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Personalized Skincare: Correlating Genetics with Skin Phenotypes through DNA Analysis

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ABSTRACT

Genetic mapping through DNA sequencing for skin represents a novel method to elucidate detailed information regarding the relationship between genes and skin. This method analyzes genetic influences on various skin characteristics, crucial in the skin aging process. In this study, we aimed to explore the efficacy and potential of skin DNA sequencing as a valuable tool in dermatological research. Employing a purposive sampling method based on diverse skin types, we sought to ensure representativeness within the target population. The sample comprised four different skin types (five participants), selected to encompass a wide range of ages and diverse racial backgrounds. We precisely controlled for potential confounding factors such as age, gender, and race in study design. All participants exhibited consistent Fitzpatrick skin type classifications based on questionnaire responses and measurements from the Automatic Plasma Skin Type Analyzer or melanin reader. This consistency underscores the reliability of the Fitzpatrick skin type classification technique for determining skin phenotypes. Such classification holds significant importance in clinical research, guiding professionals and consumers in selecting suitable cosmetic products and skincare regimens. Furthermore, our study investigated into participants' skin characteristics and their genetic predispositions to various skin-related attributes including dermal sensitivity, protection against glycation, antioxidant capacity, freckles, and cellulite. DNA skin tests offer critical insights into understanding and managing one's unique skin traits. Our findings highlight the substantial impact of genetics on skin attributes. Notably, our observations indicate that individuals with similar skin types may harbor distinct genetic predispositions, underscoring the necessity for personalized skincare approaches. The results aim to empower clients, dermatologists, and beauty consultants to make knowledgeable skincare decisions based on genetic factors. The reliability of the Fitzpatrick skin type classification technique was validated through both questionnaire-based assessments and measurements from the Automatic Plasma Skin Type Analyzer or melanin reader, affirming its consistency and accuracy in describing participants' skin phenotypes. In summary, our study contributes to a deeper understanding of skin health and equips individuals, dermatologists, and beauty consultants to make knowledgeable skincare choices based on genetic insights.

Index Terms: DNA sequencing, Fitzpatrick skin type classification, Genetic predispositions, Genetic mapping, Personalized skincare solutions

1. INTRODUCTION

The skin is the largest organ that serves as a barrier, controls body temperature and fluids, and allows a person to perceive their surroundings [1]. It is commonly admitted as the primary defense mechanism shielding the body from external harm, which is composed of two main layers the epidermis and dermis [2].

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Despite significant advancements in dermatological research and practice, skin disorders remain a pervasive global health concern, affecting up to 1 billion people worldwide at any given time and, according to the global burden of disease project, ranking as the fourth most common cause of non-fatal diseases globally. This burden underscores the need for more targeted and effective approaches to skin health management, considering more than 3000 identified skin conditions. The prevalence and patterns of these diseases are shaped by a multitude of factors, including environmental conditions, hygiene standards, societal habits, and genetic predispositions. Notably, infections and infestations tend to be more prevalent in developing communities [1].

Skin conditions can impose financial, socioeconomic, and psychological challenges on communities, often leading to depression, frustration, social isolation, and even thoughts of self-harm or suicide. Common methods for diagnosing skin diseases involve patient history, symptom analysis, skin scraping, visual examination, dermatoscopy, and skin biopsies. Nonetheless, these diagnostic techniques can be labor-intensive, time-consuming, require experience and excellent visual perception, are subject to subjective interpretation, and are prone to error. Furthermore, they often necessitate the expertise and keen visual perception of dermatologists [1].

Recently, the relationship between an individual's genes and their skin characteristics has been a topic of interest in dermatological research. Despite growing interest, there is a notable absence of comprehensive studies directly investigating the genetic basis of individual skin characteristics and their correlation with skincare practices and treatment outcomes [3]. An analysis of the skin's DNA sequence provides comprehensive information about the connection between a person's genes and their skin, illustrating how the skin reacts to various conditions such as oxidation, premature ageing [4], varicose veins [5], redness and freckles [6] cellulite, and more [7].

According to our current understanding, there are insufficient studies in this area to provide a comprehensive understanding of the genetic basis of skin attributes. In many societies, and also in Kurdistan region of Iraq, skincare is becoming increasingly important for both women and men evident in the proliferation of skincare centers, rising dermatologist visits, and the extensive use of a range of skincare products and treatments. However, in certain circumstances, the haphazard use of skincare products and treatments can worsen skin problems [8]. This study aims to address the aforementioned gap by exploring the efficacy and potential of skin DNA sequencing as a valuable method in dermatological research. By analyzing an individual's genetic sequencing, this method aims to provide personalized insights into skincare. The study seeks to enhance our comprehension of skin health by understanding the genetic basis of skin attributes such as sensitivity, predisposition to ageing, and susceptibility to various disorders such as redness, freckles, varicose veins, and cellulite. Ultimately, the precision offered by this information can empower individuals to make informed decisions when selecting skincare products and treatments. The additional objectives of this study were to determine skin type using different methods and evaluate their reliability in providing additional information about participants' skin, which all together aim to support specialists, including dermatologists, as further support during skin diagnosis and in prescribing interventions that are more likely to achieve positive results, thus satisfying the increasing demand for evidence-based skincare practices.

