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Association Between Diet Quality and Premature Gray Hair Among Young Adults: A Cross-Sectional Study in Faisalabad, Pakistan

Dn. Anum
National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture, Faisalabad, Pakistan.
anummirza2222@gmail.com

Muhammad Gulzar
National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture, Faisalabad, Pakistan.
gulzar.muhammad.z8@s.gifu-u.ac.jp

Areeba Fatima
National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture, Faisalabad, Pakistan.
areebafatimast@gmail.com

Mahpara Ch
National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture, Faisalabad, Pakistan.
paripie67@gmail.com

Dn. Areesh
National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture, Faisalabad, Pakistan.
areesh98765@gmail.com

Muhammad Issa Khan (Corresponding Author)
National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture, Faisalabad, Pakistan.
drkhan@uaf.edu.pk

Muhammad Abdullah Butt (Corresponding Author)
Department of Food Science, Faculty of Life Sciences, Government College University Faisalabad
muhammadabdullahbuttfst@gmail.com

Author Details

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Corresponding E-mail & Author*:

Muhammad Issa Khan
National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture, Faisalabad, Pakistan.
drkhan@uaf.edu.pk

Abstract

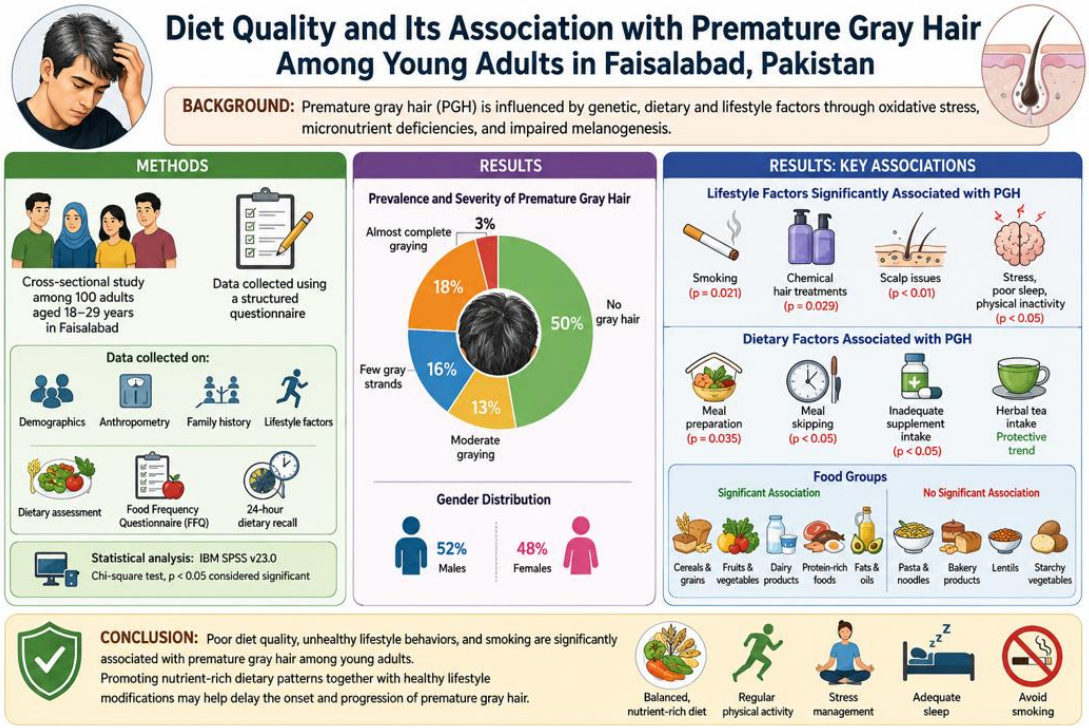
Background: Premature gray hair (PGH) is an increasingly prevalent cosmetic and psychosocial concern among young adults. Although genetic predisposition is considered the primary determinant, dietary quality and lifestyle-related factors have emerged as potential contributors through oxidative stress, micronutrient deficiencies, and impaired melanogenesis. This study investigated the association between diet quality and the prevalence of premature gray hair among young adults in Faisalabad, Pakistan.

