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Effects of one year of daily face mask wearing on the skin during the coronavirus disease 2019 pandemic

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Abstract

Background: As coronavirus disease 2019 (COVID-19) continues, the long-term daily use of masks is increasing. A full year includes the four seasons of spring, summer, autumn, and winter. Skin may have been affected by the seasons and further affected by the use of masks. In a previous study, we confirmed the short-term and 6-month effects of wearing face masks. In this study, we investigated how certain characteristics of the skin change when wearing a mask for 1 year. Furthermore, we compared skin covered by the mask (mask-skin zone) to skin that was not covered.

Materials and methods: The participants were 18 healthy adults (8 men; 10 women) who were asked to wear masks in their daily lives from June 2020 to June 2021. During this period, participants' skin characteristics, such as trans-epidermal water loss, skin hydration, skin elasticity, skin keratin amount, skin pore area, skin temperature, skin redness, and skin color, were measured five times.

Results: Trans-epidermal water loss, skin keratin amount, skin pore area, skin color, and skin elasticity changed significantly during the year. Furthermore, trans-epidermal water loss, skin hydration, skin keratin amount, skin pore area, and skin color were significantly different between the mask-wearing and non-mask-wearing areas of the face.

Conclusion: The skin characteristics of the mask-skin zone can be affected by long-term wearing of a face mask under lifestyle and environmental conditions. During the COVID-19 pandemic, skin care for the mask-skin zone is also necessary for people who do not wear masks on a daily basis.

KEYWORDS
COVID-19, four seasons, mask-skin zone, skin aging, skin barrier, skin characteristics

1 | INTRODUCTION

Coronavirus disease 2019 (COVID-19) has spread worldwide since it was first discovered in December 2019, and the pandemic continues to this day.[1] The main disease transmission route is by droplets of an infected person. Personal protective equipment (PPE), such as face masks, can help prevent infection.[2] Before COVID-19, PPE was often worn for occupational needs, such as in health care workers (HCWs); however, currently, most members of society are wearing PPE in their daily lives. Accordingly, studies of side effects[3–5] to skin caused by

TABLE 1 The type of mask worn between the measurement points and the average temperature and humidity by season[12]

	Surgical mask	KF-AD mask	KF80 mask	KF94 mask	Mean temperature (°C)	Mean relative humidity (%RH)
June to September (summer)	15	2	–	1	24	81
September to December (autumn)	12	3	1	2	14.4	71
December to March (winter)	2	4	–	12	1.2	60
March to June (spring)	4	6	1	7	13	65

Abbreviations: KF-AD, Korean Filter-Anti-droplet mask; KF80, Korean Filter 80 mask; KF94, Korean Filter 94 mask.

wearing a mask, related research areas such as changes in skin characteristics due to wearing a mask,[6–9] and studies on the effects of face masks on the general public, not HCW,[6,10] are also expanding.

In previous short- and long-term studies, we investigated how and what skin characteristics are changed by mask wearing. In a short-term study,[6] skin was compared before and after wearing a mask for 1 day. A long-term study[11] involved general office workers and compared skin changes for 6 months. In the current study, we compared the skin measured at 3-month intervals from June 2020 to June 2021 and examined the effect and changes imposed on the skin by 1 year of mask wearing.

2 | MATERIALS AND METHODS

2.1 | Participants and environment

Eighteen healthy adults (mean age, 34.6 years; 8 men/10 women) participated in the study. The participants were fully informed about the details and objectives of the study. Participation was voluntary, and written informed consent was obtained from the included participants. The skin of the participants was measured five times from June 2020 to June 2021. The first measurement period (base) was from June 22 to July 2, 2020, the second period was from September 21 to 25, 2020, the third period was from December 14 to 16, 2020, the fourth period was from March 2 to 9, 2021, and the fifth period was from June 9 to 16, 2021. The 1-year period included the four seasons in Korea, which are sequentially divided into summer, autumn, winter, and spring. Four types of face masks were worn during the measurement period: (1) surgical mask, (2) Korean Filter-Anti-droplet mask, (3) Korean Filter 80 mask, and (4) Korean Filter 94 mask. The grades and characteristics of each mask were the same as those summarized in our previous study.[11] Table 1 shows the type of mask worn during the measurement periods and the seasonal temperature and humidity.[12] With changing seasons and external environments observed throughout the year, the type of mask that is worn may change.

All participants were office workers, and the average daily mask-wearing time based on five working days per week is shown in Table 2. During the measurement period, participants worked from home or from their respective offices. They did not wear a mask when working at home, thereby changing the mask-wearing time. Because of the change in the rate of working from home depending on the virus situation, the distribution of mask-wearing time at each measurement point was slightly different. At all measurement points, the average mask-wearing time was 8–10 h. Participants used cosmetic products of their choice and set up hygiene routines freely. There were some changes in their routines according to the season change, but the overall usage pattern was similar.

Before measurements, participants washed their faces and stayed in a controlled room with a temperature of 22 ± 2°C and relative humidity (RH) of 50 ± 5% to stabilize the skin. Most of the participants' skin measurements were performed in the morning to exclude the effect of the circadian rhythm as much as possible. The measured skin characteristics were as follows: trans-epidermal water loss (TEWL), skin hydration, skin keratin amount, skin pore size, skin elasticity, skin temperature, skin color, and skin redness. The areas measured for each skin characteristic are shown in Figure 1. The mask-skin zone (mask-wearing regions) includes the cheek, chin, and perioral areas, while the non-mask-wearing region includes the forehead.

2.2 | Measuring trans-epidermal water loss

TEWL measurements were performed on the forehead, cheeks, perioral area, and chin using a Vapometer (Delfin Technology Ltd., Kuopio, Finland).

2.3 | Measuring skin hydration and skin elasticity

Skin hydration and skin elasticity were measured using Corneometer and Cutometer MPA580 devices (C+K, Köln, Germany), respectively. Skin hydration and skin elasticity were measured on the forehead, cheeks, perioral area, and chin.

