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The Impact of Lifestyle on the Immune System (WBC)

Amel almayar[1 *], Eman EL Ferjani [2], Saleh almayar [3], Nadia Al-Qatani [4], Mabrouka Hamad [5]
[1, 2, 4, 5] Department of Medical Laboratories, Higher Institute of Science and Technology-Tocra. Libya
[5] Tocra Rural Hospital, Tocra, Libya

تأثير نمط الحياة على جهاز المناعة (خلايا الدم البيضاء)

امل الميار[1*]، ايمان الفرجاني[2]، صالح الميار[3]، نادية القطعاني[4]، مبروكة حمد[5]
[1،2،4،5] قسم المختبرات الطبية، المعهد العالي للعلوم التقنية - توكرة، ليبيا
[3] مستشفي توكرة القروي، توكرة ، ليبيا

[*]Corresponding author: Amalalmayar@gmail.com

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Abstract:
This study investigates the effect of lifestyle on the immune system (WBC) of 55 healthy participants aged 19–50 years. Daily behaviors and living patterns of the participants were evaluated using a dedicated questionnaire covering main domains (dietary pattern, sleep quality, and behavioral activity). In parallel, a peripheral blood smear (blood film) was performed for all samples (n = 55) to verify cellular integrity and to assess the morphological and relative distribution of white blood cells (WBC differential count).
The results revealed statistically significant differences, where the blood smear examination showed a statistically significant increase (p = .009) in the percentage of monocytes in the irregular lifestyle group (n = 30) compared to the regular lifestyle group (n = 25), with percentages reaching 12.18% versus 9.48%, reflecting an early immune response status. This variation was accompanied by highly statistically significant differences in dietary pattern (p < .001) in favor of the regular lifestyle group.
Although psychological health and other individual variables—such as sleep quality and healthy habits—did not show independent statistical significance (p > .05), the regular pattern group recorded higher arithmetic means in sleep quality, lower obesity, and compliance with daily healthy habits compared to the irregular group, whose inconsistent behavioral routine was associated with higher rates of obesity and lower sleep quality.
In contrast to these results, adaptive immunity indicators and overall immune balance maintained their statistical stability without significant differences, despite the presence of indicators of higher immune response in the irregular group. These included lymphocytes at 29.65% for the irregular group versus 31.42% for the regular group (p = .285), neutrophils at 51.17% versus 49.42% (p = .365), and the NLR index at a value of 1.82 versus 1.66 (p = .292), while eosinophils recorded no statistically significant differences between the two categories.

Keywords: Lifestyle and Health, Immunity and Immune System, Daily Habits, White Blood Cells, Tocra.

الملخص
تتناول هذه الدراسة تأثير نمط الحياة على الجهاز المناعي (WBC) ل 55 مشاركاً أصحاء تراوحت أعمارهم بين(19_50) عاما حيثً تم تقييم السلوكيات اليومية والأنماط المعيشية للمشاركين باستخدام استبيان مخصص شمل محاور أساسية (النمط الغذائي، جودة النوم، والنشاط السلوكي). بالتوازي مع ذلك، أُجري فحص مسحة الدم (Blood Film / Peripheral Blood Smear)لجميع العينات (ن = 55) للتحقق من السلامة الخلوية، وتقييم التوزيع المورفولوجي والنسبي لخلايا الدم البيضاء(WBC differential count) ،

كشفت النتائج عن وجود فروق ذات دلالة إحصائية، حيث أظهر فحص المسحة الدموية ارتفاعاً دالاً إحصائياً ($p = .009$) في نسبة الخلايا الوحيدة (Monocytes) لدى مجموعة نمط الحياة غير المنتظم ($n = 30$) مقارنة بمنتظمي نمط الحياة ($n = 25$)؛ حيث بلغت النسبة 12.18% مقابل 9.48%، مما يعكس حالة استجابة مناعية مبكرة واقترن هذا التباين باختلافات عالية الدلالة الإحصائية في النمط الغذائي ($p < .001$) لصالح مجموعة النمط المعيشي المنتظم،

علاوة على ذلك، لم تُظهر الصحة النفسية والمتغيرات المنفردة الأخرى—كجودة النوم والعادات الصحية—دلالة إحصائية مستقلة($p > .05$) ، إلا أن مجموعة النمط المنتظم سجلت متوسطات حسابية أعلى في جودة النوم، وانخفاض السمنة، والامتثال للعادات الصحية اليومية مقارنة بالمجموعة غير المنتظمة، والتي ارتبط عدم اتساق روتينها السلوكي بمعدلات أعلى من السمنة وانخفاض جودة النوم.

في المقابل هذه النتائج حافظت مؤشرات المناعة التكيفية والتوازن المناعي الشامل على استقرارها الإحصائي دون فروق معنوية، وشملت الخلايا اللمفاوية (Lymphocytes) بنسبة 29.65% للمجموعة غير المنتظمة مقابل 31.42% للمنتظمة ($p = .285$)، والخلايا المتعادلة (Neutrophils) بنسبة 51.17% مقابل 49.42% ($p = .365$)، ومؤشر NLR بقيمة 1.82 مقابل 1.66 ($p = .292$)، بينما لم تسجل الخلايا الحامضية (Eosinophils) أي فروق ذات دلالة إحصائية بين الفئتين.

الكلمات المفتاحية: نمط الحياة والصحة، المناعة والجهاز المناعي، العادات اليومية، كريات الدم البيضاء، توكرة.

1. Introduction

The immune system represents a highly complex and integrated biological network, consisting of specialized cellular and molecular barriers that work harmoniously to provide continuous defense for the body's vitality. This system is functionally divided into innate immunity (Innate Immunity), which provides an immediate, non-specific response, and acquired immunity (Adaptive Immunity), characterized by high specificity and long-term immune memory to counter microbial threats and tumors (Murphy & Weaver, 2022).

Recent epidemiological studies in the field of "Lifestyle Medicine" indicate that an individual's daily behaviors a fundamental driver in determining the efficiency of the immune response and resistance to chronic diseases. Are Genetic factors are no longer the sole determinant; behavioral patterns-most notably dietary quality and physical activity-play a pivotal role in modulating the gene expression of immune cells and reducing mortality rates associated with systemic inflammation (Bodai *et al.,* 2020).

