

The Response of the Hormone Cortisol as a Biomarker of Stress and Its Influence on Blood Glucose Levels After 6 Weeks of Routine *Tahajjud* in Healthy Young Men

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Article Information:

Received 2023-11-19

Revised 2024-02-17

Published 2024-03-16

Keywords:

cortisol
glucose
prayer
stress
Tahajjud

Abstract

Stress is a trigger for various metabolic diseases such as hypertension, dyslipidemia, obesity, and diabetes; therefore, therapeutic approaches like *Tahajjud* are necessary to control stress. The study was to determine the effect of *Tahajjud* on cortisol as a marker of stress and its relation to glucose levels in healthy men. The research design was a randomized controlled trial. The subjects were male, Muslim, and healthy, with a total of 20 people and $n=10$ for each control and *Tahajjud* group. Midnight prayer (8 rak'ahs *Tahajjud* and four rak'ahs witir), duration 20-35 minutes, frequency 3-7 times/week, for six weeks as the treatment. Data analysis used descriptive analysis and a t-test ($p < 0.05$). The results showed an average percentage decrease in cortisol and blood glucose levels of 8.91% and 19.71%, respectively, following *Tahajjud*. The mean cortisol and glucose levels before *Tahajjud* did not differ substantially between the control and *Tahajjud* groups ($p = 0.336$ and $p = 0.808$). On the other hand, cortisol and glucose levels in the *Tahajjud* and control groups differed significantly after *Tahajjud* ($p = 0.031$ and $p = 0.004$). Cortisol and blood glucose levels significantly dropped after six weeks of therapy ($p = 0.005$ and $p=0.014$), while cortisol levels increased slightly and were not significantly higher in the control group ($p = 0.305$ and $p = 0.279$). *Tahajjud* prayer is a complementary and alternative therapy for stress by reducing cortisol hormone levels as a biomarker of stress and its responses to lowering blood glucose levels in healthy males.

INTRODUCTION

Stress is a type of pressure that an individual experiences from environmental loads. It impairs their capacity to adjust, leading to psychological and physical issues, and raises their risk of illness (Salleh, 2008). Stressors are defined as anything that has the potential to produce stress and can manifest at any point in a person's life (Salleh, 2008). In essence, people require mild stress because, on a physiological level, it triggers a favorable reaction that helps to boost drive, attention, and concentration. However, if stress drags on and occurs long-term, or what is usually called chronic stress, it will have various impacts on physical and psychological health (Toussaint et al., 2016). The mental problem that arises due to prolonged stress is called depression, which is a condition of loss of interest and pleasure due to a depressed mood that lasts for a long time and drags on without any solution (World Health Organization, 2023; Zafar et al., 2021).

How to cite:

Yusni, Y., & Rahman, S. (2024). The Response of the Hormone Cortisol as a Biomarker of Stress and Its Influence on Blood Glucose Levels After 6 Weeks of Routine *Tahajjud* in Healthy Young Men. *Islamic Guidance and Counseling Journal*, 7(1). <https://doi.org/10.25217/0020247447700>

E-ISSN:

2614-1566

Published by:

Institut Agama Islam Ma'arif NU (IAIMNU) Metro Lampung

Based on data from 2023, the World Health Organization (WHO) estimates that up to 280 million adults worldwide, or 5% of the total population (4% of males and 6% of females), suffer from depression (World Health Organization, 2023). Depression is a threat since it can lead to suicidal thoughts and actions (Zafar et al., 2021). Suicide is currently the fourth leading cause of death for those between the ages of 15 and 29. It is estimated that over 700,000 people commit suicide annually (World Health Organization, 2023). The prevalence of depression in Indonesia is around 5.6% in adults (18–24 years) and 5.1% in adolescents (15–17 years) (Suryaputri et al., 2022). However, it turns out that in Indonesia, the prevalence rate of stress and depression among students is higher, reaching 38.9% and 25.0%, respectively (Astutik et al., 2020). Symptoms of depression are impaired concentration, sleep disturbances, decreased or increased appetite, severe fatigue, feelings of excessive guilt, hopelessness, feeling like you have lost your future, and wanting to commit suicide (World Health Organization, 2023). A study conducted in Indonesia showed that depression 11 times increased the risk of suicide (Suryaputri et al., 2022).