Methods: A cross-sectional study was conducted among 100 randomly selected adults aged 18–29 years. Data were collected using a structured questionnaire comprising demographic characteristics, anthropometric measurements, family history, lifestyle factors, dietary assessment, Food Frequency Questionnaire (FFQ), and 24-hour dietary recall. Statistical analysis was performed using IBM SPSS version 23.0. Chi-square tests were applied to determine associations between premature gray hair and dietary as well as lifestyle variables, considering $p < 0.05$ as statistically significant.

Results: Among the participants, 52% were males and 48% were females. Premature gray hair was reported as significant graying (18%), moderate graying (13%), a few gray strands (16%), and almost complete graying (3%). Smoking demonstrated a significant association with PGH (p=0.021). Meal preparation practices were significantly associated with PGH (p=0.035). Dietary assessment revealed significant associations between PGH and the intake of cereals, fruits, vegetables, dairy products, protein-rich foods, and fats and oils, whereas pasta, noodles, bakery products, lentils, and starchy vegetables showed no significant relationship. Participants with poor dietary quality, meal skipping, inadequate supplement intake, and unhealthy eating behaviors exhibited a greater prevalence of premature graying.

Conclusion: Poor diet quality, unhealthy lifestyle behaviors, and smoking were significantly associated with premature gray hair among young adults. Promoting nutrient-rich dietary patterns together with healthy lifestyle modifications may contribute to delaying the onset and progression of premature gray hair.

Graphical Abstract



1. Introduction

Hair pigmentation is primarily determined by the synthesis and distribution of melanin produced by melanocytes located within hair follicles. The gradual decline in melanocyte function is a normal consequence of aging; however, when depigmentation occurs before the expected age, it is referred to as premature gray hair (PGH). Premature graying is generally defined as the appearance of gray hair before 20 years in Caucasians, before 25 years in Asians, and before 30 years in African populations (Bhat et al., 2013; Anggraini et al., 2019).

Premature gray hair has become an increasingly common cosmetic and psychological concern among young adults. Although it is not a life-threatening disorder, early hair graying frequently affects self-esteem, body image, and social confidence. Several studies have demonstrated that individuals with PGH experience greater psychological distress, anxiety, and reduced quality of life compared with age-matched individuals without premature graying (Ashraf et al., 2018; Parihar et al., 2023).

The pathogenesis of PGH is multifactorial and involves complex interactions between genetic susceptibility, oxidative stress, environmental exposure, nutritional deficiencies, endocrine disorders, and lifestyle habits. Genetic predisposition remains the strongest predictor; however, increasing evidence suggests that modifiable factors substantially influence melanocyte survival and melanin synthesis (Desai et al., 2024; Almudimeegh et al., 2025).

Oxidative stress has been recognized as one of the principal biological mechanisms underlying premature hair depigmentation. Excessive reactive oxygen species (ROS) damage melanocytes within hair follicles, resulting in impaired melanogenesis and progressive pigment loss. Smoking, ultraviolet radiation, emotional stress, environmental pollutants, and chronic inflammation have all been reported to increase oxidative stress, thereby accelerating premature hair graying (Fatemi et al., 2012; Seiberg et al., 2013; Emerit et al., 2004).

Nutrition also plays a critical role in maintaining healthy hair follicles. Hair follicles possess one of the highest cellular turnover rates in the human body and therefore require a continuous supply of proteins, essential fatty acids, vitamins, minerals, and antioxidants. Deficiencies of vitamin B12, folate, vitamin D, iron, zinc, copper,

selenium, calcium, and other micronutrients have been associated with impaired melanocyte activity and early hair depigmentation (Almohanna et al., 2019; Bhat et al., 2013; Sonthalia et al., 2017).

Diet quality extends beyond individual nutrient intake and reflects overall dietary patterns, including food diversity, nutrient adequacy, moderation, and dietary balance. Diets characterized by frequent consumption of fruits, vegetables, whole grains, lean proteins, dairy products, and antioxidant-rich foods have been associated with improved antioxidant defense mechanisms and reduced systemic inflammation. Conversely, diets rich in processed foods, refined carbohydrates, saturated fats, and sugar may increase oxidative stress, thereby adversely affecting melanocyte function (Alkerwi, 2014; Trueb and Trueb, 2020).

