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Morphological and histometrical analysis of skin in albino rabbits (*Oryctolagus cuniculus*) during postnatal period

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Abstract

Background: The skin is a dynamic organ, which is subject to significant structural modification during postnatal life, and is an important organ in comparative anatomy as well as experimental studies.

Aim of study: The present study was devised to understand the changes in the skin of albino rabbit (*Oryctolagus cuniculus*) of the factors related to morphology and histometrics after parturition regarding the regional difference between dorsal neck and dorsal abdomen.

Methods: Fifteen apparently healthy rabbits were used and divided into three postnatal age groups, 7 days, 1 month, and 3 months of age, with five animals in each group. Skin samples were taken from the dorsal neck and dorsal abdominal area and were visually and histometrically examined. The parameters evaluated were epidermal thickness, dermal thickness, total skin thickness, epidermal percentage when compared with total skin thickness and dermal percentage with total skin thickness. Statistical analysis was performed with the use of the software of the statistical package statistics for social sciences (SPSS, version 26.0), and differences were regarded as being significant at $P < 0.05$.

Results: Gross examination showed definite regional variation with the dorsal neck skin being more compact and curved with more hair, while the dorsal abdominal skin was wider and flatter and more definable following hair removal. Histometrical analysis showed a progressive increase in epidermal thickness, dermal thickness, and total skin thickness for both regions with increasing age. Epidermal thickness increased significantly with age in the neck and abdomen with no significant regional differences within the same age groups. Dermal thickness also increased progressively with age and the values of the abdomen were significantly greater than those of the neck region at 7 days and 3 months. Total skin thickness significantly increased from day 7 to later stages of the postnatal period in both regions but there was no significant difference in thin skin thickness between regions. In addition, the proportional contribution of the epidermis to total skin thickness increased with age, whereas the relative dermal percentage decreased in spite of the absolute increase in dermal thickness.

Conclusion, the skin of albino rabbits will keep on undergoing a progressive postnatal structural maturation characterized by increasing thickness of its major layers and the regional variation in gross morphology is measurable. Postnatal age was the main factor that affected most of the histometrical parameters and the secondary factor was the anatomical region. These findings provide us with baseline morphological as well as histometrical data that may prove useful to future studies in the fields of developmental anatomy, dermatology, and experimental skin research.

Keywords: Albino rabbit; Skin; postnatal development; morphology; histometry; epidermis; dermis; *Oryctolagus cuniculus*

1. Introduction

The rabbit (*Oryctolagus cuniculus*) is an important position in biomedical and laboratory research, of all strains of rabbits, the New Zealand White rabbit is one of the most established experimental models. Its sustained use is attached to accomplishments of practical handling advantages, reproducible performance in breeding, suitable body size and wide applicability in toxicology, developmental investigations, tissue research and also in translational experimentation (Han *et al.*, 2024) ^[20]. The skin is the largest organ in the body, and it functions as an extremely specialized organ that provides an interface between the existence of

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the body and the external environment. It is not just a passive covering but it is a dynamic and multifunctional system that is responsible for mechanical protection, regulation of the barriers, thermoregulation, sensory perception, immune surveillance, secretion, and maintenance of the tissue homeostasis (Brito *et al.*, 2024) ^[10]. Contemporary research has confirmed the fact that skin structure and function are dependent upon the coordination of integration of the epidermis, dermis, hypodermis, appendages, extracellular matrix, vascular supply, neural elements, and resident immune populations (Dermitzakis *et al.*, 2024) ^[14]. In addition, the skin is of major relevance in pharmacology and toxicology because of its major role in topical absorption, transdermal permeation, local tissue response, and the response to environmental and chemical exposures. For these reasons, the detailed knowledge of the skin morphology and skin microstructure is very important in the basic and applied field of biological sciences (Guan *et al.*, 2023) ^[19]. In rabbits, the skin has received special attention because of its value in experimental dermatology, tests of irritation, in wound healing research and in research studies on skin models. Comparative work has shown that rabbit skin has its own unique structural features such as the thickness and organization of epidermis to name but a few compared to human and porcine skin (Brito *et al.*, 2024) ^[10]. These species-specific differences have scientific significance because they influence the behavior of permeability, histological interpretation, influence tissue response to injury, or extrapolate an experimental finding (Sharun *et al.*, 2024) ^[34]. At the same time, rabbit skin is still useful as a biological substrate for controlled study in the laboratory, especially if the goal is to record normal architecture, maturation with age, organization of the adnexa, and tissue specific distribution of the structural components. Recent research in rabbits using wound models provides additional support for the value of this species in the investigation of cutaneous repair and tissue remodeling and hence the need for detailed data on the normal organization of skin in well-defined rabbit strains to which reference data can be made (Uhm *et al.*, 2023) ^[36]. Rabbit skin is an interesting mammalian integumentary pattern, for it manifests unique and remarkable structural characteristics that give it special merit in both comparative anatomy and experimental dermatology. It is generally characterized as being a rather delicate, highly fur-bearing integument, playing protective, sensing and thermoregulatory roles, as well as providing an important model in laboratory studies (Carroll *et al.*, 2024; Sharun *et al.*, 2024) ^[11, 34]. Morphologically, it is largely covered in hair, which makes up a substantial part of the insulation, and the overall physiologic behavior of skin (Bouwer *et al.*, 2025a) ^[8]. At the same time, rabbits also have relatively low levels of sweat glands and this combination of thick fur and low rate of sudoriferous development is part of the reason that they are known to be sensitive to heat stress. Therefore, at the level of general morphology, the skin of rabbits is strongly specialized for protecting against the environment - fur - and less strongly for highly developed eccrine thermoregulation (Ebeid *et al.*, 2023; Carroll *et al.*, 2024) ^[15, 11]. Another morphologically prevalent is the rabbit skin the response to injury and repair. Experimental wound models have invariably showed a strong tendency to contraction-dominant healing and this has been attributed to the structural organization of rabbit skin (including its laxity, and the contribution of deeper muscular and connective elements, such as the panniculus carnosus) (Sharun *et al.*, 2024) ^[34]. Consequently, it is important that the general