2. METHODS

In this study, we precisely conducted the selection of four different skin types (five participants or volunteers) through two distinct methods. The first method employed the Fitzpatrick skin type classification, which is a numerical classification scheme detailed in Table 1 and Fig. 1, in which participants were instructed to complete a concise questionnaire that sought information about genetic factors and personal tanning habits. The questionnaire was designed to evaluate their skin's response to sun exposure, considering factors such as burning and tanning tendencies, with the aim of establishing their self-reported Fitzpatrick skin type group [9].

TABLE 1: Total score equivalent to Fitzpatrick skin type [9]

Skin type score	Fitzpatrick skin type
0–7	I
8–16	II
17–25	III
25–30	IV
Over 30	V-VI

Fig. 1. Fitzpatrick scale for skin types classification [9].

The second method involved the use of an Automatic Plasma Skin Type Analyzer sensor for laser SPMU Melanin Fitzpatrick, a device manufactured under the SKINtastic brand. This device, manufactured under the SKINtastic brand, serves as a melanin reader and personnel operated it following the provided instructions.

We selected these four different skin types from a group of five unrelated participants or volunteers, consisting of three males (participants 1, 2, and 4) and two females (participants 3 and 5), with diverse skin pigmentation. They underwent thorough skin investigations using genetic sequencing. The group included individuals of varying ages, ranging from 25 to 58 years old, representing different genders, races, and a variety of skin tones, as detailed in Table 2.

Subsequently, we collected saliva samples from four different skin types (five participants) who had been previously selected for inclusion in this study. To ensure accuracy, participants followed specific guidelines in the 60–120 min preceding sample collection. They were instructed to abstain from drinking, eating, smoking, brushing their teeth, and chewing gum. During sample collection, both inner cheeks were vigorously rubbed with a swab for 1 min while personnel wore gloves and avoided contact with other surfaces. The collected samples were sealed in test tubes with stabilizer capsules, labeled with barcode stickers, and then sent to 24 Genetics DNA testing company in Spain After the DNA extraction from the samples, 24 Genetics DNA testing company used high-throughput sequencing technologies to carry out the subsequent DNA analysis. Then, a comprehensive procedural sequence starts, involving an in-depth analysis of the genetic material. This genetic testing relied exclusively on advanced Illumina technology, encompassing sequencing machines and chips, all within a reputable European laboratory. Following the genetic analysis, the resulting data were subjected to a comprehensive examination to identify genetic variants associated with different skin characteristics, such as oxidation, premature ageing, redness, freckles, varicose veins, and cellulite. The interpretation of the genetic map for each skin characteristic genotype depends on (Fig. 2). In this process, a comprehensive scrutiny of the approximately 0.7 million distinct gene markers present in the DNA samples was required. In this study, the DNA sequencing included only a sample of the genes that were analyzed.

Subsequently, algorithms were used to combine the individual genotypes from the markers examined. The scientific community broadly accepts the international genetic research standards on which this study's DNA sequencing method is based. Furthermore, the genetic tests utilized databases containing studies that achieved a certain level of consensus before including them in the analysis.

3. RESULTS

In this study, we assessed the participants' skin types and colors, and the results indicated Fitzpatrick skin types I, II, II, III, and IV, as determined by their questionnaire scores (4, 14, 13, 23, and 27, respectively), as presented in Table 2. In addition, when utilizing the Automatic Plasma Skin Type Analyzer or melanin reader, all participants displayed

TABLE 2: Total score (questionnaire) equivalent to Fitzpatrick skin type compared to the Automatic Plasma Skin Type Analyzer or melanin reader

Participants no	Gender	Age	Race	Skin type score based on a questionnaire	Skin type score	Fitzpatrick skin type	Skin type score based on the Automatic Plasma Skin Type Analyser or melanin reader	Skin type colour
Participant 1	M	25	Europeans	4	0–7	I	I	Very fair skin
Participant 2	M	58	Central Asian descent	14	8–16	II	II	Fair skin
Participant 3	F	31	Middle Eastern descent	13	8–16	II	II	Fair skin
Participant 4	M	43	Middle Eastern descent	23	17–25	III	III	Medium skin
Participant 5	F	47	Middle Eastern descent	27	25–30	IV	IV	Olive skin

identical results, aligning with the Fitzpatrick skin type scores obtained from the questionnaire, as illustrated in Table 2.

The results of skincare DNA sequencing, as shown in Table 3, revealed that Participant 1 (skin type I) possesses genetic variants associated with normal dermal sensitivity, representing a favorable genotype. Conversely, Participant 1 carries an unfavorable genotype, indicating a heightened susceptibility to potential damage caused by external agents. In addition, the genetic test shows that Participant 1 has a low antioxidant capacity, which means that they have an unhealthy genotype and are more likely to be hurt by free radicals.

The genetic results for Participant 1 show that they are more likely to get acne, less likely to have skin that is excessively inflamed, and have an intermediate tendency to develop freckles.

