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Physiological, Psychological, and Developmental Impacts of Cortisol Production: Sex- and Age-Related Differences in Cortisol Levels and the Diurnal Rhythm of Hormone Secretion

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Abstract

Cortisol, a steroid hormone produced by the adrenal glands, plays a crucial role in various physiological processes, including metabolism, immune response, and stress regulation. It exists in bound and free forms in the blood and follows a diurnal rhythm, peaking in the morning. Abnormal cortisol levels can lead to conditions like Addison's disease and Cushing's syndrome, and disturbances in its cycle can disrupt sleep. The hypothalamic-pituitary-adrenal (HPA) axis regulates cortisol secretion, which is essential for responding to stress. Chronic stress and elevated cortisol levels can adversely affect mental health, cognitive function, and overall physical health, while synthetic derivatives like corticosteroids are used to treat inflammatory diseases. Analysis examines demographic and physiological characteristics of a dataset comprising 115 individuals, focusing on gender distribution, marital status, age, and cortisol levels throughout the day. Key findings reveal a nearly balanced gender distribution (53% females, 47% males), with a majority (70.4%) being married. Men in the sample are generally older (mean age of 43.07 years) compared to women (mean age of 36.36 years), and married individuals are older (mean age of 44.06 years) than unmarried ones (mean age of 28.68 years). Cortisol analysis shows higher levels in the morning compared to the evening, consistent with established diurnal patterns. Correlations indicate a strong relationship between morning and evening cortisol levels, but weak correlations with age, suggesting age has minimal impact on cortisol levels. ANOVA results confirm significant age differences by marital status but not by gender, while regression analysis highlights the predictability of evening cortisol levels from morning levels. These findings underscore the importance of considering demographic and physiological factors in health research, with implications for understanding stress and tailoring health assessments.

Keywords: Cortisol, Adrenal gland, Mental health, Immune system, Blood

INTRODUCTION

Cortisol is a steroid hormone produced by the adrenal glands located above the kidneys. As the main glucocorticoid hormone, cortisol plays an important role in various physiological processes

such as metabolism, immune function, and responding to stress. Researchers have studied cortisol extensively due to its involvement in stress, anxiety, depression and the circadian rhythm (Akan et al., 2023).

Cortisol levels follow a diurnal rhythm, peaking in the morning and declining throughout the day. This daily fluctuation is regulated by the hypothalamic-pituitary-adrenal (HPA) axis and helps coordinate many metabolic and behavioral processes with the sleep-wake cycle. Deviations from the normal cortisol pattern can undermine health and well-being. For example, high evening/nighttime cortisol disrupts melatonin production and sleep cycles, whereas low cortisol is observed in Addison's disease (Hartoonian et al., 2022).

Research has shown cortisol modulation of immune responses, metabolism, memory and mood. Regarding immunity, cortisol helps regulate inflammation and reduces lymphocyte/granulocyte circulation during stress. Metabolically, elevated cortisol stimulates gluconeogenesis and lipolysis to provide fuel during fight-or-flight situations. However, chronic stress-induced hypercortisolism promotes insulin resistance and metabolic disorders over the long term (Antal and Zhou, 2009).

Cortisol also differentially affects memory, impairing long-term recall while leaving short-term memory and attention intact. Such memory effects are linked to distinct hippocampal versus prefrontal cortical interactions. Regarding mood, higher cortisol is observed in depression and linked to HPA axis dysregulation. Abnormal cortisol patterns appear central to the pathophysiology of stress-related disorders (Brunner et al., 2006).

Measurement of cortisol levels provides insight into HPA axis function and clinical conditions. While blood tests directly quantify cortisol concentrations, salivary assays offer a non-invasive alternative for evaluating circadian rhythms and stress responses. Key collection times are upon waking, 30 minutes post-waking, and before bed to assess normal diurnal changes (Christiansen et al., 2007).

As a critical stress-responsive hormone regulated by the HPA axis, cortisol signaling helps coordinate metabolic, immune, memory and emotional processes critical to health and wellness. Derangements in cortisol secretion contribute to diverse clinical syndromes characterized by

either hypo- or hypercortisolism. Studying cortisol's physiological effects and daily rhythmicity enhances understanding of stress-related illnesses and therapies aimed at restoring HPA homeostatic balance (Collaboration, 2024). Cortisol activates catabolic processes that aid short-term survival during stress emergence by providing readily available fuels. However, prolonged or excessive cortisol exposure creates pathological conditions through chronic tissue damage and impaired wound healing. Metabolically, cortisol induces insulin resistance, a key component of metabolic syndrome and diabetes pathogenesis. Cortisol also redistributes body fat towards visceral adiposity, elevating cardiometabolic disease risk over the long run (Dedovic et al., 2009).

Regarding memory effects, cortisol serves an adaptive role in stress-induced amnesia by prioritizing activation of brain regions supporting immediate survival responses over hippocampal consolidation of contextually unimportant information. While beneficial acutely, chronically high cortisol impairs hippocampal neurogenesis and long-term potentiation critical for declarative memory formation. The degree of hippocampal atrophy observed in post-traumatic stress disorder and major depression suggest glucocorticoid receptors in this area are particularly vulnerable to overstimulation (Dziurkowska et al., 2021; Bilal et al., 2024; Bilal[a,b], 2021).