A balanced diet is a cornerstone for regulating and programming immune cells. Micronutrients, such as Vitamin C, Vitamin D, Zinc, and Selenium, play a crucial role as antioxidants and cofactors in activating T and B cells. Additionally, macronutrients, such as amino acids derived from proteins, represent the essential building blocks for synthesizing antibodies and cytokines, while a fiber-rich diet supports the gut microbiome, which guides the efficiency of the immune system(Childs *et al.,* 2019).

Regulated sleep is closely linked to the body's biological clock (Circadian Clock), which controls the daily fluctuation of white blood cell counts and their distribution in the bloodstream. Sleep deprivation or disruption of these daily rhythms leads to the suppression of daytime peak production of cytokines during the night, which weakens adaptive immune memory and leaves the body more vulnerable to acute infections (Besedovsky *et al.,* 2019).

Continuous exposure to psychological stress leads to the chronic activation of the HPA axis, resulting in the sustained secretion of stress hormones such as cortisol and catecholamines. This chronic elevation suppresses lymphocyte functions, reduces the capacity of natural killer (NK) cells to eradicate infected cells, and drives the body into a state of low-grade systemic inflammation (Low-grade inflammation) that weakens general defenses (Dhabhar, 2018).

Moderate and regular exercise contributes to stimulating the dynamic redistribution of immune cells between tissues and the bloodstream, which enhance the efficiency of the "immunosurveillance" process. Continuous physical activity also acts as an anti-inflammatory factor by lowering levels of C-reactive protein (CRP) and inflammatory cytokines, thereby protecting the body from premature immune aging (Nieman & Pence, 2020).

From this perspective, this research relies on the descriptive, analytical, and experimental approach to shed light on the correlational relationship between contemporary lifestyle patterns and the level of the body's defensive efficiency.

1.1 Research Importance:

1. Enhancing community health literacy by highlighting optimal health behaviors and fostering preventive practices to boost natural immunity.

2. Clarifying the pivotal role a healthy lifestyle plays in supporting the immune response, as well as identifying mechanisms to maintain immune system efficiency and biological homeostasis.
3. Contributing to the reduction of over-reliance on pharmaceutical treatments by establishing a preventive lifestyle as a primary, sustainable line of defense for health.

1.2 Research Objectives:

1. Providing scientifically backed, evidence-based recommendations and strategies to enhance natural immunity through lifestyle optimization.
2. Investigating and evaluating how daily habits and lifestyle choices (e.g., nutrition, physical activity, sleep quality, and stress levels) affect immune system performance and overall function.

1.3 Research Problem:

The human immune system is constantly exposed to various environmental and behavioral factors that directly influence its efficiency. Despite advances in modern medicine, chronic and infectious diseases remain strongly linked to daily lifestyle choices. (Kopp, 2019). The core research problem centers on determining the nature and extent of the impact that an unhealthy lifestyle exerts on immune capacity, as well as the potential to restore and modulate immune responses through behavioral changes.(Childs *et al.*, 2019).

2. literature review

2.1 The Immune System:

The immune system refers to a collection of cells, chemicals, and processes that function to protect the skin, respiratory passages, intestinal tract, and other areas from foreign antigens, such as microbes (organisms such as bacteria, fungi, and parasites), viruses, cancer cells, and toxins (Marshall *et al.*, 2018). It comprises a complex network involving organs, leukocytes (including several types of white blood cells commonly measured in routine blood tests), proteins, and various chemicals, working together to monitor and protect all tissues of the body, generate a protective response against pathogens and abnormal cells (such as tumors and transplanted cells), recognize the host organism, and limit damage to it self (Wang *et al.*, 2024; Nicholson, 2016).

This system operates through two interconnected arms: innate immunity and acquired (adaptive) immunity. Innate immunity serves as the first line of defense against pathogens, acting quickly as soon as infection occurs through multiple defense mechanisms, such as phagocytes, antimicrobial peptides, and the complement system (Iwasaki & Medzhitov, 2015). Its role is not only to contain infection in the early stages but also to contribute to regulating, directing, and controlling the adaptive immune response, making it an essential element in protecting the body and enhancing the overall efficiency of immune defense (Iwasaki & Medzhitov, 2015). Working in tandem, adaptive immunity is primarily composed of T lymphocytes and B lymphocytes (Chaplin, 2010; Bonilla & Oettgen, 2010). While B cells develop in the bone marrow and are responsible for antibody production, T cells mature in the thymus (Chaplin, 2010; Bonilla & Oettgen, 2010).

2.1.1 White blood cells (Leukocytes):

White blood cells are classified based on their cellular structure and nuclear shape under a microscope into two main groups: Granulocytes and Agranulocytes.

Here are all types of white blood cells formatted in a precise academic research style (Mayadas *et al.,* 2014), along with the approved scientific references for each type:

2.1.1.1 Granulocytes

These are characterized by the presence of granules in their cytoplasm that contain enzymes and defensive chemicals (Mayadas *et al*., 2014). They include:

- **Neutrophils**:

Research Description: They are considered the first cellular line of defense and the most abundant in the blood circulation (comprising 50% to 70% of total white blood cells).

They attack pathogens (especially bacteria and fungi) via phagocytosis, the release of lytic enzymes, and the formation of neutrophil extracellular traps (NETs)(Mayadas *et al.,* 2014).

- **Eosinophils**:

Research Description: They constitute 1% to 4% of white blood cells. They specialize in combating large parasitic infections (such as intestinal worms) that are difficult to phagocytose by secreting cytotoxic proteins. They also play a major role in allergic responses and asthma inflammation (Rothenberg & Hogan, 2006).

- **Basophils:**

Research Description: The least common type in the blood (less than 1%). Their granules contain histamine (a vasodilator) and heparin (an anticoagulant). They play a pivotal role in triggering acute inflammatory responses and anaphylactic reactions (Anaphylaxis)(Siracusa *et al.*, 2013).

2.1.1.2 Agranulocytes:

These are characterized by a cytoplasm free of apparent granules and a non-lobated (mononuclear) nucleus. They include:

- **Lymphocytes**:

They constitute 20% to 40% of white blood cells and form the fundamental pillar of acquired (adaptive) immunity. They are functionally divided into three main types:

- **T-cells:** Responsible for cell-mediated immunity and destroying virus-infected cells. (Nicholson, 2016).
- **B-cells**: Responsible for humoral immunity and the production of specific antibodies. (Nicholson, 2016).
- **Natural Killer (NK) cells:** Act as a bridge to innate immunity by destroying cancerous and early-infected cells (Nicholson, 2016).