Epidemiological studies found that around 14% of chronic diseases are caused by neuropsychiatric disorders, including stress (Santos et al., 2016). Chronic stress increases the risk of heart disease, hypertension, stroke, type 2 diabetes, and dyslipidemia, thereby increasing morbidity and mortality rates (Misra et al., 2023; Moyers & Hagger, 2023; Robert-mccomb et al., 2015). Chronic stress has a negative impact on the body due to the activation of the autonomic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis, which triggers an increase in cortisol secretion (Matzer et al., 2017). Cortisol is a steroid hormone and one of the main catabolic hormones produced by the zona fasciculata of the adrenal cortex in the kidneys (Hannibal & Bishop, 2014; Noushad et al., 2021). This hormone is synthesized from cholesterol by an enzyme called the cytochrome P450 enzyme.

Cortisol secretion is influenced by the circadian rhythm or body's biological clock, whose levels are very low in the middle of the night, starting to increase in the early morning and reaching a peak in the morning around 30-45 minutes after waking up (Palacios & Maroto-sánchez, 2015). Cortisol is a key hormone that plays a role in regulating metabolism and maintaining blood glucose levels, and it is also a potent anti-inflammatory hormone (Hannibal & Bishop, 2014). Cortisol, also known as the stress hormone, also plays an important role in the stress response and will increase during stress; therefore, cortisol is a biomarker of chronic stress (Ahmed et al., 2023; Hannibal & Bishop, 2014). A continuous and long-term increase in cortisol will trigger cortisol dysfunction, which can result in insulin resistance, thereby causing an increase in blood glucose levels (Hannibal & Bishop, 2014).

Stress definitely occurs throughout human life and cannot be prevented; therefore, everyone needs to make efforts to reduce or eliminate stress. Regular *Tahajjud* prayer is one action that we think can help relieve stress. Tahajjud is a kind of sunnah prayer that Muslims typically say in the latter part of the night. It is believed that tahajjud lowers cortisol levels in the blood. A research result that has been conducted reports that tahajjud can significantly reduce stress (Utami & Usiono, 2020). In this study, we tested the influence of *Tahajjud* on stress control by analyzing the molecular pathway of the stress response through the response to cortisol levels and its relationship to blood glucose levels. The results of this research will be used as a guideline so that tahajjud can be used as a complementary and alternative therapy for stress therapy and blood sugar control.

METHODS

Subjects: inclusion and exclusion criteria

The selection of subjects for research was carried out through screening by a questionnaire to determine their habits of carrying out *Tahajjud*. All the subjects selected were those who did not perform the *Tahajjud* prayer at all or performed the *Tahajjud* prayer

irregularly (less than twice a week). Subject selection was carried out in accordance with the inclusion and exclusion criteria of the study.

The inclusion criteria for research subjects were: Muslim, male, adult, aged between 19 and 25 years, healthy, not currently undergoing a diet or therapy to control blood sugar levels, not exercising regularly or exercising less than 2x per week, and willing to volunteer as research subjects. The subject is deemed healthy if, at the time of subject selection, the findings of a medical examination demonstrate that they are in good physical and mental health. The subjects do not have any chronic illnesses or mental health problems, according to the doctor's diagnosis. Meanwhile, the exclusion criteria include experiencing an injury during the research so that they are unable to perform *Tahajjud*, athletes, diabetes based on a doctor's diagnosis, having psychiatric problems based on a doctor's diagnosis, not having *Tahajjud* three times in a row, and not following all research protocols.

The control group and the trial group were the two groups that comprised the subjects. Groups without treatment are known as control groups, whereas groups with treatment are known as trial groups. The total number of subjects included in this study was $n = 20$, or ten males from each of the two groups: the trial group ($n = 10$) and the control group ($n = 10$). The minimal number of individuals required for experimental study, five, serves as the basis for determining the sample size. Therefore, the minimal sample size requirements have been satisfied by employing a total sample of 20 males (10 in the trial group and 10 in the control group).

Study Design

This research was a phase 1 clinical trial using healthy humans as subjects. The research design was a randomized control trial. The technique for selecting samples was to take samples based on screening results that had been adjusted to the research criteria. At first, the screening findings indicated that thirty subjects met the inclusion and exclusion criteria for the investigation. However, only 20 subjects were willing to be research participants. Thus, the total number of subjects used for this research was 20 men. Meanwhile, determining subjects for the control and trial groups was carried out using random sampling techniques.

The simple random sample via a lottery mechanism was the random sampling method employed. Each of the twenty subject names is placed into an empty can, shaken, and then removed one at a time throughout the lottery process. The control group will consist of the ten names that are pre-selected, while the treatment group will consist of the remaining ten names. By signing a formal document indicating their willingness to be research subjects, all subjects are committed to participating in research and do so voluntarily throughout all procedures.

