

Breathing for Diabetes Workshop Bibliography

25,000 opportunities for better health

- This is a broad generalization that comes out to around 17 breaths/min. This is on the higher end of normal, but if we account for exercise and periods of faster breathing rates, it seems pretty reasonable.

IDF statistics on diabetes

- Diabetes Facts & Figures. International Diabetes Federation. (2021, September 12). Retrieved December 15, 2021, from <https://idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html>

a person with diabetes has healthcare costs that are more than twice as much as someone without the disease

- <https://www.diabetes.org/about-us/statistics/cost-diabetes>

The cost of insulin in the United States has risen more than 1000% in the past two decades.

- The High Cost of Insulin in the United States: An Urgent Call to Action: [https://www.mayoclinicproceedings.org/article/S0025-6196\(19\)31008-0/fulltext](https://www.mayoclinicproceedings.org/article/S0025-6196(19)31008-0/fulltext)

Nasal breathing redistributes blood flow in the lungs

- <https://journals.physiology.org/doi/full/10.1152/japplphysiol.00285.2009>
 - And here's my The Breathing Diabetic (TBD) short summary of the paper: <https://www.thebreathingdiabetic.com/science-library/sanchez-crespo-et-al-2010>

Nose-in/mouth-out increases tissue oxygenation by 10%

- Inhalation of nasally derived nitric oxide modulates pulmonary function in humans <https://pubmed.ncbi.nlm.nih.gov/8971255/>

Tissue hypoxia as the root of diabetic complications

- *Integrated cardiovascular/respiratory control in type 1 diabetes evidences functional imbalance: Possible role of hypoxia:* [https://www.internationaljournalofcardiology.com/article/S0167-5273\(16\)34745-3/fulltext](https://www.internationaljournalofcardiology.com/article/S0167-5273(16)34745-3/fulltext) A good quote from it: "We show in the present study that what is normally called "autonomic neuropathy" could be in many cases a functional condition of sympathetic activation, driven by many factors, one of which seems to be resting hypoxia."
 - And the TBD short summary of this paper: <https://www.thebreathingdiabetic.com/bianchi-et-al-2017>
- *Integrated Cardio-Respiratory Control: Insight in Diabetes:* <https://link.springer.com/article/10.1007/s11892-016-0804-9>

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- And the TBD short summary: <https://www.thebreathingdiabetic.com/bernardi-and-bianchi-2016>

Nasal breathing during sleep reduces upper airway resistance and obstructive sleep apnea:

- Effect of nasal or oral breathing route on upper airway resistance during sleep: <https://erj.ersjournals.com/content/22/5/827.long>
 - And the TBD short summary of it: <https://www.thebreathingdiabetic.com/fitzpatrick-et-al-2003>

Nasal breathing during sleep reduces sleep-disordered breathing

- The reference above applies here.
- Role of Nose in Sleep-Disordered Breathing: <https://www.sleepmedres.org/journal/view.php?number=47>
 - TBD short summary of that paper: <https://www.thebreathingdiabetic.com/park-2014>
- Nasal Obstructions, Sleep, and Mental Function: <https://academic.oup.com/sleep/article/6/3/244/2750282?login=false>
 - TBD Short summary of that paper: <https://www.thebreathingdiabetic.com/lavie-1983>

Nasal breathing during sleep and insulin sensitivity

- Poor sleep reduces insulin sensitivity: *A single night of partial sleep deprivation induces insulin resistance in multiple metabolic pathways in healthy subjects:* <https://pubmed.ncbi.nlm.nih.gov/20371664/>
- Therefore, the deeper sleep achieved through nasal breathing at night will inadvertently improve insulin sensitivity. There's no direct study for this one, just a generalization based on deductive logic, my own experience, and the experiences of others.

“During sleep, breathing entrains and coordinates neural activity across the limbic system, and enhances memory consolidation.”

