JOURNAL OF NUTRITION FASTING AND HEALTH

The Effect of 12 Weeks of Dry and Steam Sauna on Fasting Glucose, Sleep Quality, and Cortisol Hormone in Middle-Aged Men

Jalal Fatahi [1], Mehdi Baigzadeh [2], Mehran Ghahramani [3*]

1. MSc, Department of Exercise Physiology, Eslamabad-E-Gharb Branch, Islamic Azad University, Eslamabad-E-Gharb, Iran.
2. Department of Exercise Physiology, Eslamabad-E-Gharb Branch, Islamic Azad University, Eslamabad-E-Gharb, Iran.
3. Department of Exercise Physiology, Gilan-E-Gharb Branch, Islamic Azad University, Gilan-E-Gharb, Iran.

ARTICLEINFO

Article type:
Research Paper

Article History:
Received: 05 Oct 2023
Accepted: 12 Nov 2023
Published: 20 Nov 2023

Keywords:
Sauna
Fasting glucose
Sleep quality
Cortisol hormone

ABSTRACT

Introduction: This study aimed to evaluate the impact of 12 weeks of sauna (both dry and steam) on fasting glucose levels, sleep quality, and cortisol hormone levels in middle-aged men residing in Kermanshah, Iran.

Methods: This quasi-experimental study employed a pre-test-post-test design with two training intervention groups and one control group and examined all middle-aged men between 45 to 60 years old. Finally, based on the research objectives, 36 men in the age group of 45 to 60 years were chosen as the subjects of the purposive and convenient sampling method. At the end of the familiarization session, the pre-test values of the tested variables (glucose, hunger, sleep quality, cortisol hormone) were measured and then the subjects were randomly divided into three groups including 1) dry sauna 2) steam sauna and 3) control group. Then, the experimental group performed the dry and steam sauna program for 12 weeks. The post-test values in the variables were measured in the same conditions as the pre-test 48 hours after the last training session. One-way analysis of variance and Bonferroni tests were used to analyze the data.

Results: A significant difference was observed between the mean values before and after implementing the dry sauna and steam sauna program in fasting glucose, sleep quality, and cortisol hormone ($p \leq 0.05$).

Conclusion: Based on the results, the program involving both dry and steam sauna positively affected glucose. The exercises of the dry sauna program had less impact on sleep quality compared to the steam sauna. The dry sauna program was more influential on cortisol compared to the steam sauna.

► Please cite this paper as:
Fatahi J, Baigzadeh M, Ghahramani M. The Effect of 12 Weeks of Dry and Steam Sauna on Fasting Glucose, Sleep Quality, and Cortisol Hormone in Middle-Aged Men. J Nutr Fast Health. 2023; 11(3): 225-236. DOI: 10.22038/JNFH.2023.75385.1470.

Introduction

Midlife and aging research has been rapidly evolving in recent decades. The traditional perspective of aging as an unalterable reality has been replaced by the hopeful possibility of increased longevity and better quality of life. According to a widely accepted definition, longevity refers to the duration of a healthy life, free from chronic illnesses and physical disabilities that are commonly associated with aging (1).

The process of aging in middle age shows itself more than ever. Some people may get sick or feel a decrease in their physical abilities. Therefore, it is essential to minimize the crises of this period. Physical activity and sports training have been widely recognized as effective strategies for preventing various health problems and diseases associated with this stage of life (2). As per the current health and exercise guidelines, it is recommended that middle-aged adults engage in moderate-intensity physical activity for 150 to 300 minutes, three to five times per week. Furthermore, it is recommended that resistance exercises be carried out at least twice per week (3). There is a comprehensive understanding of the benefits of exercise and how it can enhance cardiovascular health during this stage of life. Despite its increasing use worldwide, heat therapy and the health benefits of sauna bathing for the prevention of midlife problems are still not well known, unlike exercise(4), even though studies conducted around the world by researchers (5, 6) have found that regular sauna use is positively associated with multiple cardiovascular outcomes in middle age. Sauna

* *Corresponding authors:* Mehran Ghahramani; Department of Exercise Physiology, Gilan-E-Gharb Branch, Islamic Azad University, GilanE-Gharb, Iran. Tel: +98 9188342771, Email: Mehran.physiology@gmail.com.

facilities often claim health benefits that include detoxification, increased metabolism, weight loss, increased circulation, pain relief, anti-aging, skin rejuvenation, improved cardiovascular and immune function, sleep, stress management, and relaxation. However, rigorous medical evidence to support these claims is scant and incomplete, as highlighted in a recent multidisciplinary review of sauna studies (7). Healthy adults generally consider sauna bathing safe, and specific populations may also be able to enjoy this practice under medical supervision. Heat stress through sauna use induces hormetic responses mediated by molecular mechanisms that protect the body from injury, similar to those caused by moderate-to-vigorous exercise, and maybe a means of preventing the effects of aging, and increasing life expectancy.

Saunas have been used for cleansing and healing for thousands of years in many cultures. This practice can be observed in Russian Banyas, American Indian sweat lodges, and Finnish saunas. A sauna bath involves short-term passive exposure to high temperatures, which usually range from 45° to 100°C (113 to 212 F). Sauna baths cause mild hyperthermia, increasing in core body temperature and triggering a thermoregulatory response involving neuroendocrine, cardiovascular, and cellular protective mechanisms. As result of these mechanisms homeostasis is restore and the body is prepared to deal with for stressors. Observational, interventional, and mechanistic studies have provided compelling data to support the claim that sauna use can increase lifespan. Several recent reviews have described sauna use's cardiovascular, neurological, and metabolic benefits (8, 9, 10, and 11). Vandana et al. (2018); examined the effects of steam sauna baths on fasting blood glucose levels (FBGLs). In Vandana et al (2018), 80 subjects, 40 males and 40 females, between the ages of 30 and 50 were exposed to seven steam baths on alternate days.