Intervention

The treatment in the study was 11 *rak'ahs* of midnight prayer, consisting of 8 *rak'ahs* of the *Tahajjud* prayer plus three *rak'ahs* of the Witr prayer. Based on the Great Dictionary of the Indonesian Language (KBBI), *rak'ahs* is part of a prayer or prayer cycle that consists of one standing, one bowing, and two prostrations. The Tahajut prayer was performed by saying one greeting for every two *rak'ahs* of prayer, while the Witr prayer was done by saying one greeting for every three *rak'ahs* of prayer. The *Tahajjud* performed must be in accordance with Islamic guidelines, the correct prayer movements, and the tumakninah. To ensure this and minimize errors during the implementation of the *Tahajjud*, the research participants were all involved in Islamic religious activities and were volunteers at the Syiah Kuala University campus mosque. Before giving treatment, all subjects were briefed to be given guidance and procedures for carrying out *Tahajjud* according to Islamic guidance.

The reading of the Al-Quran surahs used was the same, consisting of Surahs An-Nas, Al Falaq, Al-Ikhlash, Al-Lahab, An-Nasr, Al-Kafirun, Al-Kautsar, Al-Maun, Al-Quraish, Al-Fiil,

Al-Humazah, Al-Asr, At-Takatsur, and Al Qadr. Reading the same surah of the Al-Quran for all participants aims to homogenize the duration of prayer. The frequency of *Tahajjud* prayers given was a minimum of 3 times and a maximum of 7 times a week, with a prayer duration of between 20 and 35 minutes for each Tahajud session, without any rest periods, and given for six consecutive weeks. *Tahajjud* is held from 3.30 to 4.30 WIB and is carried out individually (not in congregation).

Prior to the intervention, the subjects were briefed on how to say the *Tahajjud* prayer in line with Islamic principles, how long it takes to complete, which verses of the Al-Quran to read, and how many *rak'ahs* it takes. The lead researcher and the coordinator of the research subjects closely monitored the application of this research intervention. The study participants were housed in the same dormitory at Universitas Syiah Kuala to streamline the processes for intervention and keep an eye on their health. The head researcher monitored the subjects every day, while health checks were carried out every week or according to the subjects' complaints. During the treatment, no subjects experienced health problems, and no one dropped out.

Examination of Cortisol and Blood Glucose Levels

Plasma cortisol levels were examined using the enzyme-linked immunosorbent assay (ELISA) method. Cortisol levels were measured using blood samples. Blood was taken through the median cubital vein, with the amount of blood taken being 3–4 ml. The morning's blood collection took place between 07.30 and 08.30 WIB. The procedure for collecting blood was performed sterilely and in compliance with guidelines. Before blood was drawn, the subjects fasted for ten to twelve hours. The units of measurement for the serum cortisol test were µg/dL. We used the enzymatic calorimetric approach to measure blood glucose levels after a fast. The measurements of fasting blood glucose were given in milligrams per deciliter. Before and after six weeks of treatment, cortisol and blood glucose levels were measured.

Statistical analysis

The data analysis used was the t-test ($p < 0.05$), which included an independent sample t-test ($p < 0.05$) and a paired sample t-test ($p < 0.05$). An independent sample t-test was carried out to test the difference in mean values of plasma cortisol levels and blood glucose levels before and after administration of Tahajud between the control group and the trial group. The results of this analysis indicate the effect of *Tahajjud* intervention on cortisol levels and blood glucose in both groups.

The paired sample t-test was used to analyze the differences in mean values of plasma cortisol levels and blood glucose levels before and after Tahajud intervention in each control and trial group. The difference in the mean values of cortisol and blood glucose levels before and after giving therapy shows that there was an effect of *Tahajjud* therapy on cortisol and blood glucose for each control and trial group.

Ethical approval

The medical and health research ethics committee of the Faculty of Medicine, Universitas Syiah Kuala, with registration number 110/EA/FK/2023, approved this study through an ethical approval process and deemed it ethically appropriate in compliance with the seven 2011 WHO standards.

RESULTS AND DISCUSSION

Results

Subject Characteristics

Data regarding the characteristics of the research subjects are shown in Table 1. Results of the independent sample t-test analysis to determine differences in the mean values of the

subjects' physical characteristics (age, weight, height, BMI, systolic blood pressure (SBP), and diastolic blood pressure (DBP)) between the control group and the *Tahajjud* treatment group showed that there were no significant differences in the characteristics of research subjects such as age ($p = 0.91$), weight ($p = 0.75$), height ($p = 0.42$), BMI ($p = 0.91$), SBP ($p = 0.16$), and DBP ($p = 0.13$) between the control group and the *Tahajjud* treatment group ($P < 0.05$).

