ASSOCIATION OF ULTRA-PROCESSED FOOD CONSUMPTION, PHYSICAL INACTIVITY, AND STRESS WITH LOW-GRADE INFLAMMATION IN ADULTS AGED 18–45 YEARS

Original Research

Tabeen Irfan[1]*, Rimsha Mudassar[2], Muhammad Ibrar Rafiq[2], Javeria Kaukab[2], Iman Fatima[2]

[1]Lecturer, Department of Human Nutrition and Food Technology, Faculty of Allied Health Sciences, Superior University, Lahore, Pakistan.

[2]Student of BS Human nutrition and dietetics, Department of Human Nutrition and Food Technology, Superior University Lahore, Pakistan.

Corresponding Author: Tabeen Irfan, Lecturer, Department of Human Nutrition and Food Technology, Faculty of Allied Health Sciences, Superior University, Lahore, Pakistan, tabeen.irfan@superior.edu.pk

Conflict of Interest: None   Grant Support & Financial Support: None

ABSTRACT

Background: Low-grade inflammation (LGI) is a persistent, subclinical immune response linked to the pathogenesis of non-communicable diseases (NCDs) such as obesity, type 2 diabetes, and cardiovascular conditions. Unlike acute inflammation, LGI is primarily influenced by lifestyle-related factors including dietary choices, physical inactivity, chronic psychological stress, and poor sleep. As NCD prevalence continues to rise in low- and middle-income countries, understanding the modifiable behavioral contributors to LGI is vital for developing preventive public health strategies.

Objective: To assess the association between lifestyle-related factors—specifically ultra-processed food (UPF) intake, physical inactivity, psychological stress, sleep duration—and symptoms of low-grade inflammation among young to middle-aged adults in Lahore, Pakistan.

Methods: A cross-sectional study was conducted among 200 adults aged 18–45 years at Superior University and CMA Hospital, Lahore. Convenience sampling was used. A structured, self-administered 30-item questionnaire was employed to collect data on dietary habits, physical activity levels, stress perception, sleep patterns, and self-reported LGI symptoms such as fatigue, joint pain, muscle stiffness, and sudden weight gain. Body mass index (BMI) was calculated and categorized based on WHO standards. Data were analyzed using SPSS v25.0, and chi-square tests were applied to examine associations between variables, with statistical significance set at p<0.05.

Results: Of the participants, 91.5% consumed sweets weekly, 70% reported high-fat food intake, and 69.5% regularly ate home-cooked meals. Moderate to severe stress levels were observed in 63%, and 70% did not engage in regular physical activity. LGI symptoms showed significant associations with low fruit intake (p=0.010), low dairy intake (p=0.043), poor sleep (p=0.000), high stress (p=0.025), and joint pain (p=0.001).

Conclusion: Lifestyle patterns involving processed food consumption, inactivity, and chronic stress contribute significantly to the manifestation of low-grade inflammation symptoms. Public health interventions promoting balanced diets, stress reduction, and active living are essential to mitigating LGI and its related health risks.

Keywords: Dietary Habits, Inflammation, Noncommunicable Diseases, Physical Activity, Psychological Stress, Sleep Deprivation, Ultra-Processed Foods.

