



Rosella flower extract (*Hibiscus sabdariffa*) has no significant impact on lowering blood glucose levels in healthy men after physical activity

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ABSTRACT

Purpose of the study: This study aims to analyze rosella flower extract supplementation on blood glucose levels after physical activity.

Methods: This experimental research uses a pre and post control group design. Subjects were selected using purposive sampling technique. A total of 20 healthy men aged 19–25 years participated in this study and were divided into two groups, namely group K1 with placebo and K2 with rosella flower extract at a dose of 500 mg. Data collection begins with collecting data on subject characteristics. Next, the subjects were asked to warm up and do physical activity in the form of running 2400 meters with moderate intensity. One hour after running 2400 meters, the subject took a pre-test blood draw to measure blood glucose levels. Then the samples were given supplementation intervention based on their respective groups, K1 by giving a placebo and K2 by giving rosella flower extract at a dose of 500 mg. 60 minutes after administering the supplementation intervention, the subject underwent a post-test blood draw.

Results: The results of this study showed that there was no decrease in blood sugar levels in either the control or treatment groups ($p > 0.05$).

Conclusion: It can be concluded that administering rosella flower extract after physical exercise does not have a significant effect on reducing post-exercise blood glucose levels.

Keywords: glucose homeostasis, insulin sensitivity, healthy adults, glucose uptake

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Экстракт цветков розеллы (*Hibiscus sabdariffa*) не оказывает значительного влияния на снижение уровня глюкозы в крови у здоровых мужчин после физической нагрузки

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РЕЗЮМЕ

Цель исследования: изучить влияние приема экстракта цветков розеллы на уровень глюкозы в крови после физической нагрузки.

Материалы и методы. В данном экспериментальном исследовании использовался дизайн с контрольной группой до и после. Субъекты были отобраны с помощью метода целенаправленной выборки. В исследовании приняли участие 20 здоровых мужчин в возрасте 19–25 лет, которые были разделены на две группы: группа K1, принимавшая плацебо, и группа K2, принимавшая экстракт цветков розеллы в дозе 500 мг. Сбор данных начинается со сбора данных о характеристиках субъектов. Затем субъектам было предложено размяться и выполнить физическую нагрузку в виде бега на 2400 метров с умеренной интенсивностью. Через час после пробежки на 2400 метров у испытуемых был взят предварительный анализ крови для измерения уровня глюкозы в крови. Затем испытуемым были даны добавки в соответствии с их группами: K1 получила плацебо, а K2 — экстракт цветков розеллы в дозе 500 мг. Через 60 минут после приема добавок у испытуемых был взят повторный анализ крови.

Результаты: ни в контрольной, ни в экспериментальной группах не было снижения уровня сахара в крови ($p > 0,05$).

Заключение: прием экстракта цветков розеллы после физических упражнений не оказывает значительного влияния на снижение уровня глюкозы в крови после тренировки.

Ключевые слова: глюкозный гомеостаз, чувствительность к инсулину, здоровые взрослые, усвоение глюкозы

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Для цитирования: Экстракт цветков розеллы (*Hibiscus sabdariffa*) не оказывает значительного влияния на снижение уровня глюкозы в крови у здоровых мужчин после физической нагрузки. Аюби Н., Куснаник Н.В., Вибава Дж.К., Калликсте С., Дафун П.Б. Мл., Бени А.О.Н., Марио Д.Т., Ильхам И., Комаини А., Юльфадината А. *Спортивная медицина: наука и практика*. 2025;15(4):45–52. <https://doi.org/10.47529/2223-2524.2025.4.6>

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1. Introduction

Diabetes mellitus is a serious problem that must be addressed immediately throughout the world. The reason people can suffer from diabetes mellitus is because they do not maintain a good diet, are overweight, obese, have high triglyceride levels, and hypertension in both women and men [1]. There are common factors that can influence people to get diabetes mellitus including smoking, unhealthy diet, sedentary lifestyle, sedentary, lack of exercise, elevated blood

sugar, and cholesterol will all have a detrimental effect on people's health if they are not treated [2]. American Diabetes Association in 2022 argues that type 2 diabetes mellitus is also a serious diabetic disease characterized by the condition of the body experiencing hyperglycemia due to the progressive loss of insulin hormone production due to insulin resistance. According to predictions from the International Diabetes Federation, 10.5 % of people will have diabetes in 2021; this number will rise to 11.3 % in 2030 and 12.2 % in

2040 (Magliano, 2021). Individuals diagnosed with diabetes mellitus are more susceptible to organ dysfunction and failure, particularly involving the kidneys, eyes, and nerves. This can lead to a lower quality of life and greater medical examination and treatment costs [5].