- **Monocytes**:

The largest white blood cells in size, with proportions ranging from 2% to 8%. They circulate in the blood for a short period before migrating into tissues to differentiate into Macrophages or Dendritic Cells. They function to phagocytose cellular debris and microbes, and act as antigen-presenting cells (APCs) to activate lymphocytes (Jakubzick *et al.*, 2017).

2.2 Lifestyle:

Nutritional interventions (including caloric restriction and fasting-related approaches), stress reduction, and vaccination as key modulators of immune ageing, reporting quantitative effect estimates from underlying trials—for example, that vitamin D supplementation reduced autoimmune disease incidence by 22%, while caloric restriction reduced C-reactive protein and TNF-α by 40% and 50%, respectively. The authors also discussed emerging but still inconsistently. Cakała-Jakimowicz *et al.*2026)

2.2.1 Nutrition:

Contemporary immunonutrition evidence (e.g., Gombart *et al.*, 2020) highlights that immune resilience depends on a balance of both macronutrients and micronutrients:

2.2.1.1 Proteins & PEM:

Protein-energy malnutrition produces lymphoid atrophy, depressed delayed-hypersensitivity responses, reduced secretory IgA, and impaired phagocyte and complement function. (Micronutrient Forum, 2023)

2.2.1.2 Carbohydrates & Sugars:

Excessive consumption of refined sugars promotes systemic inflammation and gut dysbiosis, whereas complex carbohydrates serve as a key energy source for immune cells without inducing inflammatory cascades. (Micronutrient Forum, 2023).

2.2.1.3 Dietary Fats:

Healthy fatty acids (e.g., omega-3s) actively resolve inflammation and modulate lymphocyte activity, whereas high saturated/trans-fat intakes drive chronic low-grade inflammation. (Micronutrient Forum, 2023).

2.2.1.4 Vegetables & Micronutrients:

A diet rich in vegetables delivers crucial dietary fiber, antioxidants, and essential micronutrients—particularly zinc, selenium, iron, and vitamins A, C, D, E, and B6—whose deficiencies independently compromise immunity even when mild. (Micronutrient Forum, 2023).

2.2.1.5 Nutritional Supplements:

Dietary supplements face regulatory challenges worldwide due to the absence of a unified international definition. Products classified as dietary supplements in one country may be regulated as foods, medicines, or controlled substances in another. These differences are further complicated by varying legal frameworks, especially in countries with established traditional medicine systems. (Dwyer *et al.*, 2018).

Nutritional immunology is a field of immunology that describes the influence of nutrition on the immune system, antiviral activity, and associated protective functions. Deficiency in macronutrients and/or micronutrients causes impairment of immune function, which can usually be reversed by nutrient repletion. Poor dietary composition, which is common among the elderly population, and excess calorie consumption are major concerns. (Newsholme, 2021).

2.2.2 Stress:

chronic stress accelerates an inflammatory trajectory otherwise associated with normal ageing. They further showed, via controlled laboratory stress-induction paradigms (e.g., public-speaking tasks), that even brief, minor stressors provoke measurable elevations in circulating inflammatory markers, and that repeated exposure to the same stressor does not necessarily habituate the IL-6 response even though cardiovascular and cortisol reactivity do habituate. (Morey *et al.*, 2015)

Dhabhar (2014), writing from Stanford University, proposed an influential conceptual framework distinguishing "good" short-term stress from "bad" chronic stress in terms of their opposing immunological consequences. Synthesizing psychoneuroimmunological evidence, Dhabhar showed that short-term stress (lasting minutes to hours) enhances innate and adaptive immunity through redistribution and activation of dendritic cells, neutrophils, macrophages, and lymphocytes, thereby improving wound healing, vaccination responses, and anti-infectious and anti-tumour immunity. In contrast, chronic stress was shown to suppress or dysregulate immune responses by shifting the Type 1/Type 2 cytokine balance, inducing low-grade chronic inflammation, and reducing protective T-cell function—effects that increase vulnerability to infection and certain cancers.

2.2.3 Smoking:

Lee *et al.*, (2012), synthesized cellular and molecular evidence on how cigarette smoke (CS) disrupts immunological homeostasis. Their review documented that CS—a complex mixture containing trace bacterial lipopolysaccharide alongside thousands of cytotoxic and antigenic compounds—exerts both pro-inflammatory and immunosuppressive effects depending on dose, chronicity, and exposure route, impairing innate pathogen defenses, altering antigen presentation, and promoting autoimmune processes, with particularly well-documented effects on oral and periodontal immunity.

2.2.4 Alcohol:

Consumption weakens innate immunity by inhibiting macrophages and neutrophils and increasing intestinal permeability, which allows toxins to leak into the bloodstream. It also depletes adaptive immunity by triggering apoptosis in T and B lymphocytes and disrupting antibody production, ultimately increasing susceptibility to infections and delaying tissue recovery (Barr *et al.*, 2022; Sarkar *et al.*, 2015).

2.2.5 Physical activity:

Nurmasitoh (2015) reviewed how exercise intensity modulates immune function and infection risk, drawing on the classic J-shaped curve model (Nieman, 1994, as cited in Nurmasitoh, 2015) and its later reversed-J refinement (Woods *et al.*, 1999, as cited in Nurmasitoh, 2015). The review concluded that regular moderate-intensity exercise (e.g., brisk walking, cycling, jogging) enhances innate immune parameters—including natural killer (NK) cell activity, neutrophil function, and antibody production—and is associated with reduced upper respiratory tract infection (URTI) risk, whereas both sedentary behaviour and high-intensity or prolonged exercise increase infection susceptibility. The review also described the "open window" phenomenon, in which intense exertion produces a transient, cortisol-mediated period of immunosuppression lasting several hours post-exercise.

2.2.6 Obesity:

Andersen *et al.* (2016) demonstrated that obesity and metabolic syndrome directly impair immune competence by disrupting lymphoid tissue architecture and promoting chronic, low-grade inflammation. These immunological alterations empirically correlate with higher vaccine failure rates and increased severity of infectious complications. The primary strength of this review lies in its mechanistic integration of immunology with endocrine physiology, establishing adiposity as an independent modifier of host defense. Furthermore, it highlights the critical conceptual overlap between obesity, poor diet, and physical inactivity as interconnected lifestyle variables that collectively compromise the immune system.

