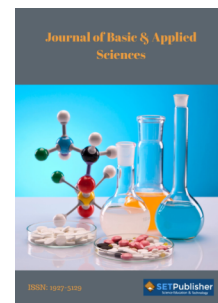




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Case Study: Long-Term Monitoring of Health Biomarkers after Drinking Structured Water Over 43 Months

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Abstract:

This case study presents a three-year monitoring of personal biomarkers before and after drinking structured water for a single subject. The five biomarkers were specifically chosen to assess the long-term effects of structured water (SW) on overall health status. The biomarker results show that Resting Energy Expenditure (REE) decreased by 18.3 %, and resting oxygen consumption rate (VO₂) decreased by 21.6% after 43 months of drinking SW water. The positive changes in the five biomarkers suggest that SW water effectively replenished and maintained BSW water levels in the subject. Furthermore, the improved biomarker results indicate that drinking SW water significantly reduced the additional stress of relying solely on aerobic respiration to meet all cellular energy needs. Replenishing BSW water levels by drinking SW water could potentially reverse dehydration and aging health issues.

INTRODUCTION

This case study reports several biomarker results from a multi-year drinking water trial for a single subject. The subject undertook a biomarker monitoring study before and after commencing to drink structured water (SW) to evaluate the effects of water on health longevity and personal health status. The fundamental premise of monitoring several resting, active, and blood biomarkers over a multi-year time is that replenishing with SW water would enhance the subject's health status and longevity. This case study was divided into two parts to avoid a protracted, lengthy, and difficult-to-read report.

Most natural water sources comprise about 20-40% SW water at room temperature. Structured water contains clusters or networks of water molecules with stronger hydrogen bonds (H-bonds) [1-3]. The H-bonded, structured water is mixed in a two-phase system with free water that has weaker H-bonds that flicker on and off at femto second intervals [1-3]. The polymeric combinations in structured water range from dimers to hexamer arrangements of water molecules that may form into larger H-bonded networks containing clusters or supra molecular structures. The SW to free water ratio varies widely depending on water temperature and energy inputs into bulk water, which alter and strengthen the H-bonds, increasing the ratio of SW water to free water. Coherent domains are polymeric structures in supramolecular assemblies (0.1 μm), each containing about 5.5 million molecules [4-16]. Coherent domains exist in liquid water at room temperature and pressure [6-16]. Each coherent domain is a supramolecular arrangement with delocalized and quasi-free electrons and protons in the π orbitals above and below each cyclic, hexamer water ring [1, 4-5]. Each CD can donate millions of quasi-free electrons within biological systems, thereby maintaining redox homeostasis at all biological scales [1, 4-5].

Structured water formation is a function of energy inputs that alter the hydrogen bond strength [17-23] or the number of hydrogen bonds [24-25] in free water. The H-bond strength is an almost linear relationship with the H-bond length between O-H [17, 19]. The H-bond length is just four picometers shorter between water molecules in ice than in liquid water. This shorter molecular distance converts liquid water to the solid crystalline phase [17]. The hydrogen bonds in water are a tradeoff between electrostatic (about 90%) and electron sharing, covalent bonds (about 10%) in water [19]. Based on bonding strength, H-bonds have been

classified as weak (with energies between -2.4 and -12 kcal/mol), strong (with energies between -12 and -24 kcal/mol), and very strong (with energies more than -24 kcal/mol) [24].

Structured water converts into Biologically Structured Water (BSW) after being ingested by animals or taken up by plant roots. After ingestion, SW water utilizes electromagnetic energy fields, such as infrared energy, to self-assemble on cell and membrane surfaces [1-2]. As SW water adheres and self-assembles on biological surfaces, it converts into BSW water that covers membrane surfaces. BSW water forms a liquid crystalline lattice of multi-layered sheets of hexagonal-ringed water molecules with openings for aquaporins and ion channels in cell membranes [1- 2, 7-14]. A substantial volume of literature shows the significance of drinking SW water and BSW water levels in biology on overall health and extending longevity [1-3].

Several health studies involving rehydration for the elderly, human longevity, and age-related diseases have concluded that "biological water" decreases with age [25-27]. As dehydration accelerates during aging, it becomes critical to replenish BSW water levels for everyone over 50 or 60 years old [28-31]. One review on aging and dehydration states that the total water content in a 45-year-old adult ranges from 65-70 %, which decreases to about 45-50% in a 70-year-old man [32]. Another dehydration review by Lavizzo-Mourey [33] states that the total percent body water decreases to 50.8 percent in men aged 61 to 74 years and to 43.4 percent in women aged 61 to 74 years. A third dehydration review by Hooper *et al.* [34] states that the percentage of body water content decreases from 70 to 60 to 50%, respectively, in newborn babies, childhood, and older adults. These human dehydration reviews generally agree about a 10 to 15% loss in water content as young adults mature into their sixties and seventies. An abundance of medical literature has shown that even a conservative loss of 10 to 15% water content due to aging has proven strongly correlated to many age-related diseases [25-27]. The relationships between dehydration, aging, and bioenergetics show a correlation between BSW water, reduced energy levels, and age-related diseases in the BSW water review by Ramsey [1-3]. No medical research has directly evaluated the effects of SW drinking water on age-related diseases. However, a few water drinking studies have shown that SW water is associated with human longevity and that rehydration at the cell level can be enhanced.

Biomarkers are measurable indicators of health status. At the start of this case study, the subject decided to monitor several biomarkers to test the effects of drinking SW water for any increase in overall health status. The four physiological biomarkers were resting heart rate, saturated oxygen, resting energy expenditure, and oxygen consumption. There was a discernable reduction in the biomarkers within a few months of drinking the SW water. The promising results from early monitoring initiated a search for other biomarkers to be added to lend more credibility to the overall results. However, the additional biomarkers don't include any baseline data, which limits their usefulness. This lack of baseline data can be partially offset by referencing larger clinical studies involving the biomarkers used in this study. Fortunately, all the biomarkers in this study have a long clinical history, which allows direct comparison between this study and the large cohort studies. Comparing the results with other clinical research adds valuable credence to assessing whether drinking the SW water improved the overall health status of the single subject in this study.

The four initial biomarkers were all measured after waking up from a night's sleep. Two activity-based biomarkers were included later in the study to monitor the effects of drinking SW water on physical exercise. The biomarkers were Heart Rate Recovery (HRR) and an oxygen consumption test (VO₂ max). The VO₂ results will be discussed in Part 2 of this case study. HRR is defined as the ability of a heart pulse rate to recover from a peak pulse after exercise to a resting rate when measured over a one-minute time interval [35]. The heart pulse rate's ability to recover to its resting state is a valuable and easy-to-measure biomarker for overall health and mortality risk. Research has shown that HRR is a function of age, fitness status, and health status [36-39].

METHODS

Structured Water Description

Measuring the physicochemical properties of SW water is an inexpensive method of quantifying proton concentrations and potential for electron exchange rates. SW water's physicochemical properties differ from tap water, indicating the potential functional properties when SW water is converted into BSW water. Three physicochemical water properties are readily measured and are directly related to the ability of SW water to exchange electrons and protons in redox reactions. These properties are pH, oxidation-

reduction potential (ORP), and electrical conductivity (EC), which directly or indirectly measure the concentrations of protons (H⁺) or electron potential (e⁻) in a water sample.

A portable multimeter (Oakton PC 650 ORP/EC/pH meter—Oakton Instruments, Vernon Hills, IL, USA) was used to measure all three water properties. The water properties were measured using pre-sterilized 50 ml vials. The ORP measurements were allowed to stabilize for approximately 15 to 30 minutes before recording the data.

Physiological Biomarkers

Biomarkers are measurable indicators of a biological state or condition. Monitoring biomarkers over time allows assessing any changes in health status due to aging, exercise, diet, or medical treatments. The original monitoring schedule included the following resting biomarkers: resting heart rate (RHR), saturated blood oxygen (SpO₂), resting oxygen consumption (VO₂), and Resting Energy Expenditure (REE) taken after a whole night's rest. Resting body temperature was added as a fifth biomarker seven months after starting the SW drinking water schedule. These physiological resting biomarkers are easy to measure at home using handheld devices. Also, these four resting biomarkers have extensive research and clinical history that allows comparison with identical biomarker values that are analyzed using much larger databases.