Based on this observation, it is feasible to conclude that the two groups fit the conditions to be used as study participants because of their similar physical traits. The subjects in the *Tahajjud* group and the control group were either normo-weight (BMI value: > 18.50 – 25.00 kg/m²) based on their average body mass index. Both groups' mean blood pressure readings fell within the normal range, with the DBP averaging 60–80 mmHg and the SBP measuring 90–120 mmHg.

Table 1. Characteristics of research subject

Characteristics	Group	n	Means $\pm$ SD	Minimum	Maximum	p-value
Age (year)	Control	10	21.80 $\pm$ 1.75	19	24	0.91
	<i>Tahajjud</i>	10	21.70 $\pm$ 2.16	19	25	
Weight (kg)	Control	10	66.21 $\pm$ 8.11	54	78	0.75
	<i>Tahajjud</i>	10	64.56 $\pm$ 14.57	46	87	
Height (cm)	Control	10	169.50 $\pm$ 3.86	163	175	0.42
	<i>Tahajjud</i>	10	169.69 $\pm$ 4.11	159	171	
BMI (kg/m ²)	Control	10	23.09 $\pm$ 3.19	18.62	29.40	0.91
	<i>Tahajjud</i>	10	23.64 $\pm$ 5.62	16.68	32.90	
SBP (mmHg)	Control	10	115.20 $\pm$ 7.08	111	122	0.16
	<i>Tahajjud</i>	10	116.10 $\pm$ 2.54	112	120	
DBP (mmHg)	Control	10	73.40 $\pm$ 8.25	65	86	0.13
	<i>Tahajjud</i>	10	74.40 $\pm$ 5.61	64	83	

*The level of significance ($p < 0.05$)

Figure 1 illustrates that after completing regular *Tahajjud* for six weeks, eight individuals, or 80% of the ten male patients in the therapy group, showed a drop in cortisol levels. The largest decrease in cortisol levels was around 6.60 μ g/dL, while the smallest decrease was 1.80 μ g/dL. Although the amount of decrease in cortisol levels is not the same between one subject and another in the same group, these results show that *Tahajjud* can reduce cortisol levels in as many as 80% of subjects.

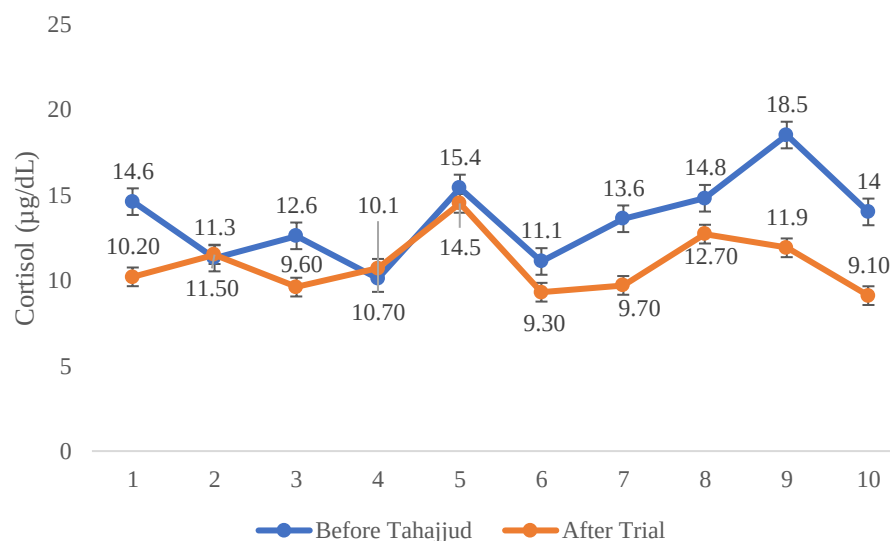


Figure 1. Differences in the cortisol levels of each subject before and after giving the *Tahajjud* prayer in the *Tahajjud* treatment group

As shown in Figure 2, after six weeks of consistent *Tahajjud*, all individuals in the *Tahajjud* group experienced a decrease in their blood glucose levels. These results show that blood sugar dropped in up to 100% of the subjects. *Tahajjud* can be used as an anti-hyperglycemic or anti-diabetic drug as a result of this decline in blood sugar. This phenomenon lends weight to the study on the effects of *Tahajjud* on decreasing blood sugar levels.

