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Review Article

Impact of Diet and Nutrition on Memory T Cell Development, Maintenance and Function in the Context of Healthy Immune System

Joyeta Ghosh[1], Khusboo Singh[2], Sudrita Roy Choudhury[2]*, Samarpita Koner[2], Neelanjana Basu[2] and Subhasis Maity[3]

[1]Assistant Professor, Department of Dietetics and Nutrition, NSHM Knowledge Campus-Kolkata, West Bengal, India

[2]Research Scholar, Department of Dietetics and Nutrition, NSHM Knowledge Campus-Kolkata, West Bengal, India

[3]Director of NSHM college 124,60 BL Saha Road Kolkat, West Bengal, India

***Corresponding Author:** Sudrita Roy Choudhury, Research Scholar, Department of Dietetics and Nutrition, NSHM Knowledge Campus-Kolkata, West Bengal India.

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Abstract

A well-functioning immune system is censorious for permanence in today's earth. The immune system must be persistently alert, keep track of intimation of danger or invasion. Optimum nutrition is always one crucial factor for every cell to function optimally, including cells in the immune system as well. Memory T cells are one rudimentary component of immunological memory, furnishing rapid and powerful host protection against secondary challenges. The diet and nutritional status of the host are two major regulators of T cell functioning and immune system. Present article will review literature considering the crucial impact of diet and nutrition on memory T cell development, maintenance and function in the context of healthy immune function. Caloric restriction without having undernutrition influence memory T cell functioning, while undernutrition or protein energy malnutrition or diet induced obesity predisposes T cell dysfunctionality. On one hand, undernutrition causes immunodeficiency (increased susceptibility to infection), whereas overnutrition/obesity results in inflammation due to increase in pro-inflammatory regulators. Gut dysbiosis also has a significant role in T cell biology and host fitness. In order to maintain a healthy gut microbiome proper dietary intervention are very crucial. Although more detailed research is needed in the current field to unfold the exact role of balanced diet in T cell development, maintenance and function in the context of healthy immune function.

Keywords: Diet; T Cells; Immune System; Microbiota; Nutrition

Introduction

A well-functioning immune system is censorious for permanence in today's earth. The immune system must be persistently alert, keep track of intimation of danger or invasion. The immune cells should be able to differentiate self from non-self and additionally capable to segregate between non-self-molecules which are injurious (e.g., from pathogenic sources) and safe non-self-molecules (e.g., from food sources). Optimum nutrition is always one crucial factor for every cell to function optimally, including cells in the immune system as well. Furthermore, in conditions like infection or during fever an "activated '' immune system raises the demand for energy with greater basal energy expenditure. Therefore, an optimal nutrition for the better immunological outcomes would be the nutrition which provides the functionality of the immune cells along with initiation of effective responses against pathogens as well as resolve the retaliation rapidly when necessary and to avoid

any underlying chronic inflammation. These nutritional demands of the immune system can be met from the diet or if dietary sources are unavailable, it can be met from the endogenous sources like body stores. Thus, the state of undernutrition impairs the immune function through various ways. The extent of deficiency depends upon the severity of malnourishment, whether there are nutrient interactions to consider, the presence of infection and the age [1]. One single nutrient can employ multiple diverse immunological effects, for example vitamin E plays the role as both antioxidant and inhibitor of protein kinase C activity, and potentially interacting with enzymes and transport proteins [2]. Whereas consumption of excessive food can also be associated with impaired immune functions. At present there is a great deal of research interest in whether specific nutrient interventions can further enhance immune function in sub-clinical situations, and so to prevent the onset of infections or chronic inflammatory diseases. Memory T cells are one rudimentary component of immunological memory, furnishing rapid and powerful host protection against secondary challenges [3]. As a consequence, memory T cells are the fundamental targets in the blueprint of vaccination strategies and cancer immunotherapies, prevailing it critical to understand the factors and mechanisms that modulate their biology [3,4]. Likewise diet as a crucial environmental feature impacts all aspects of host physiology including T cell functioning. One recent report on T cell functioning reveals that caloric restriction without undernutrition promotes memory T cell functionality, while a diet high in fiber also plays a positive role in this case [5]. Undernutrition or diet-induced obesity both have a negative impact on T cell functioning. Thus, the diet and nutritional status of the host are two major regulators of T cell functioning and immune system. Present article will review literature considering the crucial impact of diet and nutrition on memory T cell development, maintenance and function in the context of healthy immune function.

