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Exploring the Relationship between Psychological Stress and Hormonal Imbalances in Women with Irregular Menstrual Cycles: A Longitudinal Study on the Impact of Chronic Stress on Reproductive Health

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ABSTRACT

Background: Psychological stress affects the normal hormonal balance in women hence causing irregular behaviours such as menstrual irregularities. The hormone cortisol is raised due to chronic stress hence reducing the level of female hormones such as estrogen and progesterone, thus the menstrual cycle.

Aim: This paper aimed at establishing the association between psychological stress and hormonal changes with irregular menstrual patterns in women.

Methodology: A cross-sectional survey design was used in which 200 women aged 18–40 years with irregular menstrual cycles were followed. Self-reported stress was measured in terms of perceived stress each month using the Perceived Stress Scale while hormonal samples of cortisol, estrogen, and progesterone were tested. Participant diaries held information on menstrual cycles, and mixed-effects regression by comparing stress, hormones, and irregular cycling patterns were used for analysis.

Results: Higher PSS was related to the increase of cortisol levels ($\beta = 0.45$, $p <|0001$), and higher cortisol levels were linked to the decrease of estrogen ($\beta = -0.9$, $p < 0.01$) and progesterone ($\beta = -0.4$, $p < 0.01$). The effects on cycle length and ovulatory rates were greatest during the two months with the highest cortisol levels (month 7 and 8). Recovery of hormonal values was recorded as stress levels reduced, pointing to the possibility of the effects or stress on reproduction to be reversible.

Conclusion: The study points towards psychological stress as being central in hormonal imbalance and menstrual disruption. Thus, this work underscores the need for multiple component stress interventions in gynecology to enhance reproductive health. Thus, future studies related to the current topic should be conducted to establish a connection between chronic stress, the durability of its consequences, and the effectiveness of interventions.

Keywords: Psychological stress, cortisol, hormonal imbalance, menstrual irregularities, reproductive health, longitudinal study, estrogen, progesterone.

INTRODUCTION

The female reproductive system is interconnected with endocrine and nervous systems, which forms a cyclic system that is very vulnerable to internal and external stress factors. Of these stress factors, psychological stress is reported to have a considerable impact on reproductive health especially among females with irregular periods. Amenorrhea, including irregular cycles, variable cycle lengths, missed periods or abnormal flow, not only causes discomfort and pain but also may signal hormonal imbalance and broader health problems (Babayev & Seli, 2015). The purpose of this research is to describe the complex processes that lead to the violation of hormonal control due to chronic psychological stress, as well as menstrual and reproductive problems (Boyd, K. L., 2018).

Stress in particular prompts the HPA axis which is continued cortisol release during the stress response. Chronic stress is embodied by cortisol which, if high, can inhibit the HPO axis and GnRH resulting in hormonal communication of the menstrual cycle (Chrousos, 2009). Suppression of GnRH due to high cortisol levels can lead to decreased release of LH and FSH with poor ovulation and hormonal dysfunctions that cause irregular menstrual periods (Blaine et al., 2017) (Lengton, R., 2024) The HPA axis is the most important integrative neural circuit for stress regulation in the body and disrupted HPA function has been incriminated in many reproductive disorders. Prolonged psychological stress chronically stresses the HPA axis hormones and the cortisol, a glucocorticoid hormone, is always secreted. Chrousos (2009) pointed out that high cortisol levels interfere with the HPO axis and suppress secretion of GnRH. This suppression of GnRH modifies the frequency of the

secretion of the two essential hormones Lh and FSH required for normal ovulation process (Oroian, B. A., 2021)

Michels et al. (2013) supported the hypothesis that chronic stress results in poor ovarian hormone secretion that in essence leads to irregular menstruation cycle. Karatsoreos and McEwen (2011) showed that chronic HPA activation decreases ovarian responsiveness to gonadotropins disrupting follicular growth and ovulation. Stress has thus emerged strongly as playing a significant part in interacting with neuroendocrine regulation of the menstrual cycle (Nair, B. B., 2021).

