Low Deuterium Water

Isotopes and Isotopologues

The term **Isotope** refers to atomic species having the same atomic number, while different atomic masses:

- Hydrogen has two stable isotopes:
  ^{1}H and ^{2}H
- Oxygen has three stable isotopes:
  ^{16}O, ^{17}O, and ^{18}O

The term originates from Greek ***isos topos***, 'in the same place' of Mendeleyev's table.

Hereinafter, we use symbols $^{1}H=H$, $^{2}H=D$ (deuterium), and $^{16}O=O$ for the simplicity:

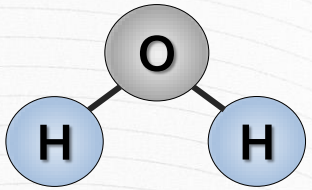
$$^{1}H^{16}O^{1}H = H_2O$$

$$^{1}H^{16}O^{2}H = HOD$$

The term **Isotopologue** refers to molecular entities different only in isotopic composition.

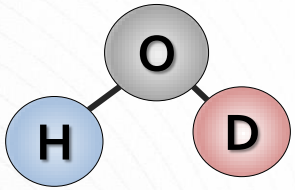
In theory, stable isotopes of hydrogen and oxygen may form nine different water isotopologues with masses from 18 to 21 g/mol.

Mass = **18** g/mol



H2O

19 g/mol



HOD

Facts about H_2O

	Abundance, %	Molar mass g/mol
$H_2{}^{16}O$	99.73	18
$H^{16}OD$	0.031	19
$H_2{}^{17}O$	0.037	19
$H_2{}^{18}O$	0.200	19
$H^{17}OD$	0.00001	20
$H^{18}OD$	0.00006	20
$D_2{}^{16}O$	0.0005	20
$D_2{}^{17}O$	ND	21
$D_2{}^{18}O$	ND	21
	100 %	

H_2O

Rothman et al., J. Quant. Spectrosc. Radiat. Transfer, 1998, 60:665; 2003, 82:9

Natural water is not an individual substance, but a composition of water molecules with different masses (isotopologues).

Four isotopologues $H_2{}^{16}O$, $H_2{}^{17}O$, $H_2{}^{18}O$, and $H^{16}OD$ (= HOD) account for 99.9997% of water.

HOD is major deuterium-bearing molecule: 99.8% of all deuterium in water is bound into HOD.

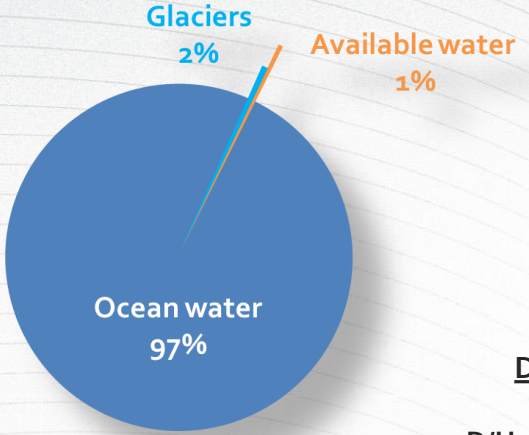
HOD content is measured and expressed as deuterium-to-protium ratio (D/H), in parts per million (ppm). Hereinafter, we will use the term "deuterium content" as equivalent to D/H ratio to specify HOD content in water.

Note: In contrast to other isotopologues, HOD content may vary dramatically between waters, up to by 50%.

What water do people drink?

- **97%** of Earth's water is Ocean water, with constant deuterium content of **155** ppm.
- **2%** (or 2/3 of fresh water) is held by Glaciers, in particular in Antarctica and Greenland, with lowest in Nature deuterium content of **85-125** ppm.
- **1%** (or 1/3 of fresh water) is surface- and ground water (Available water) having deuterium content of **140-155** ppm. This water can be easily tapped for human use.

Note: A vast majority of people consume water having deuterium content of **140-155** ppm.



Deuterium content

	D/H, ppm	Max change to Ocean, %
Ocean	155	0
Pools of arid zones	175	+7%
Desalinated water	153-155	-1%
Rivers and Lakes	140-155	-10%
Greenland ice	125	-19%
Antarctic precipitations	85-117	-43%

How much HOD do people consume daily?