During the study by Vandana et al (2018), the temperature of the steam sauna was maintained at 50°C and each bath was taken for 15 minutes. Blood samples for FBGL were taken before the first steam bath, and again after the seventh steam sauna bath, to estimate FBGL. The results indicated that the FBGLs significantly decreased after seven steam souna baths compared to pre-team sauna FBGLs. The researchers concluded steam saunas may help prevent hyperglycemia diabetes mellitus (12). Several other studies have also documented the positive effects of sauna on the human body (12, 13, 14, 15, and 16). Sauna bathing promotes more effective rehabilitation after injuries and relieve pain syndromes (17). There is considerable evidence that sauna bathing can produce profound physiological effects (18, 19). Most studies investigating the effects of sauna bathing have been either acute (0-30 minutes post-sauna) or short-term (2-4 weeks) (20). As pointed out by a recent review, there is a need for long-term experimental evidence in heat therapy (8), based saunas. The effectiveness of regular sauna use when combined with exercise has been shown in trained cyclists (21) and runners (22), as well as in patients with heart failure (23) and other diseases (24). A combination of sauna use and exercise has shown to be beneficial for specific populations, such as cyclists, runners, and those with heart failure. However, these studies are not availablefor the general population. Therefore, adding sauna bathing could benefit more than regular exercise alone. Previous research has shown promising results in acute responses using a sauna (25) and a combination of training followed by a sauna (25). However, it is currently unclear whether steam saunas produce the same degree of physiological responses as dry saunas (26). Reacting, more humidity leads to water condensation on the skin and reduced sweat evaporation (27).Therefore, this reasearch aimed to expand these findings and discover the possibility of sugar and hormonal compatibility and raising immunity as primary outcomes. Valuable information should be provided for using the sauna and its potential as an intervention in lifestyle along with exercise in this sensitive period. Therefore, the imposition of material and spiritual costs on the economy of families and society can be avoided mainly by preventing the problems of the middle age period. To date, few studies have been conducted on the effect of sauna bathing on sleep quality in older adults. However, the results of several studies have shown improvement in sleep quality regardless of duration (28).So far, research on the effects of saunas and their aftermath on fasting glucose, sleep quality, and cortisol hormone levels of middle-aged men has been limited to a few foreign studies, and no research has been conducted. Therefore, investigating whether sauna bath affects fasting glucose, sleep

quality, and cortisol hormone or not and whether the effect of dry sauna and steam bath is different between middle-aged people. Hence, the researcher has decided to conduct a study to investigate the effects of 12 weeks of sauna use on fasting glucose, sleep quality, and cortisol hormone in middle-aged men in Kermanshah.

Material and Methods

This experimental study was conducted using an applied design with a pre-test-post-test design and a control group. The research objective was to investigate the effect of 12 weeks of sauna use on fasting glucose, sleep quality, and cortisol hormone in middle-aged men from Kermanshah. The statistical population of the present study included all middle-aged men between 45 and 60 years old in Kermanshah, Iran, of whom 36 men between 45 and 60 were selected by targeted and convenient sampling methods. The subjects' average age, weight, height, and body mass index were 52.4±0.7 years, 76.7±3.5kg, 176.5±4.58cm, and 25.9±2.8kg/m^2, respectively. First, all the subjects attended the study protocol familiarization program. The pre-test values of the tested variables (glucose hunger, sleep quality, cortisol hormone) were measured at the end of the familiarization session, and then the subjects were randomly divided into three groups, including 1) dry sauna for 45 minutes; several 12 people 2) steam sauna for 45 minutes; several 12 people and 3) the control group was divided into 12 people. Then, the experimental group performed the dry sauna and steam program for 12 weeks. The post-test values of the desired variables (glucose hunger, sleep quality, and cortisol hormone) were measured in the same conditions as the pre-test 48 hours after the last training session. The inclusion criteria were no history of illness, surgery, medication, or smoking.

Measuring Tools

The subjects' height was measured using a wall-mounted height meter model 44440 of Kaveh Company, Iran, with an accuracy of 0.0±0.1cm. Subjects' weight was measured using a Sairan PDS200 brand digital scale, France Immunotech Kit. Cortisol hormone levels are calculated using the Pars test kit made in Iran using the photometric method to measure blood glucose. The self-report Pittsburgh Sleep Quality Index, developed by Bise et al. (29) and measuring good and bad sleep quality, was used as a measurement tool to assess sleep quality. Pittsburgh index has nine general questions and measures seven components, which include subjective sleep quality, sleep delay (time from when a person goes to bed to the time of sleep onset), sleep duration, sleep adequacy (ratio of actual sleep to the time spent in bed), sleep disturbance, use of sleeping pills and daytime dysfunction. Most of the questions are of the four-choice type (never during the last month=0, less than once a week=1, 1-2 times a week=2, and three or more times a week=3) and are scored from 0 to 3. The total sleep quality index score ranges from 0 to 21, with high scores indicating poor sleep quality. Scores above five also indicate the existence of sleep disorder. The reliability of this scale was calculated as 0.83, and its validity was reported as 89.6 in the patient subjects compared to the control group (29). The validity of this index has also been confirmed in internal studies, and its reliability has been reported as 0.89 (30). The consent form was used to ensure the complete consent of the subjects to cooperate with the researcher during the implementation of the research.

Exercise Protocol

The sauna program lasted 12 weeks, with three weekly sessions, each lasting 60 minutes. The total duration of the sauna program was divided into 30 minutes of steam sauna and 30 minutes of dry sauna (31).

Research Limitations

The research limitations included the lack of complete knowledge of the subject's health, nutrition, and lifestyle, the inability to fully control the level of attention, concentration, and motivation of the participants during the tests, lack of control over the individual differences of the participants such as stress, anxiety, and excitement during the tests, lack of control over the hereditary backgrounds of the people in Physical and movement tests.

