

Review Article

Adequate Nutrition and Premature Hair Graying: A Review of Literature

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Abstract

People nowadays are very much concerned about their appearance and personality traits. Among these, hair colour plays an imperative role in overall look and adds to aesthetic value in this modern era of cosmetology mutiny. Hair graying whether timely or premature has a direct pessimistic impact on one's social well-being. However, in latter the management of hair graying is believed to have significant and direct impact on the quality of life in adolescents. The hair cycle responsible for pigmentation of hairs is dependent on multiple factors viz. enzymes, pH, excessive stress, hormones, hereditary causes, sedentary lifestyle and nutritional deficiencies. Of these, if considered carefully, macronutrients and micronutrients obtained from diet in human body are playing an immense role directly or indirectly in normal hair cycle. A caloric deprivation or deficiency of these dietary components can lead to structural abnormalities in hair as well as pigmentation changes. In this review, an effort is being made to understand the role of various vitamins, minerals, proteins and antioxidants in canities. A broad literature search of PubMed and Google Scholar was performed to compile the information available in research as well as review articles. As per the available data, it can be suggested that there is direct relationship between the low levels of copper, iron and vitamin B12 and PHG. However, reaching a defined conclusion seemed unlikely because of limitations in studies related to the above-mentioned scenario.

Keywords: Antioxidants; Trace Elements; Nutrition; Premature Hair Graying; Vitamins

Introduction

Lustrous hair is one of the major attributes of healthy-looking people who takes good care of their body and looks. The hair and scalp conditions have psychosomatic impact on human society. A minor change in one's look viz. premature hair graying, slow growth, less density or hair fall can have an effect a negative impact on the self-esteem of an individual [1]. Hair, a thin fibre like structure present on epidermal layer of skin, is made of protein "keratin" and hair colour chiefly depends on melanin pigment and fabrication of this pigment takes place in melanosomes through the process of melanogenesis [2]. With age, the hair strand characteristics like fibre elasticity, cuticle layers, diameter and color changes [3]. The depigmentation of hair or "canities" with age is one of the significant physiological phenomena; while Premature Hair Graying (PHG) is the condition in which graying occurs before the normal ageing process [1]. Knowledge on PHG is coupled with major concept of partial or complete loss of melanogenesis that leads to the production of pheomelanin as well as eumelanin. The studies conducted in this direction identify multiple factors acting alone or in combination leading to PHG. Various internal (auto-immune diseases) and external factors [Ultraviolet (UV) Rays, REACTIVE OXYGEN SPECIES (ROS), smoking, lifestyle, stress, nutrition, cosmetics and hair care products] are known to be associated with PHG worldwide [4]. Though, previous studies have indicated the hidden role of reactive oxygen species (ROS) as one of the major players behind PHG; still the baseline phenomenon is poorly understood leading to the lack of solutions [5]. At present, the only available solution appears to be the application of temporary hair colorants. Ironically, the use of dyes even being the most common has various side effects such as allergic reactions, inflammation, hair loss etc. Thus, there is an urgent need to come up with better alternative approaches to combat PHG which can be applied as a preventive or curative measure.

Nutrition, defined as chemical compounds present in food, provides a key contribution for the active metabolism of hair follicles [6]. It is worthy to note that apparent deficiency of a single nutrient has a cascading effect on optimum utilization of multiple

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other nutrients and functioning of other body systems. Nutrients can further be divided into two categories: micronutrients and macronutrients. Micronutrients are those nutrients which the body require in smaller amounts i.e., vitamins, mineral, antioxidants; whilst macronutrients are the one required in large amounts i.e. carbohydrates, fatty acids and proteins [7]. A caloric shortage of lot of essential nutritional components such as minerals, proteins, antioxidants, significant fatty acids and vitamins causes depigmentation of hairs, structural abnormalities and poor hair loss [8]. A strong association of PHG with sedentary lifestyle and irregular food habits (Vitamin B12, biotin, copper, zinc, selenium and iron) has been hypothesised in various studies [9,10]. The studies focussing on nutritional deficiency and its impact both on hairs structure and hair growth clearly highlights that patients with hair loss must be screened for nutritional deficiencies [11]. The fact that nutrient deficiencies cannot always be detected clinically as these are masked and compensated by self regulating processes of redistributing the utilization of nutrients in the body, it becomes difficult to understand underlying phenomenon.

