Original Research Article

Biophysical Analysis of Facial Skin According to Skincare Practices and Gender Differences

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ABSTRACT

There is limited data on the relationship between skincare routines and facial skin biophysical parameters among Malaysians, particularly with respect to gender differences. The objectives of this study are to determine various types of skincare routines among Pharmacy students at UiTM Puncak Alam, to determine the facial skin biophysical profile differences between genders, and to compare the differences in facial skin biophysical properties between three different skincare routines: single, simple, and advance. In this cross-sectional study, 115 pharmacy students at UiTM Puncak Alam underwent biophysical skin measurements including transepidermal water loss (TEWL), skin hydration, elasticity, and melanin content, using an MPA 580 multi-probe adaptor system. The measurements were taken at the submalar region of the left side of the cheek. There is a significant correlation between skincare routine and skin condition**.** The advance routine group recorded the lowest TEWL (11.66 ± 2.16 g/h/m²) and highest skin hydration (63.59 ± 11.34 AU) and elasticity (0.90 ± 0.03 AU) compared to simple and single routine groups ($p < 0.001$). No significant differences were observed in melanin content among the routine groups. Gender analysis revealed that males had higher skin hydration and melanin content compared to females ($p < 0.05$). In conclusion, skincare routine type and gender influence skin biophysical characteristics, emphasizing the importance of tailored skincare practices for maintaining optimal skin health.

Keywords: Skincare routine, TEWL, hydration, elasticity, melanin, gender differences

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1.0 Introduction

Skin performs a variety of critical functions such as protection, excretion, absorption, thermoregulation and hormone synthesis rather than solely covering the organism (1). This is due to the presence of stratum corneum at the skin's outermost layer, the epidermis, which serves as a skin barrier (2–4). The skin microbiota comprises countless bacteria, fungi, and viruses that regulate the human skin. An imbalance of commensals and pathogens can easily disrupt human skin, resulting in a broken skin barrier. The skin barrier is crucial to protect the human body against variety of external stressors, including mechanical, thermal, radiation stress, chemical stress and environmental condition. It also helps to prevent the loss of vital components from the skin, such as ions, water, and serum proteins (5–7). Importantly, the skin barrier is a dynamic system influenced by both intrinsic and extrinsic factors. Intrinsic factors such as age, gender, and genetic background can alter barrier properties and repair mechanisms, while extrinsic factors such as environmental humidity, UV exposure, pollution, and skincare practices can further modulate skin hydration, elasticity, and overall barrier integrity (8–10).

Face skin is thinner and more sensitive than the skin on other body areas; hence, its structure is distinct. Facial aging causes the skin to become thinner and less elastic, making it more susceptible to infection. Without healthy skin, the skin will be more susceptible to disease and infection (8). According to a study by Engebretsen *et al*. (9) (2016), environmental factors such as relative humidity (RH) can influence the condition of human skin where low RH might cause fragile skin that is more vulnerable to mechanical stress than skin exposed to high RH. This is indicated by a reduction in skin hydration and elasticity in individuals exposed to a low RH environment compared to those exposed to a normal or high RH environment (9). In addition, seasonal changes can affect the function of the skin's barrier, as skin becomes more sensitive and permeable in cold environments, making it susceptible to chapping. This is because water is being pushed out of the epidermis, causing the skin to dry up and eventually increase the likelihood of skin irritation. Moreover, countries with tropical climates, such as Malaysia, can increase the incidence of sunburn. The application of a UV protective layer when exposed to direct sunlight can lower the risk of severe skin damage, such as elasticity loss, wrinkles, skin aging, and in the worst cases, skin cancer (8).

Skincare products are widely used around the world with the prevalence of skin diseases such as acne vulgaris, xerosis, pruritus, wrinkles, and even skin cancer. The introduction of cosmeceuticals, which give therapeutic effects on the skin's condition beyond the period of application, has increased the awareness of the use of skincare products (10). A study demonstrated both short-term and long-term use of skincare products are beneficial to the skin. For example, the reduction of wrinkles may take up to 12 weeks with daily application of a skincare product, yet skin hydration can be improved significantly in as little as two days with daily application (11). Skincare products are often associated with the practice of skincare routine. A skincare routine is a method for maintaining the healthy condition of the skin by incorporating skincare products based on the intended usage. Distinct skin types which can be normal, oily, combination or sensitive and skin concerns will necessitate a distinct routine, specifically the functional

ingredients in the skin product (12–14). Most Malaysian women use cosmetics products in their daily makeup routines, such as moisturiser, sunscreen, and skin-lightening product, which may change the biophysical characteristics of the skin (15). In terms of the type of skincare routine, two studies indicate that advanced skincare routines have demonstrated a significant improvement in skin condition over time, particularly in individuals with specific skin concerns, in contrast to simpler skincare routines, which have demonstrated only slight improvements in the appearance of skin condition (11,16).