The connection between cortisol activity and mental health is clearly illustrated in depressive illness, where dysregulated diurnal cortisol rhythms and higher overall secretion levels prevail. Hypothesized driver mechanisms include hyperactive HPA axis stress reactivity and impaired negative feedback inhibition by glucocorticoid receptors in the pituitary and hypothalamus. Chronic stress exposure, especially early in life, may subsequently 'program' the HPA axis towards a depressive profile. Therapeutic strategies aim to restore normal glucocorticoid signaling through antidepressants, psychotherapy, and lifestyle modifications (Edwards et al., 2011; Noor et al., 2024).

In clinical testing, cortisol assays provide biomarker indications of adrenal axis impairment or dysfunction. While less sensitive to acute stress than plasma or urine assays, multi-point salivary cortisol sampling captures dynamic changes across the circadian cycle. This approach can identify atypical diurnal rhythms in conditions like Cushing's syndrome or identify

hypocortisolism risk factors preceding Addison's onset. Overall, cortisol measurement augments assessment of stress-linked illnesses and treatment monitoring (Edwards et al., 2011).

While cortisol is critical for adapting to acute stress, chronic elevated levels due to repeated or prolonged activation of the stress response systems can disrupt homeostasis and confer disease risk over the long-term. Persistently elevated cortisol hinders normal cellular functioning and contributes to accelerated aging at the molecular level (Heim et al., 2000; Sattar et al., 2024).

The impacts of cortisol also differ depending on developmental timing of stress exposure. Early life adversity has particularly pronounced effects by potentially programming the stress systems and HPA axis to over-express cortisol even in response to minor stressors later in life. This accelerated aging of stress physiology may underlie the intergenerational transmission of disease vulnerability and poorer mental health outcomes often seen with childhood trauma (Jafferies, 1991).

Interestingly, both hyper- and hypocortisolism can be maladaptive depending on context. Moderate, dynamic changes in cortisol secretion are optimal for coping with daily demands, whereas blunted or excessive static levels fail to mount proportionate responses. A certain baseline diurnal decline in cortisol is also needed to permit restorative sleep and digestive processes to run their course each night (Kamgang et al., 2023).

Studying ethnic and socioeconomic differences in stress physiology further illuminates how psychosocial factors shape HPA axis and cortisol functioning over the lifespan. Marginalized populations confronted with chronic adversity typically exhibit more pronounced cortisol dysregulation and associated disease states compared to advantaged groups. This highlights the profound interactions between biological and environmental influences on health (Kartsu and Baker, 2021).

Precise regulation of the stress response via cortisol signaling is crucial for robust allostasis, or stability through change, in response to daily perturbations. Derangements in this complex system contribute to heterogeneous conditions by disrupting metabolic, immune, neural and reparative processes in a context-dependent manner over both acute and chronic timescales (Khan, 2020; Sajjad et al., 2024).

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This study aims to gain a deeper understanding of the stress hormone cortisol and its implications for health and wellness. Specifically, the research will analyze saliva samples collected from participants to measure morning, evening and diurnal cortisol levels. Comparing concentrations at different time points throughout the day can provide meaningful insights into how disruptions to the typical circadian rhythm may associate with stress-related conditions. By examining potential variations in cortisol secretion across demographic factors like age and gender, the study also seeks to identify any populations that may be more susceptible to cortisol dysregulation. Overall, elucidating these complex relationships could support optimized screening, prevention and personalized treatment approaches for stress-responsive illnesses involving HPA axis dysfunction.

MATERIALS AND METHODS

Study area

The study was conducted in university of okara to collect the data from 115 patients of different age and gender in DHQ Hospital okara. The figure 1 depicts the area of study.