In the context of genetic predisposition to varicose veins and protection against glycation, the analysis indicates a moderate

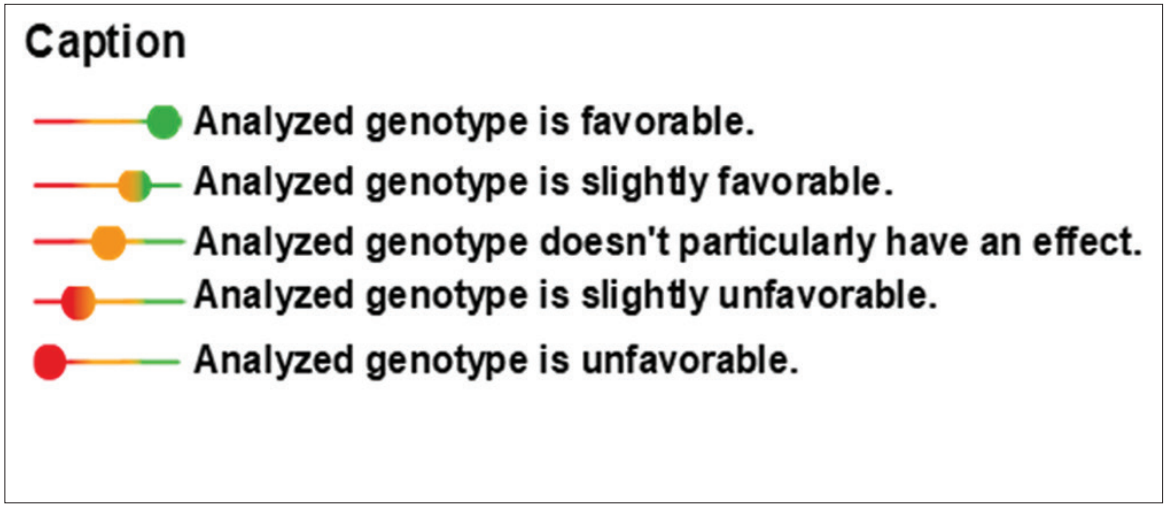

Fig. 2. Genotype interpretation of each skin characteristic genetic map (24 genetic).

TABLE 3: Genetic maps and interpretation results for skincare disease analysis of participant 1 (skin Type I)

Skin Conditions	Genetic map		Genetic results	Skin Conditions	Genetic map		Genetic results
	Gene	Genotype			*Gene*	Genotype	
Dermal sensitivity	*IL18*	CC		Freckles	*intergenic*	TT	
	ADAD1	GG			*intergenic*	GG	
	EPHX1	TT			*IRF4*	TC	
Protection against pollution	*EPHX1*	TT			*TYR*	CC	
	NQO1	AG			*TYR*	AG	
Antioxidant capacity	*CAT*	CC			*MC1R*	CC	
	NQO1	GG		Varicose veins	*MTHFR*	TT	
	SOD2	GG			*MTHFR*	AG	
	EPHX1	TC		Protection against glycation	*AGER*	AA	
	CAT	TC			*AGER*	AG	
Acne	*NQO1*	AG			*GLO1*	AG	
	SELL	GG		Cellulitis	*HIF1A*	CC	
	TGFB2	AG					
	Intergenic	GG					
Inflammation of the skin	*IL18*	CC					
	IL6	AG					
	IFNG	AG					
	ADAD1	GG					
	IL10	GG					
	IL6	GC					

influence (the analyzed genotype does not significantly impact these factors) and very limited protective capacity, respectively.

Finally, the results reveal that Participant 1 lacks the protective genotype, indicating a higher predisposition to cellulite, an unfavorable genotype.

In this study, as illustrated in as shown in Table 4, the skincare DNA sequencing analysis illustrated that Participant 2 (skin type II) harbors genetic variants associated with both normal dermal sensitivity and a high level of protection (a favorable genotype) against external factors capable of damaging their skin. The genotypes also indicated that Participant 2 exhibits very high antioxidant capacity.

In addition, Participant 2's genetic maps reveal a slightly unfavorable genotype predisposition (indicating a higher risk of developing acne) and a slightly favorable genotype predisposition (suggesting a lower risk of excessive inflammatory responses).

Regarding freckles and varicose veins, Participant 2's genotype is slightly unfavorable for freckles, indicating a higher probability of developing freckles, and genotype does not have particularly effect for varicose veins, suggesting an intermediate chance of suffering from varicose veins.

Furthermore, the genotype of this participant predisposes them to a high risk of glycation in their skin's components, while their predisposition to cellulite is considered average.

Table 5 illustrates that participant 3's (skin type II) genetic map exhibits favorable genotypes, signifying high potency for both dermal sensitivity and protection against pollution. However, the overall antioxidant capacity is at a moderate level. In addition, their genotypes indicate a slightly unfavorable predisposition (indicating a higher risk of acne) and a slightly favorable predisposition (suggesting a lower risk of excessive inflammatory responses).

The freckles genotype also indicated the slightly unfavorable, suggesting that their skin is at a high risk of developing freckles. In addition, the likelihood of their skin experiencing varicose veins is low. Finally, Participant 3's genetic map reveals a high risk of glycation in their skin's components and an average predisposition to cellulite.

