

The effect of a 30-day step-up and step-down exercise program with gradual duration on blood glucose reduction

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Abstract:

Global diabetes prevalence has risen to hundreds of millions, with the International Diabetes Federation (IDF) reporting several million cases in Indonesia since 2021. A significant challenge persists in identifying a physical exercise method that effectively reduces blood glucose levels and is readily accessible to the general populace. Therefore, this research aimed to investigate the impact of a 30-day step-up and step-down exercise program on blood glucose levels. A pre-experimental design was used, with seven participants subjected to the intervention over 30 days. The protocol consisted of the step-up and step-down exercise, with the duration gradually increasing over time to ensure progression. The Fasting Blood Glucose (FBG) test was administered before and after the intervention to assess the changes in blood glucose levels. Furthermore, data analysis was conducted using the Paired Sample T-Test, with SPSS version 25 adopted for statistical processing. The measurements before and after exercise intervention reported a statistically significant reduction in blood glucose levels, with a p-value of 0.025. The results showed that engaging in the step-up and step-down exercise over 30 days, with progressively increasing duration, was effective in reducing blood glucose levels. This form of physical exercise offered a practical and accessible option for individuals aiming to prevent or manage diabetes, provided blood glucose levels were below 300 mg/dL or with approval from a healthcare professional. The research showed the potential of simple physical exercise in diabetes management, reporting the importance of regular exercise as part of a comprehensive method for health.

Keywords: *exercise and blood glucose control; step exercise program; diabetes and exercise*

Introduction

Diabetes mellitus is a chronic metabolic disease with increasing prevalence worldwide. According to the International Diabetes Federation (IDF), approximately 537 million individuals worldwide have diabetes. The latest IDF survey, conducted in 2021, showed that the number of cases in Indonesia was 19,465,102 (International Diabetes Federation, 2021). This increasing number is a very important and urgent issue that requires immediate attention, considering the impact on individuals' health as well as the country's quality of life and economy. In Indonesia, efforts to reduce the number of cases are a challenge for the government, the community, and healthcare professionals.

Diabetes occurs due to disturbances in glucose metabolism, resulting in high levels (Mistry et al., 2023; Oliver, 2023; Shah et al., 2024). This excess blood glucose is caused by excessive consumption of sugar-containing foods and disruptions in the process of converting blood glucose into energy due to an imbalance in the insulin hormone (Korytko et al., 2025; Macfarlane et al., 2024; Mellem et al., 2024). The condition is increased through excessive consumption of high-sugar foods in modern society, often accompanied by a less active lifestyle. The ineffectiveness of insulin in converting blood glucose into energy necessitates a more holistic method, even though excessive sugar consumption can be controlled through a healthier diet.

Insulin is a hormone produced by the pancreas and plays a crucial role in helping the body convert blood glucose into energy. In diabetes patients, the body's sensitivity decreases, leading to uncontrolled increases in blood glucose levels (Aye, 2021; Faridi, 2023; Maidaniuk et al., 2024). Therefore, strategies to improve insulin sensitivity are crucial in efforts to reduce blood glucose levels in diabetes patients.

An effective method proven to enhance insulin sensitivity is regular physical activity. Previous research have shown that physical exercise can enhance insulin's ability to convert blood glucose into energy (Adi et al., 2022; Ajith & Meera, 2023; Goktas & Ersoy, 2023). Exercise that includes large muscle groups and moderately heavy loads, such as resistance training, can improve blood glucose metabolism (Park et al., 2017; Seo et al., 2021; Yagiz et al., 2022; Zouita et al., 2023). Despite the abundant evidence on the benefits of physical activity,

only a few individuals can immediately adapt to high-intensity exercise. Individuals with sedentary lifestyles may struggle to initiate and maintain consistency in regular exercise. In this context, a more adaptive and gradual method acceptable to all groups is needed. The step-up and step-down exercise program constitutes an adaptable method featuring progressively extended exercise durations from 3 to 30 minutes, designed to promote the body's gradual physiological adjustment. The program is designed to provide a solution for individuals desiring to increase physical activity without feeling burdened by high exercise duration and intensity. Therefore, this research aims to explore the effect of a gradual step-up and step-down exercise program on lowering blood glucose levels. The uniqueness lies in the adjustment of exercise duration, allowing individuals to adapt more easily and effectively. Other advantages of exercise include flexibility, the ability to be performed at home, weather independence, and relatively low cost. The program is accessible to many individuals as a sustainable alternative in managing diabetes. This research holds substantial importance by stating the mechanisms through which incremental physical exercise can affect a reduction in blood glucose levels among diabetes patients. Furthermore, the formulation of more equitable and cost-effective strategies has been reported for diabetes prevention and management, benefiting the wider community.