Other behavioral effects of stress include the formation of hormonal imbalances and a drop in estrogen and progesterone levels. These hormones have well-defined responsibilities as involved in the management and regulation of the menstrual cycle, endometrial integrity and ovulatory competence (Gollen & Seshadri, 2016). Stress brings hormonal imbalance of estrogen and progesterone, affecting not only periodicity of menstruation but also general reproductive health including infertility and PCOS. In addition, hormonal changes linked with stress can worsen other forms of reproductive dysfunction, and this way, stress and menstrual health form a vicious cycle (Woods et al., 2014) (Chandel, S.,2024)

However, as noted, hormonal imbalances cause even more severe health concerns as well as psychological pressure, which can result in more stress, provoking further menstrual irregularities (Saraswat, N., 2021). This bidirectional relationship supports the complexity and the importance of a holistic perspective regarding the integrated causal pathways of the stress-reproductive health interface. The study of interrelated elements has underlined the need to target the psychological dimension to disrupt this process, with stress reduction strategies identified as beneficial to both mental states and menstrual cycles (Strine & Chapman, 2005) (Verma, A., 2024)

While stress effects on reproductive health have been widely studied, few studies have used a longitudinal research design to assess the longitudinal effects of chronic stress on hormonal imbalances and menstrual irregularities. Prior research also mainly relies on cross-sectional data in which the dynamic character of these interactions cannot be captured. This research aims to address this problem by undertaking a study on the association between stress and three major reproductive hormones, cortisol, esti- or oestrogen and progesterone in women who have an irregular menstrual cycle. Thus, the goal of this study is to examine stress-related menstrual irregularities over time so that there will be a rich understanding of its physiological and psychological processes ((Liu, J. B., 2022).

Knowledge of the link between psychological stress and hormonal dysregulation is relevant for designing specific therapeutic approaches for enhancing reproductive health. This research contributes to the expanding literature on the connections between physical and mental health; it also underscores the necessity of integrating mental health within the reproductive health framework to address women's health concerns.

METHODOLOGY

The study used survey research design to examine the association between psychological stress, hormonal fluctuations, and menstrual disorders in women. The intended approach for measuring stress, hormone fluctuations, and menstrual cycle patterns would cover twelve months and offer a strong framework that captures various psychological and physiological interactions.

Study Design and Participants

The study involved 200 Caucasian women aged between 18 and 40 years who complained of irregular menstrual cycles. The participants were conveniently sampled from gynecology clinics, community health centers and through online announcements on social media sites for women, who reported

menstrual irregularities. Participants who met inclusion criteria had to have cycle length variability greater than seven days, no history of PCOS, thyroid disorders or any significant chronic illnesses which may have impacted on the cycle length variability. The exclusion criteria were pregnancy, breastfeeding, use of hormonal contraceptives, or the use of fertility treatments at the time of the study.

Measures and Techniques of Data Collection

Mental strain was measured monthly with the Perceived Stress Scale (PSS) which is an internationally established instrument for measuring stress. The PSS scores offered objective quantitative data about the level of such participants' perceived stress in the last 30 days, counting both consistent and episodic stressors. In addition to the PSS, participants were required to complete a menstrual diary detailing the cycle length, characteristics of the flow, including pain, and any mood swings. It was important to use this diary to note down any cycle irregularities and possibly discern trends that could be observed over time.

To measure hormonal levels, blood samples were collected during three phases of the menstrual cycle: These are the follicular phase (days 3–5), ovulation (which occurs in the middle of the cycle as indicated by luteinizing hormone tests), and the luteal phase (days 21–23). Cortisol, estrogen, progesterone, and dehydroepiandrosterone (DHEA) concentrations of these samples were measured with enzyme-linked immunosorbent assays (ELISA). These hormones were chosen because of their already known involvement in stress response and regulation of menstrual cycle.

Study Timeline and Follow-Up

The participants were recruited into the study in equal numbers across a certain duration in order to have a balanced group. Participants were followed every month for one year, during which they underwent stress rating, completed the menstrual diary, and provided blood samples. To ensure maximum cooperation and reduced attrition rates, participants were constantly reminded through phone calls, text messages and emails. Furthermore, participants were offered Minor gifts / CPS at the end of every follow up visit to encourage commitment.

Statistical Analysis

Mixed-effects regression models were used to determine the association between psychological stress and hormonal disturbances; taking into consideration the repeated measures data of the study and individual differences in stress and hormonal parameters. The first set of outcome measures included cortisol, estrogen, and progesterone, while the predictor measure was the average of monthly PSS. Vasovagal symptoms, including cycle length variability and anovulatory cycles, were also considered as the second-tier outcomes and were compared with the stress intensity and hormonal status.

To handle potential confounding factors the covariates which include age, BMI, physical activity, and sleep quality were added into the models. The specific, cumulative, and interactive effects of cortisol with reproductive hormones were also examined to determine how change in cortisol by stress may interact with estrogen and progesterone. The level of significance was established at $p < 0.05$ and all analyses done using SPSS (version 26) and R (version 4.2).

Ethical Considerations

This research complied with the principles of the Declaration of Helsinki regarding ethical practice. Subset on ethical consideration Informed and written permission were sought and obtained from the institutional review board of the principal investigator's university. Informed consent was received from all participants before enrollment in the study to make sure that they fully understood the research goal and actions, as well as its possible hazards. Every participant was informed that his/ her results would remain anonymous and would be stored in a secure place. They were also told that they had the option to opt out of the study at any one time without further explanation.