Data synthesis

Relevant published articles were summarized by performing computerized literature searches of different authentic databases using keywords: T -cell, Immunity, Nutrition, Micronutrients, diet etc. Potential studies with original data were selected and their important findings were incorporated into conclusion regarding the importance of nutrition on T cell functions.

Immune system-immunity

Overall immune system may be divided into two parts: innate and adaptive immune response, in which the innate immune response is the primary response to an invading pathogen. The responsible cells for innate immune response include phagocytes (e.g., macrophages and monocytes), neutrophils, dendritic cells, mast cells, eosinophils etc. Considering adaptive immune response, the innate response is more rapid, but not specialized and thus remains less effective. Whereas adaptive immune response has the ability to recognize pathogens specifically and memorize it if exposed again. Thus, in the adaptive immune system the T cells are crucial in antigen recognitions and the modulation of immune responses [6]. The T cell represents distinguishable subtypes that modulate different types of immune responses. For example, they are divided into the cytotoxic T cells (consisting of CD8 receptor), which play an important role in direct killing of infected damaged cells and tumor cells, and the T helper cells. Whereas the T helper (Th) cells consist of CD4 receptors and one important modulator of immune responses. According to the different cytokine productions there are different subtypes of Th cells present in the immune system. Primarily it is two types, the Th1 cells, produces interferon gamma (IFN-γ) and interleukin (IL)-2 and are important in antiviral and cellular immune responses as well. Whereas the Th2 subset produces IL-4, IL-5, and IL-13 and involved in humoral (antibody) and anti-parasitic responses (but also in allergic responses) [6]. There are other Th subtypes as well, including Th17 cells, produces IL-17A, IL-17F, and IL-22 and are important in fighting extracellular pathogens (bacteria and fungi) [7]. Another important T cells were the T regulatory cells(T reg),CD4-bearing cells plays crucial role in maintaining immune tolerance to allow the immune system to avoid non-harmful non-self(such as pollen, food, latex etc.) components. Therefore, the chief role of T cells is modulation of immune response following specific immune stimulation or challenge.

In the adaptive system the other responsible lymphocytes are the B cells, crucial for antibody or immunoglobulin (Ig) production. It also responds specifically to an antigen. B cells can be differentiated into short-lived plasma cells, mostly produce Igs in the short term, or can become long-lived plasma cells. The pathogen-specific molecule Igs help the immune system to recognize and destroy pathogens. There are five classes of plasma cells of Ig (IgM, IgD,

IgG, IgA, and IgE) and each of these classes have a specialized role in our immune system [8]. Among the Ig the IgM is the first to be expressed during development and capable of binding with an antigen to identify it for destruction by immune cells. It is often found as a multimeric molecule (for example pentameric). Generally, IgD is available in low concentration in the plasma and the important role of IgD is still unclear to the researcher. Among the Ig the IgG is the predominant Ig and exists for a longer period of time. IgG helps in antigen labeling and thus play a crucial role in effective removal of antigens. IgA gives protection against bacteria or viruses and thereby plays an important role in preventing infections. Considering food antigens IgA plays a neutralizing role and helps to maintain immune tolerance to food antigens (protect against food allergy) [9]. In case of extracellular parasites (e.g., helminths) IgE plays the role in clearance, but while produced inappropriately to nontoxic environmental and food antigens, has an important role in having IgE-mediated allergy. B lymphocyte cells have a process called class switching, which is mostly controlled by the cytokines present or produced according to situation particularly IL-4, IL-6, and IFN-γ secreted from Th cells [10]. The T and B lymphocytes can be specialized to form memory cells, remains permanently for very long period of time and are able to recognize the encountered antigen and elicit a rapid, pathogen-specific immune response. Thus, an effective implementation of the immune system against various pathogens or harmful components and quick resolution of the immune response is required for better survival. Cytokines are the key component of effective resolution of immune responses. One important anti-inflammatory cytokine, the IL-10 is produced by a range of immune cells including Tregs and has the capability to suppress the inflammatory cytokine production as well [11]. The inducement of an immune response and the activities of the immune cells predispose to the causation of inflammation, which are the consequence of the damage to the tissue going on while the immune system does its effort. In modern lifestyle there is one increasing concern of immune sensitivity, resulting in the promotion of ongoing whole-body inflammation (systemic) caused by immune and other cells (e.g., adipocytes, the cells that store lipids in fat tissue) [12]. Thus, diet is crucial in this context as well [13].