After drinking the SW water, two other biomarkers were added that measure physiological responses to strenuous exercise. These biomarkers are Heart Rate Recovery (HRR) and maximum oxygen consumption (VO₂ max). Both of these biomarkers measure health status and recovery after strenuous exercise. These exercise-based biomarkers were measured to counter the bias of the other five biomarkers measured during rest. Extensive clinical articles compare these two biomarkers against these test results.

Subject Description and Biomarker Monitoring Description

This study used a biomarker dataset compiled from the subject's monitoring records after receiving his consent to analyze and write up his data for this case study. The subject in this case study is anonymous due to medical privacy regulations and requirements. At the start of the drinking water study, the male subject was in his mid-60s, in moderately good physical shape, with

no underlying medical conditions. The subject said he was interested in monitoring the effects of drinking SW water and decided to collect baseline data for 22 days before starting to drink the SW water. The subject was supplied on a monthly basis with enough SW water to drink approximately 230 to 300 ml of SW water daily. Over time, the subject decided to change daily monitoring to periodic monitoring for the rest of this case study.

The resting biomarkers were collected daily for 58 days after drinking the SW water. The daily monitoring was stopped, which switched to longer intervals after two or three months. The subject waited several more months and then another set of 18 data points at seven and eight months after starting the SW drinking water schedule. The subject waited another 34 months and collected another set of 16 data points at 42 and 43 months after drinking SW water. In total, 22 data points were collected before, and 65 data points were collected after starting the SW drinking water schedule. A total of 87 daily measurements were recorded over 1,297 days.

The original four biomarkers were monitored after the subject woke up and before eating or drinking and recorded by date. The measurements were taken before significant physical activity to record the biomarkers at complete rest. Also, measurements were taken after a fasting period of about 11 to 12 hours. All the records were then compiled into a master dataset for all five biomarkers for the entire length of the study.

Biomarker Monitor Description

Resting body temperature was measured using a digital thermometer placed under the tongue. It was recorded between 6 and 7 a.m. before starting any physical activities. This data was recorded and compiled into a master biomarker dataset with the four other biomarkers.

A pulse oximeter with data logger memory (Cmsf 50 model) (Innovo, Stafford, TX) collected RHR (BPM) and SpO₂ (%). Using the built-in data logger, both biomarkers were measured at one-second intervals over five minutes. This data was averaged and then recorded along with the two biomarkers for REE and VO₂ that monitored energy expenditure over 87 days for continuous daily measurements.

A portable, indirect calorimeter (Breezing Inc. Tempe, AZ) was used to measure the Resting Energy

Expenditure (REE) and resting oxygen consumption rate (VO₂). This pocket-sized calorimeter measured six liters of exhaled air using colorimetric chemistry to quantify VO₂ and VCO₂. This data was then used to calculate REE based on the Weir equation [40].

$$\text{Resting Metabolism (kCal/day)} = [(3.9(\text{VO}_2) + 1.1(\text{VCO}_2))] * 1.44 \quad (1)$$

Indirect calorimetry measurements are sensitive to any physical activity. Any activity such as sitting up, talking, or moving causes physical exertion, rapidly increasing oxygen consumption and energy expenditure rate. The optimal method for measuring stable energy expenditure is to monitor oxygen consumption rates after a long period of complete rest, i.e., early morning after a full night's rest. The REE biomarker is generally relatively stable, with lower variability in temporal biomarker datasets. Lower variability in REE allows the detection of subtle treatment effects without being lost or overshadowed by the added noise of oxygen consumption introduced by any physical activity.

Physical Activity Test for Heart Rate Recovery

A biomarker used to measure heart rate recovery (HRR) after physical exercise has been reported in several clinical papers. An HRR test determines the difference between heart rate during strenuous exercise and heart rate one minute after stopping the exercise. An HRR test was conducted about 11 months after starting the SW drinking water schedule. A treadmill test was performed to measure the peak and recovery pulse rate at 60 seconds after stopping the treadmill exercise. The subject warmed up on a treadmill for ten min. with a walking speed of 1.5 miles per hour (MPH) with the treadmill incline at #5. The subject then increased the treadmill speed to 5 MPH for 90 sec. The treadmill speed was reduced to 1.5 MPH while measuring the pulse rate and percent blood oxygen at one-second intervals with the oximeter data logger. The treadmill test was replicated four times, once a day for four days. The data was compiled into one dataset for HRR test analysis.

Blood Analysis

The subject conducted a series of blood panel tests before and after starting to drink the SW water. The blood samples were collected at a medical clinic that offers blood sampling and multi-panel analysis services to the general public. One blood sample was collected before, and two blood samples were collected after

drinking the SW water. Analysis of the blood samples included biomarkers for inflammation caused by radical oxygen species, including white blood cell (WBC) types and C-reactive protein (CRP).

White blood cell types in this blood test include neutrophil, basophil, and eosinophil cells, classified as granulocytes. These WBC types are considered biomarkers for inflammation and compromised health status. Lymphocytes and platelet counts were also measured as WBC biomarkers. Granulocytes are white blood cells with small granules inside the cells. Lymphocytes are also classified as WBC cells and include T and B cells and innate lymphoid cells, of which natural killer cells are an essential subtype. The ratio of granulocytes to lymphocytes, otherwise known as the neutrophil/lymphocyte ratio (NLR), was calculated from the WBC data. The WBC data was also used to calculate the ratio of platelets to lymphocytes (PLR).

In addition to the WBC biomarkers, three blood sample tests included the C-reactive protein (CRP) blood biomarker. The CRP test is another indicator of inflammation levels in blood samples. CRP is a protein produced in the liver that acts as a signaling agent to generate proinflammatory cytokines. In essence, the CRP protein signals the start of the inflammation process, which in turn triggers an immune response to the site of inflammation. The WBC and CRP blood tests are blood-based biomarkers for inflammation and immunity responses to compromised or higher health risk conditions.

Analysis Methods

The biomarker monitoring data was not replicated among different subjects, so this should only be considered a case study. However, the biomarker data was collected before and after drinking the SW water over varying time intervals. The biomarker data allowed longitudinal analysis of the effects of drinking SW water on a single subject. Analysis of the multi-year biomarker data allowed reporting from short-term to long-term health responses to drinking SW water.

Four biomarkers were analyzed using multivariate correlation tests. Pairwise correlations were tested before and after drinking the SW water. Correlation analysis provided insight into the biomarker's interconnectivity with overall health status. Regression analysis tested the four biomarkers' temporal effects over time and reported the time delay before reaching

biomarker stability. Regression results also showed the overall progression of the biomarkers toward improved health status over time.

RESULTS

The physicochemical properties of the custom-generated SW drinking water were measured and reported in Table 1. This table was compiled from two tables on water properties reported in the BSW water review by Ramsey [2]. The physicochemical water properties are a direct measure of the electrochemical charge properties of the generated water. These water properties also indicate the potential effects of the SW water on biological activities. The SW drinking water used in this study was diluted to match the SW water properties from several natural water sources known for their healing properties. Approximately 34 batches of SW water were custom-generated to supply a uniform quality of drinking water needed for the 43-month duration of this study (Figure 1).

Multivariate correlation analysis shows the correlation strength and p -values for five pair-wise correlations for three monitoring dates (Table 2). Pairwise correlations reveal how the biomarkers may or may not be interconnected or related to each other and the strength of any relationship. The pairwise correlation tests reveal that RHR was interconnected with VO₂ and REE. In other words, for the baseline comparison test, RHR was moderately connected with VO₂ (0.5384 and p -value = 0.0174) and REE (0.561 and p -value = 0.0125). In contrast, as RHR decreased, there was an increase in SpO₂ based on the pairwise correlation strength (-0.5815) with a p -value = 0.0072 for the baseline test.

