

# Skin biophysical properties of a population living in Valais, Switzerland

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**Background/purpose:** Switzerland has one of the highest rates of skin diseases and particularly skin cancer, in Europe. Skin elastosis, roughness and atopy are also frequent. High UV exposure and prevalence of light skin individuals could be the cause. Valais, in Southern Switzerland, is a mountain region with elevated sun irradiation and low air humidity, an ideal location to study the effect of the environment and life style on skin biophysical characteristics. The purpose of the study was to measure skin biophysical parameters non-invasively on healthy subjects living in Valais, and to correlate the measures with their life style.

**Methods:** One hundred and ten women were examined between October 2001 and February 2002. Measures of skin hydration, sebum content, pH and visco-elasticity were taken in a closed environment with constant temperature and controlled air humidity, utilizing commercially available non-invasive devices. Subjects were interviewed using a questionnaire and data on personal traits and life style were collected. Correlations between subject's skin parameters and life style were statistically examined.

**Results:** On average we observed low values of skin capacitance that identify subjects with dry skin. Measures of skin visco-elasticity ratios were also particularly low, while skin pH and sebum content were in the normal range. Age was correlated with a decrease of skin elasticity and sebum content, but there was no correlation with hydration or pH.

**Conclusions:** We confirm, as reported in other studies, the effect of age on skin elasticity and sebum content and we identify, for the first time, a region with a population characterized by particularly low levels of skin hydration and skin visco-elasticity. Although people examined were free of skin diseases, we believe that protection from the sun and treatment of skin with hydrating products need to be emphasized as a prevention strategy, in regions such as Valais, with high sun irradiation and low humidity.

**Key words:** elasticity – hydration – pH – sebum – skin – UV

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SKIN BIOPHYSICAL properties are influenced by chronological and environmental factors. Age and sun exposure are responsible for decreased skin elasticity and hydration causing elastosis, atopy and formation of wrinkles (1–4). Chronic UV exposure has been associated to photo-aging and skin cancer (5–8). For example, the time spent at the beach during the youth has been associated with basal cell carcinoma (9). Although sunlight seems evidently beneficial for health (vitamin D synthesis, stimulated by sun exposure, is useful against coronary heart diseases and mental health depreciation), adverse effects possibly overcome positive effects (10), and it seems that about 90 percent of all skin cancer is a result of long-term UV exposure (2). Switzerland has one of the highest rates of skin diseases and in particular skin cancer in Europe (Swiss Tumour Registry). The altitude of

residence and mountaineering activities, both parameters closely tied to higher UV exposure as well the prevalence in the country of a light skin photo-type seem responsible for the effect observed (8, 10–13).

The region of Valais, in the southern part of the Swiss Alps, is renowned for its dry and sunny climate (14) (Data Meteo Suisse, Zurich). Prevalence of skin diseases in this region has been previously reported (11), but information is lacking concerning skin biophysical parameters of healthy individuals. Additional information could also be derived from correlation of skin biophysical parameters with personal traits and life style.

In this study, non-invasive devices were used to detect *in vivo* skin biophysical properties. Skin hydration, sebum content, pH and visco-elasticity were measured. Personal traits and life style

habits were recorded with the aid of a questionnaire. Finally, a statistical analysis was employed to correlate skin biophysical measurements with the subject's life style.

## Materials and methods

### *Subjects and measurements*

A total of 110 Caucasian female subjects living in Valais, Switzerland for at least 2 years and aged 18–73 years (mean  $45.9 \pm 2.3$  SE) were examined. Volunteers needed to comply with precise pre-analytical requirements, namely not using cosmetics immediately before testing and reporting to the study with a clean face. Measurements were taken in our laboratory between the months of October 2001 and February 2002, when skin conditions are more stable. They were performed during the morning, in a closed environment with the indoor temperature at  $23.5^\circ\text{C} \pm 0.2$  SE, and relative humidity between 36% and 60% (mean  $48.4 \pm 1.1$  SE) (Certified Thermo-Hygrometer, NOVO-5048, G. Lufft GmbH, Fellbach, Germany). The same investigator performed all the measurements. A maximum of three persons/morning were examined. Before measurement, the volunteer had to rest for 30 min to equilibrate her skin to the indoor conditions. All the subjects of this study were interviewed using a medical type questionnaire and data on personal traits and life styles were carefully collected after informed consent. Volunteers generally self-reported to be healthy. No signs of skin disease were observed.