Several studies on the biophysical properties of facial skin, including elasticity, hydration, transepidermal water loss (TEWL), and melanin content, have been conducted all over the world. There is one study conducted in Ireland that investigated the benefits of using an advance skincare routine versus a simple skincare routine and prove that advance skincare routines show better benefits than other skincare routines (16). However, there is insufficient current data available on the effect of different types of skincare routines on skin conditions among Malaysians is currently available. Most studies conducted in Malaysia did not compare the effects of different skincare routines, such as single routines, simple routines, and advance routines, on the skin biophysical characteristics of Malaysian individuals, including gender differences. It was reported that males generally exhibited higher skin hydration and melanin index compared to females, whereas no significant differences were observed in TEWL and elasticity. These physiological variations highlight the importance of considering gender when evaluating skincare routine effects on skin biophysical parameters (17). Two papers have been published that investigate Malaysian individuals' skin biophysical parameters in relation to the use of skincare. One paper published by Goh *et al.* (2021) (2), investigated the facial skin biophysical profile of Malaysian women, but the measurement was limited to Malaysian women only. Meanwhile, another paper published by Hadi *et al*. (2016) (17), investigated Malaysian skin biophysical properties, including gender comparisons, but the measurement of skin biophysical parameters was performed at the forearm. Based on the above studies, there is still lack of data on the differences in facial skin biophysical profile between skincare routine groups and gender.

Thus, the aim of this study is to determine various types of skincare routines among Pharmacy students at UiTM Puncak Alam, to determine the facial skin biophysical profile differences between gender and to compare the differences in facial skin biophysical properties between three different skincare routines: single, simple, and advance.

It is critical for consumers to fully comprehend the use of specific skincare products on their skin. This study will benefit the community by raising awareness of the importance of having a skincare routine to maintain healthy facial skin. This is important because knowing the condition of the facial skin allows individuals to choose the appropriate skincare product. Furthermore, these findings will broaden the researcher's understanding of the differences in skin biophysical profiles between genders, as well as the correlation between the type of skincare routine and skin condition among individuals. In addition, the findings of this study will assist potential researchers in conducting additional research on the functional ingredients in each skincare product that are suitable for Malaysian skin conditions.

2.0 Materials and methods

2.1 Ethical approval

This study has been approved by the Universiti Teknologi MARA (UiTM) Research Ethics Committee with reference number REC/08/2023 (UG/FB/3) and conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and the guidelines of Good Clinical Practice (GCP). The participant information sheets were distributed to each participant, and their consent was obtained. The purpose of the research, research design and benefits were briefed before the study began. Each of the participants was assured that their information would be kept confidential, and their participation in this study was entirely voluntary.

2.2 Participants

Data collection for this analytical, cross-sectional study was conducted for three months, from the beginning of April 2023 until the end of June 2023. A total of 115 participants were recruited via convenience sampling, comprising 39 males and 76 females. Recruitment was conducted through announcements made in lecture halls and postings on student social media groups (e.g., WhatsApp and Telegram). Interested students were invited to contact the research team and were screened for eligibility before enrollment. Inclusion criteria were: (i) pharmacy students aged 18–26 years, (ii) generally healthy without chronic systemic diseases, and (iii) willing to provide informed consent. To minimize age-related variability, only young adults within this narrow age range were included. Participants with severe facial skin problems (e.g., those treated with systemic retinoids or steroids), serious medical conditions (e.g., diabetes mellitus, hypertension, infectious or malignant diseases), pregnancy, lactation, or recent use (within two weeks) of topical medications such as retinoids or corticosteroids were excluded.

2.3 Study design

Participants who met the inclusion criteria were briefed on the research protocol, which includes the study procedure, before each participant was provided with informed consent. They were instructed to bring along their skincare products during the assessment day to record the type of skincare product used and the functional ingredients present in the skincare products. They were then divided into three different groups based on the skincare product used: the single skincare routine group which was defined as those who only used one type of skincare product; the simple skincare routine group, which was defined as those who only used basic skincare routines such as cleanser and moisturiser and advance skincare routine group, which was defined as those who used additional skincare products than a simple skincare routine, such as cleanser, toner, essence, serum, moisturiser, sunscreen, day cream, and night cream.

