and flexibility measurements are elaborated below.

### Body Composition

Body composition measurements were conducted by gathering data on body weight, BMI, and body fat percentage through the Bioelectric Impedance Analysis (BIA) method. BIA is a technique that indirectly measures total body fat percentage by using a low electric current, leveraging the conductive properties of body tissues. This method is commonly employed in health research, clinics, and fitness centers. In this study, BIA measurements were obtained using the Omron Karada Scan tool. Prior to the measurements, participants were advised to wear comfortable and light-weight clothing. The categorization of body fat percentage for individuals aged 20-39 was based on the norms established by Gallagher et al., (2000). The BMI standards applied in this research correspond to the Asia Pacific population BMI guidelines set by the World Health Organisation (2000).

### Flexibility

Flexibility measurements were conducted using a sit-and-reach assessment method with the assistance of a sit-and-reach box. Participants were instructed to wear casual or sports attire and remove their footwear before the measurements. They were then guided to sit on the floor with legs extended forward, ensuring the soles of their feet were in contact with the sit-and-reach box. The tester maintained the participants' feet on the floor by holding their knees. Participants placed their hands together with palms facing downward while seated. After taking a deep breath, they exhaled while reaching as far forward as possible along the measurement line on the box. The sit-and-reach test was performed twice with a brief rest in between. The best result from both trials, based on the furthest reach in centimeters, was selected for analysis. These results were compared against Fukuda's (2019) standards to determine the flexibility category for each participant in the study.

### Statistical analysis

In this research, the data analysis involved several key stages: descriptive statistical tests, normality test, paired sample t-test, and Cohen's d effect size test.

Descriptive statistical tests included calculations for mean, standard deviation, minimum value, and maximum value. Normality was assessed using the Shapiro-Wilk test, with normal data distribution confirmed if the significance value (p) exceeded 0.05 for both experimental groups. To compare vari-

**Table 1.** Training sessions distribution in the intervention period

Exercise	Week 1-2*		Week 3-4**	
	Sets	Reps	Sets	Reps
<b>SESSION 1</b>				
Leg Press	2-3	16-20	3-4	12-15
Chest Press	2-3	16-20	3-4	12-15
Pulley	2-3	16-20	3-4	12-15
Shoulder Press	2-3	16-20	3-4	12-15
Total Abdominal	2-3	16-20	3-4	12-15
Lower Back	2-3	16-20	3-4	12-15
Triceps Pushdown	2-3	16-20	3-4	12-15
Arms Curl	2-3	16-20	3-4	12-15
<b>SESSION 2</b>				
Goblet Squat	2-3	16-20	3-4	12-15
Reverse Lunges	2-3	16-20	3-4	12-15
Barbell Romanian Deadlift	2-3	16-20	3-4	12-15
Bench Press	2-3	16-20	3-4	12-15
Barbell Bent-Over Row	2-3	16-20	3-4	12-15
Barbell Overhead Press	2-3	16-20	3-4	12-15
Diagonal Chop	2-3	16-20	3-4	12-15
Kettle Bell Swing	2-3	16-20	3-4	12-15
<b>SESSION 3</b>				
Prisoner Squat Jump	2-3	16-20	3-4	12-15
Dumbbell Bench Step-Up	2-3	16-20	3-4	12-15
Chest Fly	2-3	16-20	3-4	12-15
Machine Lat Pull-down	2-3	16-20	3-4	12-15
Upright Row	2-3	16-20	3-4	12-15
Crunch Coaster	2-3	16-20	3-4	12-15
Biceps Curl	2-3	16-20	3-4	12-15
Triceps Pushdown	2-3	16-20	3-4	12-15

\*) Reps according to 60-65% of 1 RM; Rest 2-3 minute between round/circuit; rhyme. Contraction: smooth-fast.

\*\*) Reps according to 65%-70% of 1 RM; Rest 1-2 minute between round/circuit

ables between pre-test and post-test within the groups, the paired sample t-test was applied. A significant difference was indicated by a significance value of less than 0.05 ( $p < 0.05$ ). Following the paired sample t-test results, the analysis proceeded with the Cohen's d test to assess the effect size before and after the intervention. Effect size categories, as per were defined as small (0.2), medium (0.5), and large (0.8). The data analysis was conducted using the SPSS Version 27 software application.

