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Resistance training significantly increases insulin-like growth factor-1 levels in women with a sedentary lifestyle: A randomized controlled trial

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ABSTRACT

Purpose of the study: To determine the effects of physical exercise resistance training and aerobic exercise on Insulin-Like Growth Factor-1 (IGF-1) levels in women with a sedentary lifestyle.

Methods: Thirty-three female respondents with sedentary lifestyle were randomly selected and divided into three groups: resistance training group (n = 11), aerobic training group (n = 11), and control group (n = 11). Study participants were between 18 and 26 years old. Data collection took place over the course of two days, beginning with the collection of information regarding the characteristics of the subjects. Before the exercise, the subjects had their blood drawn as pre-test data. The subjects were then instructed to warm up. Then, the subjects performed physical exercises according to their group. After the exercise intervention, blood samples were taken as post-test data.

Results: The data showed that training significantly increased IGF-1 levels in resistance training group (p = 0.012).

Conclusion: acute resistance exercise has the potential to raise IGF-1 levels. Growth hormone's effects are mediated by IGF-1, which is also essential for controlling somatic growth and organ development, including brain. Resistance training can be recommended as an alternative exercise for people with a sedentary lifestyle to improve cognitive function.

Keywords: Sedentary; Resistance Training; Physical Exercise; IGF-1

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Силовые тренировки значительно повышают уровень инсулиноподобного фактора роста-1 у женщин, ведущих сидячий образ жизни: рандомизированное контролируемое исследование

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АННОТАЦИЯ

Цель исследования: определить влияние силовых тренировок и аэробных упражнений на уровень инсулиноподобного фактора роста-1 (ИФР-1) у женщин, ведущих сидячий образ жизни.

Материалы и методы: Тридцать три женщины, ведущие сидячий образ жизни, были случайным образом разделены на три группы: группа силовых тренировок (n = 11), группа аэробных тренировок (n = 11) и контрольная группа (n = 11). Участницы исследования были в возрасте от 18 до 26 лет. Сбор данных проводился в течение двух дней начиная со сбора информации о характеристиках испытуемых. Перед началом упражнений у испытуемых взяли кровь для предварительного анализа. Затем испытуемым было предложено размяться. После этого испытуемые выполняли физические упражнения в соответствии с их группой. После завершения упражнений были взяты образцы крови для повторного анализа.

Результаты: Данные показали, что уровень ИФР-1 был значимо повышен в группе силовых тренировок (p = 0,012).

Вывод: интенсивные силовые упражнения могут повысить уровень ИФР-1. Действие гормона роста опосредуется ИФР-1, который также необходим для контроля соматического роста и развития органов, включая мозг. Силовые тренировки можно рекомендовать в качестве альтернативных упражнений для людей, ведущих сидячий образ жизни, с целью улучшения когнитивных функций.

Ключевые слова: малоподвижный образ жизни; силовые тренировки; физические упражнения; ИФР-1

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1. Introduction

Intensive physical exercise has a positive impact on improving health and is one of the most important elements for healthy aging, while sedentary behavior, lack of physical activity, and physical exercise are considered triggers for various health disorders that have an impact on the risk of developing diseases [1]. The incidence of people with chronic illnesses will rise as a result of this sedentary behavior [2]. The objectives of medical interventions, however, are increasingly seen to include more than simply preventing and treating physical or mental illness; they should to help people achieve or maintain resilience, good health, and a high quality and quantity of life [3]. Young people often struggle with sedentary behavior and physical inactivity, particularly college students. The shift to college life frequently entails more social and academic obligations, which frequently result in less regular exercise. Both the physical and neurocognitive levels of health are significantly impacted by this sedentary lifestyle [4].

Working memory, executive and inhibitory functions, spatial learning, language and vocabulary understanding, processing speed, and language and reading decoding are all components of the complex system that is cognitive [5]. It is believed that associative connections between various cerebral cortex regions produce this [6]. Connectivity is a very dynamic process since inhibitory and stimulatory inputs can either increase or decrease synaptic activity. The degree of physical exercise has a significant impact on executive functions, a group of higher-order cognitive functions, such as cognitive flexibility and working memory, and inhibitory control [7]. Self-control, goal-oriented conduct, and academic performance all depend on these processes. Existing research findings indicate the detrimental effects of low levels of physical activity on cognitive function. On the other hand, it has been demonstrated that regular exercise enhances cognitive performance [7]. In several organ systems, IGF-1 primarily regulates cell growth, metabolism, proliferation, and apoptosis. Therefore, the effects of IGF-1 include giving adults anabolic properties and encouraging the growth of newborns and youngsters [8].