The skin electrical capacitance was measured with the Corneometer CM825<sup>®</sup> (Courage and Khazaka Electronic GmbH, Cologne, Germany). This parameter is an estimator of the stratum corneum hydration. It measures the highest water dielectrical constant compared to the rest of the skin components. The degree of epidermal skin humidity is indicated in system-specific units. One unit corresponds to a water content of stratum corneum of  $0.02\text{ mg/cm}^2$ , for a measurement depth of 20 nm (15). Six measurements were conducted on the forehead and three on the left volar forearm, at different locations.

The amount of sebum in the skin was measured on the subject's forehead with the Sebumeter SM810<sup>®</sup> (Courage and Khazaka Electronic GmbH, Cologne, Germany). The quantity of sebum absorbed is proportional to the variation of light intensity through a plastic strip. The

level of sebum was expressed as  $\mu\text{g/cm}^2$ . Three measurements at different locations were performed on each volunteer.

Skin surface pH was measured with a flat glass electrode connected to a pH-meter device, pH 900<sup>®</sup> (Courage and Khazaka Electronic GmbH, Cologne, Germany). Three measurements were performed on the forehead of the volunteer.

Skin visco-elasticity was measured with the Cutometer<sup>®</sup> SEM 575 (Courage and Khazaka Electronic GmbH, Cologne, Germany). Skin elastic properties were obtained through the principle of suction/elongation. An optical unit measures the skin deformation inside the probe. Operating conditions were as follows: the load was 450 mbar pressure vacuum, 3 s pre-time, 5 s on-time, 3 s relaxation period, three repetitions. Results are expressed using the factor  $U_r/U_f$  that represents a measure of the skin's ability to regain its initial position after deformation (16). Three measurements were performed on the left volar forearm of the volunteer.

### *Statistical analysis*

In order to relate volunteers' skin biophysical measurements with their life style, the data collected were statistically analyzed. Because of the amount of data, the first approach was to diminish the importance of the raw matrix. The mean values of multiple measurements were calculated. To obtain an overview of the general tendency, the correlation analysis was used. If a good relationship was established between some parameters, polynomial regression analysis was performed between them to suppress the effect of relevant factors on the crude values, and the matrix of the residues was kept for further analysis. To evaluate the impact of each life style parameter on those 'new' factors, the Student's *t*-test and ANOVA were applied. The possible influence of environmental factors on the measurements were confirmed or not confirmed by one-way ANOVA.

## Results

### *Population*

Personal data and life style habits of the volunteer were collected with the help of a questionnaire. In our sample, 88% of the examinees had been living in Valais since more than 15