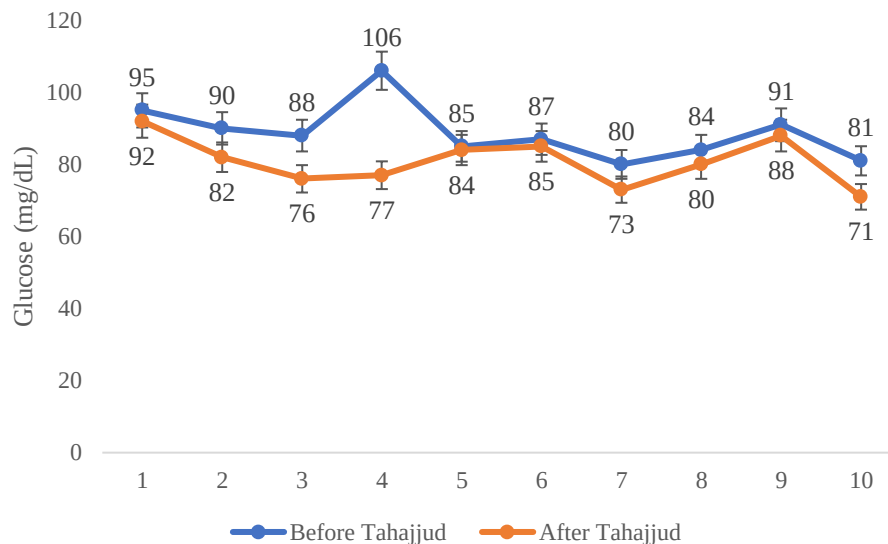


Figure 2. Differences in blood glucose levels of each subject before and after treatment in the *Tahajjud* treatment group

The average decrease in cortisol levels after treatment can be seen in Figure 3. The results show that the average decline in cortisol levels after giving *Tahajjud* was 19.71%. Meanwhile, Figure 4 also shows that the decrease in blood glucose levels was lower than cortisol, namely around 8.91%. The results of this descriptive analysis of the description of cortisol and glucose values show that *Tahajjud* performed regularly can reduce cortisol and blood glucose levels in healthy young men. However, to discover whether this decrease was statistically significant, a difference test was carried out using the t-test ($p < 0.05$), as can be seen in tables 2 and 3.