An average intake for total water is 3.7 liters per day for a man and 2.7 liters per day for a woman. Dietary Guidelines for Americans, 2005, U.S. Department of Health & Human Services.

When people consume available water (140-155 ppm) in above amounts, accompanying inescapable intake of HOD is estimated as:

- 0.7-0.8 gram per day (woman)
- 1.0-1.3 gram per day (man)

Note, HOD intake would be up to by 30-40% less, in a case of consuming Antarctic water.

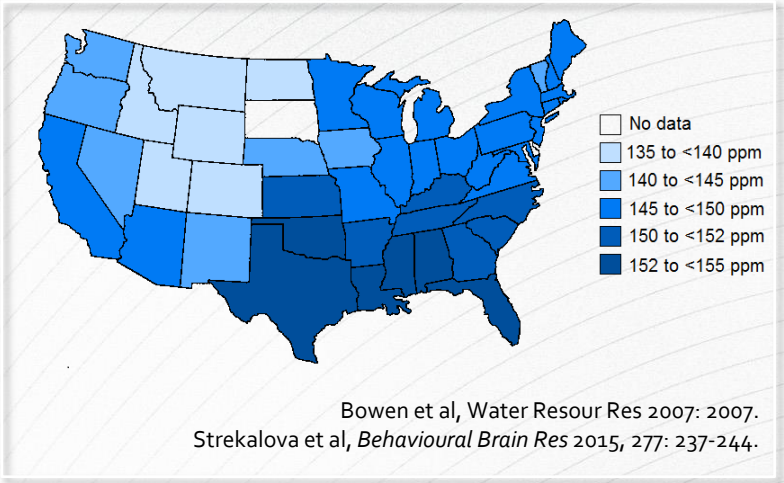
Deuterium content in available waters

Water source	Place of origin	D/H, ppm
Ocean (standard)	Ocean	155,76
Dubai tap water	Dubai	153,87
Smart Water	Coca-Cola	147,14*
Spring water, Stäfa	Switzerland	145,75
Henniez Mineral Water	Switzerland	145,47
Eptinger Mineral Water	Switzerland	145,20
Evian Mineral Water	France	144,83
Zurzacher Mineral Water	Switzerland	144,40
Farmer Mineral Water	Switzerland	143,35
Elmer Mineral Water	Switzerland	143,15
Walensee	Switzerland	143,03
Adello Mineral Water	Switzerland	143,00
Valser Mineral Water	Switzerland	142,07
Spring water, Mainenfeld	Switzerland	141,76
Rhäzunser Mineral Water	Switzerland	141,36
Aproz Mineral Water	Switzerland	140,10
Antarctic glacier (standard)	Antarctic plateau	89,09

Measured by Dr. Rolf Siegwolf, Paul Scherrer Institute ;*OAO ALMAZ

Does deuterium content of water is a factor influencing on public health?

Deuterium content in Tap Water, ppm



Bowen et al, Water Resour Res 2007: 2007.
Strekalova et al, *Behavioural Brain Res* 2015, 277: 237-244.

Facts:

- ✓ Deuterium content of ground- and surface water is a constitutive environmental factor for every place.
- ✓ Deuterium content of tap water corresponds to those of ground- and surface water of the place.
- ✓ Deuterium content of bottled water corresponds to those of tap water in the proximity of 200 miles.

Thus, deuterium content of water is environmental factor, attributed to the place.

To address an issue whether deuterium content of water may influence on human health, we measured relationships between deuterium content of water and prevalence of disorders using Pearson correlation analysis.

(see graphs on next pages)

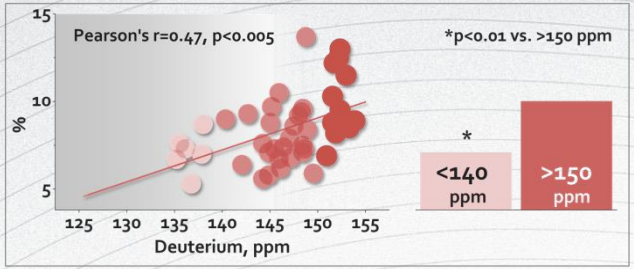
Mental disorders

disorder prevalence vs. deuterium content in tap water across U.S.A.