Importance of T cells in immunity

During the condition of immune responses, the T cells (antigen specific) interact with antigen presenting cells, responsible for displaying cognate antigen in the context of major histocompatibility molecules. Thus, resulting in an extensive T cell proliferation and the accretion of an effectors program [3]. After completion of the role of controlling the threat, most of the effector T cells undergo apoptosis, leaving behind the stable populations of memory T cells with the capability to confer life-long immunity [3]. According to the functionality the memory T cells are divided into two parts, it comprises central (T_{CM}) and effector (T_{EM}) memory T cells [14]. Most commonly the T_{CM} exists between secondary lymphoid organs (SLO), lymphatics and blood. Activation of these cells drive them to be highly proliferative, contributing secondary effector cells to combat the challenge. Whereas, the T_{EM} mostly circulates between peripheral tissues and blood. They are capable of having low proliferative actions but able to provide immediate effector functions, which include the production of pro-inflammatory cytokines and direct killing of target cells through the expression of cytotoxic granules. Another type of T cells called the tissue-resident memory T cells (T_{RM}) are non-migratory in nature and reside long time in tissues without entering the blood circulation again [4]. These cells are capable of producing cytokines that initiate and amplify local immune responses, thus helps in providing exposed sites with an essential layer of protection [4,15-17]. Additionally

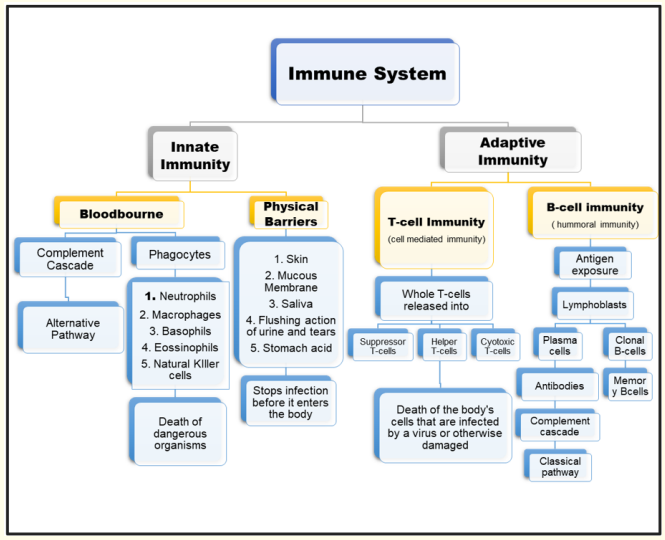

Figure 1: Flowchart of basic components of the human immune system [121].

the other subsets of Memory T cells such as stem cell (T_{SCM}) [18], recirculating(T_{RCM}) [19]and peripheral(T_{PM}) [20] developed from activated effector cells, regulated by several elements including the strength of signaling received through the t cell receptor during activation, also during exposure to inflammatory factors over the course of the response [3]. Antigen is always not required for the long-term maintenance of memory T cells, but it is dependent on specific transcription factors and the homeostatic cytokines IL-7 and IL-15, promotes a quiescent, pro-survival program [22-24]. For proper functioning of memory T cells, the IL-7 signaling is critical in many aspects, such as to promote the mitochondrial function in generating ATP for proper energy production to the cell [26]. Previously mentioned, many reports stated regarding oxidative phosphorylation of long chain fatty acid (LCFA) probably plays a key role in T cell development, maintenance and function [26-32]. These reports are also indicating that the calorie intake, alteration in dietary composition, environmental exposure plays a crucial role in the immune system and specifically the memory T cell compartment [5,30-34].