De Frel *et al.*, (2020), representing a consortium of Dutch academic medical centres (Leiden, Rotterdam, Amsterdam), conducted a structured literature review examining the relationship between obesity, chronic disease, lifestyle factors, and immune susceptibility to viral infection, motivated directly by the early COVID-19 pandemic.Their synthesis showed that obesity independently increases the risk of severe COVID-19 by approximately threefold, with each unit increase in BMI raising severe-disease risk by roughly 12%, and that unhealthy diet

The review by Cheng and *et al.*, (2022) from West China Hospital, Sichuan University, examines how excessive fructose consumption disrupts immune homeostasis, as it alters the metabolic programming of immune cells, distorts the composition of the gut microbiome community, and increases intestinal barrier permeability. Furthermore, the metabolism of fructose yields products such as uric acid, free fatty acids, and lactate, which are linked to oxidative stress and localized tissue inflammation. This dietary pattern is also associated with obesity, diabetes, and metabolic syndrome, with emerging evidence suggesting its role in promoting resistance to cancer immunotherapy.

2.2.7 Sleep:

Besedovsky *et al.*, (2019), sleep enhances multiple immune parameters, is associated with reduced infection risk, and improves vaccination response, while immune activation itself alters sleep architecture (e.g., increasing slow-wave sleep during infection). Critically, the authors demonstrated that prolonged sleep deficiency—whether through short sleep duration or fragmented, poor-quality sleep—produces chronic, systemic low-grade inflammation associated with diabetes, atherosclerosis, and neurodegenerative disease.

Walker *et al.*, (2023), of West Virginia University,All aspects of immune activity display circadian variation, that the SCN communicates temporal signals to the immune system via neuroendocrine and autonomic pathways, and that immune activity in turn feeds back to influence circadian clock function. Circadian disruption—arising from shift work, irregular light exposure, or erratic sleep-wake schedules—was shown to be associated with dysregulated immune cell trafficking and elevated disease.

49.29% of medical students exhibited poor immune fitness. There was a strong correlation between poor immunity, fast-food consumption, and daytime sleepiness, while immune fitness increased with exercise. The study also revealed a perception-reality gap, as 41.23% of students rated their health as normal, whereas the results showed it was poor (Alharbi's ،2023).

3. Material and Method

3.1 Study Population and Design:

This descriptive analytical study was conducted at Al-Farabi Laboratory, involving a total sample of 55 participants within the age range of 19–50 years. The study design classified the participants into two distinct groups based on specific behavioral parameters:

- **The First Group (Regular Lifestyle):** Included 25 participants who followed a consistent and health-conscious lifestyle, and were affiliated with a number of sports institutions and gyms, such as Al-Asrar Club, Mohamed Al-Barghathi Gym, and Sedra Gym from Tokra.
- **The Second Group (Irregular Lifestyle):** Included 30 participants randomly selected from the community, whose daily routines lacked behavioural consistency.

3.2 Data Collection and Questionnaire:

Personal and behavioral data for each participant were gathered using a customized questionnaire (Appendix I) designed for this purpose. The questionnaire provided a detailed assessment of several vital variables affecting biomarkers, primarily focusing on Dietary habits and nutritional patterns, Physical activity levels and exercise frequency, Sleep quality and duration and stress.

3.3 Biological Sample Collection

A single whole blood sample (Figure 1) was collected from each participant. The samples were drawn into anticoagulant tubes (EDTA) according to standard laboratory protocols in preparation for subsequent laboratory analyses.

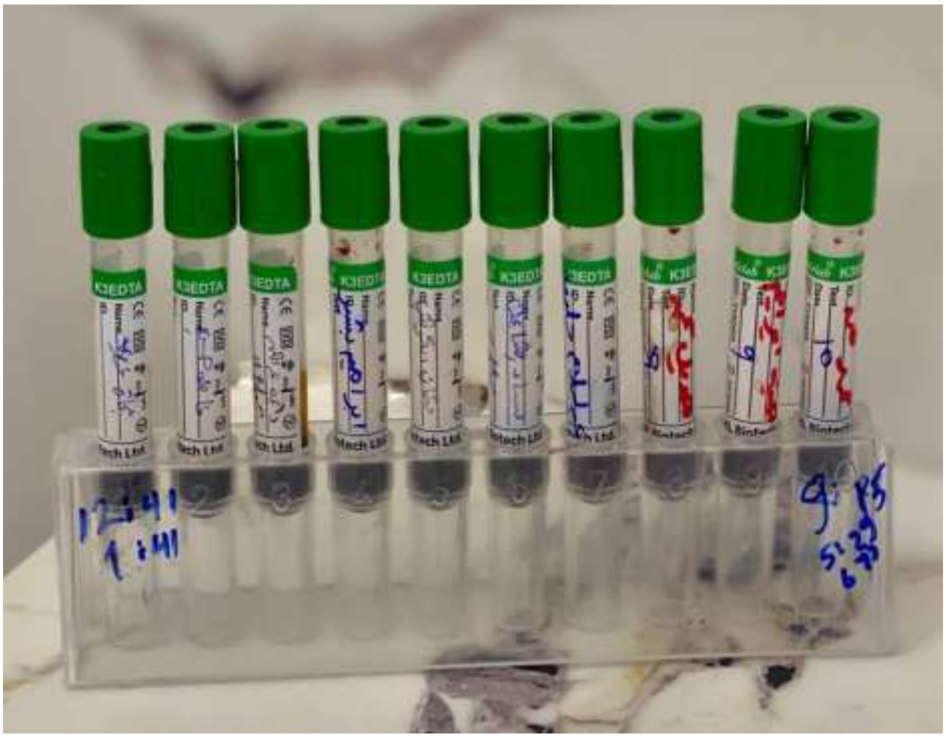

Figure 1: whole blood sample

3.4 Instruments and Reagents: (Figure 2)

- **Instruments:**
    - Compound Light Microscope.
- **Disposables and Labware:**
    - Sterile Disposable Syringes: Utilized for intravenous blood collection.
    - EDTA Tubes.
    - Microscope Glass Slides.
- **Chemicals and Stains:**
    - Giemsa Stain.
    - Methanol (Absolute).