INTRODUCTION

Low-grade inflammation (LGI), characterized by persistent and subclinical immune activation, has been increasingly recognized as a significant contributor to the pathogenesis of various non-communicable diseases (NCDs) such as type 2 diabetes mellitus, obesity, and cardiovascular disorders (1). Unlike acute inflammation, which is typically a short-lived immune response to injury or infection, LGI arises from sustained lifestyle and environmental influences that subtly alter immune function over time (2). Recent research highlights how poor dietary choices, especially the frequent consumption of ultra-processed foods (UPFs), insufficient physical activity, chronic psychological stress, and inadequate sleep contribute cumulatively to this pro-inflammatory state (3). UPFs, rich in trans fats, refined carbohydrates, and sodium, have been linked to increased systemic inflammation, thereby exacerbating metabolic dysfunctions (4). Moreover, psychosocial stress activates the hypothalamic-pituitary-adrenal (HPA) axis, elevating circulating cortisol levels, which in turn amplify inflammatory processes and impair immune regulation (5). Similarly, sleep deprivation and a sedentary lifestyle have been associated with heightened levels of inflammatory biomarkers such as C-reactive protein (CRP), further aggravating chronic disease risk. The burden of NCDs is rising alarmingly in developing nations, including Pakistan, where rapid urbanization and lifestyle shifts are fostering conditions conducive to LGI (6-8). Despite this growing concern, there remains a significant gap in localized data exploring the interplay between modern lifestyle behaviors and subclinical inflammation in South Asian populations. Understanding these associations within the sociocultural and economic context of Pakistani adults is crucial to inform preventive strategies and health education campaigns. Therefore, this study aims to investigate the relationship between lifestyle-related risk factors—specifically UPF consumption, physical inactivity, chronic stress, and insufficient sleep—and the presence of low-grade inflammation in young to middle-aged individuals residing in Pakistan.

METHODS

This cross-sectional study was conducted over a period of four months at Superior University and CMA Hospital, Lahore, targeting adults aged 18 to 45 years. A total of 200 participants were recruited through convenience sampling. Eligibility criteria included adults within the specified age range who were willing to provide informed consent and had no current diagnosis of acute infections or autoimmune diseases that could confound markers of inflammation. Individuals with diagnosed psychiatric illnesses, recent hospitalization, or pregnancy were excluded to minimize potential bias. Prior to data collection, ethical approval was obtained from the institutional review board (IRB). Written informed consent was obtained from all participants, ensuring adherence to ethical research practices. Data were collected using a structured, self-administered 30-item questionnaire designed to assess various lifestyle parameters relevant to low-grade inflammation (LGI). The questionnaire included items on dietary habits, specifically the frequency of consumption of ultra-processed foods such as candies, desserts, and fatty snacks, as well as intake of healthier food groups including dairy, fruits, vegetables, and protein-rich items (9,10). Physical activity was assessed by categorizing participants' weekly activity levels into sedentary, light, moderate, or vigorous, with additional questions on routine exercise behavior. Stress levels were evaluated based on self-reported experiences and classified as mild, manageable, distressing, or severe (11). Contextual social stressors were also considered to better capture psychosocial burden. Sleep patterns were assessed by recording the average duration of nightly sleep, grouped into four categories: 4, 6, 8, or 12 hours. Symptoms potentially indicative of LGI—such as fatigue, muscle tightness, joint pain, weight fluctuations, and dermatological issues—were documented to evaluate inflammatory manifestations (12,13). Additional variables included smoking status, previous history of chronic diseases, and body mass index (BMI). BMI was calculated using the standard formula (weight in kilograms divided by height in meters squared) and categorized per World Health Organization (WHO) guidelines into underweight (<18.5), normal weight (18.5–24.9), overweight (25–29.9), and obese (≥30). All data were entered and analyzed using SPSS version 25.0. Descriptive statistics were applied to summarize the data, while chi-square tests were employed to determine associations between lifestyle-related factors and the presence of LGI symptoms. A p-value of less than 0.05 was considered statistically significant for all analyses.

Volume 3 Issue 4: Lifestyle Factors and Low-Grade Inflammation
Irfan T et al.