The participants were instructed to rest for 20 minutes in a room maintained at a temperature of 22 ± 2°C and relative humidity of 60 ± 5%. Then, a series of biophysical parameters, including TEWL and skin barrier function, melanin content, skin hydration and elasticity were measured at the submalar region of the left side of the cheek. This site was selected because it provides a relatively flat and uniform surface that is less affected by facial hair, makeup, and sebum secretion compared to other areas such as the forehead or nose. Furthermore, previous

studies, including Goh *et al*. (2021) (2), have standardized the cheek region as a representative site for assessing facial skin biophysical properties.

2.4 Instrumental Skin Measurement

The skin biophysical measurements were carried out with the aid of scientific skin measuring instruments, an MPA 580 multi-probe adapter system (Courage + Khazaka (C&K) electronic GmbH). The method used in the instrument skin measurement was adapted from Goh *et al*. (2021) (2). The measurement sites were cleaned with a cleansing tissue before each probe was placed on the measurement site. Each probe was placed onto the measurement site one after another, and the data collected were recorded in the participant's data collection form.

The measurement for TEWL was taken by using Tewameter® TM300 (Courage & Khazaka, Cologne, Germany), attached to an MPA 580 multi-probe adapter system. The measurement was taken by placing the probe on the skin surface for 30 seconds. The water evaporation rate, which will be expressed in g/h/m², was obtained upon contact with the skin and was shown on the screen of a multiprobe adaptor system.

The measurement of skin hydration was taken by using Corneometer® CM 825 (Courage & Khazaka, Cologne, Germany) connected to the multiprobe adaptor system. The measurement of skin hydration was taken by placing the probe onto the measurement site for approximately one second, and the result was expressed in arbitrary units (AU). The higher value of AU, the better the skin hydration.

Skin elasticity was measured by using Cutometer® MPA580 (Courage & Khazaka, Cologne, Germany) probe that was connected to the MPA 580 multi-probe adapter system. The R2 value with an arbitrary unit (a.u) indicated the elasticity of the skin.

As for melanin content, it was measured by using Mexameter® MX18 (Courage & Khazaka, Cologne, Germany) which was a device responsible for skin color or pigmentation. Mexameter® measured the melanin content at two different wavelengths, 660nm and 880nm, which correspond to the absorption peak of the melanin pigment. The measurement was taken by placing the probe onto the skin surface with constant pressure and the intensity of the absorbed and reflected light at 660nm and 880nm were then used to calculate the melanin index.

2.5 Statistical analysis

The collected data were analysed using Statistical Package for the Social Sciences (SPSS). The skewness and kurtosis of the data was monitored to determine the distribution of the data. The Kolmogorov-Smirnov test was used to determine the data's normality. The result of melanin content was found to be fell outside of the acceptable range of normality. The outliers were identified using boxplots and 5 outliers were reported and excluded from the data analysis where 3 outliers are from single skincare routine group and 2 outliers from simple skincare routine group. Thus, the data presentation and statistical analysis were based on 110 participants out of a total of 115. One-way ANOVA was utilised to analyse the statistical difference in skin biophysical characteristics in three different skincare routine group except for melanin content as the data for melanin content was analysed by using Kruskal-Wallis test with Tukey honestly significant difference (HSD)

as post hoc test. Statistical difference on skin biophysical parameters across gender were analysed by using independent sample t-test except for melanin content data, which was analysed using Man-Whitney U test with $p<0.05$ considered statistically significant. The data on the skincare products used by participants were analysed in the form of frequencies and percentages, and the common ingredients used were analysed based on their function with the result reported in their respective tables. All data were expressed as mean $\pm$ standard deviation, and $p < 0.05$ considered statistically significant.

3.0 Results

3.1 Skin biophysical parameter in three skincare routine groups

Table 1 compares the facial skin biophysical parameters of three different skincare routine groups: single skincare routine, simple skincare routine, and advance skincare routine. Except for melanin content, facial skin biophysical characteristics indicate a significant difference in three different groups, with $p<0.05$ considered statistically significant for TEWL, skin hydration, and skin elasticity. The advance skincare routine group had the lowest TEWL value, followed by the simple skincare routine and single skincare routine. Skin hydration and elasticity were also shown to be highest in the advance skincare routine group when compared to the other groups. Meanwhile, there is no statistically significant difference in melanin content across three distinct skincare routine groups, as expected.

3.1.1 Transepidermal water loss

Based on the result obtain in Figure 1, individuals with single skincare routine shown to have higher TEWL value followed by simple skincare routine group and advance skincare routine group with $P < 0.001$ as stated in Table 2 of multiple comparison between each group.