## Results

The study results reveal significant changes in all research variables, encompassing both body composition and flexibility measures. These data transformations are evident when

**Table 2.** Statistical Description of Pre-Test Score

Groups	Variables	Mean	Std. Dev	Min	Max
Non-Sport Group (n = 30)	BM	64.97	7.95	49.00	80.00
	BMI	23.10	1.79	19.95	27.61
	BF%	21.12	3.58	13.5	27.00
	S&R	30.66	4.91	21.00	42.00
Sport Group (n = 30)	BM	60.36	6.16	48.00	78.00
	BMI	21.56	1.65	17.85	26.67
	BF%	15.33	3.94	7.00	23.00
	S&R	33.60	3.58	26.00	41.00

**Table 3.** Statistical Description of Post-Test Score

Groups	Variables	Mean	Std. Dev	Min	Max
Non-Sport Group (n = 30)	BM	26.00	7.95	49.00	80.00
	BMI	23.10	1.79	19.95	27.61
	BF%	21.12	3.58	13.50	27.00
	S&R	30.66	4.91	21.00	42.00
Sport Group (n = 30)	BM	60.36	6.16	48.00	78.00
	BMI	21.56	1.65	17.85	26.67
	BF%	15.33	3.94	7.00	23.00
	S&R	33.60	3.58	26.00	41.00

**Table 4.** Normality and Homogeneity Test Result

Groups	Variables	Pre-test		Post-test	
		s-w	p	s-w	p
NS	BB	0.966	0.431	0.973	0.637
	BMI	0.957	0.293	0.986	0.949
	BF	0.944	0.116	0.956	0.240
	S&R	0.951	0.185	0.936	0.70
S	BB	0.960	0.315	0.957	0.253
	BMI	0.948	0.147	0.935	0.065
	BF	0.956	0.251	0.936	0.70
	S&R	0.990	0.992	0.989	0.984

**Table 5.** Paired Sample T with Cohen's D Test Results

Variables	Non-Sport Group (n = 30)					Sport Group (n = 30)				
	Pre-Test	Post-Test	t	p	E.S.	Pre-Test	Post-Test	t	p	E.S.
Body Weight (kg)	64.97±7.95	62.77±7.36	7.940	<0.001	1.45	60.36±6.16	60.04±5.93	2.644	0.013	0.483
Body Mass Index (BMI)	23.10±1.79	22.23±1.71	7.579	<0.001	1.38	21.56±1.65	21.46±1.58	1.925	0.064	0.351
Body Fat (%)	21.12±3.58	18.62±2.72	9.733	<0.001	1.77	15.33±3.93	15.01±3.76	2.561	0.016	0.468
Sit and Reach (cm)	30.66±4.91	34.71±4.65	-7.714	<0.001	-1.40	33.60±3.58	34.52±3.29	-2.543	0.017	-0.464

comparing the measurement outcomes of the two groups before and after the tests, as illustrated in Tables 2 and 3 below.

## Normality and Homogeneity Results

The normality test results using Shapiro-Wilk for all variables in this study show non-significant values ( $p > 0.05$ ). In this case, the obtained results indicate that the data have a normal distribution. Furthermore, detailed normality test results can be viewed in Table 4.

Based on the assumption test requirements for the paired sample t-test, all data that have passed the normality test are considered suitable for the paired sample t-test.

## Hypothesis Testing

In general, the results of the paired sample t-test in this study indicate significant differences in the pre- and post-test measurements in groups S and NS. The significance difference of the paired sample t-test in group NS is known to be more significant than in group S for the variables body weight ( $t_{(29)} = 7.940$ ,  $p < 0.001$ ), body mass index ( $t_{(29)} = 7.579$ ,  $p < 0.001$ ), body fat % ( $t_{(29)} = 9.733$ ,  $p < 0.001$ ), and sit and reach ( $t_{(29)} = -7.714$ ,  $p < 0.001$ ). On the other hand, group S is found to have significant differences for the variables body weight ( $t_{(29)} = 2.644$ ,  $p = 0.013$ ), body fat ( $t_{(29)} = 2.561$ ,  $p = 0.016$ ), and sit-and-reach ( $t_{(29)} = -2.543$ ,  $p = 0.017$ ) but is not superior to group NS. The Cohen's d test results also show a larger effect size in the pre- and post-test variables of group NS for body weight ( $d = 1.45$ ), body mass index ( $d = 1.38$ ), body fat % ( $d = 1.77$ ), and sit-and-reach ( $d = -1.40$ ) compared to group S ( $d = 0.483$ ,  $d = 0.351$ ,  $d = 0.468$ , and  $d = -0.464$ , respectively) (table 5).