These nutritional aspects have long been into picture and but have received greater attention in terms of hair growth and hair loss rather than PHG. The available data points towards the hidden potential of nutritional components in view of PHG, thus this review aims to understand whether there is any direct association between nutritional components and PHG.

Review of Literature

Biology of Human Hair

In humans, hair not only serves as sexual acuity but also helps in maintaining thermoregulation and UV protection. Nearly the whole human body surface is covered with hairs apart from a few regions like soles, palms and mucosal parts of lips and exterior genital track. Approximately 5 million hair follicles are present on human body out of which about 100,000 are located on the scalp [12].

Structure of Hair

Hair, is made up of tough protein called keratin, comprises of two discrete structures: a) the Hair Follicle (HF) - living part situated beneath the skin and b) hair shaft-lifeless, entirely keratinized part situated on the surface the skin. The HF helps in maintenance of the hair growth by means of a complex relation among immune cells and neuropeptide hormones, which is further split into two parts infundibulum and isthmus. While hair shaft comprises of three layers: cuticle, cortex and in certain cases medulla [13]. The square-shaped cuticle cells are held firmly to the cortex cells which facilitate protective properties and blockade functions against chemical and physical stress. The cortex contains accumulation of the shaft and melanin [14]. Lastly, the medulla positioned in the middle of the hair shaft is further made up of structural proteins (Sperling LC).

Within the hair follicle cells, the melanocytes originate in two main locations, the primary is the anagen bulb and the secondary is situated in the sub-bulge region of the buldge and Outer Root Sheath (ORS) [15]. The melanocytes located in the anagen bulb transfers melanin to keratinocytes which helps in formation of hair shaft. Such bulbar melanocytes are considered as the component of pigmentary unit as these are the merely ones contributing to the hair pigmentation [16]. On the other hand, the melanocytes located in the ORS and buldge region are undeveloped and immobile dopaoxidase-negative that does not articulate melanogenic enzymes, i.e., tyrosinase or tyrosinase-related protein TRP [1]. These ancestor cells not only acts as a pool in catagen/telogen stage, but also strengthen their progeny at some stage in anagen phase [17]. The melanocytes other than that present in the bulb and ORS region, they are also present in the infundibulum and in sebaceous glands [18].

Hair Pigmentation and Hair Cycle

The human hair color is specified by the pigment melanin formed by melanocytes that are the derivatives of neural crest. The human hair follicles include two types of melanin pigment: eumelanin (black-brown pigment) and pheomelanin (yellow-red pigment). Eumelanin is responsible for darker hair colour and pheomelanin mainly present in auburn and blonde hair. The process is considered to be regulated by various genes at different levels [4]. A progressive decline in tyrosinase activity is seen due to reduced pH leading to increased pheomelanin and reddish or blonde hair. Melanin is considered to be synthesized via an enzymatic response catalyzed by Dihydroxyphenylalanine (DOPA) Chrome Tautomerase [DCT], Tyrosinase (TYR) and Tyrosinase-Related Protein 1 (TRP1) on the substrate tyrosine to make the end product [19]. It is a known fact, like any other biological process hair follicle cells have a speedy yield that needs good supply of energy and nutrition for its active metabolism [8]. Hair cycling is the periodic alteration of the hair follicle all the way through phases of development (anagen), degeneration (catagen) and rest (telogen). The period of phase change is based on the location of hair and individual's age, hormonal status

and nutritional balance. Role of iron in normal functioning of genes required for normal hair follicle is well documented [20]. A study revealed the role of copper ions binding to the enzyme tyrosinase, essential for enzyme activity involved in the process of melanogenesis [21]. Similarly, deficiency of zinc is linked as one of the troubling reason for the growth of hair [22]. Thus, it wouldn't be wrong to say that nutritional components (i.e, proteins, minerals, antioxidants, vitamins and essential fatty acids) are playing some role in pigmentation.