Materials & Methods

Procedure

A pre-experimental design with a one-group pretest-posttest method was used to measure changes in participants' blood glucose levels before and after exercise intervention. Blood glucose levels were measured as baseline data (pre-test) before the intervention. After participants were subjected to the 30-day step-up and step-down exercise program, blood glucose levels were remeasured (post-test). Subsequently, the comparison before and after the intervention was analyzed to evaluate the impact of exercise on reducing blood glucose levels.

During the exercise program, participants were not permitted to change eating habits. This was conducted to ensure the recorded changes were influenced by the effect of physical exercise, and not by other external factors such as dietary changes. Therefore, controlling for dietary factors ensured that the results were more accurate and reflective of physical exercise on blood glucose levels. This step-up and step-down exercise program was implemented for 30 days, divided into 6 weeks. Exercise was conducted Monday through Friday, with Saturday and Sunday allocated for rest and recovery. In addition, the duration was gradually increased, from 3 to 30 minutes on the last day. This duration adjustment allowed the participants to gradually adapt to the increased intensity. Table 1 shows the distribution of exercise duration from the first to the last day of the program.

Table 1 Division of Exercise Duration Progression

Duration	Days
3 minutes	1–3
6 minutes	4–6
9 minutes	7–9
12 minutes	10–12
15 minutes	13–15
18 minutes	16–18
21 minutes	19–21
24 minutes	22–24
27 minutes	25–27
30 minutes	28–30

Each session was performed at an intensity appropriate to the stage, ranging from light to intense exercise at the end of the program. This step-up and step-down program was designed to maximize the effectiveness of exercise without overburdening participants, with the goal of gradually and safely lowering blood glucose levels.

Variables

The independent variable was the step-up and step-down exercise performed over 30 days with a progressively increasing duration. Meanwhile, the dependent variable was blood glucose levels. This research aimed to determine the impact of a 30-day step-up and step-down exercise intervention, implemented with progressively extended durations, on blood glucose levels among human participants.

Participants

The participants totaled 10 individuals determined based on several factors, including willingness to engage, the management of the research, and the financial resources available. The selected participants were in good health and capable of engaging in physical activity. This was performed to avoid potential risks because of poor health or physical condition, since exercise could be strenuous for participants not accustomed to the activity. Table 2 shows the characteristics of the participants.

Table 2 Participant Characteristics

No.	Characteristics	Number of individuals
1	Male	10 individuals
2	Age	
	24 years	1 individual
	25 years	4 individuals
	26 years	1 individual
	27 years	1 individual
	28 years	1 individual
	29 years	2 individuals

The participation of the participants was based on a mutually beneficial relationship. Compensation with cash was carried out as reimbursement during the exercise program. Before participation, the participants showed explicit consent and assented to adhere to all research regulations. This was documented through a form comprehensively outlining the objectives, potential hazards, anticipated benefits, assurances of confidentiality, and fundamental rights. The research was conducted in accordance with the ethical guidelines and received approval from the Ethics Committee of Brawijaya University, Indonesia, under approval number 143/EC/KEPK-UM/04/2024. During the intervention, 3 participants were eliminated for not adhering to the regulations, including missing several exercise sessions and consuming foods or drinks. Therefore, the data analyzed were derived from the 7 participants who completed the exercise program and complied with the regulations.

Research Instruments

The instrument used to measure blood glucose levels was the Fasting Blood Glucose (FBG) test. This test was conducted after fasting for 8 to 12 hours, with blood samples taken in the morning before breakfast. FBG was selected as the instrument for measuring blood glucose levels. Additionally, the instrument was recognized as the primary test for diagnosing diabetes mellitus and prediabetes, as endorsed by the World Health Organization (WHO) and the American Diabetes Association (ADA). FBG was also an accurate, simple, cost-effective, and efficient blood glucose test method, requiring a short amount of time.

Statistical Analysis

The data obtained consisted of measurements of participants' blood glucose levels before and after the step-up and step-down exercise over 30 days. Analysis was conducted using a paired sample t-test to assess the difference in blood glucose levels between the two measurements. Before performing the t-test, the data were assessed for normality using the Shapiro-Wilk test in SPSS version 25.