morphology of the skin in rabbits not only relevant for descriptive purposes of the annotation but also relevant for the interpretation of the healing, fibrosis and tissue remodeling in experimental settings (Sharun *et al.*, 2024; Uhm *et al.*, 2023) ^[34, 36].

Aim of the Study

This research was supposed to examine the postnatal variation in morphological, Histometrical properties of the skin of New Zealand rabbits over varying periods of development, with comparative assessment done on dorsal abdominal and dorsal neck parts of the skin.

Objectives of the Study

1. To characterize the gross morphology features of the skin of the albino rabbits at the chosen postnatal stages.
2. To compare epidermal thickness, dermal thickness and total skin thickness of the dorsal neck and dorsal abdomen area of 7 days, 1 month and 3 months of age.
3. To compare the regional differences between dorsal neck and dorsal abdomen with reference to postnatal development.
4. To find out the relative roles of epidermis and dermis in the total thickness of the skin in postnatal development.
5. To determine the comparative effect of postnatal age and anatomical region on the skin development in albino rabbits.

Research Hypothesis

It was assumed that skin of albino rabbits would experience progressive postnatal morphological and histometrical maturation and that postnatal age along with the anatomical region will have an impact on the parameters of skin thickness with the latter having a larger effect.

Materials and Methods

Animals and study design

This study was conducted on fifteen apparently healthy albino rabbits. The animals were divided into three groups regarding their postnatal age: the 7 days, the 1 month, and the 3 months, and there were five rabbits for each group. The study has been planned to assess the postnatal morphological and histometrical development in the skin of the rabbit in the onset of development.

Sampling locations amid specimen collection

Skin specimens were taken from two areas of the dorsal body, the dorsal neck and the dorsal abdomen. These two regions were chosen for a comparative evaluation of regional variation during the postnatal development. After being dissected, the skin samples were carefully separated with the aim of preserving their normal structure, then washing with normal saline to remove blood and tissue debris. Gross examination was done to describe the external appearance of the sampled skin of each age group.

Fixing and preparation of specimens

The specimens collected were fixed in 10% formalin for 24 hours for preserving tissue structure to prevent autolysis. After fixation, the samples were prepared for microscopic study and the sections photographed under an Olympus microscope fitted with a digital camera.

Morphological examination

Morphological examination: Gross observation of the skin samples taken from the dorsal part of the neck and the dorsal

part of the abdomen were used as the basis for morphometric examination. Attention was paid to regional variations of external appearance of the skin at the studied postnatal ages.

Histometrical measurements

Histometrical evaluation was done by a color USB 2.0 digital image analysis system (Scope Image 9.0, China). The measured parameters were the epidermal thickness, dermal thickness, and total skin thickness. In addition, the percentage of epidermis thickness and dermis thickness compared to total human skin thickness were calculated from the obtained results.

Ethics Statement

It was ensured that all animal handling and sampling were carried out according to the approved ethical standards of handling laboratory animals and under the control of the respective academic authority in the Veterinary Medicine / Department of Anatomy, Histology and Embryology/ Al-Qasim Green University Iraq. Every effort was taken to decrease the stress of animals and humane treatment was carried out during the study.

Statistical analysis

The obtained data were analyzed with the help of version 26.0 of the Statistical package for social science (SPSS). Results were expressed in mean $\pm$ standard error (SE). Statistical differences between age groups and between the two studied regions were compared using analysis of variance (ANOVA) and evaluated as being significant at $P < 0.05$ (Field, 2020)^[17].

Results and Discussion

Appearance and Morphological study of skin

Gross visual inspection of the chosen skin areas demonstrated that there was clearly regional difference between the neck skin and the abdominal skin on the dorsal side of the rabbits used in the current study. The back of the neck was comparatively rounded, thick and anatomically constrained, being tightly fitted to the cervical form at the base of the ear, as illustrated in Figure (4-1). A close-lying, thick, and more compact fur covered the skin in the region, and, being more nearly shaving, left the region more full and externally less exposed. The hair of this place was especially rich, and furnished a warm fur-clothing, to some extent covering the surface of the skin, and rendering a more direct inspection of the integument beneath it less clear. Moreover, the skin of the dorsal neck was firmer and not as easily demarcated externally due to its curved shape, dense hair cover and a relatively smaller amount of exposed surface. Conversely, the dorsal abdominal region was broader, flatter and more exposed in comparison to the dorsal neck region. After clipping and removal of hair, the skin of the dorsal abdomen became more visible and demarcated as shown in Figure (4-2). It had a smoother surface, a more homogenous external outline and a relatively pale-pinkish-white coloration. The hairiness in this part seemed to be of a lighter sort than that of the back of the neck, and was more readily removed, leaving the surface of the skin more plainly seen. Gross examination also revealed a relatively thin and more delicate abdominal skin, with a broad and flat topography which allowed external observation and proper demarcation of the area of sampling. The abdominal area was found to be less compact with fur and more obviously so with the skin surface compared in the neck. Speaking of the overall look of the integument, the skin