In the last 30 years, exercise has become the best preventive effort to improve the health status of the community, especially people with diabetes mellitus by increasing lowering blood glucose levels and improving insulin sensitivity [6]. Another beneficial effect of exercise is that it improves cardiovascular health and keeps the body fit [7]. The recommended physical exercise for patients with diabetes mellitus is 150 minutes per week of moderate to vigorous intensity [8]. In addition to moderate-intensity exercise, people with diabetes mellitus are also recommended to do resistance training 2x workouts per week to maintain blood glucose levels [9]. Exercise is known as the best way to control blood glucose levels in patients with type 2 diabetes mellitus [10].

Rosella is a plant with the name *Hibiscus sabdariffa* which is native to India and Malaysia which is extensively grown throughout the world's tropical and subtropical climates, including Africa and Asia [11]. Research evidence shows that rosella flowers contain remarkable benefits, its pharmacological effects can prevent hypertension and hyperlipidemia, and it also has anti-inflammatory, antimicrobial, antidiuretic, and anemia treatment effects [12]. Interesting potential bioactive compounds with antibacterial, anti-inflammatory, hypocholesterolemic, antihypertensive, antioxidant, and anticarcinogenic properties have been found in rosella petals. Furthermore, rosella petals are abundant in polyphenols and flavonoids, which are antioxidants that can counteract free radicals, according to numerous scientific research [11]. Due to its antioxidant effects, researchers are interested in conducting experiments related to the pharmacological effects of rosella flower extract and physical exercise on reducing blood glucose levels. Previous research has demonstrated that giving rosella flower tea to people with diabetes mellitus for seven days in a row significantly lowers their blood glucose levels [13].

The exact effect of the combination of physical exercise and administration of rosella extract on reducing blood glucose levels is still unknown. This study aims to analyze rosella flower extract supplementation on blood glucose levels after physical activity.

Research Methods

Study Design

This experimental research uses a pre and post control group design. Subjects were selected using purposive sampling technique. Purposive sampling is used as a subject selection technique based on certain criteria that have been determined according to the research objectives, so that the selected subjects are considered the most representative to answer the research hypothesis. The study subjects were divided into two groups: group K1 with a placebo and group

K2 with a 500 mg rosella flower extract supplement. The supplements were administered in capsule form, purchased from Kimia Farma, a leading pharmaceutical manufacturer in Indonesia. All dosages were in accordance with the manufacturer's complete standard operating procedures for manufacturing and administration. The placebo contained unflavored flour.

Subjects

Twenty men in normal health condition without any medical condition who had undergone health screening participated in this study (Table 1 shows the characteristics of the subjects). To determine whether volunteers could meet the needs of this study, inclusion and exclusion criteria were established. Students with a normal Body Mass Index (BMI) between the ages of 19 and 25 years were included in the inclusion criteria. Additionally, students may not exercise regularly. In addition, this study did not involve participants who were under 20 years of age or who had high blood pressure before engaging in physical activity. Additionally, if subjects were taking nonsteroidal anti-inflammatory drugs (NSAIDs), they were excluded. 20 research volunteers were divided into 2 groups, namely the physical exercise + rosella treatment group ($n = 10$), and the control group with physical exercise + placebo ($n = 10$).

Research Instruments

Some of the instruments used in this study were blood pressure gauges, height gauges, weight gauges, data collection sheets, stationery, rosella flower extract, and placebo capsules.

Procedure

The data collection process in this research involved several steps. Study subjects underwent screening procedures before starting the study. Certain parameters that allow information to be analyzed and whether to include it or not form the basis of this approach. Additionally, they fill out Informed Consent.