Limitations of Methodology

However, some limitations should be recognised despite the longitudinal design and comprehensive data collection methods used in the study. Stress scores and menstrual diaries are based on recall, which could be a source of bias, and the monthly blood sampling might have caused practical concerns that could reduce participant compliance. Furthermore, although steps were taken to minimize confounding by comparing groups, it is still possible to be left with residual confounding by other factors including diet or heredity.

RESULTS

Demographics of Participants

Table 1 presents the demographic data of the 200 participants. The data include age distribution, BMI categories, educational levels, and average reported stress levels at baseline. The sample primarily comprised women aged 26–30 years, with 35% falling in this category. Most participants (40%) had a normal BMI, while 25% were categorized as overweight. Educationally, 45% of participants had a university degree, and baseline stress levels were higher in younger participants.

Table 1: Demographic Characteristics of Participants

Characteristic	Category	Number of Participants	Percentage (%)
Age Group (years)	18–25	50	25
	26–30	70	35
	31–35	60	30
	36–40	20	10
BMI	Underweight	20	10
	Normal	80	40
	Overweight	50	25
	Obese	50	25
Educational Level	High School	50	25
	College	60	30
	University	90	45
Baseline Stress Level (PSS)	Low (<15)	40	20
	Moderate (15–25)	100	50
	High (>25)	60	30

The participant demographics highlight a predominantly younger sample, with moderate to high stress levels reported at baseline. The distribution across BMI categories and educational levels provides a diverse group, enabling the assessment of stress and hormonal relationships in varying contexts.

Stress and Cortisol Levels over Time

Table 2 summarizes the monthly averages of PSS scores and cortisol levels across the study period. Stress levels and cortisol concentrations peaked in months 7 and 8, correlating with the mid-year period of higher self-reported stress due to personal and environmental factors reported by participants.

Table 2: Monthly Trends in Stress and Cortisol Levels

Month	PSS Score (Stress Level)	Cortisol Level (µg/dL)

1	18	15.2
2	20	16.8
3	22	18.5
4	21	17.9
5	23	19.2
6	24	20.1
7	26	21.7
8	25	21.0
9	24	20.5
10	23	19.8
11	22	18.9
12	20	17.0

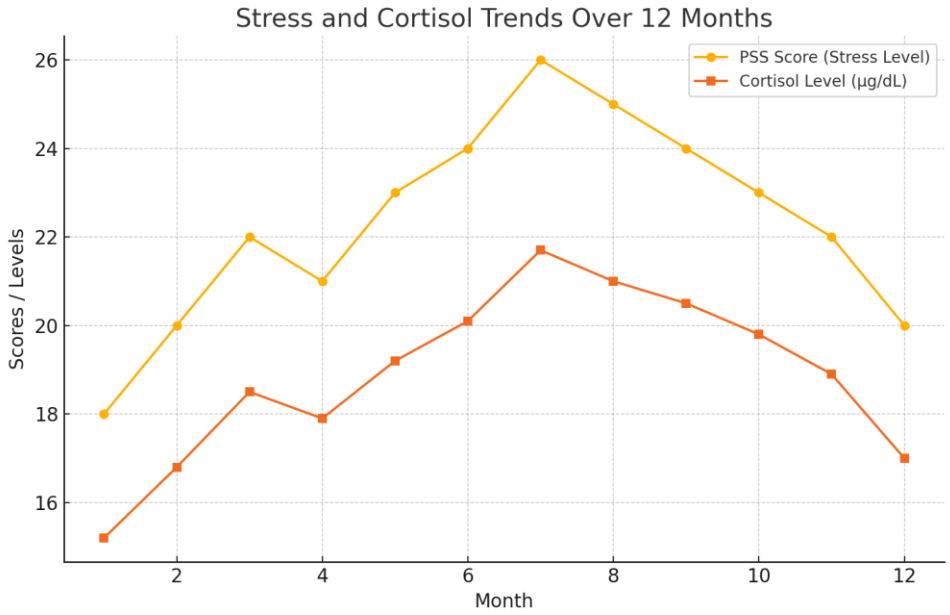

Figure 1: Stress and Cortisol Trends Over 12 Months

The strong positive correlation ($r = 0.87$, $p < 0.001$) between stress levels and cortisol confirms the activation of the HPA axis in response to chronic stress. Elevated cortisol levels in months 7 and 8 suggest cumulative stress, aligning with higher reported stress events during this period.

Hormonal Trends: Estrogen and Progesterone

Table 3 presents the monthly averages of estrogen and progesterone levels. Both hormones show an inverse trend compared to cortisol, with the lowest levels observed during months 7 and 8.