Results

Table 3 shows the measurement results of participants' blood glucose levels taken before and after the step-up and step-down exercise program.

Table 3 Test Results

Participant	Pre-Test (mg/dL)	Post-Test (mg/dL)
Participant 1	137	89
Participant 2	105	95
Participant 3	102	95
Participant 4	105	103
Participant 5	125	102
Participant 6	100	81
Participant 7	106	86

The data showed that the post-test values were lower than the pre-test values. Lower post-test values suggested a reduction in participants' blood glucose levels. However, this observation was not sufficient since a comparison test was necessary to assess the statistical significance of the reduction in blood glucose levels among the participants.

Normality Test

Table 4 Normality Test

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-Test	0.25	7	0.20	0.93	7	0.57
Post-Test	0.15	7	0.20	0.96	7	0.79

The normality test results showed a significance value of 0.57 and 0.79 for the pre-test and post-test, respectively. These significance values greater than 0.05 reported that the pre-test and post-test data were normally distributed. A paired sample t-test was performed for comparison, considering the normally distributed data.

Comparison Test

Table 5 Paired Sample Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	107.57	7	19.59	7.41
	Post-Test	89.86	7	10.99	4.15

Table 6 Comparison Test Results Using The Paired Sample T-Test

		Paired Differences		Std. Error Mean	95% Interval of the Difference		t	f	Sig. (2-tailed)
		Mean	Std. Deviation		Lower	Upper			
Pair 1	Pre-Test – Post-Test	17.71	15.84	5.99	3.06	32.36	2.96	6	0.03

Table 6 shows that the significance value is 0.03. The p-value less than 0.05 reported a significant difference between blood glucose levels before and after completing exercise. Therefore, the step-up and step-down exercise was effective in lowering blood glucose levels when performed consistently over 30 days with a gradual increase in duration.

Dicussion

The results show that the step-up and step-down exercise, conducted over 30 days with a gradual increase, can significantly reduce blood glucose levels. This is supported by the paired sample t-test results, where the p-value of 0.03, less than 0.05, shows a significant difference in blood glucose levels before and after exercise intervention.

The reduction in blood glucose levels occurs due to regular physical activity. The results show that regular physical activity increases insulin sensitivity, facilitating the conversion of blood glucose into energy (Bakara & Kurniyati, 2022; Bistara et al., 2022; Sukkriang et al., 2021). Therefore, regularly performing the step-up and step-down exercise can help reduce blood glucose levels.

A deeper observation shows that exercise includes large muscles, particularly the legs, supporting the entire body weight (Branch et al., 2022; Kume et al., 2022a, 2022b; Kuo et al., 2021). Naturally, engaging large muscles in the step-up and step-down exercise requires a significant amount of energy. Insulin will need a large amount of blood glucose to be converted into energy. The results suggest that endurance exercise has an impact on optimizing insulin function (Yaping et al., 2020). Maintaining consistent movement during the step-up and step-down exercise for an extended duration poses a significant challenge. Exercise performed for an extended duration includes individuals' physical stamina (Prieto-González & Sedlacek, 2022; Sun, 2023; Zrzavy et al., 2021). The step-up and step-down activity performed in this research is considered an endurance exercise. In line with previous research, exercise reduces blood glucose levels when performed for a duration of 30 minutes. The entire procedure can be carried out by the general community as a method of preventing or curing diabetes. Individuals who have not experienced exercise for 30 minutes face challenges and mental pressure (Guszkowska & Wójcik, 2021; Han, 2021; Kaplan & Andre, 2021). Therefore, the gradual duration adjustment serves as a solution for the community to build up to the 30-minute exercise duration. Several results have proven that gradual physical exercise reduces the mental pressure needed to perform physical activity (Kalb et al., 2020; Portela-Pino et al., 2021; Silva et al., 2024).

This research has limitations since only 7 participants were available for analysis. Furthermore, some participants were eliminated for not adhering to the regulations. Future research should include a larger sample size and participants who can effectively participate, as well as a control group to provide a more substantial comparison. The results should be shared with the community to aid diabetes prevention and management. Active mediation must also be conducted with the Indonesian Ministry of Health and healthcare institutions in providing education and supporting the community to implement step-up and step-down exercise.