2.4 | Measuring skin keratin amount

Skin keratin was collected using a D-Squame pressure instrument (Cuderm Corporation, Dallas, TX, USA) and D-Squame Stripping discs (Cuderm Corporation). The amount of keratin on the stripping disc was quantified and analyzed using the D-Squame Scan 850A (Cuderm Corporation). Skin keratin amounts were measured on the forehead, cheeks, perioral area, and chin.

TABLE 2 Average daily mask-wearing time based on working days (Monday–Friday)

	1–2 h	2–4 h	4–6 h	6–8 h	8–10 h	More than 10 h
June to September	–	–	2	7	7	2
September to December	1	4	2	3	7	1
December to March	–	1	3	5	8	1
March to June	–	–	4	4	7	3

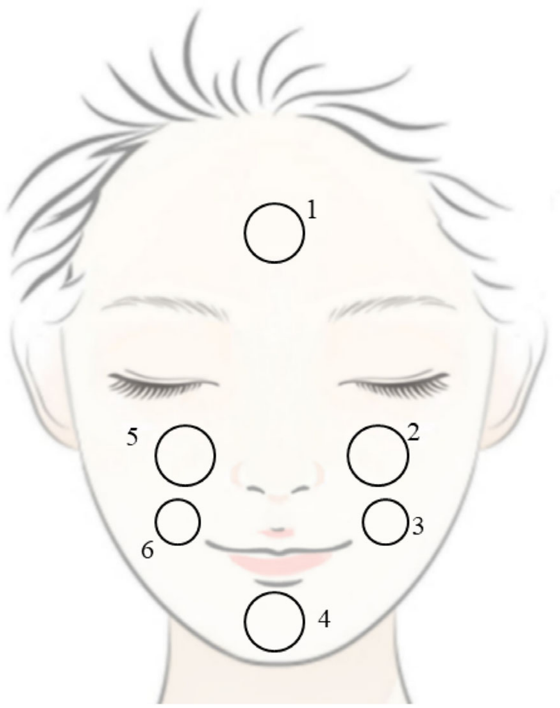

FIGURE 1 Areas measured by skin characteristics. Mask-skin zone (mask-wearing area): 2, 3, 4, 5, 6; non-mask-wearing: 1; skin temperature: 1, 2, 3, 4; trans-epidermal water loss (TEWL): 1, 4, 5, 6; skin hydration: 1, 2, 3, 4; skin pore: 1, 2, 3; skin redness: 1, 2; skin elasticity: 1, 2, 3, 4; skin keratin amount: 1, 4, 5, 6; skin color: 1, 5

2.5 | Measuring skin pore area

Facial images for skin pore analysis were obtained using VISIA-CR (CANFIELD, Fairfield, CT, USA). Skin pore analysis was performed on the forehead, cheeks, and perioral areas using the cross-mode from VISIA-CR. Several filters in Image-Pro 10 software (Media Cybernetics, Silver Spring, MD, USA) were used to emphasize the skin pores in the analysis area. The skin pore area (measured in pixels) was then analyzed.

2.6 | Measuring skin temperature and skin redness

Skin temperature measurements were performed on the forehead, cheeks, perioral area, and chin using a thermal imaging camera (FLIR T640, Wilsonville, OR, USA). Facial images were captured using VISIA-CR (CANFIELD). Skin redness was analyzed on the cheeks and forehead using RBX red mode images from VISIA-CR.

2.7 | Measuring skin color

Skin color, lightness (L*), redness (a*), and yellowness (b*) were measured on the cheeks and forehead using a Spectrophotometer CM-2600d (Minolta, Japan).

2.8 | Statistical analysis

Statistical analyses were performed using SPSS Statistics 24 (IBM Corp., Armonk, NY, USA). The changes in skin characteristics between mask-wearing and non-mask-wearing areas were compared using repeated measures analysis of variance (RM-ANOVA). If normality was not satisfied, Friedman and Wilcoxon signed-rank tests were used. Statistical significance was set at $p < 0.05$.

3 | RESULTS

3.1 | Trans-epidermal water loss

TEWL of the cheek significantly increased by 29.15% ($p < 0.001$) in September compared to June 2020 (base) (Figure 2). The TEWL of the perioral area and chin increased by 16.21% ($p = 0.224$) and 4.86% ($p = 0.21$), respectively. Changes in TEWL for the cheek and perioral areas were significantly different from that of the forehead (non-mask-wearing area).

TEWL of the cheek significantly increased by 47.49% ($p < 0.001$) in December compared to the base. The TEWL of the perioral area and chin increased by 15.48% ($p = 0.359$) and 10.45% ($p = 0.14$), respectively. The change in TEWL for the cheek was significantly different from that of the forehead.

TEWL of the cheek significantly increased by 35.67% ($p < 0.01$) in March 2021 compared to the base. The TEWL of the perioral area increased by 10.81% ($p = 1.000$). The change in TEWL for the cheek and perioral area were significantly different from that of the forehead.

TEWL of the cheek significantly increased by 25.77% ($p < 0.01$) in June 2021 compared to the base. The TEWL of the chin decreased by 4.804% ($p = 1.000$). The change in TEWL for the cheek was significantly different from that of the forehead.

