Silicon, Ethanol and Connective Tissue health: A Case for Moderate Beer Consumption?

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MRC HNR, Elsie Widdowson Laboratory:
Fellow, Hughes Hall College, University of Cambridge.
Cambridge (UK).
The First Solvay Congress 1911
Hotel Metropole
Cardiovascular or Bone Mortality and Alcohol

ALCOHOL INTAKE

Risk
0 Moderation Excess Abuse
Nutritional Aspects of Beer

- Orthosilicic Acid (Silicon)
- Moderate Ethanol Content
- Anti-oxidants
- B Vitamins
- Other Minerals
- Calories
Nutritional Aspects of Beer

- Orthosilicic Acid (Silicon)
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Dietary Silicon

Dietary intake of Si is 15-40 mg Si/day
## Silicon Values in Beer

<table>
<thead>
<tr>
<th></th>
<th>Mean±SD (mg/l)</th>
<th>Range (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lager</td>
<td>22.1 ± 8.3</td>
<td>11.7 - 39.4</td>
</tr>
<tr>
<td>Bitter</td>
<td>19.8 ± 5.7</td>
<td>12.6 - 29.8</td>
</tr>
<tr>
<td>Mild</td>
<td>16.7 - 30.1</td>
<td></td>
</tr>
<tr>
<td>Stout</td>
<td>9.6 - 19.7</td>
<td></td>
</tr>
</tbody>
</table>

Silicon Absorption

Serum Si (μmol/l) vs. Time (h)

- Red square: Beer (20 mg Si)
- Green circle: Food Supplement (20 mg Si)

Four-week-old chicks on silicon-supplemented diet (left) and low-silicon basal diet (right) (Carlisle, 1972).
Body level of Si is 140-700 mg

Collagenous Tissues

CARTILAGE
- Larynx
- Trachea
- Bronchi

HAIR & SKIN
- Hair shaft
- Arrector pili
- Hair follicle
- Hair root
- Pacinian corpuscle

NAILS
- Lunula
- Nail body
- Nail root (hidden)

JOINTS
- Outer side of bone
- Inner side of bone
- Articular cartilage

BONES
- Compact bone
- Spongy bone
- Medullary (marrow) cavity
- Epiphysis (head)
- Diaphysis (shaft)
- Epiphysis (end)

VASCULATURE
- Aorta
- Right Coronary Artery
- Left Anterior Descending Coronary Artery
- Circumflex Coronary Artery
- Left Main Coronary Artery
BONE

[Diagram of human skeleton with labeled bone parts]

- Intervertebral Disc
- Vertebral Body
- Facet Joints
- Pedicle

BONES

- Epiphysis (head)
- Compact Bone
- Medullary ( marrow) cavity
- Epiphysis (shaft)
Bone Homeostasis

(Adapted from Harada & Rodan Nature 2003.)
Osteoporosis

Normal Bone

Osteoporotic Bone

UK Osteoporosis costs: 1 billion pounds per annum.
Dietary silicon intake and BMD

Framingham Offspring cohort (USA)
1251 men and 1596 women (306 pre-menopausal)

Dietary silicon intake and BMD

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Adjust BMD (g/cm^2) vs. silicon intake (mg/d)

POST-MENOPAUSAL WOMEN
PRE-MENOPAUSAL WOMEN
MEN

SILICON INTAKE (mg/d)

Dietary silicon intake and BMD

Framingham Offspring cohort (USA)
1251 men and 1596 women (306 pre-menopausal)

<table>
<thead>
<tr>
<th>SILICON INTAKE (mg/d)</th>
<th>TOTAL HIP</th>
<th>FEMORAL NECK</th>
<th>TROCHANTER</th>
<th>WARD'S AREA</th>
<th>LUMBAR SPINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0.96</td>
<td>0.96</td>
<td>0.96</td>
<td>0.88</td>
<td>1.24</td>
</tr>
<tr>
<td>30</td>
<td>1.04</td>
<td>1.04</td>
<td>0.96</td>
<td>0.96</td>
<td>1.32</td>
</tr>
<tr>
<td>45</td>
<td>1.12</td>
<td>1.04</td>
<td>0.96</td>
<td>0.92</td>
<td>1.40</td>
</tr>
</tbody>
</table>

### Silicon Intake & BMD: separate menopausal status, HRT use

<table>
<thead>
<tr>
<th>Menopausal Group</th>
<th>FN BMD</th>
<th></th>
<th>LS BMD</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$r$</td>
<td>$P$</td>
<td>$r$</td>
<td>$P$</td>
</tr>
<tr>
<td>Pre-menopausal ($n=109$)</td>
<td>0.206</td>
<td>0.03</td>
<td>0.152</td>
<td>0.12</td>
</tr>
<tr>
<td>Pre- &amp; Peri-menopausal ($n=333$)</td>
<td>0.098</td>
<td>0.07</td>
<td>0.083</td>
<td>0.13</td>
</tr>
<tr>
<td>Post-menopausal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no-HRT ($n=1018$)</td>
<td>-0.025</td>
<td>0.43</td>
<td>0.010</td>
<td>0.74</td>
</tr>
<tr>
<td>past-HRT ($n=664$)</td>
<td>0.076</td>
<td>0.05</td>
<td>0.066</td>
<td>0.09</td>
</tr>
<tr>
<td>current-HRT ($n=1170$)</td>
<td>0.086</td>
<td>&lt;0.01</td>
<td>0.019</td>
<td>0.52</td>
</tr>
</tbody>
</table>

