

## Differences in the stratum corneum of Indonesian infants and adults

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### Abstract

**Background** Although understanding the stratum corneum (SC) of infant skin is important to avoid skin diseases such as atopic dermatitis, there has been no such investigation in Indonesian infants to date.

**Objective** To obtain a basic knowledge of SC characteristics in Indonesian infants in order to develop methods for infant-specific skin care and to prevent dermatitis and infection.

**Methods** Seventy-two healthy, full term infants aged 1 to 24 months who were native Indonesians residing in Jakarta were enrolled in this study. Some of the mothers were also enrolled in the study as adults (n=30). Transepidermal water loss (TEWL) and hydration of the SC (capacitance) on the thigh, buttock, and upper arm were measured after sufficient acclimation in an air-conditioned room, in both infants and mothers.

**Results** The SC hydration was significantly higher in infants than adults at all sites measured, including the buttocks, which is a diaper area. Infant TEWL values were also significantly higher than in adults at all sites. Hydration of the SC and TEWL values showed no significant correlation with age of infant for any site. The SC hydration and TEWL values of Indonesian infants did not decrease to adult values within 24 months, which indicates that the SC characteristics in infants continue to develop after 24 months of age.

**Conclusion** Indonesian infants aged 0-24 months have significantly higher SC hydration and TEWL values than Indonesian mothers. However, infant age has no correlation to SC hydration or to TEWL values. [Paediatr Indones. 2017;57:35-40. doi: 10.14238/pi 57.1.2017.35-40].

**Keywords:** *infant skin, stratum corneum, Indonesian*

Hydration of the stratum corneum (SC) and transepidermal water loss (TEWL) are measurable parameters indicative of SC functions.<sup>1,2</sup> A decrease of the hydration value indicates the dryness of the SC, which occasionally leads to xerosis (dry skin) accompanied by desquamation, and/or pruritus. The TEWL value is a measurement of the barrier function of the SC. Elevated TEWL values indicate barrier disruption, which occasionally leads to an incursion of extraneous substances resulting in infections, contact dermatitis, and/or allergenic diseases.

Therefore, monitoring and understanding the SC properties of infant skin is important to avoid skin diseases, such as diaper dermatitis, infections, and atopic dermatitis. Indeed, many published studies have reported skin changes during infant growth and differences from adult skin, with regards to SC function and skin structure.<sup>3-13</sup> Many factors, such as age, body site, skin type, and ethnicity are likely to

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influence the changes in SC characteristics, namely, hydration expressed by capacitance (also known as the conductance value) and TEWL.

To date, there has no such study on SC characteristics in Indonesian infants. Hence, we investigated the SC changes during growth and the differences between Indonesian infant and adult skin in subjects residing in Jakarta. The purpose of this study was to obtain a basic knowledge of the SC traits in Indonesian infants in order to develop infant-specific skin care methods, skin-protective diaper formulations, as well as to prevent dermatitis and infection.

## Methods

All clinical tests were performed according to the Declaration of Helsinki. All protocols were approved by the Ethical Committees of the Medical Faculty, University of Indonesia and Biological Science Research, Kao Corporation (Tochigi Japan). All protocols were submitted to the Indonesian national regulatory authority (*Badan Pengawas Obat dan Makanan/BPOM*) for approval. Subjects were recruited and their parents provided signed informed consent.

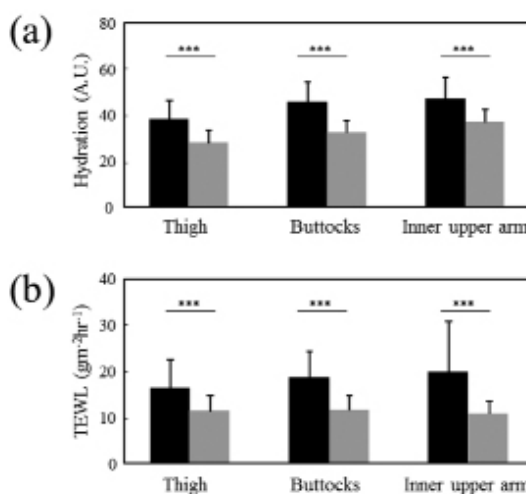
The source population of the study was eligible volunteers according to the inclusion criteria, who lived in Jakarta. This study was conducted at the clinical laboratory of Equilab International (Jakarta, Indonesia) in two separate, but similar, examinations, in November 2010 (1<sup>st</sup> examination: 30 infants and 30 their mothers as adults) and in March/April 2012 (2<sup>nd</sup> examination : 42 infants only). A total of 72 healthy, full term infants aged 1 to 24 months (35 girls and 37 boys) and 30 adults who were native Indonesians were enrolled in the study. Infants were biological children of the mothers, with proof of birth certificate. Infants who were genetically mixed with other races (non-Indonesian native races) such as Chinese, Arabic, American, etc. were excluded from the study. Subjects were from a middle-to-upper class socioeconomic status and used more than 2 diapers daily. Exclusion criteria were the presence of dermatitis at the sites of measurement, the use of systemic medicine within 2 weeks of the test, or those deemed inappropriate by the study physician.

