

VARIATIONS OF THE HISTOMORPHOLOGICAL CHARACTERISTICS OF HUMAN SKIN OF DIFFERENT BODY REGIONS IN SUBJECTS OF DIFFERENT AGE

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Abstract: The aim of this paper was to create a reference model for the qualitative and quantitative characteristics of healthy human skin in different body regions and different life periods. For this purpose we have taken skin biopsy specimens from 15 different body regions: capillitium, forehead, cheeks, anterior neck, thorax, axilla, abdomen, back, gluteus, anterior arm, anterior forearm, palm, anterior leg, anterior lower leg and sole. The biopsies were histologically elaborated according to a standard paraffin technique, and the obtained histological slides were qualitatively and quantitatively analysed with the use of a computer system for image processing and analysis (*Lucia M, Version 3, System for Image Processing and Analysis*).

The examinees were divided by age into five groups: from full-term infants up to the age of 1 year; from the age of 2 up to the age of 12 years; from the age of 13 up to the age of 22; from the age of 23 up to the age of 55; from the age of 56 up to the age of 73. In each exemplar were determined: the total skin thickness in each region at each age group, total thickness of the epidermis, total thickness of the corium, thickness of the papillary and reticular layers of the corium. In this period the thickening is about 4–4.5 times. The growth of the thickness comes as a result of the growth of the thickness of the reticular corium, values of which grow by 4–5 times. The height of the epidermis in new-borns shows higher values than the second group (childhood). In the third and fourth group the values of the epidermis are from 1.5 to 2.5 times higher on those parts of the body which are uncovered and exposed to externalities.

The essence of the changes that happen to the skin is structural final formation, which is turbulent and targeted in youth (in order to harmonize structural and functional

abilities of the human organism) and in mature age to synchronize the function of the skin with the other systems of the organism.

Key words: human healthy skin, different body regions, age-related variations, epidermis, dermal-epidermal junction, corium, skin appendages.

Introduction

The main purpose of this research was to create a reference model for the qualitative and quantitative characteristics of healthy human skin in different body regions at different ages. Because we want to make a contribution, taking into consideration our personal experience based on these data while conducting this research, we put our main accent on:

- Determining the qualitative and quantitative characteristics of human skin in 15 different body regions;
- Observing and noticing the structural specifics of the human skin in different body regions at different ages.

Each part of the body skin has its own structural and functional variations, which are equal or the same but on different sites on the body. Regarding this fact, we made a histomorphometric analysis of the components of the skin in each region. Our purpose was also to present the skin throughout different life periods, with which we presented the changes of each analysed component during a lifetime. The essence of the changes is structural final formation, which is turbulent and targeted in youth (in order to harmonize structural and functional abilities of the human organism) and in mature age to synchronize the function of the skin with the other systems of the organism. This scope of changes could simply be compared with a bell curve showing a rise, plateau and fall (that is an implication of the physiological regressive changes which appear in the entire organism and are mostly manifested on the skin).

Material and methods

The material for this research and analyses were skin biopsy specimens from healthy human skin, taken from 15 different body regions: the capillitium, forehead, cheeks, anterior neck, thorax, axilla, abdomen, back, gluteus, anterior arm, anterior forearm, palm, anterior leg, anterior lower leg and sole.

The skin biopsy specimens were of dimensions from 0.5 to 1 cm and covered the total skin thickness and part of the sub cutis. They were collected from patients from the Skopje University Plastic Surgery Clinic who had undergone skin transplantation; autopsy procedures done at the Pathology Institute;

and autopsy procedures done at the Forensic Medicine Institute, in cases where the cause of the death did not include diseases that affect the skin directly. In order to examine the characteristics of the skin at different periods of life, we classified the biopsies of each region into five different subgroups according to the age of the patients, i.e. the cadaver they were taken from. Full-term infants up to the age of 1 year; from the age of 1 up to the age of 12; from the age of 13 up to the age of 22; from the age of 23 up to the age of 55; from the age of 56 up to the age of 73. We also took into consideration the proportional representation of both sexes. Each age group contains at least 10 exemplars and the whole research material consisted of 750 skin biopsy specimens.