## Skin biophysical properties of a Population living in Valais, Switzerland

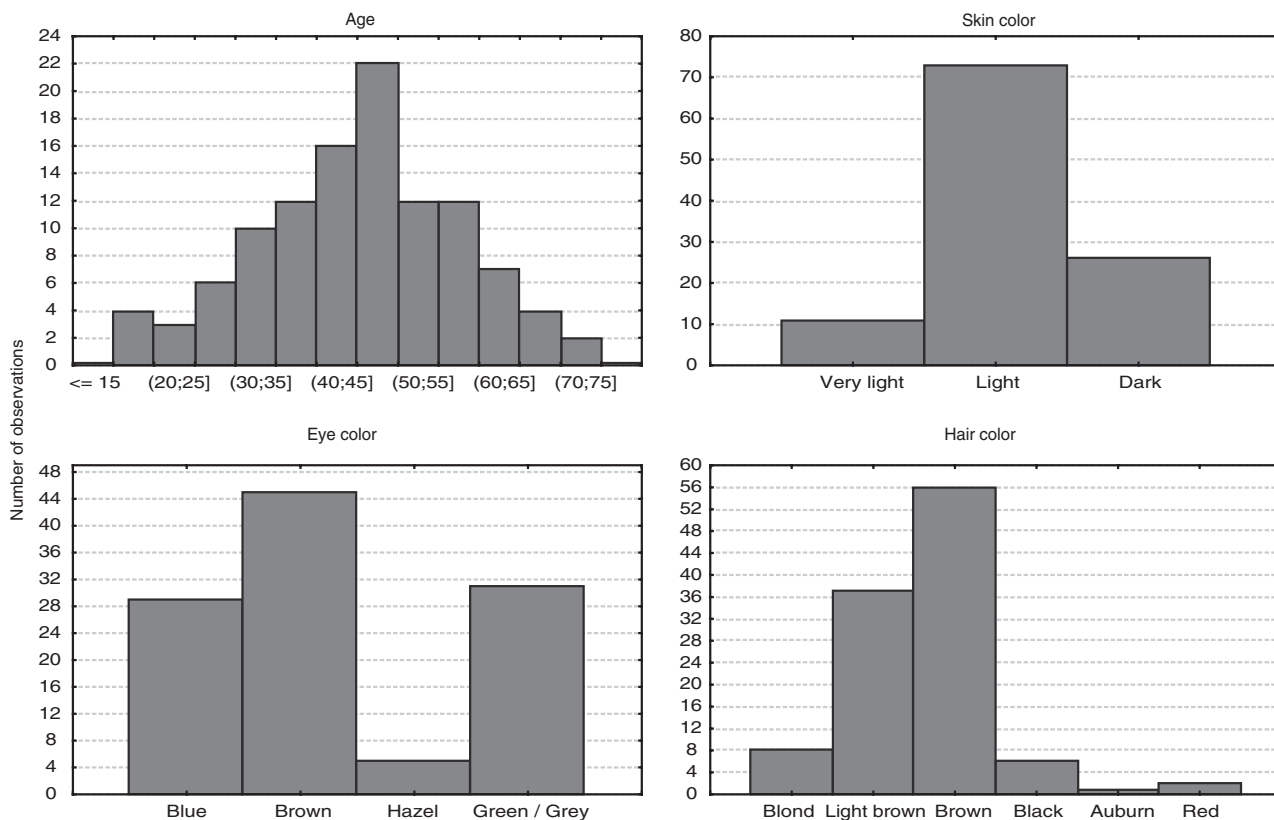


Fig.1. Distribution of age, skin color, eye color and hair color for each individual.

years. 65% originated directly from Valais, and 20% from Switzerland.

Figure 1 summarizes some traits of our population sample. The data indicate that the majority of our population sample has light skin with brown eyes and brown hair. These characteristics are common to a skin photo-type 2–3, typical of people living in Central and Northern Europe. Our population is almost identical to the one recently described in a paper by Berret et al. (13) on sunscreen use in Switzerland, supporting the evidence of a predominantly light skin photo-type in Switzerland.

Table 1 summarizes life style habits of our population. The results show a uniform panel with an overall healthy life style; most of the volunteers did not smoke or drink alcohol and had a good amount of liquid ingestion and sleeping hours. Although some of them took hormones and contraceptive pills, they were not on medical treatment.

### *Skin hydration*

Values of skin capacitance are shown in Table 2. As shown in Fig. 2, these values are similar over

TABLE 1. Percent distribution of life style parameters in our population sample

Subjects drinking alcohol	Never	70.9
	Occasionally	8.2
	Every day	20.9
Subjects drinking water	< 1 L/day	22.7
	1–2 L/day	56.4
	2–3 L/day	19.1
	> 3 L/day	1.8
Subjects smoking	Never	70.0
	> 10 cigarettes/day	8.1
	10–20 cigarettes/day	15.5
	> 20 cigarettes/day	6.4
Subjects sleeping	< 5 h/night	0.9
	5–7 h/night	19.1
	7–8 h/night	57.3
	> 8 h/night	22.7
Subjects under drug treatment	Never	66.4
	Hormones	19.1
	Contraceptive pills	13.6
	Other	0.9
Subjects' home temperature	< 18°C	4.5
	18–20°C	40.0
	20–22°C	35.5
	> 22°C	20.0

different ages, indicating that in our sample there is no correlation between age and skin hydration. We could not find significant correlations between skin hydration and life style parameters.