Statistical Method

Smirnov-Kolmogorov and Levene's tests were used for the normality of the data distribution and homogeneity of the groups, respectively. One-way analysis of the variance model was used to analyze intragroup changes. The Bonferroni's test was utilized to determine the difference between training methods. All statistical analyses were performed using SPSS software version 20, with a significance level of $P \leq 0.05$.

Results

The results of the first question showed that 12 weeks of dry sauna significantly affected glucose fasting in middle-aged men. A significant difference between the average values before and after the implementation of the dry sauna program can be seen in the subjects' glucose, and the averages also show that the glucose level has decreased, which was significant ($p \leq 0.05$) (Figure 1).

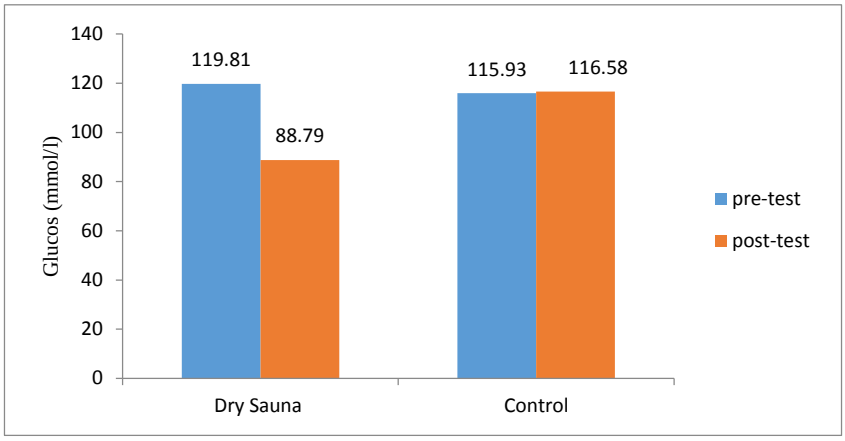

Figure 1. Glucose changes before and after the dry sauna program

The results of the second research question showed that 12 weeks of steam sauna significantly affected fasting glucose in middle-aged men. Significant differences can be seen between the average values before and after the implementation of the steam sauna program in the glucose level of middle-aged men, and the averages also showed that the glucose level decreased, which was significant ($p \leq 0.05$) (Figure 2).

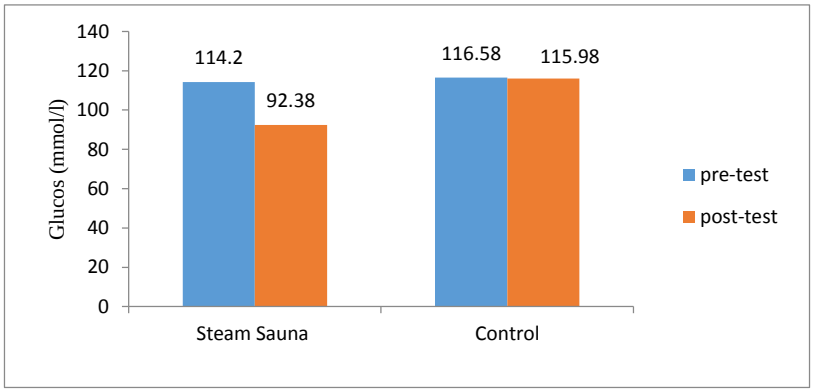

Figure 2. Glucose changes before and after steam sauna program

According to the third question of the research, 12 weeks of dry sauna use significantly affected the quality of sleep in middle-aged men. The mean values before and after the sauna program showed a significant difference in sleep quality among the participants. Additionally, the averages indicate that the sleep quality increased, which was significant ($p \leq 0.05$), as shown in Figure 3.

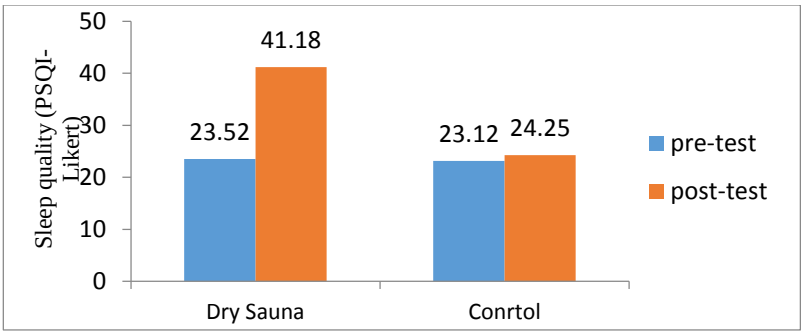

Figure 3. Changes in sleep quality before and after dry sauna

According to the fourth research question, 12 weeks of steam sauna use significantly affected sleep quality in middle-aged men. A significant difference was observed between the average values before and after the sauna program in the sleep quality among the participants. Additionally, the averages indicated that the sleep quality increased, which was significant ($p \leq 0.05$), as shown in Figure 4.

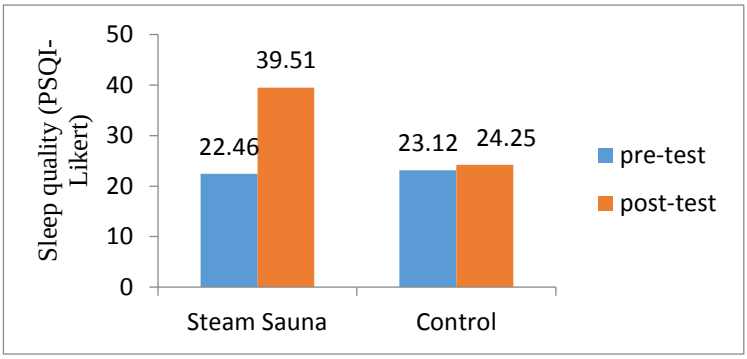

Figure 4. Changes in sleep quality before and after steam sauna

According to the fifth research question results, 12 weeks of dry sauna use significantly affected the concentration of cortisol hormone in middle-aged men. A significant difference was observed between the mean values before and after the sauna program on cortisol hormone concentration among the participants. Additionally, the averages indicated that the concentration of cortisol hormone decreased, which was significant ($p \leq 0.05$), as shown in Figure 5.