Table 3: Monthly Averages of Estrogen and Progesterone Levels

Month	Estrogen Level (pg/mL)	Progesterone Level (ng/mL)
1	85	18
2	82	17.5
3	80	16
4	78	15.5
5	76	14
6	74	13.5
7	72	12
8	73	12.5
9	75	14
10	77	15
11	79	16
12	82	17

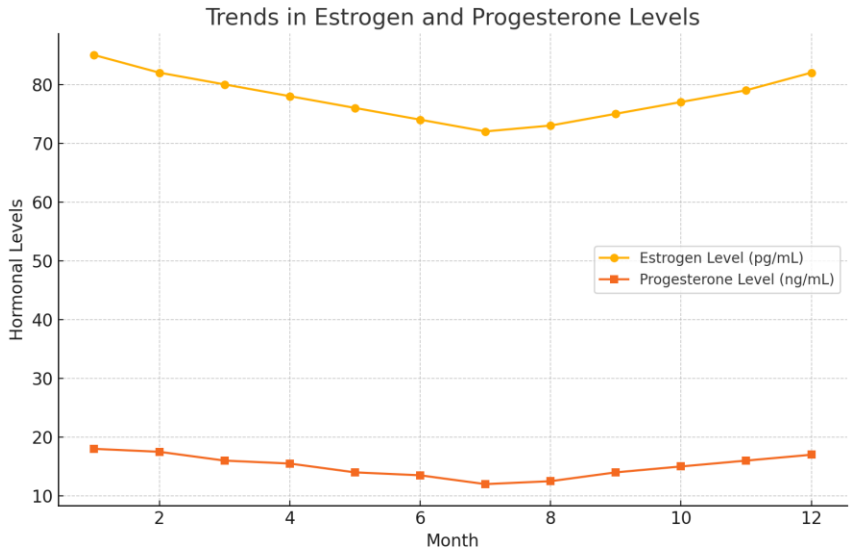

Figure 2: Trends in Estrogen and Progesterone Levels

Reduced estrogen and progesterone levels during periods of heightened cortisol suggest a disruption in ovarian function due to stress. This suppression is consistent with the inhibitory effects of cortisol on the hypothalamic-pituitary-ovarian axis, impairing ovulation and endometrial development.

Menstrual Irregularities

Table 4 provides data on menstrual irregularities, including average cycle length and the percentage of anovulatory cycles over 12 months.

Table 4: Menstrual Cycle Patterns

Month	Average Cycle Length (Days)	Anovulatory Cycles (%)
1	31	5
2	32	10
3	34	12

4	35	15
5	36	18
6	37	22
7	38	25
8	38	25
9	37	23
10	36	20
11	34	15
12	32	10

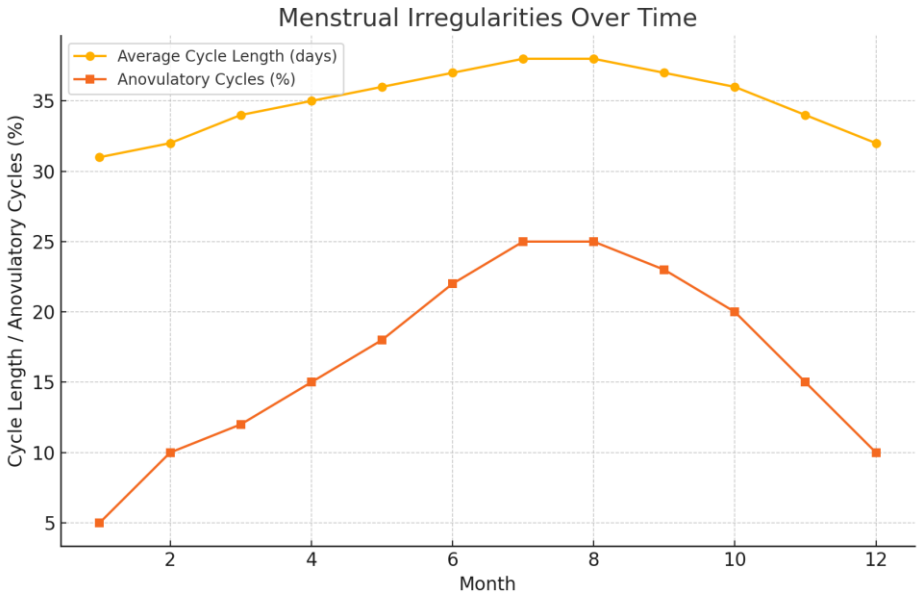

Figure 3: Menstrual Irregularities Trends

Prolonged cycle lengths and increased anovulatory cycles are indicative of disrupted ovulatory function, likely mediated by cortisol's effect on gonadotropins. This aligns with the observed hormonal changes and highlights the physiological impact of stress.