3.1.2 Skin hydration

Based on Figure 2, skin hydration is highest in those with an advance skincare routine group compared to other two groups. Meanwhile, single skincare routine group having the lowest skin hydration. As shown in Table 3, the differences between all three groups were statistically significant ($p < 0.05$), suggesting that the number of steps in a skincare routine has a measurable impact on skin moisture.

3.1.3 Skin elasticity

Based on Figure 3, skin elasticity is the highest in individuals with advance skincare routine followed by simple skincare routine and then single skincare routine. In addition, Table 4 showed the differences between all three groups were statistically significant ($p < 0.05$), suggesting that the difference in the practice of skincare routine has a measurable impact on skin elasticity.

Table 1: Biophysical parameters among different skincare routine groups.

Biophysical parameter	Single skincare routine group (n =23)	Simple skincare routine group (n = 34)	Advance skincare routine group (n =53)	Sig.	Sig. Correlation
TEWL, g/m^2/h	18.0522 ±1.59456	15.6141 ±1.85292	11.6596 ±2.15568	<0.001	<0.001
Skin hydration (AU)	49.7468 ±5.78753	55.5796 ±2.22809	63.5877 ±11.34437	<0.001	<0.001
Skin elasticity (AU)	0.7472 ±0.6530	0.8178 ±0.4853	0.9006 ±0.03008	<0.001	<0.001
Melanin content (AU)	183.4625 ±31.9978	164.0491 ±37.6255	163.9826 ±57.9223	0.059	0.042

TEWL, transepidermal waterloss; AU, arbitrary units; SD, standard deviation; sig, significance; p<0.05 significance different; p<0.01 significant correlation for TEWL, skin hydration and skin elasticity using Pearson correlation coefficient; p<0.05 significant correlation for melanin content using Spearman's rank correlation coefficient.

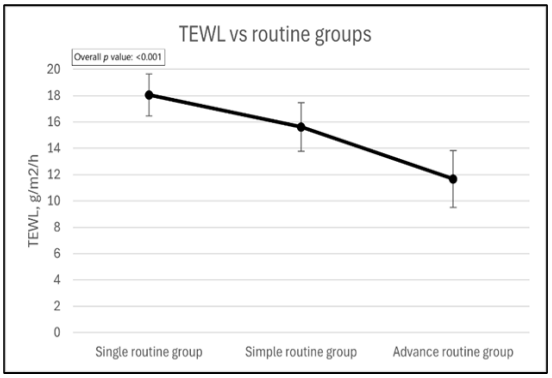

Figure 1: TEWL comparison between skincare routine group.

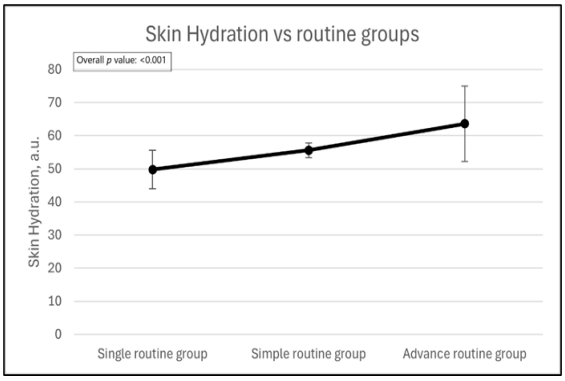

Figure 2: Skin hydration comparison between skincare routine group.

Table 2: Multiple comparison of TEWL between skincare routine groups.

Groups		Sig. (P<0.05)
Single routine group	Simple routine group	<0.001
	Advance routine group	<0.001
Simple routine group	Single routine group	<0.001
	Advance routine group	<0.001
Advance routine group	Single routine group	<0.001
	Simple routine group	<0.001

Table 3: Multiple comparison of skin hydration between three different skincare routine group.

Groups		Sig. (P<0.05)
Single routine group	Simple routine group	0.031
	Advance routine group	<0.01
Simple routine group	Single routine group	0.031
	Advance routine group	<0.001
Advance routine group	Single routine group	<0.001
	Simple routine group	<0.001

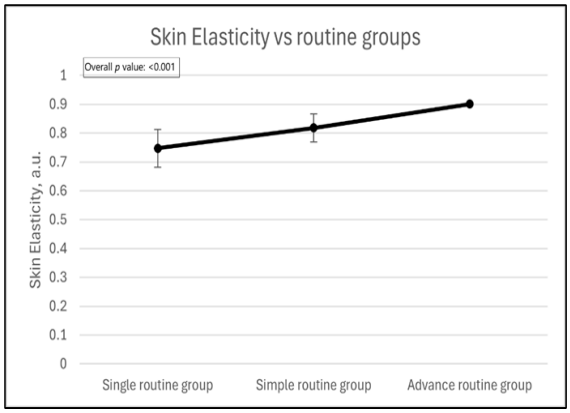

Figure 3: Skin elasticity comparison between skincare routine group.