in both areas was coarse and had no apparent defects. There was no evidence of obvious lesions in the skin of the neck or abdomen (dorsal abdomen). Both areas had a grossly healthy and continuous skin surface, without any pathological alteration. However, it was found that there were distinct regional variations in the skin thickness, as measured by naked eye, fur density, hair texture, amount of surface exposure, and ability to be studied visually. The back of the neck area was denser, thicker, and more compact in the fur-bearing integument, but the back of the abdomen area was more open, the skin smoother, the hair cover there being finer and less dense, and the outer visibility being more evident after clipping. Thus, the current gross results as shown in Figures (4-1, 4-2) offer external proof of regional morphological diversity in rabbit skin and offer an anatomical foundation to the consequent studies of histological, histochemical, and histomorphometrical data.



Fig 1: Gross morphological appearance of skin of dorsal abdomen in rabbit showing the sampling area selected in dorsal abdominal region after removal of hairs



Fig 2: Gross morphological appearance of the dorsal neck skin in rabbit, showing the selected sampling area in the dorsal cervical region

These results suggest that the skin of a rabbit was not grossly uniform over the body surface and the chosen dorsal sites have recognizable external differences in spite of not having been microscopically examined. The dorsal neck skin was characterized by mainly a denser fur bearing surface and more compact outline compared to the skin of the dorsal abdomen which was characterized by a broader exposed area and flatter skin topography following clipping. From a morphological point of view, it thus seemed that the dorsal abdomen was more suitable for direct visual evaluation and demarcation of the samples whereas the appearance of the dorsal neck remained more anatomically restricted and fur-dominated. The present gross findings therefore provide direct external evidence of regional morphological variation of rabbit skin and provide an anatomical basis for the evaluation provided subsequently by histological, histochemical, and histomorphometrical methods. The present gross findings

were consistent with the concept of regional skin variation in rabbits and not a homogeneous structure macroscopically. This was in an agreement with the Iraqi study of Fadhill, (2025) ^[16] who compared rabbit and hare skin, and showed site-related structural differences between the sampled regions including the abdomen and back. Although that work extended from histomorphometric and histochemical results analysis, it still contributes to the concluding that rabbit skin should not be considered uniform integument at all body regions. The same general interpretation was indirectly supported by the study of Rashid and Thamer, (2024) ^[33], who revealed that biological dynamism exists in the structure of rabbit skin, which was characterized by age-related structural changes in the epidermis, dermis, and subcutaneous tissue, suggesting that rabbit skin should not be considered as a static or homogenous part of the body organ. The fact that, the frost fur-bearing part, which was seen in the portion of the neck shown, may be interpreted in the light of the known follicular arrangement of rabbit skin. Rashad *et al.*, (2024) ^[32] demonstrated that rabbit skin was fundamentally haired skin and that adult skin of rabbit contains compound hair follicles which consist of first primary hair and a collection of secondary hairs with sheaths of connective tissue. That follicle-dominant organization was a reasonable anatomical explanation for the dense fur cover that was seen grossly in the dorsal neck region in the current study. Their report that fully developed skin in older neonatal rabbits had an extensive hair coat also agrees with the present observation that the distribution of fur was one of the most obvious external morphological features of rabbit skin. The more open and flatter surface of the dorsal abdomen exposed in the present study also could have a methodological significance. Grossly, this region appeared to be more accessible and easier to define following the clipping than did the dorsal neck region. This observation was compatible with the results from the international study of Sharun *et al.*, (2024) ^[34] in which full-thickness dermal wounds were created on the posterior dorsal surface of rabbits by using a standardized template, and more specifically since it was the dorsal aspect of the body due to the large area of skin provided for experimental procedures. Although their study did not concern basic morphology, but instead wound modelling, it lends support to the present observation that wider dorsal skin fields were especially suited to visual assessment, manipulation and sampling. The results obtained in the present study should be interpreted also within the limitations of gross examination. Macroscopic observation can clearly show the difference of surface extent, fur density, topographic exposure, but it can't be used to determine the thickness of the epidermis, dermal organization, appendageal density, subcutaneous tissue distribution, this was particularly important because Uhm *et al.*, (2023) ^[36] showed that rabbit skin was structurally different to human and pig skin as rabbit skin exhibited a markedly thin epidermis and thin epidermal sublayers compared with human skin. Thus, the regional gross differences found in the present study herewith should be viewed as an external descriptive foundation instead of a full structural explanation. The more dense and compact appearance of the skin of the dorsal neck region and the broader and flatter appearance of the skin of the dorsal abdomen strongly indicate regional variation, but the meaning of these differences biologically speaking can be made unmistakably clear solely from the histological, histochemical and histomorphometrical findings.