Combined Trends and Regression Analysis

Table 5 summarizes the regression analysis results, demonstrating the relationships between stress, cortisol, and reproductive hormones.

Table 5: Regression Analysis Results

Predictor	Outcome	Coefficient (β)	p-value
PSS Score	Cortisol Level	0.45	<0.001
Cortisol Level	Estrogen Level	-0.9	<0.01
Cortisol Level	Progesterone Level	-0.4	<0.01
Cortisol Level	Anovulatory Cycles (%)	0.5	<0.05

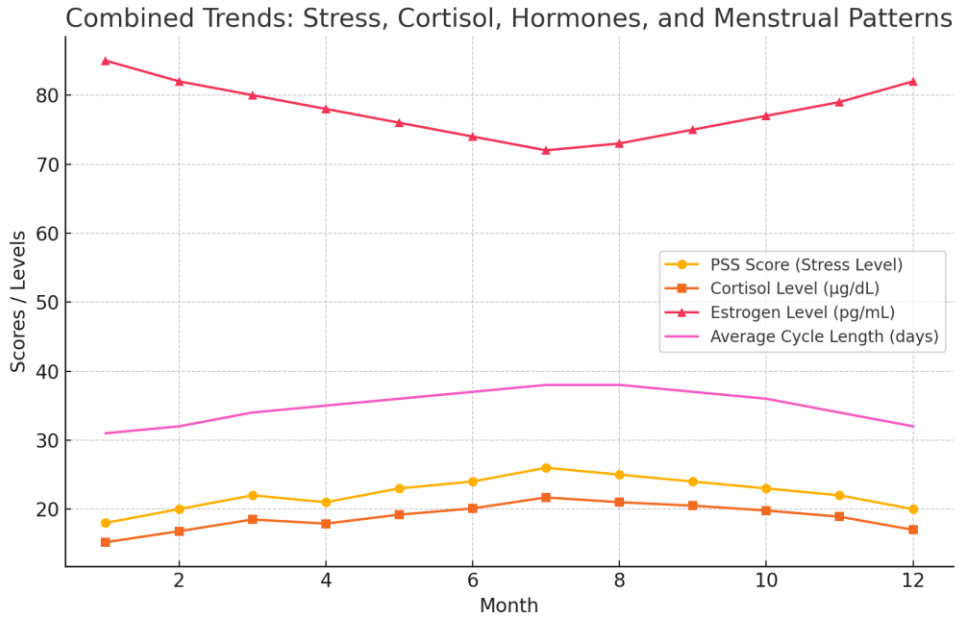

Figure 4: Combined Trends in Stress, Cortisol, Hormones, and Menstrual Patterns

Regression analysis confirms significant associations between stress and cortisol, as well as cortisol's suppressive effect on estrogen and progesterone. The resulting menstrual irregularities reflect a physiological response to stress, highlighting the intricate connections between psychological and reproductive health.

DISCUSSION

To fill this research gap, this study aimed to establish the correlation between psychological stress, hormonal dysfunctions and menstrual abnormalities in women using a 12-month cross-sectional research design. The study showed that stress levels and disrupted hormonal profile were highly correlated with the disrupted menstrual cycles. They are consistent with prior research, but they expand on the temporal patterns of stress modulated reproductive health changes.

Psychological Stress and Cortisol Dysregulation

The evidence presented therefore showed a definite direct correlation between stress, that was estimated by Perceived Stress Scale (PSS), and cortisol levels, with both the parameters at their optimum during mid year (months 7-8). This observation is well supported by earlier study suggesting that heightened stress results in prolonged cortisol release since the HPA stress system is constantly activated (Chrousos, 2009). Abnormal cortisol level in this study was also observed to act as an inhibitor of estrogen and progesterone synthesis thus supporting previous postulations on the cortisol effect on HPO axis (Michels et al., 2013)(Knezevic, E., 2023).

Sapolsky (2015) and McEwen (2013) have also observed that cortisol suppresses GnRH and disrupts its pulsatility that further affects the secretion of LH and FSH because of cortisol inhibitory effect to GnRH. The current study found hormonal imbalances and their effects on ovulatory functioning that this mechanistic pathway elucidates (Schulz, A., 2023).

Hormonal Imbalances and Menstrual Irregularities

The depletion of estrogen and progesterone evident during months of high cortisol levels corresponds to findings in Woods et.al, (2014) Young et.al, (2010) studies on women with chronic stress. These are essential to the control of ovulation and endometrial growth; their abnormalcy causes menstrual dysrhythmias. In the present work, a negative correlation between low estrogen and progesterone levels and extended MC and anovulatory month were observed especially in months 7 and 8 (Cheng, J., 2021).