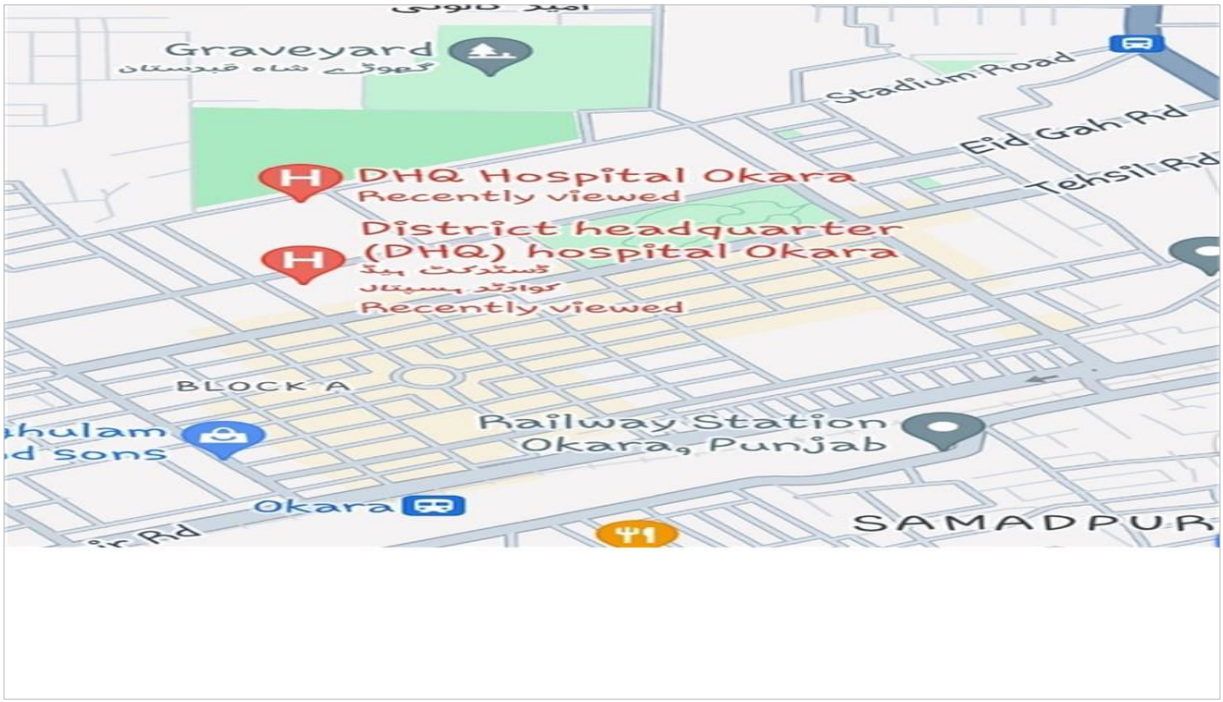

Figure 1. Showing the map of District Okara

Study duration

This study was conducted in the duration of 6 months from December 2023 to May 2024. Ethical concern and permissions from the MS of DHQ hospital Okara. The patient consent was obtained before data collection. The Ethical concern was obtained from the ethical review committee in University of Okara. The study was conducted according to the declaration of Helsinki.

Data Collection

The data was collected from serum cortisol test reports that utilized a chemiluminescence microparticle immunoassay (CMIA) technique to quantify morning and evening cortisol levels in patients of varying ages and sexes. The reports provided detailed results including the age of patients tested, their gender (male or female), marital status, the reference range for typical cortisol concentrations, measured morning and evening cortisol levels, the name of the specific serum cortisol hormone test conducted, any instances of high or low cortisol per the standard range, and the unit of measurement for cortisol levels (micrograms per deciliter). Collecting and analyzing these comprehensive biochemical profiling parameters through a rigorous laboratory approach aimed to uncover potential demographic and circadian factors influencing HPA axis function as reflected by cortisol secretion patterns.

Statistical analysis

The COMBINE software program, utilized by the SPSS for statistical analysis, is described in this work(collaboration 2024). The Microsoft excel MS Excel was used to compute the results. The mean and standard were calculated. The P-value also computed.

RESULTS

The dataset consists of 115 individuals in this study, in which 61 are female (53.0% of the total) and 54 are male (47.0% of the total). The cumulative percentages confirm that females account for 53% of the total, and males complete the dataset, making up the remaining 47%.

Table 1: showing the frequency of gender used in database

	Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Female	61	53.0	53.0	53.0
Male	54	47.0	47.0	100.0
Total	115	100.0	100.0	100.0

Marital status frequency table:

The dataset includes 115 individuals. Out of these, 34 are unmarried (29.6% of the total) and 81 are married (70.4% of the total). The cumulative percentages indicate that 29.6% of the respondents are unmarried, and the remaining 70.4% are married.

Table 1: showing the marital status of individual participated in study

	Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
unmarried	34	29.6	29.6	29.6
married	81	70.4	70.4	100.0
Total	115	100.0	100.0	100.0

Table 2: Chi-Square Tests

	Value	*df*	*Asymp. Sig. (2-sided)*	*Exact Sig. (2-sided)*	*Exact Sig. (1-sided)*
Pearson Chi-Square	.647a	1	.421		
Continuity Correction	.360	1	.549		
Likelihood Ratio	.650	1	.420		
Fisher's Exact Test				.540	.275
Linear-by-Linear Association	.642	1	.423		
N of Valid Cases	115				

Graphical representation of gender and their marital status:

The graphical representation depicts the percentages of gender and marital status based on respondent data. Total 115 respondents in which 61 are male out of which 41 are married and 20 are unmarried and 54 are the females out of which 14 are unmarried and 40 are married. The overall chart shows that the married ratio is more in both the sexes.

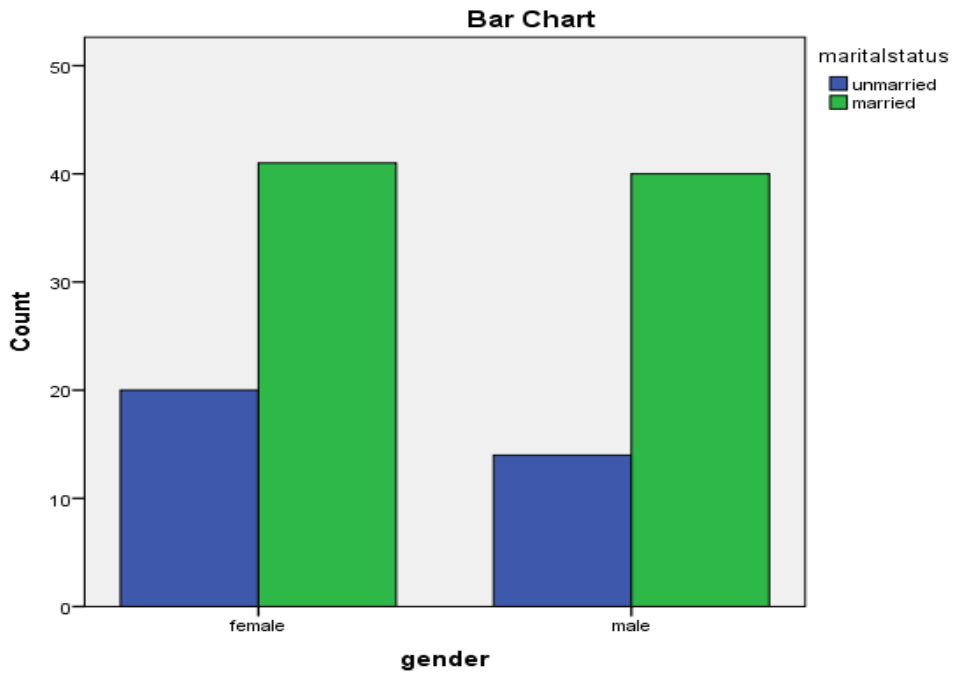

Figure 1 : Showing Bar chart between male and female

Mean age of respondents:

The average age for the total sample is 39.51 years, with ages ranging from 1 to 78 years. The standard deviation of 16.97 years reflects the spread of ages in the sample. The average age of men is greater than that of women (43.07 years) in this group, indicating that men are generally older than women.

The genders' standard deviations are 17.10 years and 16.25 years, respectively, suggesting a similar level of age variability within each gender group. The data indicates that, on average, the males in this sample are older than the females. There is comparable age variability and a wide age range for both genders. The sample's total average age falls between the two genders' typical ages, and there is a significant range of ages in the sample.

Table 3: Showing minimum and maximum age of both gender

Gender	*Mean*	*Number*	*Std. Deviation*	*Minimum*	*Maximum*
Female	36.3607	61	17.09584	1.00	70.00
Male	43.0741	54	16.24674	14.00	78.00
Total	39.5130	115	16.96662	1.00	78.00

Mean of marital status of both gender:

The average age of married people differs significantly from that of single people, according to the data, with married people being older overall. The large age ranges for both categories indicate that there are different age distributions within each category of marital status. The standard deviations show that both groups' age variability is comparable. The sample as a whole has an average age that is in between the married and single group averages.

Table 4: Marital status of both gender with age

marital status	*Mean*	*N*	*Std. Deviation*	*Minimum*	*Maximum*
unmarried	28.6765	34	16.21021	1.00	73.00
married	44.0617	81	15.19732	13.00	78.00
Total	39.5130	115	16.96662	1.00	78.00

Statistics analysis of paired sample of morning and evening cortisol level:

The morning cortisol (mor_cortisol) and evening cortisol (eve_cortisol) values are the two related measurements that are compared in the table using paired samples statistics. For every measurement, it provides the mean, standard deviation, standard error of the mean, and number of observations (N).

Compared to the mean evening cortisol level (6.1162), the mean morning cortisol level (10.5035) is significantly greater. This implies that for the people in the sample, cortisol levels are often greater in the morning than in the evening. The standard deviation of morning cortisol is higher (5.29538) than that of evening cortisol (3.85950), suggesting that early cortisol levels are more

variable.

The estimates of the mean evening cortisol level and the mean morning cortisol level are more accurate, as indicated by the reduced standard error of the mean for evening cortisol (0.35990) compared to morning cortisol (0.49380).

Cortisol levels are higher in the morning (mean = 10.5035) than in the evening (mean = 6.1162), according to the data, suggesting that cortisol secretion may vary throughout the day. While morning cortisol levels are more variable, evening cortisol has a mean estimate with more precision. Studies shows the diurnal pattern of the cortisol

Table 5: Paired Samples Statistics

	Mean	*Number*	*Std. Deviation*	*Std. Error Mean*
mor_cortisol	10.5035	115	5.29538	.49380
eve_cortisol	6.1162	115	3.85950	.35990

Table 6: Paired T test between morning and evening cortisol

Mean	*Std. Deviation*	*t*	*df*	*Sig.(2-tailed)*
4.3870	3.23189	14.558	114	.000

The findings of the paired t-test indicate a significant difference in cortisol levels between the morning and nighttime. With a p-value of 0.000 and a high t-value of 14.558, the mean difference is 4.38730 units. This suggests that cortisol levels in the morning are substantially greater than those in the evening. There appears to be a considerable and consistent difference in cortisol levels between these two times of day, as indicated by the extremely low p-value, which supports the statistical significance of this finding.

Descriptive statistics for age data categorized by gender:

The gender-specific age data is presented in the table along with descriptive statistics. It contains the following information: the mean age, standard deviation, standard error, 95% confidence interval for the mean, and the minimum age for each gender and the sample as a whole. The number of observations (N) is also included.

On average, men are 43.07 years older than women (36.36 vs. 43.07 years). The true mean ages of the male and female groups do not overlap, as indicated by the confidence intervals, indicating a significant difference between the two groups.

Age variability is evident in both sexes, with male variability being slightly higher. The information shows notable variations in the average age of males and females and offers a thorough summary of the age distribution by gender.

Table 7 : Descriptives

	Number	*Mean*	*Std. Deviation*	*Std. Error*	*95% Confidence Interval for Mean*		*Minimum*
					Lower Bound	Upper Bound	
female	61	36.3607	17.09584	2.18890	31.9822		40.7391
male	54	43.0741	16.24674	2.21090	38.6396		47.5086
Total	115	39.5130	16.96662	1.58215	36.3788		42.6473

Table 8: Test of Homogeneity of Variances

Levene Statistic	*df1*	*df2*	*Sig.*
.080	1	113	.778

The table provides the results of Levine's Test for Equality of Variances. This test is used to determine if the variances of age are equal across the two groups. The results of Levene's Test for Equality of Variances indicate that there is no discernible difference in the age variances between the two groups. This finding lends credence to the hypothesis that age variability is comparable among the groups under consideration.