TABLE 2. Average values for skin hydration, sebum content, pH and elasticity

Hydration (a.u. $\pm$ SD)	Forehead	53.1 $\pm$ 8.7
	Forearm	35.0 $\pm$ 7.2
Sebum content ( $\mu\text{g}/\text{cm}^2 \pm$ SD)	Forehead	126.9 $\pm$ 65.9
pH $\pm$ SD	Forehead	5.5 $\pm$ 0.4
Visco-elasticity ( $U_f/U_t \pm$ SD)	Forearm	0.43 $\pm$ 0.1

a.u.: arbitrary units;  $U_f/U_t$ : visco-elasticity ratio; SD: standard deviation.

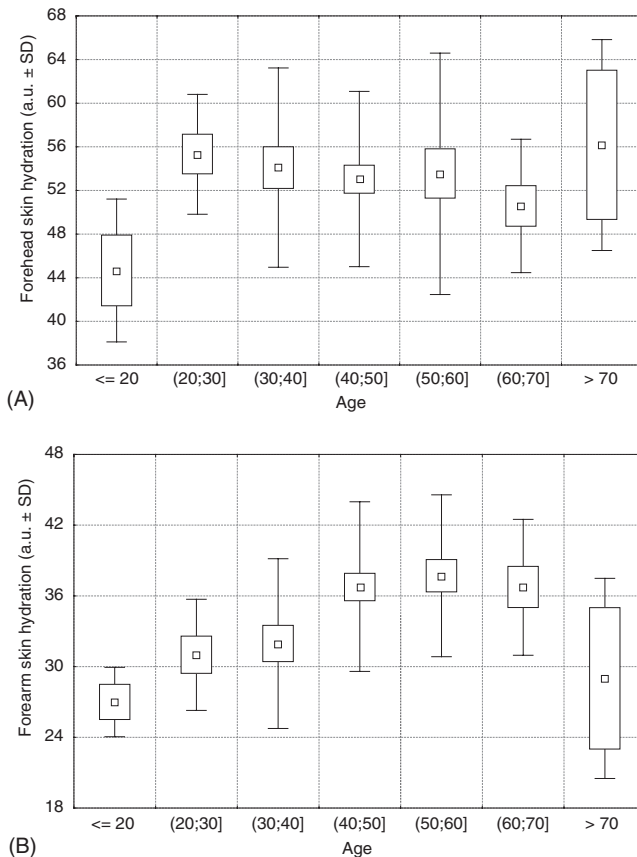


Fig. 2. Values of stratum corneum hydration measured by capacitance on the forehead (A) and the forearm (B) of volunteers in relation to age groups. a.u.: arbitrary unit.

*Skin visco-elasticity*

Skin visco-elasticity average value is indicated in Table 2. As shown in Fig. 3, values decreased with aging (ANOVA;  $P < 0.01$ ). The Student's *t*-test was significant ( $P < 0.001$ ) between the two groups ' $< 50$  years old' ( $n = 69$ ) and ' $\geq 50$  years old' ( $n = 41$ ). After deduction of the age effect on skin's elasticity values, we could not find any other correlation with other life style parameters on the residual values.

*Skin sebum content*

Skin sebum content average value, measured on the forehead, is shown in Table 2. It decreased

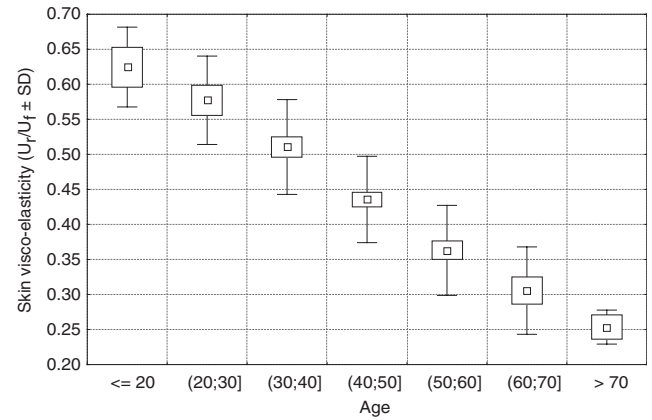


Fig. 3. Values of skin visco-elasticity measured on the forearm of the volunteer in relation to age groups.  $U_f/U_t$  represents the visco-elasticity ratio. Skin visco-elasticity was correlated with age ( $P < 0.01$ , ANOVA).