## Discussion

This study found a statistically significant difference between groups NS and S for all variables: body weight ( $t_{(29)} = 7.940$ ,  $p < 0.001$ ), BMI ( $t_{(29)} = 7.579$ ,  $p < 0.001$ ), body fat% ( $t_{(29)} = 9.733$ ,  $p < 0.001$ ), and Flexibility ( $t_{(29)} = -7.714$ ,  $p < 0.001$ ). Furthermore, advanced tests to determine the effect size through Cohen's d showed that group NS had better changes with a very large effect size on the impact of resistance training from  $64.97 \pm 7.95$  kg to  $62.77 \pm 7.36$  kg ( $d = 1.45$ ), BMI from  $23.10 \pm 1.79$  to  $22.23 \pm 1.71$  ( $d = 1.38$ ), body fat% from  $21.12 \pm 3.58\%$  to  $18.62 \pm 2.72\%$  ( $d = 1.77$ ), and flexibility from  $30.66 \pm 4.91$  cm to  $34.71 \pm 4.65$  cm ( $d = -1.40$ ) compared to group S with results of the impact on weight from  $60.36 \pm 6.16$  kg to  $60.04 \pm 5.93$  kg ( $d = 0.483$ ), BMI from  $21.56 \pm 1.65$  to  $21.46 \pm 1.58$  ( $d = 0.351$ ), body fat% from  $15.33 \pm 3.93\%$  to  $15.01 \pm 3.76\%$  ( $d = 0.468$ ), and flexibility from  $33.60 \pm 3.58$  cm to  $34.52 \pm 3.29$  cm ( $d = -0.464$ ).

The variable BMI in the pre- and post-tests in group S is the only variable that did not show significant differences in this study. Nevertheless, the changes in group S for the BMI variable tend to decrease as seen from the descriptive test results in Tables 2 and 3 above. Overall, the impact of resistance training on groups NS and S shows significant differences (except for the BMI variable in group S), where group NS outperforms group S. These findings support previous research that training status affects the adaptation results of resistance training or, in this study's context, changes in body composition and flexibility. Furthermore, the information obtained from this study can be used to promote resistance training and motivate students, especially the untrained ones, to participate more in resistance training due to its beneficial effects.

### *The Effects of Training Status Toward Body Composition*

It is well known that besides muscle adaptation, resistance training is effective in helping regulate fat or body composition in various populations (Buskard & Petrella, 2023; Campa et al., 2020; Dias et al., 2015; Ribeiro et al., 2022; Schranz, Tomkinson, & Olds, 2013). Similar to resistance training aimed at muscle adaptation, resistance training aimed at weight loss or regulation can also lead to different adaptation results depending on the interaction of factors such as types, methods, and interactions of the highly complex training regimen, in addition to age differences, genetics, gender, and others (Hughes et al., 2018). According to Ataenosrat et al. (2022), resistance training using circuit training or interval resistance training methods can significantly reduce weight compared to resistance training using traditional resistance training methods. Meanwhile, the study by Kapsis et al. (2022) shows that there are differences in the impact of weight selection in High-Intensity Functional Training, where training with light weights (30% of 1 RM) is more significant for fat loss compared to moderate weights (70% of 1 RM) in healthy adult populations. Even more simply, resistance training using different modalities such as body-weight, free-weight, and resistance bands can also affect weight loss adaptation results (Liu et al., 2021). Through this study, resistance training with moderate weights (60-70% of 1 RM) to muscle failure using circuit training methods and a combination of free weight, gym machines, and body weight modalities can significantly reduce weight, BMI, and fat percentage in the student population (young adults) regardless of their training status.

Meanwhile, changes in weight, specifically fat, are caused by the interaction of intake, expenditure, and energy needs in the homeostatic energy system (Reis, Júnior, Zajac, & Oliveira, 2011; Ribeiro et al., 2022). Simply put, the key to success in weight loss is the ability to manage these three factors well to support a reduction in body fat percentage. Therefore, individuals who can limit calorie intake and increase their energy expenditure are more likely to reduce their body fat percentage. Interestingly, this study shows that resistance training to muscle failure with 60-70% of 1 RM alone as one factor of energy expenditure, without strict calorie restriction, can still reduce body fat percentage in both groups.