Consistent exercise is a method to optimize human potential throughout life, but there are many others well-known strategy to lessen physical and cognitive deterioration as well as the psychological and social difficulties that come with growing older [3]. IGF-1 has been identified as one of the major mediators in the connection between brain function and physical activity. A neurotrophic and neuroprotective hormone, IGF-1 plays a role in neuronal survival, neurogenesis, and synaptic plasticity [9]. There is increasing evidence that IGF-1 levels are correlated with cognitive ability, despite the fact that they are not typically employed in clinical cognitive examinations. This is especially noticeable in areas linked to the hippocampus and prefrontal cortex, which are crucial for executive function. For instance, both young adults and the elderly have shown improved performance on tests of processing speed, memory, and attention when peripheral IGF-1 concentrations are higher [10].

Additionally, this experimental study has demonstrated that physical activity causes peripheral tissues to express and release IGF-1. This circulating IGF-1 can improve brain plasticity by overcoming the blood-brain barrier [11]. Even in communities of young people where cognitive impairment is not clinically evident, this mechanistic link lends credence to the use of IGF-1 as a biomarker of cognitive health and physical activity efficacy [5]. In this regard, it is indisputable that athletics and exercise are excellent countermeasures for reaching this challenging objective. However, it is also evident that there is a deficiency in physical exercise can hasten aging and the deterioration of physiological processes, particularly in cases of chronic illness [12]. Furthermore, skeletal muscle atrophy brought on by inactivity can impair Alzheimer's disease patients' cognitive abilities [13], nonetheless, resistance training can improve the physiological structure and function of the skeletal muscles [14].

Resistance exercise is widely recognized for its potential to improve athletic performance, its applicability to certain tasks, and its capacity to evaluate physical fitness. Notably, IGF-1 is a 70 amino acid peptide that shares 50 % sequence homology with insulin and 70 % homology with IGF-1 [15]. IGF-1's capacity to attach to the insulin receptor is justified by its comparable structure [16]. Resistance training is currently recommended for the prevention of cognitive impairment as a non-pharmacological therapy [17]. Although several randomized controlled trials (RCTs) have shown that resistance training can improve and delay behavior and cognition in Alzheimer's disease, most trials have focused on the effects of resistance training on brain structure and function, including cerebrovascular function and cerebral blood flow perfusion, brain structure, synaptic development, and neurotrophic factors, to elucidate the mechanisms by which resistance training improves cognitive function in Alzheimer's disease patients [18]. However, there is still limited information regarding which types of exercise, aerobic or resistance training, are more effective in increasing IGF-1 levels. Research on this topic is still limited. It is important to understand which exercises are effective in increasing IGF-1 levels. Therefore, the purpose of this study was to determine which types of exercise are most effective in acutely increasing IGF-1 levels in women with a sedentary lifestyle.

Research Methods

Study Design

Thirty-three female respondents were randomly selected and divided into three groups: resistance training (RT) group (n = 11), aerobic training (AT) group (n = 11), and control (CO) group (n = 11). The RT group underwent weight training according to a program determined by the researcher, and the AT group performed aerobic exercise on a treadmill according to a predetermined program, while the control group did nothing. Details of the exercise program will be further explained in the exercise intervention below.

Subjects

The Malang State Polytechnic of Health's ethical committee accepted this study, which was carried out in compliance with the Declaration of Helsinki. This study involved thirty-three healthy women (the subjects' characteristics are shown in Table 1). The researchers created inclusion and exclusion criteria to assess if volunteers met the study requirements. Subjects had to be between the ages of 18 and 26, have a normal body mass index (BMI), lead a sedentary lifestyle, do not smoke, have no history of cancer, cardiovascular disease, or musculoskeletal disorders, do not use dietary or ergogenic supplements, and be willing to participate in the study. According to the short form of the International Physical Activity Questionnaire (IPAQ), a sedentary lifestyle is defined as a physical activity level of less than 600 MET minutes per week [19]. Additionally, respondents were not required to engage in regular exercise. Participants under the age of eighteen were not permitted to participate in this study. Our study additionally eliminated respondents with hypertension who had abnormal blood pressure before exercise (systolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85 mmHg). Subjects were also excluded if they were taking nonsteroidal anti-inflammatory medicines (NSAIDs).