Data collection was carried out for 1 day, starting with data collection on subject characteristics. Research subjects are prohibited from consuming anything before carrying out the research. One day before the study, subjects were given instructions to maintain a regular diet and rest pattern. After that, they were asked to warm up. Physical activity is carried out afterwards. This activity includes running a distance of 2400 meters with moderate intensity using polar heart rate monitor. After carrying out the running test, the sample was directed to a shaded room not far from the field to rest and wait for further intervention. After running, pre-test blood glucose data is taken. After that, the subjects were given placebo intervention and rosella flower extract according to their respective groups. 60 minutes later, post-test blood glucose data was taken. As a final step in accountability, the researcher examines the data and produces a written report.

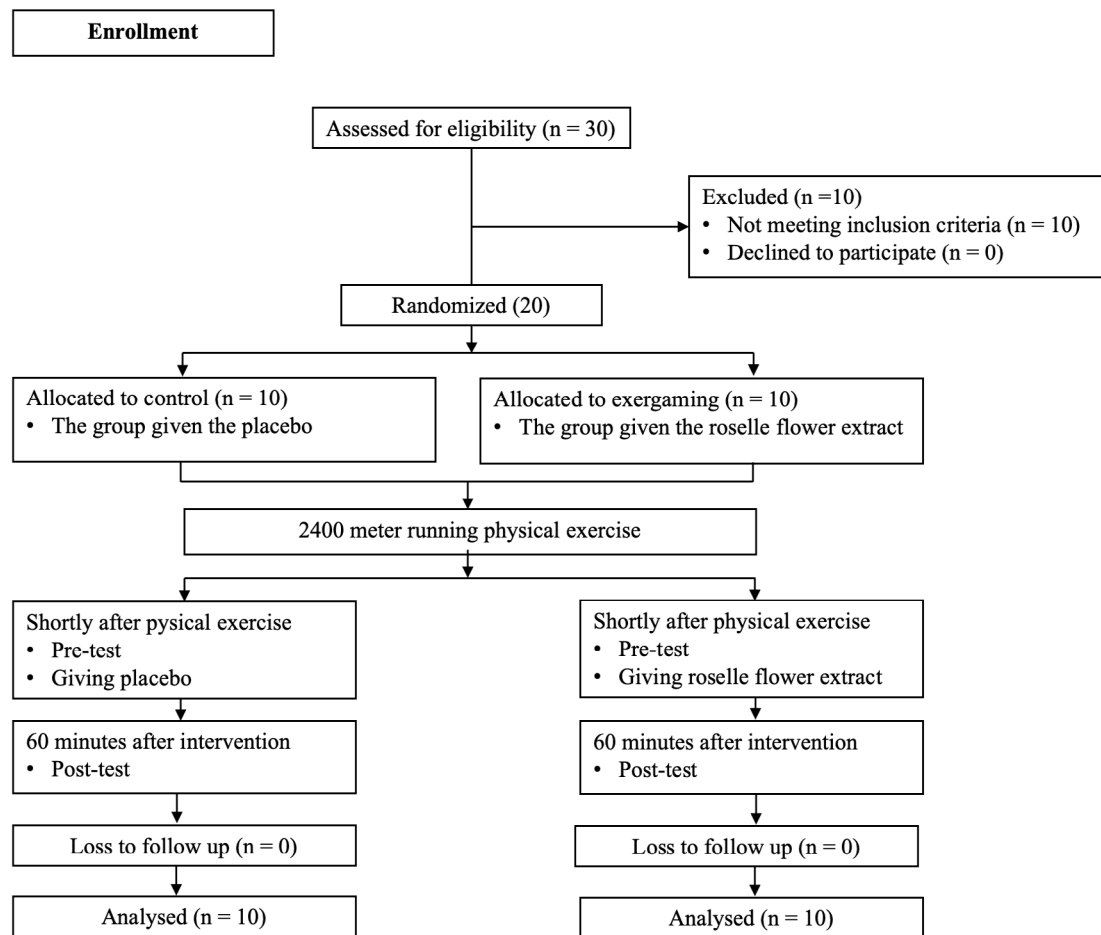


Fig. 1. The CONSORT flowchart
Рис. 1. Блок-схема CONSORT

CONSORT flowchart

Ethics

Prior to data collection, we obtained ethical approval from the Ethics Committee of Malang Health Polytechnic with registration number DP.04.03/F.XXI.31/0486/2024.