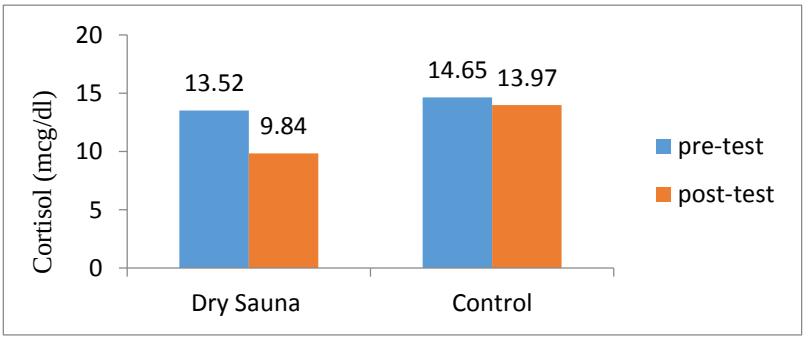

Figure 5. Cortisol hormone changes before and after the dry sauna program

Based on the results of the sixth research question, 12 weeks of steam sauna significantly affected the cortisol hormone in middle-aged men. A significant difference can be observed between the average values before exercise and after steam sauna in cortisol hormone in middle-aged men. In addition, the averages show that the amount of cortisol hormone has decreased, and this increase is significant (p≤0.05) (Figure 6).

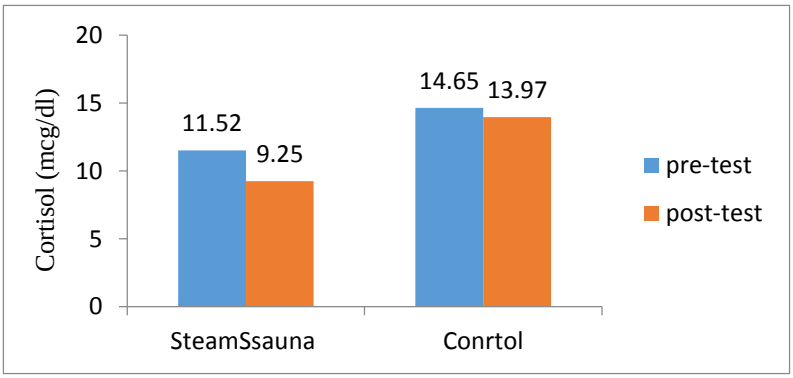

Figure 6. Cortisol hormone changes before and after the steam sauna program

The results of the seventh question showed a significant difference between 12 weeks of dry sauna and steam on fasting glucose in middle-aged men. Bonferroni's post hoc test measured the difference between groups and compared the means pairwise. Based on the results, the dry sauna and steam sauna were influential on the glucose variable of middle-aged men in the post-test stage (p≤0.05). In addition, the results indicated no significant difference in the glucose variable between the effectiveness of these two training methods in the post-test stage (P<0.05) (Figure 7).

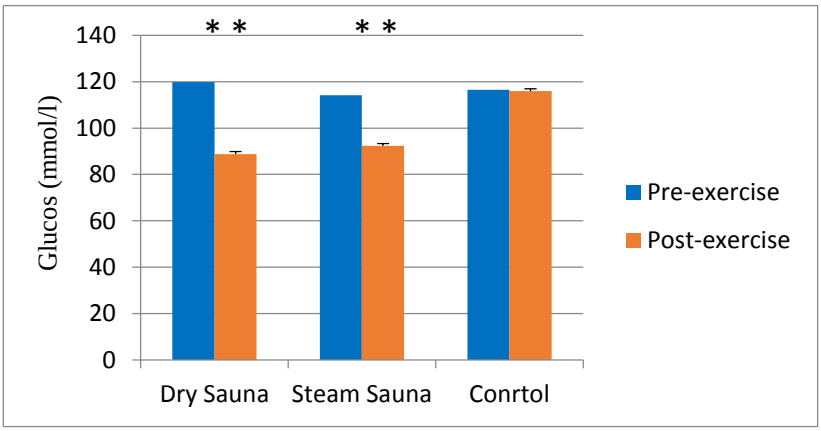

Figure7. Comparison of the average fasting glucose after exercise compared to before the sauna in the three subject groups

The results of the eighth question showed a significant difference between twelve weeks of dry and steam sauna on the sleep quality in middle-aged men. Bonferroni's 12 hoc test measured the difference between groups and compared the means pairwise. According to the results, the dry and steam sauna programs influenced the variable of sleep quality in middle-aged men in the post-test stage (p≤0.05). The results showed a significant difference in the sleep quality variable between the effectiveness of the dry sauna program and the steam sauna program in the post-test stage (P<0.05). The exercises of the dry sauna program had less effect on the variable of sleep quality than the steam sauna program (P<0.05) (Figure 8).

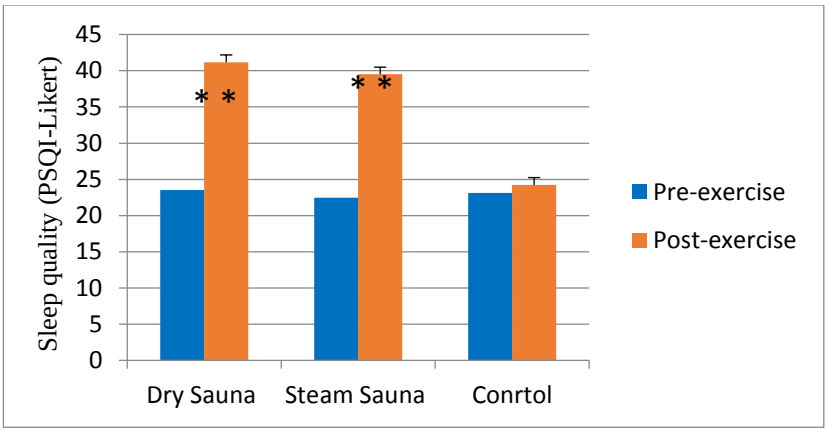

Figure 8. Comparison of the average sleep quality after the exercise compared to before the sauna in the three subject groups

The results of the ninth question indicated a significant difference between 12 weeks of dry and steam sauna on the cortisol of middle-aged men. Bonferroni's post hoc test measured the difference between groups and compared the means pairwise. Based on these results, the dry and steam sauna program influenced the cortisol variable of middle-aged men in the post-test phase ($p \leq 0.05$). Moreover, the results indicated a significant difference in cortisol between the effectiveness of the dry and steam sauna programs in the post-test stage ($P<0.05$). In other words, the dry sauna program was more influential on cortisol than the steam sauna ($P<0.05$) (Figure 9).