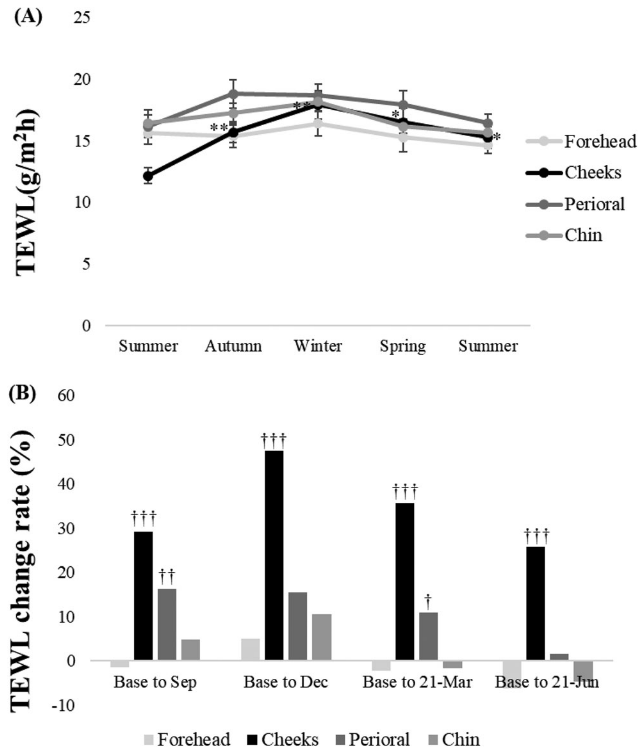

FIGURE 2 Trans-epidermal water loss (TEWL) measurement results in June 2020, September, December, March 2021, and June. (A) TEWL measurement results for each part. (B) TEWL change rate at each measurement point compared to the base for each part. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$ base versus September, December, March 2021, and June 2021. $^{\dagger}p < 0.05$, $^{\dagger\dagger}p < 0.01$, $^{\dagger\dagger\dagger}p < 0.001$ non-mask-wearing area versus mask-skin zone (mask-wearing area)

3.2 | Skin hydration

Skin hydration of the perioral area, cheek, and chin decreased by 18.54% (p = 0.309), 7.885% (p = 0.178), and 12.782% (p = 0.128), respectively, compared to the base (Figure 3). Skin hydration changes of the perioral area and chin were significantly different from that of the forehead.

Skin hydration of the perioral area significantly decreased by 24.04% ($p < 0.05$) in March 2021 compared to the base. Skin hydration of the chin decreased by 6.57% (p = 1.000). Skin hydration changes of the perioral area and chin were significantly different from that of the forehead.

Skin hydration of the perioral area decreased by 16.58% (p = 0.208) in June 2021 compared to the base. Skin hydration of the cheek and chin increased by 8.21% (p = 0.120) and 4.39% (p = 0.422), respectively. Skin hydration changes of the perioral area, cheek, and chin were significantly different from that of the forehead.

3.3 | Skin keratin amount

Skin keratin in the cheek significantly increased by 24.34% ($p < 0.05$) in September compared to the base (Figure 4). The amount of skin keratin in the perioral area and chin increased by 3.54% and 7.50%, respectively ($p > 0.05$). The keratin level change in the cheek was significantly different from that in the forehead.

Skin keratin in the cheek, perioral area, and chin significantly increased by 50.62% ($p < 0.001$), 26.47% ($p < 0.05$), and 22.12% ($p < 0.05$), respectively, in December compared to the base. The keratin level change in the cheek was significantly different from that in the forehead.

Skin keratin in the cheek significantly increased by 33.39% ($p < 0.05$) in March 2021 compared to the base. The amount of keratin in the chin increased by 10.49% ($p > 0.05$), whereas skin keratin in the perioral area decreased by 6.04% ($p > 0.05$). Skin keratin changes in the cheek and chin were significantly different from that in the forehead.

Skin keratin levels in the cheek and chin significantly increased by 41.01% ($p < 0.01$) and 27.01% ($p < 0.001$), respectively, in June 2021 compared to the baseline. Skin keratin in the perioral area increased by 32.13% (p = 0.08). Skin keratin changes in the cheek and chin were significantly different from that in the forehead.

3.4 | Skin pore area (pixel)

The skin pore area of the cheek and perioral area significantly increased by 84.48% ($p < 0.05$) and 95.46% ($p < 0.01$), respectively, in December compared to the base (Figure 5). The skin pore area change of the cheek was significantly different from that of the forehead.

The skin pore area of the cheek and perioral area significantly increased by 66.09% ($p < 0.01$) and 149.22% ($p < 0.05$), respectively, in March 2021 compared to the base. The skin pore area change of the cheek was significantly different from that of the forehead.

The skin pore area of the cheek significantly increased by 78.59% ($p < 0.05$) in June 2021 compared to the base. The skin pore area of the perioral area increased by 129.43% (p = 0.086). The skin pore area change of the cheek was significantly different from that of the forehead.

3.5 | Skin elasticity

Skin elasticity of the cheek and perioral area significantly decreased by 7.63% ($p < 0.01$) and 6.37% ($p < 0.05$), respectively, in September 2020 compared to the base (Figure 6).

Skin elasticity of the cheek, perioral area, and chin significantly decreased by 15.26% ($p < 0.001$), 12.38% ($p < 0.001$), and 8.39% ($p < 0.01$), respectively, in December 2020 compared to the base.

Skin elasticity of the cheek, perioral area, and chin significantly decreased by 21.94% ($p < 0.001$), 16.86% ($p < 0.001$), and 13.05% ($p < 0.01$), respectively, in March 2021 compared to the base.

Skin elasticity of the cheek and perioral area significantly decreased by 11.31% ($p < 0.01$) and 8.02% ($p < 0.001$), respectively, in June 2021 compared to the base. Skin elasticity of the chin decreased by 7.06% (p = 0.053).