After drinking SW water for 43 months, only VO₂ was negatively correlated with RHR, with a correlation strength of -0.6868 and p -value = 0.0095 (Table 2). The pairwise correlations between RHR, REE, and SpO₂ became non-correlated with p -values >0.05 after 43 months of drinking the SW water. In addition, the correlation for pulse rate was reversed from a positive to a negative relationship for pulse rate and VO₂ after drinking the SW water for 43 months (Figure 2). In summary, after drinking the SW water for 43 months, the significantly correlated biomarkers in the baseline tests were either converted, or transformed into non-correlated biomarkers, or the correlation is reversed (Figure 2).

Table 1: Average Physicochemical Water Properties Compared among Several Water Sources. The SW Water used in This Study is Reported in the Top Row of this Table

Water Description	Electrical Conductivity (uS/cm)	Oxidation Reduction Potential (mV)	pH	Total dissolved solids (ppm)
Generated structured water-diluted	1,047	-85	8.6	697
Surface sea water ^a	50,000	+450	7.9	-
Mineral water ^b	378.5	-178.0	8.33	189
Filtered bottled water	192	-136.1	6.42	96.1
Commercial alkaline drinking water ^c	195.7	+33.2	9.27	97.82
Brandholz at Nordenau slate cave water ^d	Na	-250	8.01	Na
Water from Hunza river ^e	30.37 to 113.5 for river samples	-50 to -450	8.32 to 7.13 for river samples	22.61
Zamzam natural well water ^f	976-1390	Na	7.73	798-1000

^aAverage value for surface seawater

^bCommercial water from the Colorado aquifer

^cWater generated from electrolysis using the cathode probe to collect alkaline water.

^dHenry M, Chambron J. Physico-chemical, biological and therapeutic characteristics of electrolyzed reduced alkaline water (ERAW). Water. 2013 Dec;5(4):2094-115.

^eAli A. Hussain Z. Khan Z. Hussain A. An Assessment of Physico-Chemical and Microbiological Parameters of Water from Hunza and Gilgit Rivers, Gilgit-Baltistan Pakistan 2015 (www.jcbcs.org).

^fAbdullatif BM, Baeshen AA. Assessment of Different Water supplies in Jeddah as an indicator of water quality and their impact on seed germination. Life Science Journal. 2013 Jan 1;1:10.

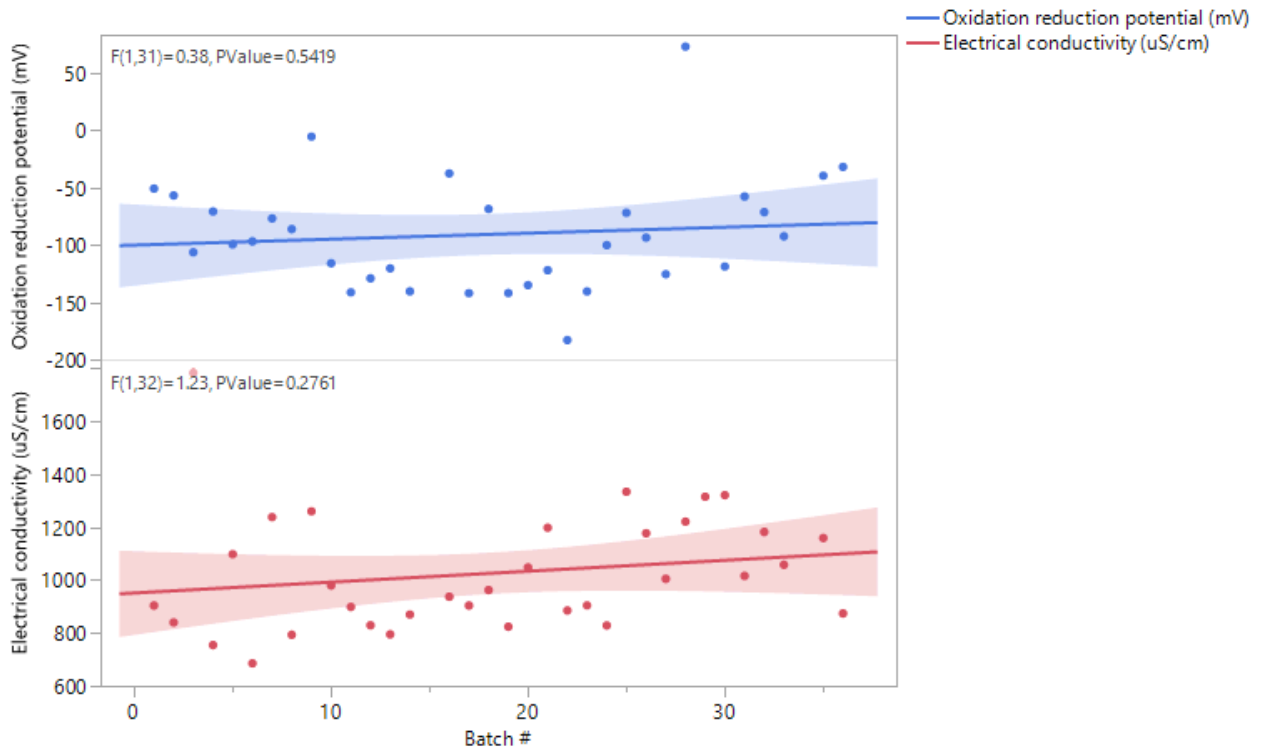


Figure 1: Electrical conductivity and Oxidation Reduction Potential for the 34 batches of SW water generated during this case study.

Table 2: Multivariate Correlation and Significant Probability for Four Biomarkers at Baseline, 7-8 Months, and 42-43 Months after Starting the SW Drinking Water Schedule

Variable	by Variable	Baseline Correlation	Baseline Signif Prob (p -value)	Month 7-8 Correl	Month 7-8 Signif Prob (p -value)	Month 42-43 Correl	Month 42-43 Signif Prob (p -value)
RHR (BPM)	VO2 (ml/min/kg)	0.5384	0.0174	0.4329	0.094	-0.6868	0.0095
RHR (BPM)	REE (kcal/day)	0.561	0.0125	0.3808	0.1456	-0.2797	0.3328
Blood oxygen (%)	VO2 (ml/min/kg)	-0.329	0.169	-0.2853	0.2841	-0.2315	0.4466
Blood oxygen (%)	REE (kcal/day)	-0.362	0.1277	-0.2938	0.2694	-0.065	0.8252
Blood oxygen (%)	RHR (BPM)	-0.5815	0.0072	-0.5235	0.0258	-0.1153	0.6708

There is a linear relationship (p -value <0.05) between REE and VO2 for the baseline, 1-2, and 7 -8 months after starting the SW drinking water schedule (Figure 3). However, after drinking the SW water for 43 months, this relationship became non-significant (p -value = 0.0997). In other words, drinking SW over the long term shifts this basic metabolic relationship between REE and VO2 so that it becomes unlinked or non-correlated. The Weir equation directly links REE with VO2 (Eq. 1). The linear relationship in the Weir equation became invalid for predicting REE from VO2 after drinking SW water over the long term.

The four biomarkers were monitored before and after starting the SW drinking schedule. Table 3 reports the means for the four biomarkers at the baseline and 43 months after starting the SW drinking water schedule. The table also reports the percent reduction in the four biomarkers after drinking SW water for 43 months (Table 3). All four resting biomarkers were reduced after drinking SW water for 43 months. The most significant reduction occurred in the indirect calorimetry results, with a reduction of 18.3 and 21.6% in REE and VO2.

The original monitoring schedule did not include resting body temperature. Monitoring body temperature started seven months after starting the SW drinking water schedule. Thus, any changes in body temperature can only be tested between 7 to 8 months and 42 to 43 months after starting the water schedule.