Table 4: Multiple comparison skin elasticity between skincare routine groups.

Groups		Sig. (P<0.05)
Single routine group	Simple routine Group	<0.001
	Advance routine Group	<0.001
Simple routine group	Single routine Group	<0.001
	Advance routine Group	<0.001
Advance routine group	Single routine Group	<0.001
	Simple routine Group	<0.001

3.1.4 Melanin content

Figure 4 shows the comparison of melanin content among participants in different skincare routine groups. Overall, melanin content appeared slightly lower in the simple and advanced routine groups compared to the single routine group. However, the differences between groups were not statistically significant (overall $p = 0.059$).

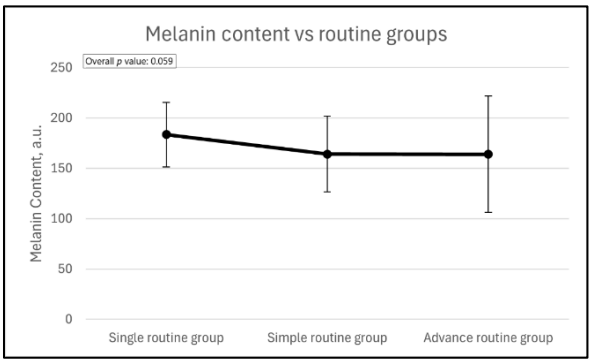

Figure 4: Melanin content comparison between skincare routine group

3.2 Significant correlation

From Table 1, there is a significant correlation between skincare routine and skin condition with TEWL, skin hydration, skin elasticity, and melanin content, with TEWL, skin hydration, and skin elasticity having significant correlations ($p<0.01$) and melanin content having significant correlation ($p<0.05$). Even though participants in advance skincare routine group used different number of skincare product daily, however the result of skin biophysical parameter tested are nearly identical with no outliers observed.

3.3 Skin biophysical parameters between gender

Table 5 shows skin biophysical parameters comparison between gender. Surprisingly, there is no significant difference between gender in TEWL and skin elasticity across all groups. However, there is a significant difference between genders in terms of skin hydration in both single and advance skincare routine group ($p<0.05$) and melanin content

Table 5: Biophysical parameters among different skincare routine group when compared to gender.

Biophysical parameter	Gender	Single skincare routine group Male (n =17) Female (n =6)	Simple skincare routine group Male (n =12) Female (n =22)	Advance skincare routine group Male (n =10) Female (n =43)
TEWL, g/m^2/h	Male	17.8000±1.57361	15.7500±1.79114	10.8500±1.56738
	Female	18.7667±1.56034	15.5400±1.92313	11.7380±2.21828
Sig.		**0.209**	**0.757**	**0.438**
Skin hydration (AU)	Male	51.4055±5.14218	55.5578±2.74711	75.2017±8.95205
	Female	45.0472±5.18731	55.5915±1.96158	62.6397±11.05679
Sig.		**0.017**	**0.967**	**0.032**
Skin elasticity (AU)	Male	0.7493±0.06638	0.8015±0.06247	0.9180±0.2904
	Female	0.7413±0.06786	0.8267±0.03771	0.8984±0.3116
Sig.		**0.803**	**0.151**	**0.231**
Melanin content (AU)	Male	182.2663±28.67812	196.0836±36.7594	221.7675±137.4088
	Female	186.8517±43.0643	146.5758±24.7098	159.2655±46.40652
Sig.		**0.771**	**<0.001**	**<0.001**

TEWL, transepidermal waterloss; AU, arbitrary units; SD, standard deviation, P<0.05 significance difference; sig, significance.

Table 6: Skincare product used by participants.

Skincare product	Frequency	Percentage (%)
Facial Cleanser	98	89
Toner	40	36.4
Essence	28	25.5
Serum	32	29.1
Moisturiser	87	79.1
Sunscreen	48	43.6
Day cream	18	16.4
Night cream	20	18.2
Eye cream	7	6.4
Spot treatment	26	23.6
Face mask	13	11.8
Others	9	8.2

which can be observed in simple and advance skincare routine group (p<0.05). Males also reported to have higher skin hydration and melanin content as compared to female. The frequency with which skincare products are used can be observed in Table 6. In this study, 89% of individuals routinely used face cleanser skincare products. Aside from facial cleanser, pharmacy students at UiTM Puncak Alam favour products with moisturising and photoprotective characteristics such as moisturiser (79.1%) and sunscreen (43.6%).