Lifestyle behaviors further modify the risk of PGH. Cigarette smoking has consistently been associated with a two- to three-fold higher risk of premature graying due to its pro-oxidant effects on melanocytes. Similarly, chronic psychological stress, poor sleep quality, physical inactivity, and frequent exposure to hair dyes or chemical treatments have been implicated in accelerated hair depigmentation (Babadjouni et al., 2021; Zhang et al., 2020; Sehrawat et al., 2017).

Despite increasing international evidence, data describing the relationship between diet quality and premature gray hair among Pakistani young adults remain limited. Understanding these associations is important because dietary and lifestyle modifications represent potentially modifiable risk factors that may delay the onset or progression of premature graying.

Therefore, the present study aimed to evaluate the association between diet quality and the prevalence of premature gray hair among adults aged 18–29 years residing in Faisalabad, Pakistan. In addition, the study investigated the influence of demographic characteristics, anthropometric status, family history, lifestyle behaviors, and dietary patterns on the occurrence of premature gray hair.

2. Materials and Methods

2.1 Study Design and Study Area

A cross-sectional analytical study was conducted to investigate the association between diet quality and premature gray hair (PGH) among young adults residing in Faisalabad, Punjab, Pakistan. The cross-sectional design was selected because it permits the simultaneous assessment of exposure variables and health outcomes within a defined population and is widely used in epidemiological studies investigating lifestyle-related conditions (Montgomery et al., 2017).

2.2 Study Population

The study included adults aged **18–29 years** living in Faisalabad. Participants were selected through random sampling from universities, residential communities, and surrounding localities. Individuals diagnosed with acute or chronic diseases that could influence hair pigmentation or nutritional status were excluded to minimize potential confounding effects.

2.3 Inclusion and Exclusion Criteria

Inclusion Criteria

- Adults aged 18–29 years.
- Male and female participants.
- Individuals willing to participate voluntarily.
- Participants who provided complete questionnaire responses.

Exclusion Criteria

- Individuals aged 30 years or above.
- Participants with acute or chronic systemic diseases.
- Individuals with incomplete questionnaires.
- Participants unwilling to provide informed consent.

2.4 Sample Size

A total of **100 participants** were enrolled in the study. The sample represented young adults from different educational and occupational backgrounds within Faisalabad.

2.5 Data Collection

Data were collected using a structured, pre-tested questionnaire designed specifically for this study. The questionnaire consisted of six major sections:

- Demographic characteristics
- Anthropometric measurements
- Family history of premature gray hair
- Clinical characteristics of PGH
- Dietary assessment
- Lifestyle-related factors

The questionnaire was administered both physically and electronically to maximize participant recruitment and ensure complete data collection.

2.6 Demographic and Anthropometric Assessment

Demographic information included age, gender, educational status, and occupation.

Anthropometric measurements included height, body weight, and body mass index (BMI). Body weight was recorded in kilograms, while height was measured in centimeters. Body Mass Index (BMI) was calculated using the standard formula:

BMI=Weight (kg)Height (m)2BMI=\frac{Weight\ (kg)}{Height\ (m)^2}BMI=Height (m)2Weight (kg)

Participants were categorized as underweight, normal weight, overweight, or obese according to standard BMI classification criteria (Casadei and Kiel, 2019).

2.7 Family History Assessment

Participants were asked whether their parents or siblings had experienced premature gray hair before the age of 30 years. Information regarding the approximate age at onset and severity of graying among family members was also collected to evaluate the hereditary contribution to PGH. Previous studies have identified family history as one of the strongest predictors of premature hair graying (Ali et al., 2024).

2.8 Dietary Assessment

Dietary intake was assessed using two complementary methods.

2.8.1 Food Frequency Questionnaire (FFQ)

A semi-quantitative Food Frequency Questionnaire (FFQ) was used to evaluate habitual food consumption across major food groups, including:

- Cereals and grains
- Fruits and vegetables
- Milk and dairy products
- Meat and protein-rich foods
- Sugar, fats, and oils

The FFQ enabled assessment of dietary diversity and overall diet quality among participants (Batubo et al., 2024).