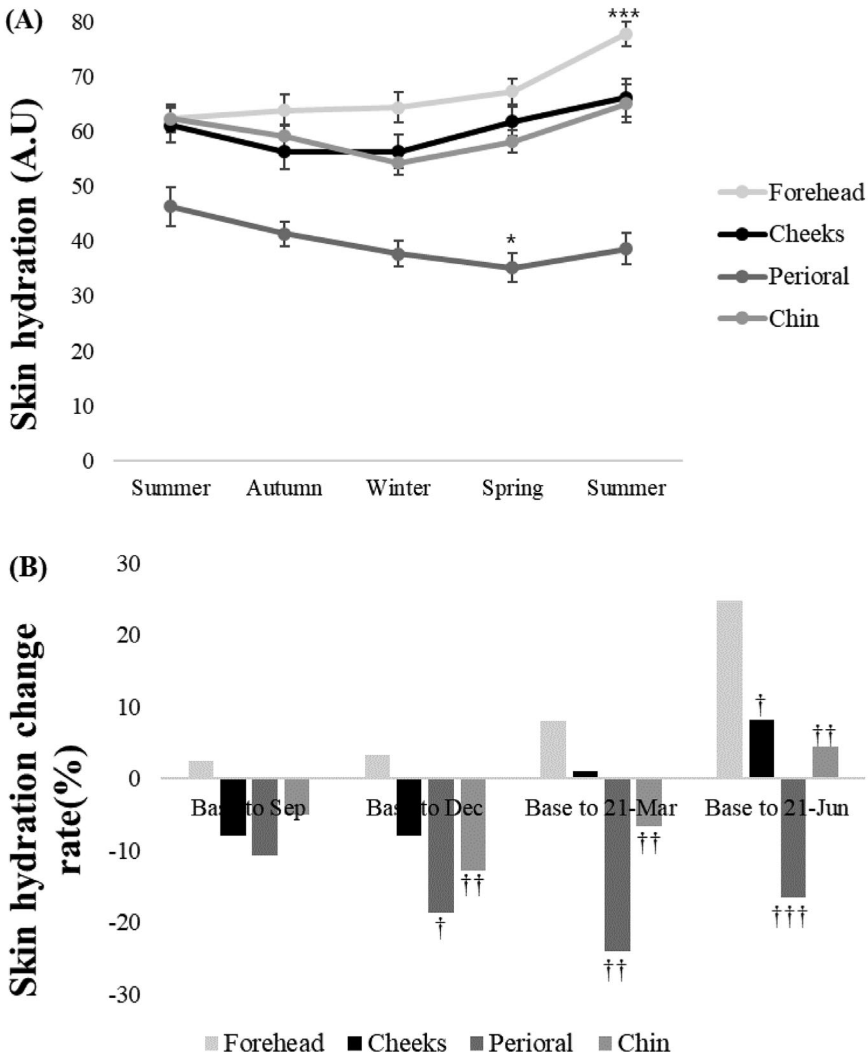

FIGURE 3 Skin hydration measurement results in June 2020, September, December, March 2021, and June. (A) Skin hydration measurement results for each part. (B) Skin hydration change rate at each measurement point compared to the base for each part. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ base versus September, December, March 2021, and June 2021. †$p < 0.05$, ††$p < 0.01$, †††$p < 0.001$ non-mask-wearing area versus mask-skin zone (mask-wearing area)

3.6 | Skin temperature

The skin temperature of the cheek, perioral area, and chin significantly increased by 5.01% ($p < 0.001$), 2.27% ($p < 0.05$), and 2.49% ($p < 0.05$), respectively, in September compared to the base (Figure S1). The skin temperature change of the cheek was significantly different from that of the forehead ($p < 0.001$).

The skin temperature of the cheek, perioral area and chin significantly increased by 7.29% ($p < 0.001$), 3.63% ($p < 0.001$), and 3.94% ($p < 0.01$), respectively, in December compared to the base. The skin temperature change of the cheek was significantly different from that of the forehead ($p < 0.001$).

Skin temperature of the cheek, perioral area, and chin significantly increased by 5.81% ($p < 0.001$), 2.78% ($p < 0.001$), and 4.06% ($p < 0.01$), respectively, in March 2021 compared to the base. The skin temperature change of the cheek was significantly different from that of the forehead ($p < 0.001$).

The skin temperature of the cheek significantly increased by 2.70% ($p < 0.05$) in June 2021 compared to the base. The skin temperature of the perioral area increased by 0.86% ($p > 0.05$). Additionally, the skin temperature changes of the cheek ($p < 0.001$) and perioral area ($p < 0.05$) were significantly different from that of the forehead.

3.7 | Skin color

Skin redness of the cheek increased by 3.60% ($p > 0.05$), while skin yellowness significantly decreased by 6.19% ($p < 0.05$) in September compared to the base (Figure 7).

Cheek redness was significantly increased by 13.19% ($p < 0.01$) in December compared to the base. Skin lightness of the cheek significantly decreased by 1.61% ($p < 0.01$), and skin yellowness decreased by 7.38% ($p > 0.05$). Redness and lightness changes of the cheek were significantly different from that of the forehead.

Cheek redness was increased by 10.77% ($p = 0.054$) in March 2021 compared to the base. Skin yellowness of the cheek significantly decreased by 8.87% ($p < 0.01$). Redness and lightness changes of the cheek were significantly different from that of the forehead.

Redness of the cheek increased by 6.47% ($p > 0.05$), while yellowness of the cheek decreased by 8.87% ($p > 0.05$) in June 2021