INSIGHTS-JHR
INSIGHTS–JOURNAL OF HEALTH
AND REHABILITATION ■ ■ ■

RESULTS

Among the 200 adult participants, 58.0% had a normal body mass index (BMI), 13.5% were underweight, 21.5% were classified as overweight, and 7.0% were obese. High consumption of ultra-processed foods was notable, with 91.5% of participants consuming sweets weekly and 70.0% consuming high-fat foods with similar frequency. Despite these dietary patterns, 69.5% reported consistently eating home-cooked meals, while 27.5% occasionally consumed snacks. Regarding physical activity, 14.0% of participants reported a sedentary lifestyle, and only 9.0% engaged in vigorous activity. Moreover, 70.0% did not engage in regular exercise. The majority of participants (63.0%) reported experiencing moderate to severe stress, with 43.0% identifying their stress levels as intense. Social pressures were cited as the primary cause by 66.0% of these individuals. Sleep duration was suboptimal for many, with 44.0% sleeping only 6 hours per night and 11.5% sleeping for just 4 hours. The most common symptoms associated with low-grade inflammation (LGI) included sudden weight gain (reported as significant by 29.0%), joint pain (23.0% often or always), and fatigue (19.0% always or occasionally). Significant statistical associations were observed between several lifestyle factors and LGI symptoms. Reduced dairy and fruit intake were significantly associated with low energy levels (p=0.043 and p=0.010, respectively), while high stress levels were also significantly linked to fatigue (p=0.025) and poor sleep (p=0.011). Joint pain or muscle stiffness showed a strong association with both low energy (p=0.000) and high stress (p=0.001). Additional correlations included a significant relationship between sedentary behavior and elevated stress levels (p=0.027), and between BMI and both sudden weight gain (p=0.025) and processed food intake (p=0.052, borderline significance). Consumption of home-cooked meals was inversely related to sweets intake (p=0.050, borderline significance). Other relevant findings included significant associations between stress and skin problems (p=0.044), physical activity and protein source preference (p=0.026), and between dairy and fruit intake and adequate sleep (p=0.000 and p=0.020, respectively).

Table 1: Participant Characteristics and Lifestyle Factors

Variable	Category	Frequency (n)	Percentage (%)
BMI	Underweight	27	13.5
	Normal	116	58.0
	Overweight	43	21.5
	Obese	14	7.0
High-Fat Food Consumption	Never	11	5.5
	Daily	47	23.5
	Once a week	75	37.5
	2–3 times a week	67	33.5
Sweets Consumption	Never	17	8.5
	Daily	45	22.5
	Once a week	85	42.5
	2–3 times a week	53	26.5
Home-Cooked Meals	Rarely	13	6.5
	Sometimes	15	7.5
	Often	33	16.5
	Always	139	69.5
Snack Food Consumption	Rarely	47	23.5
	Sometimes	99	49.5
	Often	38	19.0
	Always	16	8.0
Physical Activity/Week	Sedentary	28	14.0
	Light	71	35.5
	Moderate	83	41.5
	Vigorous	18	9.0
Regular Exercise	Yes	60	30.0
	No	140	70.0

Stress Level	Mild	17	8.5
	Tolerable	57	28.5
	Distressing	40	20.0
	Intense	86	43.0
Sleep Hours	4 hours	23	11.5
	6 hours	88	44.0
	8 hours	77	38.5
	12 hours	12	6.0
Joint Pain/Muscle Stiffness	Rarely	87	43.5
	Sometimes	67	33.5
	Often	27	13.5
	Always	19	9.5