Figure 2: Material and equipment used for Giemsa staining and microscopic examination of peripheral blood smears.

3.5 Principle:

Smear Preparation and Giemsa Staining. (Figure 3)

1. A small drop of well-mixed peripheral blood was placed near one end of a clean glass slide.
2. A spreader slide was held at an angle of approximately 30–45°, pulled backward until it touched the blood drop, and then pushed forward smoothly to prepare a thin blood smear with a feathered edge.
3. The smear was allowed to air dry completely an
4. subsequently fixed in absolute methanol for 2–3 minutes.
5. After fixation, the slide was air-dried and stained with Giemsa stain for 10–15 minutes, depending on the stain concentration.
6. The stained smear was then gently rinsed with tap water, placed in a vertical position, and allowed to air dry completely.
7. Finally, the prepared smear was examined under a light microscope using the 10× objective to assess smear quality, followed by the 100× oil immersion objective for detailed morphological examination of blood cell.

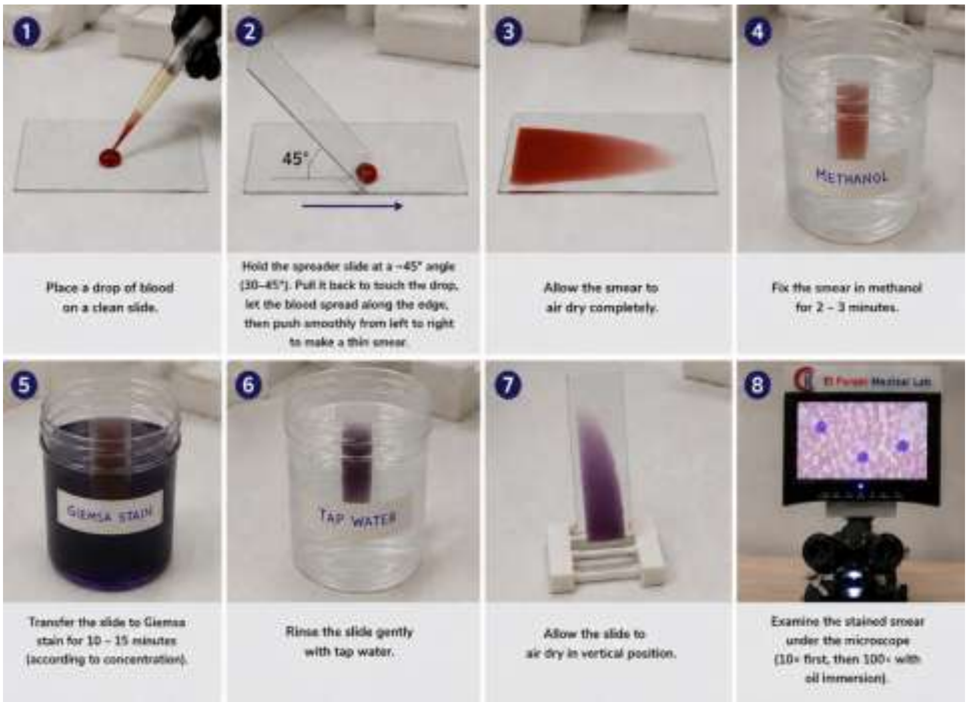

Figure 3: showing step by step workflow for peripheral blood smear preparation, Giemsa staining, and microscopic examination.

3.6 Microscopic Identification of Leukocytes:

The stained blood films were examined under the oil immersion objective lens (100\times magnification). Identification and differentiation of leukocyte subpopulations were based on established morphological criteria as follows (Figure 4)

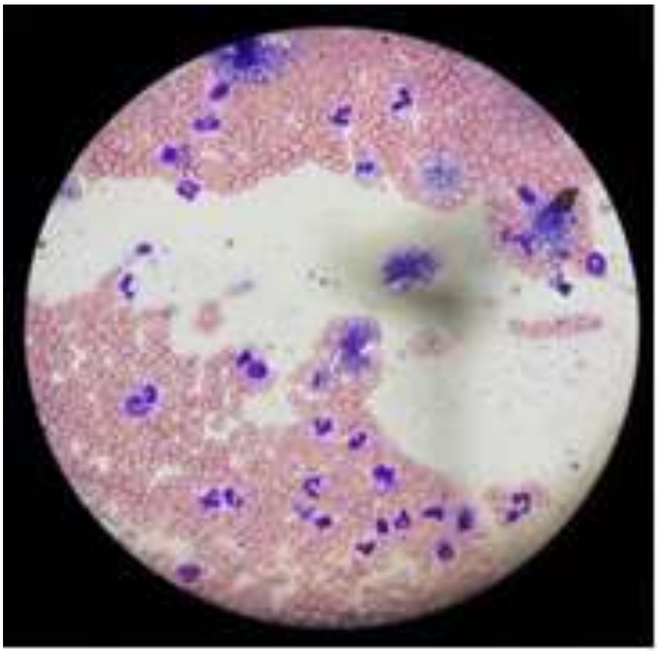

Figure 4: Representative complete microscopic field of peripheral blood smear.

3.7 Differential White Blood Cell Counting:

"The differential white blood cell (WBC) count was performed manually using the longitudinal examination method (zig-zag technique) under the oil immers Absolute. (100x magnification) of the compound light microscope. A minimum of 100 leukocytes were counted and classified into their respective types (e.g., lymphocytes, neutrophils, monocytes). The relative percentage for each cell type was calculated directly. To determine the absolute counts, the relative percentages were multiplied by the total WBC count obtained for each participant.

Absolute Count (cells/µL) = (Differential Count (%) × Total WBC Count (cells/µL)) / 100

3.8 Statistical Analysis:

All data gathered from the study groups were compiled and statistically analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including means and standard deviations (Mean ± SD) or percentages, were calculated to summarize the participants' demographic and lifestyle characteristics. To evaluate the significant differences in leukocyte counts and percentages between the stable and inconsistent lifestyle cohorts, an Statistical significance was set at a p-value of less than 0.05 ($p < 0.05$).