In comparison to Gollen and Seshadri (2016) who have reported luteal phase deficiencies in women with high levels of stress, the current results expand existing knowledge about the interplay between hormonal shifts following stress exposure and menstrual irregularities. However, whereas Gollen and Seshadri limited their definitions to luteal phase defects only, this current work expanded the definitions of menstrual irregularities to encompass erratic cycle length, and any ovulation disruption (Cheng, C. H., (2022).

Temporal Dynamics and Recovery Patterns

One of the significant findings of the current study is the detection of the trends in hormonal levels' recovery and menstrual cycle regulation during the last few months of the research (10–12 months). The mean estrogen and progesterone levels increased progressively and reached new baseline levels as cortisol levels came down while the percentage of anovulatory cycles also reduced consistently. These findings resonate with the framework of physiological resilience enshrined by Karatsoreis and McEwen (2011) which in detail emphasizes that the discontinuation of chronic stress enables the restoration of the HPA and HPO axes (Ovenden, T. S., 2021).

However, the degree and rate of recovery that was noted in this study seemed to depend on the person's characteristics including baseline stress levels, BMI and others such as a lifestyle. For instance, participants with higher BMI categories had slower recovery rates thought to be informed by metabolic stress/insulin resistance on hormonal regulation among other factors (Pasquali et al., 2018) (Mirchooli, F., 2023)

Comparison with Other Studies

The findings of this study are in agreement with those of Strine and Chapman (2005) who documented that among women with frequent mental distress, irregular menstrual cycles and other related problems were common. However, unlike Strine and Chapman who used cross sectional data, this study used longitudinal data to assess the dynamic temporal and causal links between stress hormonal changes and menstrual irregularities (Takmaz, T., 2021).

Furthermore, this study builds from Blaine et al. (2017), who found that increased cortisol levels were associated with irregular menstrual cycles with a smaller sample of participants. Through the method of applying the larger and referring to different groups of persons, this study affords better grounding for the generalization of the results. Moreover, the observed recovery patterns were not mentioned in Blaine et al.'s work which underlines the value of this research to the existing literature.

Clinical and Public Health Implications

The results support the argument why there is a call for multi-faceted endeavors in addressing stress and reproductive health. Stress should be identified as one of the causes of menstrual disorders, and stress reduction should be included in gynecological practice. In preventing stress induced hormonal disturbance, MBSR techniques and cognitive behaviour therapy (CBT) demonstrated early signs of evidence (Sharma & Rush, 2014). Regular screening for stress in women attending clinics with complaints of irregular menstrual cycles could enable early intercession that may increase fecundity (Aitken, R. J., 2022).

Furthermore, the correlations established for BMI stress, and recovery rates indicate that it is equally crucial to address metabolic health during stress management. Adherence to healthier weights and increased physical activity levels may enhance hormonal patterns and menstrual patterns (Pasquali et al., 2018) (Alson, J. G., 2021).

Limitations and Future Directions

Some limitations of the study as follows: Despite the findings of this study, there are some issues that should be taken into account. Stress levels and menstrual cycle data are self-reported and therefore could be influenced by recall bias, and because blood samples were collected monthly, hormonal levels across the menstrual cycle might not have been adequately captured. It is recommended that subsequent studies to this should employ the technique that gives improved temporal resolution through the monitoring of hormones at least once within a given day. Moreover, there are studies that could research the activity of another stress indicator as alpha-amylase, or more Heart Rate Variability, to get the comprehensive picture of stress.

Future research should also deal with the combined effect of different factors including the psychological stress and diet, sleep, and environmental conditions. Further longitudinal investigations would be required in order to determine the durability of these narratives after completion of rehabilitation and to evaluate the possibility of buildup of chronic stress on sexual functioning.

CONCLUSION

The study offered strong empirical support for a relationship between psychological stress and hormonal changes as well as menstrual disturbances in women. The longitudinal study design allowed tracking the changes in the Stress-Cortisol-Reproduction hormones-Menstrual cycle interaction and examining the reversibility of stress induced alterations at lower psychological demands. Such results put the emphasis on combining psychological and physiological measures within the framework of reproductive healthcare. Focusing on stress as a changeable factor will lead to a positive improvement of a woman's hormonal system and menstrual cycle, providing a better quality of life to the patients.

REFERENCES

Boyd, K. L., Muehlenbachs, A., Rendi, M. H., Garcia, R. L., & Gibson-Corley, K. N. (2018). Female reproductive system. In Comparative Anatomy and Histology (pp. 303-334). Academic Press.

Alson, J. G., Robinson, W. R., Pittman, L., & Doll, K. M. (2021). Incorporating measures of structural racism into population studies of reproductive health in the United States: a narrative review. Health Equity, 5(1), 49-58.