Pregnancy, starting a particular diet, using medication, and not wanting to continue the recommended exercise intervention (not attending all of the sessions) were all reasons for exclusion. A formal consent form was read and signed by each chosen participant. The study's thirty-three female volunteers were split up into three groups: eleven for resistance training (RT), eleven for aerobic training (AT), and eleven for control (CO). The study was conducted at a Fitness Center in Tulungagung City, East Java Province. Additionally, all participants were guided by certified professional fitness trainers during the exercise intervention.

Research Instruments

The following instruments we used include blood pressure, height, and weight measurements, data collection sheets, stationery, blood drawing equipment, treadmills, and gym equipment used for weight training.

Procedure

The data collection procedure in this study consisted of several steps. Subjects underwent a screening process before beginning the study. This approach was based on specific parameters that allowed information to be included or excluded from the analysis. Furthermore, they gave their informed agreement to take part in the research after being explained the research procedures. Out of the trial participants, three groups were chosen at random and split into treatment groups receiving resistance training and aerobic training interventions and a control group receiving no intervention.

Data collection was conducted over two days, beginning with information on the subjects' characteristics. Before the investigation, the subjects were not allowed to eat anything. Subjects were told to follow a typical diet and sleep schedule the day before the research. They were then instructed to warm up before exercising. Afterward, they engaged in physical activity, consisting combining moderate-intensity aerobic exercise and resistance training.

Before exercise, 3cc of blood was drawn as pretest data, and after exercise, 3cc of blood was drawn as post-test data. After that, the blood samples were centrifuged to separate the serum. After the centrifuge was completed, the blood serum was taken for laboratory analysis to examine IGF-1 expression. This laboratory analysis was carried out at the Physiology Science Laboratory Installation, Faculty of Medicine, University of Brawijaya, Malang. The method for examining IGF-1 expression used the ELISA (Enzyme-linked immunosorbent assay) method with Human IGF-1 reagents. Lastly, as a measure of responsibility, following the data review, the researchers prepared a written report of the research results.

Exercise Intervention

Resistance Training (RT) consists of group training sessions where participants receive instruction on exercise techniques and have their performance evaluated by trained professional trainers. Each training session lasts 60 minutes and is delivered acutely. A 10-minute warm-up, 40 minutes of core training, and a 10-minute cool-down precede the workout. Targeting both the upper and lower body, the 40-minute strength training session consists of three sets of ten exercises, such as the seated row, shoulder press, chest press, lateral pull-down, abdominal crunch, leg press, leg extension, triceps pushdown, and seated bicep curl. Each resistance exercise is carried out in compliance with the National Strength and Conditioning Association's criteria, which have been applied in earlier research [20]. Each exercise involved 8–10 repetitions in 3 sets, with 5–10 minutes of recovery between sets. The intensity of the exercise was 75–80 % of 1RM. Participants were assessed using seated leg presses and upper and lower body bicep curls to determine their 1RM. Participants were placed with their knees bent at a 90-degree angle following their leg press warm-up. After applying a conservative load to the machine, participants were told to completely extend their knees and repeat the process until they became tired. The weight was raised for sitting bicep curl participants in a range of 100 degrees, from full extension to fatigue. Due to the participants' inexperience and potential for harm, 1RM was calculated for each participant using a formula rather than being measured directly Brzycki, 1993: 1RM = (Total weight lifted (kg)/(102.78 — (002.78 × number of repetitions)).

Aerobic exercise (AE) consists of brisk walking on a treadmill at a speed of 5–6 km/h for 30 minutes. The intensity of the exercise is based on the maximum heart rate (HRmax) estimated for each participant using the following formula: HRmax = 208 — (0.7 × age) [22]. The intensity of the exercise starts at 65 % of HRmax and gradually increases to 75 % of HRmax during one training session.