The routine histological elaboration of the biopsy material included: fixation in 10% neutral formalin, the usual procedure for tidying up and making of a paraffin section of a thickness from 3 to 5 microns and routine painting with H.E., Azan – Mallory, PAS, Floranten, Linder technique of impregnation with silver, in order to present the nerves and nerve endings.

The morphological analysis covered the epidermis with its layers, corium and dermis with both dermal segments: the papillary and reticular layer, vascularisation, innervations, the disposition of the collagens, elasticity, reticulum fibers, cell elements, etc.

The quantitative morphometric analysis was done using a computer system for image processing and analysis (*Lucia M, Version 3, System for Image Processing and Analysis*) at the Pathology Institute.

The morphometric analysis gave us the quantitative dimensions of the structural skin components. With quantitative analysis we determined: the total skin thickness in each specific region at different ages, the total thickness of the epidermis, the total thickness of the corium, the thickness of the papillary and reticular layers of the corium. The obtained numerical data were mathematically and statistically elaborated and this makes it possible to notice the regional differences in the structure of a healthy human skin and its specifics according to age.

Results

Table1

Average values of skin thickness at examined regions in different age groups (expressed in micrometres)

REGIONS	AGE GROUPS				
	0–1 age	1–12 age	13–22 age	23–53 age	53–73 age
Capillitium	1714,6 (µm)	1401,9 (µm)	3879,3 (µm)	3211,1 (µm)	1782,8 (µm)
Forehead	1320,6	1799,8	2222,3	2250,3	2361
Cheeks	1025,5	1114,3	1562,8	2062,2	1573,3
Anterior neck	1279,8	1381,5	2512,9	2763,4	3542,0

Torax	1403,9	1631,3	1991,5	3197,7	2278,9
Axilla	977,4	1053,9	2044,2	2203,1	1773,6
Abdomen	1458,7	2453,3	3199,5	3253,8	2657,5
Back	1431,3	2085,8	4787,0	4178,9	3758,3
Gluteus	1288,3	3977,5	5891,8	5190,2	4642,2
Anterior arm	1399,0	2301,6	4137,0	2332,8	1155,5
Anterior forearm	1105,1	1791,3	3120,54	3056,6	1892,9
Palm	1015,0	1648,0	2939,0	3560,0	2310,0
Anterior leg	1613,1	1631,0	3428,2	4948,8	2126,7
Anterior lower leg	1467,9	1658,5	2192,9	1658,8	1417,1
Sole	913, 1	2328,8	3883,1	4395,9	1598,6

Table 2

Average values of thickness of corium at examined regions in different age groups (expressed in micrometres)

REGIONS	AGE GROUPS				
	0–1age	1–12 age	13–22 age	23–53 age	53–73 age
Capillitium	1553,8 (µm)	1303,6 (µm)	3720,6 (µm)	3036,5 (µm)	1670,8 (µm)
Forehead	1192,2	1662,8	2016,9	2005,9	2253,2
Cheeks	885,1	1053,9	1351,8	1823,6	1359,4
Anterior neck	1161,8	1281,5	2418,8	2632,5	3457,6
Torax	1267,7	1527,9	1815,9	3065,3	2192,2
Axilla	828,0	1053,9	1876,3	2079,5	1669,0
Abdomen	1297,0	2312,3	2981,4	3074,5	2548,0
Back	1330,6	1972,3	4692,8	4105,7	3698,4
Gluteous	1138,0	3900,5	5776,0	5093,2	4565,5
Anterior arm	1251,9	2182,0	4017,4	2219,8	1063,4
Anterior forearm	995,7	1696,1	3013,5	2965,2	1825,1
Palm	873,0	1422,0	2582,0	3105,0	1934,0
Anterior leg	1470,2	1550,5	3329,9	4804,9	2026,3
Anterior lower leg	1323,8	1517,7	2058,2	1538,7	1310,5
Sole	719,9	2069,4	3515,6	3949,5	1442,4