Benefit of caloric restriction on memory T cells

History denotes organisms most likely experienced prolonged periods of reduced food availability. Such phenomenon helps them to adapt and thrive when food becomes unavailable and may have postulated the most important aspect in shaping human evolution. The term Caloric Restriction (CR) denotes the decreased caloric intake without undernutrition or deficiency in vitamins, minerals or amino acids [33,35]. Report shows that CR promotes host fitness in organisms spanning from yeast to humans for decades [35]. The best advantage include increasing longevity, better metabolic profiles, also reducing cardiovascular risk, neurodegeneration, inflammation and the occurrences of certain cancer [35-42]. Studies also shows that CR has positive impact on the migration, intrinsic cellular state and functional capability of predefined $CD4^+$ and $CD8^+$ memory T cells [5]. 50%CR during one week in mice persuade the redistribution of circulating memory T cells from secondary lymphoid organs and blood to the Bone Marrow(BM).The reports are also showing that the naïve B cells [43] and monocytes [44] were also accumulate in BM during fasting, indicating that this BM may be "safe heaven" [34] or "metabolic refuge" [45] for cells of the immune system during reduced caloric intake. Glucocorticoids used to coordinate the redistribution of memory T cells. It also induces the expression of the BM-homing receptor CXCR4 on T cells [46-49]. Certainly during CR, the BM drastically remodeled during CR to be enriched for T cell trophic factor, adipocytes, red blood cells. All of which worked consequently to retain, recruit, and protect memory T cells [5]. Thus, BM adipocytes are the crucial sources of hormone during the course of CR, which requite the loss of peripheral white adipose tissue(WAT) [50-53]. Following the clearance of an infection the memory T cells mostly gathered at the peripheral WAT site [54-57]. Whereas memory T cells were unable to accumulate in BM efficiently if adipocytes were ablated during the course of CR [5], indicating that BM adipocytes hold up memory T cell homeostasis within this niche. Anyhow the mice model on CR explained similar activity regarding uptake, store and utilize fatty acids compared to memory T cells from mice fed *ad libitum* [5]. But still the exact mechanism is not clear and is one promising research area indeed.

The effect of undernutrition and reductions in dietary metabolites on memory T cells

Undernutrition has highly detrimental consequences for immunity [58], affecting more than 800 million people globally, thus increases the susceptibility to infection, as well as a sharp reduction in the synthesis and production of the antibody responses elicited to certain vaccines [58-60]. Thus undernutrition is one dominant cause of immunosuppression worldwide [60], highly associated with chronic infections, low grade inflammation, increased intestinal permeability, dysbiosis of the intestinal microbiota etc. [58,61,62]. Research has already shown that the dietary protein plays one major role in regulation of memory T cell development, maintenance and functions [63]. One severe reduction of dietary protein that is from 18% to 0.6% protein reduction resulting during protein energy malnutrition(PEM) shown to reduce the ability of established memory $CD8^+$T cells proliferation drastically [63]. The mice model also shown that the state of PEM were more susceptible to secondary infections of lymphocytic choriomeningitis virus (LCMV) [63]. Another study on vaccine-elicited *Mycobacterium tuberculosis (M-tb)* study on mice model shown suppressed immune responses during the state of PEM [64]. The study was specifically on $CD4^+$ T cells, where the memory $CD4^+$ T cell in the lungs of a PEM mice were compromised in their ability to produce effector cytokines [64]. Thus indicating the crucial role of dietary protein in supporting the function of memory T cells [64]. Similar

studies on PEM also indicate that severe dietary protein deficiency may lead to malfunctioning of memory T cells [65-68].

Further understanding is required whether decrease in certain amino acids is the responsible factor behind certain suppressive behavior of memory T cells during PEM, which can lead to the development of novel therapies that restore suppressed immunity in the undernutrition settings. Recent findings on amino acid serine shown interesting result on effector $CD8^+$ T cell proliferation and function [69,86]. Serine -free diet resulted the decline in development of memory T cell, leading to poor pathogen control [69]. Considering T cell biology, the serine is required for proper nucleotide synthesis during proliferation [69]. Methionine is another specific amino acid which promote T cell activation [68]. In mice model with restricted methionine showed reduced $CD4^+$ T cell activation and differentiation, due to altered regulation of chromatin accessibility and gene expression [70]. L-Arginine also shown essential function on regulating different metabolic pathways in $CD4^+$ T cells [71]. Report also indicating that L-arginine at high level increases mitochondrial metabolism in promoting T cell survival and differentiation into T_{CM} that had potent anti-tumor activity [71].

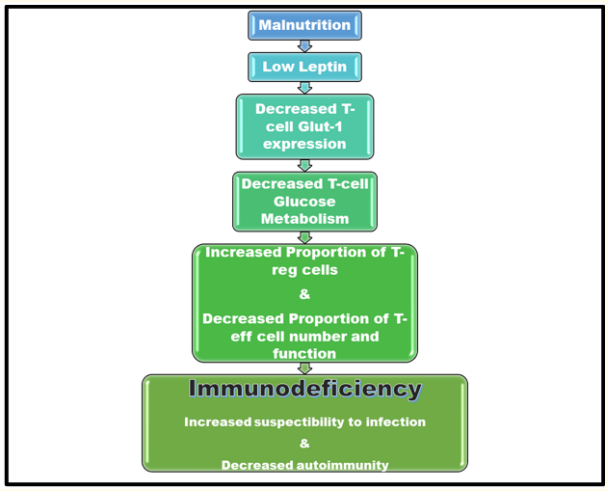

Figure 2: Malnutrition leads to changes in adipocytes secreting-hormones and T cell number and function. [113].