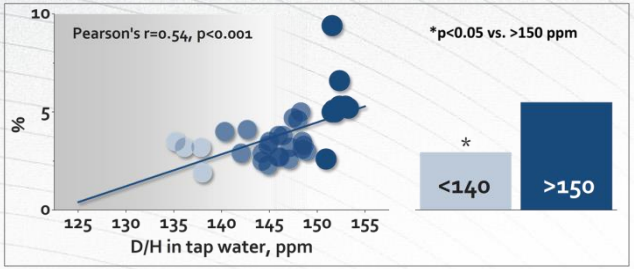
Disorder prevalence data are obtained from open source of Centers for Disease Control and Prevention (USA).

Deuterium content data are obtained from survey on deuterium content in tap water in the USA.

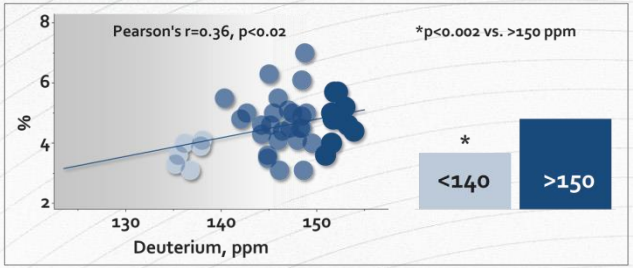
Prevalence of Current Depression, age 18+



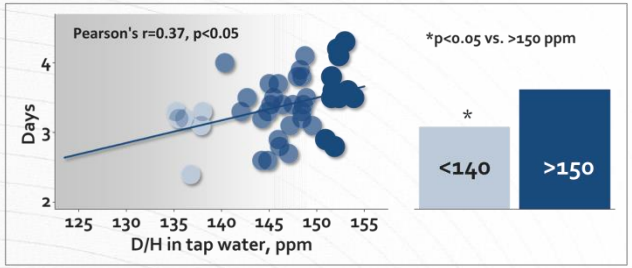
Psychosocial Distress, age 18+



Dissatisfied in their lives, age 50+ (2006)



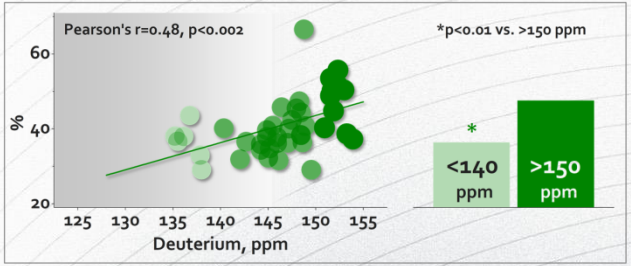
Mentally Unhealthy Days per month, age 18+



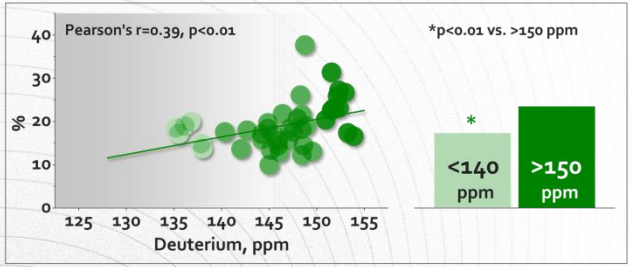
Oral health

Percentage of adults with tooth loss vs. deuterium content in tap water across U.S.A.

Tooth loss (≥6) among adults, age 65+



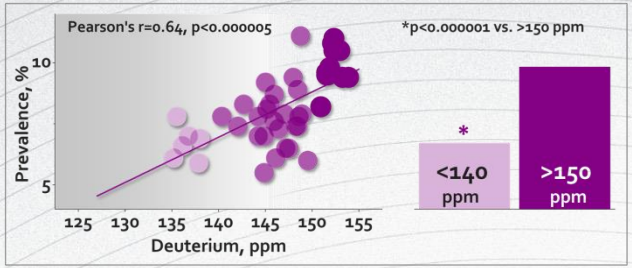
Complete tooth loss, age 65+



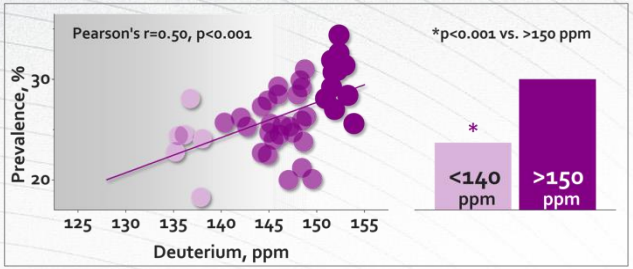
Metabolic disorders & CVD

disorder prevalence vs. deuterium content in tap water across U.S.A.