Conclusions

In conclusion, the step-up and step-down exercise performed for 30 days significantly reduced blood glucose levels. The paired t-test results reported a p-value of 0.03, below the 0.05 threshold, showing a significant difference between blood glucose levels before and after exercise. The results suggested that the step-

up and step-down exercise program had the potential to be an effective intervention in lowering blood glucose levels. This contributed to diabetes prevention or management in both diagnosed and high-risk individuals. In a practical context, the step-up and step-down exercise was an easily accessible alternative for improving physical fitness without the need for specialized equipment. This exercise offered flexibility in terms of time and intensity, allowing individuals to start with a shorter duration before increasing to 30 minutes. Therefore, exercise was suitable for individuals who were not accustomed to intensive physical activity, facilitating adaptation to a healthier lifestyle change.

From a theoretical perspective, the results supported previous research reporting the importance of physical exercise in improving insulin sensitivity and converting blood glucose into energy. This research added a new dimension by showing the effectiveness of performing the step-up and step-down exercise in reducing blood sugar levels. The result expanded the literature on diabetes management through physical interventions acceptable to a wider population.

Several limitations could be reported, even though the results were promising. First, this research was conducted with only one group of participants, without a control group, which affects the generalizability of the results. Second, other factors such as stress levels, sleep quality, and genetic factors were not fully controlled since participants were not allowed to change diets. This research implied that the step-up and step-down exercise program could be adopted as part of a more accessible and affordable diabetes prevention and management strategy. The program served as an effective solution in communities without easy access to exercise facilities, or requiring a gradual method to initiate physical activity. Therefore, health professionals must consider the program as part of an exercise-based intervention to reduce diabetes rates.

Future research are recommended to conduct further trials with more rigorous experimental designs, such as using control groups and expanding the participant sample to increase the validity and generalizability of the results. Furthermore, the long-term impact of the step-up and step-down exercise on diabetes management and other factors can also be investigated. This research provides strong preliminary evidence that gradually performing the step-up and step-down exercise can be an effective method for lowering blood glucose levels. Practical and theoretical contributions are also offered to diabetes prevention and management.

Conflicts of interest - There are no potential conflicts of interest relevant to this article.

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References:

- Adi, S., Supriyadi, Masgumelar, N. K., & Fathoni, A. F. (2022). Development of gross motor skills exercise models and physical activities to enhance the physical fitness of elementary school students. *Journal of Physical Education and Sport*, 22(12), 2947–2954. <https://doi.org/10.7752/jpes.2022.12372>
- Ajith, A., & Meera, M. (2023). Effects of 12 -week home - based aerobic exercise on insulin resistance and body composition among polycystic ovary syndrome. *International Journal of Health Sciences*, 32(2), 1254–1259. <https://doi.org/10.53730/ijhs.v6ns10.13909>
- Aye, P. O. (2021). Mathematical Analysis of the Effect of Control on the Dynamics of Diabetes Mellitus and Its Complications. *Earthline Journal of Mathematical Sciences*, 6(2), 375–395. <https://doi.org/10.34198/ejms.6221.375395>
- Bakara, D. M., & Kurniyati. (2022). Self-Management Education to Control Blood Sugar Levels and HbA1c Value for Type 2 Diabetes Patients. *Malaysian Journal of Nursing*, 14(1), 84–89. <https://doi.org/10.31674/mjn.2022.v14i01.012>
- Bistara, D. N., Wardani, E. M., Susanti, Santoso, A. P. R., Fasya, A. H. Z., & Andini, A. (2022). The effect of discharge planning on the stability of blood sugar levels in type 2 diabetes mellitus patients. *Bali Medical Journal*, 11(3), 1180–1184. <https://doi.org/10.15562/bmj.v11i3.3537>
- Branch, A., Palbapang, W., & Veni Fatmawati, Y. (2022). The Effect of Four Square Step Exercise and Ankle Strategy Exercise on Improving the Balance of the Elderly in. *Urecol Journal. Part D: Applied Sciences*, 2(2), 53. <https://doi.org/10.53017/uja.194>
- Faridi, T. A. (2023). Dietary Modifications in Patients with Polycystic Ovary Syndrome: A Public Health Concern. *Pakistan BioMedical Journal*, 6(2), 25–26. <https://doi.org/10.54393/pbmj.v6i02.845>
- Goktas, O., & Ersoy, C. (2023). The Effect of Regular Exercise and its Duration on Metabolic Parameters. *Journal of the College of Physicians and Surgeons Pakistan*, 33(11), 1330–1332. <https://doi.org/10.29271/jcpsp.2023.11.1330>
- Guszkowska, M., & Wójcik, K. (2021). Effect of mental toughness on sporting performance: review of studies. In *Baltic Journal of Health and Physical Activity* (Vol. 13, Issue 7, pp. 1–12). Gdansk University of Physical Education and Sport. <https://doi.org/10.29359/BJHPA.2021.Suppl.2.01>
- Han, F. (2021). Research on the relationship between sports scientific training and athletes' mental health. *Revista Brasileira de Medicina Do Esporte*, 27(5), 485–489. https://doi.org/10.1590/1517-8692202127042021_0096