Premature Canities

Canities, or graying of hair, is a physiological phenomenon occurring regardless of race or gender; having variation in age related to with ethnicity. In typical aging, hair graying occurs at the age of 34 ± 9.6 in Caucasians, 43.9 ± 10.3 in African Americans and 39 ± 9 in Asians, respectively. On the contrary, graying occurring before the "usual" age of onset i.e. at the age of 20 years in Caucasians, 25 years in Asians and 30 years in Africans; is termed as Premature Hair Graying (PHG) [18]. This condition is often linked as a sign of old age, loss of health, various judgemental and social reactions. Various factors like genetic variations, exposure to environmental pollutants, chemical toxins, changes in climate & seasons and stress levels seem responsible for affecting the normal hair cycle [23]. However, the basic phenomenon resulting in loss of pigmentation in young adults is still unclear.

Methodology: The curative search of literature was done to categorise significant research on PHG. The five databases viz. PubMed, Google Scholar, OVID, Web of Science and Scopus were used. For each database, a set of common keywords were applied to ensure thoroughness. The keywords included "Premature graying of hair", "Premature hair graying", "PGH", "PHG", "Canities", "White hair", "Early hair graying", "diet", "Nutrition", " Vitamins ", " Minerals ", " Antioxidants ", "impact", "association", "relationship". The goal was to capture all possible variations and terms related to PHG and its association with nutrition. This methodical approach allowed us to gather a wide range of studies and ensure that our review was as comprehensive and inclusive as possible.

Interplay Between Nutrients and PHG

The healthy human scalp is comprised of 100,000 hair follicles approximately out of which 90% are in anagen phase requiring vital elements, such as vitamins, minerals, proteins and antioxidants to efficiently fabricate healthy hair [8]. These nutritional elements play a key role in the cellular changes of the matrix cells in the follicle bulb that divides rapidly and are key elements in a typical hair follicle cycle [24,25]. The common mineral element associated with PHG includes copper, zinc, iron, calcium, vitamins, proteins antioxidants and fatty acids. The lack of micronutrients i.e., copper, zinc, iron, calcium has been associated with variety of investigational manifestations particularly in skin xerosis, erythematous scaly papules and plaques, cheilitis, vesiculobullous eruption, sparse light-colored hair and hair loss [11]. Whereas, vitamins and antioxidants which serves numerous roles in human body acts as potent agents preventing the damage from free radicals, helps in modulating the growth and segregation of keratinocytes typically associated to body hair abnormalities [26]. Similarly, low intake of protein than that of normal daily dietary intake can lead to hair loss and pigment changes, even though the accurate mechanism(s) are not well understood [27].

The role of nutritive elements in treating premature canities represents an active and budding area of inquiry. The clinical interest between the trace elements and diagnosis of premature canities has attracted many researchers in recent years. The next section of the review is an attempt to summarize the role of these essential elements and PHG explored till date. A brief summary in the table form highlighting the limitations of the selected studies has been added thereafter (Table 1).

Iron

World Health Organization has ranked iron deficiency as the world's most common deficiency distressing up to 80% of human race. Several clinical manifestations are related due to the deficiency of iron and impaired keratin production leading to thinner anagen hairs [21]. Studies have provided enough evidence for the role of iron in the modulation of the activity of tyrosinase. Improvement in the heterochromic hair and melanin composition of a 15 year old Japanese girl was associated with iron supplementation. The role of iron in melanogenesis, through rearrangement of dopachrome to 5, 6 - dihydroxyindoles and the oxidative polymerization of the 5, 6 - dihydroxyindoles to melanin pigments has been reported [10]. A case-controlled study done by Bhat, et al., [8] investigated haematological parameter such as serum ferritin (S. Ferritin), haemoglobin total iron binding capacity, serum iron (S. Iron) and found low levels of S. Ferritin in patients with PHG. Similar trends were seen in a case-

controlled study with 52 self reporting respondents having premature canities with low levels of serum folic acid. On the other hand, a negative correlation between the severity of PHG and serum iron level was also reported in study carried out in Egypt [26].

Calcium

It is considered as a chief element that plays a major role in maintenance of hair in their appropriate state. A study conducted by Heath and Sidbury [27] found the association of osteopenia with PHG indicating a possible role for calcium and vitamin D3. Another group of scientists, Sheikh, et al., showed a statistically significant reduction in serum calcium level in the patients with PHG in contrast to the control group [26]. In concordance Bhat, et al. and Anggraini, et al., mentioned the relationship between low levels of serum calcium and vitamin D3 levels with PHG [8,22]. However, a study done in India by Chakraborty, et al., reported no significant relationship connecting PHG and serum calcium levels [28].