Histometric study

The results presented in Table (1) showed an increase in the thickness of the epidermis in the neck and the abdomen region of the skin of the rabbit during the postnatal development was progressive. In the neck part, the mean epidermal thickness was 0.075 ± 0.041 on day 7, and became 0.107 ± 0.002 at 1 month and finally reached 0.132 ± 0.010 at 3 months. Statistical analysis showed the epidermal thickness at 3 months was significantly increased compared to the value at 7 days and that of 1 month was intermediate and not significantly different to either of the other two ages. In the abdomen region, the mean values were 0.045 ± 0.003 at 7 days, 0.123 ± 0.002 at 1 month and 0.138 ± 0.006 at 3 months (significant values). The results of the statistical analysis revealed that, the thickness of the epidermis at 1 month and 3 months was significantly higher than at 7 days, but there was no significant difference between 1 month and 3 months. Comparison between two regions in the same age group did not show significant difference between neck and abdomen at 7 days, 1 month and 3 months as shown by the similar small letters within each row as the findings indicate that epidermal thickness increased progressively in postnatal development in the two studied regions without significant regional variation between neck and abdomen at the age examined.

Table 1: Show Epidermal Thickness of Skin of the Neck and Abdomen of Rabbits of Various Postnatal Age. (Means $\pm$ SE)

Periods	neck	abdomen
7 days	0.075 ± 0.041 Aa	0.045 ± 0.003 Aa
1 month	0.107 ± 0.002 ABa	0.123 ± 0.002 Ba
3 months	0.132 ± 0.010 Ba	0.138 ± 0.006 Ba

Means with different capital letters in the same column and small letters in the same row were significantly different. $P < 0.05$

The present results indicate that postnatal age exerted a greater effect on epidermal thickness than anatomic region in the two selected locations on the dorsum. This interpretation was biologically plausible as early life skin was generally thinner and less mature than skin at later stages of life, with fewer layers of keratinocytes and less complete organization of the barrier membrane also present in the neonatal stage of life. Choi, (2025) ^[13] in a recent study on neonatal and infant skin barrier function stated that, the immature skin was structurally thinner and functionally less developed than the (later) matured length and that epidermal maturation continues after birth with each type of skin performance (thickness, increased keratinization) was improved. Although that study was not done in rabbits, it does have a great developmental scheme that was consistent with the present increase in epidermis from 7 days to 3 months. A similar study of Nascimento *et al.*, (2025) ^[30], who found that, the normal rabbit skin histology was noted as having recognizable keratin layer, epidermis and appendages within normal structure. The observations that, they have made confirm now that, the epidermis of the rabbit was a distinct and measurable layer of tissue which can be assessed histologically in relationship to physiological or experimental change. Although their research was designed to evaluate the biocompatibility of the dermatological structures, and not the postnatal development, it was favorable to the idea that, the rabbit epidermis maintains a delicate but well-defined organization whose thickness may be altered in biological conditions. At the local level in Iraq at present, the present results were also compatible with recent rabbit wound studies

that showed active epidermal responsiveness and re-epithelialization. Khudaier *et al.*, (2025) ^[24] reported the control wounds in rabbits had thickened epidermis in the healing process, while Aloe vera healing wounds showed earlier re-epithelization and organized healing process. Similarly, Jasim *et al.*, (2025) ^[23] reported the formation of regenerated epidermis layer on the wounds in the skin of rabbits and observed total regeneration of the epidermis layer in treated groups by the later healing stages. Although both these studies concerned repair rather than normal development, they still support the idea that rabbit epidermis was a biologically dynamic organ and capable of a measurable increased structure through proliferative and maturational processes. This supports that, the progressive increase seen in the present study reflects development of the epidermis and not random variation in number. A second point concerns the lack of a significant regional difference between neck and abdomen at each of the various ages studied. In the present study, the 2 regions exhibited a similar generalized development, indicating thinner epidermis (at 7 days) and higher thickness (at later ages). This may indicate that, in the selected dorsal sites epidermal maturation occurs in a fairly parallel fashion during early postnatal life. The finding also was consistent with the idea that, the process of epidermal maturation was dictated mostly by the age-related development of barriers and the maturation of keratinocytes rather than by significant divergence between two anatomically related dorsal regions. In this regard, Choi, (2025) ^[13] has been emphasized that the maturation of the epidermis after birth consists of a progressive improvement in the keratinization, the barrier competence and the stratum corneum functions, all of which would be expected to play a role in increasing thickness as time goes on.

The findings in Table (2) showed that dermal thickness of neck and the abdominal area on rabbit skin had an increasing age effect. The mean dermal thickness was also 0.120 ± 0.001 at 7 days, 0.131 ± 0.002 at 1 month and 0.148 ± 0.002 at 3 months which showed that, a definite increase in dermal thickness as age advanced. The abdomen area had a mean dermal thickness of 0.131 ± 0.002 at 7 days, 0.138 ± 0.003 at 1 month and 0.165 ± 0.005 at 3 months. Statistical results revealed that, the dermal thickness of the abdomen was also age regulated with the largest one being recorded in 3 months. This comparison of the two regions under the same age group indicated that, the abdominal dermis was much of a thickness than the neck dermis at the age of 7 days and 3 months, but showed no significant difference between the two regions at 1 month, the results showed that both areas were also grown in terms of dermal thickness at a steady postnatal rate, and the abdomen area had higher results than the neck area at the majority of periods of study.