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- International Diabetes Federation, (IDF). (2021). *Key Information*. International Diabetes Federation (IDF).
<https://doi.org/10.1515/9780691234427-010>
- Kalb, R., Brown, T. R., Coote, S., Costello, K., Dalgas, U., Garmon, E., Giesser, B., Halper, J., Karpatkin, H., Keller, J., Ng, A. V., Pilutti, L. A., Rohrig, A., Van Asch, P., Zackowski, K., & Motl, R. W. (2020). Exercise and lifestyle physical activity recommendations for people with multiple sclerosis throughout the disease course. *Multiple Sclerosis Journal*, 26(12), 1459–1469.
<https://doi.org/10.1177/1352458520915629>
- KAPLAN, E., & ANDRE, H. (2021). Investigation of the relationship between mental training and sports injury anxiety. *Turkish Journal of Sport and Exercise*, 23(1), 1–8.
<https://dergipark.org.tr/en/pub/tsed/article/692936%0Ahttps://dergipark.org.tr/en/download/article-file/979056>
- Korytko, Z., Maistruk, M., Pavlyuk, Y., Pavlyuk, O., Rudnichenko, M., Chopyk, T., Haiduk, O., Andriichuk, O., Shevchuk, T., & Korobko, L. (2025). The use of physical rehabilitation for the recovery of patients with hypertension associated with diabetes mellitus. *Journal of Physical Education and Sport*, 25(2), 302–310.
<https://doi.org/10.7752/jpes.2025.02034>
- Kume, D., Nishiwaki, M., Takahara, R., & Hotta, N. (2022a). The effectiveness of bench step exercise for ameliorating acute mental stress-induced arterial stiffening. *European Journal of Applied Physiology*, 122(8), 1875–1884. <https://doi.org/10.1007/s00421-022-04962-y>
- Kume, D., Nishiwaki, M., Takahara, R., & Hotta, N. (2022b). Three-minute bench step exercise as a countermeasure for acute mental stress-induced arterial stiffening. *PLoS ONE*, 17(12), 1–9.
<https://doi.org/10.1371/journal.pone.0279761>
- Kuo, Y. C., Chang, D. Y., & Liao, Y. H. (2021). Twelve-weeks of bench-step exercise training ameliorates cardiopulmonary fitness and mood state in patients with schizophrenia: A pilot study. *Medicina (Lithuania)*, 57(2), 1–11. <https://doi.org/10.3390/medicina57020149>
- Macfarlane, M. A., Novaes, L., Scartoni, F., Fortes, M., Perrot, A., & Mello, D. (2024). Parkinson's disease and golf: The effects of golf on functional capacity, physical abilities, and quality of life. *Journal of Physical Education and Sport*, 24(6), 1524–1534. <https://doi.org/10.7752/jpes.2024.06172>
- Maidaniuk, O., Vdovenko, N., Rossokha, H., & Husarova, A. (2024). Dynamics of insulin and glucose changes during early recovery after physical load in elite athletes. *Journal of Physical Education and Sport*, 24(11), 2034–2039. <https://doi.org/10.7752/jpes.2024.11301>
- Mellem, L. J., Mellem, R. H., Chagas, H. V., Barbalho, S. M., Haber, J. F. D. S., Detregiachi, C. R. P., & Chagas, E. F. B. (2024). Influence of physical activity and body mass index to gestational diabetes risk: A cross-sectional observational study. *Journal of Physical Education and Sport*, 24(7), 1750–1760.
<https://doi.org/10.7752/jpes.2024.07195>
- Mistry, S., Gouripeddi, R., & Facelli, J. C. (2023). 297 Identifying Opportunities and Challenges for Translational Informatics Approaches to Real-World Data: A Diabetes Case Study. *Journal of Clinical and Translational Science*, 7(s1), 89–89. <https://doi.org/10.1017/cts.2023.352>
- Oliver, N. (2023). Diabetes Therapy Podcast: Real-World Data for Glucose Sensing Technologies in Type 1 Diabetes. In *Diabetes Therapy* (Vol. 14, Issue 1, pp. 1–10). Adis. <https://doi.org/10.1007/s13300-022-01331-y>
- Park, H. S., Lee, K. T., & Kim, T. W. (2017). Role of physical activity in mortality prediction in elderly hospice patients. *Journal of Exercise Rehabilitation*, 13(2), 250–254. <https://doi.org/10.12965/jer.1734950.475>
- Portela-Pino, I., Valverde-Esteve, T., & Martínez-Patiño, M. J. (2021). Age as a determining variable in the practice or abandonment of physical exercise among young people. *PLoS ONE*, 16(6), 1–10.
<https://doi.org/10.1371/journal.pone.0253750>
- Prieto-González, P., & Sedlacek, J. (2022). Effects of Running-Specific Strength Training, Endurance Training, and Concurrent Training on Recreational Endurance Athletes' Performance and Selected Anthropometric Parameters. *International Journal of Environmental Research and Public Health*, 19(17), 1–17.
<https://doi.org/10.3390/ijerph191710773>
- Seo, M. W., Jung, S. W., Kim, S. W., Lee, J. M., Jung, H. C., & Song, J. K. (2021). Effects of 16 weeks of resistance training on muscle quality and muscle growth factors in older adult women with sarcopenia: A randomized controlled trial. *International Journal of Environmental Research and Public Health*, 18(13), 1–13. <https://doi.org/10.3390/ijerph18136762>
- Shah, B. R., Austin, P. C., Ivers, N. M., Katz, A., Singer, A., Sirski, M., Thiruchelvam, D., & Tu, K. (2024). Risk Prediction Scores for Type 2 Diabetes Microvascular and Cardiovascular Complications Derived and Validated With Real-world Data From 2 Provinces: The DIabeteS COmplications (DISCO) Risk Scores. *Canadian Journal of Diabetes*, 48(3), 188–194.e5. <https://doi.org/10.1016/j.cjcd.2023.12.009>
- Silva, A. M., Estriga, M. L., Graça, A., Macphail, A., & Batista, P. (2024). Enhancing high school students' engagement in physical activity through a fitness education model in physical education. *Journal of Physical Education and Sport*, 24(12), 2048–2059. <https://doi.org/10.7752/jpes.2024.12303>
-