Results and Discussion:

The statistical results obtained from analyzing the study samples (n = 55) aimed to evaluate the impact of lifestyle patterns (regular vs. irregular) on the participants' physiological and immunological parameters, and discussing these results, along with their consistency with relevant literature and previous studies.

4.1 Morphological identification of different leukocyte types observed in peripheral blood smear samples:
(Figure 5)

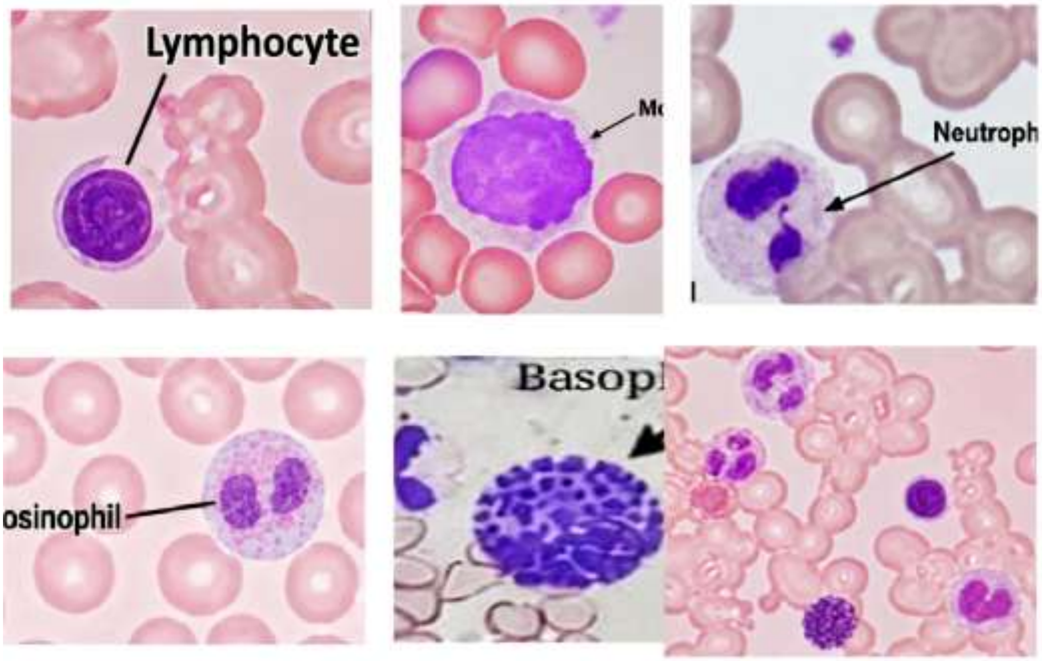

Figure 5: Morphological identification different leukocyte

4.2 Distribution of participants' responses regarding differential white blood cell count:

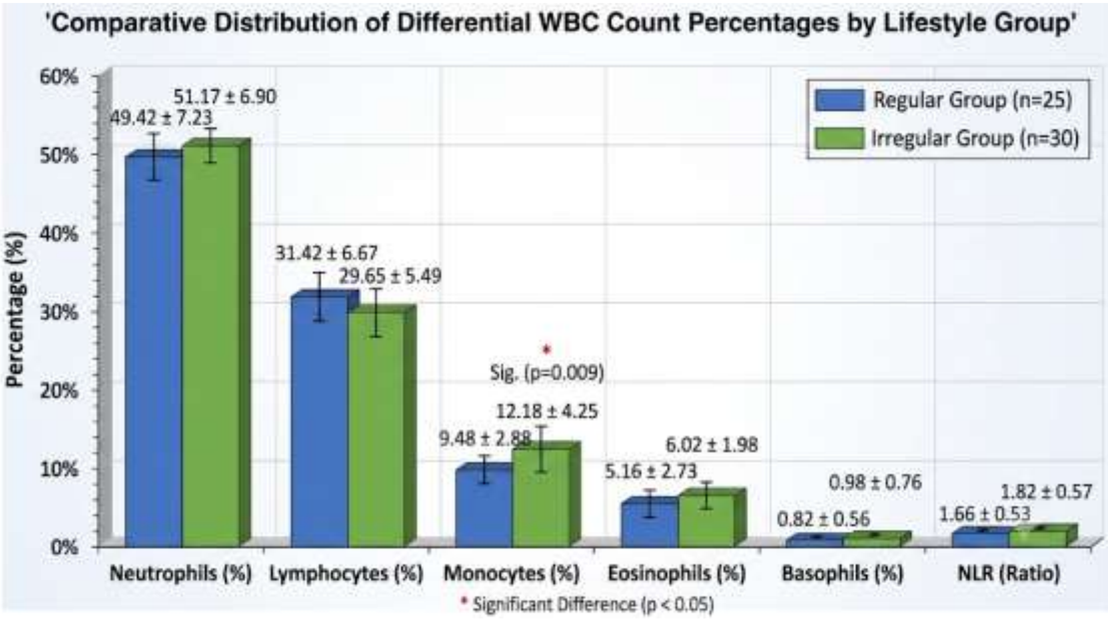

Figure 6 : differential white blood cell.

- Neutrophils (%):
  μ: Regular Group (49.42) . Irregular Group (51.17).
  X̄: Regular Group (7.23) vs. Irregular Group (6.90).
  Significance (p): p = .365 (t = -0.914).

- Lymphocytes (%):
  μ :
  Regular Group (31.42) . Irregular Group (29.65).
  X̄: Regular Group (6.67) . Irregular Group (5.49).
  Significance (p): p = .285 (t = 1.079).

- Monocytes (%):
  μ : Regular Group (9.48) vs. Irregular Group (12.18). $\bar{X}$:
  Regular Group (2.88) vs. Irregular Group (4.25). Significance (p): p =
  .009 (Sig. = .009, t = -2.705).

- Eosinophils (%): μ :
  Regular Group (5.16) vs. Irregular Group (6.02). $\bar{X}$:
  Regular Group (2.73) vs. Irregular Group (1.98). Significance (p): p =
  .184 (t = -1.348).

- Basophils (%):
  μ : Regular Group (0.82) vs. Irregular Group (0.98). $\bar{X}$:
  Regular Group (0.56) vs. Irregular Group (0.76). Significance (p): p =
  .376 (t = -0.893).