The control group (CO) was asked to just sit and lie down at the designated research location. The only activities allowed were playing with cell phones, sitting, and walking to the bathroom in the designated area. Participants in this group were allowed to play with their cell phones and communicate with their groupmates to overcome boredom while waiting in line to have their blood drawn.

2. Statistical analysis

Following data collection, statistical analysis was performed using SPSS software. The data was subjected to a descriptive analysis in order to ascertain the mean and standard error. As a normalcy test, the Shapiro-Wilk test was also employed in this study. To determine if the data were normally distributed, a difference test was developed using the paired *t*-test methodology. The data was examined using the Wilcoxon signed-rank test, however the results showed differently.

3. Ethics

With registration number DP.04.03/F.XXI.30/00841/2025, we received ethical approval from the Malang Health Polytechnic Ethics Committee prior to data collection.

4. Results

This section presents statistics and information regarding the general description of the participants in Table 1. The characteristics of each group can be understood in detail from these statistics. Data are presented as mean ± standard deviation. There were no significant differences ($p > 0.05$) between the resistance training, aerobic training, and control groups based on the *t*-test results of this study.

Based on the normality test in Table 2, the IGF-1 data for all groups were normally distributed ($p > 0.05$). Therefore, the next test performed was a paired-samples *t*-test.

The results of the IGF-1 analysis between pre-test and post-test in each group are presented in Figure 2.