The findings of this study may be supported by Brunelli et al. (2019), who found that resistance training with low and

high weights (30% or 80% of 1 RM) performed to muscle failure results in almost the same total amount of energy expenditure, which can be applied to aid in weight loss. Thus, resistance training can be utilized as one strategy in regulating weight in a healthy manner. However, the study highlights that low-resistance training is more effective in assisting weight loss. This is due to the higher level of energy expenditure during low-resistance training compared to high-resistance training. In addition to this study, various research also supports the findings of this study stating that resistance training is an effective exercise for weight regulation.

In this study, differences in resistance training responses were observed between untrained and trained populations. We acknowledge that without measurements for other supporting variables, the process of connecting why the effects of training status lead to apparent changes in body composition variables becomes challenging to comprehend. Nevertheless, these differences in response to resistance training stimuli, particularly regarding changes in weight, BMI, and body fat percentage between untrained and trained populations can be attributed to various factors such as differences in BMR, the floor-ceiling effect, and sensitivity to training stimulus responses as indicated by available literature sources (Farhana & Rehman, 2021; Souza, Barbalho, & Gentil, 2020). Studies by Poehlman, Melby, and Goran (1991) indicates that the resting metabolic rate in trained populations is higher compared to untrained populations, implying that trained individuals require significantly more energy. As a result, trained populations may exhibit relatively effective regulation of body fat percentage compared to the untrained group. However, despite their lower RMR, untrained populations tend to experience more significant changes, including notable weight loss, possibly due to other factors such as rapid metabolic adaptations or increased sensitivity to training stimuli in this group.

Furthermore, the ceiling effect is a phenomenon in the sports world wherein an individual (or a population sharing the same characteristics) experiences adaptation to the maximum level as a result of the stimulus response from training (Lochbaum et al., 2022; Wetmore et al., 2020). In this case, someone experiencing the ceiling effect will find it difficult to improve their athletic performance to the next level because they have reached a certain peak performance (Behm et al., 2024; Schoenfeld et al., 2019). Regardless of the various factors that can influence the ceiling effect, this phenomenon has been extensively documented and researched in various aspects of athletic performance such as muscle strength and endurance (Hughes et al., 2018; Peterson, Rhea, & Alvar, 2005), hypertrophy (Lopez et al., 2021),  $VO_2$ max (Santisteban, Lovering, Halliwill, & Minson, 2022), speed (Behm et al., 2017), power (Moran et al., 2023), and even skill acquisition commonly observed in trained individuals. In relation to this, the significant differences in weight loss, BMI, and body fat percentage between the NS and S groups may be greatly influenced by this effect. Participants in the S group in this study are athletes from various sports disciplines who regularly undergo training sessions focusing on both technical and physical aspects. On the other hand, untrained individuals in this study show low levels of sports participation, especially in resistance training. Given these conditions, it is logical that the untrained group

experienced significant decreases in all body composition variables compared to the trained group.

Meanwhile, although not yet precisely understood, the ceiling effect theory may be associated with the theory of beginner gains. The theory of beginner gains emphasizes the potential of the untrained population to adapt more significantly to training stimuli compared to the trained population (Fyfe & Loenneke, 2018). In this case, untrained individuals exhibit a higher potential for sensitivity to stimuli compared to trained individuals. Some studies suggest that differences exist in strength improvement, muscle size, and overall fitness between trained and untrained individuals, with greater improvements observed in the untrained population. Furthermore, the differing sensitivity to stimuli based on training status may also influence the adaptation outcomes of body composition aspects from resistance training. Trained individuals may require more advanced training methods and/or increased training volume compared to untrained individuals (Wetmore et al., 2020).