- Neutrophil-to-Lymphocyte Ratio (NLR):
  μ: Regular Group (1.66) vs. Irregular Group (1.82). $\bar{X}$:
  Regular Group (0.53) vs. Irregular Group (0.57). Significance (p): p
  = .292 (t = -1.065).

McMaster *et al.* (2021) indicated that a sustained increase in the percentage of monocytes serves as a biomarker for the body's response to chronic lifestyle stress. These cells secrete inflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (alpha), which explains the link between an irregular lifestyle and an increased susceptibility to chronic diseases.

Studies (Christ *et al.*, 2019; Lordan et al., 2021) indicate that a typical Western diet triggers epigenetic and immune reprogramming in bone marrow stem cells, a phenomenon known as trained innate immunity this stimulation directs the bone marrow toward rapid myeloid lineage differentiation, leading to increased production and release of monocytes into the bloodstream as a primary responder to pro-inflammatory dietary factors.

The lack of significant changes in lymphocytes and NLR($p > 0.05$) is explained by adaptive immunity being primarily linked to severe malnutrition. In contrast, an irregular lifestyle with excess caloric availability triggers an immunometabolic response manifested chiefly in innate immunity via monocytes (Esposito *et al.*, 2022).

4.3 Distribution of participants' responses regarding the nutrition dimensions:

Table 1: the nutrition.

Lifestyle			Nutrition
Irregular	Regular		
10	25	Yes	Proteins
20	0	No	
30	22	Yes	Carbohydrates
0	3	No	
16	4	Yes	Sugars
14	21	No	
3	3	Yes	Fats
27	22	No	
10	11	Yes	Vegetables
20	14	No	
0	25	Yes	Supplements
30	0	No	

Regular Lifestyle Group: Showed significantly higher agreement on Proteins (25 vs. 10) and, Nutritional Supplements (25 vs. 0).

Irregular Lifestyle Group: Recorded higher agreement on items such as Sugars.

Similar Responses: Both groups showed relative convergence regarding Fats and Vegetables.

μ : Regular Group (1.40) vs. Irregular Group (1.61) Significance (p): $p < .001$ (Sig. = .000).

studies indicate that behaviors such as adhering to a high-protein diet or taking nutritional supplements require a consistent daily routine and health literacy, which is directly reflected in the dietary practices of individuals leading a regular lifestyle (Conklin et al., 2016; Gellert *et al.*, 2012).

Studies have demonstrated that stress resulting from an irregular lifestyle stimulates dopaminergic pathways in the brain, driving individuals to consume "comfort foods" rich in sugars as a rapid compensatory mechanism to alleviate stress (Chao *et al.*, 2017).

4.4 Distribution of participants' responses regarding the sleep dimension:

Table 2: the sleep.

Lifestyle			**Sleep**
Irregular	Regular		
10	7	Yes	Insomnia
20	18	No	
4	0	5 or less	Hours
20	22	6-8	
6	3	More than 8	

Regular Lifestyle Group (n = 25): Insomnia: Insomnia: 7 individuals (28.00%) vs. Healthy: 18 individuals (72.00%). Sleep (6–8 Hours): 22 individuals (88.00%). sleep (5 or less hours): 0 individuals (0.00%) . sleep (> 8 hours): 3 individuals (12.00%).

Irregular Lifestyle Group (n = 30): Insomnia: Insomnia: 10 individuals (33.33%) vs. Healthy: 20 individuals (66.67%). Sleep (6–8 Hours): 20 individuals (66.67%). Sleep (5 or less hours): 4 individuals (13.33%) sleep (> 8 hours): 2 individuals (6.67%)

μ: Regular Group (1.92) vs. Irregular Group (1.86). Significance (p): $p = .570$ ($p > .05$).

The higher proportion of optimal sleep duration among regular lifestyle adherents aligns with principles of circadian biology, where structured daily routines stabilize central suprachiasmatic nucleus (SCN) pacemakers and maintain physiological melatonin secretion patterns (Besedovsky et al., 2019; Irwin, 2019). Sleep disruption and insomnia are associated with the activation of neuroendocrine stress axes, elevating nocturnal catecholamine and cortisol secretion that dysregulates peripheral immune cell trafficking in systemic circulation (Besedovsky et al., 2019; Saint-André et al., 2024).

4.5 Distribution of participants' responses regarding the Psychological Health dimension:

Table 3: the Psychological Health.

Lifestyle			Psychological Health
Irregular	Regular		
8	9	Yes	Stress
9	10	No	
13	6	sometimes	

Regular Lifestyle Group:

Stress (No): (10 individuals, 40.00%).
Stress (Yes): 9 individuals (36.00%).
Sometimes: (6 individuals, 24.00%).

Irregular Lifestyle Group:
Sress (No): 9 individuals (30.00%).
Stress (Yes): 8 individuals (26.67%).
Sometimes: Highest category (13 individuals, 43.33%).

μ: Irregular (2.17) vs. Regular (1.88).
Significance (p): p = .197 (p > .05).

Descriptive results for psychological stress reveal distinct behavioral patterns between the two study cohorts. Within the regular lifestyle group (n = 25), the 'no stress' category constituted the largest proportion at 40.00% (n = 10), followed by stress present at 36.00% (n = 9), and occasional stress ('sometimes') at 24.00% (n = 6). Conversely, the irregular lifestyle group (n = 30) demonstrated that occasional stress was the most prevalent category at 43.33% (n = 13), followed by the absence of stress at 30.00% (n = 9), and chronic stress at 26.67% (n = 8). Although individuals with a regular lifestyle exhibited a lower mean stress score (μ = 1.88) compared to the irregular group (μ = 2.17), inferential analysis indicated that this difference did not reach statistical significance (p = .197).

The higher proportion of stress-free individuals among regular lifestyle adherents aligns with established principles of neuroendocrine regulation, where structured sleep, physical activity, and dietary habits contribute to dampening hypothalamic-pituitary-adrenal (HPA) axis hyperreactivity (McEwen & Akil, 2020; Saint-André et al., 2024). Chronic psychological stress leads to sustained glucocorticoid secretion, which over time impairs glucocorticoid receptor sensitivity in immune cells and alters baseline white blood cell differentials (Morey *et al.*, 2015; Saint-André *et al.*, 2024).