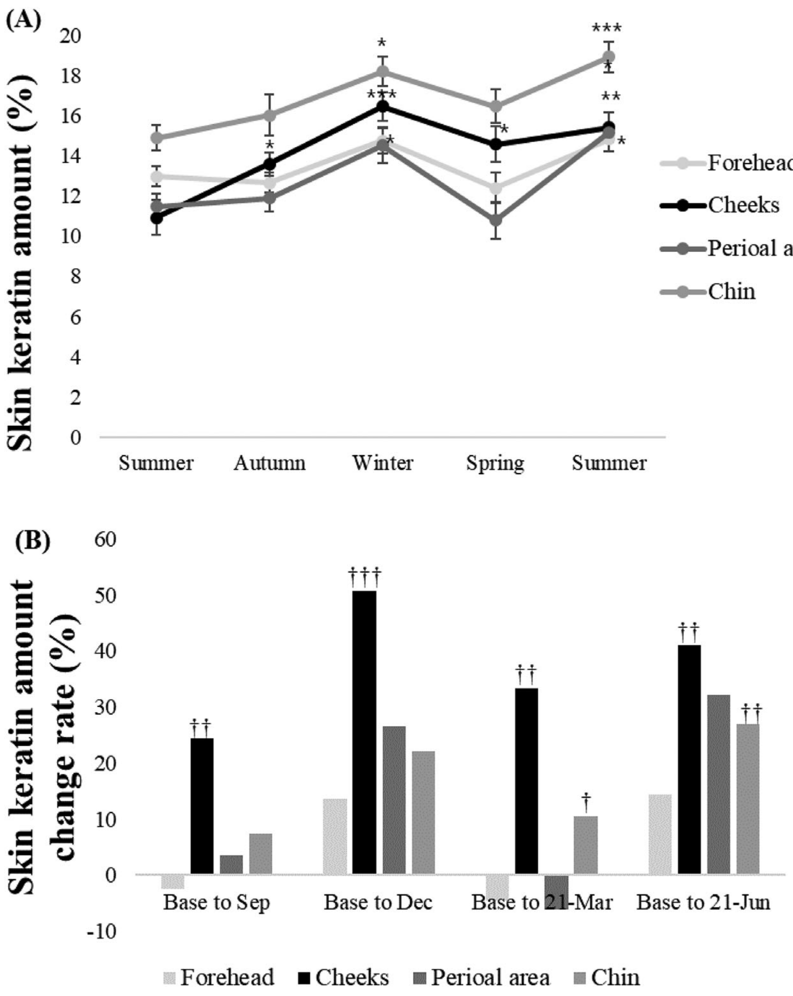

FIGURE 4 Skin keratin amount measurement results in June 2020, September, December, March 2021, and June. (A) Skin keratin amount measurement results for each part. (B) Skin keratin amount change rate at each measurement point compared to the base for each part. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$ base versus September, December, March 2021, and June 2021. $^{\dagger}p < 0.05$, $^{\dagger\dagger}p < 0.01$, $^{\dagger\dagger\dagger}p < 0.001$ non-mask-wearing area versus mask-skin zone (mask-wearing area)

compared to the base. Cheek redness change was significantly different from that of the forehead.

3.8 | Skin redness

Skin redness of the cheek increased by 5.36% ($p > 0.05$) in September compared to the base. Cheek redness increased by 11.41% ($p > 0.05$) in December compared to the base, and cheek redness change was significantly different from that of the forehead.

4 | DISCUSSION

When people wear a face mask, the internal temperature and humidity in the mask tend to increase, leading to a substantial increase in the skin temperature of the mask-wearing area.[13,14] In addition, the skin may be "blocked" and bodily fluids such as perspiration may remain on the skin. The high temperature of the mask microclimate could increase the skin surface temperature, lowering the inflammatory threshold and reducing skin resistance.[15] High humidity around the skin increases the hydration of the stratum corneum. When the skin is overhydrated, keratinocytes swell and change the skin structure, which can damage the skin barrier.[15,16] In addition, when the sebaceous glands are compressed and blocked by face mask, the secretion of sebum may not occur well. This can increase the inflammatory response and change the pH of the skin.[17] In this study, we investigated how the skin was affected by microclimate changes around the skin caused by prolonged use of mask.

After participants started to wear a mask daily, the skin variables were measured for a total of 1 year at 3-month intervals from the first measurement time (June 2020). During this period, the skin may have been naturally affected by aging and the external environment (seasonal changes). Considering this, TEWL, an indicator of skin barrier damage, showed significant changes in the mask-skin zone, especially in the cheek. The cheek is affected by the mask microclimate; simultaneously, there is physical stimulation caused by the direct contact of the mask.[5] The TEWL of the skin in the period without wearing a mask was highest in winter and the next highest in spring.[18] The seasonal change results of the current study are similar to these results. Therefore, mask wearing and the effect of seasons worked together to cause a large change in the cheek, which may have led to the significant difference from the non-mask-wearing areas. The perioral area, another mask-skin zone, also had a large TEWL change rate, and at