Table 6 displays that participant 4's (skin type IV) genetic map exhibits favorable genotypes, signifying high potency for both dermal sensitivity and protection against pollution.

However, it was observed that Participant 4 exhibits a very low antioxidant capacity (unfavorable genotype), indicating a heightened susceptibility to the detrimental effects of free radicals. On the other hand, Participant's 4 genetic results

TABLE 4: Genetic maps and interpretation results for skincare disease analysis of participant 2 (Skin Type II)

Skin Conditions	Genetic map		Genetic results	Skin Conditions	Genetic map		Genetic results
	Gene	Genotype			*Gene*	Genotype	
Dermal sensitivity	*IL18*	CC		Freckles	*Intergenic*	TT	
	ADAD1	GG			*Intergenic*	GG	
	EPHX1	TC			*IRF4*	TC	
Protection against pollution	*EPHX1*	TC			*TYR*	CC	
	NQO1	GG			*TYR*	AG	
Antioxidant capacity	*CAT*	TT			*MC1R*	CC	
	NQO1	GG			*MC1R*	CC	
	SOD2	AA		Varicose veins	*MTHFR*	TT	
	EPHX1	TC			*MTHFR*	AG	
	CAT	CC		Protection against glycation	*AGER*	AA	
Acne	*NQO1*	GG			*AGER*	AA	
	SELL	AA			*GLO1*	GG	
	TGFB2	AG		Cellulitis	*HIF1A*	CC	
	intergenic	GG					
Inflammation of the skin	*IL18*	CC					
	IL6	GG					
	IFNG	AA					
	ADAD1	GG					
	IL10	AA					
	IL6	GG					

TABLE 5: Genetic maps and interpretation results for skincare disease analysis of participant 3 (Skin Type II)

Skin Conditions	Genetic map		Genetic results	Skin Conditions	Genetic map		Genetic results
	Gene	Genotype			*Gene*	Genotype	
Dermal sensitivity	*IL18*	CC		Freckles	*intergenic*	TT	
	ADAD1	GG			*intergenic*	GG	
	EPHX1	TC			*IRF4*	TC	
Protection against pollution	*EPHX1*	TC			*TYR*	CC	
	NQO1	GG			*TYR*	AG	
Antioxidant capacity	*CAT*	TC			*MC1R*	CC	
	NQO1	AG		Varicose veins	*MTHFR*	TT	
	SOD2	AA			*MTHFR*	AG	
	EPHX1	TT		Protection against glycation	*AGER*	TA	
	CAT	TT			*AGER*	AA	
Acne	*NQO1*	GG			*GLO1*	AG	
	SELL	AA		Cellulitis	*HIF1A*	CC	
	TGFB2	AG					
	intergenic	GG					
Inflammation of the skin	*IL18*	CC					
	IL6	AA					
	IFNG	AG					
	ADAD1	GG					
	IL10	AG					
	IL6	CC					

TABLE 6: Genetic maps and interpretation results for skincare disease analysis of Participant 4 (Skin Type III)

Skin Conditions	Genetic map		Genetic results	Skin Conditions	Genetic map		Genetic results
	Gene	Genotype			*Gene*	Genotype	
Dermal sensitivity	*IL18*	CG		Freckles	*intergenic*	TC	
	ADAD1	GG			*intergenic*	GG	
	EPHX1	TC			*IRF4*	CC	
Protection against pollution	*EPHX1*	TC			*TYR*	AC	
	NQO1	GG			*TYR*	GG	
Antioxidant capacity	*CAT*	CC			*MC1R*	CC	
	NQO1	GG			*MC1R*	CC	
	SOD2	AA		Varicose veins	*MTHFR*	GG	
	EPHX1	TC			*MTHFR*	GG	
	CAT	TC		Protection against glycation	*AGER*	AA	
Acne	*NQO1*	GG			*AGER*	AA	
	SELL	AG			*GLO1*	AA	
	TGFB2	AG		Cellulitis	*HIF1A*	CC	
	Intergenic	AG					
Inflammation of the skin	*IL18*	CG					
	IL6	GG					
	IFNG	AA					
	ADAD1	GG					
	IL10	GG					
	IL6	GG					

predispose to acne, high risk of excessive inflammatory responses on their skin, and unlikely to have freckles. The genotype also illustrated that Participant 4 is at an increased risk of varicose veins and protection against glycation (unfavorable genotype). The result also showed Participant 1 predisposition to cellulite is average.

The genetic map of Participant 5 (skin type V), as shown in Table 7, reveals a favorable genotype, indicating normal dermal sensitivity. Simultaneously, their genotype shows a very low tendency for protection (an unfavorable genotype) against external factors. The overall antioxidant capacity of Participant 4 is considered very high capacity. In addition,

TABLE 7: Genetic maps and interpretation results for skincare disease analysis of participant 5 (Skin Type IV)