4.6 Distribution of participants' responses regarding the Smoking dimension:

Table 4: the Smoking

Lifestyle			Healthy habits
Irregular	Regular		
10	14	Yes	Smoking
20	11	No	

Regular Lifestyle Group.
Non-Smokers: 14 (56.00%) individuals.
Smokers: 11 (44.00%)individuals

Irregular Lifestyle Group.
Smokers: 20(66.67%) individuals.
Non-Smokers: 10 (33.33%)individuals

μ: Regular Lifestyle (1.44) vs. Irregular Lifestyle (1.67).
Significance (p): p = .095 (p > .05).

Non-smokers constituted the majority within the regular lifestyle group (56.00%). This higher proportion of non-smoking status among individuals adhering to a regular lifestyle reflects the well-established scientific phenomenon of "Health Behavior Clustering," where structured practices—such as physical activity, balanced nutrition, and consistent sleep schedules—synergize to reduce exposure to chronic risk factors like smoking (Prochaska et al., 2020; Saint-André et al., 2024). Furthermore, the literature indicates that daily discipline and regular engagement in healthy behaviors preserve the functional efficiency of immune cells by preventing low-grade chronic leukocytosis induced by tobacco use and erratic lifestyle patterns (Saint-André et al., 2024).

Furthermore, while the study sample spanned an age range of 19 to 50 years, age-related immunological variations and cumulative behavioral exposure could subtly modulate immune parameters alongside lifestyle regularity (Saint-André et al., 2024). Overall, the descriptive distribution highlights that adopting a regular lifestyle serves as a protective behavioral framework that suppresses smoking prevalence and supports immunological homeostasis (Prochaska *et al.*, 2020; Saint-André *et al.*, 2024).

4.7 Distribution of participants' responses regarding the body measurements and BMI:

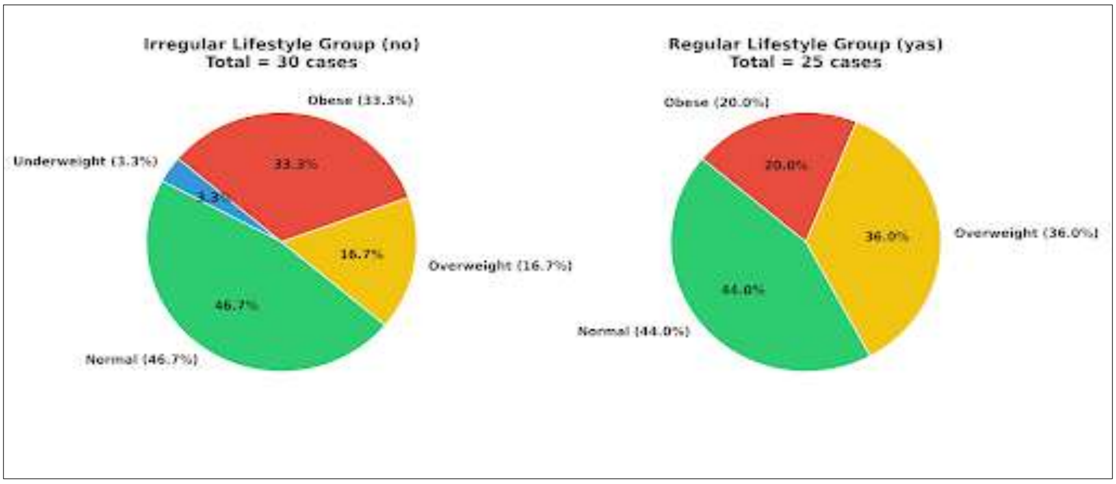

Figure 7 : the body measurements and BMI

Irregular Lifestyle Group (no) — Total Count = 30:
Normal Weight: 14 cases (46.67%)
Obesity: 10 cases (33.33%)
Overweight: 5 cases (16.67%)
Underweight: 1 case (3.33%)

Regular Lifestyle Group (yas) — Total Count = 25:
Normal Weight: 11 cases (44.00%)
Overweight: 9 cases (36.00%)
Obesity: 5 cases (20.00%)
Underweight: 0 cases (0.00%)

μ: Regular Lifestyle (26.19 kg/m) vs. Irregular Lifestyle (26.80 kg/m).
Significance (p): p = .692 (p > .05).

The disparity in participants' weights and heights reflects a fundamental difference in the source of weight gain. Among individuals with a regular lifestyle, weight gain was associated with muscle hypertrophy (e.g., 185cm

/107kg and 182cm/ 93kg). Conversely, for those with an irregular lifestyle, excess weight resulted from severe adiposity relative to height (e.g., 170cm /140kg with BMI= 48.4, and 162cm/ 96kg with BMI = 36.6).

Modern medical and sports literature emphasizes that using the Body Mass Index BMI in isolation frequently leads to the misclassification of physically active individuals. Many strength and resistance-trained athletes are erroneously categorized as overweight or obese, despite possessing a low body fat percentage and a reduced risk for metabolic and cardiovascular diseases (Garrido-Chamorro *et al.,* 2021; Campa *et al*., 2022).

Conclusion

The findings of the study revealed a statistically significant elevation in the proportion of monocytes ($p = .009$) among individuals in the irregular lifestyle group. This variation was accompanied by highly statistically significant differences in dietary pattern ($p < .001$) in favor of the regular lifestyle group, whose members demonstrated a higher level of adherence to healthy dietary behaviors. Although individual variables did not reach statistical significance independently, the regular lifestyle group recorded higher mean scores in sleep quality, reduced obesity, and compliance with daily health habits compared to the irregular group, whose behavioral routine inconsistency was associated with higher rates of obesity and lower sleep quality.

Recommendations

1. Preparing and implementing health awareness programs emphasizing that consistency in daily habits is as vital as food quality in supporting immune function and enhancing its efficiency.
2. Executing educational programs to promote healthy behaviors as a primary preventive approach that reduces reliance on pharmaceutical treatments and future medical interventions.
3. Adopting a preventive perspective that views a regular lifestyle not merely as a luxury, but as a protective immune defense line mitigating long-term health risks.
4. Integrating lifestyle and health habit evaluations into routine medical examinations within primary healthcare to detect immune and health risks early.
5. Formulating national guidelines for a healthy lifestyle that highlight the importance of consistency and regularity in daily health behaviors for the general public.
6. Encouraging individuals and communities to invest in healthy nutrition and physical prevention as an economic investment that lowers future diagnostic and treatment expenditures.

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