Diabetes, age 18+



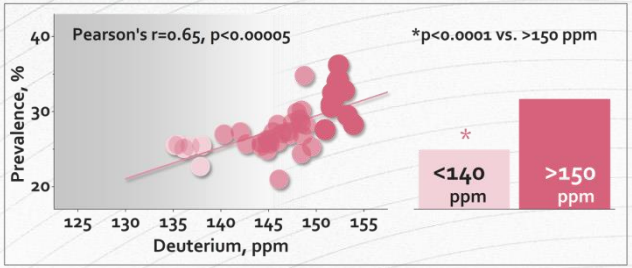
Obesity, age 18+



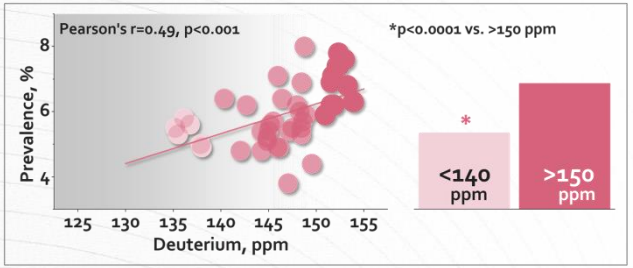
Cardiovascular disorders

disorder prevalence vs. deuterium content in tap water across U.S.A.

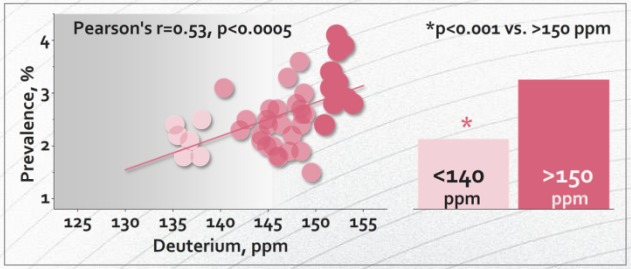
Hypertension, age 18+



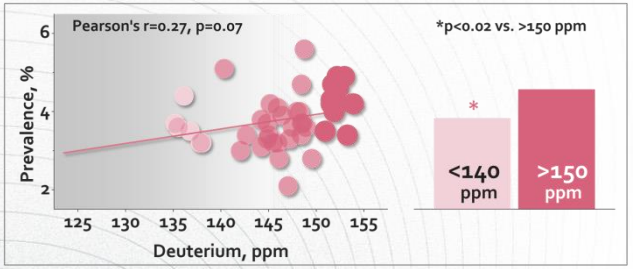
Coronary Heart Disease, age 18+



Stroke, age 18+



Myocardial Infarction, age 18+



Summary of results

Disorder		Prevalence (%), < 140 ppm *vs.* >150 ppm	
		Absolute*	Relative
Mental disorders	Psychosocial Distress	3.0 vs. 5.5%	-45%
	Depression	7.1 vs. 10.0%	-29%
Metabolic disorders	Diabetes	6.7 vs. 9.8%	-31%
	Obesity	23.7 vs. 30.0%	-21%
Cardiovascular disorders	Hypertension	25.0 vs. 31.7%	-21%
	Coronary Heart Disease	5.4 vs. 6.9%	-22%
	Stroke	2.1 vs. 3.3%	-36%
	Myocardial Infarction	3.6 vs. 4.3%	-16%
Tooth Loss	Loss of 6 or more teeth	36.4 vs. 47.6%	-23%
	Complete tooth loss	17.4 vs. 23.5%	-16%

*All differences are significant (*p<0.05)