Skin Conditions	Genetic map		Genetic results	Skin Conditions	Genetic map		Genetic results
	Gene	Genotype			*Gene*	Genotype	
Dermal sensitivity	*IL18*	CC		Freckles	*intergenic*	CC	
	ADAD1	GG			*intergenic*	GG	
	EPHX1	TT			*IRF4*	CC	
Protection against pollution	*EPHX1*	TT			*TYR*	AC	
	NQO1	AG			*TYR*	GG	
Antioxidant capacity	*CAT*	TT			*MC1R*	CC	
	NQO1	AG			*MC1R*	CC	
	SOD2	AA		Varicose veins	*MTHFR*	TG	
	EPHX1	TT			*MTHFR*	GG	
	CAT	TT		Protection against glycation	*AGER*	TA	
Acne	*NQO1*	AG			*AGER*	AA	
	SELL	GG			*GLO1*	AG	
	TGFB2	GG		Cellulitis	*HIF1A*	TC	
	intergenic	GG					
Inflammation of the skin	*IL18*	CC					
	IL6	GG					
	IFNG	AG					
	ADAD1	GG					
	IL10	AA					
	IL6	GG					

this participant's genotype predisposes them to a higher risk of developing acne.

Furthermore, the genetic results suggest a heightened risk of excessive inflammatory responses in their skin. In addition, their freckle genotype is highly favorable, indicating a very low risk in their genetic predisposition to develop freckles.

Based on the genotype results, the probability of Participant 5 experiencing varicose veins and cellulitis is notably low and very low, respectively. Finally, Participant 5's genotype indicates a significantly reduced ability to protect against glycation (high risk of glycation).

4. DISCUSSION

In this age of advancing genetic testing, comprehending the genetic factors that impact skin characteristics can help individuals adapt their skincare routines according to their personal demands. DNA Skin Tests can help people customize skincare routines to fit their individual needs. Pinedo-Donelli and Ball (2020) considered DNA sequencing for skin, as a novel method to demonstrate detailed information about the relationship between genes and skin [10]. This test analyzes how genetics influence skin characteristics, such as hydration, elasticity, and antioxidant capacity, which play a key role in the skin aging process [3].

One of the findings of this study is that the Fitzpatrick skin type scores based on questionnaire responses and the Automatic Plasma Skin Type Analyzer or melanin reader consistently agree on how to classify skin types. This alignment is further corroborated by the findings of Magin *et al*., who emphasized the reliability of the Fitzpatrick Skin Type Classification technique for determining skin phenotypes [11]. It is important to emphasize that the classification of skin types holds great significance in the realm of clinical research and plays an essential role in guiding professionals and consumers in their selection of appropriate cosmetic products and skincare routines [12]. Furthermore, even psychological morbidity in acne also tends to be significantly influenced by skin type [11].

To ensure proper skincare, understanding your skin well is the first step. Some of its attributes are readily noticeable through visual inspection. For instance, individuals with very pale skin are more sensitive to the sun's rays. On the other hand, certain characteristics, such as glycation, might not be visibly discernible. Nevertheless, a simple DNA skin test can uncover these hidden aspects and assist in selecting the most suitable treatments. Hence, genetic testing serves multiple purposes, including disease screening, diagnosis, and prognosis, when conditions are suspected to have a genetic basis. It is also employed to optimize drug therapy, enhancing both drug effectiveness and minimizing the risk of adverse effects [13]. Some single nucleotide polymorphisms (SNPs)

have been associated with skin characteristics as a result of recent developments in genomics and bioinformatics [3]: Skin diseases studied in this research include:

4.1. Dermal Sensitivity

The skin acts as a protective barrier that prevents harmful pathogens and toxins from entering the body. Increases the likelihood of skin sensitivity developing when there is an immune response overreaction to allergens or when there is a lack of defense against environmental toxins. This can result in atopic dermatitis, also known as eczema. Factors such as genetics and the environment appear to be the causes of increased dermal sensitivity. Researchers have identified various genetic variants associated with an increased risk of this condition through large-scale studies [14], [15].

Various immune and non-immune cells, including T and B lymphocytes, secrete interleukin-18 (IL-18), which is a member of the IL-1 cytokine family. IL-18 acts as an anticancer and procancer. In common skin tumors, this protein has been shown to be overexpressed [16]. In the present study, all participants 1-5 with diverse skin types demonstrated a favorable genotype, indicating normal dermal sensitivity. Skin sensitivity can occur among all skin types; however, there is a restricted understanding of which skin types more frequently believe that they have sensitive skin. According to some sources, many factors of the biological basis of skin affect skin sensitivity, such as stratum corneum thickness, increased blood flow, and neuronal activation. However, other survey studies have shown similar rates of skin sensitivity across ethnic groups, and therefore, the correlation between skin sensitivity and skin type remains unclear, so the effect of Fitzpatrick skin type in relation to overall sensitivity remains unclear [17]. These findings align with the results of our study. In addition, the prevalence of eczema (atopic dermatitis), a common skin disorder affecting 15-20% of children and 1-3% of adult's worldwide [14], supports our findings. Since all participants in our study are adults over 25 years.