Statistical analysis

Using SPSS software, statistical analysis was conducted once the data was collected. To determine the mean and standard error, a descriptive analysis was performed on the data. Additionally, the Shapiro—Wilk test was used to conduct a normality test in this investigation. The paired t-test method was used to construct a difference test if the data were normally distributed. The Wilcoxon signed-rank test was used to analyze the data, however, in case the outcomes revealed otherwise.

2. Results

This section presents the data and provides information about the general characteristics of the participants in Table 1. These data allow us to better understand the characteristics of each group. Data are presented as mean ± standard error. The first analysis produced t-test results showing no significant difference between K1 and K2 ($p > 0.05$).

The results of the normality test are shown in Table 2.

Based on the normality test in Table 2, the pre-test and post-test blood glucose data were normally distributed ($p > 0.05$).

The results of blood glucose analysis between pre-test and post-test in each group are presented in Figure 2.

3. Discussion

The purpose of this experimental study was to determine how the effect of supplementing 500 mg rosella flower extract after physical exercise on reducing blood glucose levels. The results showed that there was no significant difference in the group with rosella flower extract. However, the placebo group experienced a significant increase in blood glucose levels. It may be known that acute and momentary exercise will make blood glucose levels decrease, but over time the process of adaptation and physiological response of the body's blood glucose levels will return to normal numbers [14].

Research results from Ambelu & Teferi, 2023 proved that the intervention of strength training, combination training, and aerobic training for 12 weeks in patients with diabetes mellitus proved to significantly reduce blood glucose levels [15]. In this case, it turns out that the period of training and

Table 1

Characteristics of research subjects

Таблица 1

Характеристики участников исследования

Data	Group	N	$x \pm SD$	p-value
Age (y)	K1	10	23.70 ± 0.51	0.652
	K2	10	23.30 ± 0.77	
Height (cm)	K1	10	168.70 ± 1.77	0.701
	K2	10	170.20 ± 2.27	
Weight (kg)	K1	10	62.20 ± 2.62	0.722
	K2	10	64.00 ± 3.97	
BMI (kg/m ²)	K1	10	21.79 ± 1.99	0.851
	K2	10	21.99 ± 1.06	
Systolic (mmHg)	K1	10	122.80 ± 3.38	0.962
	K2	10	123.10 ± 4.07	
Diastolic (mmHg)	K1	10	80.00 ± 2.25	0.720
	K2	10	81.50 ± 3.05	

Table 2

Normality test results

Таблица 2

Результаты теста нормальности

Data	Group	Shapiro—Wilk	
		n	p-value
Blood glucose (pre-test)	K1	10	0.487
	K2	10	0.391
Blood glucose (post-test)	K1	10	0.274
	K2	10	0.115

intervention also affects the reduction of blood glucose levels. Of the three types of training that have been used other research reports recommend that the most promising training is a combination of strength training and aerobics. In accordance with national and international physical activity guidelines, this training has a good effect on patients with diabetes mellitus [16].

Rosella flower extract as an herbal plant that has many benefits, especially high in antioxidants. Research report data shows that the administration of red rosella flower tea has a notable impact on lowering blood glucose levels in diabetic patients [13]. Numerous illnesses, including those of the heart, diabetes, obesity, renal, skin, and digestive systems, as well as cough, hypercholesterolemia, and hypertension, may be treated using rosella petals. Because rosella petals are high in protein (5.5–9.14 %), carbs (7.4–12.3 %), and fat (0.47–1.32 %), they are well known for their possible medicinal benefits [17].

Furthermore, one of the natural remedies that may be utilized is rosella, which may have antioxidant and anti-inflammatory properties. Potent antioxidants include vitamins, minerals, and bioactive substances found in Hibiscus

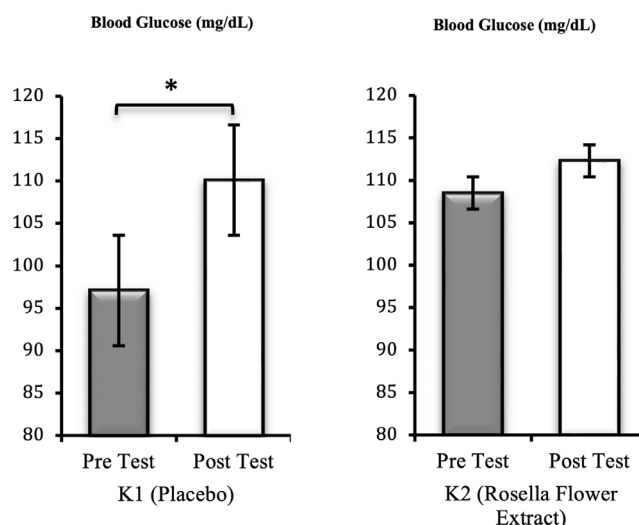


Fig. 2. The results of blood glucose analysis between pre-test and post-test * $p > 0.05$.