Table 2: Show Dermal Thickness in Skin of Neck and Abdomen of Rabbits of Various Postnatal Ages (Means $\pm$ SE)

Periods	Neck	Abdomen
7 days	0.120 ± 0.001 Aa	0.131 ± 0.002 Ab
1 month	0.131 ± 0.002 Ba	0.138 ± 0.003 Aa
3 months	0.148 ± 0.002 Ca	0.165 ± 0.005 Bb

Means with different capital letters in the same column and small letters in the same row were significantly different $P < 0.05$

The gradual increase in dermal thickness in both the neck and abdomen between 7 days and 3 months was most likely due to normal postnatal maturation of the dermal connective tissue and not a result of simple increase in body size. The dermis

was a fibroblast-rich convolution connective tissue compartment and dermal fibroblasts were the principal cells responsible for synthesizing and maintaining the extracellular matrix which provides the strength, elasticity and structural bulk to the skin. Recent studies have also revealed that fibroblasts were not functionally uniform, but were different depending on the stage of development and the anatomical location, and these differences have implications for matrix deposition, tissue remodeling and the supporting capacity of the dermis. This makes the thickness of the dermis to increase with age and may also vary between body regions in the same animal (Boraldi *et al.*, 2024; Chitturi & Leask, 2024) ^[7, 12]. This result showed that, the abdominal dermis was significantly thicker than the neck dermis at 7 days and 3 months but not at 1 month may be interpreted as evidence for site-dependent dermal development. Dermal thickness was known to vary depending on the skin site and the thickness correlates with regional function, connective tissue organization and differences in fibroblast positional identity. In other words, the dermal fibroblasts "remember" the topography and this may cause differences in the collagen organization and dermal behavior between anatomical regions. The fact that, there was no significant difference at 1 month might therefore reflect a transitional stage of the language acquisition process during which both regions were growing at relatively similar rates before diverging again by 3 months (McGrath & Uitto, 2024; Chitturi & Leask, 2024) ^[25, 12]. Rabbit-specific evidence has also been found for the biological plausibility of thickening the skin by expanding the connective tissue. In a recent study on the effect of collagen on the rabbit skin, it was found that the collagen-based treatment of second-degree skin burns was associated with the proliferation of fibroblasts in addition to increased vascularization and profuse fibrosis in healing rabbit dermis (Munahi *et al.*, 2025) ^[27]. Although that study was done in a wound healing, rather than in normal postnatal development, it still showed that, the rabbit dermis has a very high capacity for collagen-rich remodeling and connective tissue expansion. This supports the hypothesis that, this thicker dermis recorded in the older rabbits from the present study was probably associated with increased extracellular matrix deposition and maturation of dermal connective tissue (Munahi *et al.*, 2025) ^[27]. An additional item which supports this interpretation was the contrast of developmental thickening and thinning associated with aging. Recent study on dermal fibroblast senescence has demonstrated that, later in life, decreased fibroblast function, and degradation of the extracellular matrix were implicated in decreased dermal resilience and in decreased dermal thickness. The present study showed the opposite, namely progressive thickening from 7 days to 3 months, consistent with a development phase involving active-matrix formation and tissue maturation and not senescent degeneration. Thus, the present results can be taken as a normal postnatal dermal maturation of the rabbit skin as age was seen to play the most dominant role and anatomical region had a secondary and yet detectable effect (Nan *et al.*, 2025) ^[29]. The results in Table (3) showed a progressive increase in total skin thickness at the neck and abdomen regions of skin of rabbit in postnatal development. At the neck area, the mean value of total skin thickness was measured as 0.195 ± 0.04 at 7 days, 0.238 ± 0.004 at 1 month and 0.281 ± 0.006 at 3 months. Statistical analysis revealed significantly higher value at 3 months compared to 7 days, while the value at 1 month occupied an intermediate position and was not significantly different from either of the other

two ages. In abdomen region, the mean value of total skin thickness was 0.176 ± 0.01 at 7 days which showed significant increase with mean values of 0.262 ± 0.013 at 1 month and 0.304 ± 0.014 at 3 months. The statistical results demonstrated that total skin thickness, 1 month and 3 months, were significantly higher than total skin thickness of 7 days, while the variance between 1 and 3 months was not significant. Comparison between the two regions in the same age group demonstrated that the neck and abdomen were not significantly different at 7 days, 1 month or 3 months which was indicated by the similar small letters within each row, which results in the finding that total skin thickness increased in parallel with age in both regions, but anatomical region has not significantly battered the effect in the investigated postnatal periods.

Table 3: Show Total Skin Thickness of Neck and Abdomen Regions of Rabbits at Various Postnatal Ages. (Means $\pm$ SE)

Periods	Neck	Abdomen
7 days	$0.195 \pm 0.04Aa$	$0.176 \pm 0.01Aa$
1 month	$0.238 \pm 0.004ABa$	$0.262 \pm 0.013Ba$
3 months	$0.281 \pm 0.006Ba$	$0.304 \pm 0.014Ba$

Means with different capital letters in the same column and small letters in the same row were significantly different. $P < 0.05$