4.2. Protection Against Pollution

Environmental pollution can cause skin ageing, inflammation, and dark spots. Enzymes EPHX1 and NQO1 play crucial roles in protecting the skin's outer layer from toxins. EPHX1 converts epoxides into less reactive forms, while NQO1 alters coenzyme ubiquinone to ubiquinol, capturing free radicals and detoxifying quinones. Decreased enzyme levels can lead to reduced skin protection against environmental toxins. Genetic variations in the EPHX1 gene can cause deficiencies in these enzymes, and the NQO1 gene can decrease ubiquinol production [18]–[21]. In the present study, Participants 1 and 5 exhibited genotypes indicating very low protection against pollution and toxins which mean that they are at a greater risk of not properly eliminating the external agents that can damage their skin. To address this concern, it is advisable for Participant 1 to consider the use of Coenzyme Q10 supplements, incorporate antioxidants like astaxanthin, also utilize products enriched with antioxidants and Coenzyme Q10, and employ a high sun protection factor. Reducing exposure to contaminants and implementing a nightly skincare routine are considered beneficial practices [22], [23], whereas Participants 2, 3, and 4 displayed genotypes suggesting very high protection against pollution.

4.3. Antioxidant Capacity

Stability between free radicals and antioxidants is necessary. To maintain proper physiological functioning and healthy-looking skin. In the skin, when the free radicals (known as oxidative stress) attack, the collagen (structural support of the skin) starts to breakdown, disrupting the cell regeneration cycle and leading to premature ageing (dull complexion, spots, and non-uniform texture), and altering proteins and lipids. Free radicals can affect all skin layers, including the hypodermis, dermis, and epidermis, making them particularly vulnerable [24], [25]. Antioxidants act as a natural defense system against free radicals, and they convert harmful free radicals into less harmful products. By reducing wrinkles and preserving the skin's natural shine, antioxidants can significantly reduce some signs of aging. Genetic variations in antioxidant enzymes, such as SOD2, EPHX1, CAT, and NQO1, have been linked to an increased risk of oxidative stress and a decline in antioxidant activity, which accelerates the aging of the skin [3], [26], [27].

In the present study, Participants 1 and 4 exhibited (an unfavorable genotype), which mean that they have a greater predisposition to suffer the harmful effects of free radicals. In response to this condition, it is recommended to maintain a diet rich in antioxidants. In addition, the use of antioxidant-rich skincare products, which may include ingredients such as green tea, caffeic acid, Vitamin C, carotenoids, Vitamin E, and glutathione, complements the antioxidants naturally presents in Participant 1's skin [28], whereas Participants 3 displayed genotypes indicating average antioxidant capacity, suggesting that some genetic variants are beneficial while others diminish the skin's antioxidant capacity. Participants 2 and 5 show high-capacity antioxidant.

4.4. Acne

Acne is a skin disorder that is especially frequent among adolescents and young adults, but can affect people of all ages.

It predominantly affects sebaceous glands linked to skin pores. These glands produce sebum, transporting dead skin cells to the skin's surface. Blockage of follicles leads to zit formation, exacerbated by bacterial growth. Anti-acne treatments are offered topically and orally. Acne is influenced by hormonal changes, stress, the use of certain medicines, and oily cosmetics. Acne is also influenced by hereditary factors, as this disorder is associated with numerous gene variants [29]–[31].

In the present study, the genotypes of all participants exhibited (slightly unfavorable genotypes), which mean a slight predisposition toward the development of acne, a trend supported by prior research indicating that individuals of various racial and ethnic backgrounds can be susceptible to acne. Furthermore, the prevalence of acne appears to be similar among individuals with lighter skin (Fitzpatrick skin types I–III) and those with darker skin (Fitzpatrick skin types IV–VI) [32]. Singh and Singh 2019 also indicated that acne can manifest in individuals across various skin types (all skin types) [33].

4.5. Inflammation of the Skin

An excessive response to allergens or toxins causes skin inflammation, which can be temporary and aid in skin regeneration. Various stressors such as UV radiation, toxins, and pathogen infections trigger persistent inflammation, leading to skin damage. Inflammation serves as the skin's basic defense mechanism, but excessive inflammation can accelerate skin aging. Chronic inflammation manifests as skin sensitivity, redness, and irritation, and variations in pro-inflammatory and anti-inflammatory genes elevate the risk of chronic skin inflammation [34]–[36].

In the present study, the genotypes of participants 1-3, representing skin types I–III, exhibited slightly favorable genotypes, indicating a lower risk of excessive inflammatory responses to inflammation. However, Participants 4 and 5 (skin types III and IV) displayed slightly unfavorable genotypes, suggesting a higher risk of excessive inflammatory responses to inflammation.

According to Bosma *et al*., atopic dermatitis, also known as atopic eczema, is a chronic, inflammatory skin disorder with a higher prevalence among black and mixed-race communities, particularly those with darker skin types (IV-VI) compared to lighter individuals (I-III), attributed to genetic and immunological differences [37].

4.6. Freckles

Freckles are pigmentation features found in fair-skinned and red-haired individuals, categorized into ephelides and solar lentigines (SL). Ephelides are small spots influenced by genetics and sunlight, appearing during childhood and increasing in adolescence. They are more susceptible to sunburn and skin cancer. SLs are larger, appearing after age 50 on sun-exposed skin. Freckles are viewed differently in Western and Asian cultures, leading to confusion about their nomenclature.