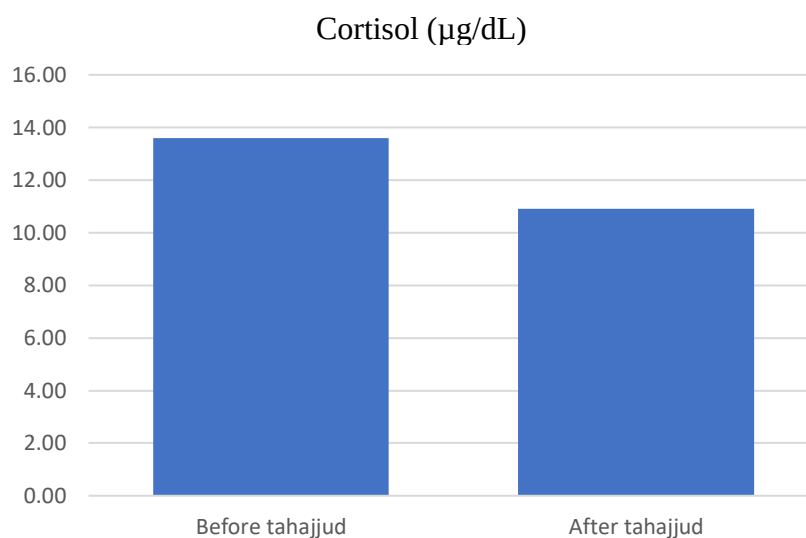


Figure 3. Mean decrease in cortisol levels among those receiving Tahajud therapy

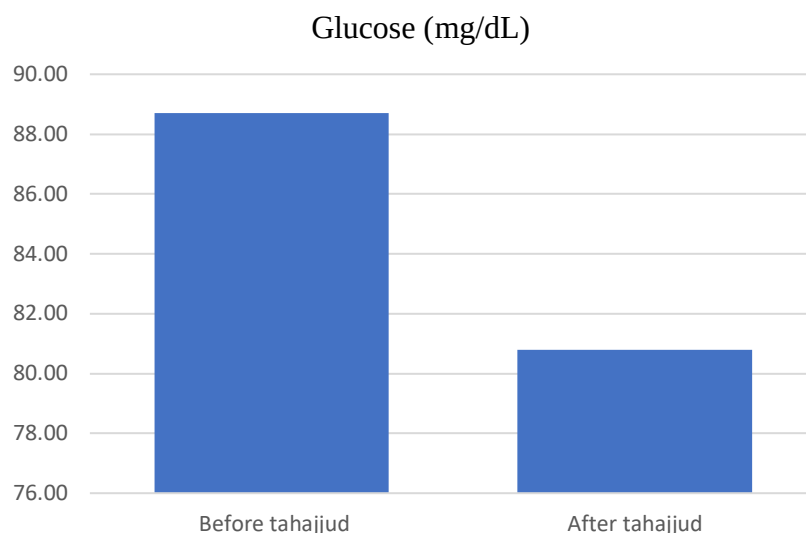


Figure 4. The average drop in blood sugar levels among the *Tahajjud* therapy group

The impact of treatment (Tahajjud) on cortisol and blood glucose levels in the control and Tahajjud groups

The results of the independent sample t-test analysis to determine the difference in mean values in cortisol and blood glucose levels before and after giving *Tahajjud* therapy between the control group and the *Tahajjud* treatment group can be seen in Table 2. These results show that the levels of cortisol and glucose before giving There was no significant difference between the control group and the *Tahajjud* treatment group ($p = 0.336$ and $p = 0.808$). On the other hand, following *Tahajjud* therapy, there was a significant difference in blood glucose and cortisol levels between the *Tahajjud* and control groups ($p = 0.004$ and $p = 0.031$). Cortisol and blood glucose levels in the control group were higher compared to the *Tahajjud* treatment group. These findings demonstrate that six weeks of 11 rak'ah *Tahajjud* can lower blood glucose and cortisol levels in young, healthy men.

Table 2. Effect of *Tahajjud* on serum cortisol and blood glucose levels in the control and the *Tahajjud* groups

Variable	Data	Group	Means $\pm$ SD	p-value
Cortisol	Before trial	Control	12.47 $\pm$ 2.65	0.336
		<i>Tahajjud</i>	13.60 $\pm$ 2.46	
	After trial	Control	13.46 $\pm$ 2.96	0.031*
		<i>Tahajjud</i>	10.92 $\pm$ 1.73	
Glucose	Before trial	Control	87.70 $\pm$ 10.33	0.808
		<i>Tahajjud</i>	88.70 $\pm$ 7.61	
	After trial	Control	91.70 $\pm$ 8.19	0.004*
		<i>Tahajjud</i>	80.80 $\pm$ 6.68	

*The level of significance ($p < 0.05$)

The differences in mean cortisol and blood glucose levels before and after *Tahajjud* therapy were assessed for each control group as well as the *Tahajjud* treatment group using the results of paired sample t-test analysis ($p < 0.05$), as presented in Table 3. This outcome demonstrates that there was no discernible difference between the blood glucose and cortisol levels in the control group before and after *Tahajjud* therapy; cortisol levels in the control group increased somewhat but not significantly ($p = 0.305$ and $p = 0.279$). On the other hand, after receiving *Tahajjud* therapy for six weeks, there was a substantial drop in both blood glucose and cortisol levels in the *Tahajjud* treatment group ($p = 0.014^*$ and $p = 0.005^*$).

These findings show that doing 11 rak'ah *Tahajjud* for six weeks had a substantial impact on the blood glucose and serum cortisol levels in healthy young males. *Tahajjud* has the potential to be utilized as stress therapy for young males because it can lower levels of the stress biomarker cortisol. However, more clinical investigations are required to confirm this assumption. The findings of this study also imply that tahajjud might be created as a cutting-edge, alternative medication for blood glucose regulation or anti-hyperglycemic therapy due to its capacity to lower blood glucose levels. However, more clinical studies involving diabetic patients are still necessary.

Table 3. Differences in cortisol and blood glucose levels before and after therapy in the control group and the group given post-operative treatment

Variable	Group	Intervention	Means±SD	p-value
Cortisol (µg/dL)	Control	Before	12.47±2.65	0.305
		After	13.46±2.97	
	<i>Tahajjud</i>	Before	13.60±2.46	0.005*
		After	10.92±1.73	
Glucose (mg/dL)	Control	Before	87.70±10.33	0.279
		After	91.70±8.19	
	<i>Tahajjud</i>	Before	88.70±7.60	0.014*
		After	80.80±6.68	

*The level of significance ($p < 0,05$)