### *The Effects of Training Status Toward Flexibility*

Flexibility can be enhanced through various methods such as static stretching, dynamic stretching, PNF, and foam rolling (Kasahara et al., 2023). Recent advancements in scientific literature suggest that resistance training, when performed without incorporating flexibility training, can actually improve flexibility across different populations (Leite et al., 2017). A recent meta-analysis by Afonso et al. (2021) supports the notion that resistance training can enhance flexibility by increasing the range of motion (ROM) in specific joints. This type of resistance training involves utilizing free weights, gym machines, and Pilates. Furthermore, several studies concur that specific resistance training exercises can improve flexibility and joint ROM to a significant extent, comparable to traditional flexibility exercises like static and dynamic stretching (Alizadeh et al., 2023; Behm, Aragão-Santos, Korooshfard, & Anvar, 2023). Additionally, flexibility was observed to increase following resistance training interventions due to factors such as increased muscle fiber length (Blazevich et al., 2014), alterations in tendon-muscle stiffness (Pate et al., 2012), and the effects of the stretch-shortening cycle during exercise (Afonso, Ramirez-Campillo, et al., 2021; Kubo et al., 2017). These findings shed light on why both groups in the study experienced significant improvements in flexibility.

Moreover, research indicates a strong correlation between muscle flexibility, range of motion (ROM), and muscle weakness (Frasson et al., 2020; Pettersson et al., 2019). Studies have demonstrated that weak muscles can lead to a reduction in joint flexibility and ROM, as highlighted by Zeng et al. (2021). While the researchers did not directly measure muscle strength in this study, it is plausible that the enhancements observed in both the NS and S groups could be attributed to gains in muscle strength. The notably greater improvement in flexibility among the untrained group may be attributed to their initial lower muscle strength compared to the trained group. This discrepancy in muscle strength levels between the groups likely influenced how they responded to resistance training in terms of flexibility. Additionally, as per Alizadeh et al. (2023), the trained group started with higher baseline flexibility, potentially limiting further significant

gains in flexibility. Conversely, the untrained group, with initially poorer flexibility fitness, benefited from a more pronounced response to the resistance training stimulus, leading to a more substantial increase in flexibility.

Some studies propose that stretch tolerance could play a role in how resistance training affects flexibility gains. Trained individuals often exhibit higher muscle stretch tolerance, possibly due to their regular engagement in resistance training and exercises that stretch muscles to their maximum capacity. Conversely, the untrained group typically shows lower flexibility fitness and poorer stretch tolerance. Resistance training is believed to enhance stretch tolerance, potentially explaining the more substantial increase in flexibility observed in the untrained group compared to the S group.

In summary, variations in responses to resistance training among populations with different training statuses (trained and untrained) could be attributed to the interplay of several intricate factors. While the NS group demonstrated superior adaptation results regarding body composition, the S group also exhibited significant outcomes. This implies that resistance training proved advantageous for both groups. The researcher acknowledges that this study alone is inadequate to comprehensively explain a broad subject, such as the effects of diverse training statuses, given the limitations inherent in this research.

Resistance training response results can vary based on the training program's design, regimen, and methodology. The researchers propose that relying solely on maximum repetitions may not offer sufficient insight into the outcomes of this study. While maximum repetitions can tailor to individual characteristics, a more diverse and intricate training regimen is necessary for comprehensive understanding. Additionally, as this study exclusively focused on a young adult population, its findings may not be universally applicable. Research across different age groups is essential to explore variations in the effects of training status. Drawing from existing literature, this study suggests the presence of mediator variables that influence how training status impacts body composition and flexibility. To delve deeper into these differences, researchers advocate for the inclusion of various variables such as RMR, ceiling effect, training stimuli sensitivity, muscle fascicle length, and muscle stiffness. Furthermore, the limited research on the effects of resistance training on flexibility contrasts with the extensive studies on strength, speed, power, and other variables.

### **Conclusions**

The research findings indicate that resistance training programs aimed at weight loss, utilizing 60-70% of 1 Repetition Maximum (RM) over a one-month intervention period without strict calorie restrictions, can significantly decrease weight and Body Mass Index (BMI) while enhancing flexibility, irrespective of training status differences. Nonetheless, the NS group in this study exhibited greater improvements compared to the S group, suggesting that training status influences how groups respond to training stimuli differently. Therefore, it is hoped that the outcomes of this study can serve as a catalyst to underscore the significance of fitness, body composition, and flexibility, particularly within the student demographic.

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## Conflict of interest

The authors declare that they have no conflicts of interest associated with this research, including financial interests, affiliations, or involvement with any organization that might have a stake in the findings presented.