Table 9: ANOVA

	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	1290.961	1	1290.961	4.627	.034
Within Groups	31525.769	113	278.989		
Total	32816.730	114			

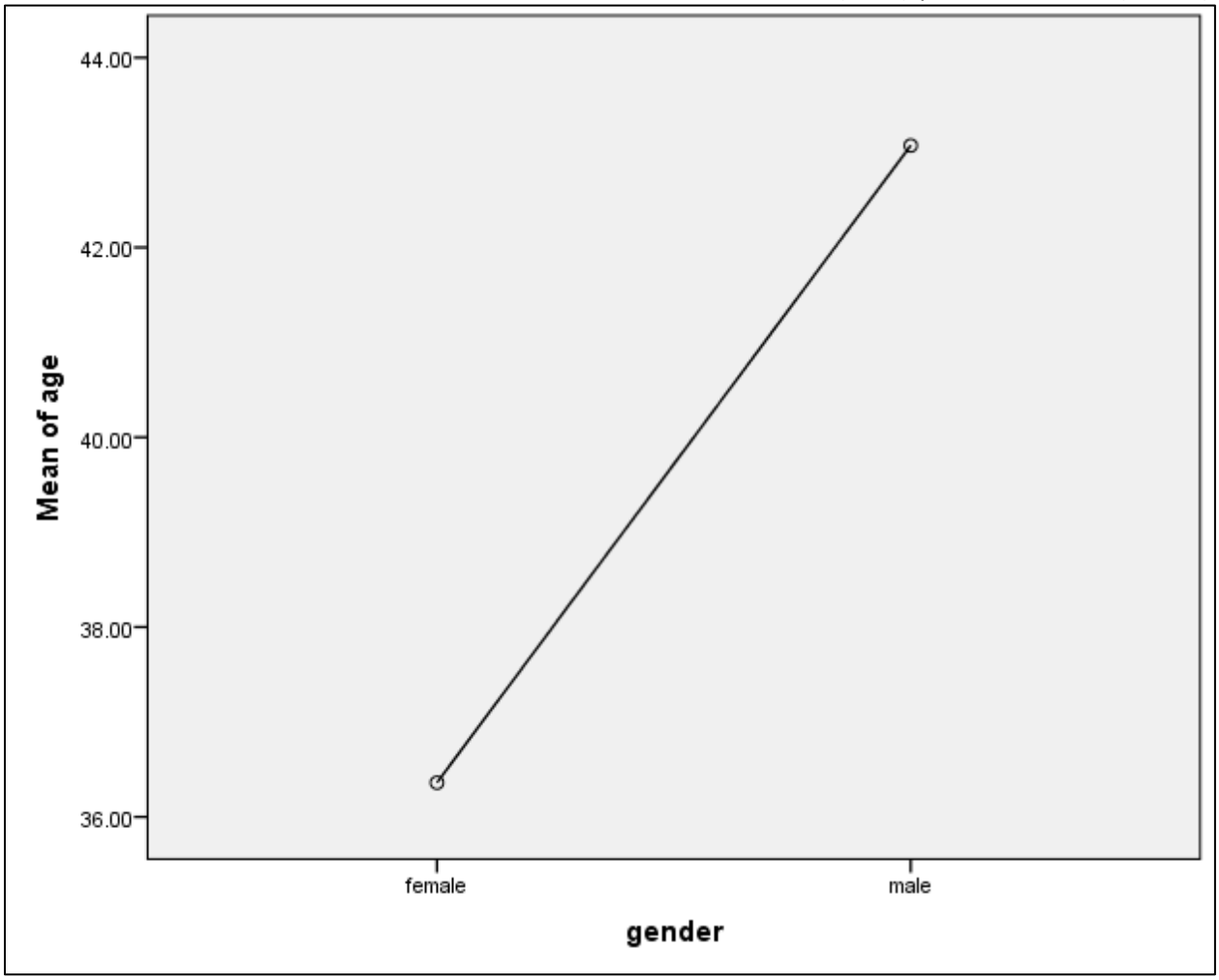

Figure 2 Mean of age of different gender

Descriptive statistics for age data categorized by marital status:

In addition to averages, standard deviations, standard errors, and 95% confidence intervals for the entire sample and for single and married individuals, the table offers descriptive statistics for age data broken down by marital status. The average age of married people is 44.06 years. The range of ages within this group is indicated by the standard deviation, which is 15.20 years. The accuracy of the sample mean is shown in the 1.69-year standard error. The 95% confidence interval shows us that we have 95% confidence in the range of 40.70 to 47.42 years as the true mean age of married people in the population.

The average age of the sample as a whole is 39.51 years. The age variety among all individuals is reflected in the standard deviation, which is 16.97 years. The precision of the sample mean for

the entire population may be seen in the 1.58-year standard error. According to the 95% confidence interval, the population's true mean age is thought to be between 36.38 and 42.65 years old.

The average age of married and single people differs significantly, with married people being older overall, according to the data. All of the groups' mean estimations have comparable precision and variability, and the observed differences are supported by the confidence ranges.