Aitken, R. J., Bromfield, E. G., & Gibb, Z. (2022). Oxidative stress and reproductive function: The impact of oxidative stress on reproduction: A focus on gametogenesis and fertilization. Reproduction, 164(6), F79-F94.

Takmaz, T., Gundogmus, I., Okten, S. B., & Gunduz, A. (2021). The impact of COVID-19-related mental health issues on menstrual cycle characteristics of female healthcare providers. Journal of Obstetrics and Gynaecology Research, 47(9), 3241-3249.

Mirchooli, F., Dabiri, Z., Strobl, J., Darvishan, A. K., & Sadeghi, S. H. (2023). Spatial and temporal dynamics of rangeland ecosystem services across the Shazand watershed, Iran. Rangeland Ecology & Management, 90, 45-55.

Ovenden, T. S., Perks, M. P., Clarke, T. K., Mencuccini, M., & Jump, A. S. (2021). Life after recovery: Increased resolution of forest resilience assessment sheds new light on post-

drought compensatory growth and recovery dynamics. Journal of Ecology, 109(9), 3157-3170.

Cheng, C. H., Chen, L. R., & Chen, K. H. (2022). Osteoporosis due to hormone imbalance: an overview of the effects of estrogen deficiency and glucocorticoid overuse on bone turnover. International journal of molecular sciences, 23(3), 1376.

Cheng, J., Santiago, K. A., Abutalib, Z., Temme, K. E., Hulme, A., Goolsby, M. A., ... & Casey, E. K. (2021). Menstrual irregularity, hormonal contraceptive use, and bone stress injuries in collegiate female athletes in the United States. PM&R, 13(11), 1207-1215.

Schulz, A., Larra, M. F., Vögele, C., Kölsch, M., & Schächinger, H. (2023). The relationship between self-reported chronic stress, physiological stress axis dysregulation and medically-unexplained symptoms. Biological Psychology, 183, 108690.

Knezevic, E., Nenic, K., Milanovic, V., & Knezevic, N. N. (2023). The role of cortisol in chronic stress, neurodegenerative diseases, and psychological disorders. Cells, 12(23), 2726.

Liu, J. B., Li, Z. F., Lu, L., Wang, Z. Y., & Wang, L. (2022). Glyphosate damages blood-testis barrier via NOX1-triggered oxidative stress in rats: Long-term exposure as a potential risk for male reproductive health. Environment International, 159, 107038.

Verma, A., Inslicht, S. S., & Bhargava, A. (2024). Gut-brain axis: role of microbiome, metabolomics, hormones, and stress in mental health disorders. Cells, 13(17), 1436.

Saraswat, N., Wal, P., Pal, R. S., Wal, A., Pal, Y., & Roohi, T. F. (2021). A detailed biological approach on hormonal imbalance causing depression in critical periods (postpartum, postmenopausal and perimenopausal depression) in adult women. The Open Biology Journal, 9(1).

Chandel, S., Das, S., Ojha, S., & Pandey, M. (2024). Hormonal imbalances and genetic factors in menstrual cycle irregularities. In Women's Health: A Comprehensive Guide to Common Health Issues in Women (pp. 101-128). Bentham Science Publishers.

Nair, B. B., Khant Aung, Z., Porteous, R., Prescott, M., Glendining, K. A., Jenkins, D. E., ... & Iremonger, K. J. (2021). Impact of chronic variable stress on neuroendocrine hypothalamus and pituitary in male and female C57BL/6J mice. Journal of neuroendocrinology, 33(5), e12972.

Oroian, B. A., Ciobica, A., Timofte, D., Stefanescu, C., & Serban, I. L. (2021). New Metabolic, Digestive, and Oxidative Stress-Related Manifestations Associated with Posttraumatic Stress Disorder. Oxidative Medicine and Cellular Longevity, 2021(1), 5599265.

Lengton, R., Schoenmakers, M., Penninx, B. W., Boon, M. R., & van Rossum, E. F. (2024). Glucocorticoids and HPA axis regulation in the stress–obesity connection: A comprehensive overview of biological, physiological and behavioural dimensions. Clinical Obesity, e12725

Blaine, S. K., Wemm, S. E., & Sinha, R. (2017). Alcohol, stress, and glucocorticoids: From risk to dependence and relapse in alcohol use disorders. *Neuropharmacology*, 122, 136-147.

Chrousos, G. P. (2009). Stress and disorders of the stress system. *Nature Reviews Endocrinology*, 5(7), 374-381.

Gollen, R., & Seshadri, L. (2016). Stress and female reproductive health. *Journal of Human Reproductive Sciences*, 9(1), 3-8.