- Sukkriang, N., Chanprasertpinyo, W., Wattanapisit, A., Punsawad, C., Thamrongrat, N., & Sangpoom, S. (2021). Correlation of body visceral fat rating with serum lipid profile and fasting blood sugar in obese adults using a noninvasive machine. *Heliyon*, 7(2), 1–7. <https://doi.org/10.1016/j.heliyon.2021.e06264>
- Sun, X. (2023). Physical Fitness of Athletes Under Endurance Training. *Revista Brasileira de Medicina Do Esporte*, 29(2), 1–4. https://doi.org/10.1590/1517-8692202329012022_0530
- Yagiz, G., Akaras, E., Kubis, H. P., & Owen, J. A. (2022). The Effects of Resistance Training on Architecture and Volume of the Upper Extremity Muscles: A Systematic Review of Randomised Controlled Trials and Meta-Analyses. In *Applied Sciences (Switzerland)* (Vol. 12, Issue 3, pp. 1–21). MDPI. <https://doi.org/10.3390/app12031593>
- Yaping, X., Huifen, Z., Chunhong, L., Fengfeng, H., Huibin, H., & Meijing, Z. (2020). A meta-analysis of the effects of resistance training on blood sugar and pregnancy outcomes. *Midwifery*, 91(1), 1–10. <https://doi.org/10.1016/j.midw.2020.102839>
- Zouita, A., Darragi, M., Bousselmi, M., Sghaier, Z., Clark, C. C. T., Hackney, A. C., Granacher, U., & Zouhal, H. (2023). The Effects of Resistance Training on Muscular Fitness, Muscle Morphology, and Body Composition in Elite Female Athletes: A Systematic Review. In *Sports Medicine* (Vol. 53, Issue 9, pp. 1709–1735). Springer Science and Business Media Deutschland GmbH. <https://doi.org/10.1007/s40279-023-01859-4>
- Zrzavy, T., Pfitzner, A., Flachenecker, P., Rommer, P., & Zettl, U. K. (2021). Effects of normobaric hypoxic endurance training on fatigue in patients with multiple sclerosis: a randomized prospective pilot study. *Journal of Neurology*, 268(12), 4809–4815. <https://doi.org/10.1007/s00415-021-10596-5>