2.8.2 Twenty-Four-Hour Dietary Recall

Participants recalled all foods and beverages consumed during the previous 24 hours. Information regarding meal frequency, snack consumption, dietary supplements, herbal tea intake, and meal preparation practices was also collected. Twenty-four-hour dietary recall remains a widely accepted approach for evaluating short-term dietary intake (McLean et al., 2019).

2.9 Lifestyle Assessment

Lifestyle characteristics were evaluated using structured questions covering:

- Smoking status
- Physical activity
- Sleep duration
- Stress frequency
- Hair dye and chemical treatment use

- Scalp conditions
- Self-perceived contributing factors for premature graying

These variables were included because previous studies have demonstrated their potential influence on oxidative stress and melanocyte function (Treesirichod et al., 2025; Babadjouni et al., 2021).

2.10 Outcome Variable

The primary outcome was the prevalence and severity of premature gray hair. Participants self-reported the degree of hair graying using five categories:

- No gray hair
- Few gray strands
- Moderate graying
- Significant graying
- Almost complete graying

This classification enabled comparison of dietary and lifestyle characteristics according to the extent of hair depigmentation.

2.11 Statistical Analysis

All collected data were entered into **IBM Statistical Package for Social Sciences (SPSS) version 23.0** for statistical analysis.

Descriptive statistics were used to summarize demographic, anthropometric, dietary, and lifestyle characteristics. Categorical variables were expressed as frequencies and percentages.

Associations between premature gray hair and independent variables were examined using the **Pearson Chi-square test**. A **p-value less than 0.05** was considered statistically significant, whereas **$p < 0.01$** was regarded as highly significant (Montgomery et al., 2017; Montgomery et al., 2019).

2.12 Ethical Considerations

Participation in the study was voluntary. Participants were informed about the objectives of the research before enrollment, and confidentiality of all collected information was maintained throughout the study. Personal identifiers were not included in the statistical analysis, and all responses were analyzed anonymously.

3. Results

A total of **100 adults aged 18–29 years** participated in this cross-sectional study. The respondents included both males and females from different educational and occupational backgrounds in Faisalabad. Statistical analysis was performed using the Pearson Chi-square test to determine the association between premature gray hair (PGH) and demographic characteristics, lifestyle factors, and dietary quality. Only the most relevant findings are presented below.

3.1 Demographic Characteristics of the Participants

Variable	Category	Frequency (%)
Gender	**Male**	**52**
	Female	**48**

Occupation	**Student**	**55**
	Teacher	**16**
	Dietitian	**9**
	Job holder	**11**
	Housewife	**6**
	Banker	**3**
BMI	**Underweight**	**7**
	Normal	**61**
	Overweight	**30**
	Obese	**2**
Family history of PGH	**Yes**	**31**
	No	**69**

Of the 100 participants, **52% were males** and **48% were females**. Most participants belonged to the **24-year age group (19%)**, while students constituted the largest occupational category (55%). Regarding anthropometric status, **61% had normal BMI**, 30% were overweight, 7% were underweight, and only 2% were obese. A positive family history of premature gray hair was reported by **31%** of participants.

Table 1. Demographic and anthropometric characteristics of study participants (n = 100)

3.2 Prevalence of Premature Gray Hair

Among the study participants, **50% reported no gray hair**, whereas the remaining participants exhibited varying degrees of premature graying. Significant graying was observed in **18%**, moderate graying in **13%**, a few gray strands in **16%**, and almost complete graying in **3%**. Furthermore, a significant association was found between age and the prevalence of premature gray hair ($\chi^2 = 258.149$, $p < 0.01$).

Table 2. Prevalence and severity of premature gray hair among participants

Variable	Frequency (%)
No gray hair	**50**

Few gray strands	**16**
Moderate graying	**13**
Significant graying	**18**
Almost complete graying	**3**
Age vs PGH	
Pearson Chi-square	**258.149**
p-value	**<0.01**

3 Association Between Lifestyle Factors and Premature Gray Hair

Smoking showed a statistically significant association with premature gray hair (χ^2 = **12.698, p = 0.021**). Likewise, chemical hair treatments were significantly associated with PGH (χ^2 = **26.028, p = 0.029**). Participants reporting scalp disorders such as dandruff and hair fall demonstrated a highly significant association with premature graying (χ^2 = **50.521, p < 0.01**). In addition, inadequate physical activity, irregular sleeping habits, and high stress levels were more frequently observed among individuals with premature gray hair.