Table 3

Average Values of thickness of papillary and reticular layers of corium at examined regions in different age groups (expressed in micrometres)
Pap = Stratum papillarae, Ret = Stratum reticularae

REGIONS Corium	AGE GROUPS									
	0–1 age		1–12 age		13–22 age		23–53 age		53–73 age	
	PAP	RET	PAP	RET	PAP	RET	PAP	RET	PAP	RET
Capillitium	105,6	1448,2	85,5	1218,1	141,6	3579,0	256,7	2779,8	72,2	1598,6
Forehead	157,4	1034,8	98,5	1564,3	98,9	1920,0	107,9	1898	39,2	2214,0
Cheeks	66,1	819,0	76,5	910,0	101,8	1250,0	153,6	1670,0	100,5	1258,9
Anterior neck	111,4	1050,4	118,1	1163,4	120,3	2298,5	128,7	2503,8	60,6	3397,0
Torax	110,7	1157	107,9	1420,0	156,5	1659,4	192,3	2873	93,2	2099,0
Axilla	128,4	699,6	154,3	899,6	172,5	1703,8	104,7	1974,8	118,0	1551,0
Abdomen	125,4	1171,6	120,5	2191,8	192,9	2788,5	215,6	2858,9	173,3	2374,7
Back	80,9	1249,7	110,8	1861,5	160,1	4532,7	154,7	3951,0	90,7	3604,7
Gluteous	85,8	1052,2	120,5	3780,0	146,0	5630,0	114,2	4979,0	105,5	4460,0
Anterior arm	80,3	1171,6	125,4	2056,6	169,6	3847,8	188,9	2030,9	63,6	999,8
Anterior forearm	77,9	917,8	114,5	1581,6	133,5	2880,0	146,2	2819,0	121,0	1704,1
Palm	127,0	746,0	154,0	1268,0	217,0	2365,0	310,0	2795,0	220,0	1714,0
Anterior leg	62,9	1407,3	126,1	1424,4	144,9	3185,0	314,9	4490,0	155,6	1870,7
Anterior lover leg	112,7	1211,1	139,1	1378,6	231,7	1826,5	189,2	1349,5	126,5	1184,0
Sole	186,7	533,2	144,4	1920,0	725,6	2790,0	949,1	3000,4	357,0	1085,4

Table 4

Average values of thickness of epidermis at examined regions in different age groups (expressed in micrometres)

REGIONS	AGE GROUPS				
	0–1 age	1–12 age	13–22 age	23–53 age	53–73 age
Capillitium	160,8 (µm)	98,3 (µm)	158,7 (µm)	174,6 (µm)	112,0 (µm)
Forehead	128,4	137,0	203,4	244,4	108,4
Cheeks	140,5	127,8	211,0	238,6	213,9
Anterior neck	117,5	92,8	94,1	130,0	84,4
Torax	136,2	103,4	175,6	132,4	86,7
Axilla	149,4	101,1	167,9	123,6	104,6
Abdomen	161,6	141,0	218,1	179,3	109,5
Back	150,3	77,0	115,8	97,0	76,7
Gluteous	100,7	113,5	94,3	73,2	59,9
Anterior arm	147,1	119,6	150,0	113,0	92,1
Anterior forearm	109,5	95,2	107,0	91,4	67,8
Palm	142,0	226,0	357,0	455,0	376,0
Anterior leg	142,9	80,5	98,3	143,9	100,4
Anterior lover leg	144,1	140,8	134,7	120,1	106,6
Sole	193,2	259,3	367,5	446,4	156,2

Discussion

In the case of newborns, the skin is soft, thin and vulnerable. Numerical data have shown that these characteristics are due to the small total thickness (weight) of the corium (Table 2) especially because of its reticular layer (Table 3). In contrast to the corium, the epidermis of newborns has bigger considerably greater ripeness and functionality (Table 4). Its total thickness is noticeable and huge. The dermal-epidermal layer of newborns is weaker compared to this layer in the case of the elderly, because the elastic fibres which are connected to the basal lamina are thin and not completely developed. The papillae layer of the corium during the first year of life is loose and is very difficult to separate from the reticular segment. The rich amorphous compound prevails and the fibrillose component is particularly loose. It is organized in soft and low network ridges where a lot of thin reticular fibres can be found. When they come closer to the margin of the epidermis, they start to form the face of the ridges.