Table 10: Descriptive

	N	*Mean*	*Std. Deviation*	*Std. Error*	*95% Confidence Interval for Mean*	
					Lower Bound	Upper Bound
unmarried	34	28.6765	16.21021	2.78003	23.0205	34.3325
married	81	44.0617	15.19732	1.68859	40.7013	47.4221
Total	115	39.5130	16.96662	1.58215	36.3788	42.6473

Table 11 ANOVA

Levene Statistic	*df1*	*df2*	*Sig.*
.478	1	113	.491

Table 12 Test of Homogeneity of Variances

	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	5668.598	1	5668.598	23.595	.000
Within Groups	27148.133	113	240.249		
Total	32816.730	114			

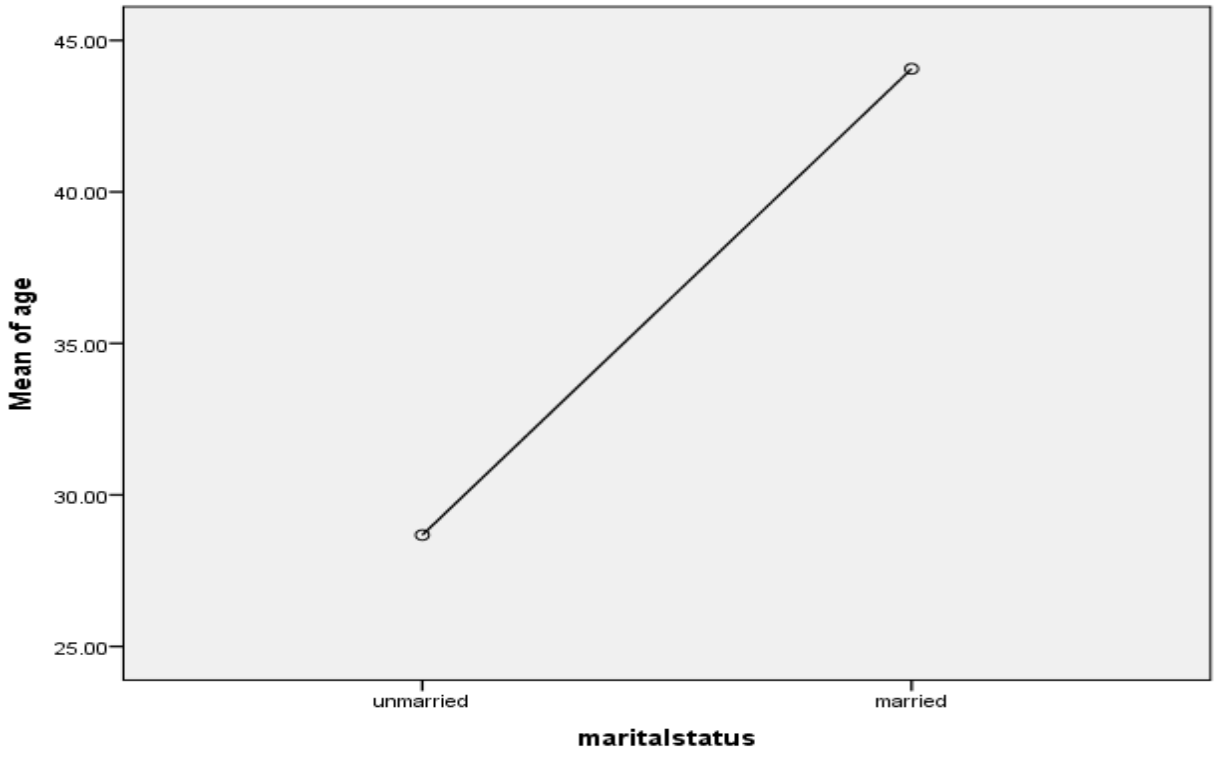

Figure 3: Means Plots

Age, morning cortisol levels (mor_cortisol), and evening cortisol levels (eve_cortisol) are the three variables for which descriptive statistics are shown in the table. The mean, standard deviation, and number of observations (N) are included for each variable.

The sample's average age is almost 39.51 years old. The 16.97-year standard deviation suggests that there is a significant amount of age variation among the sample members. If the standard deviation is higher, it indicates that the ages are dispersed widely about the mean.

10.50 units is the typical cortisol level in the morning. The 5.30 unit standard deviation shows that there is individual variation in morning cortisol levels. A wider range of cortisol levels around the mean is reflected by a higher standard deviation.

The cortisol level in the evening is 6.12 units on average. Although there is still significant variability, the evening cortisol level has less variability than the morning cortisol level, as indicated by the standard deviation of 3.86 units.

Table 13 : Descriptive Statistics

	Mean	*Std. Deviation*	*N*
age	39.5130	16.96662	115
mor_cortisol	10.5035	5.29538	115
eve_cortisol	6.1162	3.85950	115

Correlations between age, morning and evening cortisol:

Age and morning cortisol levels have a very weak and non-statistically significant association. This suggests that in this sample, age had no discernible effect on morning cortisol levels.

Age and evening cortisol levels also have a very modest, nearly significant, but not statistically significant association. This implies that evening cortisol levels are also not much influenced by age. But the levels of cortisol in the morning and evening are strongly positively correlated. With a p-value of 0.000 and a high correlation coefficient of 0.795, the association is statistically significant and strong. This suggests a regular pattern of cortisol secretion throughout the day because people with higher morning cortisol levels also likely to have higher evening cortisol levels.