- <https://neurosciencenews.com/breathing-sleep-19984/>

Two key relationships between breathing and the nervous system

- Inhaling being sympathetic and exhaling being parasympathetic can be found in many places. A good place to start is [A Pocket Guide to the Polyvagal Theory](#).
- For slow and fast breathing, here are two good places to start:
 - The physiological effects of slow breathing in the healthy human: <https://breathe.ersjournals.com/content/13/4/298>
 - Sympathetic neural outflow and chemoreflex sensitivity are related to spontaneous breathing rate in normal men: <https://www.ahajournals.org/doi/10.1161/01.HYP.0000197613.47649.02>

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Heart Rate Variability Resources

- [Heart Breath Mind](#) by Leah Lagos
- [Biofeedback and Mindfulness in Everyday Life](#) by Inna Khazan
- Thought #1 here: <https://www.thebreathingdiabetic.com/blog/hrv-sleep-keep-breathing>
- Thought #2 here: <https://www.thebreathingdiabetic.com/blog/inner-blood-flow>
- Characteristics of Resonance in Heart Rate Variability Stimulated by Biofeedback: <https://link.springer.com/article/10.1007/s10484-006-9009-3>
 - TBD short summary of that one: <https://www.thebreathingdiabetic.com/vaschillo-et-al-2006>

Baroreflex Sensitivity (BRS) Resources

- There's a nice general overview of the baroreflex in this paper: <https://www.frontiersin.org/articles/10.3389/fpsyg.2014.00756/full>
- I haven't read this one, but it's an open-source paper (most of the references I have aren't open-source) that looks like it provides everything we'd need to know about the BRS: Baroreflex Sensitivity: Measurement
- and Clinical Implications (<https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1542-474X.2008.00219.x>)

People with diabetes generally have lower HRV & BRS than healthy individuals

- Heart rate variability in type 2 diabetes mellitus: A systematic review and meta-analysis (<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0195166>)
- Heart Rate Variability in Diabetes Patients (<https://journals.sagepub.com/doi/pdf/10.1177/147323000603400308>)
- Trained breathing-induced oxygenation acutely reverses cardiovascular autonomic dysfunction in patients with type 2 diabetes and renal disease (<https://pubmed.ncbi.nlm.nih.gov/25956276/>)
- Deep breathing improves blunted baroreflex sensitivity even after 30 years of type 1 diabetes (<https://link.springer.com/article/10.1007/s00125-011-2164-y>)
- Short-term oxygen administration restores blunted baroreflex sensitivity in patients with type 1 diabetes (<https://link.springer.com/article/10.1007/s00125-011-2195-4>)
- Oxygen-induced impairment in arterial function is corrected by slow breathing in patients with type 1 diabetes (<https://www.nature.com/articles/s41598-017-04947-4>)

People with diabetes and low HRV are at increased risk of coronary heart disease

- Lower heart rate variability is associated with the development of coronary heart disease in individuals with diabetes: the atherosclerosis risk in communities (ARIC) study (<https://diabetesjournals.org/diabetes/article/51/12/3524/34253/Lower-Heart-Rate-Variability-Is-Associated-With>)

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Low HRV is an early marker of cardiac autonomic neuropathy, which can lead to heart disease, the number one cause of mortality in people with diabetes

- Type 1 diabetes mellitus and cardiovascular disease: a scientific statement from the American Heart Association and American Diabetes Association (<https://www.ahajournals.org/doi/10.1161/CIR.0000000000000034>)

Heart Rate Variability as an Index of Resilience

- <https://academic.oup.com/milmed/article/185/3-4/363/5586497?login=false>

“The overall evidence from clinical trials and meta-analyses suggests that device-guided slow breathing can significantly lower BP.”

- <https://www.ahajournals.org/doi/10.1161/HYP.0b013e318293645f>

Slow Breathing Significantly Reduces Blood Pressure in Hypertensive Diabetics

- Effects of guided breathing on blood pressure and heart rate variability in hypertensive diabetic patients ([https://www.autonomicneuroscience.com/article/S1566-0702\(13\)00674-7/fulltext](https://www.autonomicneuroscience.com/article/S1566-0702(13)00674-7/fulltext))
 - TBD short summary: <https://www.thebreathingdiabetic.com/howorka-et-al-2013>

Meta-Analysis of 17 Studies on Blood Pressure Reduction and Slow Breathing

- <https://www.sciencedirect.com/science/article/abs/pii/S0965229918304242?via%3Dihub>
 - TBD short summary: <https://www.thebreathingdiabetic.com/science-library/chaddha-et-al-2019>

“Johns Hopkins Medical Center reports that people with diabetes are twice as likely to develop hypertension.” and “A person with diabetes and hypertension is four times more likely to develop heart disease.”