Discussion

This study found that cortisol levels decreased in 80% of the subjects, with an average reduction value of 19.71%. Cortisol levels decreased significantly after giving *Tahajjud* for six weeks to healthy male subjects. These results show that routine *Tahajjud* can reduce stress. Hans Selye defines stress as a syndrome that arises due to a stimulus involving a complex neuroendocrine mechanism and preparing the body to provide a fight or flight response (James et al., 2023; Ortega et al., 2020). Acute stress occurs momentarily, alone, and does not drag on. Generally, this stress has a positive effect on the body in the form of increased motivation and energy; however, this response only appears briefly and within a few minutes (Smyth et al., 2013). Acute stress will also activate the fight-or-flight response mechanism needed by the body, and this stress is individual and its level will depend on a person's coping mechanisms; thus, acute stress is adaptive (Hannibal & Bishop, 2014; Smyth et al., 2013).

Chronic stress results in activation of the central nervous system, secretion of sympathetic catecholamines (epinephrine and norepinephrine), and the neuroendocrine system, especially the hypothalamic-pituitary-adrenal (HPA) axis for increasing cortisol secretion (Hannibal & Bishop, 2014; Tafet et al., 2001; Zafar et al., 2021). Cortisol secretion is regulated through a negative feedback mechanism (James et al., 2023). Stress will activate the HPA axis for cortisol secretion by activating the hypothalamus for corticotropin-releasing hormone (CRH) secretion (James et al., 2023). Then CRH synergizes with arginine vasopressin (AVP) to stimulate the secretion of adrenocorticotropin hormone (ACTH) by the anterior lobe of the pituitary gland, and the increase in ACTH triggers the activation of adrenocorticotropic receptors in the adrenal cortex to stimulate the release of the hormone cortisol (Anderson & Wideman, 2017; James et al., 2023).

High plasma cortisol will stimulate the hippocampus (which contains many corticosteroid receptors) to inhibit the HPA-axis, and as a result, cortisol secretion will be inhibited (James et al., 2023). Chronic stress causes damage to the hippocampus, including hippocampal atrophy, which results in the negative feedback mechanism being disrupted, causing cortisol production to remain high (James et al., 2023). HPA-axis dysfunction and impaired stress response regulation are triggers for depression (Ahmed et al., 2023).

Cortisol is a glucocorticoid that is secreted by the adrenal cortex and released into the blood circulation in response to stress; thus, cortisol is a biomarker of stress (Matousek et al., 2010; Mills et al., 2014; Misra et al., 2023; Nys et al., 2022). Normal cortisol levels for the morning are 5.0 and 25.0 µg/d (Gomes et al., 2012). Under normal conditions, cortisol functions as a potent anti-inflammatory, immunosuppressive, regulates metabolism, modulates glucose reserves for energy, and maintains homeostasis in the body (Hannibal & Bishop, 2014; Ortega et al., 2020; Park & Murlasits, 2023). Cortisol plays an important role during physical activity to increase energy availability by accelerating the gluconeogenesis process and increasing lipolysis and fat mobilization (Gomes et al., 2012; Rosa et al., 2012).

Chronic stress-related increases in cortisol secretion are dangerous because they weaken the immune system, raise blood pressure and the risk of hypertension, and raise blood sugar levels (Ortega et al., 2020). The secretion of cortisol is regulated by the biological clock located in the suprachiasmatic nucleus (SCN) of the hypothalamus. Its levels rise in the morning, progressively decline over the day, and peak around midnight (Anderson & Wideman, 2017; Nys et al., 2022). The pattern of cortisol production, which is regulated by circadian rhythms and whose levels in the blood begin to build in the early hours of the morning, helps to explain why Allah SWT commands Muslims to say the *Tahajjud* prayer in the latter part of the night. because, as this study's results have shown, the body can decrease the cortisol increase by praying *Tahajjud* in the last third of the night.

Tahajjud is a type of sunnah prayer performed by Muslims, where prayer is widely known to have physical and psychological health benefits such as reducing anxiety, depression, and stress (Fatima et al., 2022; Ghous & Malik, 2016; Sarkingobir et al., 2022). The findings of the studies indicate that *Tahajjud* can lessen the stress reaction (Utami & Usiono, 2020). One of the health benefits of prayer is improving health and physical fitness, which occurs as a result of perfect movements carried out in each prayer position, and these movements will change systematically, regularly, and measurably (İmamoğlu, 2016). In addition to its spiritual advantages, prayer can be seen as a new kind of physical exercise (Nazish & Kalra, 2018). Exercise is an appropriate non-pharmacological therapy to reduce stress and has an effect on cortisol control (Moraes et al., 2018; Praveena & Shashikala, 2022).