Table 2: Significant Associations with Low-Grade Inflammation Symptoms

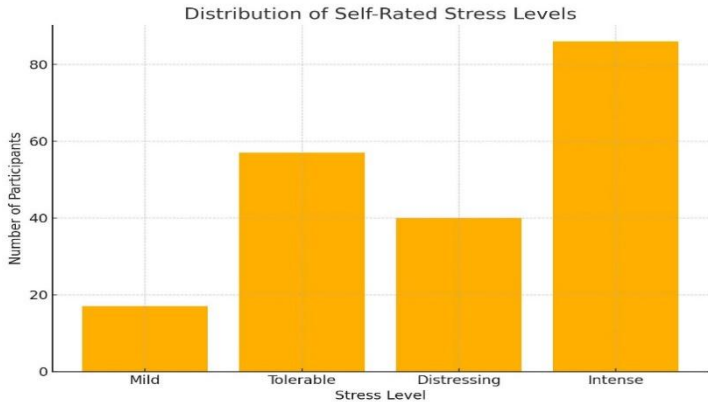| Variable Pair	P-Value	Significance
Low energy vs. low dairy intake	0.043	Significant
Low energy vs. low fruit intake	0.010	Significant
Low energy vs. high stress	0.025	Significant
Low energy vs. joint pain/stiffness	0.000	Highly significant
Stress vs. joint pain/stiffness	0.001	Significant
Stress vs. poor sleep duration	0.011	Significant
Physical activity vs. stress	0.027	Significant
BMI vs. sudden weight gain	0.025	Significant
BMI vs. processed food consumption	0.052	Borderline significant
Home-cooked meals vs. sweets consumption	0.050	Borderline significant
Stress vs. skin issues	0.044	Significant
Physical activity vs. protein source preference	0.026	Significant
Dairy consumption vs. adequate sleep	0.000	Highly significant
Fruit consumption vs. adequate sleep	0.020	Significant
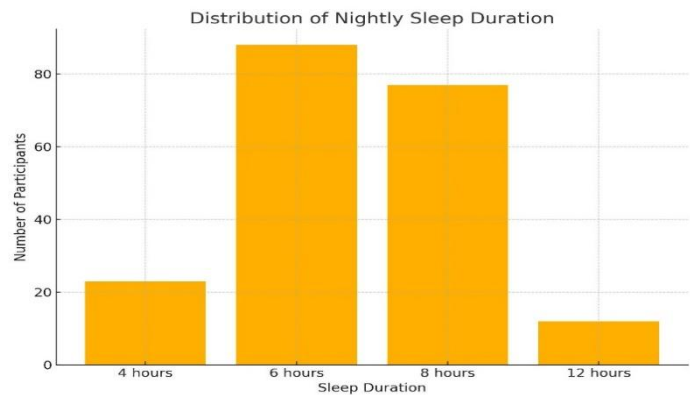
Figure 1 Distribution of Nighty Sleep Duration

Figure 2 Distribution of Self-Rated Stress Levels

Volume 3 Issue 4: Lifestyle Factors and Low-Grade Inflammation
Irfan T et al.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH
AND REHABILITATION ▪ ▪ ▪

DISCUSSION

This study, conducted among 200 urban adults in Lahore aged 18–45 years, underscores a concerning relationship between modern lifestyle patterns and symptoms of low-grade inflammation (LGI). The findings reveal that the high prevalence of ultra-processed food (UPF) consumption, physical inactivity, and psychosocial stress are major contributors to inflammatory symptoms such as fatigue, joint pain, and poor sleep. The dietary profile of participants demonstrated excessive intake of high-fat foods (70%) and sweets (91.5%) on a weekly basis, reflecting a shift toward nutrient-poor, calorie-dense diets. These dietary patterns are consistent with previous findings that link frequent UPF intake with elevated systemic inflammation and increased mortality risk (14,15). Although 69.5% of participants reported regular consumption of home-cooked meals, the continued influence of social and environmental pressures—cited by 61% of participants—appears to drive reliance on processed foods, mirroring broader dietary transitions in urban Pakistan. The significant associations observed between reduced dairy and fruit intake with fatigue and inadequate sleep (p=0.043, p=0.010, p=0.000) suggest that nutrient deficiencies may contribute to LGI manifestations. These findings align with earlier evidence that inadequate consumption of whole foods correlates with increased inflammatory responses and impaired sleep quality (16-18). Furthermore, a borderline significant association between UPF intake and elevated BMI (p=0.052), alongside a notable proportion of participants being overweight (21.5%) or obese (7%), reinforces the inflammatory burden associated with metabolic dysregulation. The present data strengthen the argument for dietary interventions that emphasize anti-inflammatory, whole-food-rich nutrition.