Table 3. Association between lifestyle factors and premature gray hair

Lifestyle factor	Pearson χ^2	p-value	Interpretation
Smoking	**12.698**	**0.021**	**Significant**
Chemical hair treatments	**26.028**	**0.029**	**Significant**
Scalp issues	**50.521**	**<0.01**	**Highly significant**
Physical inactivity	**—**	**<0.05**	**Significant trend**

Poor sleep pattern	**—**	**<0.05**	**Significant trend**
High stress	**—**	**<0.05**	**Significant trend**

3.4 Association Between Dietary Habits and Premature Gray Hair

Dietary assessment demonstrated that participants who skipped meals, consumed fewer nutrient-rich foods, and rarely used dietary supplements exhibited a higher prevalence of premature gray hair. Meal preparation practices were significantly associated with PGH ($\chi^2 = 19.403$, $p = 0.035$). Individuals consuming home-prepared balanced meals had comparatively lower prevalence of premature graying than those relying primarily on commercially prepared foods.

Table 4. Association between dietary habits and premature gray hair

Dietary variable	Pearson χ^2	p-value	Interpretation
Meal preparation	**19.403**	**0.035**	**Significant**
Meal skipping	**—**	**<0.05**	**Significant trend**
Dietary supplements	**—**	**<0.05**	**Significant trend**
Herbal tea intake	**—**	**<0.05**	**Protective trend**
Poor diet quality	**—**	**<0.05**	**Significant association**

3.5 Association Between Food Groups and Premature Gray Hair

Analysis of the Food Frequency Questionnaire revealed significant associations between premature gray hair and the consumption of major food groups. Significant relationships were observed for cereals and grains, fruits and vegetables, milk and dairy products, meat and protein-rich foods, and fats and oils. However, intake of pasta/noodles, bakery products, lentils, and starchy vegetables did not demonstrate statistically significant associations with PGH.

Table 5. Summary of food group associations with premature gray hair

Food group	Association with PGH
Cereals and grains	**Significant**

Fruits and vegetables	**Significant**
Milk and dairy products	**Significant**
Meat and protein sources	**Significant**
Sugar, fats and oils	**Significant**
Pasta and noodles	**Non-significant**
Bakery products	**Non-significant**
Lentils	**Non-significant**
Starchy vegetables	**Non-significant**

4. Discussion

The present study investigated the association between diet quality and the prevalence of premature gray hair (PGH) among young adults in Faisalabad, Pakistan. The findings demonstrate that both dietary quality and several modifiable lifestyle factors were significantly associated with premature gray hair. In addition to genetic predisposition, unhealthy dietary habits, smoking, stress, poor sleep, physical inactivity, and chemical hair treatments appeared to contribute to the occurrence of PGH. These findings support the growing evidence that premature hair graying is a multifactorial condition influenced by both hereditary and environmental determinants.

The prevalence of premature gray hair observed in the present study indicates that a considerable proportion of young adults experience early hair depigmentation before the age of 30 years. Similar findings have been reported in Saudi Arabia, where Almudimeegh et al. (2025) documented a high prevalence of premature graying among young adults and identified nutritional deficiencies and lifestyle characteristics as important predictors. Likewise, Nath et al. (2020) and Saad et al. (2019) reported relatively high frequencies of premature gray hair among Pakistani university students, suggesting that PGH has become increasingly common in young populations.

Genetic predisposition remains one of the strongest determinants of premature gray hair. Approximately one-third of the participants in the present study reported a positive family history of PGH, supporting previous reports that hereditary factors substantially influence melanocyte aging. Similar observations were reported by Ali et al. (2024), who concluded that parental history is one of the strongest predictors of premature graying, indicating that genetic susceptibility may predispose individuals to early

depletion of melanocyte stem cells. Nevertheless, the presence of participants without a family history who also developed PGH suggests that environmental and lifestyle factors substantially contribute to disease development.