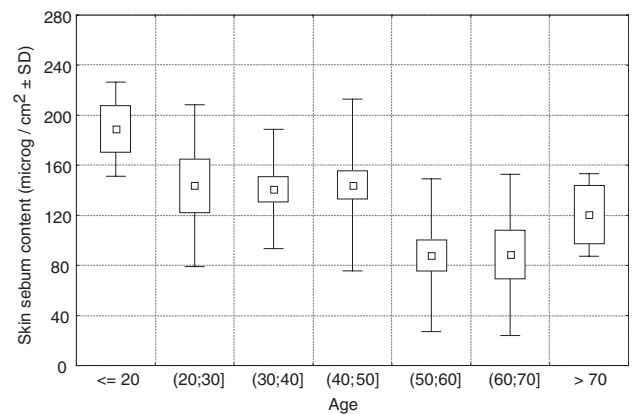


Fig. 4. Values of skin sebum content in relation to age groups. Sebum content was measured by sebum adsorption on a plastic strip from the forehead of the volunteer. The amount of sebum is expressed as  $\mu\text{g}/\text{cm}^2$ . Sebum content was correlated with age ( $P < 0.01$ , ANOVA).

with age (ANOVA,  $P < 0.01$ ) as indicated in Fig. 4. It was correlated with elasticity (one-way ANOVA,  $P < 0.05$  and Student's *t*-test,  $P < 0.01$ ) (Fig. 5) and with the amount of liquid ingested per day (Fig. 6), where the difference was noticeable between the two groups 'normal-drinking' females and 'not enough-drinking' females. There were no other statistical correlations with other life style parameters.

*Skin pH*

The average value of skin pH is reported in Table 2. We found a correlation with sweating, where volunteers reporting to sweat had a significant lower mean skin pH on the forehead ( $P < 0.001$ , Student's *t*-test) (Fig. 7). We could not find a

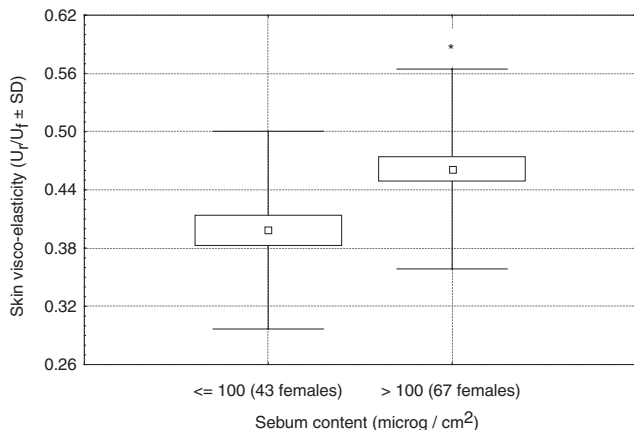


Fig.5. Values of skin sebum content in relation to skin elasticity. Sebum content was measured by sebum adsorption on a plastic strip from the forehead of the volunteer. The amount of sebum is expressed as  $\mu\text{g}/\text{cm}^2$ .  $U_r/U_f$  represents the visco-elasticity ratio. Visco-elasticity increased with increased sebum content (\* $P < 0.05$ , ANOVA,  $P < 0.01$ , Student's  $t$ -test).