Physical inactivity was another key factor in this cohort, with 70% of participants not engaging in regular exercise and only 9% reporting vigorous activity. This sedentary behavior was significantly associated with elevated stress levels (p=0.027), which in turn were linked to multiple inflammatory symptoms including joint pain (p=0.001), fatigue (p=0.025), and disturbed sleep (p=0.011). These findings are in line with prior studies that have demonstrated a strong link between chronic stress, activation of the hypothalamic-pituitary-adrenal axis, and sustained low-grade inflammation (19,20). The social dimension of stress, reported by 66% of participants, emphasizes the need for public health strategies that address both psychological well-being and physical activity in tandem. Despite the compelling correlations observed, the cross-sectional design inherently limits the ability to infer causality. All exposures and outcomes were measured simultaneously, which constrains temporal interpretation. Additionally, reliance on self-reported symptoms such as joint pain and fatigue introduces subjectivity and the possibility of recall bias. The absence of objective biomarkers, such as serum C-reactive protein or pro-inflammatory cytokines, is another limitation that affects the robustness of inflammation assessment. However, the use of symptom-based markers is still supported by emerging evidence suggesting that LGI can manifest subclinically through persistent fatigue, musculoskeletal discomfort, and metabolic shifts (21,22).

A key strength of this study lies in its focus on a young to middle-aged demographic in a low-middle income country, an underrepresented group in LGI research. The holistic assessment of lifestyle behaviors—including diet, physical activity, sleep, and stress—offers a multifactorial view of LGI determinants. Nevertheless, the urban and convenience-based sampling approach limits the generalizability of findings to broader rural or socioeconomically diverse populations. Future investigations should prioritize longitudinal study designs and incorporate inflammatory biomarkers to validate and expand upon these associations (23). In addition, qualitative research into behavioral motivators behind UPF consumption and stress-coping mechanisms may offer deeper insights. Public health interventions promoting dietary education, structured physical activity, and accessible mental health resources could serve as practical tools to mitigate LGI risk among Pakistan's urban youth. Collectively, the findings of this study support the hypothesis that lifestyle factors including UPF consumption, physical inactivity, inadequate sleep, and stress significantly contribute to the symptom burden of low-grade inflammation in young to middle-aged adults. Addressing these modifiable behaviors through targeted public health measures could play a crucial role in reducing the long-term risk of non-communicable diseases.

CONCLUSION

This study concludes that unhealthy dietary habits, insufficient physical activity, chronic stress, and inadequate sleep are closely linked to symptoms of low-grade inflammation in young to middle-aged adults living in urban Pakistan. These interconnected lifestyle factors underscore the growing burden of non-communicable diseases driven by modern behavioral patterns. The findings highlight the urgent need for comprehensive public health strategies that encourage balanced nutrition, regular physical activity, stress management, and sleep hygiene. Tailored interventions addressing social and environmental influences in urban settings could play a vital role in mitigating inflammation-related health risks and fostering long-term wellness among the youth.

Volume 3 Issue 4: Lifestyle Factors and Low-Grade Inflammation
Irfan T et al.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH
AND REHABILITATION ■ ■ ■

AUTHOR CONTRIBUTION

Author	Contribution
Tabeen Irfan*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Rimsha Mudassar	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Ibrar Rafiq	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Javeria Kaukab	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Iman Fatima	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

REFERENCES

1. Crudele L, Piccinin E, Moschetta A. Visceral Adiposity and Cancer: Role in Pathogenesis and Prognosis. Nutrients. 2021;13(6).

2. Li Z, Gao Y, Byrd DA, Gibbs DC, Prizment AE, Lazovich D, et al. Novel Dietary and Lifestyle Inflammation Scores Directly Associated with All-Cause, All-Cancer, and All-Cardiovascular Disease Mortality Risks Among Women. J Nutr. 2021;151(4):930-9.

3. Shi H, Schweren LJS, Ter Horst R, Bloemendaal M, van Rooij D, Vasquez AA, et al. Low-grade inflammation as mediator between diet and behavioral disinhibition: A UK Biobank study. Brain Behav Immun. 2022;106:100-10.

4. Medawar E, Witte AV. Impact of obesity and diet on brain structure and function: a gut-brain-body crosstalk. Proc Nutr Soc. 2022;81(4):306-16.

5. Xia B, Li Y, Hu L, Xie P, Mi N, Lv L, et al. Healthy eating patterns associated with reduced risk of inflammatory bowel disease by lowering low-grade inflammation: evidence from a large prospective cohort study. BMC Med. 2024;22(1):589.