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## Вплив інтервенцій з виконання силових тренувань на показники ваги, індексу маси тіла, процентного вмісту жиру в тілі та гнучкості у студентів коледжів: порівняльний аналіз між показниками студентів, які займаються і не займаються спортом

Галлант Памункас<sup>1ABCDE</sup>, Черіка Рісмаянті<sup>1AB</sup>,  
Ахмад Насруллох<sup>1BC</sup>, Фаткурахман Арджуна<sup>1BDE</sup>

<sup>1</sup>Джок'якартський державний університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 10 с., 5 табл., 59 джерел.

**Історія питання.** Силові тренування — це ефективна форма фізичних вправ, що сприяє здоровому регулюванню маси тіла та покращує показники гнучкості. Однак існують розбіжності щодо різних факторів впливу силових тренувань залежно від стану тренуваності осіб стосовно різних компонентів фізичної форми, таких як композиція тіла та гнучкість.

**Мета дослідження.** Основна мета цього дослідження полягає в оцінці того, чи існують значні відмінності в результатах реакцій на силові тренування між тренуваними та нетренуваними групами щодо композиції тіла та гнучкості.

**Матеріали та методи.** У цьому експериментальному дослідженні з вивчення впливу силового тренування взяли участь 60 студентів чоловічої статі (вік = 20,83 ± 0,85 років) з одного університету. Учасники були розділені на дві групи залежно від їхнього стану тренуваності: тренувана група (S; n = 30) і нетренувана група (NS; n = 30). Обидві групи проходили ідентичний тренувальний режим, що складався з трьох занять на тиждень протягом чотирьох тижнів або 12 тренувань.

**Результати.** Значні відмінності спостерігалися в аналізі Т-коефіцієнту парної вибірки між результатами до і після тесту в нетренованій групі для показників маси тіла ( $t_{(29)} = 7,940$ ,  $p < 0,001$ ,  $d = 1,45$ ), індексу маси тіла ( $t_{(29)} = 7,579$ ,  $p < 0,001$ ,  $d = 1,38$ ), процентного вмісту жиру в тілі ( $t_{(29)} = 9,733$ ,  $p < 0,001$ ,  $d = 1,77$ ) і тесту на гнучкість sit-and-reach (спосіб вимірювання загальної гнучкості тіла при згинанні тулуба вперед, сидячи на підлозі з витягнутими вперед руками) ( $t_{(29)} = -7,714$ ),  $p < 0,001$ ,  $d = -1,40$ ). Аналогічним чином, тренувана група досліджуваних продемонструвала значні зміни у показниках маси тіла ( $t_{(29)} = 2,644$ ,  $p = 0,013$ ,  $d = 0,483$ ), вмісту жиру в тілі ( $t_{(29)} = 2,561$ ,  $p = 0,016$ ,  $d = 0,351$ ) і гнучкості ( $t_{(29)} = -2,543$ ,  $p = 0,017$ ,  $d = 0,351$ ), тоді як в індексі маси тіла істотної різниці не спостерігалось ( $t_{(29)} = 1,925$ ,  $p = 0,064$ ,  $d = -0,464$ ).

**Висновок.** В ході дослідження було встановлено, що використання протоколів силових тренувань, спрямованих на зниження ваги з рівнем 60-70% від одного повторення з максимальною вагою (RM) протягом одного місяця інтервенції, без суворого обмеження калорій, сприяло значному зменшенню ваги та ІМТ, підвищивши показники гнучкості. Слід зазначити, що незалежно від розбіжностей у стані тренуваності, нетренована група продемонструвала більш виражене покращення показників порівняно з групою тренуваних осіб, що вказує на вплив стану тренуваності на варіації реакції відносно тренувальних стимулів.

**Ключові слова:** силове тренування, композиція тіла, гнучкість, стан тренуваності.

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#### Information about the authors:

**Pamungkas, Gallant:** gallantpamungkas.2022@student.uny.ac.id; <https://orcid.org/0009-0002-6330-9649>; Department of Health and Sports Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

**Rismayanthi, Cerika:** cerika@uny.ac.id; <https://orcid.org/0000-0002-6588-1983>; Department of Health and Sports Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

**Nasrulloh, Ahmad:** ahmadnasrulloh@uny.ac.id; <https://orcid.org/0000-0003-2859-7091>; Department of Health and Sports Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

**Arjuna, Fatkurahman:** arjuna@uny.ac.id; <https://orcid.org/0000-0001-6920-928>; Department of Health and Sports Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

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