Solar exposure and influencing parameters on the endogenous vitamin D production

P. Knuschke

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davos / CH, 15-16 July 2014
Effects of solar UV radiation on humans

bio-positive vitamin D

adverse
Synthesis of vitamin D$_3$
Efficiency of solar UV radiation
(summer : winter)

Solar data: Dresden/Germany (51° N)
Epidemiological studies proofed a correlation

Risk of squamous cell carcinoma

Outdoor workers : Indoor workers
1.8 : 1

Metaanalysis from 18 epidemiological Studies (Schmitt J et al., BJD 2011):
Investigation of lowest UV exposure level to realize an increase in 25OHD₃-serum level and the influencing factors

- **2007/2011:** „UV-dependent vitamin D₃ synthesis – balancing of UV exposure time and the production of an optimal vitamin D₃ status in men“
  
  
  (BMU/BfS support-N°: StSch 4538)

- **2013/2015:** „Optimization of recommendations to the public on UV radiation and vitamin D status by investigation of everyday life related influences in realization of an optimal vitamin D status by minimization of solar UV radiation“

  (BMU/BfS support-N°: FV 3612S70026)
To characterize the vitamin-D-status: serum level of 25-OHD$_3$

- Basing on bone metabolism (high evidence)
  - $< 12$ ng/ml: health risk
  - $> 20$ ng/ml: no risk $> 97.5\%$ of the population

- Optimal status in discussion with respect to several diseases (low evidence)
  - $\geq 30$ ng/ml

Unit for 25OHD$_3$ i.S.: $1$ ng/ml $= 2.5$ nmol/l
Studies A. – E.

Structure of the study groups

- UV skin type:  
  - SkT II, normal pigmentation (n = 20)
  - SkT III, normal pigmentation (n = 20)

subgroups:

- age:  
  - 18-30 y; 40-65 y

- gender:  
  - male; female
Season dependences of vitamin D status
Normalized distribution functions of 25OHD$_3$ serum level in the volunteers of the project studies

Knuschke P et al. (2012) urn:nbn:de:0221-201210029658
Study C.1 – C.3 and D.1 – D.3
MED-controlled applications of UV exposure on
• face and hands
• whole body
to determine the effect on 25OHD$_3$ increase
UV exposure to induce vitamin D synthesis with respect to the individual erythema sensitivity.

Photodiagnostic to detect the MED

1 MED
Study C.1 / C.2 / C.3

„Erythemal-effective exposure $H_{er} = 0.1 \text{ MED} / 0.3 \text{ MED} / 0.7 \text{ MED};$

solar simulated radiation (Arimed B)“

Study D.1 / D.2 / D.3

„Erythemal-effective exposure $H_{er} = 0.1 \text{ MED} / 0.3 \text{ MED} / 0.7 \text{ MED};$

sunbed lamp radiation ($H_{er}(\text{UVB}) : H_{er}(\text{UVA}) = 1 : 1.5 / \text{Cosmolux RAplus } )“

UV exposure schedule

6x face+hands for 3 weeks - 3 weeks break - 6x whole body for 3 weeks
MED-controlled application of solar UV exposure by
- RB-type-meter
- PSF-dosemeter
to determine the effect on $25\text{OHD}_3$ increase

- face and hands
- whole body
Study E.1.1 / E1.2

„Erythemal-effective exposure $H_{er} = 0.3 \text{ MED} / 0.7 \text{ MED};$

solar radiation “

UV exposure schedule

4x face + hands for 2 weeks - 4x face + hands for 2 weeks

Study E.2.1 / E2.2

„Erythemal-effective exposure $H_{er} = 0.1 \text{ MED} / 0.3 \text{ MED};$

solar radiation “

UV exposure schedule

4x whole body for 2 weeks - 4x whole body for 2 weeks
SSR vs. solar radiation vs. sunbed lamps - increase in 25OHD₃ serum level -

<table>
<thead>
<tr>
<th>UV exposure (dose; skin area)</th>
<th>Δ25OHD₃ / ng/ml (mean per 1x UV exposure)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SSR</td>
</tr>
<tr>
<td>0.1 MED (face + hands)</td>
<td>0.27</td>
</tr>
<tr>
<td>0.3 MED (face + hands)</td>
<td>0.55</td>
</tr>
<tr>
<td>0.7 MED (face + hands)</td>
<td>0.82</td>
</tr>
<tr>
<td>0.1 MED (whole body)</td>
<td>0.99</td>
</tr>
<tr>
<td>0.3 MED (whole body)</td>
<td>1.53</td>
</tr>
<tr>
<td>0.7 MED (whole body)</td>
<td>2.72</td>
</tr>
</tbody>
</table>

Knuschke P et al. (2012) urn:nbn:de:0221-201210029658
Possible explanation:

Vitamin D destruction by the high UVA content of sunbed lamps

Webb AR, DeCosta BR, Holick MF. Sunlight regulates the cutaneous production of vitamin D by causing its photodegradation. JCE&M 68(1989)5, 882-887
Traceability for surface spectral solar ultraviolet radiation
- one example the necessity
Study E.3

„Follow up of 25OHD$_3$ serum levels under every day life conditions for two years including control of personal UV-monitoring and global radiation”

- 25OHD$_3$-controls: Sep/Jan/Mai/Sep/Jan/Mai

- personal UV monitoring: continuously for 2 year 1 PSF-dosemeter per 2 weeks
$H_r(GS) / J/m^2$

$H_r(PersDosi) / J/m^2$

$25OHD_3 / ng/ml$

Pathological deficiency

Normal

Optimal

$2 \times 0.1 \text{ MED/Wo}$

$2 \times 0.3 \text{ MED/Wo}$

$2 \times 0.7 \text{ MED/Wo}$

Knuschke, P et al. (2012) urn:nbn:de:0221-201210029688
Summary

Endogenous vitamin D production:
• also in field control: 2x/week 30 % MED
  25OHD$_3$ > 20 ng/ml

• down to 0.1 MED 2x/week
  (perpendicular on face+hands): 25OHD$_3$

• behaviour influences:
  important up to primarily
  (on endogenous VD$_3$-production)
  (more than constitutional effects skin type I-IV)

• Influence of UVA-2, UVA-1:
  morning/evening sun? current sunbed lamps?

Season-depending 25OHD$_3$-status
• in summer: 75/50 % > 20/30 ng/ml
• in winter: 25/5 % > 20/30 ng/ml
Facts on further results

- **25OHD\(_3\) efficiency of sun bed lamps:** 30 % of solar radiation or SSR (VD\(_3\)-photodegradation caused by the high UVA-fraction?)
- **25OHD\(_3\)-efficiency [UV-skin-serum]:** anatomical variations up to 400 %
- **UVR only on face and hands:** >80 % VD\(_3\)-production via face skin
- **body distribution of solar UV-exposure:** has to take into account for real skin exposure estimations!
- **outdoor times in summer:** e. g. 2x/week, 20-30 min walking (60/10 min overcast sky/sun seeking)
- **winter (Central Europe):**
  - no vitamin D production (essential times too long)
- **Provitamin-D-content (7-DHC) in the skin:** independent on age (up to 65 y)
On behalf of

the co-workers of the research project

• Prof. Dr. med. Andrea Bauer
• Dr. rer. nat. Bodo Lehmann
• Dipl.-Chem. Andrea Püschel
• Schwester Kristin Mersiowsky
• Dipl.-Soz. Henriette Rönsch
Thank you for your attention!