6. Simopoulos AP. Genetic Variation, Diet, Inflammation, and the Risk for COVID-19. Lifestyle Genom. 2021;14(2):37-42.

7. Iacoviello L, Bonaccio M, de Gaetano G, Donati MB. Epidemiology of breast cancer, a paradigm of the "common soil" hypothesis. Semin Cancer Biol. 2021;72:4-10.

8. Koutaki D, Michos A, Bacopoulou F, Charmandari E. The Emerging Role of Sfrp5 and Wnt5a in the Pathogenesis of Obesity: Implications for a Healthy Diet and Lifestyle. Nutrients. 2021;13(7).

9. Millar SR, Navarro P, Harrington JM, Perry IJ, Phillips CM. Dietary Quality Determined by the Healthy Eating Index-2015 and Biomarkers of Chronic Low-Grade Inflammation: A Cross-Sectional Analysis in Middle-to-Older Aged Adults. Nutrients. 2021;13(1).

10. Hart MJ, Torres SJ, McNaughton SA, Milte CM. Dietary patterns and associations with biomarkers of inflammation in adults: a systematic review of observational studies. Nutr J. 2021;20(1):24.

11. Wang Y, Armijos RX, Xun P, Weigel MM. Dietary Inflammatory Index and Cardiometabolic Risk in Ecuadorian Women. Nutrients. 2021;13(8).

12. Natalucci V, Virgili E, Calcagnoli F, Valli G, Agostini D, Zeppa SD, et al. Cancer Related Anemia: An Integrated Multitarget Approach and Lifestyle Interventions. Nutrients. 2021;13(2).

13. Trichia E, MacLean F, Perez-Cornago A, Tong TYN, Emberson JR, Key TJ, et al. Associations of fruit intake with adiposity and cardiometabolic biomarkers in UK Biobank. BMC Public Health. 2024;24(1):2227.

14. Millar SR, Harrington JM, Perry IJ, Phillips CM. Associations between a protective lifestyle behaviour score and biomarkers of chronic low-grade inflammation: a cross-sectional analysis in middle-to-older aged adults. Int J Obes (Lond). 2022;46(3):476-85.

15. Quartiroli M, Roncallo C, Pala V, Simeon V, Ricceri F, Venturelli E, et al. Adherence to Diet Quality Indices and Breast Cancer Risk in the Italian ORDET Cohort. Nutrients. 2024;16(8).

16. Antoniazzi L, Arroyo-Olivares R, Bittencourt MS, Tada MT, Lima I, Jannes CE, et al. Adherence to a Mediterranean diet, dyslipidemia and inflammation in familial hypercholesterolemia. Nutr Metab Cardiovasc Dis. 2021;31(7):2014-22.

Volume 3 Issue 4: Lifestyle Factors and Low-Grade Inflammation
Irfan T et al.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH
AND REHABILITATION ▪ ▪ ▪

17.   Contreras-Rodriguez, O., y., et al. (2023). The intake of ultra-processed foods is linked to depression, mesocorticolimbic volume, and inflammation. Journal of Affective Disorders, 335, 340–348.

18.   Mete, B., et al. (2024). The link between consuming ultra-processed foods and experiencing low-grade inflammation during childhood. Nutrition Bulletin, 49(4), 538–549.

19.   Millar, S. R., et al. (2022). Links between dietary scores and indicators of persistent low-grade inflammation. European Journal of Nutrition, 61(7), 3377–3390.

20.   Norde, M. M., et al. (2020). Factors related to lifestyle, diet, and genetics are associated with systemic low-grade inflammation. Nutrition, 70, 110596.

21.   Pinhasov, A., & Kirby, M. (2022). Connecting stress and inflammation. Expert Review of Clinical Immunology, 18(4), 321–323.

22.   Quetglas-Llabrés, M. M., et al. (2023). High consumption of ultra-processed foods is associated with oxidative stress and inflammatory markers. Antioxidants, 12(8), 1532.

23.   Werneck, A. O., et al. (2020). Does engaging in physical activity affect the link between symptoms of depression and low-grade inflammation in adults? Physiology & Behavior, 223, 112967.