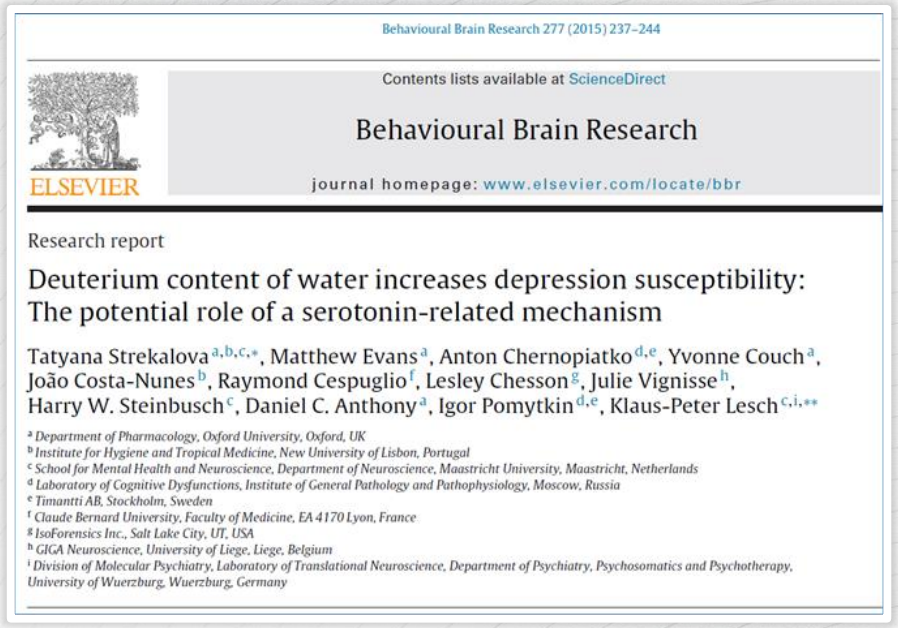
There are significant linear correlations between deuterium content of tap water and rates of certain disorders (see on left).

Generally, people are healthier, if they live at places with deuterium content of water **<140** ppm, than those who live at places with deuterium content of water **>150** ppm.

Note: Psychosocial distress is the most sensitive condition to deuterium content of water among other disorders.

Experimental evidence supports above correlations:

deuterium generates a risk of diseases



Behavioural Brain Research 277 (2015) 237–244

Contents lists available at ScienceDirect

Behavioural Brain Research

journal homepage: www.elsevier.com/locate/bbr

Research report

Deuterium content of water increases depression susceptibility: The potential role of a serotonin-related mechanism

Tatyana Strekalova[a,b,c,*], Matthew Evans[a], Anton Chernopiatko[d,e], Yvonne Couch[a], João Costa-Nunes[b], Raymond Cespuglio[f], Lesley Chesson[g], Julie Vignisse[h], Harry W. Steinbusch[c], Daniel C. Anthony[a], Igor Pomytkin[d,e], Klaus-Peter Lesch[c,i,**]

[a] Department of Pharmacology, Oxford University, Oxford, UK
[b] Institute for Hygiene and Tropical Medicine, New University of Lisbon, Portugal
[c] School for Mental Health and Neuroscience, Department of Neuroscience, Maastricht University, Maastricht, Netherlands
[d] Laboratory of Cognitive Dysfunctions, Institute of General Pathology and Pathophysiology, Moscow, Russia
[e] Timantti AB, Stockholm, Sweden
[f] Claude Bernard University, Faculty of Medicine, EA 4170 Lyon, France
[g] IsoForensics Inc., Salt Lake City, UT, USA
[h] GIGA Neuroscience, University of Liege, Liege, Belgium
[i] Division of Molecular Psychiatry, Laboratory of Translational Neuroscience, Department of Psychiatry, Psychosomatics and Psychotherapy, University of Wuerzburg, Wuerzburg, Germany

Presentation on 3rd International congress on Deuterium Depletion, 2015, Hungary.

Study design: Mice receiving **140** ppm or **91** ppm water were exposed to **10**-days chronic stress and then tested on depression symptoms.

Results: **37%** and **80%** of mice exposed to stress become depressive in 91 ppm and 140 ppm group, respectively.