All measurements were carried out in the same air-conditioned room, which was kept at  $20 \pm 2^\circ\text{C}$  and  $50 \pm 10\%$  relative humidity. All measurements were conducted in a similar manner using the same apparatus, technician, and conditions. After removing the infants' clothing, skin areas were wiped with a wet towel, left to dry for 20 minutes, then acclimated for 20 minutes. The measuring sites on the adults were treated in a similar manner. The TEWL was measured using a *Tewameter*<sup>®</sup> (Courage & Khazaka Electronic GmbH, Köln, Germany). Subsequently, the SC capacitance was measured using a *Corneometer*<sup>®</sup>CM (Courage & Khazaka), according to previously reported specifications.<sup>14, 15</sup>

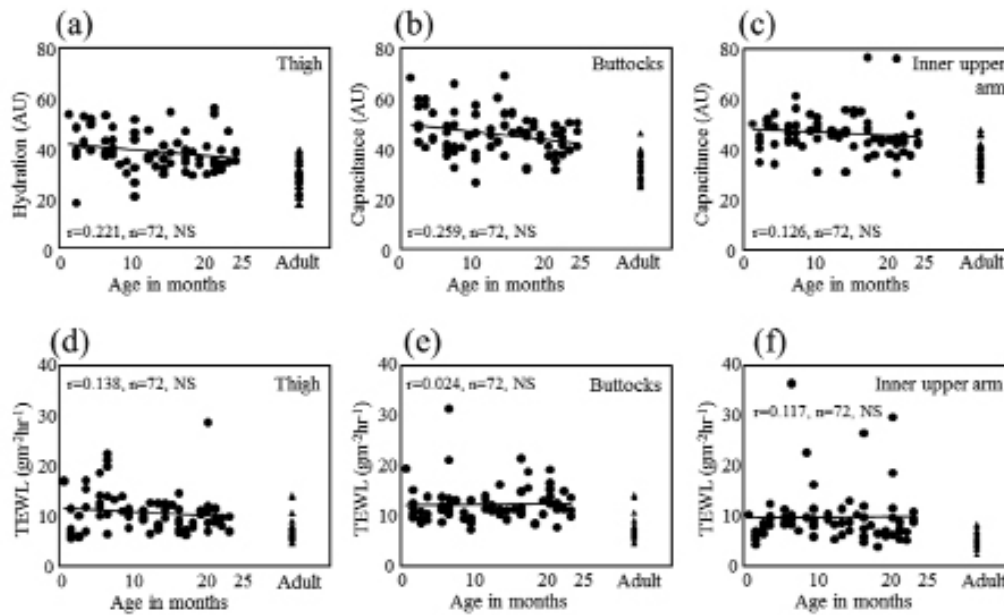
Measurements were performed on subjects' skin of the inner thigh, buttock, and inner upper arm. Crying infants were not measured until they became quiet or fell asleep. Student's T-test or Tukey's test were used to determine statistical significance ( $P < 0.05$ ). Correlation coefficient values were determined by linear regression using the statistical function of Microsoft Excel. The statistical significance ( $P < 0.05$ ) of the correlation coefficient was determined by a correlation coefficient ( $r$ ) table.

## Results

The mean SC hydration (capacitance) and TEWL values of infants and adults are shown in **Figure 1**. The mean SC hydration in infants was significantly higher than in



**Figure 1. Stratum corneum characteristics of infants and adults (mother).** (a) Hydration (Capacitance), (b) TEWL, solid bar ■: infants age in 1-24 months age (n=72), gray bar ▒: adults (mother, n=30). Bars show means  $\pm$  SD. Student-t test was used to determine statistical significance. \*\*\* $p < 0.001$ .



**Figure 2. Individual plots of stratum corneum hydration and TEWL values versus age in month of infants on three sites.**  
 (a), (b), (c): Hydration (Capacitance), (d), (e), (f): TEWL, (a)(d): thigh, (b)(e): buttocks, (c)(f): inner upper arm. Correlation coefficient values were determined by linear regression. The statistical significance ( $p < 0.05$ ) of the correlation coefficient was determined by a correlation coefficient ( $r$ ) table. NS means not significant.

adults, at all sites, including the buttock (diaper area).

The mean TEWL value in infants was also significantly higher than in adults, at all sites.

Individual plots of SC hydration and TEWL values against age (in months) are shown in **Figure 2**. Hydration of the SC had no significant correlation with infant age at any of the sites. The TEWL value also had no significant negative correlations with infant age at any of the sites. The SC and TEWL values of the infants did not approach the adult values even at 24 months of age, which indicates that the growth of infant skin continues to develop after 24 months of age.