A body temperature website designed by Stanford [41] calculates model-based temperature based on age,

gender, height, and weight. This website estimated that the resting temperature should be 36.7 C (98.1 F) for 68-year-old males when measured just after waking up in the morning. The subject's resting temperature was 36.1 and 35.5 C (97 and 95.9 F) at about 8 and 43 months after starting to drink SW water when measured between 6 and 7 am (Figure 4). This reduction in body temperature was significant. The baseline temperature was not collected at the start of the study. The resting temperature was approximately 0.6 C(2 F) lower than the male body temperature calculated by the Stanford U. website after adjusting for gender, age, height, weight, and measurement time.

Oximeters measure saturated oxygen in blood (SpO2) using an algorithm that estimates the difference between saturated blood and unsaturated oxygenated blood in finger tissue [42]. Pulse oximeters clip onto a fingertip and transmit red and infrared light through the finger tissue [43]. The oximeter sensors measure the difference between the amount of light transmitted and absorbed by oxygen as it passes through the blood and finger tissue. The amount of oxygen in the tissue is measured as oxygen saturation determines the absorption rate of the red and infrared light. The saturated blood oxygen (SpO2) was 92.2 and 91.43 % before and 43 months after drinking the SW water (Figure 5).

There was a reduction in RHR (p -value = 0.0011) between the baseline and 43 months after drinking the SW water (Figure 6A). The linear regression is deceptive in that it doesn't reveal the temporal dynamics in the RHR response. The second graph with

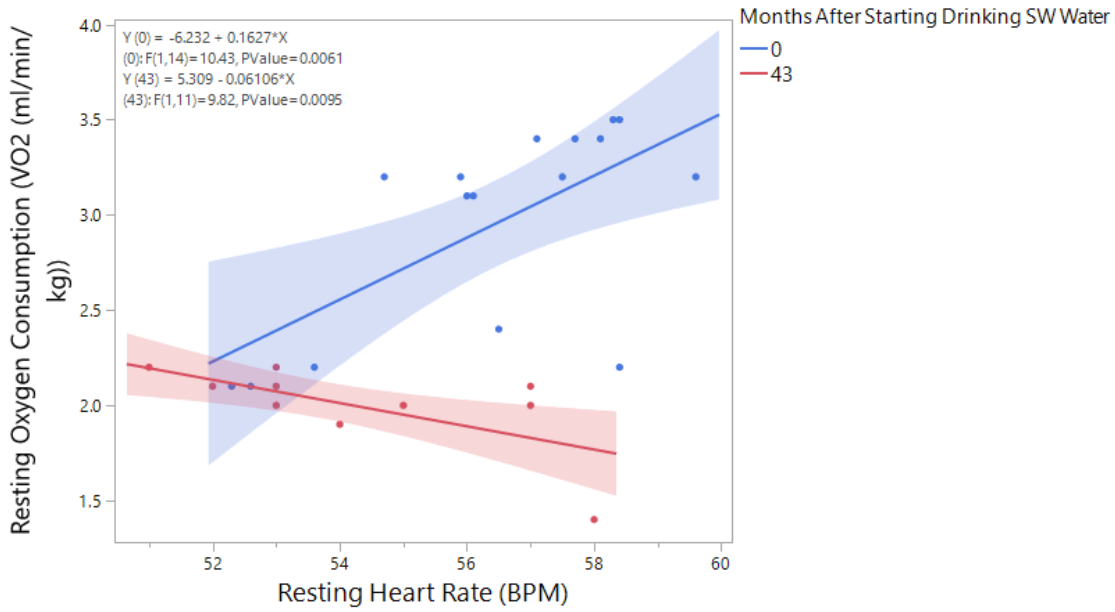


Figure 2: The linear relationships between VO2 and RHR biomarkers for the baseline and 43 months after starting the drinking water schedule (legend).

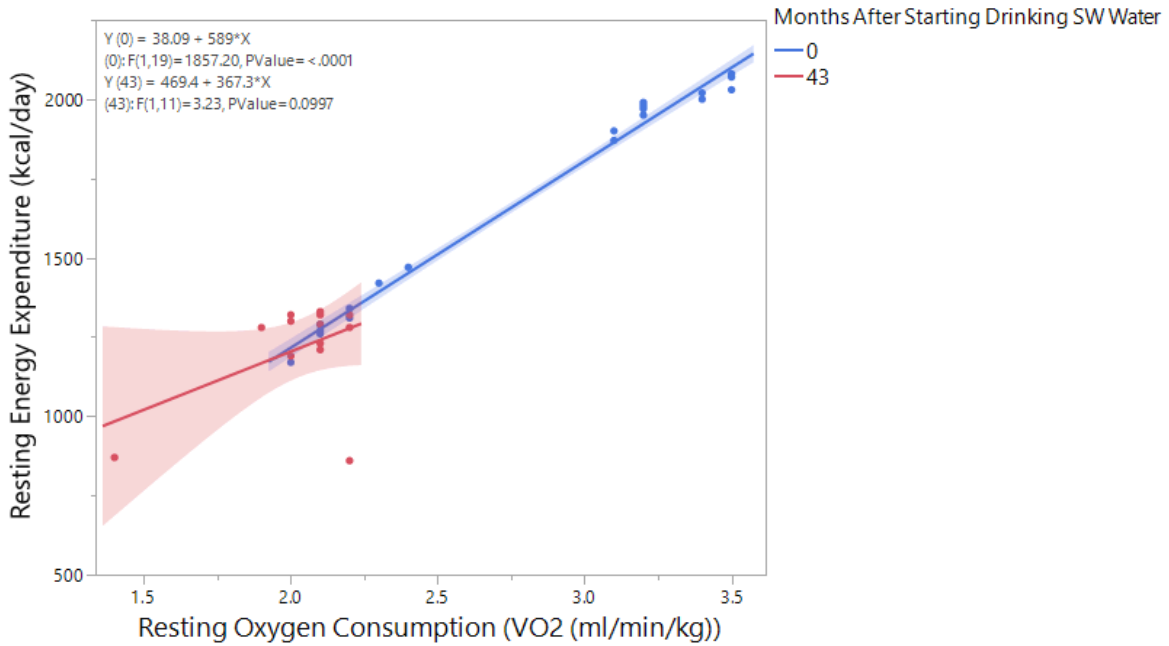


Figure 3: The relationships between REE and VO2 biomarkers for baseline and 43 months after starting the SW drinking water schedule (legend).

Table 3: Average of Four Resting Biomarkers for Baseline and 43 Months after Starting the Drinking Water Schedule

Months	REE (kCal/day)	VO2 (ml/min/kg)	RHR (BPM)	SpO2 (%)
Baseline	1,516	2.59	56.5	92.2
43 months	1,238	2.03	54.2	91.43
Percent reduction (%)	18.3	21.6	4.1	0.8

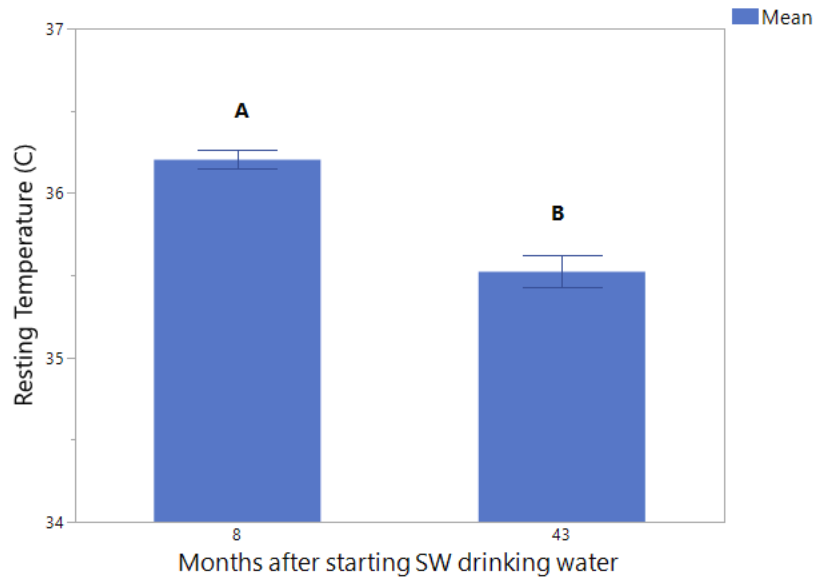


Figure 4: Resting body temperature for eight and 43 months after starting the SW drinking water schedule.