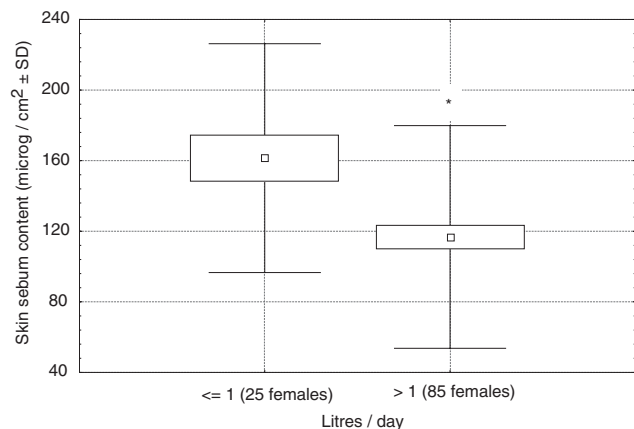


Fig.6. Values of skin sebum content in relation with drinking. Sebum content was measured by sebum adsorption on a plastic strip from the forehead of the volunteer. The amount of sebum is expressed as  $\mu\text{g}/\text{cm}^2$ . Decreased sebum was correlated with  $> 1\text{L}$  liquid intake group (\* $P < 0.05$  ANOVA,  $P < 0.01$ , Student's  $t$ -test).

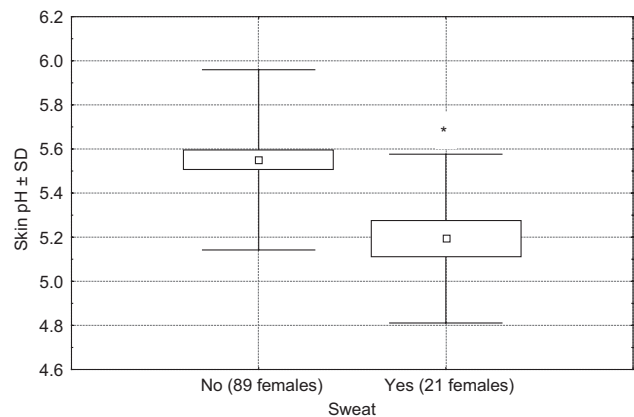


Fig.7. Values of skin pH measured by a flat electrode on the volunteer's forehead in relation to sweating. A lower pH was correlated with increased sweating (\* $P < 0.001$ , Student's  $t$ -test).

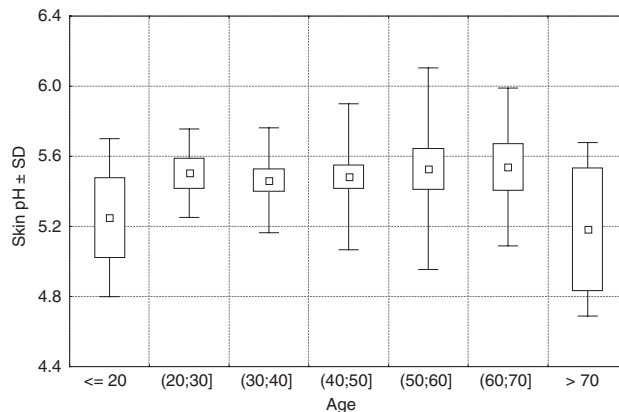


Fig.8. Values of skin pH measured by a flat electrode on the volunteer's forehead in relation to age groups. No statistical correlation was found.

statistical correlation with age (Fig. 8) and life style parameters.

### Self-perception of the skin

People were asked to qualify their skin type in terms of normal, dry, mixed or oily skin. Interestingly, the perception of the skin was correct in only 46% of the population. Most of the examinees thought that the words dry, mixed or oily were only references to sebum repartition on the face, without taking into account hydration.

### Discussion

The aim of this study was to establish skin biophysical parameters of people living in a region (Valais) characterized by high altitude (average 1000m above sea), elevated UV exposure and particularly low humidity and finally to relate these parameters with their life style characteristics recorded with the aid of a questionnaire.

Values of sun exposure and rain fall are well documented in Switzerland by Meteo Suisse, Zurich, every month and have been extensively analyzed (14). Average values of sun exposure (hs) and rain fall (mm) of four representative sites in Valais (Sion, Montana, Visp, Zermatt) during the period 2001–2002, indicate 1871 h of sun/year and 788 mm of rain/year. For comparison, measurements taken in 46 sites in the remaining regions of Switzerland show an average of 1635 h of sun/year and 1530 mm

rain/year in the same period. During our study (October 2001–February 2002), average values were: 120 h sun/month and 35 mm rain/month (Switzerland had values of 105 h sun/month and 77.2 mm rain/month).