A, Pro-collagen 1 C-terminal polypeptide synthesis (ng/µg protein).
B, Osteocalcin synthesis (ng/µg protein).
C, TGF-β1 synthesis (pg/µg protein).
* p < 0.01, ** p < 0.005; (paired t-test) control vs Si.
Collagen type 1 synthesis in cell lysates by Western blot

(Unpublished results.) A graph showing an increase collagen in the extracellular matrix and cell lysate of human skin fibroblast cells exposed to different concentrations of orthosilicic acid (Si(OH)₄).

Silicon may facilitate matrix formation through collagen deposition.
Soluble silica and coral sand suppress high blood pressure and improve the related aortic gene expressions in spontaneously hypertensive rats

Fusako Maehira\textsuperscript{a,*}, Kyoko Motomura\textsuperscript{a}, Nau Ishimine\textsuperscript{a}, Ikuko Miyagi\textsuperscript{a}, Yukinori Eguchi\textsuperscript{b}, Shoei Teruya\textsuperscript{c}

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\textsuperscript{b}Research Laboratory Center, Faculty of Medicine, University of the Ryukyus, Nishihara, Okinawa 903-0215, Japan
\textsuperscript{c}Okinawa Industrial Technology Center, Gushikawa, Okinawa 904-2234, Japan

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Silicon reduces hypertension
Circumference (diameter) is greater in the silicon treated mice which would allow lower pressures for equivalent blood flow

(Unpublished results.) Preliminary findings from a study (in collaboration with the Medical University of Vienna) investigating the effect of silicon supplementation on atherosclerosis and aortic health. A significant increase in aortic circumference was found in the silicon supplemented groups, compared to the control group.
Nutritional Aspects of Beer

Orthosilicic Acid (Silicon)

Moderate Ethanol Content

Anti-oxidants
B Vitamins
Other Minerals
Calories
Moderate Alcohol Intake and Bone Mineral Density

Framingham Cohort  Post-menopausal Women

Troc BMD

0.64
0.66
0.68
0.7
0.72
0.74
0.76

Total Alcohol Consumption (serving/day)

Post_meno Women

Serum CTx following Ca Ingestion

Sripanyakorn et al., J Bone Miner Res 2009;24:1380-1388.
Serum CTx following Ca or Alcohol Ingestion

Sripanyakorn et al., J Bone Miner Res 2009;24:1380-1388.
Sripanyakorn et al., *J Bone Miner Res* 2009;24:1380-1388.
Final Model of Moderate Beer Consumption on Inhibition of Bone Resorption

Estimated Patterns adjusted for Sex

Sripanyakorn et al., J Bone Miner Res 2009;24:1380-1388.
Bone Homeostasis

(Adapted from Harada & Rodan Nature 2003.)
Bone Homeostasis

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Associations between alcohol intake and BMD in men (in the Framingham Cohort): dissecting out the contribution from silicon with (circles) and without (squares) adjustment for silicon intake.

BUT: CONFOUNDERS!!!!!!

Moderate drinkers are moderate people eating moderately and exercising moderately..........................
APOSS Cohort:

- Lifestyle, Moderate Alcohol Intake & Bone Mineral Density

N = 3883 women
50-62 years old
Two-Step cluster analysis

<table>
<thead>
<tr>
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<th>Cigarettes</th>
<th>Fruit &amp; Vegetables</th>
<th>Physical Activity</th>
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<tr>
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<th>“Bad” 50%</th>
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</tr>
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<th>“Good” 27%</th>
<th>“Bad” 50%</th>
<th>“Ugly” 23%</th>
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</thead>
<tbody>
<tr>
<td>Cigarettes</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
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<td>↑</td>
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<td>↔</td>
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(Unpublished results.) Our findings confirm that the positive impact of moderate alcohol (beer) ingestion on bone health cannot be explained by confounding factors and is a real phenomenon.
Conclusions

• Beer is a potential major source of dietary silicon as absorbable orthosilicic acid.

• Silicon (orthosilicic acid or precursor forms such as MMST) is involved in bone **Formation** and other aspects of connective tissue health.

• *Moderate* Alcohol intake is associated with acute suppression of bone **Resorption**.

• Ingestion of high levels of dietary silicon and *moderate* alcohol consumption is positively associated with bone health in humans.

• Moderate beer consumption appears to address bone health from two sides: promotion of bone formation (silicon) and inhibition of bone resorption (ethanol).
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• Institute of Brewing and Distilling