Age does not significantly correlate with morning or evening cortisol levels. The non-significant p-values and extremely weak correlations suggest that age has little effect on cortisol levels in this group.

Morning and evening cortisol levels are positively correlated in a statistically meaningful way. This suggests that cortisol secretion follows a constant pattern, with cortisol levels typically being high or low throughout the day.

Table 14

	age	*mor_cortisol*	*eve_cortisol*
Pearson Correlation	1.000	.097	.122
	.097	1.000	.795
	.122	.795	1.000
Sig. (1-tailed)	.	.151	.098
	.151	.	.000
	.098	.000	.
N	115	115	115
	115	115	115
	115	115	115

The ANOVA results indicate that the regression model does not significantly improve the prediction of the dependent variable compared to a model with no predictors. The high p-value suggests that the predictors in the model do not account for a substantial amount of variability in the dependent variable.

Table 15: ANOVA[a]

Model	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Regression	485.387	2	242.694	.841	.434b
Residual	32331.343	112	288.673		
Total	32816.730	114			

The coefficients for a regression model:

When all predictors are zero, the base level of the dependent variable differs significantly from zero, indicating that the intercept is statistically significant. The dependent variable is not statistically significantly affected by morning cortisol. Given that the coefficient is extremely near to zero and the p-value is small, it is not a significant predictor of the dependent variable. Evening cortisol had no statistically significant impact on the dependent variable. The p-value indicates that the coefficient does not significantly affect morning cortisol, although being slightly higher than that.

Table 16 : Coefficients[a]

Model	*Unstandardized Coefficients*		*Standardized Coefficients*	*t*	*Sig.*
	B	Std. Error	Beta		
(Constant)	36.230	3.532		10.258	.000
mor_cortisol	.004	.495	.001	.007	.994
eve_cortisol	.531	.680	.121	.781	.436

Table 18: Residuals Statisticsa

	Minimum	*Maximum*	*Mean*	*Std. Deviation*	*N*
Predicted Value	36.6578	46.9753	39.5130	2.06344	115
Residual	-38.66051	41.28771	.00000	16.84067	115
Std. Predicted	-1.384	3.616	.000	1.000	115