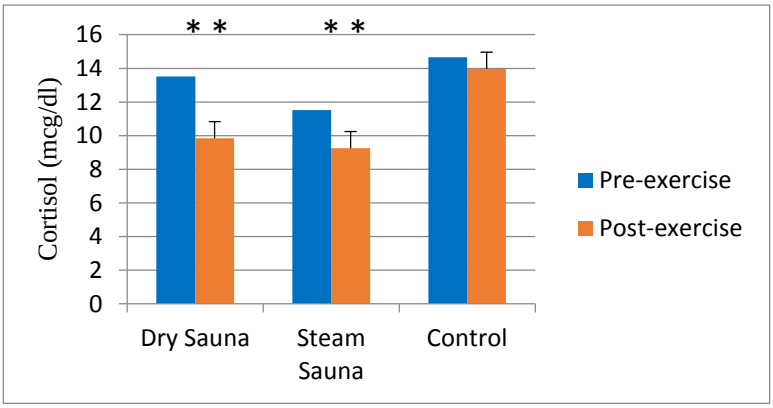

Figure 9. Comparison of the average cortisol after exercise compared to before the sauna in the three subject groups

Discussion

Recent studies have shown that sauna, also known as sauna bathing, involves short-term passive exposure to high temperatures ranging from 45 to 100°C (113 to 212°F), inducing mild hyperthermia. This exposure triggers a thermoregulatory response involving neuroendocrine, cardiovascular, and cytoprotective mechanisms working together to maintain homeostasis. The body becomes acclimated to heat with repeated sauna use and optimizes its response to future exposures, mostly due to the phenomenon of hormesis. Sauna bathing has emerged as a probable means to extend healthspan in recent decades, with strong evidence from observational, interventional, and mechanistic studies. Large, prospective, population-based cohort studies have reported strong dose-dependent relationships between sauna use and reduced morbidity and mortality rates, which are particularly interesting. During this review, the body's physiological response to heat stress is explained, as well as the molecular mechanisms involved; the numerous health benefits of sauna use are discussed, as well as concerns about

saunas. The present study investigated the effect of sauna programs (dry and steam) on glucose metabolism in middle-aged men. Based on the test results in two groups, dry and steam sauna positively and significantly affected glucose depletion. In addition, the test results showed a more significant effect of the dry sauna selected in the present study than the steam group, and the fasting glucose of the dry sauna group was significant compared to the control group. Therefore, the fasting glucose of the steam group is significant compared to the control group. These results are independent of the implementation time of the sauna program, in line with those of Arena et al. (2015) (34), Stanley et al. (22), and Pleich et al. (2013) (36). Stanley et al. (2015) noted an average increase in axillary body temperature of 2.6°C after the first sauna versus an average increase of only 1.9°C after completing five months. The researchers also found that the sauna bath increased the average venous pH after ultrasound, decreased the average baseline excess, and increased the average venous 2O and hemoglobin concentration. Lubin pointed in the blood was 5.2%, and the change of the oxygen-hemoglobin dissociation curve, the reduction of affinity, and the release of 2O to the tissues after the first sauna returned with similar changes in the specified parameters were observed after the final sauna five months later (22). There is considerable evidence that sauna bathing can produce profound physiological effects (19, 20). When exposed to short-term extreme heat, skin and core body temperatures increase, and thermoregulatory pathways through the hypothalamus (37) and CNS (central nervous system) are activated. As a result, the autonomic nervous system is activated. The sympathetic nervous system, the hypothalamic-pituitary-adrenal hormonal axis, and the renin-angiotensin-aldosterone system are all activated, resulting in established cardiovascular effects such as an increase in heart rate, skin blood flow, cardiac output, and sweating (16). The sweat from the sauna evaporates from the skin's surface, producing a cooling effect that facilitates temperature homeostasis. Sauna therapy capitalizes on the thermoregulatory property of homeothermy as the physiological ability of mammals and birds to maintain a relatively constant core body temperature with minimal deviation from a set point (38). The degree of these reactions is affected by the humidity level, as increased humidity can lead to water condensation and reduced sweat evaporation. At the cellular level, both wet and dry forms of thermotherapy can produce metabolic changes such as the production of heat shock proteins, reduction of reactive oxygen species and oxidative stress, reduction in inflammatory pathway activities, increased availability of nitric oxide and insulin sensitivity, and changes in endothelial-dependent vasodilation metabolic pathways (39). Hoekstra et al. (2020) demonstrated that exercise coupled with a passive elevation of body temperature can lead to acute increases and chronic reductions in inflammatory markers while positively impacting glycaemic control markers (40). Additionally, the study revealed that dry sauna significantly affected the sleep quality of middle-aged men, with the sleep quality of the dry sauna group being significantly higher than that of the steam sauna group. Furthermore, an increase in sleep quality was reported after a session of both dry and steam sauna. However, the dry sauna group improved sleep quality more than the steam sauna group. The results showed that a dry sauna bath improves sleep quality more than a steam sauna. The results of the research are consistent with those of Ainye and Vardani (2021) and Hayasaka et al. (2010) (28), who determined the effect of spa and sauna on sleep quality and blood glucose levels in people with type 2 diabetes. This study showed that the diabetic foot spa bath and sauna affected sleep quality and blood glucose levels. Ainye and Vardani (2021) indicated the effect of saunas and diabetic foot spas on the sleep quality of people with type 2 diabetes. The average sleep quality decreased after the intervention. Diabetic foot spa is a massage on the soles of the feet to improve blood circulation and increase insulin. In comparison, a sauna bath is a heat or temperature therapy using heat so people can sweat. Sauna bathing can increase blood circulation, detoxify the body, improve cardiovascular function, and improve sleep quality (41). Previous research has reported on the impact of diabetic foot spas on the sleep quality of individuals with type 2 diabetes (42). A study assessed the effect of diabetic foot spa and sauna bathing on sleep quality and blood glucose levels in individuals with type 2 diabetes. The participants underwent three consecutive sauna