CONSORT flowchart

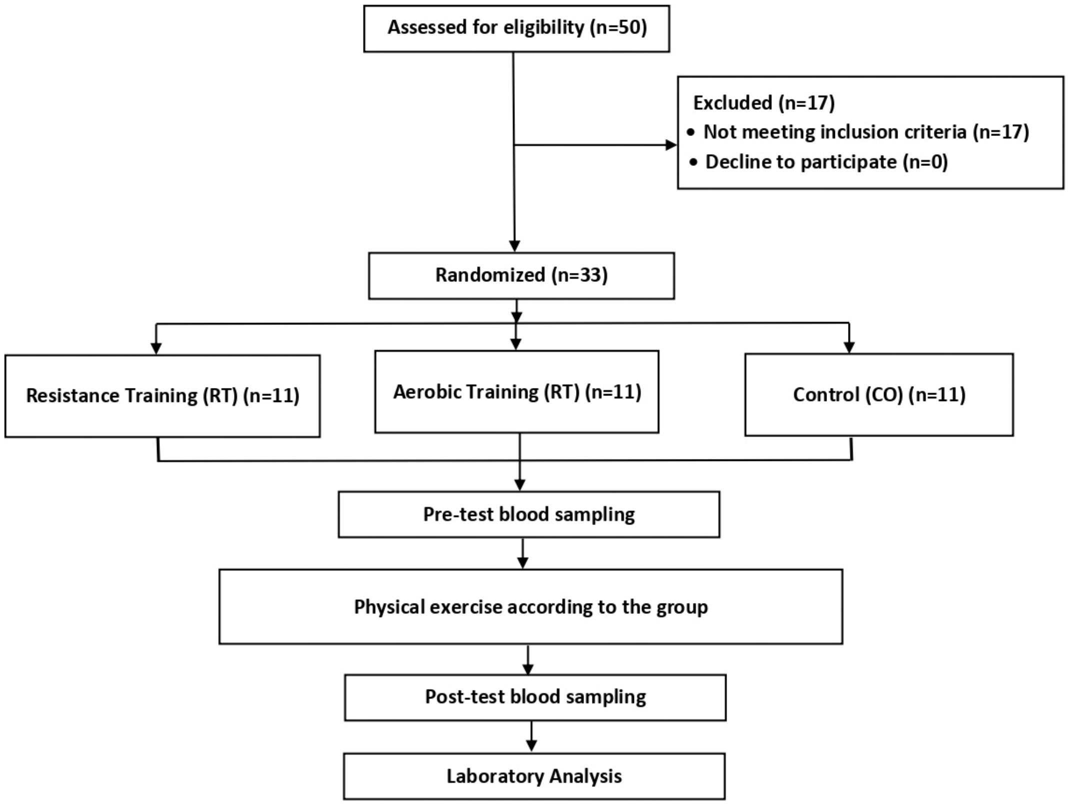

Fig. 1. The CONSORT flowchart
Рис.1. Блок-схема CONSORT

Table 1

Characteristics of research subjects

Таблица 1

Характеристики участников исследования

Data	Group	*N*	Mean ± SD	*p*-value
Age (y)	RT	11	20.18 ± 0.75	0.509
	AT	11	20.55 ± 2.16	
	CO	11	21.00 ± 1.67	
Height (cm)	RT	11	157.64 ± 4.15	0.510
	AT	11	155.00 ± 4.17	
	CO	11	156.91 ± 7.36	
Weight (kg)	RT	11	56.91 ± 6.64	0.325
	AT	11	54.36 ± 7.94	
	CO	11	52.27 ± 6.73	
BMI (kg/m^2)	RT	11	22.89 ± 2.45	0.386
	AT	11	22.59 ± 2.88	
	CO	11	21.32 ± 3.00	
Systolic (mmHg)	RT	11	115.73 ± 15.40	0.745
	AT	11	116.27 ± 8.41	
	CO	11	112.27 ± 14.67	
Diastolic (mmHg)	RT	11	77.36 ± 9.52	0.645
	AT	11	74.09 ± 10.26	
	CO	11	74.00 ± 8.71	

Table 2

Normality test results

Таблица 2

Результаты теста нормальности

Data	Group	Shapiro—Wilk	
		N	*p*-value
IGF-1	RT (Pre-test)	11	0.165
	RT (Post-test)		0.792
	AT (Pre-test)	11	0.256
	AT (Post-test)		0.801
	CO (Pre-test)	11	0.631
	CO (Post-test)		0.450

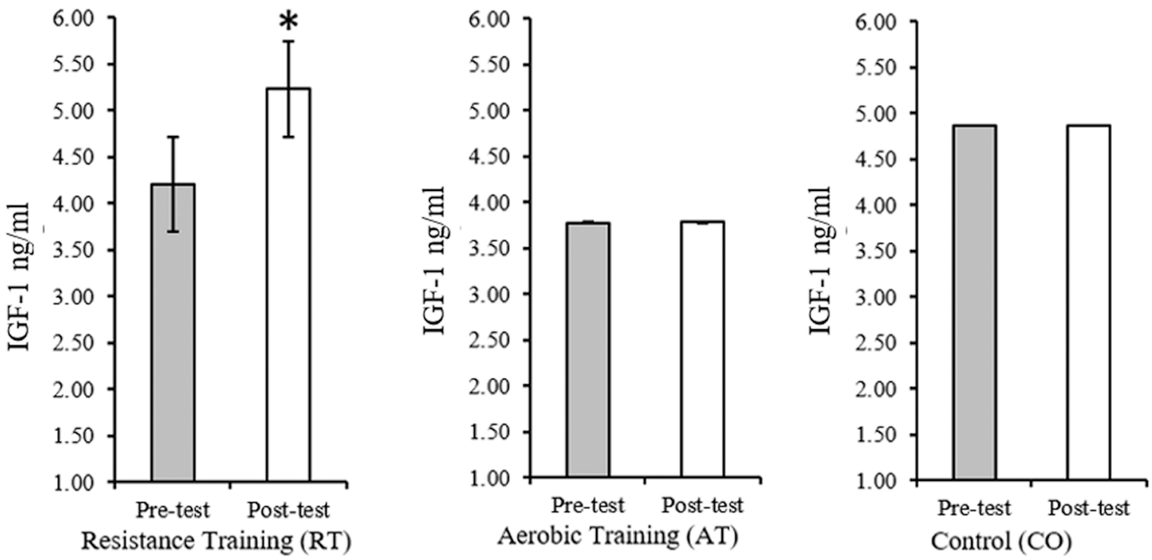

Fig. 2. Results of IGF-1 (ng/ml)
Рис. 2. Измерения ИФР-1 (нг/мл)

Table 3

Analysis of IGF-1 changes (ng/ml)

Таблица 3

Анализ изменений ИФР-1 (нг/мл)

Data	Group	Paired-Samples *t*-Test	
		Mean ± SD	*p*-value
IGF-1	RT (Pre-test)	4.21 ± 1.30	*0.012
	RT (Post-test)	5.23 ± 1.29	
	AT (Pre-test)	3.78 ± 1.10	0.975
	AT (Post-test)	3.79 ± 1.44	
	CO (Pre-test)	4.86 ± 0.74	0.987
	CO (Post-test)	4.86 ± 0.65	

Figure 2 shows that the RT group given the resistance training intervention significantly increased IGF-1 levels in women with a sedentary lifestyle (*$p < 0.05$).