Рис. 2. Результаты анализа уровня глюкозы в крови до и после теста * $p > 0,05$.

Table 3

Blood glucose level results after giving rosella flower extract

Таблица 3

Результаты измерения уровня глюкозы в крови после приема экстракта цветков розеллы

Difference test method	Group	P
Paired t-test	K1 (pre-test and post-test)	0.012
	K2 (pre-test and post-test)	0,442

sabdarriffa, also referred to as Rosella. These include polyphenols (anthocyanins, flavonoids, phenolic acids, tannins), polysaccharides, pectin, non-phenolic organic acids, carotenoids, caffeic acid, chlorogenic acid, ascorbic acid, and quercetin [18]. Anthocyanin is one of the flavonoid polyphenols with potent antioxidant qualities [19], [20]. By preventing glycation and scavenging superoxide anion, this substance is a strong free radical scavenger that can increase antioxidant activity or lower ROS to detoxify oxidative damage [21].

From the results of this study, there are many factors that can affect blood glucose levels ranging from food consumption before intervention, quantity factors from the sample, and other factors that can make the results of the study different. Apart from that, exercise remains the best effort in improving health status, especially in improving blood glucose control in patients with diabetes mellitus [22]. The administration of rosella flower extract shortly after exercise and the process of taking blood glucose levels is 60 minutes post intervention may have different effects on blood glucose levels. Exercise significantly and momentarily makes the body experience hypoglycemia, which is a condition where the body is at low blood glucose levels [23]. This effect is caused because during exercise, the need for energy is greater, so this makes the body to make immediate physiological adaptations to fulfill energy [24].

During exercise, the body also increases the contraction mechanism of skeletal muscles and organs [25]. The need for oxygen also increases. So, the body is well designed to adapt to this. Repeated activation of the phosphagen system and sustained increase in aerobic metabolism contribute to the formation of a specific metabolic stress cycle in the organism [26]. During exercise, insulin hormone levels will decrease, while glucagon hormone will gradually increase in order to adapt to make the body meet its needs, especially to make blood glucose levels normal again [27]. For a moment, blood glucose levels when checked after exercise will decrease, but

physiologically there is a fulfillment of blood glucose through gluconeogenesis so that over time blood glucose levels become normal [28]. In this study, researchers certainly have limitations in the reviews that have been analyzed. There are still many other factors that can influence the study, for example, it is also necessary to look at several minutes after exercise the phenomenon of increasing blood glucose levels, the form of supplementation is only limited to using capsules, of course future research can be done further related to how effective rosella flower extract with other methods such as giving drinks such as tea or others after physical exercise interventions on the mechanism of the time of return of blood glucose levels or can actually reduce blood glucose levels. It is also possible that pharmacological factors also have an influence in the absorption process of the content of rosella flower extract on reducing blood glucose levels, so it may be possible to look beyond 60 minutes and beyond to find out the graph of the mechanism of changes in blood glucose levels after administration and intervention.

4. Strength and Limitations

The strength of this study is that it was a randomized controlled experiment, the most reliable scientific method, which eliminates the possibility of ambiguous cause-and-effect relationships. Regarding the limitations of the study, such as limited sample size, it is acknowledged that a larger sample size would provide a better understanding of the results. This intervention focused only on rosella flower extract supplementation at a dose of 500 mg. Certainly, comparing doses could improve the results of future studies. Future research recommendations include examining the impact on more specific biomarkers, such as free radical and antioxidant levels.

Conclusion

Supplementation of 500 mg rosella flower extract after moderate intensity physical exercise intervention did not affect the reduction of blood glucose levels.

Authors' contribution

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

Nining Widyah Kusnanik — data collection and interpretation, visualization, and formal analysis.

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

Вклад авторов

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

Нининг Видья Куснаник — сбор и интерпретация данных, визуализация и формальный анализ.