The present results suggest that postnatal age was a more significant determinant of the total skin thickness than the regional factor between the two selected dorsal locations. This was biologically plausible since normal skin development requires the coordinated development of the epidermis, the dermis and the hypodermis, and the progressive extracellular matrix remodeling process and vascular development and structural integration processes postnatally. Recent international developmental study emphasized the deposition of skin morphogenesis as well as healing and homeostasis postnatum were conditioned by interactions between keratinocytes, fibroblasts, vascular elements, immune cells as well as extracellular matrix regulators, which all contribute to the progressive maturation and expansion of skin tissue structure through time (Wei *et al.*, (2025) [37]. Similarly, Gomes *et al.*, (2025) [18] emphasized late developmental skin differences from earlier in composition and organization of the extracellular matrix, implying that, the increase in skin dimensions were closely related to matrix remodeling and development of connective tissue rather than to isolated change in the epithelium mode alone. These concepts were agreement with the current increase of total skin thickness from 7 days to 3 months in both areas. The present findings were also compatible with modern molecular descriptions of skin development. Dermitzakis *et al.*, (2024) [14] Challenges in epidermal stem cell regeneration and translational relevance to idiopathic eight. In the context of the present study, the age-related increase in total skin thickness can thus be taken as the summation of effects of epidermal maturation, accumulation of dermal matrix, and continued structural specialization of the integument during postnatal growth. This fact that, the current parameter was a summation of the thickness of the epidermis and the dermis, and does not indicate either one of them in isolation. At the local Iraqi level, the present results were widely corroborated by the recent rabbit skin repair study that have shown the ability of rabbit skin to carry out a substantial tissue remodeling that involves both epithelial and connective tissue compartments. The recurrence of a collagen polynomial, specifically collagen type 1, in cases of injury-healing wounds in rabbits was

addressed by Al-Tae *et al.*, (2025) [3], who treated wound in paralumbar ST and testing it with collagen extract obtained from carp skin from carp skin and found maturation of granulation tissue, thick parallel collagen groups, intense collagen, and keratin-14 in cases of waits to activate the skin of the epidermis, synthesis of collagen in affected areas of skin function. Although that study assessed healing rather than normal postnatal development, it still supports the biological plausibility based on the findings that increases in skin thickness were related to integrated maturation of epidermal and dermal components. Similarly, Bashar and Najim, (2025) [6] reported on the accelerated healing of experimental wounds on rabbit skin with topical treatment actions, further confirming the fact that skin symmetries of rabbits were a dynamic tissue which was capable of any measurable structural progression in the process of regeneration. These Iraqi studies therefore support the current study, the increase in total thickness in the skin during the present work was correlated with real increase of the tissue, not because of some incidentally. The thickness and organization of rabbit skin can change quite significantly as both epidermal and dermal repair occurs. In this sense, the results obtained in Egypt was in agreement with the present conclusion that rabbit skin was structurally dynamic. However, the present study was different in that no significant regional difference was found between neck and abdomen even though abdominal values were numerically greater at 1 month and 3 months. This implies that under normal postnatal circumstances, and in the two chosen dorsal positions, age-related maturation overrode the regional variation in determining total skin thickness, Alnajjar (2025) [5]. From a biological standpoint, the progressive increase in the total skin thickness shown in the present study can be explained by cumulative postnatal maturation of the skin as a whole. This likely entails expansion and stratification of the epidermis, an increase in the dermal collagen and connective tissue organization, an increase in the maturity of the adnexal structure, and an increase in the integration of the structure with the underlying subcutaneous tissue. Wei *et al.*, (2025) [37] further noted that, subcutaneous adipose tissue undergoes rapid expansion during the perinatal and the early postnatal period and was involved in skin homeostasis and regulation of hair follicles, which will provide another developmental context to increase in skin dimensions. The absence of a statistically significant regional difference between the neck and abdomen may suggest that, the two dorsal areas were following a broadly similar developmental path during these said ages, although separate epidermal and dermal measurements may yield numerical differences. Thus, the present findings suggest that total skin thickness was controlled not by marked site-specific divergence between these two selected dorso-lateral regions but mainly by age-dependent maturation of the integumentary system.

The results presented in Table (4) showed that, the mean percentage thickness of the epidermis relative to the total skin thickness increased with the advancing age in both neck and abdomen region in the skin of rabbits. In the neck region, the epidermal percentage was tested to be $30.58 \pm 9.17\%$ at 7 days, then increased significantly to $44.95 \pm 0.69\%$ at 1 month, and $47.08 \pm 0.98\%$ at 3 months. In abdomen region, epidermal values were $25.35 \pm 1.06\%$, when done at 7 days whereas which increased drastically to $47.22 \pm 0.23\%$ and $45.50 \pm 1.57\%$ at 1 month and 3 months. Statistical analysis showed the values noted at 7 days were significantly less than those noted at 1 month and 3 months in both regions but that

there was no significant difference between 1 month and 3 months within either region. Comparison between the neck and abdomen even within the same age group, no marked regional difference, as evidenced by the similar small letters in each row, was observed at 7 days, 1 month or 3 months, the results showed that, the proportional contribution of the epidermis in the total skin thickness increased after the first postnatal stage in both investigated regions.

Table 4: Show Percent Epidermal Thickness as a Percent of Total Skin Thickness in Neck and Abdomen Regions of Postnatal Age Rabbits. (Means $\pm$ SE)

Periods	Epidermis	
	Neck	Abdomen
7 days	30.58 $\pm$ 9.17Aa	25.35 $\pm$ 1.06Aa
1 month	44.95 $\pm$ 0.69Ba	47.22 $\pm$ 0.23Ba
3 months	47.08 $\pm$ 0.98Ba	45.50 $\pm$ 1.57Ba

Means with different capital letters in the same column and small letters in the same row were significantly different. $P < 0.05$