## Discussion

In this study, we assessed the SC characteristics of 72 healthy, full term Indonesian infants aged 1 to 24 months. Hydration of the SC is a parameter that reflects skin dryness. Decreased SC hydration (capacitance) indicates a drier SC. It is well known that a dry environment and/or an exposure to a detergent often causes xerosis (dry skin) accompanied

by desquamation and/or pruritus. Some types of dermatitis, such as atopic dermatitis, are commonly accompanied by the symptom of decreased SC hydration.

In infant skin, SC hydration tends to decrease within several days after birth, followed by an increase with post-neonatal age.<sup>3-6,8,9</sup> The SC hydration of infants aged 1 to 24 months has been reported as higher than<sup>4,5,8,10</sup> or similar to that of adults.<sup>6</sup> However, site-dependent differences have also been reported. A significant difference in capacitance between infant and adult skin was observed on the forearm skin, but not on the buttocks.<sup>3</sup> In addition, variations in changes with growth during the first 90 days of life on the forearm, buttocks, and facial skin have been reported.<sup>4</sup> Some differences in SC hydration between thigh skin and diaper-covered buttocks were also observed.<sup>10</sup>

In this study, Indonesian infants aged 1-24 months had significantly higher SC hydration than adults at all sites, including the buttocks (**Figure 1**). Infant age-related increases or decreases in capacitance were not noticeable (**Figure 2**). These results agree with most of previous reports, except for

some site-specific differences.<sup>3,5,6,8,10</sup> Collectively, it is likely that the SC in Indonesian infants is hydrated enough from even the 1<sup>st</sup> month of age and is stable to at least 24 months of age, the same as previously reported for other ethnicities.<sup>5, 6, 11</sup>

The TEWL value is generally used to evaluate the skin barrier function, especially for the inside-out barrier.<sup>16</sup> Elevated TEWL values indicate a disruption of the skin barrier, which occasionally leads to an incursion of extraneous substances resulting in infection, contact dermatitis, and/or allergenic diseases. The barrier function of the skin has an important relationship to the onset of allergic dermatitis in infants, which has been clarified clinically.<sup>17,18</sup>

Full-term neonates are reported to have sufficient barrier function of the skin.<sup>19, 20</sup> Recent studies have indicated that healthy neonates at the first 24 hours after birth have a much higher TEWL value than adults.<sup>21, 22</sup> Nikolovski *et al.* reported that infants (3 to 12 months of age) showed much higher TEWL values on their arm skin than adults.<sup>5</sup> Several ethnicities have higher TEWL values in infants than in adults, on the upper inner arm skin.<sup>8</sup> However, other reports have shown that infants have similar TEWL values to adults.<sup>3,6</sup> In general, no difference in TEWL values have been noted between the buttock and forearm skin,<sup>3</sup> although some differences between diaper-covered buttock skin and the thigh have been reported.<sup>10</sup>

In our study, Indonesian infants aged 1-24 months showed significantly higher TEWL values than the adults, at all sites including the buttocks. Infant age-related increases or decreases were not noticeable in TEWL values, similar to the SC hydration value results. However, some outliers were observed in the TEWL values at all sites (**Figure 2**). The TEWL value is a very sensitive parameter because it can be influenced by physiological and environmental factors, such as whether an infant is active or at rest, room temperature, and humidity. Therefore, these factors may be responsible for the inconsistency among past studies. Also, the differences in body site, age, measuring instruments, and living habits may have contributed to the inconsistency. Hence, TEWL results should be interpreted with care.

Hydration of the SC depends on two major factors: natural moisturizing factor (NMF, derived

from filaggrin) and intercellular lipids (ICL). The amount of NMF changes dynamically with age, with newborns typically showing significantly higher levels of NMF than children of other ages and adults.<sup>6</sup> In contrast, another report showed that infants have significantly lower levels of NMF than adults at the SC surface.<sup>5</sup> Ceramide, a major constituent of ICL, is known to play key roles, not only in moisturizing, but also in skin barrier functions of the SC,<sup>23, 24</sup> but only a few studies have reported such. Minami-Hori *et al.* reported that ceramide content decreases remarkably with growth within the first 6 months after birth, and gradually becomes equal to adult values.<sup>10</sup> On the other hand, infants aged 6-24 months showed significantly lower levels of ceramide than children of other ages.<sup>25</sup>

A limitation of our study was the lack of clarifying the differences in SC characteristics of infants from those of adults specifically in terms of by two major factors: NMF and ceramide. Minami-Hori *et al.* reported that SC functions are not determined by single factors such as NMF, ceramides, etc., but are the result of the overall effects of numerous SC components that vary during growth.<sup>10</sup> In our study, NMF and ceramide levels in the SC were not determined. Further investigation is required to clarify the relationship between SC functions and biological factors, which apply to all ethnicities including Indonesian infants.

In conclusion, Indonesian infants aged 0-24 months have significantly higher SC hydration and TEWL values than Indonesian mothers. However, infant age has no correlation to SC hydration or to TEWL values. We consider that Indonesian infants also need a lot of attention for skin treatments even after 24 months of age, the same as shown in other ethnicities.

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## Conflict of interest

None declared.

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