Protein energy malnutrition (PEM) with T cells

Nutrition is a very important but poorly understood determinant of immunity. There are many epidemiological evidences connecting protein malnutrition to impaired vaccine efficacy and increased sensitivity to infections; yet, the part of dietary protein in immune memory homeostasis remains poorly recognized. Upon Ag reencounter, Ag-specific memory T cells respond more rapidly and efficiently than naive T cells, conferring the host with long-term protection [72]. This memory pool is preserved at a relatively constant size for lengthening periods, even up to a lifetime, by homeostatic proliferation [73]. Cell existence and turnover also depend on nutrient accessibility; very little, however, is known about how nutrition impacts memory T cell homeostasis. Since rapid increase of memory cells imposes a metabolic demand on amino acids to assist protein synthesis, dietary protein may be critical in sustaining T cell memory. PEM is crucial form of malnutrition and defined as an imbalance between intake of protein and energy and the optimal requirement to secure the most favorable body growth and purpose [74]. In a mice model they are fed with a low-protein (LP) diet to develop PEM and adequate-protein (AP) as a control diet. After 4 week of dietary intervention, LP mice demonstrated a 2-fold reduction in Ag-specific memory CD8 cells compared with AP-fed controls, suggesting impaired proliferation due to PEM. Using adoptive transfer of CFSE-labeled memory cells from AP mice into naive LP or AP mice, it was confirmed that PEM caused profound defects in homeostatic proliferation. decreased CD8 memory in LP hosts could be due to defects in homeostatic proliferation; because the receptors for the g-chain cytokines are key signals for homeostatic proliferation [75], The maintenance of memory CD8 T cells are requirements to support at least two fundamental processes, increased bioenergetic demands and increased protein synthesis [76].

The cell-mediated immune responses are compromised in protein-malnourished individuals. Salimonu., *et al*. [88] found notably lower T lymphocyte count in malnourished compared with well-fed children at baseline and at 3, 10, and 21 days of post immunization with measles virus. Studies have also shown reduced reaction to tuberculin test in infants and children with PEM [77,78]. amino acids such as glutamine are important for building of IFN-g in T cells [78] It is noteworthy that in malnourished children, an improvement in immune function, as measured by Ab titers, after protein supplementation has been reported [79].

In another study it exhibited that Protein energy malnutrition decreased the number of T lymphocytes, of T4 positive cells and their capacity to provide help to B cells in antibody synthesis.

There was a depletion in serum thymic hormone activity and an elevation of leucocyte terminal transferase and plasma cortisol levels [80]. About 15% of malnourished children showed lymphopenia and T cells are invariably reduced. On providing supplements to correct nutritional deficiency, there is a rapid surge in these cells. The quick and dramatic recovery in T cell number had led to the suggestion that this index could be used as a sensitive and functional measure of nutritional recovery [81]. The changes in the proportion and function of T cell subsets may explain some of the clinical and immunological features of PEM. The reduced ability of malnourished individuals to deal with many common infections may be due to inefficient antibody synthesis. PEM results in decreased antibody response to those antigens which require T cell help but response to these antigens improves if they are given in adjuvant or in repeated large doses [82].

Nevertheless, human malnutrition is usually a composite and variable, modulated further by the contaminated environments in which malnutrition evolves. Vitamin and mineral deficiencies commonly occur with energy and protein deficiency; each interrelate with the others. Infection, a common accompaniment of malnutrition, may also obstruct both immune responses and body metabolism [83,84] The clinical significance of the reduction in T4+ cells is still uncertain.