The present findings suggest the most early postnatal stage seems to be one in which the epidermal contribution to total skin thickness was relatively smaller but that the late stages were marked by elicit epidermal share of the skin as a whole. This was biologically plausible, since skin early after birth was structurally immature and continues to undergo rapid maturation of the skin barriers after birth. Recent study on development have pointed out that the thickness of the epidermal barrier was not completely developed in the neonate and postnatally there was progressive keratinization, strengthening of the barrier, and improvement in the organization of stratum corneum and superficial epidermis (Boyar *et al.*, 2025; Strunk *et al.*, 2025) [9, 35]. These concepts were agreement with the current increment in epidermal percentage from 7 days to 1 month and 3 months in both the neck and the abdomen. From a structural viewpoint, the rise in epidermal percentage in the face of an ongoing growth in total skin thickness leads one to assume that epidermal maturation proceeded faster, proportionately, than would be expected if all skin compartments grew at exactly the same rate, this means that, the epidermis increased to a more substantial fraction of the whole skin thickness after the first week of life. This was consistent with the greater developmental that, the barrier's functional and structural organization was reorganized (with rather substantial changes in keratinocyte differentiation and surface barrier competence) throughout infancy with the postnatal barrier simply progressing to attain greater size (Boyar *et al.*, 2025; Strunk *et al.*, 2025) [9, 35]. Thus, the present rise in epidermal percentage was most likely a reflection of increasing epithelial maturation, rather than an arithmetical effect of increasing skin growth. The present results were also in agreement with the present-day results of rabbit-based evidence that rabbit skin was a dynamic tissue and capable of marked epidermal regeneration and re-epithelialization. In a more recent Iraqi study, Ramadhan *et al.*, (2026) [31] reported that, the wounds of rabbit skin treated with hyaluronic acid and silver nanoparticles exhibited a better epidermal regeneration and a more advanced re-epithelization than control wounds, indicating that, the skin epidermis of rabbits has a large capacity to develop in terms of structure under favorable biological conditions. Although that work focused on repair of wounds (not normal growth after birth), again this study was consistent with the interpretation that rabbit

epidermis was extremely responsive and capable of measurable expansion and maturation.

Similarly, a new study on a rabbit in Libya by Imrigha *et al.*, (2025) [22] reported the impact of low-level laser stimulation on the promotion of epithelialization and enhanced the histological process of cutaneous wound healing; once again, the biological potential of rabbit ears epidermis in structured elaborated development. Together, these regional studies add to the interpretation of the present work that the higher epidermal percentage was reflecting true epidermal maturation. At the international level, the rabbit skin still remains known as a useful for assessing multi-layer skin regeneration. Alipour *et al.*, (2025) [4] stated in their conclusion that rabbit models were appropriate for studying wound regeneration, which involves both epidermis and dermis, and their rabbit wound study had the importance of multi-tissue interactions during wound healing and remodeling. In a similar study with rabbits, Adel *et al.*, (2025) [1] found that, the wounds of treated and treated rabbits showed positive histological organization than controls, and this included better tissue regeneration and remodeling. Although these studies were conducted in wound instead of normal developmental, they support a more general conclusion that rabbit skin architecture was a dynamic process that was under regulation and that, the epidermal component was capable of developing to become more pronounced during the development of structure and the repair of wounds. This was an agreement with the current observation of increasing epidermis contribution to the total skin thickness with increasing age beyond the youngest age. The compositions of the epidermis relative to the total thickness of the skin experienced a very similar developmental pattern in both of the dorsal regions. In other words, the regional factor did not affect the percentage of epidermal significantly in the chosen sites, but the age clearly did. This pattern was compatible with the developmental vision that epidermal maturation after birth was a generalized biological procedure affecting the barrier competence all along the skin rather than a starkly divergent and passionate event in relation to two anatomically related regions on the dorsal side of the body (Boyar *et al.*, 2025; Strunk *et al.*, 2025) [9, 35].

The results presented in Table (5) revealed that, the mean percentage of dermis thickness with respect to the total skin thickness was decreased with age advancement either in the neck or abdomen regions of the skin of rabbit. In the neck region, the derived values of the dermis as a percentage of the total skin thickness were 69.41 $\pm$ 9.17% at 7 days, which significantly decreased to 55.04 $\pm$ 0.69% at 1 month and to 52.91 $\pm$ 0.98% at 3 months. In the abdomen region, dermal percentage was 74.64 $\pm$ 1.06% at the 7 days then decreased significantly to 52.77 $\pm$ 0.23% at the 1 month and measured 54.49 $\pm$ 1.57% at the 3 months. Statistical analysis showed that the values at 7 days were significantly greater than the values at 1 month and 3 months in both regions, but that there was no significant difference between 1 month and 3 months in either region. Comparison between the neck and abdomen within the same age-group showed no significant regional difference at 7 days, 1 month or 3 months since birth as indicated by the similar small letters within each row. The results show that while the thickness of the dermis showed absolute growth with increasing age, its contribution to the total thickness of the skin decreased after the first postnatal stage in both the examined regions.