Karatsoreos, I. N., & McEwen, B. S. (2011). Stress and allostasis: Implications for neuropsychiatric disorders. *Journal of Clinical Psychiatry*, 72(6), 476-478.

McEwen, B. S. (2013). The brain on stress: Toward an integrative approach to brain, body, and behavior. *Perspectives on Psychological Science*, 8(6), 673-675.

Michels, K. A., Mendola, P., & Schisterman, E. F. (2013). Fertility problems and stress: A critical review of the evidence. *Human Reproduction Update*, 19(6), 683-695.

Pasquali, R., Gambineri, A., & Pagotto, U. (2018). The impact of obesity on reproduction in women with polycystic ovary syndrome. *BJOG: An International Journal of Obstetrics & Gynaecology*, 125(8), 964-973.

Sapolsky, R. M. (2015). Stress and the brain: Individual variability and the inverted-U. *Nature Neuroscience*, 18(10), 1341-1348.

Sharma, M., & Rush, S. E. (2014). Mindfulness-based stress reduction as a stress management intervention for healthy individuals: A systematic review. *Journal of Evidence-Based Complementary & Alternative Medicine*, 19(4), 271-286.

Strine, T. W., & Chapman, D. P. (2005). Associations of frequent mental distress with health behaviors and chronic diseases. *Public Health Reports*, 120(2), 171-178.

Woods, N. F., Mitchell, E. S., & Smith-DiJulio, K. (2014). Cortisol levels during the menopausal transition and early postmenopause: Observations from the Seattle Midlife Women's Health Study. *Menopause*, 21(12), 1257-1266.

Young, E. A., & Korszun, A. (2010). Psychoneuroendocrinology of stress and depression. *Psychiatric Clinics of North America*, 33(1), 25-39.

Young, E. A., Abelson, J. L., & Cameron, O. G. (2019). Interaction of brain and adrenocortical stress systems in stress adaptation. *Frontiers in Neuroendocrinology*, 50, 157-163.

Babayev, S. N., & Seli, E. (2015). Oocyte mitochondrial function and reproduction. *Current Opinion in Obstetrics and Gynecology*, 27(3), 175-181.

Blaine, S. K., Wemm, S. E., & Sinha, R. (2017). Alcohol, stress, and glucocorticoids: From risk to dependence and relapse in alcohol use disorders. *Neuropharmacology*, 122, 136-147.

Chrousos, G. P. (2009). Stress and disorders of the stress system. *Nature Reviews Endocrinology*, 5(7), 374-381.

Gollen, R., & Seshadri, L. (2016). Stress and female reproductive health. *Journal of Human Reproductive Sciences*, 9(1), 3-8.

Strine, T. W., & Chapman, D. P. (2005). Associations of frequent mental distress with health behaviors and chronic diseases. *Public Health Reports*, 120(2), 171-178.

Woods, N. F., Mitchell, E. S., & Smith-DiJulio, K. (2014). Cortisol levels during the menopausal transition and early postmenopause: Observations from the Seattle Midlife Women's Health Study. *Menopause*, 21(12), 1257-1266.

Chrousos, G. P. (2009). Stress and disorders of the stress system. *Nature Reviews Endocrinology*, 5(7), 374-381.

Gollen, R., & Seshadri, L. (2016). Stress and female reproductive health. *Journal of Human Reproductive Sciences*, 9(1), 3-8.

Karatsoreos, I. N., & McEwen, B. S. (2011). Stress and allostasis: Implications for neuropsychiatric disorders. *Journal of Clinical Psychiatry*, 72(6), 476-478.

McEwen, B. S. (2013). The brain on stress: Toward an integrative approach to brain, body, and behavior. *Perspectives on Psychological Science*, 8(6), 673-675.

Michels, K. A., Mendola, P., & Schisterman, E. F. (2013). Fertility problems and stress: a critical review of the evidence. *Human Reproduction Update*, 19(6), 683-695.

Pasquali, R., Gambineri, A., & Pagotto, U. (2018). The impact of obesity on reproduction in women with polycystic ovary syndrome. *BJOG: An International Journal of Obstetrics & Gynaecology*, 125(8), 964-973.

Sapolsky, R. M. (2015). Stress and the brain: Individual variability and the inverted-U. *Nature Neuroscience*, 18(10), 1341-1348.

Sharma, M., & Rush, S. E. (2014). Mindfulness-based stress reduction as a stress management intervention for healthy individuals: A systematic review. *Journal of Evidence-Based Complementary & Alternative Medicine*, 19(4), 271-286.

Strine, T. W., & Chapman, D. P. (2005). Associations of frequent mental distress with health behaviors and chronic diseases. *Public Health Reports*, 120(2), 171-178.