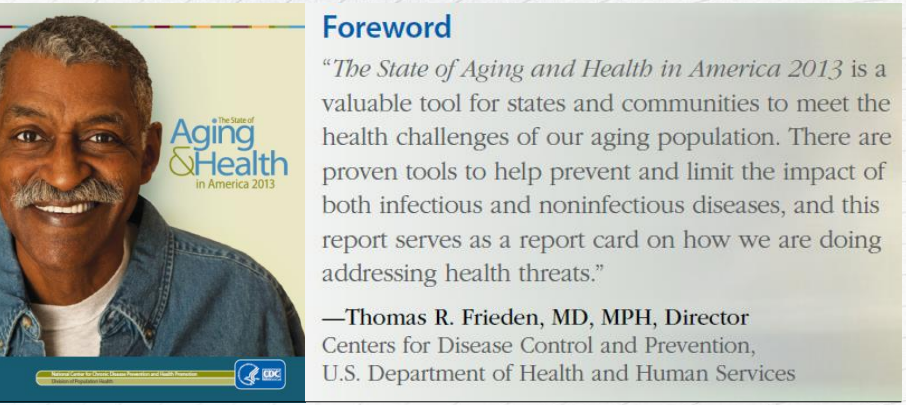
Relative risk: **0.46** (91 vs. 140 ppm, p=0.014)

Besides that, mice from **91** ppm group had:

- ✓ significantly higher hippocampal neurogenesis
- ✓ significantly decreased duration of REM sleep
- ✓ about 10-fold lower expression of hippocampal serotonin reuptake transporter (5HTT) (*p<0.05).

Conclusion: Within natural range of deuterium (91-140 ppm), deuterium significantly increases risk of depression, in full agreement with human data.

Healthy aging vs. deuterium content of water



Foreword

"*The State of Aging and Health in America 2013* is a valuable tool for states and communities to meet the health challenges of our aging population. There are proven tools to help prevent and limit the impact of both infectious and noninfectious diseases, and this report serves as a report card on how we are doing addressing health threats."

—Thomas R. Frieden, MD, MPH, Director
Centers for Disease Control and Prevention,
U.S. Department of Health and Human Services

The State of Aging and Health in America 2013 provides a snapshot of progress in promoting prevention, improving the health and well-being of older adults.

Based on State-by-State data from *The State of Aging and Health in America 2013* and *Survey data on deuterium content of tap water*, we measured the strength of association between deuterium content of water and indicators of older adult Health Status and Health Behavior using Pearson correlation analysis.

Results:

There is a significant linear correlation between deuterium content of tap water and indicators of Health Status (3 from 4) and Health Behavior (3 from 5).

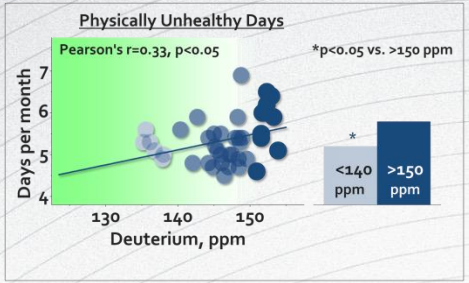
Conclusion:

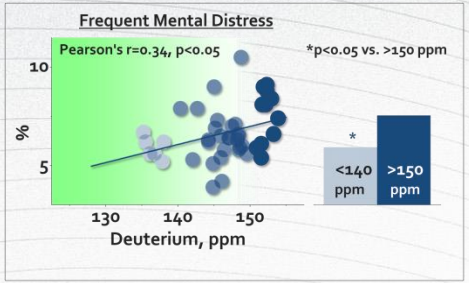
Older adults who reside at places with deuterium content of water **<140** ppm are healthier compared to those, who live at places with deuterium content of water **>150** ppm

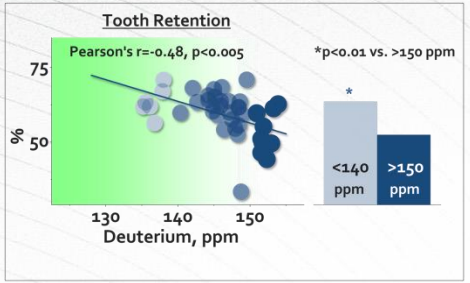
(see graphs on the next page)

Health status indicators (green)

among older adults, 65+ an indicator vs. deuterium content in tap water across U.S.A.