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

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Deby Tri Mario — methodology, data collection, interpretation, and writing.

Ihham Ihham — methodology, data collection, and editing.

Anton Komaini — data collection and interpretation, visualization, and formal analysis.

Afifan Yulfadinata — methodology, data collection, and editing.

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Прокопио Б. Дафун младший — редактирование и визуализация.

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Ильхам Ильхам — методология, сбор и редактирование данных.

Антон Комаини — сбор и интерпретация данных, визуализация и формальный анализ.

Афифан Юльфадината — методология, сбор и редактирование данных.

References / Список литературы

1. Zhang H., Ni J., Yu C., Wu Y., Li J., Liu J., et al. Sex-based differences in diabetes prevalence and risk factors: A population-based cross-sectional study among low-income adults in China. *Front. Endocrinol.* (Lausanne). 2019;10:658. <https://doi.org/10.3389/fendo.2019.00658>
2. Wahidin M., Achadi A., Besral B., Kosen S., Nadjib M., Nurwahyuni A., et al. Projection of diabetes morbidity and mortality till 2045 in Indonesia based on risk factors and NCD prevention and control programs. *Sci. Rep.* 2024;14(1):5424. <https://doi.org/10.1038/s41598-024-54563-2>
3. American Diabetes Association Professional Practice Committee. 2. Classification and diagnosis of diabetes: standards of medical care in diabetes — 2022. *Diabetes Care.* 2022;45(Suppl 1):517–538. <https://doi.org/10.2337/dc22-S002>
4. International Diabetes Federation. Five questions on the IDF Diabetes Atlas. *Diabetes Res. Clin. Pract.* 2013;102(2):147–148. <https://doi.org/10.1016/j.diabres.2013.10.013>
5. Baena-Díez J.M., Peñafiel J., Subirana I., Ramos R., Elo-sua R., Marín-Ibañez A., et al. Risk of cause-specific death in individuals with diabetes: A competing risks analysis. *Diabetes Care.* 2016;39(11):1987–1995. <https://doi.org/10.2337/dc16-0614>
6. Munan M., Oliveira C.L.P., Marcotte-Chénard A., Rees J.L., Prado C.M., Riesco E., Boulé N.G. Acute and Chronic Effects of Exercise on Continuous Glucose Monitoring Outcomes in Type 2 Diabetes: A Meta-Analysis. *Front. Endocrinol.* (Lausanne). 2020;11:495. <https://doi.org/10.3389/fendo.2020.00495>
7. Liu J.X., Zhu L., Li P.J., Li N., Xu Y.B. Effectiveness of high-intensity interval training on glycemic control and cardiorespiratory fitness in patients with type 2 diabetes: a systematic review and meta-analysis. *Aging Clin. Exp. Res.* 2019;31(5):575–593. <https://doi.org/10.1007/s40520-018-1012-z>
8. Diabetes Canada Clinical Practice Guidelines Expert Committee; Sigal R.J., Armstrong M.J., Bacon S.L., Boulé N.G., Dasgupta K., Kenny G.P., Riddell M.C. Physical Activity and Diabetes. *Can. J. Diabetes.* 2018;42(Suppl 1):S54–S63. <https://doi.org/10.1016/j.cjcd.2017.10.008>
9. Colberg S.R., Sigal R.J., Yardley J.E., Riddell M.C., Dunstan D.W., Dempsey P.C., Horton E.S., Castorino K., Tate D.F. Physical activity/exercise and diabetes: A position statement of the American Diabetes Association. *Diabetes Care.* 2016;39(11):2065–2079. <https://doi.org/10.2337/dc16-1728>
10. Sari I. Effect of Diabetes Exercise on Reduction of Blood Glucose Levels in Patients with Type II Diabetes Mellitus. *Heal. Tadulako J. (Jurnal Kesehat. Tadulako).* 2025;16(4):43–49. <https://doi.org/10.22487/htj.v11i4.1785>
11. Thiagarajah K., Ong M.K., Teh L.K., Lye H.S. Plants Infused Water as Preferred Healthy Drinks. In: Grumezescu A.M., Holban A.M. (eds). *Bottled and Packaged Water. Vol. 4: The Science of Beverages.* Elsevier Inc.; 2019, pp. 367–402. <https://doi.org/10.1016/b978-0-12-815272-0.00013-1>