3.4 Facial skincare product use

Meanwhile, the usage of skincare products for the eyes is the least common (6.4%). As shown in Table 6, most individuals used additional skincare products such as toners, serum, essence, spot treatment, day cream, night cream, and face mask. Meanwhile, 8.2% of the participants used products not specified in Table 6, such as face mist and face oil.

4.0 Discussion

The study provides an overview of the differences in facial skin biophysical profile between skincare routine groups and gender. Through distinct skincare routine, this study reveals the implication of facial skin care product use on the skin biophysical parameters including TEWL, skin hydration, and elasticity as well as melanin content. The results also help to identify the common ingredients used in skincare products based on skin concerns.

4.1 Influence of skincare routine group on skin biophysical parameters

Due to the unique structure of the human skin, it has become the most effective first-line defence system that ever existed in the human body. The unique structure, physical and chemical qualities have made it an effective barrier. To have a good functioning and effective barrier, it is necessary to understand what factors influence the effectiveness of the skin. Factors such as TEWL, skin pH value, skin moisture, sebum secretion, and melanin content are the most significant factors which will affect the condition of the skin barrier (2, 17, 18). Therefore, it is very essential to understand each of the factors that will influence the skin function and the properties of the skin as well.

The single skincare routine indicates that only one product, typically a facial cleanser, is used in the skincare routine. For a simple skincare routine, it only involves the cleanser and also the moisturiser. For an advance skincare routine, it includes multiple cosmetic products such as the cleanser, moisturiser, day cream, night cream and serum (12).

4.1.1 Transepidermal water loss (TEWL)

The TEWL measures the rate of water loss from the skin surface that indicates the level of moisture at the skin layer. Using the TEWL, one may determine the condition of the skin barrier, whether it is healthy or impaired with higher TEWL value indicated impaired skin barrier function (19,20). Consistent with the interpretation that lower TEWL reflects better barrier integrity, the advanced routine group showed the best skin barrier integrity, followed by the simple routine group, while the single routine group exhibited the poorest barrier integrity (Figure 1).

A healthy epidermal barrier, which prevents harmful substances from penetrating the skin and wards off harmful bacteria and serves as an indicator of healthy skin. Many skin illnesses cause lesions when this barrier is disrupted, either structurally or functionally (21). This was the most expected result since individuals in advance skincare routine group and simple skincare routine group reported to have number of skincare product applied and frequency of the skincare product used is greater than those in single skincare routine group. The functional ingredients such as ceramide present in skincare product aids in improve the permeability of skin and water and overall skin barrier function (22).

Generally, aside from skincare product used, environmental factors may also influence normal skin condition which contribute to the TEWL value. This is because humid weather can cause excessive sweating, which can irritate the skin. This could be due to the acidic pH of sweat, which can activate inflammatory mediators on the skin. In addition, low humidity may increase evaporation on the skin's surface, causing

dryness and leading to skin barrier dysfunction as it promotes TEWL (23).

4.1.2 Skin hydration

Findings in Figure 2 and Table 3 align with previous evidence that multi-step routines incorporating moisturizers are more effective in enhancing stratum corneum hydration than minimal-step routines (2, 12). The improvement in hydration observed in the advanced routine group highlights the importance of consistent application of hydrating products, which may strengthen the skin barrier and reduce susceptibility to dryness or irritation. However, the epidermal thickness and the density of sweat and sebaceous glands in a given skin region can influence its moisture content (3, 4). The moisture content of the skin may be also affected when the humidity and temperature change. However, in this study, all participants were instructed to rest in acclimatisation environment prior to test procedure, and the test region was fixed in the submalar region, thus these factors will be insignificant.

Moreover, the presence of hygroscopic substances in skincare product applied moisturiser such as hyaluronic acid that help to maintain skin hydration by retain the water content at the stratum corneum also appear to be the most plausible reason that individuals in the advance skincare routine group have greater skin hydration compared to other groups. However, other factors may also contribute to the poor skin hydration such as the types of meals eaten which may have an impact on the moisture value (24). For example, a high intake of saturated or monounsaturated fatty acids has been related to a reduction in epidermal moisture, as revealed in at least one study (25).