bathing sessions for 15 minutes each, accompanied by a diabetic foot spa. The intervention reduced the physiological response to stress and promoted relaxation, thereby improving sleep quality. Additionally, a significant decrease was observed in the average blood sugar level after the intervention. The results suggested that diabetic foot spa and sauna bathing may have a positive effect on sleep quality and blood glucose levels in individuals with type 2 diabetes. According to previous research, a high blood glucose level before intervention may be influenced by gender. However, bathing in a sauna has increased body temperature, glucose metabolism, and consumption. In addition, more capillaries are opened, allowing insulin receptors to become more active. Running a spa and sauna bath can accelerate the reduction of blood glucose levels by increasing glucose consumption while improving blood circulation. During a session, individuals often feel relaxed, which can improve the quality of sleep. The hot temperature in the sauna causes the body to sweat, dilate blood vessels, stimulate blood circulation, and release endorphins, ultimately promoting relaxation. Diabetic foot spa and sauna baths may increase sleep quality. (43). Other research has shown that hot baths can have the same health benefits as exercise, including reducing inflammation, improving blood sugar, and lowering blood pressure. Still, other studies have indicated that exposure to extreme cold can help people burn fat, improve the immune system, and counteract some of the effects of type 2 diabetes. Exposure to high temperatures significantly strains the system and regulates heat and blood circulation. The human body actively responds to thermoregulatory mechanisms to maintain thermal homeostasis. Sweating on the body's surface efficiently eliminates excess heat that reaches the body from a hot environment. However, intense sweating is often associated with water loss from the body, which can lead to a decrease in blood volume and blood plasma volume and loss of body mass (36). Hayasaka et al. (2010) investigated the effects of such bathing on health status and quality in research using a population-based cross-sectional study including 617 Japanese participants who underwent routine medical examinations. Bathing times were classified into two levels: "less than seven times a week" (less bathing group) and "seven times or more a week" (frequent bathing group). The characteristics of age, body mass index, blood pressure, blood chemical findings, health, self-assessment, and sleep quality were compared between the two groups. The group that bathed frequently had better health and sleep quality with an adjusted odds ratio based on age and gender for self-rated and reported health. Besides sleep quality, other survey items were similar between the two groups. Bathing in a bathtub every day or more was associated with good health status and sleep quality (44), consistent with the present study. Another result of this research was the positive and significant effect of selected sauna (dry-steam) on cortisol in middle-aged men. The results showed that the dry sauna program had a greater and more significant effect on the hormone levels of the subjects than the steam, which is in contradiction with the research of Lee et al., 2019 (45) due to the type and amount of training and even the subjects' age. The alternating hot and cold conditions used in the sauna bath are considered to accelerate biomedical sports recovery and are often used as therapy in sports, recreation, and rehabilitation. During a sauna session, the human body is exposed to cold and hot stimuli. The hot air in the sauna room affected the skin and respiratory system, increasing core body temperature to 39°C, while skin surface temperature may even rise to 42°C (46). A body unable to release heat will likely overheat (15, 16). The increase in central temperature caused by the sauna session causes the release of psychotropic adrenochor, cortisol, and catecholamines (36). Elevated cortisol concentrations after a sauna session provide a highly sensitive indicator of heat stress in response to excessive heat during sauna bathing. In Folnius et al., the level of peripheral blood cortisol increased in both groups of men in this experiment, but the strongest secretion of this hormone was observed in untrained men compared to athletes. Thus, sauna bathing induces more thermal stress in untrained individuals than athletes. Adaptation to heat stress in the sauna is manifested by a lower increase in cortisol levels. The findings of different researchers about the changes in cortisol levels caused by hyperthermia in the sauna are not the same. Most studies investigating this issue show that cortisol levels are not increased or decreased (36). Subjects

who had never been to a sauna or who had adapted to heat stress in a sauna after several exposures were especially affected. According to other authors, a significant cortisol secretion was observed in people not adapted to a warm environment, both in men and women (36). Although Fulnius et al. (1982) argued that cortisol is a sensitive indicator of heat stress, the rectal temperature threshold at which cortisol secretion increases is 38°C. In the present experiment, the rectal temperature exceeded this threshold at the end of the sauna session. In contrast, in the above studies (15), the rectal temperature did not exceed the level of 38°C, and no increase in peripheral blood cortisol concentration was observed. The results of Fatoros et al. (2002) stated that the day time does not affect aerobic performance, which is contradictory. One of the other reasons why the evening program helps the subjects perform better is that the body is under a type of stress in the morning due to the release of cortisol and hormone cortisol in stressful situations (environmental effects, emotional pressure, activity sports, injury, infection, etc.). This hormone is called adaptation or stress hormone, and stress also causes changes in the immune system and the level of performance. The mechanisms of this difference in the increase in cortisol hormone after a dry sauna and steam bath are unclear. This difference seems to be due to the thermoregulatory and circulatory systems. Exposure to high temperatures imposes a significant burden on the thermoregulatory and circulatory systems. the body actively responds to thermoregulatory mechanisms to maintain thermal homeostasis. Sweating on the body's surface is an efficient way for the human body to get rid of excess heat that reaches it from a hot environment. However, when intense sweating occurs, water loss from the body can result in a decrease in blood and plasma volume and loss of body mass. (36).