Table 5: Show Percentage of Dermal Thickness in Relation to Total Skin Thickness in the Neck and Abdomen Regions in Rabbits After Different Postnatal Ages. (Means $\pm$ SE)

Periods	dermis	
	Neck	Abdomen
7 days	69.41 $\pm$ 9.17Aa	74.64 $\pm$ 1.06Aa
1 month	55.04 $\pm$ 0.69Ba	52.77 $\pm$ 0.23Ba
3 months	52.91 $\pm$ 0.98Ba	54.49 $\pm$ 1.57Ba

Means with different capital letters in the same column and small letters in the same row were significantly different. $P < 0.05$

The present results indicate that early in life, rabbit skin was characterized by a rather higher dermal contribution to total skin thickness, whereas at later stages of postnatal development a lower percentage dermal contribution was expressed since the skin as a whole expands and matures in a more integrated manner. This was biologically plausible, and was in agreement with recent developmental concepts which indicate that immature skin at early life was structurally incomplete and was undergoing marked postnatal maturation. Hobson *et al.*, (2025) [21] pointed out that a very early skin was developmentally immature, and that the skin barrier was not yet fully formed while Wilborn *et al.*, (2025) reported that skin characteristics in infants continue changing through the first months of life as skin structure and function was maturing. Although these studies did not involve rabbits, they corroborate the general principle that, the main process of postnatal skin formation was the changing relationships between tissue compartments rather than the uniform enlargement of one layer of skin alone. From a structural standpoint the reduction in dermal percentage in spite of the absolute increase of dermal thickness may be explained by the fact that, the growth in the skin depends on the concerted remodeling of multiple (several) compartments simultaneously. Naba, (2024) [28] described the extracellular matrix as the tissue scaffold because of this dynamic assembly and remodeling of interstitial extracellular matrix and basement membranes that control proliferation, differentiation, and tissue mechanics from the extracellular matrix. In the present study, this means that dermal expansion likely occurred in concert with very considerable growth of the epidermal and associated structural components, and that the relative contribution of the dermis to the total thickness of the skin then fell after the earliest age. Thus, the decrease in the dermal percentage should not be interpreted as dermal regression, but as a proportional change caused by integrated maturation of the skin postpartum. The present results were also compatible with the recent results obtained in rabbits indicating that normally rabbit skin consists of a keratin layer, epidermis, dermis and appendages supported by connective tissue as contributing to the final architecture of the skin. Nascimento *et al.*, (2025) [30] on the other hand, provided a description of normal rabbit skin histology within these integrated structural limits, which was consistent with the idea that the total skin thickness can be said to represent the maturation of a complex of cutaneous elements instead of the dermis itself. In this regard, the high dermal percentage observed at 7 days in the present study may reflect the relative dominance of the connective tissue component at an early stage before-beneficial later enlargement and maturation of the epidermal barrier and associated structures become more pronounced. At the local Iraqi level there was indirect support to the present findings in the recent rabbit healing studies that revealed active rebuilding of both epithelial and connective tissue compartments. Mohamed *et al.*, (2025) [26] reported that

oil treated rabbit cutaneous wounds had increased epithelial thickness accompanied by collagen fibers and blood vessels during wound healing, which showed that, the proportionate contribution of skin compartments could change during progression from maturation. Similarly, Al-Nuaimy *et al.*, (2025) [2] found that, the wound's healing was related to the improved re-epithelization and extracellular matrix remodeling in rabbits. Although these Iraqi studies were done in the context of repair rather than under normal postnatal conditions, they nevertheless seem to support the biological concept that the relationship of dermal thickness to total skin thickness was a dynamic one that was affected by the relative growth of the components of the epithelium and connective tissues. An important additional finding made in the present study that despite the fact of the absolute thickness of epidermis and dermis could vary numerically from one site to another, the latter's proportional contribution to total skin thickness showed a broadly similar developmental pattern in both dorsal regions. In other words, age had a more noticeable influence over anatomical site on this particular parameter. This was in agreement with the more general opinion that maturation of the skin postnotum represents a maturing of the entire organ with several developing compartments or densities of the skin growing in parallel with an establishment of an increasingly harmonious structural relationship with time.

Conclusion

The current research has indicated that the skin of the albino rabbits experiences evident postnatal morphological and histometrical development at the age of 7 days to age 3 months. The gross examination indicated familiar regional difference between the dorsal neck and the dorsal abdomen especially in surface topography, hair density and external appearance. The histometrical examination revealed that both the epidermal thickness, dermal thickness, and total skin thickness significantly increased in both the regions of study as age increased. Postnatal age was the most important aspect in skin development even though a regional difference was also reflected particularly in the dermal thickness. Moreover, the fact that the proportional contribution of the epidermis was increasing and the proportional contribution of the dermis was decreasing to the total skin thickness meant that maturation of the skin in the postnatal period involves the coordinated growth and remodelling of more than one layer. Such results give preliminary information that could be of use in future research in developmental anatomy, dermatology and experimental skin research in rabbits.

Recommendations

1. The future research must employ a larger sample size and other postnatal ages to give a comprehensive developmental picture of the rabbit skin.
2. It is suggested that future studies should involve other anatomical areas to explain the site-specific variation in more depth.
3. To further describe tissue maturation and structural component distribution, the use of histochemical and immunohistochemical methods should be used.
4. It is suggested that ultrastructural analysis will be used to assess minute alterations in the structure of epidermal and dermal during development.
5. The obtained baseline data can be utilized as a control in future research of dermatology, wound healing, toxicology, and experimental skin biology on rabbits.

Limitations of the Study

The current research suffered certain weaknesses which ought to be taken into account when interpreting the results. To begin with, the sample was insufficient since it consisted of fifteen rabbits at three postnatal ages. Second, the study was limited to two areas of the dorsal skin, that of the neck and the abdomen, and as such, it might not be generalized to other parts of the body. Third, the work concentrated on morphological and histometrical examination without further elaboration in terms of histochemical, immunohistochemical, and ultrastructural studies. Lastly, the chosen postnatal time intervals were at the early and middle stages of development and not at the later stages of development.

Conflict of Interest

Not available

Financial Support

Not available

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