Table 3 shows the results of the paired-samples *t*-test. Data are presented as mean ± standard deviation.

Information:

The group (AT) with aerobic exercise intervention and the control group (CO) did not show any significant difference between the pretest and posttest ($p > 0.05$), while the group (RT) with endurance exercise intervention showed a significant increase in IGF-1 levels between the pretest and posttest (*$p < 0.05$).

5. Discussion

This study sought to ascertain how acute strength training and aerobic exercise affected the rise in IGF-1 levels. The findings of this study indicate that resistance training acutely increases IGF-1 levels in inactive women ($p < 0.05$). Previous findings from resistance training in women performed three times a week for eight weeks support the findings of this study, which showed significant increases in IGF-1 levels [23]. IGF-1 levels were shown to increase significantly through resistance training three times a week for 16 weeks, according to findings from another study in women [24]. As shown by a previous study conducted on participants who received a twice-weekly physical exercise intervention for eight weeks, the findings showed that IGF-1 levels in the physical exercise intervention group increased, according to the data. However, this data compared three different forms of exercise: combination, aerobic, and strength training. An unexpected result was that the combination exercise group had the highest IGF-1 levels. This is interesting to study further to determine the best type of exercise to increase IGF-1 levels [25].

The results of this investigation, which demonstrate that weight training increases IGF-1 expression in comparison to aerobic exercise, are corroborated by the findings of other investigations [26]. As a result, this study discovered that the type of activity conducted affected the amount of IGF-1 expressed. Increased IGF-1 expression was also shown in another study that used resistance training interventions with 60-minute sessions for 12 weeks, three times a week [27]. This further supports the idea that resistance exercise is good for raising IGF-1. Being healthy and free of underlying medical issues is another factor that contributes to high IGF-1 levels. Research comparing the levels of IGF-1 in individuals with and without dementia revealed that the latter had higher amounts of the protein [28]. Research from Pierce et al., 2020 additionally verified that IGF-1 expression was markedly elevated by resistance exercise. We can therefore draw the conclusion that resistance training raises IGF-1 levels.

6. Molecular Mechanisms of Resistance Training Increase IGF-1 Levels

The best non-pharmacological method for enhancing health and averting disease is physical activity. Engaging in physical activity lowers the chance of brain illnesses as well as metabolic, cardiovascular, and chronic diseases. Physical exercise provides evidence that it can trigger improvements neuroplastic pathways and cognitive performance in numerous research [30]. Some diseases and their incidence rates include neurodegenerative diseases like Parkinson's and Alzheimer's, depression, schizophrenia, and addiction [31]. Researchers are still debating the exact mechanism by which exercise causes an elevation in IGF-1. Clear important information about intricate chemical events that take place within cells during exercise. The amount of ATP needed during exercise rises as activity does. The body uses physical exercise to handle oxidative and nitrosative stress, which are important procedures that produce and accumulate reactive nitrogen species (RNS) and reactive oxygen species (ROS). These systems are essential for cellular signaling, regulation, and balance maintenance [32]. As a physiological reaction, ROS will cause adenosine monophosphate-activated protein kinase (AMPK) to become active [33]. AMPK, an intracellular sensor that regulates ATP consumption, is the primary regulator of skeletal muscle metabolism [34].