Freckles are associated with genetic variations in several genes, including the IRF4 gene (blue eyes, brown hair, freckles, and sun sensitivity), the MC1R gene (red hair, fair skin, UV sensitivity, and freckles), the ASIP gene (red hair, freckling, and sun sensitivity), the TYR gene (blond hair, blue eyes, and freckles), and the BNC2 gene (lined to freckles and skin color saturation) [38].

The genotypes of Participants 1-3 (skin Types I-III) indicated slightly unfavorable genotypes, signifying a high risk of developing freckles. Treatment for this disease involves various approaches, including the regular daily use of sunscreens, chemical peeling, cryotherapy, and laser therapy [39]. In contrast, Participants 4 and 5 (skin Types IV and V) showed low and very low risks, respectively, of developing freckles.

A previous study by Singh and Singh in 2019 effectively communicated that freckles are typically more common in individuals with Fitzpatrick skin types 1 and 2, but they can also be observed in those with skin types 3-5, particularly if they have red or blond hair [33].

4.7. Varicose Veins

Varicose veins, enlarged, twisted veins found in the legs, are strongly purple-blue and extend into the skin like roots. Genetic variations in the MTHFR gene increase the risk of developing varicose veins [40], while non-genetic factors increase the risk of developing varicose veins (chronic cough, constipation, family history of venous disease, being female, obesity, advanced age, pregnancy, and prolonged periods of standing). The exact cause of varicose veins is not entirely understood, but it involves a combination of genetic predisposition, weakened vessel walls, incompetent valves, and increased pressure in the veins [41].

The genetic mapping results revealed that Participants 1 and 2 (skin types I and II), exhibited a moderate genotype, indicating that the analyzed genotype has a limited impact on these aspects. In contrast, Participant 4 (skin type III) showed an unfavorable genotype, suggesting a very high risk of developing varicose veins. The recommended treatment

for varicose veins typically involves options such as oral inotropic drugs containing *Ginkgo biloba* plant that improves peripheral circulation [42].

More aggressive treatment options include external laser treatment, injection sclerotherapy, endovenous interventions, and surgery. Limited comparative data exist on the efficacy of different treatment modalities, and the choice of therapy is influenced by several factors, such as symptoms, patient preference, cost, potential complications, available medical resources, insurance coverage, and physician expertise [41].

Participants 3 and 5 (skin types II and IV) displayed slightly favorable genotypes, indicating a lower risk of developing the disease.

Based on a previous study by Aslam *et al.*, a population-based investigation conducted in San Diego found a higher prevalence of varicose veins among individuals of various racial and ethnic backgrounds. Specifically, the prevalence was 18% in Asians (Fitzpatrick skin types III–IV), 26% in Hispanics (Fitzpatrick skin types IV–VI), while varicose veins were more frequently observed in non-Hispanic Whites (Fitzpatrick skin types I–III), with a prevalence of 58%. However, various risk factors are associated with the development of varicose veins, including age, gender, occupation, pregnancy, family history, smoking, BMI, obesity, exercise, genetic factors, and current lifestyle [43].

4.8. Protection Against Glycation

Glycation is a non-enzymatic reaction between reducing sugars or reactive oxoaldehydes and proteins, lipids, or nucleic acids that leads to the creation of advanced glycation end products (AGEs) [44]. Glycation contributes to skin aging and affects the skin's capacity to regenerate and repair itself [45]. Glycated collagen fibers become inflexible and less elastic, leading to wrinkles, dryness, increased skin thickness, and a loss of firmness. AGEs develop with age and are dangerous when combined with UV exposure. Dietary measures can reduce glycation by lowering blood glucose, LDL cholesterol, and triglyceride levels. Gene variants such as GLO1 and AGER are linked to accelerated ageing and altered energy metabolism and glucose levels [44], [45].

All participants exhibited unfavorable genotypes, signifying a very low capacity for protection against glycation. Biological products caused by glycation are mostly linked to a number of age-related illnesses, such as neurodegenerative diseases, atherosclerosis, renal failure, immune system changes, retinopathy, skin photoaging, osteoporosis, and the growth of some tumors. Epigenetic factors, oxidative stress, UV radiation, and nutrition all have an impact on the accumulation of AGEs [46]. In addition, studies done in 2022 by Zheng *et al.* suggest that exogenous factors like ultraviolet radiation make AGEs in the skin worse over time [47]. Green tea, Vitamin C, Vitamin E, niacinamide, and carnosine can lower the amount of advanced glycation products on the skin [45].

4.9. Cellulitis

Cellulite, also known as gynoid lipodystrophy or orange peel syndrome, is a common lipodystrophy disorder affecting post-adolescent women. It is characterized by subcutaneous tissue disorders such as nodules, edema, and aberrant fibrosis, giving an uneven skin appearance. Caucasian women are more likely to develop cellulitis. The pathophysiology of cellulite is complex and poorly understood, with hypotheses suggesting hormonal abnormalities, endothelial dysfunction, and genetic predispositions. Hormones such as estrogen and progesterone may contribute to fat distribution and tissue structure, while endothelial dysfunction can impair blood and lymphatic drainage. Genetic factors may also influence vulnerability to cellulite. Treatment methods for cellulite include topical creams, massages, and medical-aesthetic procedures, but their effectiveness may vary. Maintaining a healthy weight, staying active, adhering to a nutritious diet, and staying hydrated are recommended to reduce cellulitis risk [48]. Variations in the HIF1A and ACE genes, among others, have been associated with the risk of developing cellulitis [49].