One of the most important findings of the present study was the significant association between smoking and premature gray hair. Cigarette smoking increases the production of reactive oxygen species (ROS), resulting in oxidative damage to melanocytes and accelerated depletion of melanin-producing cells. Similar findings have been reported by Babadjouni et al. (2021), who demonstrated that smokers have a markedly greater risk of developing premature gray hair than non-smokers. Earlier studies by Fatemi et al. (2012) and Seiberg et al. (2013) also proposed that oxidative stress induced by tobacco smoke damages hair follicles and accelerates depigmentation. Therefore, smoking cessation may represent an effective preventive strategy against premature hair graying.

Psychological stress was also commonly observed among participants with premature gray hair. Chronic stress activates the sympathetic nervous system and elevates oxidative stress, resulting in depletion of melanocyte stem cells within hair follicles. Zhang et al. (2020) demonstrated that acute stress can permanently reduce melanocyte stem cell populations, whereas Yardman-Frank and Fisher (2021) further explained the biological pathways linking stress with accelerated hair depigmentation. The findings of the current study support these observations and suggest that stress management may contribute to delaying the onset of premature gray hair.

Diet quality emerged as one of the strongest modifiable factors associated with PGH. Participants consuming balanced diets rich in fruits, vegetables, dairy products, whole grains, and protein-rich foods exhibited lower frequencies of premature graying compared with individuals reporting poor dietary habits. Adequate dietary intake provides essential vitamins, minerals, antioxidants, and amino acids required for melanogenesis and maintenance of healthy hair follicles. Similar conclusions were reported by Alkerwi (2014), who emphasized that overall dietary quality rather than isolated nutrients better predicts health outcomes. Trueb and Trueb (2020) also suggested that nutrient-rich dietary patterns improve hair follicle metabolism and reduce oxidative stress.

The Food Frequency Questionnaire analysis demonstrated significant associations between most major food groups and premature gray hair. Consumption of cereals, fruits, vegetables, dairy products, and protein-rich foods was significantly associated with PGH, whereas pasta, noodles, bakery products, lentils, and starchy vegetables did not exhibit statistically significant relationships. These findings are biologically plausible because antioxidant-rich fruits and vegetables, together with micronutrients such as vitamin B12, iron, zinc, copper, folate, selenium, and vitamin D, are essential for melanocyte function and melanin synthesis. Previous investigations by Almohanna et al. (2019), Sonthalia et al. (2017), and Bhat et al. (2013) similarly reported strong relationships between micronutrient deficiencies and premature hair graying.

Meal preparation practices also demonstrated a significant relationship with PGH. Individuals consuming home-prepared meals generally exhibited a lower prevalence of premature graying than those frequently consuming commercially prepared foods. This may reflect improved nutritional quality, lower consumption of highly processed foods, and greater dietary diversity among participants preparing meals at home. Similar findings were reported by Desai et al. (2025), who suggested that dietary patterns characterized by frequent consumption of processed foods may increase oxidative stress and accelerate melanocyte dysfunction.

Lifestyle characteristics beyond diet were also associated with premature gray hair. Participants reporting inadequate physical activity, irregular sleep patterns, and frequent chemical hair treatments demonstrated higher frequencies of PGH. Regular physical activity improves circulation, enhances nutrient delivery to hair follicles, and reduces systemic inflammation, whereas sleep deprivation increases oxidative stress

and hormonal imbalance, both of which adversely affect melanocyte function. Similar conclusions have been drawn by Thompson et al. (2019), Fatima et al. (2020), and Sehrawat et al. (2017), highlighting the importance of healthy lifestyle behaviors in maintaining normal hair pigmentation.

Although the present study provides valuable evidence regarding dietary and lifestyle factors associated with premature gray hair, several limitations should be acknowledged. The relatively small sample size and cross-sectional design limit causal inference. Dietary intake and lifestyle behaviors were self-reported, introducing the possibility of recall bias. Furthermore, biochemical assessment of micronutrient status, oxidative stress biomarkers, thyroid function, and genetic polymorphisms was not performed. Future multicenter prospective studies involving larger populations and laboratory confirmation of nutritional biomarkers are recommended to further clarify the biological mechanisms linking diet quality with premature gray hair.