Conclusion

According to these results, physiological variables, especially the hot temperature in the sauna, cause the body to sweat, dilate blood vessels, start blood circulation, stimulate endorphins, and affect blood glucose levels. As a result of increasing sleep quality, different groups of society are recommended to use saunas, especially dry saunas, to improve sleep quality and reduce blood sugar. Therefore, this implementation can help prevent diabetes and blood pressure complications and improve sleep quality in middle-aged people. Based on the results, the dry and steam sauna program reduced middle-aged men's cortisol variable. The dry sauna program was more influential on cortisol than the steam sauna.

Declarations

Acknowledgments

The authors thank and appreciate all those who helped in this research.

Authors' Contributions

All the authors have the same contributions in the execution and authorship of the study.

Conflict of Interest

The authors declare no conflict of interest in this study.

Financial Support

This study received no funds.

References

1. Asiimwe D, Mauti GO, Kiconco R. Prevalence and risk factors associated with type 2 diabetes in elderly patients aged 45-80 years at Kanungu District. Journal of diabetes research. 2020;2020:1-5.

2. Kruk J. Physical activity in the prevention of the most frequent chronic diseases: an analysis of the recent evidence. Asian Pacific Journal of Cancer Prevention. 2007 Jul 1;8(3):325.

3. Piercy KL, Troiano RP, Ballard RM, Carlson SA, Fulton JE, Galuska DA, George SM, Olson RD. The physical activity guidelines for Americans. Jama. 2018; 320(19):2020-8.

4. Hussain JN, Greaves RF, Cohen MM. A hot topic for health: Results of the Global Sauna Survey. Complementary Therapies in Medicine. 2019;44:223-34.

5. Kunutsor SK, Khan H, Zaccardi F, Laukkanen T, Willeit P, Laukkanen JA. Sauna bathing reduces the risk of stroke in Finnish men and women: a prospective cohort study. Neurology. 2018; 90(22):e1937-44.

6. Laukkanen JA, Laukkanen T. Sauna bathing and systemic inflammation. European Journal of Epidemiology. 2018;33:351-3.

7. Tsonis, J. Sauna Studies as an Academic Field: A New Agenda for International Research. Literature & Aesthetics, 2017; 26, 1.

8. Brunt VE, Minson CT. Heat therapy: mechanistic underpinnings and applications to cardiovascular health. J Appl Physiol (1985). 2021 Jun 1; 130(6):1684-704.

9. Petrie M, Johnson K, McCue P, Shields RK. Neuromuscular Electrical Stimulation Primes Feedback Control during a Novel Single Leg Task. J Mot Behav. 2021; 53(4):409-18.

10. Arena R, Guazzi M, Lianov L, Whitsel L, Berra K, Lavie CJ, Kaminsky L, et al. Healthy lifestyle interventions to combat noncommunicable disease-a novel nonhierarchical connectivity model for key stakeholders: a policy statement from the American Heart Association, European Society of Cardiology, European Association for Cardiovascular Prevention and Rehabilitation, and American College of Preventive Medicine. Eur Heart J. 2015; 36(31):2097-109.

11. Piercy KL, Troiano RP, Ballard RM, Carlson SA, Fulton JE, Galuska DA, George SM, Olson RD. The Physical Activity Guidelines for Americans. JAMA. 2018; 320(19):2020-28.

12. Shiralkar VV, Jagtap PE, Belwalkar GJ, Nagane NS, Dhonde SP. Effect of Steam Sauna Bath on Fasting Blood Glucose Level in Healthy Adults. Indian J Med Biochem 2018; 22(1):18-21.

13. Wolfson S, Neave N. Preparing for home and away matches. Insight: The FA Coaches Association Journal. 2004; 2:40-3.

14. Biro S, Masuda A, Kihara T, Tei C. Clinical implications of thermal therapy in lifestyle-related diseases. Exp Biol Med (Maywood). 2003; 228(10):1245-9.

15. Miller MG, Herniman JJ, Ricard MD, Cheatham CC, Michael TJ. The effects of a 6-week plyometric training program on agility. J Sports Sci Med. 2006; 5(3):459-65.

16. Hannuksela ML, Ellahham S. Benefits and risks of sauna bathing. Am J Med. 2001; 110(2):118-26.

17. Sobajima M, Nozawa T, Ihori H, Shida T, Ohori T, Suzuki T, Matsuki A, Yasumura S, Inoue H. Repeated sauna therapy improves myocardial perfusion in patients with chronically occluded coronary artery-related ischemia. Int J Cardiol. 2013; 167(1):237-43.

18. Masuda A, Miyata M, Kihara T, Minagoe S, Tei C. Repeated sauna therapy reduces urinary 8-epi-prostaglandin F(2alpha). Jpn Heart J. 2004; 45(2):297-303.

19. Gayda M, Bosquet L, Paillard F, Garzon M, Sosner P, Juneau M, Bélanger M, Nigam A. Effects of sauna alone versus postexercise sauna baths on short-term heart rate variability in patients with untreated hypertension. J Cardiopulm Rehabil Prev. 2012; 32(3):147-54.

20. Zalewski P, Zawadka-Kunikowska M, Słomko J, Szrajda J, Klawe JJ, Tafil-Klawe M, Newton J. Cardiovascular and thermal response to dry-sauna exposure in healthy subjects. Physiology Journal. 2014; 2014.

21. Li Z, Jiang W, Chen Y, Wang G, Yan F, Zeng T, Fan H. Acute and short-term efficacy of sauna treatment on cardiovascular function: A meta-analysis. Eur J Cardiovasc Nurs. 2020; 20(2):96-105.

22. Stanley J, Halliday A, D'Auria S, Buchheit M, Leicht AS. Effect of sauna-based heat acclimation on plasma volume and heart rate variability. Eur J Appl Physiol. 2015; 115(4):785-94.