Copper

It is a vital trace mineral for aminoxydases, essential for oxidation of thiol groups to dithio crosslinks, crucial for keratin fibre and imperative for melanin synthesis. Its absorption is required for tyrosinase activity for providing normal colour to hairs. The daily dietary copper intake includes 900 mg for adults [8]. A case-controlled study done in Iran estimated the concentration of serum copper using atomic absorption which showed a significant low level of copper in patients with PHG [29]. Moreover, a change in hair colour of 3 years young Japanese patient was observed after receiving the copper histidine treatment [30]. Whilst, couple of studies done by Sheikh, et al. and Chakraborty, et al., showed absence of any relation between the two since both control group and PHG group has comparable levels of Copper in serum [26,28].

Zinc

It acts as a vital cofactor involved in metabolism of fats, proteins and carbohydrate and is said to be influencing hair growth and hair follicles. The daily required intake of Zinc is 8 -10 mg per day typically through a normal diet. Zinc deficiencies are mostly associated with telogen effluvium, thin brittle and white hair [31]. A study done using colorimetric method for evaluating zinc concentration in blood serum showed no significant relationship between PHG and Zinc. Similarly, study conducted by group of scientists i.e. Naieni, et al., found the absence of correlation of zinc levels and PHG [29].

Vitamins

Vitamins play a very important role in maintaining the healthy state of hair. The deficiency of vitamin in a balanced diet has negative impact on hair-shaft [21]. Of all vitamin types, Vitamin B12, Vitamin C, Vitamin D3, panthothenic acid (B5 vitamin) and biotin has been associated with healthy hair structure. Vitamin B12 which has shown to affect pigmentation and hair growth is also hypothesized to maintain the preliminary anagen stage of the hair follicle [11]. Similarly, the deficiency of Vitamin C has been associated with hair changes i.e corkscrew hairs, follicular plugging and curling of hairs. Pantothenic acid (B5 vitamin) is believed to prevent PHG and helps in repairing their natural colour. Vitamin B5 is also responsible in playing an immense role in cell division in hair follicles resulting in proper hair growth hence providing moisturizing abilities, anti-inflammatory properties and protection of hairs [2].

Odom RB reported first study pointing towards the association of Vitamin B12 and PHG, following which Chakraborty, et al., in 2016 investigated the levels of Vitamin B12 and Vitamin D and showed a significant low serum Vitamin B12 levels in individuals with PHG as compared to the controls [28,32]. Similar results were seen in a study done by Daulatabad, et al., in North India which confirm low vitamin B12 levels in the patients with PHG [33]. In a yet another study, vitamins such as Vitamins E and C has been exploited as antioxidants in shampoos, however their effectiveness has been questioned due to tiny contact period [34]. The presence of biotin, associated with the etiopathogenesis of premature canities was assessed by Daulatabad, et al., [35]. It was found that patients with PHG have significantly low levels of biotin in comparison to control. The application of Triphala with other ayurvedic ingredients a rich source of vitamin C is suggested as a tool for combating PHG [34]. Similarly, in yet another study have mentioned the topical application of coconut oil rich source of vitamin E which have the ability to penetrate the hair cuticle plays a chief role in delaying PHG.

Proteins

Protein which is the foremost element of diet helps in maintaining and building up the hair fiber. It is recommended that the

daily proteins should be 0.9 g/kg of body mass per day [35]. The deficiency of protein can lead to impaired hair growth/ synthesis causing hair brittle, fragile and leading to hair loss [11]. Keratin which is a basic element for hair protection and hair shaft, is responsible for providing elasticity, continuity and shine to the hairs [36]. Although, the role of protein in hair growth is well established, its impact on PHG is not understood. A first randomized, double-blind placebo-controlled study using epiluminiscence microscopy and digital image analysis demonstrated the positive effect of L cystine, pantothenic acid and medical yeast on anagen hair rate in women [37].