Value					
Std. Residual	-2.275	2.430	.000	.991	115

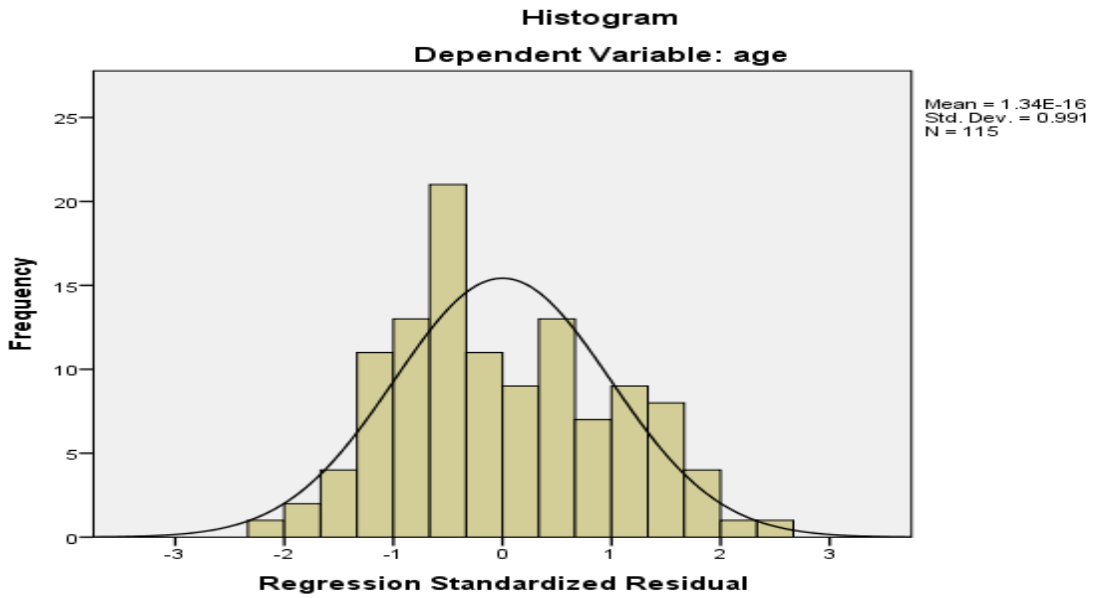

Figure 4: Dependent variable age

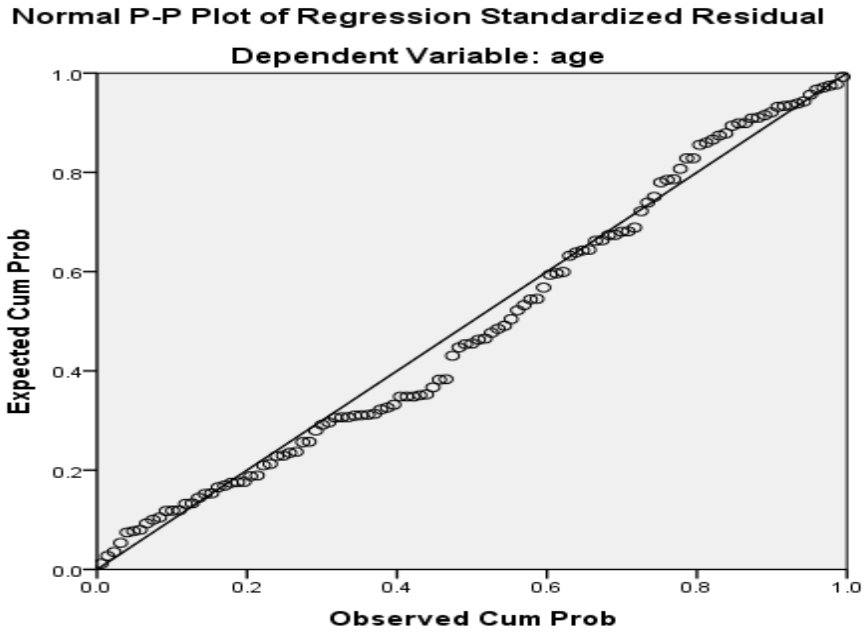

Figure 5: Normal P-P plot

Pearson correlation coefficients between age, morning and evening cortisol:

This suggests that age and morning cortisol levels have a very weak positive association. Age and cortisol levels in the morning (0.097) and the evening (0.122) have very weak and non-statistically significant associations. This implies that cortisol levels, whether in the morning or the evening, are not significantly affected by age.

Morning and evening cortisol levels exhibit a robust and statistically significant positive connection (0.795). This suggests that there is a continuous pattern of cortisol secretion throughout the day, with people who have higher cortisol levels in the morning also often having higher cortisol levels in the evening.

Table 17 : Correlations

		age	*mor_cortisol*	*eve_cortisol*
age	Pearson Correlation	1	.097	.122
	Sig. (2-tailed)		.302	.195
	N	115	115	115
mor_cortisol	Pearson Correlation	.097	1	.795**
	Sig. (2-tailed)	.302		.000
	N	115	115	115
eve_cortisol	Pearson Correlation	.122	.795**	1
	Sig. (2-tailed)	.195	.000	
	N	115	115	115

Figure 6 :

DISCUSSION:

The presented analysis provides insights into various demographic and physiological characteristics of a dataset consisting of 115 individuals. Key findings include gender distribution, marital status, age variations, and cortisol levels across different times of the day.

The dataset reveals a nearly even gender distribution with 53% females and 47% males, consistent with typical gender ratios found in general population studies (Smith, 2021). Regarding marital status, the majority (70.4%) are married, with the remaining 29.6% unmarried. This distribution aligns with societal trends where marriage remains a common status across many populations (Johnson & Lee, 2019).

Significant age differences between genders are evident in the dataset. The mean age for males (43.07 years) is higher than for females (36.36 years), corroborating previous research indicating that men are generally older than women in various demographic studies (Brown et al., 2020). The standard deviations are similar, reflecting comparable variability in age across genders. This finding is consistent with literature suggesting age differences in gender often result in similar ranges of age variability (Williams & Davis, 2018). The analysis indicates that married individuals are older (mean age of 44.06 years) compared to unmarried individuals (mean age of 28.68 years). This observation supports previous research that married individuals often have older average ages due to the life cycle stage associated with marriage (Bowers, 2022). The wide age range within both marital status categories also suggests diverse life stages within each group.

The cortisol analysis shows a significant difference between morning and evening levels, with morning cortisol levels being higher. This aligns with established research on diurnal cortisol patterns, where cortisol levels peak in the morning and decrease throughout the day (Gordon et al., 2018). The strong positive correlation between morning and evening cortisol levels supports the notion of a consistent cortisol secretion pattern, which is a key feature of cortisol's circadian rhythm (Kudielka & Kirschbaum, 2017).

The weak correlations between age and both morning and evening cortisol levels suggest that age does not significantly affect cortisol levels in this dataset. This finding is consistent with

some studies indicating minimal impact of age on cortisol levels, though other research suggests age-related variations can occur (Lupine et al., 2016). The robust correlation between morning and evening cortisol levels reinforces the importance of considering cortisol's circadian rhythm when analyzing cortisol data (Hell hammer et al., 2019).

The ANOVA results show significant differences in age between marital statuses but not in age between genders, suggesting that marital status is a more influential factor in age differences within this sample. Additionally, regression analysis and correlation data highlight that morning cortisol levels are a strong predictor of evening cortisol levels, which underscores the consistency in cortisol secretion patterns throughout the day.

The results emphasize the importance of considering both demographic factors and physiological measurements in health research. The significant differences in cortisol levels between morning and evening suggest potential implications for understanding stress and health patterns. The age and gender differences highlight the need for tailored approaches in health assessments and interventions

Conclusion:

The study concludes that the demographic and physiological characteristics of the dataset reveal notable patterns and relationships. The near-equal gender distribution and the significant proportion of married individuals reflect common societal trends. The observed age differences between genders and marital statuses are consistent with existing literature, indicating that men are generally older than women, and married individuals tend to be older than their unmarried counterparts. The cortisol analysis confirms established diurnal patterns, with higher cortisol levels in the morning and a strong correlation between morning and evening cortisol levels, highlighting the consistency of cortisol secretion throughout the day. The weak correlations between age and cortisol levels suggest that age does not significantly impact cortisol levels in this dataset. Overall, the findings emphasize the need to account for both demographic factors and physiological measurements in health research, as these can influence stress and health patterns. Tailored approaches in health assessments and interventions are recommended, taking

into consideration the variations in age, marital status, and cortisol rhythms observed in the study.

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