23. Kirby NV, Lucas SJE, Armstrong OJ, Weaver SR, Lucas RAI. Intermittent post-exercise sauna bathing improves markers of exercise capacity in hot and temperate conditions in trained middle-distance runners. Eur J Appl Physiol. 2021; 121(2):621-35.

24. Ohori T, Nozawa T, Ihori H, Shida T, Sobajima M, Matsuki A, Yasumura S, Inoue H. Effect of repeated sauna treatment on exercise tolerance and endothelial function in patients with chronic heart failure. Am J Cardiol. 2012; 109(1):100-4.

25. Matsumoto S, Shimodozono M, Etoh S, Miyata R, Kawahira K. Effects of thermal therapy combining sauna therapy and underwater exercise in patients with fibromyalgia. Complement Ther Clin Pract. 2011; 17(3):162-6.

26. Celis-Morales CA, Lyall DM, Anderson J, Iliodromiti S, Fan Y, Ntuk UE, Mackay DF, Pell JP, Sattar N, Gill JM. The association between physical activity and risk of mortality is modulated by grip strength and cardiorespiratory fitness: evidence from 498 135 UK-Biobank participants. Eur Heart J. 2017; 38(2):116-22.

27. Buono MJ, Martha SL, Heaney JH. Peripheral sweat gland function, but not whole-body sweat rate, increases in women following humid heat acclimation. Journal of thermal biology. 2010;35(3):134-7.

28. Zech M, Bösel S, Tuthorn M, Benesch M, Dubbert M, Cuntz M, Glaser B. Sauna, sweat and science–quantifying the proportion of condensation water versus sweat using a stable water isotope (2H/1H and 18O/16O) tracer experiment. Isotopes in environmental and health studies. 2015; 51(3):439-47.

29. Ainiyah N, Wardani EM. Implementation of diabetic foot spa and sauna bathing on quality of sleep and blood glucose levels in individuals with type 2 diabetes. Journal of Health Sciences. 2021;14(1):21-6.

30. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989 May; 28(2):193-213. doi: 10.1016/0165-1781(89)90047-4. PMID: 2748771.

31. Komi PV. Training of muscle strength and power: interaction of neuromotoric, hypertrophic, and mechanical factors. International journal of sports medicine. 1986; 7(S 1):S10-5.

32. Naamat KK, Sadeghi H, Sahebozamani M, Nazari S. Effect of seated leg press exercise on knee extension strength in elderly. Journal of Research in Rehabilitation Sciences. 2014;10(4):539-48.

33. Patrick RP, Johnson TL. Sauna use as a lifestyle practice to extend healthspan. Exp Gerontol. 2021; 154:111509.

34. Arena R, Guazzi M, Lianov L, Whitsel L, Berra K, Lavie CJ, et al.. Healthy lifestyle interventions to combat noncommunicable disease-a novel nonhierarchical connectivity model for key stakeholders: a policy statement from the American Heart Association, European Society of Cardiology, European Association for Cardiovascular Prevention and Rehabilitation, and American College of Preventive Medicine. Eur Heart J. 2015; 36(31):2097-109.

35. Zinchuk VV, Zhad'ko DD. [Sauna effect on blood oxygen transport function and proxidant/antioxidant balance in youths]. Fiziol Cheloveka. 2012; 38(5):112-9.

36. Pilch, Wanda; Szyguła, Zbigniew; Tyka, Anna; Palka, Tomasz; Lech, Grzegorz; Cison, Tomasz; Kita, Bartłomiej. EFFECT OF 30-Minute Sauna Sessions on Lipid Profile in Young Women.Medicina Sportiva. 2014, Vol. 18 Issue 4, p165-171. 7p.

37. Zhao ZD, Yang WZ, Gao C, Fu X, Zhang W, Zhou Q, Chen W, Ni X, Lin JK, Yang J, Xu XH. A hypothalamic circuit that controls body temperature. Proceedings of the National Academy of Sciences. 2017;114(8):2042-7.

38. Liedtke WB. Deconstructing mammalian thermoregulation. Proc Natl Acad Sci U S A. 2017; 114(8):1765-7.

39. Iguchi M, Littmann AE, Chang SH, Wester LA, Knipper JS, Shields RK. Heat stress and cardiovascular, hormonal, and heat shock proteins in humans. J Athl Train. 2012; 47(2):184-90.

40. Hoekstra SP, Bishop NC, Leicht CA. Elevating body termperature to reduce low-grade inflammation: a welcome strategy for those unable to exercise?. Exerc Immunol Rev. 2020; 26:42-55.

41. Hussain J, Cohen M. Clinical Effects of Regular Dry Sauna Bathing: A Systematic Review. Evid Based Complement Alternat Med. 2018; 2018:1857413.

42. Wardani EM, Wijayanti L, Ainiyah N. The Effect Of Diabetic Feet Spa Therapy To Blood Glucose Level And Sleep Quality Of Diabetes Mellitus Patient. InInternational Conference of Kerta Cendekia Nursing Academy 2019; 7(1).

43. Gryka D, Pilch W, Szarek M, Szygula Z, Tota Ł. The effect of sauna bathing on lipid profile in young, physically active, male subjects. Int J Occup Med Environ Health. 2014; 27(4):608-18.

44. Hayasaka S, Shibata Y, Goto Y, Noda T, Ojima T. Bathing in a bathtub and health status: a cross-sectional study. Complementary Therapies in Clinical Practice. 2010;16(4):219-21.

45. Lee E, Willeit P, Laukkanen T, Kunutsor SK, Zaccardi F, Khan H, Laukkanen JA. Acute effects of exercise and sauna as a single intervention on arterial compliance. Eur J Prev Cardiol. 2020; 27(10):1104-7.

46. Kaplan, Lindsay J.The Experience of Yoga on Children with Anxiety. Retrieved from Sophia, the St. Catherine University repository. 2013.