4.1.3 Skin Elasticity

The participants' skin elasticity was assessed using R2 value, often known as gross elasticity. R2 measures total skin stretch, including viscous deformation. It represents the ratio of total skin recovery under normal pressure following the deformation. R2 value can also be recognised as the stretchiness of hydrated skin. As the value of R2 closer to 1, it indicates greater skin elasticity (26, 27). According to Figure 3, skin elasticity is higher in individuals with advance skincare routine over those with simple and single skincare routines. Although there is significant difference between skin elasticity of individual with advance skincare routine group with simple skincare routine group ($p < 0.001$) as stated in Table 4, the mean skin elasticity of individuals in simple skincare routine group as stated in Table 1, can be considered satisfactory as the R2 value was closer to 1 (0.8178 ± 0.4853 AU).

Numerous intrinsic and extrinsic factors including age, temperature, humidity and hormonal changes can influence skin elasticity (27). However, age, temperature and humidity changes may be insignificant in this study. This is since the participants in this study are young adults between the ages of 18 and 26. Moreover, impaired in TEWL also can be associated with reduce in skin elasticity as it correlates with skin aging (28).

Long term exposure to UVA and UVB radiation can cause oxidative damages to cells and tissues, affecting the balance between the formation of reactive oxygen species (ROS) and antioxidant that act as a cellular defense resulting in photo-ageing (29). This demonstrated that individuals who do not use sunscreen, as in both single skincare routine group and simple skincare routine group, are at risk of facial aging due to UV irradiation which contributes to the

loss of skin elasticity, dryness and deep wrinkles. This is due to the UVB irradiation activating cytokine expression in the epidermal keratinocytes, triggers the cleavage of elastase fibres by the stimulation of the skin fibroblast elastase expression. The loss of configuration of elastase fibres lead to the decrease in skin elasticity (30) . Furthermore, referring to Figure 3 and Table 4, skin elasticity is reported to be higher in simple skincare routine group compared to single skincare routine group, which is likely attributable to functional ingredient in their moisturiser skincare product such as retinoids or vitamin A, vitamin C which acts as anti-oxidant agent to fight against the free radicals, ROS produce by the oxidative damage as a result of sun exposure (31).

4.1.4 Melanin content

Melanin is a pigment that are produced by melanocytes at the base of the epidermis and it can be divided into two types, namely eumelanin, which gives black or brown color, and pheomelanin which gives a red or yellow colour (32). According to Figure 4, this study found no statistically significant differences in melanin content when comparing three types of skincare routines: single, simple, and advance. This may be due to the test subjects are all in Malay race group only. There is one study proven that there is positive correlation between production of melanin of melanocytes and races in Malaysia. In the same study by Goh *et al*. (2021) (2), Malay individuals show to have higher melanin content compared to Chinese while lower melanin content compared to Indian woman.

The skin coloration, on the other hand, can be varied even within the same ethnic groups and same melanin content. The difference in the skin colour is mainly affected by the size, volume, keratinocytes and melanocytes distribution and not affected by the number of melanocytes in the ethnic group. Different in density, size, dispersion of melanosome does affect the skin coloration. For example, people with darker skin, the melanosome concentrated and evenly distributed over the basal layer people with whiter skin shown to break down the melanosome more quickly led to the small cluster of melanosomes found in the basal layer (33).

4.2 Influence of gender on skin biophysical parameters

Males' and females' skin are often having different biophysical properties. Based on Table 5, this study showed no statistically significant difference in TEWL value when compared between gender. However, according to one study conducted by Firooz *et al*. (2012) (34), males have significantly higher TEWL than females. This might be due to males tend to have more outdoor activities resulting in more environmental pollution than females. Even though males are known to have higher TEWL than females, this is not clear in this study, which may be owing to the smaller sample size in the male group.

Skin hydration was shown to be significantly different between male and female in single skincare routine group and advance skincare routine group but not in the simple skincare routine group. This may be due to unequal distribution of sample in simple skincare routine group. However, it is reported by the previous study that stratum corneum (SC) hydration to differ between gender. Study reported by Leubberding *et al*. (2013) (35), stated that SC hydration has always been greater in males than in females until the age of 40 and has shown the opposite result in the fifth decade of life as male skin dehydrates more progressively with age. On

the other hand, female SC hydration tends to be stable over a lifetime or even increasing. This argument is strengthened by the findings of this study, which found that males had higher skin hydration than females in both the single skincare routine and the advance skincare routine groups.