The effect of diet-induced obesity on memory T cells

Over nutrition is also another important public health concern throughout the world. Overfeeding, lack of physical activity, accumulation of high adipocytes has arisen very recently in the human revolution [85]. Thus, it is associated with chronic low-grade inflammation, metabolic syndrome, which are detrimental to different disease aspects of host physiology [86,88]. Obesity is shown to be one independent risk of concern in various infections, promoting morbidity and mortality [88-90]. Research also shows that over-nutrition has strong association with sub-optimal antibody responses and thus suppresses memory T cell functionality followed by vaccination [87,90-95]. Study conducted on mice model, fed with 60% fatty diet, exhibited obesity, which increased mortality upon secondary infection with influenza viruses [96]. Such phenomenon correlated with the decrease in count of functional $CD8^+ T_{EM}$ in the lungs [97]. Overnutrition or obesity causes potential defect in the maintenance of memory T cell subsets, observed in mice model as well [96]. Such observations indicate that a period of obesity would have a prolonged impact on host physiology and the immune system even after switching to a healthier diet. Although further investigation is needed in this context. One recent study shows the detrimental effect of pathogens that directly infect adipocytes, in mice model the LCMV infects WAT directly and was cleared by effector T cells in mice fed either a regular or high fat diet [101]. Study also shows that after the clearance the memory T cells were generated and presented long-term in WAT [100,101]. Another important finding was that the WAT memory T cells of obese mice caused immunopathology, lethal upon a secondary infection, whereas the mice model having normal diet remain healthy and easily control the challenges [101]. Other ways the memory T cell dependent destruction of infected adipocytes causes necrosis of WAT among obese mice also releases lipases and other factors, causing inflammation in regions of the pancreas adjacent to WAT [101]. Thus diet-induced obesity causes aberrant inflammatory program within WAT memory T cells. Obese mice also face increased production of pro-inflammatory factors that contribute to dysregulated host responses [86,98,99]. Therefore, overnutrition or obesity have a negative impact on T cell functionality. More elaborative work still needed to have a clear understanding about the impact of diet-induced obesity on memory T cells in a range of contexts.

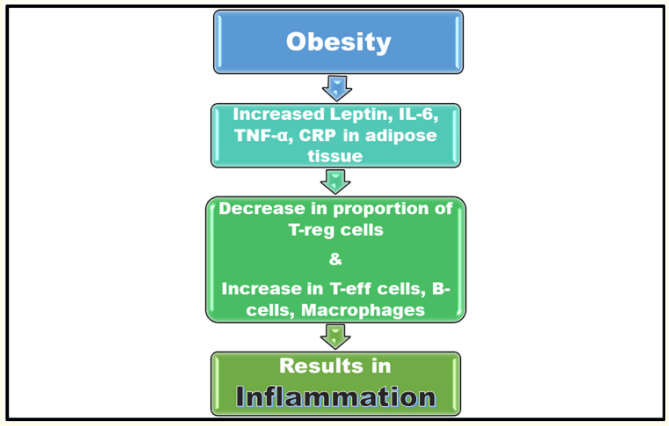

Figure 3: Obesity increases pro-inflammatory regulators and results in inflammation [120,121].

T cells and gut immunity

Most of the immune cells within the human body are observed within the gut-associated lymphoid tissue (GALT), indicating the importance of GALT in the overall immune system of the host. Consumption of food made us exposed to massive antigenic stimulation, also the strong immune system must be able to provide strong and protective immunity against invasive pathogens, while tolerating commensal bacteria and food proteins. To achieve such objectives GALT performs a variety of sensing and effector immune functions. Within GALT there are specialized immune regions known as Peyer's patches. It is rich with immune cells and allows for communication between immune cells during propagation of signals to the systemic immune function and also helps in the recruitment or efflux of immune cells [101]. Inside the gut lumen the gut microbiome produces different antigen and signals with potential interactions to the systemic immune function. Over life courses the composition of gut microbiome changes in response to the dietary components and to the other environmental factors such as antibiotic therapy etc. The most popular and common dietary interventions for healthy gut microbiome are probiotics and prebiotics therapy [102,103]. Report exists that protein hydrolysates are capable of enhancing the barrier function and IgA productions in animal models. These might have implications for inclusion within hypo-allergenic infant formula and also might relief the clinical complications during conditions such as inflammatory bowel disease [108]. Among animal models probiotics are capable to reduce gut inflammation, with concomitant decrease in pro-inflammatory Th1 and Th17 cytokines such as IL-17 and IFN-γ, and increased the production of inflammation resolving cytokine IL10 [109]. On the other hand prebiotics are also protective and increase the barrier functions of the gut, addition to their important role in selective bacterial metabolism [110]. The most important and crucial intestinal homeostasis is modulated by CD4 regulatory T cells (T_{reg}). T_{regs} are the crucial response modulators especially in the gut, which is dependent on the high luminal resident bacterial loads, change in dietary materials, pathogenic incursions etc. Whereas Th cells are an important tuner of intestinal inflammation how long or when to produce [111]. The mucosal immune system of the gastrointestinal tract faces the provocations of co-existent with the dynamic and diverse population of microbes while remaining assured to remain protective against invasive pathogens. Thus, T cells and its subtypes play the most crucial role in maintaining gut homeostasis [103-110].