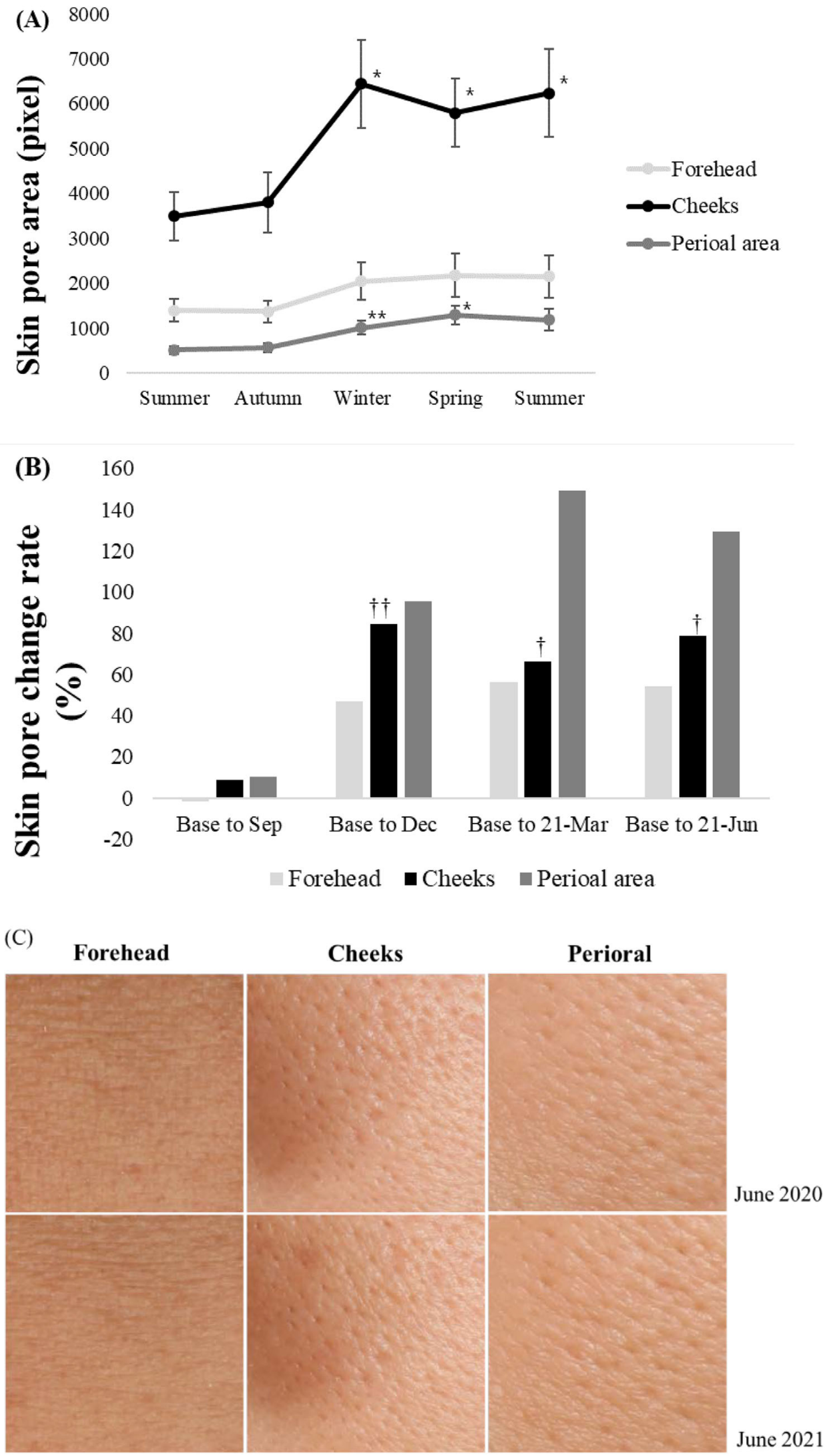

FIGURE 5 Skin pore area measurement results in June 2020, September, December, March 2021, and June. (A) Skin pore area measurement results for each part. (B) Skin pore area change rate at each measurement point compared to the base for each part. (C) Image of the skin pore area variations over 12 months. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$ base versus September, December, March 2021, and June 2021. $^{\dagger}p < 0.05$, $^{\dagger\dagger}p < 0.01$, $^{\dagger\dagger\dagger}p < 0.001$ non-mask-wearing area versus mask-skin zone (mask-wearing area)

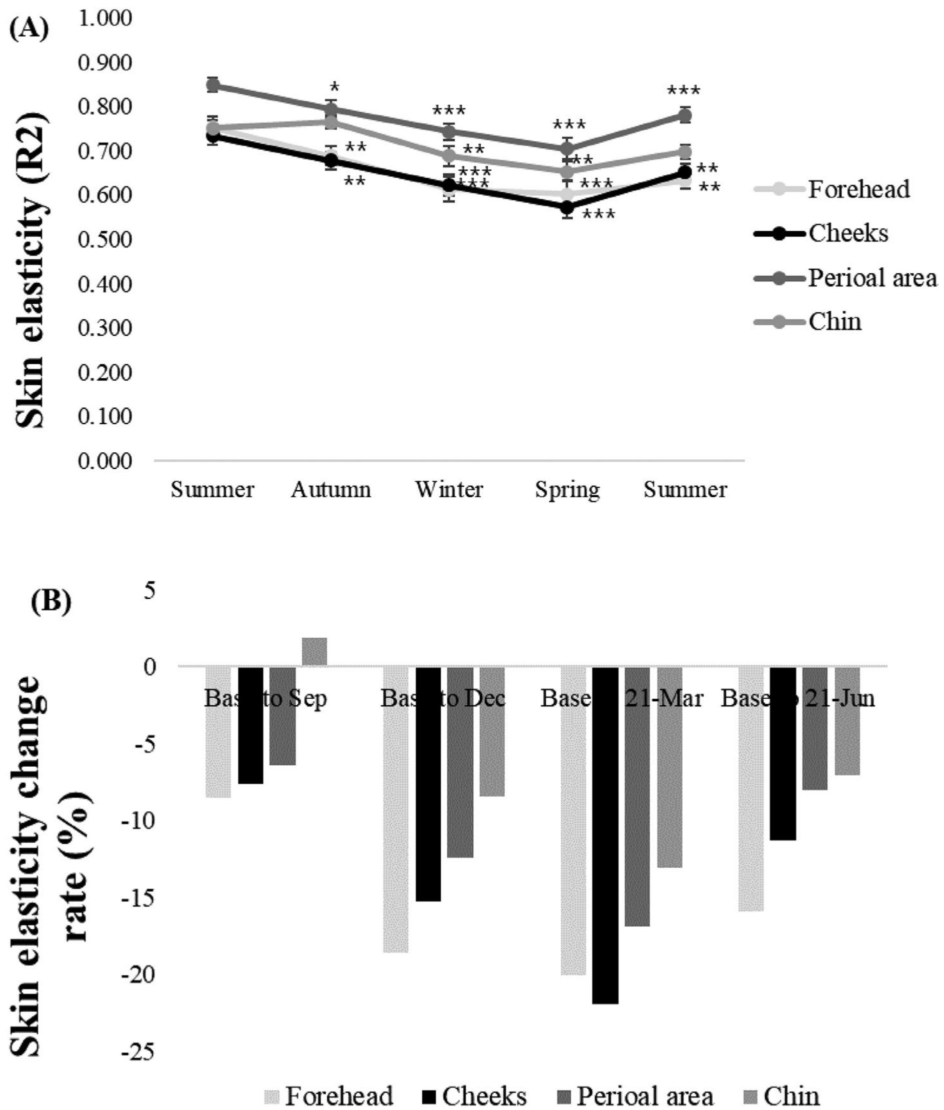

FIGURE 6 Skin elasticity measurement results in June 2020, September, December, March 2021, and June. (A) Skin elasticity measurement results for each part. (B) Skin elasticity change rate at each measurement point compared to the base for each part. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$ base versus September, December, March 2021, and June 2021. $^{\dagger}p < 0.05$, $^{\dagger\dagger}p < 0.01$, $^{\dagger\dagger\dagger}p < 0.001$ non-mask-wearing area versus mask-skin zone (mask-wearing area)

some measurement points, there was a significant difference from the forehead.