Meanwhile, there is no significance difference in terms of skin elasticity between genders in all three different group being tested. One study conducted by Dabrowska *et al*. (2018) (36), also stated that there is no statistical significance difference between elastic properties and genders (36). This may be due to various risk factor that can affect skin elasticity such as air pollution, nutrition, smoking and sun exposure (37). On the other hand, melanin content showed a significance difference between gender in both simple skincare routine groups and advance skincare routine groups with male having more melanin content than female. This result is supported by a previous study in which the researcher revealed that male has greater melanin index compared to female and it is mainly confined to the forehead area whereas the palm shows the lowest melanin index. This is mainly due to males being exposed to the sun more often than females (34).

4.3 Skincare product uses

People use skincare products to practice for maintaining optimal skin health in a variety of ways, including purchasing any item to cleanse, massage, or moisturise the skin layer. The most common skincare products being used are facial cleanser, toners, moisturisers, lotions, sunscreens, skin brighteners and etc (14, 15). The appropriate choice of cleanser, moisturiser and sunscreen is determined by skin type which can be normal, dry, or oily skin (16).

By referring to Table 6, 89% of the participants used facial cleanser in their daily skincare routine. Facial cleanser is functioned to remove exogenous pollutants presence on the skin, reduce sebum and to control the skin microbiome (38) . In general, gel- and bar-based cleansers are preferable for oily skin, whereas cream- and lotion-based cleansers are preferable for normal to dry skin (39). Moisturiser is the second most preferred skincare product among participants (79.1%). Moisturisers provide skin hydration and increase water content in stratum corneum which can aids in lower the TEWL and increase in skin hydration. Moisturiser also thought to improve skin barrier function and skin integrity (22). Oil-in-water formulations of moisturiser which typically consist of lightweight gels and lotions are ideal for normal to dry skin types while water-in-oil formulation which may be ointments or creams, provide superior hydration to dry skin (39). Meanwhile, sunscreen being the third most skincare product used by pharmacy students' at UiTM Puncak Alam (43.6%). The use of sun protection such as sunscreen is functioned to protect skin from incidental ultraviolet exposure which results in worsen hyperpigmentation and it should always be the last step of every at-home skincare regimen (39).

On the other hand, skincare product such as toner, essence, serum and other skincare product listed in Table 6 are usually used for specific skin concern. Toning and essence, for example, typically contain hydrating ingredients that provide the skin with a first load of hydration. Meanwhile, serum usually contain functional ingredients that are used to treat enlarged pored, as antioxidant and anti-aging benefits, brightening properties and provide sufficient hydration to the skin (20). Facial serum is a highly concentrated

emulsion that, due to its small molecule size, is designed to penetrate deep into the skin layer. This feature of facial serum will aid in the delivery of the beneficial effects of functional ingredients into the skin's layer and provide apparent results within a month or less. This could explain the reason serum is regarded to be the most expensive skincare product (40).

4.4 Limitations of the study

This study has several limitations. First, the participants were recruited from a single institution (UiTM Puncak Alam) and consisted mainly of young adults, which may limit the generalizability of the findings to the wider Malaysian population of different age groups and occupations. Second, the cross-sectional design only provides a snapshot of the association between skincare practices and biophysical parameters without establishing causality. Third, the study relied on self-reported skincare product use, which may be subject to recall bias and underreporting of certain practices. Finally, although skin biophysical measurements were performed under controlled environmental conditions, other unmeasured confounding factors such as diet, stress, or genetic background could also have influenced the results.

5.0 Conclusion

There is significant correlation between skincare routine and skin condition among pharmacy students at UiTM Puncak Alam. They also demonstrate different skincare routines and skincare products used. Individuals with a single skincare routine, a simple skincare routine, and an advance skincare routine have different skin biophysical profiles in terms of TEWL, skin hydration, and skin elasticity. However, there is no significant difference in melanin content between the three different types of skincare routines group. This could imply that skincare routine has little to no effect on melanin content. Furthermore, different genders have different skin biophysical profiles in terms of skin hydration and melanin content, with males having higher skin hydration and melanin content than females. However, our research found no gender difference in TEWL and skin elasticity. To summarize, this study explores a variety of skincare routines among Pharmacy students at UiTM Puncak Alam and reveals the differences of facial skin biophysical profile between different skincare routines and gender. This finding can help raise public awareness on the importance of having a consistent and appropriate skincare routine. Furthermore, it is very crucial to educate them on selecting skincare routines that align with their specific skin type and concerns, rather than relying on the trends.

Authorship contribution statement

NZN: Performed skin assessment, data analysis and writing original manuscript. **NMJ:** Training and assist in the skin assessment study and protocol. **NMH:** Manuscript editing and revision. **MIZ:** Supervise the skin assessment, methodology, data analysis, manuscript reviewing and editing.

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Conflict of Interest

The authors declared that they have no conflicts of interest to disclose.

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