Overall, the findings indicate that premature gray hair is influenced by a combination of genetic susceptibility and modifiable environmental factors. Improving dietary quality, maintaining adequate micronutrient intake, avoiding smoking, reducing psychological stress, engaging in regular physical activity, and adopting healthy lifestyle behaviors may collectively contribute to delaying the onset and progression of premature gray hair among young adults.

Future Perspectives

Future research on premature gray hair (PGH) should adopt multidisciplinary approaches integrating nutrition, functional foods, nutrigenomics, artificial intelligence (AI), and precision health. Large-scale longitudinal and multicenter studies are required to validate the influence of dietary quality on melanogenesis and oxidative stress while incorporating biomarkers, metabolomics, and epigenetic profiling. The development of functional foods, probiotics, hybrid proteins, plant-based foods, sustainable protein systems, and antioxidant-rich nutraceuticals derived from natural bioactive sources may provide novel nutritional strategies for delaying PGH (Khan et al., 2024; Ahmed et al., 2024; Butt et al., 2024, 2025a, 2025b, 2025c; Rashid et al., 2026; Butt et al., 2026a, 2026b, 2026c). Emerging technologies including CRISPR-based gene editing, nutrigenomics, AI-guided dietary modeling, precision fermentation, and predictive health analytics offer promising opportunities to personalize nutritional interventions according to individual genetic susceptibility and lifestyle risk factors (Fatima et al., 2026; Jabeen et al., 2025; Butt et al., 2026d, 2026e; Arif et al., 2026). Future investigations should also evaluate environmental contaminants, food safety, heavy metals, microplastics, metabolic disorders, and socioeconomic determinants that may indirectly influence oxidative stress and hair pigmentation (Riaz et al., 2026a, 2026b; Ullah et al., 2026a, 2026b; Riaz et al., 2026c, 2026d). Furthermore, AI-assisted decision support systems, sustainable healthcare frameworks, and interdisciplinary collaborations between nutritionists, dermatologists, molecular biologists, food technologists, engineers, and public health researchers will facilitate the development of evidence-based preventive and therapeutic strategies for PGH while promoting sustainable, precision nutrition for healthy aging (Kamal et al., 2026; Naeem et al., 2026a, 2026b, 2026c; Khurshid et al., 2026; Rehman et al., 2026; Faizi et al., 2026; Awais and Butt, 2026; Shah and Butt, 2026; Mahmood et al., 2026; Khan Swati et al., 2026a, 2026b; Butt et al., 2026f, 2026g, 2026h; Butt et al., 2026i; Butt et al., 2026j; Butt et al., 2026k).

Conclusion

Premature gray hair (PGH) is a multifactorial condition influenced by the interaction of genetic predisposition, dietary quality, and lifestyle behaviors. The findings of the present study demonstrated that poor diet quality was significantly associated with the prevalence of premature gray hair among young adults in Faisalabad. Individuals with unhealthy dietary patterns, frequent meal skipping, lower consumption of nutrient-rich foods, and inadequate intake of dietary supplements exhibited a higher prevalence of

premature graying. In contrast, participants consuming balanced diets rich in cereals, fruits, vegetables, dairy products, and protein-rich foods showed a comparatively lower occurrence of PGH.

The study further identified smoking, psychological stress, inadequate sleep, physical inactivity, chemical hair treatments, and scalp disorders as significant lifestyle factors associated with premature gray hair. These findings reinforce the concept that oxidative stress and nutritional deficiencies contribute substantially to melanocyte dysfunction and early hair depigmentation. Although hereditary factors cannot be modified, lifestyle and dietary habits represent important preventive targets that may delay the onset and progression of premature gray hair.

Overall, promoting healthy dietary practices, improving micronutrient intake, encouraging regular physical activity, reducing smoking and psychological stress, and adopting healthy lifestyle behaviors may contribute to maintaining normal hair pigmentation in young adults. Future longitudinal studies with larger sample sizes and biochemical assessment of nutritional biomarkers are recommended to establish causal relationships and further elucidate the mechanisms underlying premature gray hair.

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