Almost 90% of the people who participated in the study had been living in the region for more than 15 years. These people had a predominantly light skin, not different from the overall Swiss population (13). Our first objective was to create a profile of skin biophysical characteristics (stratum corneum hydration, visco-elasticity, sebum content and pH) of a Swiss population living in a region where the climate could have an effect on these characteristics. There is in fact a correlation between weather parameters like temperature and humidity and the skin appearance, as evidenced in the literature for atopic eczema (26, 27). It is also accepted that those with greater sun exposure and those spending many hours outside had more wrinkles and looked older (3, 5, 16). Temperature, relative humidity and chronic sun exposure are parameters affecting stratum corneum hydration (7, 28), skin elasticity (4, 23) and sebum content (29). Moreover, previous studies have evidenced a high incidence of skin cancer in the Valais region, mostly related to outdoor activities (11). When we examined results for skin elasticity, we observed a significant variation associated to the age of volunteers, with older individuals having a significantly less elastic skin. These data were in accordance with previous published investigations (16, 21, 23, 30, 31). We observed low  $U_r/U_f$  values, although comparisons with other studies are difficult due to methodological as well as seasonal differences.

When we analyzed values of skin hydration, as in the case of skin elasticity, we observed particularly low values when compared to other studies (7, 15, 17–22). Also in this case we cannot exclude seasonal and methodological differences, but these values evidence a population characterized by dry skin. Interestingly, skin hydration was independent from age of volunteers, suggesting, at least in our study, that skin hydration is not the only parameter involved in skin aging, as evidenced by other reports (22, 24). We cannot say that there was an influence of cosmetic usage on skin properties among different age groups, since 90% of all age groups utilized cosmetic creams in their current life. Our population was in good health, leading a healthy life, and we

could not detect any effect of their life style on skin visco-elasticity and hydration. It is therefore possible that climate as well as their genetics and predominantly light skin phenotype could account for the low levels of skin hydration and visco-elasticity observed.

Measured values for sebum content were similar or higher to what was reported by previous authors (7, 15, 19, 22, 24), but clearly lower than values reported by people with acne (35). Interestingly, we observed a decrease of sebum production during the aging process, as reported by other authors (32–34). This can be linked to decreased hormonal production with age (32).

The overall values of pH were also in the physiological range as reported by other authors (25). We evidenced an inverse correlation between forehead sebum content and pH, in accordance with a previous study (35).

We have finally looked for a correlation between skin biophysical parameters and life style habits of our volunteers. The only statistically significant correlation we could detect was between sebum production and daily liquid intake. We observed a higher sebum production on the forehead of women who had a low intake of liquids (<1 L/day) compared to women with normal intake (>1 L/day). Lower intake of liquid could cause less sweating, with decreased transepidermal water loss (TEWL). This condition has been associated with better hydration and increased skin surface lipid content (36).

We could not find any other relation with other life style parameters often associated to skin elastosis or sebum production like smoking, alcohol consumption or hormonal treatment. Studies designed to look at precise correlations (for example smokers vs. non-smokers) would select people in terms of the target parameter. In our case, people were chosen randomly, without any selection, except for their place of living and sex and the majority of our group did not smoke, consume alcohol or consume hormones or medications. Our target parameter was indeed the possible effect of climate on the skin, therefore people were selected for place of residence.

In conclusion, we have characterized a skin biophysical profile of a sample of people living in a mountainous region with extreme climate conditions. Interestingly, values of skin hydration and visco-elasticity were particularly low. These values could be related to the influence of

climate, but further studies more specifically directed towards people clearly exposed to high UV irradiation living in the region could create a more precise link with climate and skin parameters.

These data identify for the first time an area, Valais, as a possible reservoir of people with precise cutaneous parameters, useful for further investigations on skin cancer, skin aging, skin roughness or atopic skin.

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