When a mask was not worn, skin hydration tended to be high in the summer and low in the winter.[18–20] Among the measurement sites, except for the perioral area, the change pattern was similar to the seasonal change. Skin hydration of the perioral area continued to decrease until March 2021 and rose slightly in June. It is thought that this is because the perioral area is exposed to the mask microclimate and simultaneously affected by exhalation. Although the skin temperature varies by body part,[21] it is approximately 31°C–32°C,[19] while the exhalation temperature is higher at 31.4°C–35.4°C.[20] As a result of a mask being worn, the heat from exhalation was not circulated to the environment; therefore, the skin around the perioral area might have become particularly dry. The cheek and chin, the other mask-skin zone, also showed significant differences from the forehead at some measurement points.

The skin keratin amount increased until December 2020, decreased slightly in March 2021, and increased again in June. Skin keratin levels were not completely consistent with TEWL and skin hydration results but tended to be somewhat related. As the skin barrier weakened and the skin became dry, the amount of skin keratin increased. According to a study on the correlation between seasons and skin characteristics in the period of not wearing a mask, the amount of skin keratin had a significant negative correlation with temperature and RH.[22] The results of skin keratin measurement in the current study until March 2021 were similar to these previously reported seasonal changes. However, in June 2021, the amount of skin keratin increased despite the rising temperature and RH. It also increased substantially compared to the forehead, which is a non-mask-wearing area. The mask-skin zone may

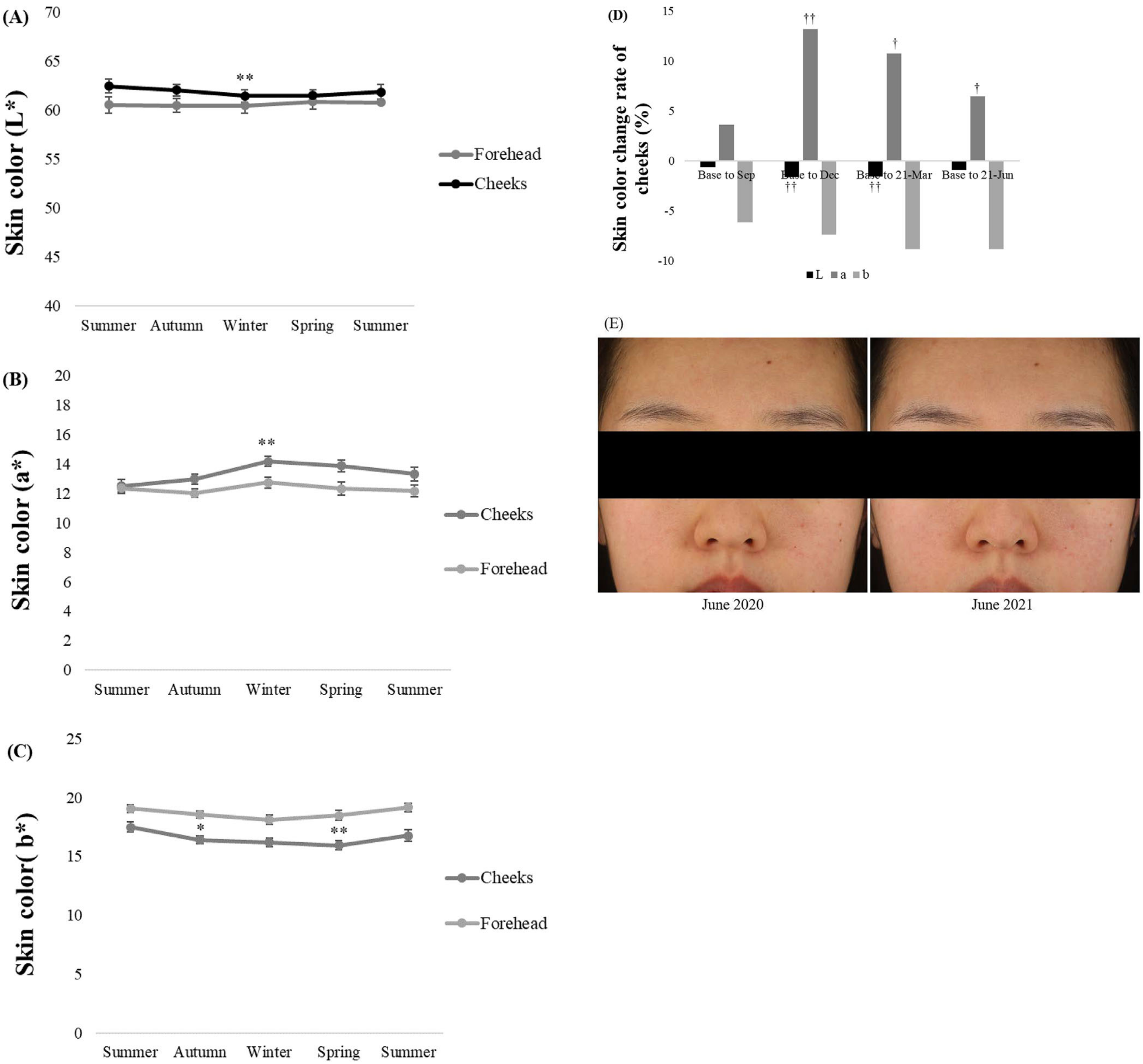

FIGURE 7 Skin color measurement results in June 2020, September, December, March 2021, and June. (A) Skin lightness measurement results for each part. (B) Skin redness measurement results for each part. (C) Skin yellowness measurement results for each part. (D) Skin color change rate at each measurement point compared to the base for each part. (E) Image of skin color changes within 12 months. Skin redness was significantly increased compared to the forehead. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$ base versus September, December, March 2021, and June 2021. $^{\dagger}p < 0.05$, $^{\dagger\dagger}p < 0.01$, $^{\dagger\dagger\dagger}p < 0.001$ non-mask-wearing area versus mask-skin zone (mask-wearing area)

have weakened the skin from accumulated fatigue after more than 1 year of mask wearing. As a result, the skin may have been in a state in which dead skin cells were more easily exfoliated, leading to increased amounts of skin keratin in the mask-skin zone.