- <https://www.hopkinsmedicine.org/health/conditions-and-diseases/diabetes/diabetes-and-high-blood-pressure>

Anywhere from 40 to 80% of diabetics have hypertension

- Blood pressure and diabetes: vicious twins (<https://heart.bmj.com/content/99/8/577.long>)

The Positive Breathing-Relaxation Feedback Loop

- Breath of Life: The Respiratory Vagal Stimulation Model of Contemplative Activity (<https://www.frontiersin.org/articles/10.3389/fnhum.2018.00397/full>)

“2021 study found that 6-months of diaphragmatic breathing and stress reduction significantly reduced depression, anxiety, and stress scores on the DASS-21 questionnaire”

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- Effects of Diaphragmatic Breathing and Systematic Relaxation on Depression, Anxiety, Stress, and Glycemic Control in Type 2 Diabetes Mellitus
(https://meridian.allenpress.com/ijyt/article-abstract/31/1/Article_13/470076/Effects-of-Diaphragmatic-Breathing-and-Systematic?redirectedFrom=fulltext)

Systematic Review of Three Studies with 1026 Participants

- Effectiveness of diaphragmatic breathing for reducing physiological and psychological stress in adults: a quantitative systematic review
(https://journals.lww.com/jbisrir/Fulltext/2019/09000/Effectiveness_of_diaphragmatic_breathing_for.6.aspx)

Stress, Anxiety, and Depression Are More Common in Diabetes

- Stress and Diabetes: A Review of the Links
(<https://diabetesjournals.org/spectrum/article/18/2/121/1827/Stress-and-Diabetes-A-Review-of-the-Links>)
- Prevalence and associations of psychological distress in young adults with Type 1 diabetes (<https://onlinelibrary.wiley.com/doi/10.1111/j.1464-5491.2007.02310.x>)
- Diabetes and anxiety in US adults: findings from the 2006 Behavioral Risk Factor Surveillance System (<https://onlinelibrary.wiley.com/doi/10.1111/j.1464-5491.2008.02477.x>)

Oxidative Stress and Diabetes References:

- Oxidative stress and diabetes: antioxidative strategies
(<https://link.springer.com/article/10.1007/s11684-019-0729-1>)
- Diabetes mellitus: The linkage between oxidative stress, inflammation, hypercoagulability and vascular complications
(<https://www.sciencedirect.com/science/article/abs/pii/S1056872715005073?via%3Dihub>)
- The role of oxidative stress in diabetic complications
(<https://link.springer.com/article/10.1385/CBB:43:2:289>)
- Oxidative stress, insulin signaling, and diabetes
(<https://www.sciencedirect.com/science/article/abs/pii/S0891584910014115?via%3Dihub>)
- Free radicals and antioxidants in normal physiological functions and human disease
(<https://www.sciencedirect.com/science/article/abs/pii/S1357272506002196?via%3Dihub>)
- The missing link: a single unifying mechanism for diabetic complications
([https://www.kidney-international.org/article/S0085-2538\(15\)47419-8/fulltext](https://www.kidney-international.org/article/S0085-2538(15)47419-8/fulltext))
- Negative consequences of glycation
([https://www.metabolismjournal.com/article/S0026-0495\(00\)80078-5/pdf](https://www.metabolismjournal.com/article/S0026-0495(00)80078-5/pdf))

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Breathing Helps Reduce Oxidative Stress:

- Diaphragmatic Breathing Reduces Exercise-Induced Oxidative Stress (<https://www.hindawi.com/journals/ecam/2011/932430/>)
 - TBD short summary: <https://www.thebreathingdiabetic.com/martarelli-et-al-2011>
- Diaphragmatic Breathing Reduces Postprandial Oxidative Stress (<https://www.liebertpub.com/doi/full/10.1089/acm.2010.0666>)
 - TBD short summary: <https://www.thebreathingdiabetic.com/martarelli-et-al-2011b>
- Oxygen-induced impairment in arterial function is corrected by slow breathing in patients with type 1 diabetes (<https://www.nature.com/articles/s41598-017-04947-4>)
 - TBD short summary: <https://www.thebreathingdiabetic.com/bernardi-et-al-2017>
- Diaphragmatic breathing exercise as a therapeutic intervention for control of oxidative stress in type 2 diabetes mellitus (<https://www.sciencedirect.com/science/article/abs/pii/S1744388112000382>)
 - TBD short summary: <https://www.thebreathingdiabetic.com/hegde-et-al-2012>

“A simple effect measurement revealed that the BIG showed a significant decrease in salivary cortisol concentration after the intervention, whereby the concentration was significantly lower in test 3 and test 4 as compared to test 1 and test 2”

- The Effect of Diaphragmatic Breathing on Attention, Negative Affect and Stress in Healthy Adults (<https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00874/full>)

2021 Study Found that 6-Months of Diaphragmatic Breathing and Stress Reduction Lowered HbA1c by an Average of 1.5%

- Effects of Diaphragmatic Breathing and Systematic Relaxation on Depression, Anxiety, Stress, and Glycemic Control in Type 2 Diabetes Mellitus (https://meridian.allenpress.com/ijyt/article-abstract/31/1/Article_13/470076/Effects-of-Diaphragmatic-Breathing-and-Systematic?redirectedFrom=fulltext)

10-15 min of diaphragmatic breathing, 2x day for 1 year lowered HbA1c by an average of 2%

- Effect of diaphragmatic breathing on heart rate variability in ischemic heart disease with diabetes (<https://www.scielo.br/j/abc/a/xWxKN3rTgRcb7QKLBxJJ59f/?lang=en>)
 - TBD short summary: <https://www.thebreathingdiabetic.com/kulur-et-al-2009>

For every 1% reduction in HbA1C, risk of heart attacked decreases by 14%, risk of death decreases by 21%, and risk of microvascular complications decreases by 37%.

- Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study (<https://www.bmj.com/content/321/7258/405.long>)

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“Given the reported positive effects of HRVB on psychophysiological outcomes in various patient profiles, it is clear that HRVB offers promising prospects in chronic diseases management.”

- Heart rate variability biofeedback in chronic disease management: A systematic review (<https://www.sciencedirect.com/science/article/pii/S0965229921000911?via%3Dihub>)

Mouth Tape at Night

- Here’s one of the best articles written on the topic by Dr. Mark Burhenne. “Mouth Tape: End Mouth Breathing for Better Sleep and a Healthier Mouth” (<https://askthedentist.com/mouth-tape-better-sleep/>)

Alternate Nostril Breathing

- We didn’t get into the science of alternate nostril breathing, but it’s one of the simplest and most effective breathing practices out there. Here are a few resources you might find helpful.
 - Deep Breathing Practice Facilitates Retention of Newly Learned Motor Skills (<https://www.nature.com/articles/srep37069.pdf>) ← This is one of the best papers on the practical application of ANB I’ve read.
 - Immediate Effect of Specific Nostril Manipulating Yoga Breathing Practices on Autonomic and Respiratory Variables (<https://link.springer.com/article/10.1007/s10484-008-9055-0>) ← this one often gets cited for the claim that the left nostril = parasympathetic and the right nostril = sympathetic.
 - Here’s a more recent one on brainwave activity during ANB: EEG signatures change during unilateral Yogi nasal breathing (this one also lends support to the left = calming and parasympathetic and right = energizing and sympathetic claims that the yogis have made (<https://www.nature.com/articles/s41598-021-04461-8>))
 - Eddie Stern’s book, ***One Simple Thing*** (<https://www.amazon.com/One-Simple-Thing-audiobook/dp/B07MFB213N/>) and Robin Rothenberg’s book, ***Restoring Prana*** (<https://www.amazon.com/Restoring-Prana-Therapeutic-Therapists-Practitioners/dp/1848194013/>), also have great sections on ANB.