Frequent physical activity, or exercise, helps manage stress by modulating cortisol secretion (Liu et al., 2021; Nys et al., 2022). Exercise is another name for physical activity. Mild-to-moderate physical activity has been shown to improve mental and physical health (Fernandes et al., 2018). Regular light-moderate-intensity physical activity has been tested as an effective strategy for dealing with stress and reducing the hormone cortisol (Caplin et al., 2021; Matzer et al., 2017). However, on the contrary, high physical activity actually triggers an increase in cortisol levels (Aguiar et al., 2021; Park & Murlasits, 2023). There was a considerable drop in cortisol levels after the following 12 weeks of aerobic exercise (Karacabey, 2009). Aerobic exercise can also reduce cortisol levels not only in healthy people but also in people with mental illness (schizophrenia) (Chaves et al., 2020).

Prayer involves some motions that are akin to those in yoga and meditation. In addition, in order to have a clear mind and not be distracted by outside issues, the performer of prayer must be devoted to and focused on Allah SWT. Likewise, yoga and meditation practitioners are required to focus and concentrate fully when carrying out their activities; therefore, prayer is also like yoga and meditation, which have health benefits for reducing stress (Kamran, 2018). Yoga and meditation are forms of mind-body therapy that can improve mental health and reduce stress, anxiety, and depression (Fukuda1 & Morimoto, 2001; Mehrtash et al., 2015; Morgan et al., 2014). Yoga increases the stability of the HPA axis, thereby resulting in a decrease in cortisol (Misra et al., 2023). Meditation and slow deep breathing 3x/week, duration 40 minutes, and for 6 weeks reduce cortisol levels and also blood glucose in women with type 2 diabetes (Obaya et al., 2023).

We also found that regular *Tahajjud* for six weeks significantly reduced blood sugar levels in healthy young men. Cortisol is closely related to blood sugar levels because cortisol plays an important role in the metabolism of glucose, fat, and protein, so an increase in cortisol will trigger an increase in blood glucose (Gomes et al., 2012). Cortisol is the main catabolic hormone that functions as a blood glucose regulator through its antagonistic effect on insulin, thereby encouraging the breakdown of carbohydrates, fats, and proteins, facilitating the work of glucagon for the gluconeogenesis process, increasing muscle glucose oxidation pathways, increasing glucose uptake, and increasing brain glucose stores to increase energy production in all body cells (Aguilar et al., 2021; Fukuda1 & Morimoto, 2001; Gomes et al., 2012).

Continuous and long-lasting high cortisol levels will trigger an increase in blood glucose and induce insulin resistance; therefore, a progressive increase in cortisol over a long period triggers type 2 diabetes (T2DM) (Ahmed et al., 2023). T2DM is a condition where chronic metabolic disorders occur due to impaired insulin secretion and insulin action abnormalities (Seiler et al., 2020). Insulin plays a role in controlling blood sugar levels (Seiler et al., 2020). Stress hurts blood glucose levels because chronic activation of the HPA-axis results in an increase in serum cortisol levels, which triggers an increase in the gluconeogenesis process, as a result of which is an increase in lipids in the blood and an increase in blood glucose levels (Obaya et al., 2023). Aerobic exercise is a non-pharmacological therapy for blood sugar control because it can increase insulin sensitivity (Obaya et al., 2023).

CONCLUSION

Tahajjud, which consists of 11 *rak'ahs* performed on a regular basis for six weeks, lowers blood glucose and cortisol levels in healthy men. Therefore, *tahajjud* could be utilized as an alternative and complementary therapy for blood sugar control and stress reduction. It will take further studies to see whether *Tahajjud* can help patients with diabetes control their blood sugar levels and address psychological issues.

ACKNOWLEDGMENTS

We sincerely appreciate all the research subjects who willingly agreed to participate in the study, making it possible to conduct it without incident. The authors express their sincere gratitude to Universitas Syiah Kuala University for providing funding for the research through a professorial research award in 2023. We also thank the clinical laboratory of Prodia Banda Aceh for its help and financial aid with laboratory examinations.

This research was funded by Universitas Syiah Kuala, Ministry of Education, Culture, Research, and Technology, in accordance with the 2023 Fiscal Year Professorial Research Assignment Agreement Letter (Agreement number: 6/UN11.2.1/PT.01.03/PNBP/2023, dated May 3, 2023). We declare that there was no conflict of interest in the conduct of research, funding, or publication of this research.

AUTHOR CONTRIBUTION STATEMENT

All authors contributed fully to the implementation of this research, manuscript preparation, revision and publication.

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Islamic Guidance and Counseling Journal

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