The utilization of genetic mapping in the present study to assess the prevalence of cellulite unveiled distinct genetic predispositions among the participants. Participant 5, belonging to skin type IV, presented a favorable genotype, indicating a notably low susceptibility to cellulite. In contrast, Participants 2, 3, and 4, all representing skin types II and III, exhibited moderate genotypes. Notably, Participant 1 displayed an unfavorable genotype, indicating a significantly elevated risk of developing cellulite. The etiopathogenesis of cellulite is complex and not well-defined, but it is known to involve various factors, including environmental, hormonal, and genetic elements. In addition, factors like sex – where it is more prevalent in women than in men – and race – where Caucasians have a higher prevalence than other racial groups – have an impact on the incidence and severity of cellulite [48]. Another study by Friedmann revealed that despite its high incidence (80%–90%) in post-adolescent female patients of all races, cellulite is rare in male patients, which is linked to a deficiency of androgen as a result of

conditions such as castration, hypogonadism, Klinefelter's syndrome, or estrogen treatment for prostate cancer [50]. Caffeine and other ingredients such as retinol, carnitine, glaucine, and tetrahydroxypropyl ethylenediamide are often used to treat cellulite [51].

In the present study, variations in skin types, ages, and genders among the participants have highlighted both differences and commonalities in their skin features. Besides genetics, other factors like lifestyle, and environmental influences are just a few of the variables that affect these differences and similarities. For instance, regardless of their diverse skin types (ranging from I to VI), all participants exhibit normal dermal sensitivity. They also share a very low capacity for protection against glycation. The characteristics of an individual's skin are determined by a combination of genetic and environmental factors. A person's DNA determines their skin type, color, and other physical characteristics. Nevertheless, environmental factors such as sun exposure, pollution, and lifestyle choices can also affect the health and appearance of their skin [52]. Recent research on twins has found that genetic factors account for up to 60% of the diversity in skin aging across individuals, while non-genetic factors such as environmental factors account for the remaining 40% [3]. This underscores the importance of considering not only genetic testing but also lifestyle and environmental factors when making skincare decisions. Furthermore, Vierkötter and Krutmann (2012) have pointed out that certain individuals may be more susceptible than others to skin injuries caused by environmental exposure. In addition, immense differences in the manifestation of extrinsic skin aging were observed between ethnic groups. The skin texture is a significant difference between the ethnic groups that is most likely relevant. However, additional genetic or behavioral differences may also be causal factors [53].

In the present study, for example, Participants 2 and 3, despite having similar skin types, exhibit variations in their antioxidant capacity and susceptibility to varicose veins. This highlights that even individuals with identical skin types may possess different genetic predispositions to photoaging [3], [54].

In the cosmetics and skincare industries, the concept of "one-size-fits-all" and "perfect for everyone" solutions is becoming obsolete as scientific research has demonstrated that every individual's skin is unique and has different requirements. Advances in technology and DNA testing have enabled the development of individualized beauty treatments tailored to the skin type, concerns, and requirements of each individual. By analyzing an individual's DNA, the cosmetics and skincare industries can create personalized products and treatments that are more effective and efficient, resulting in improved outcomes for the individual. This personalized approach to cosmetic treatments is growing in popularity and will likely become the industry standard in the near future [55]. The skincare DNA test report provides the client, dermatologist or beauty consultant with useful information for devising a personalized skincare treatment.

While dermatoscopy and functional skin testing can be valuable tools in aiding the diagnostic process, but their application appears to be confined to specialized dermatology departments, and proficiency in their correct utilization and interpretation requires training [56]. On the other hand, DNA sequencing offers excellent diagnostic performance for skin diseases. This test holds the potential to serve as a valuable decision-support tool for dermatologists, general practitioners, and health-care professionals in the field of skin disease diagnosis [1].

Based on the report generated by DNA sequencing, an individual can select the most appropriate creams for their skin type with the help of DNA skin sequencing, which will improve the results of their dermatological treatments. Health experts such as geneticists or doctors (dermatologists) should examine and authorize any changes to health or skin treatments [3], [57]. Genes are undoubtedly a key component, but the body also reacts to a variety of other situations, including lifestyle, exercise, diet, and many more [58]. Despite the small sample size, the results serve as a starting point for further research.

5. CONCLUSIONS

The study confirms the reliability of the Fitzpatrick skin type classification based on both methods, which is crucial for clinical research and guiding skincare choices. In addition, genetic mapping through DNA sequencing provides detailed insights into how genetics influence skin attributes, a vital aspect of the aging process. The research highlights the necessity for personalized skincare solutions due to the significant impact of genetics on skin characteristics. These findings empower individuals, dermatologists, and beauty consultants to make informed decisions about skincare routines and product selections. Ultimately, understanding one's genetic predispositions enables tailored skincare approaches for better outcomes, emphasizing the importance of self-awareness in skin health management. Further research is necessary to explore these genetic influences more deeply and their implications for skincare practices.

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