During *childhood* the surface of the skin increases very rapidly, but as in the other organic systems, it also goes through processes of maturation and putting into final shape. From early childhood the changes in the structural composition of the corium are obvious. Our measurement according to numerical parameters has confirmed these changes. The total skin thickness (Table 1) is three times greater compared to the thickness of the skin in earliest childhood. The increase in the reticular corium (Table 3) is recorded in all body regions and reaches 3 to 4 times higher values compared to those in early childhood. The papillae part of the corium (Table 3) shows a medium increase. There is no thickening in the epidermis, except in some uncovered regions, especially on the forehead and the sole (Table 4).

For the life period at an age between 13 and 22, the establishment of optimal equilibrium between the structural components of the corium is typical as a result of the reached ripeness of the components. The general conclusion is that all segments of the skin continue to grow and most of them reach their maximal dimensions during this period of life. That is the reason why the total thickness of the skin (Table 1) is 4–4.5 times greater than that in the case of newborns, the thickness of the corium (Tables 1 and 2) (and the thickness of its reticular layer) is 4–5 times greater than at the beginning and the highest values can be found on the skin of the stomach and gluteus. During this period the papillary layer is rapidly thickening and its attitude is 3–4 times greater. This increase is followed by a concentration of connective tissue papillae and their extension. The greatest density of papillae (both in density and depth) can be found on the skin of the sole and the smallest density of papillae on the face (as well as the lowest papillae).

There are no great differences between the qualitative and quantitative characteristics of the skin for people who are between 23 and 53 years old and

the characteristics that were previously mentioned. This period of life is characterized by the existence of huge numbers of soft variations of the parameters. Some of them continue to show a tendency to growth and organization, some keep the same values and others start to reduce gently. This multiplicity is related to some particular layers of the skin as well as to some particular regions. In any case, the general conclusion is that the total skin thicknesses, the corium and reticular layer in many regions of the body have achieved their maximum values during the previous periods. In contrast to this, the papillary layer of the corium in many regions of the body still follows the previous process for medium but progressive growth. With the measurements we took, we proved that the change refers to the total weight (thickness and structure) of the layer, while the density and attitude of papillae remain the same and in some regions even gently decrease. Regarding the epidermis, the results of our research show that on some naked parts (such as the head and neck) the thickness of the epidermis is sufficiently high and still grows gently, as a sort of mechanism for protection against external factors. In the covered parts of the body (axilla, thorax, abdomen, back, gluteus etc.) the epidermis starts to reduce its attitude gently.

In the last group, that covers people who are between 56 and 73 years old, the regressive processes clearly reflect the qualitative and quantitative characteristics of all skin regions. In general, a decrease in the thickness of the entire skin is obvious (Table 1), in all its layers (epidermis, papillary and reticular layer of the corium) as well as the dimensions of skin annexes (follicles of fibres, sebaceous and sweat glands). The dermal-epidermal boundary zone becomes smoother because of the decreasing of number and attitude of connective tissue papillae.