12. Riaz G., Chopra R. A review on phytochemistry and therapeutic uses of *Hibiscus sabdariffa* L. *Biomed. Pharmacother.* 2018;102:575–586. <https://doi.org/10.1016/j.biopha.2018.03.023>
13. Erni Tri Indarti. The Effect of Red Rosella Tea on Blood Glucose Individuals with Diabetes Mellitus Type II. *J. Heal. Sci.* 2022;15(02):154–159. <https://doi.org/10.33086/jhs.v15i02.2835>
14. Naimi S.S., Rahbar S., Asadi M.R., Radinmehr H., Talimkhani A., Doosti-Irani A., Hajvalie G.R. The Immediate Effects of Aerobic Exercise with and Without External Loads on Blood Glucose, Cardiovascular, Respiratory, and Body Temperature Indices in Type II Diabetic Patients. *J. Tehran Univ. Hear. Cent.* 2023;18(1):39–45. <https://doi.org/10.18502/jthc.v18i1.12580>
15. Ambelu T., Teferi G. The impact of exercise modalities on blood glucose, blood pressure and body composition in patients with type 2 diabetes mellitus. *BMC Sports Sci. Med. Rehabil.* 2023;15(1):153. <https://doi.org/10.1186/s13102-023-00762-9>
16. Mendes R., Sousa N., Almeida A., Subtil P., Guedes-Marques F., Reis V.M., Themudo-Barata J.L. Exercise prescription for patients with type 2 diabetes - A synthesis of international recommendations: Narrative review. *Br. J. Sports Med.* 2016;50(22):1379–1381. <https://doi.org/10.1136/bjsports-2015-094895>
17. Mohamed A.I., Salau V.F., Erukainure O.L., Islam M.S. *Hibiscus sabdariffa* L. polyphenolic-rich extract promotes muscle glucose uptake and inhibits intestinal glucose absorption with concomitant amelioration of Fe²⁺-induced hepatic oxidative injury. *J. Food Biochem.* 2022;46(12):e14399. <https://doi.org/10.1111/jfbc.14399>
18. Singh M., Thrimawithana T., Shukla R., Adhikari B. Extraction and characterization of polyphenolic compounds and potassium hydroxycitrate from *Hibiscus sabdariffa*. *Futur. Foods.* 2021;4:100087. <https://doi.org/10.1016/j.fufo.2021.100087>
19. Jin H.M., Dang B., Zhang W.G., Zheng W.C., Yang X.J. Polyphenol and Anthocyanin Composition and Activity of Highland Barley with Different Colors. *Molecules.* 2022;27(11):3411. <https://doi.org/10.3390/molecules27113411>
20. Khaleghi M., Ahmadi F., Hofmeister M. Effects of chocolate consumption on the health and performance of football players: A Systematic Review. *Sports medicine: research and practice.* 2024;14(3):26–34. <https://doi.org/10.47529/2223-2524.2024.3.2>
21. Ayubi N., Wibawa J.C., Sceisarriya V.M., Dafun Jr. P.B. Resistance training significantly increases insulin-like growth factor-1 levels in women with a sedentary lifestyle: A randomized controlled trial. *Sports medicine: research and practice.* 2025;15(3):34–43. <https://doi.org/10.47529/2223-2524.2025.3.7>
22. Syeda U.S.A., Battillo D., Visaria A., Malin S.K. The importance of exercise for glycemic control in type 2 diabe-

tes. *Am. J. Med. Open.* 2023;9:100031. <https://doi.org/10.1016/j.ajmo.2023.100031>

23. **Jung A.R., Kim H., Kim H.S., Kim C., Choi W.S.** Exercise Strategies to Prevent Hypoglycemia in Patients with Diabetes. *Korean J. Fam. Med.* 2021;42(2):91–95. <https://doi.org/10.4082/kjfm.19.0043>

24. **Brooks G.A.** Bioenergetics of exercising humans. *Compr. Physiol.* 2012;2(1):537–562. <https://doi.org/10.1002/cphy.c110007>

25. **Ashcroft S.P., Stocks B., Egan B., Zierath J.R.** Exercise induces tissue-specific adaptations to enhance cardiometabolic health. *Cell Metab.* 2024;36(2):278–300. <https://doi.org/10.1016/j.cmet.2023.12.008>

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