Antioxidants

Antioxidant enzymes are proficient of deactivating and stabilizing free radicals before they attack cellular components. These antioxidants have the capability to decrease the power of free radicals which causes them to become stable and may also diminish the injury caused to the cell by free radicals through interruption of the oxidizing chain reaction. It has been established that an extensive bond exists between free radicals and different health conditions, including the aging process, diabetes, Alzheimer's disease, cancer atherosclerosis, strokes and heart attacks etc [38]. Further, it a well-known fact that oxidative stress plays an immense role in many pathways within the hair follicle [11]. The process of melanin synthesis in hair generates oxidative stress by a generation of hydrogen peroxide (H_2O_2) and other free radicals. The common free radical scavenging enzymes and antioxidants includes catalase, superoxide dismutase and GSH glutathione peroxidase [39]. For the past decade, innumerable researchers have devoted their time to find the valuable effects of antioxidant however very few studies could observe the link between canities and antioxidants.

A study done in India was the first to assess the levels of oxidative stress in the patients with PHG in terms of parameters like whole blood reduced Glutathione (rGSH), serum Ferric Reducing Antioxidant Potential (FRAP) and serum Malonaldehyde (MDA). Results showed low GSH and FRAP levels in the patients with premature canities compared to the control [35]. Similarly, another study has mentioned the role of an antioxidant fern extract Polypodium leucotomas protecting gray hairs against sun [40,41].

Study	Study Type	Sample Type/Size	Results	Limitations
Bhat, et al., [8]	Epidemiological and investigative study	(Subjects who visited Skin Camp) 35 each cases and control	Serum calcium, Serum ferritin and Vitamin D were low in PHG group	Small sample size/study limited to patient visiting clinical set up
Daulatabad, et al., [9]	Case-control study	Out patients who visited the clinic; 52 each cases and control	Vitamin B12 and folic acid level were lower in PGH group and serum B7 level was in the lower side of normal	Small sample size/ study limited to patient visiting clinical set up
Sharma, et al., [42]	Case-control study	Out patients who visited the clinic; Total 120 cases and control	Serum calcium, Serum ferritin, Vitamin D and Vitamin B 12 were low in PHG group	Small sample size/ study limited to patient visiting clinical set
Naieni, et al., [29]	Cross sectional Study	Out patients who visited dermatology clinic; 66 each cases and control	No significance in copper, zinc and iron concentration in PHG and Non-PHG group, low serum copper in PHG	
Chakrabarty, et al., [28]	Patient who visited trichology clinic; Case-Control study	37 each cases and control	Serum ferritin, Serum Vitamin B12 were low in PHG group	Small sample size/ study limited to patient visiting clinical set up
EL- Sheikh, et al., [26]	Clinical study	Out patients who visited in the clinic; 90 patients, out of which 30	Serum iron, serum copper and serum	Small sample size/ study limited to

		controls and 60 cases	calcium were low in PHG group	patient visiting clinical set up
Anggraini, et al., [20]	Cross sectional study	University students; 40 each in cases and control	Serum zinc was lower in PHG cases, while no significance of serum copper	Small sample size/ study limited to patient visiting clinical set up
Sonthalia, et al.,	Retrospective study	Out patients who visited in the clinic; 71 patients	Significance association of Vitamin B12 and PHG	Small sample size/ study limited to patient visiting clinical set up

Table 1: Representative studies showing the relationship between nutrition and PHG.

Conclusion and Suggestions

Premature canities have always remained the cause of worry in young people and is independently associated with nutritional deficiencies along with the other external and internal factors. The available literature clearly points towards the role of vitamins, copper and iron in PHG; however, authors strongly feel that there is urgent need of more studies in this unmapped area. The studies compiled in the present article were conducted at different places, with varied sample size and test methodology. Therefore, reaching out to any conclusion does not seem promising. Keeping this in mind, the role of various nutritional elements in several diseases, immune defence mechanism and hair cycle, large scale double-blind placebo-controlled clinical trials are required to ascertain the outcome of precise nutritional supplementation to combat PHG. Once the exact role of nutritional components are clear, the experiments can be conducted in the direction of validating their impact by oral intake in diet or as capsules, obviously after assessing safety.

It is further suggested that targeting nutritional components as ‘primordial prevention’ can have multifaceted benefits. It will not only maintain health, help in the prevention of disease with change in lifestyle only, but will save money for the individual, family and the society. The conclusive outcome from experiments will end up leading us to a better idea about correct intake of nutrients for healthy hairs without shades of gray.

Conflict of Interests

The authors declare that there is no conflict of interest for this paper.

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