The IGF-1/PI3K/Akt/mTOR signaling pathway can be efficiently activated by both resistance training and aerobic endurance training, which raises mTOR, IGF-1, and IGF-1R levels as well as PI3K and Akt activity [35]. Exercise has been shown to raise IGF-1 levels, according to a prior systematic review [36]. Insulin-like growth factor-1 (IGF-1) regulates cell survival, differentiation, and proliferation, all of which are essential for reversing organ failure brought on by illness [37]. Along with controlling skeletal muscle metabolism and regeneration, IGF-1 has also been connected to the development of muscular mass and strength [38]. Irisin, a myokine released from skeletal muscle during exercise, has been shown in recent decades to improve brain function. Heart function, energy expenditure, neuronal differentiation, proliferation, and neurobehavior are all impacted by central irisin. Its possible neurotrophic role is suggested by the stimulation of hippocampus genes linked to learning, memory, and neuroprotection by elevated peripheral irisin levels [39]. Irisin may mediate the health benefits of physical activity, according to certain theories. Strength and endurance exercise increases the expression of the fibronectin type III domain-containing protein 5 (FNDC5) gene in skeletal muscle, which raises peripheral irisin levels [40]. Brain-derived neurotrophic factor (BDNF) and other neuroprotective genes are expressed more frequently in the hippocampus is correlated with FNDC5 overexpression in the liver, which dramatically raises peripheral irisin levels [41]. This implies that peripheral FNDC5 overexpression might raise hippocampal BDNF expression, which could improve memory and learning through the BDNF pathway [41].

Neurotransmitters including IGF-1, BDNF, and irisin are produced by muscles during resistance exercise may also be able in order to communicate with the brain and influence brain function, according to recent data [42]. By lowering inflammation and improving physiological function and muscle strength, resistance training enhances cognitive function. Various studies Mcleod et al., 2024 and Van Vossel et al., 2024 when compared to no training, it has been shown that resistance exercise increases muscle mass, strength, and physical function (45,46). Additionally, it has been demonstrated that IGF-1 levels are elevated by weight training and facilitates its absorption into the brain, which in turn increases angiogenesis and neurogenesis [45]. The aforementioned results are mostly in line with other research demonstrating the value of resistance exercise in raising adult IGF-1 levels [46], and the rise in IGF-1 following exercise is caused by elevated growth hormone (GH) levels. Increased blood lactate levels during high-resistance exercise cause the brain to produce more growth hormone, which in turn causes an increase in IGF-1 secretion [46].

IGF-1 may play a major role in neurogenesis because of its beneficial effect on BNDF levels. This somewhat supports the conclusion above as well. GH can also improve IGF-1-mediated muscle adaptations and finish its biosynthesis [47], as a result, elevated GH during exercise may have some effect on the body's IGF-1 levels. Lastly, during exercise, estrogen may also have an impact on the release of hormones like growth hormone [48]. Strengthening muscles may cause more irisin to be released, raising BDNF and IGF-1 levels. This mechanism enhances insulin sensitivity, encourages the creation of new neurons, and lessens oxidative stress [49]. Accordingly, it has been demonstrated that resistance exercise causes a considerable increase in IGF-1.

7. Strength and Limitations

The strength of this study is that we used a randomized controlled trial, the most reliable scientific method, which eliminates the possibility of ambiguous cause-and-effect relationships. Furthermore, we discuss the limitations of our study, including the small sample size. We acknowledge that a larger sample size would provide a better understanding of the results. This is indeed a limitation of our study. Furthermore, our intervention focused only on resistance training and aerobic exercise; perhaps in the future, we could analyze the effects of combining exercise with other types of exercise, such as resistance training. Furthermore, our age justification focused only on those aged 18 to 26. Future studies could examine how exercise increases IGF-1 levels in those aged 30 and older or approaching old age. Furthermore, it would be important to examine how exercise affects people with cognitive impairment. This would allow for a more concrete understanding of how exercise impacts cognitive decline in these patients.

8. Conclusion

Resistance training has been shown to significantly increase IGF-1 levels in inactive women. An alternative form of exercise that can improve cognitive performance is resistance training, which has been shown to increase IGF-1 levels.

Author Contributions

Ayubi Novadri — conceptualization, methodology, data collection and interpretation, writing, project administration, and formal analysis.

Wibawa Junian Cahyanto — methodology, data collection and interpretation, writing, and visualization.

Sceisarriya Vega Mareta — data collection and interpretation, visualization, and formal analysis.

Dafun Jr. Procopio B. — methodology, editing, and visualization.

Вклад авторов

Аюби Новадри — концептуализация, методология, сбор и интерпретация данных, написание текста, администрирование проекта и формальный анализ.

Вибава Джуниан Кахьянто — методология, сбор и интерпретация данных, написание текста и визуализация.

Вега Марета Сцесаррия — сбор и интерпретация данных, визуализация и формальный анализ.

Прокопио Б. Дафун-младший — методология, редактирование и визуализация.

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