Skin elasticity tended to decrease at all measurement points, and this pattern might be a phenomenon that occurs with increasing age. The skin pore area also tended to increase in all areas, which may have been affected by the decrease in skin elasticity.[23,24] However, the rate of decrease in skin elasticity was the highest in the forehead, while the rate of increase in the skin pore area was higher in the mask-skin zone, and there was also a significant difference from the forehead. Exposing the mask-skin zone to a mask microclimate, such as high temperature, high humidity, pressure, and increased sebum secretion[25–27] may alter pores along with natural aging.

Skin temperature significantly increased in the mask-skin zone and showed a significant difference from that of the forehead. However, since body temperature maintains homeostasis, it might be that skin temperature was changed easily by the external environment rather than that the basal skin temperature itself changed. Changes in skin temperature were similar to changes in TEWL and skin hydration.

TABLE 3 Skin change rates in June 2021 compared to the base of the mask-skin zone (mask-wearing area) and non-mask-wearing area

		TEWL	Skin hydration	Skin keratin amount	Skin pore area	Skin elasticity (R2)	Skin color (a)
Mask-skin zone	Cheeks	25.77%*,†††	8.21%†	41.01%**,††	78.59%*,†	−11.31%**	6.47%†
	Perioral area	1.61%	−16.58%†††	32.13%**	129.43%	−8.02%***	–
	Chin	4.80%	4.39%††	27.01%***,††	–	−7.06%**	–
Non−mask-wearing area	Forehead	-6.28%	24.85***	14.39%*	54.41%	−15.94%**	−1.49%

Abbreviation: TEWL, trans-epidermal water loss.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$, 2020 June versus 2021 June, $^{†}p < 0.05$, $^{††}p < 0.01$, $^{†††}p < 0.001$, non-mask-wearing area versus mask-skin zone (mask-wearing area).

This might be because the rate of change was large and the skin responded more to changes in external temperature when it was weakened.

The difference in skin redness was not statistically significant, but redness increased in the mask-skin zone. Skin redness increased the most in December 2020 and March 2021. This is thought to be due to the influence of wearing a mask during the dry season. As mask wearing became commonplace, the high-temperature environment around the skin continued, which lowered the threshold for inflammation, making the skin more sensitive to inflammation and leading to increased redness.[15] The redness of skin also increased ($p > 0.05$), with the highest increase in December 2020. The increase in the redness of the skin subsequently decreased, but it was higher than a year prior, and there was a significant difference from the redness of the forehead. Skin lightness was expected to increase because the cheek was covered by the mask; however, it slightly decreased. Since the mask continuously has contact with the cheek, it might cause an inflammatory reaction and increased pigmentation[28]; however, it is difficult to confirm a clear cause-and-effect relationship.

A face mask is an effective preventive method against COVID-19. However, continuous mask wearing may cause side effects. The effects of wearing a mask are also related to the wearing time[29]; wearing a mask for more than 4 h is correlated with the occurrence of skin symptoms. Before COVID-19, wearing a mask for more than 4 h was often due to occupational needs, such as for HCWs. Currently, the general public also often wears masks for 4 h. In this study, many participants wore masks for more than 4 h. The daily mask-wearing environment is likely to cause increased side effects in both the general population and in HCWs. To respond to this trend, it is necessary to know the skin characteristics affected by mask wearing. In this study, we studied skin changes during the year, including the period of mask wearing. Long-term use of a mask weakened the skin barrier, decreased skin hydration and elasticity, increased skin keratin and pore area, and affected skin redness and skin color in the mask-skin zone (Table 3). The skin could be weakened by prolonged mask wearing. In addition, the rapid environmental changes caused by donning and doffing the mask repeatedly[29] may exacerbate the changes in the skin caused by aging and the external environment.[30] Therefore, it may be necessary to provide antiaging and skin color management along with sufficient moisturizing and skin barrier care for mask-wearing skin. There are ways to relieve adverse skin symptoms caused by wearing a mask on a daily basis, such as using a gentle cleanser and appropriate moisturizer before and after wearing a mask.[31,32] This may be helpful in alleviating skin changes caused by prolonged mask use.

This study has a limitation. It was not possible to evaluate the effects of wearing a mask or not wearing a mask in the same skin area simultaneously because everyone wore a mask during the study period. Despite this limitation, we were able to confirm the skin characteristics that showed similar changes between the areas covered by the mask, unlike the forehead. In addition, we found significant differences between the areas covered by the mask and those areas that were not covered by the mask.

5 | CONCLUSION

To research the long-term effects of wearing a mask on a daily basis, we investigated the skin changes of wearing a mask for 1 year in general office workers. After 1 year of mask wearing, there were significant differences in skin characteristics compared to the base in the mask-skin zone and between the mask-skin zone and non-mask-wearing area. It is thought that skin changes in the mask-skin zone were reflected in the effects of wearing a mask as well as the effects of aging and seasonal changes. Because the human body tries to maintain homeostasis, the skin adapts to the changing environment, leading to recovery rather than continuous deterioration. This study is meaningful in that we evaluated the skin characteristics of the mask-skin zone from long-term face mask use under the lifestyle conditions of the general population. The results suggest the need for focused skin care in the mask-skin zone.

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CONFLICT OF INTEREST

All authors declare that there are no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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