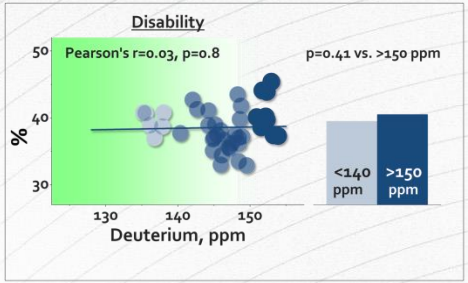


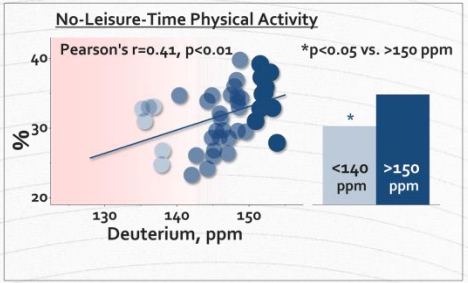


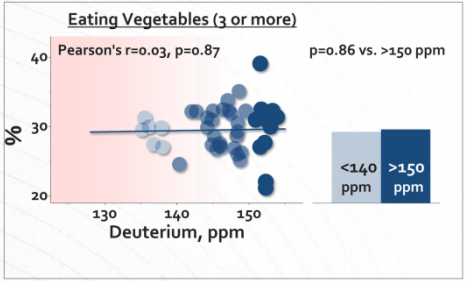


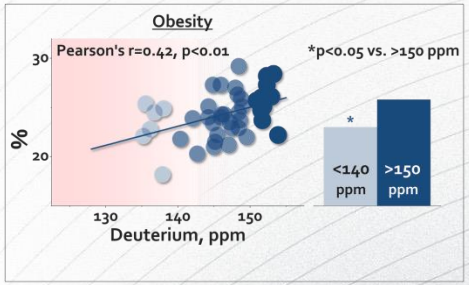
Health behavior indicators (red)

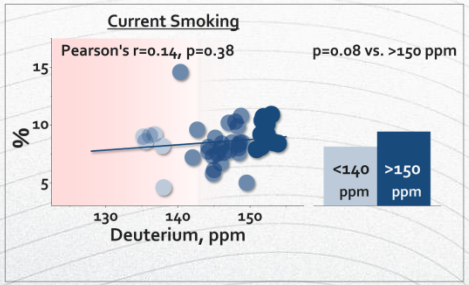
among older adults, 65+ an indicator vs. deuterium content in tap water across U.S.A.

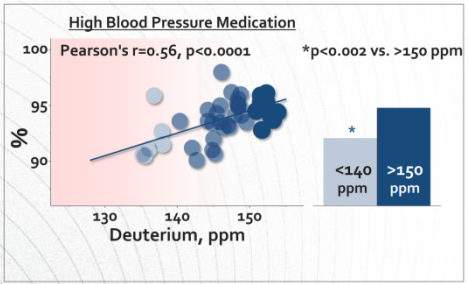












Two regimen of water use:
chronic vs. short-term

Chronic use (every day for indefinitely long period of time, e.g. throughout all life):

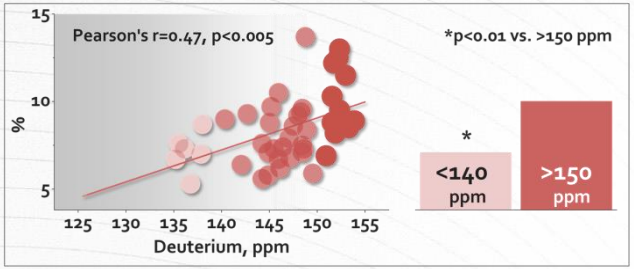
even small depletion of water of deuterium, e.g. to 140 ppm vs. >150 ppm, may provide significant benefit for health.