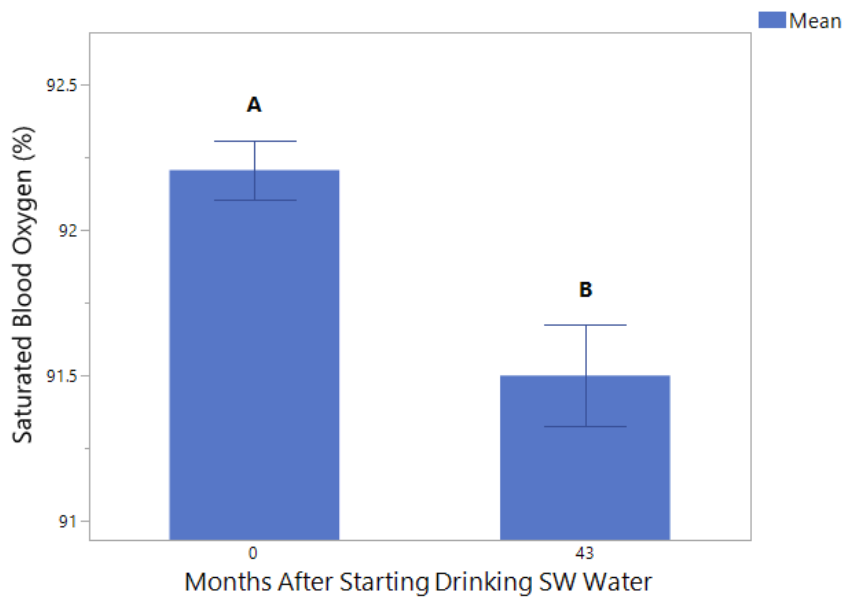


Figure 5: Saturated blood oxygen (SpO2) means at baseline and 43 months after starting the SW drinking water schedule.

the smoother curve (Figure 6B) shows that RHR declined until about ten months after starting to drink the SW water, and then there was a slight increase in RHR after 43 months of drinking SW water. The RHR smoother curve shows that it took several months of drinking the SW water before the RHR could remain stable over time. The smoother curve is only a crude approximation of the temporal dynamics of RHR. The data suggest that the temporal dynamics may best be modeled using a biphasic function.

There was also a similar temporal reduction in REE (p -value = <0.0001) that mirrored the reduction in RHR

(Figure 7A). The linear regression is deceptive in that it doesn't reveal the temporal dynamics in the REE response. The second graph for the REE smoother curve (Figure 7B) also mirrors the RHR smoother curve results. The REE smoother curve shows that it took several months of drinking the SW water before the REE could finally stabilize. The data suggest that the temporal dynamics may best be modeled using a quadratic function.

The temporal dynamics for resting VO₂ also mirror the RHR and REE responses (p -value = <0.0001), showing a reduction over time (Figure 8A). All three biomarkers

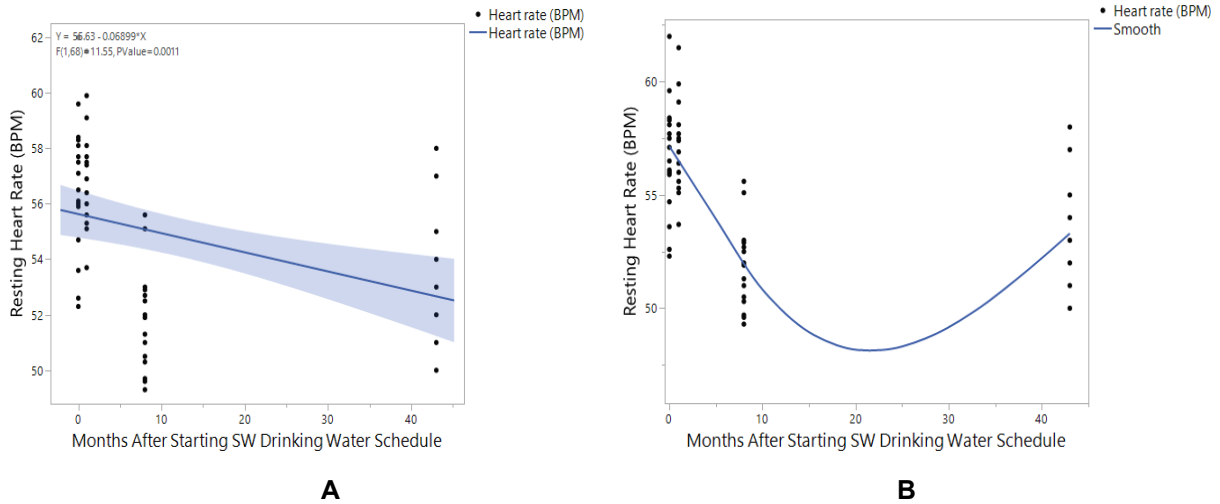


Figure 6: Linear regression between RHR and months after starting to drink SW water (A). The same RHR temporal relationship was graphed using a smoother curve instead of linear regression (B).

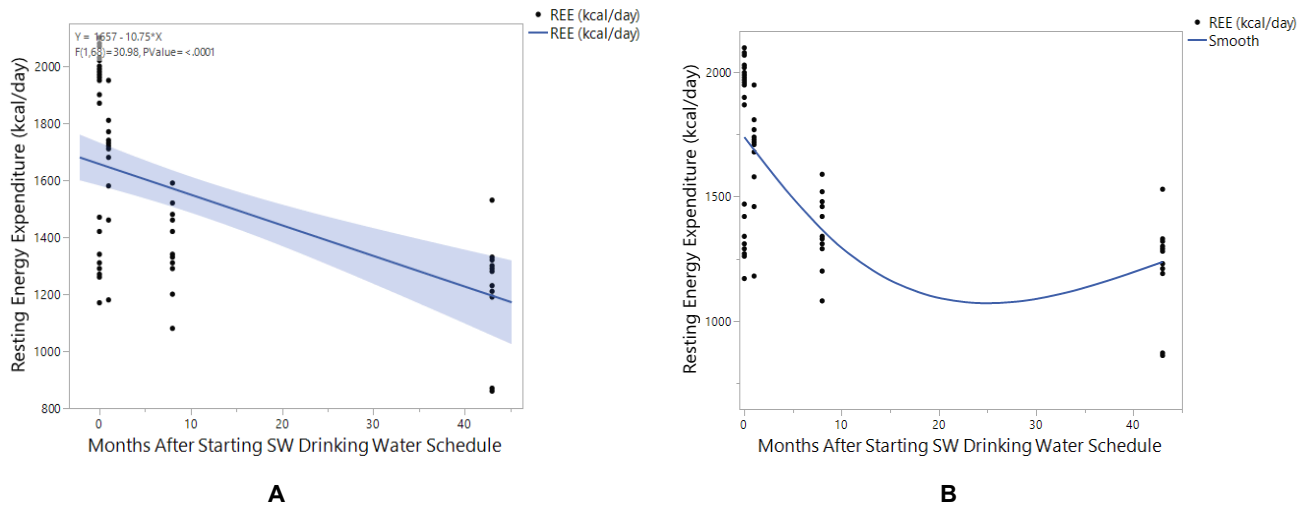


Figure 7: Linear regression between Resting Energy Expenditure rate (REE) and months after starting the SW water drinking schedule (A). The same relationship using a smoother curve instead of linear regression (B).

show a significant reduction over time. The second graph for the VO₂ smoother curve (Figure 8B) also mirrors the RHR smoother curve results. The VO₂ smoother curve shows only a few months of drinking SW water before the VO₂ finally stabilizes. The temporal dynamics suggest that a quadratic function may best fit the data.