Gut dysbiosis and diet

Gut dysbiosis is a broad term that can be defined as alterations in the gut microbiota resulting in adverse health outcomes. Dysbiosis includes the loss of beneficial and an increase in pathogenic microbes (pathobionts). Dysbiosis is believed to trigger pro-inflammatory effects and dysregulation of immune responses linked with various disease conditions [114]. One of the strongest modulators of the composition and function of microbiota are the dietary factors. Evanescent, diet-induced changes take place independently of body weight and adiposity and can be detected in humans within 24 to 48 hours post intake of a diet. A diet rich in micronutrients, high in fiber content, rich in high-quality protein along with sufficient water intake as well avoiding the western dietary components like saturated and trans-fat, simple sugar, refined flour, high-fructose corn syrup, and other processed foods etc., is considered to have a protective role in respect to intestinal dysbiosis [115,116].

Carbohydrates (CHO) that are indigestible yet metabolically available to microbes within the intestines in particular vital to the health of the microbiota. Fermentable fibers and non-digestible polysaccharides found in resistant starch foods, such as those originating from plants are collectively termed as "microbiota-accessible carbohydrates" (MACs) [117]. The microbes in the intestine produce hundred times more carbohydrate degrading enzymes than what is produced by the enterocytes of humans, and this in turn makes the microbes capable of utilizing the MACs as their primary energy source. A better way to optimize gut microbiome and human health is by bringing a balance in caloric intake in accordance to basal metabolic rate and total daily energy expenditure, along with consumption of micronutrient rich, high in fiber and well-balanced food [118]. Another approach for nullifying the adverse effects of western diet (WD) is consumption of a high-protein diet (HPD). HPD has been found to have roles in promoting fat loss, glucose homeostasis restoration and in improving sensitivity of CCK, as well as in maintaining muscle mass in caloric restriction periods [119]. It has also been reported that consumption of low-calorie diets leads to increase in diversity of microbes, neurogenesis in adults, levels of BDNF and an improved cognition. Whereas, a high fat diet (HFD) has been found to promote gut dysbiosis, decrease synaptic plasticity and increase anxiety-like behavior [120].

Diet has a vital effect on the microbiome and its capacity to in-

teract with different systems in the body. Therefore, different studies suggest the importance of maintaining a healthy gut microbiome through different dietary interventions [121].

Conclusion

An efficiently working immune system is vital to existence in today's world, and for this adequate nutrition is one of the most important factors. There should be close watch on the kind of nutrients one is consuming to enjoy a fully functioning immune system. The role of adaptive immunity including T-cells is crucial in antigen recognitions and the modulation of immune responses. The calorie intake, alteration in dietary composition, environmental exposure plays a vital role in the immune system and specifically on the memory T cell functionality. Both Undernutrition and overnutrition/obesity have adverse effects on different systems of the body, where the former causes immunodeficiency (increased susceptibility to infection) and the latter results in inflammation/autoimmunity. Most of the immune cells within the human body are observed within the gut-associated lymphoid tissue (GALT), indicating the importance of GALT in the overall immune system of the host. Here, also T-cells and its subtypes play the most crucial role in maintaining the gut homeostasis. Gut dysbiosis, that is alteration in the gut microbiota has adverse implications on the health and in order to maintain a healthy gut microbiome proper dietary intervention are crucial. A diet rich in MACs (microbiota accessible carbohydrate), high in protein, rich in fibers and low in fat along with sufficient water consumption is found to be ideal in maintaining a healthy gut microbiota. Comprehensive studies elaborating the exact mechanism of interaction of T-cells and diet are still unavailable. Therefore, extensive studies are required to unfold the exact role of proper dietary intervention in T-cell development, maintenance and functioning in relation to healthy functioning of immune functions.

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Conflict of Interest

The authors declare no conflicts of interest.

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