Short-term use (every day for short period of time, weeks or months):

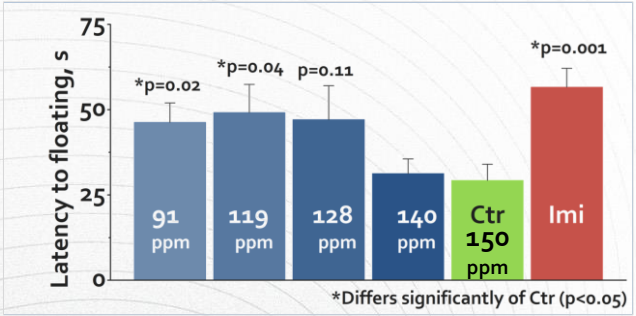
water should be depleted of deuterium more deeply to achieve significant effect compared to 150 ppm. Results of two weeks of water consumption:

140 ppm does not work
128 ppm almost works (trend, p=0.11)
119 ppm works
91 ppm works

Regimen of chronic consumption of water
Depression in humans



Regimen of short-term (2 weeks) consumption of water
Depression in mice



Site of Light water action: bioenergetics

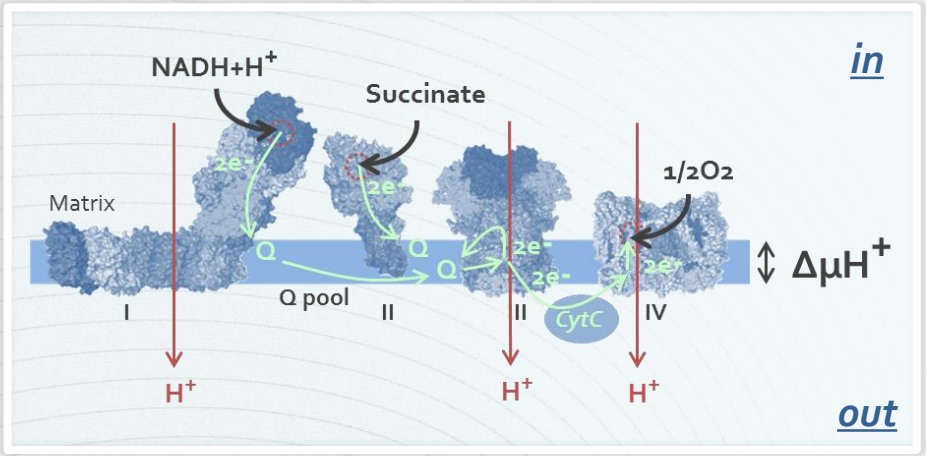
Mitochondria are the power plants of a human body and the site of light water action.

A process known as *proton-coupled electron transfers (PCET)* generate protonmotive force (ΔμH+) across mitochondrial inner membrane during oxidation of substrates, NADH and Succinate, with molecular oxygen (see scheme). Then, ΔμH+ is converted to ATP, a major energetic substrate. Collectively, this process supplies a human body with energy for life.

Deuterium retards proton-coupled electron transfers and thus retards generation of ΔμH+ and subsequent supply of a body with energy, since mitochondrial bioenergetics is based on the proton-coupled electron transfers.

Light water reduces deuterium intake with water and de-inhibits of unwanted suppressive effect of deuterium on bioenergetics.

Protonmotive force (ΔμH+) is generated by numerous proton-coupled electron transfers across mitochondrial complexes



Commercially available equipment for measurement of deuterium content of water

Isotope-ratio mass spectrometry (IRMS):

IRMS provides measurement of deuterium content by conversion of water to hydrogen gas and detection of hydrogen molecules of different masses in a magnetic field. Results are expressed as D/H ratio, in ppm. IRMS requires a professionally trained operator.

Laser spectroscopy:

It provides measurement of deuterium content in water samples by specific absorption of laser light. The fastest, most accurate tool for measurement of water isotopologues on the market. Capital costs and operating costs are a 3-4 times less compared to IRMS. It does not require a professional operator.

Method of choice

Manufacturing of light water

Currently, vacuum distillation (rectification) of plain water is the major technological process for light water production:

- ✓It provides water depleted of deuterium in the range 5-139 ppm and is considered to be safe by food and drug regulations.
- ✓The process can be realized on large scale.
- ✓The process is known for a long time and is in public domain now.

An ultimate goal in the field of production of light water by vacuum distillation is modernization of the process in a way to reduce self-costs of the manufacturing process.

Thank you!