The oxygen consumption rate (VO₂) results paralleled the REE results after drinking SW water for 43 months (Figure 7A). There was a 21.6% reduction (0.56 ml/min/kg) in VO₂ after 43 months (Table 2). This reduction in VO₂ of 0.56 ml/min/kg equals 49.53 ml/min for the subject that weighed 88 kg during the calorimetry measurements. A resting VO₂ rate of 49.53 ml/min converts to 1.38×10^{22} O₂ molecules/min, based on 1 ml O₂ containing 2.78×10^{19} O₂ molecules [44]. In

other words, drinking SW water reduces the resting oxygen consumption rate by 1.38×10^{22} O₂ molecules/min, which translates to a staggering reduction in molecular oxygen (O₂) consumption daily. The implications of reducing oxygen consumption rates, along with a concomitant reduction in ROS generation and reduced biological injury and stress, will be explored in the discussion section.

The heart rate recovery (HRR) data analysis shows a rapid heart recovery rate after drinking the SW water for 11 months (Figure 9). The linear regression test shows that all four treadmill runs had a strong negative relationship between pulse rate and recovery time after starting the measure pulse rates. In other words, the relationship was not biphasic or curvilinear, i.e., pulse rates declined at a uniform, linear rate over time. The

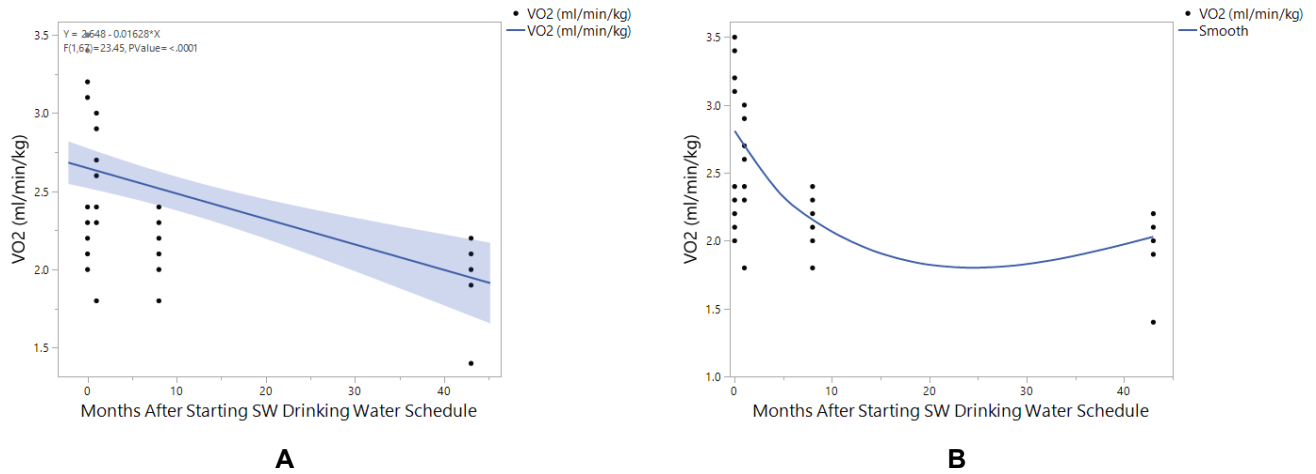


Figure 8: Linear regression between resting oxygen consumption rate (VO2) and months after starting the SW water drinking schedule (A). The same relationship using a smoother curve instead of linear regression (B).

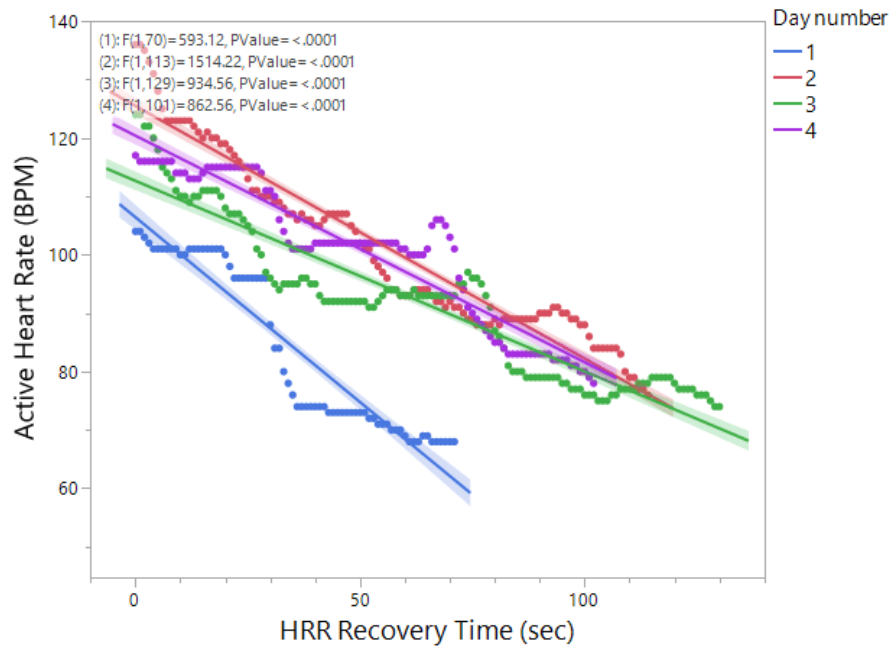


Figure 9: The linear relationships between pulse rate and recovery time for four different treadmill runs 11 months after starting the SW water drinking schedule.

peak heart and heart recovery rate after a 60-second recovery time was 121 and 84 BPM, respectively, with a calculated mean HRR of 37 BPM for the four treadmill runs.

Analysis of the HRR dataset *also* shows a negative linear relationship between heart rate and saturated blood oxygen (Figure 10). The treadmill tests show that strenuous exercise results in different correlations between biomarkers over time. The pairwise correlation between resting pulse rate and resting percent blood oxygen was non-significant (p-value = 0.6708) 43 months after starting the SW drinking water schedule

(Table 1). However, the HRR treadmill test involving strenuous exercise resulted in a significant relationship between active heart rate and active saturated blood oxygen (regression p-value = 0.001) 11 months after starting the SW water drinking schedule (Figure 10).

The WBC and CRP blood biomarker tests show that inflammation and physiological stress levels were in the normal reference ranges (Table 4). The blood test reference range from the lab blood test report for the NLR ratio was between 1.78 and 2.18. For this case study, the before and after NLR values were 1.65 and 1.79 (Table 4). These results show that the subject's

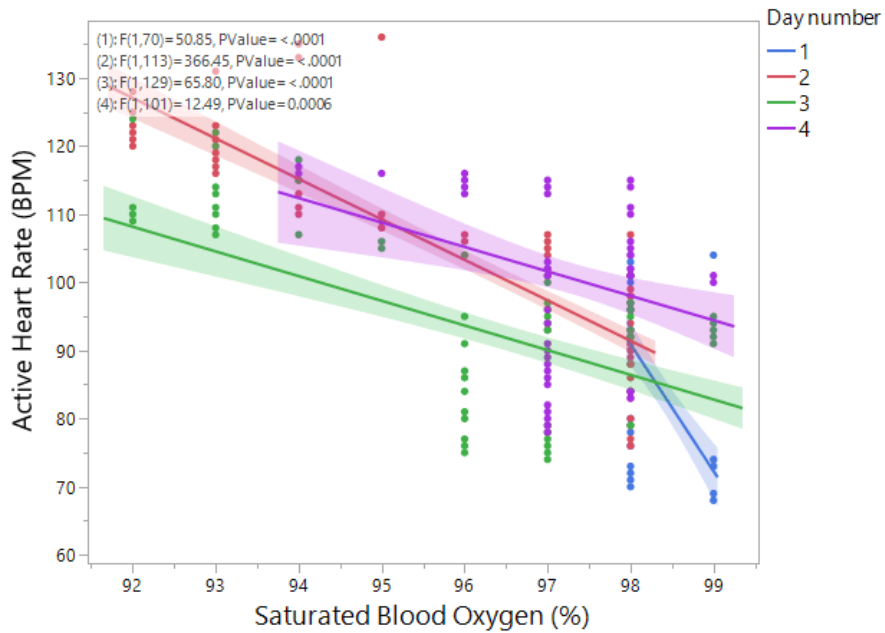


Figure 10: The linear relationships between active heart rate and active saturated blood oxygen for four different treadmill runs at 11 months after starting the SW water drinking schedule.