The results we obtained show that the epidermis is significantly spindly due to the decrease in the number of rows of cells in every particular layer, especially emphasized in the stratum spinosum. During old age the connective component of the skin undergoes substantial structural changes. Our analyses show that the most substantial change occurs to collagen bundles, especially after the 5th decade of human life. They suffer from fragmentation and disorientation, creating zones of dense collagen mass separated from spaces where a fibrillar component does not exist. In the papillary corium the delicate reticular tissue become rough and compressed. The dermal-epidermal boundary zone starts to level slowly due to fragmentation of vertically situated elastic fibres which even start to move into a horizontal position. Due to fragmentation the contact with the basal lamina becomes weaker (as well as the connection between the corium and epidermis). Thus, instead of a parallel structure the collagen fibrils all together form a structure that looks like a flower. This changed organization of the matrix and the collagen leads to a change in the physical and mechanical characteristics of the extracellular matrix.

Many authors in their own scientific researches emphasize that there are no significant differences in the structure of the skin between the sexes. Regardless this fact, at the beginning of our research, through the analysis of variance in which sex was included as a variable, we also found out that the numerical values of the examined parameters did not show any significant difference relating to sexe. This is the reason why this variable was excluded in the further analysis.

Conclusion

In order to provide a comprehensive study, we included 15 different regions from the human body in our research. In this way it was possible to obtain more data for numerical values of the skin parameters. In the available literature we have not come across such a comprehensive study. Most of the authors have analysed only one or two regions in their research. Because we did not come across complete data for the numerical data of the skin in different regions of the human body, we are convinced that our research contains relevant data for the specifics of the healthy human skin in different body regions, at different ages throughout life, in the examinees living in this country. In this way we obtained a reference numerical database for the structural elements of the skin in almost all regions of the body, which can be useful for further research in this area.

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Резиме

ВАРИЈАЦИИ НА ХИСТОМОРФОЛОШКИТЕ КАРАКТЕРИСТИКИ НА ХУМАНА КОЖА ОД РАЗЛИЧНИ РЕГИИ КАЈ ИСПИТАНИЦИ ОД РАЗЛИЧНА ВОЗРАСТ

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Апстракт: Главната цел на овој труд беше изработка на референтен модел за квалитативните и квантитативните карактеристики на нормалната хумана кожа во различните регии од телото, во различни периоди од животот. За таа цел беа земени кожни биопсии од 15 регии од телото: (капилициум, чело, образи, предна страна на вратот, граден кош, аксила, грб, стомак, глутеус, предна страна на надлактица, предна страна на подлактица, палмарна страна на шепа, предна страна на натколеница, предна страна на потколеница и плантарна страна на стопалото. Биопсиите беа

хистолошки обработени по стандардна парафинска техника, а добиените хистолошки препарати беа квалитативно и квантитативно анализирани со помош на компјутерски систем за сликовито процесирање и анализа. (*Lucia M, Version 3, System for Image Processing and Analysis*).

Испитаниците беа групирани во 5 возрастни групи: од 0–1 година, 1–12 години, 13–22 години, 23–55 години и последната група од 56 години до 73-годишна возраст. Во секој примерок беа одредувани: целосната дебелина на кожата во секоја поединечна регија кај секоја возрастна група, вкупната дебелина на епидермисот, вкупната дебелината на кориумот, дебелината на папиларниот и ретикуларниот слој на кориумот.

Резултатите покажаа дека вкупната дебелина на кожата расте и највисоките вредности ги достигнува до 22 година од животот. Тогаш зголемувањето изнесува 4–4,5 пати. Зголемувањето на дебелината главно се должи на раст на дебелината на ретикуларниот кориум чии вредности се зголемуваат од 4–5 пати. Висината на епидермисот кај новородените покажува повисоки вредности во однос на втората возрастна група. Кај третата и четврта возрастна група имаме зголемување на вредностите на епидермисот од 1,5 до 2,5 пати во главно во деловите на телото кои се откриени и изложени на надворешни влијанија.

Суштината на промените кои се случуваат во кожата можеме да констатираме дека претставува структурно дооформување кое во младоста е бурно и целно (за да ги доведе во склад структурните со функционалните можности на органот) а во зрелоста да ја усклади функцијата на овој со останатите системи во организмот.

Клучни зборови: хумана кожа, регионални карактеристики, различни возрасти, епидермис, дермо-епидермална граница, кориум, кожни аднекси.

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