Table 4: Two White Blood Cell Ratios are used as Inflammation Biomarkers for Inflammation and Radical Oxygen Species Injury Levels in Human Blood

Blood sample data	NLRB	PLR	CRP (mg/l)
Before	1.65	99.90	0.9
1 MASW	1.80	102.95	1.1
3 MASW	1.77	100.91	.
55 MASW	2.71	105.29	1.27
Reference Interval	2.0-2.45	214-145	0-3.0

^aSample date = before or after starting to drink SW water, NLR = Neutrophil/Lymphocyte Ratio, PLR = Platelet/Lymphocyte Ratio, CRP = C-Reactive Protein.

NLR blood biomarker was at the low end of the reference range. Also, the reference range for CRP from the lab blood test report was 0 to 3.0 mg/l. These blood tests confirm that the subject’s health was not at risk due to the reductions in the other biomarker results, such as lower RHR, body temperature, or blood oxygen levels.

DISCUSSION

The physicochemical water properties were measured to provide indirect evidence that the SW drinking water exhibited SW water properties. These properties are pH, oxidation-reduction potential (ORP), and electrical conductivity (EC). The ability of the liquid crystalline properties of SW water to conduct either electrons or protons has been well-researched. Electrical conductivity in SW water increases depending on the

percentage of SW water in the water sample [45-49]. The physicochemical water measurements show that the generation of the SW water batches was consistent, and all the batches had SW water properties (Figure 1).

Analysis of the resting biomarker data shows a reduction in all four biomarkers and resting temperature in the months following the start of drinking SW water. Clinical research, discussed in more detail below, shows that reducing these physiological biomarkers improves overall health and longevity. The percent reduction in the indirect calorimetry results shows that aerobic respiration was reduced. In addition, the other biomarkers show correlated reductions in physiological activities. Dehydration occurs during aging, leading to increased dependence on aerobic respiration increasing dysfunctional mitochondria levels and the production of

free radicals. Increased aerobic respiration also requires a higher resting heart rate to meet the higher oxygen demands for respiration [1-3]. The combined results imply that drinking SW water reduced the overall physiological stress and strain inherent to aging as aerobic respiration increasingly becomes the primary energy source in mature and elderly populations due to dehydration and loss of BSW water [1-2].

Analysis of the biomarker data reveals that three baseline resting biomarkers (RHR, REE, and VO₂) were either converted or transformed into non-correlated biomarkers, or the correlation was reversed (Figure 2). In other words, drinking SW water for 43 months unlinked or disassociated heart pulse rate with oxygen consumption, energy expenditure, and percent blood oxygen at a resting state before any daily physical activity started. These results pose numerous questions about the widely presumed relationships between heart rate and oxygen consumption for energy requirements.

Clinical research shows that heart rate is strongly correlated with oxygen supply in tissue, which is needed for aerobic respiration [36-39]. The RHR results indicate that the relationship between SpO₂ and RHR heart rate became unlinked as drinking SW water, based on the *p*-value (0.6708) of the pairwise correlation between SpO₂ and RHR (Table 1). The other pairwise comparison between RHR and VO₂ shows a negative pairwise correlation (*p*-value = 0.0095) after drinking SW water for 43 months (Table 1). In other words, RHR was not correlated with saturated blood oxygen and oxygen consumption rate after drinking SW water for 43 months. These results do not align with all the current clinical evidence that shows a strong correlation between RHR, SpO₂, and VO₂ in humans.

If the heart rate is not correlated with oxygen consumption or energy requirements during a rest state, it could be reduced without any negative consequences or concomitant energy supply or oxygen consumption reduction. The biomarker results show that the resting pulse rate was reduced from 56.7 to 53.3 BPM for the baseline and 43 months later (Table 2) without adverse effects on energy supply or metabolic activities. In summary, drinking SW water for 43 months reduced heart rate activity while sleeping, potentially increasing longevity.

These results also pose another fundamental question about the relationship between BSW water and

macroscopic coherence. A BSW water review by Ramsey [3] describes how BSW water relates to macroscopic coherence. The liquid crystalline properties of BSW water allow it to synchronize metabolic and physiological functions at multiple biological scales [3]. It is relatively easy to show correlations among biomarkers using statistical analysis. However, it is a much more challenging task to explain how the strength of the relationship changes or how the relationship may become unlinked or disassociated. For example, it is relatively easy to show that pulse rates are reduced by drinking SW water. However, explaining how this occurs under biological conditions is much more challenging. These findings indicate that a “master programming or organization function,” a.k.a macroscopic coherence, is needed to synchronize the biomarker activities efficiently. There are about 36 trillion cells in an adult human [50]. The metabolic activities involved with energy generation in each of these cells should be organized or synchronized to overall energy needs at multiple scales. Without any signaling and synchronization of these cellular signals at macroscopic scales, there would be no mechanistic explanation for increasing heart rates and increased oxygen supply to meet any increase in physical activity.

A rational explanation for the synchronization of the dynamic energy generation at the cell level to meet ever-changing physical activities and demands at the whole-body level is the coherence properties of BSW water [3]. Research indicates that BSW water facilitates macroscopic coherence at higher biological scales [51-57]. In other words, BSW properties facilitate coherence, or the whole-body synchronization of metabolic cell signals with physiological functions such as heart rate, basal temperature, and oxygen uptake rates. As humans age, the levels of BSW water are reduced [2]. This case study indicates that drinking SW water replenishes and maintains adequate BSW water levels in the elderly. This case study also suggests that adequate levels of BSW water maintain macroscopic coherence, which synchronizes metabolic energy generation with many physiological functions.

After drinking SW water for eight and 43 months, the resting temperature was 36.1 and 35.5 C (97 and 95.9 F), respectively (Figure). There was a reduction of 0.61 C in resting temperature after continued drinking the SW water for an additional 24 months. Recent research shows a direct, linear relationship between resting heart rate and resting temperature [58-60]. Broman *et al.* [58] found that the heart rate increased by 8.35 BPM

for every one °C increase in resting temperature between 32.0°C and 42.0°C in critically ill patients. Also, Heal *et al.* [59] found that in children under 16 years of age, the heart rate increased by 12.3 BPM for every 1 C increase in resting temperature after accounting for oxygen saturation, location of attendance, and age. Medical literature confirms that life spans are shortened as resting or basal temperature increases with increasing respiration rates [61-63].

In contrast, research findings show that lower resting temperatures are associated with longevity. Waalen and Buxbaum[64] reviewed the effects of resting temperature on longevity in 18,630 subjects. They found that resting temperature was significantly correlated with longevity. Zhao *et al.* [65] investigated the interactions of basal temperature, metabolic rate, and lifespan in two small mammals. They found that basal temperature and metabolic rates had parallel relationships, indicating that they were virtually identical biomarkers for longevity. They also found that lower basal temperatures were correlated with longevity in the small mammals. A longevity review by Kiel *et al.* [66] across many animal species found that basal temperature was generally associated with longevity, with a few notable exceptions. Unfortunately, resting temperature was not included in the original biomarker selection of this study. Thus, there are no baseline measurements for resting temperature to compare with resting temperatures taken eight and 43 months after starting the drinking water schedule.

Pulse oximeters use an algorithm that converts red and infrared absorption rates into estimating saturated oxygen levels in finger tissue [42-43]. The oximeter sensors measure the difference between the amount of red and infrared light transmitted and absorbed by oxygen as it passes through the blood and finger tissue. The amount of oxygen in the tissue is measured as oxygen saturation determines the absorption rate of the red and infrared light. The resting saturated blood oxygen (SpO₂) was 92.2 and 91.43% before and 43 months after drinking the SW water. There was a 0.77% reduction in resting blood oxygen levels after drinking SW for 43 months (Figure 4). The reduction in resting temperature and saturated oxygen indicates a concomitant reduction in heat generated by mitochondria and aerobic respiration consumption of oxygen.

These results conflict with the primary premise that resting saturated blood oxygen levels are not directly

influenced by age or gender [67]. As personal fitness devices started to incorporate pulse and oximeter sensors, multiple sets of meta-databases have been developed using individual data from people who are into fitness and willing to share their data [68]. Clinical meta-databases have been analyzed to gain more insights into human saturated blood oxygen physiology [67-68]. In addition, two review articles by Chen *et al.* [69] and Lee *et al.* [70] explored how pulse oximeters and reflective fitness devices work and measure SpO₂ in humans. Finally, a review on oxygen content and saturated blood oxygen by Collins *et al.* [71] explores the physiology of blood oxygen and how the saturated blood oxygen model was developed for pulse oximeters and reflective fitness devices. Oximeters used on fingertips have two sensors and are generally more accurate than fitness trackers that use reflectance to measure saturated blood oxygen levels. This case study used a fingertip oximeter to measure resting heart rate and blood oxygen levels.

Shapiro *et al.* [67] published a meta-database analysis that evaluated the personal pulse and oximeter data from 33,080 Apple Heart and Movement Study participants. They found that saturated blood oxygen was correlated with daily diurnal patterns, gender, age, body mass index (BMI), and altitude. They estimate that saturated blood oxygen ranged from 94 to 95% for males in the 60-70-year-old cohort, living between 1,000 to 1,500 m above sea level, when measured at about 6 am. They found that daytime SpO₂ decreases with age, increasing BMI and home altitude. These findings don't align with the subject's SpO₂ of 91.42% at 43 months after drinking SW water in this case study. Before the Shapiro study, it was generally accepted that SpO₂ levels between 90 and 94% represent hypoxia conditions or low blood oxygen levels [42]. This study's reduction in resting saturated blood oxygen (SpO₂) indicates that oxygen consumption rates due to aerobic respiration were reduced due to drinking the SW water. The resting SpO₂ results confirm and support the REE and resting VO₂ results explored in detail below.

The pulse oximeter also collected resting heart rate (RHR) data as one of the initial biomarkers. The RHR rate was 56.7 and 53.3 BPM before and 43 months after starting the SW drinking water schedule (Table 2). Research on aging shows that a lower RHR correlates with improved health status and longevity [72-74]. The RHR before starting to drink the SW water was already much lower than the findings from aging

and longevity cohort studies. Analysis of the data shows that drinking SW water further reduced RHR by 3 BPM (p -value = 0.0003) (Figure 6A). The smoother curve graph for resting heart rate indicates that RHR rates were reduced then slightly rose after drinking SW for 43 months (Figure 6B). In a review by Jensen [75], he states that a reduction of 19% in RHR (65 versus 80 BPM) was associated with 4.6 years longer life expectancy in men and 3.6 years in women. An earlier study by Jensen *et al.* [76] analyzed a large cohort study to make compelling associations between heart rates and longevity. Another meta-analysis study on RHR and longevity by Quer *et al.* [77] involved a 92,000-person cohort study. They found that the average RHR was about 62 BPM for 70-year-old men. Stressman *et al.* [78] investigated RHR and longevity in individuals aged from 70 to 90 years old. They found that the average RHR in the 70-year-old cohort was 75.1 BPM.

In this study Resting Energy Expenditure (REE) was 1,516 kcal/day and 1,238 kcal/day for the baseline and at 43 months after starting the SW drinking water schedule (Table 2, Figure 7). The smoother curve indicates that REE stabilizes by eight to ten months after beginning the SW drinking water schedule (Figure 7B). There was a 18.3% reduction in REE at 43 months after starting to drink SW water (Table 2). Several clinical studies evaluated the effects of age and gender on REE [79-86]. Frisard *et al.* investigated the relationship between REE and age in the elderly [87]. They found that REE averaged 1,465 kcal/day for men and women in the 60 to 74-year cohort. A similar study by Choquette *et al.* examined the relationship between REE, age, and gender in the elderly [88]. They found that REE averaged 1,341 kcal/day for males in the 65-year-old cohort. Another study by Roberts *et al.* [89] found that REE averaged 1,487 kcal/day for males in the 60 to 69-year-old cohort. This case study indicates that drinking SW water for 43 months can reduce REE by 18.3% without reducing the effectiveness of heart rate recovery. The HRR results mentioned above indicate that the subject was in good physical shape 11 months after drinking SW water. These two findings show that reducing REE biomarkers by 18% didn't impair the subject's physical ability to rapidly recover from a strenuous treadmill test, as demonstrated by the HRR recovery rate (Figure 9-10).

The Weir equation predicts REE from the oxygen consumption rate (VO₂) (Eq.1). The resting VO₂

biomarker was 2.59 and 2.03 ml/min/kg for the baseline and 43 months after drinking the SW water, respectively (Table 2). There was a 21.6% reduction in resting oxygen consumption, which stabilized 10 months after drinking SW water (Figure 8B). The reduction in resting VO₂ mirrors the reduction in SpO₂ reported above. In other words, resting oxygen consumption (VO₂) and resting saturated blood oxygen (SpO₂) were reduced after drinking SW water. The reduction in resting VO₂ and SpO₂ implies that aerobic respiration was decreased while maintaining an adequate cell energy supply to meet *all* the basal metabolic needs. In other words, drinking SW water boosted BSW water levels and acted as an alternate energy source at the cell level, compensating for the reduction in resting VO₂ and SpO₂ biomarkers.

During aging, the rate of dysfunctional mitochondria generating ROS species increases due to excess electrons flowing in the electron transport chain. The elderly are predisposed to suffer from excessive generation of ROS that results in inflammation and other age-related diseases due to dysfunctional mitochondria. This study shows a 21.6% reduction (0.56 ml/min/kg) in VO₂ after drinking SW water for 43 months. This 21.6% reduction in VO₂ converts to 49.53 ml/min for an 88 kg adult, which converts to 1.38×10^{22} O₂ molecules/min, based on 1 ml O₂ containing 2.78×10^{19} O₂ molecules [44]. Over a 24-hour day, drinking SW water reduced the amount of O₂ consumption for aerobic respiration by 1.98×10^{26} O₂ molecules, based on resting VO₂ results. This remarkable reduction in O₂ consumption also reduces ROS generation in the elderly due to higher levels of dysfunctional mitochondria. In short, drinking SW water significantly reduces O₂ consumption with a concomitant reduction in ROS generation and age-related diseases.

This study's REE, VO₂, and SpO₂ biomarkers support an alternative cell energy pathway and refute the universally accepted concept that aerobic respiration is the primary source of cellular energy. The findings in this study will hopefully start a debate in the biological science arena to overturn the concept that mitochondria respiration is the sole source of cell energy generation. An international team of geneticists and molecular biologists has recently discovered the first known free-living eukaryote to have lost its mitochondria [90]. Eukaryotes are classified as plants, animals, fungi, and protists, and they all rely on mitochondrial aerobic respiration to supply their cell energy needs. This recent discovery of a free-living

eukaryote is a crucial anomaly that casts unbelief or severe doubt in the universal concept that mitochondria supply all the cellular energy needed for organisms that rely on aerobic respiration. Other biologists have expressed doubt about the ability of mitochondrial respiration to supply all the cell energy needs in hibernating animals, African lungfish that remain dormant for up to four years without food or water, or resurrection plants that can survive almost complete desiccation for many months or years. Animal hibernation and plant or seed dormancy states should be reinvestigated based on oxygen consumption rates compared with cellular energy consumption rates.

Aerobic respiration is based on mitochondrial oxygen consumption rates. The reduction in the REE (18.3%), VO₂ (21.6%), and SpO₂ (0.8%) biomarkers (Table 2) after drinking SW water for 43 months implies a reduction in aerobic respiration. This reduction in respiration is possible because two metabolic pathways combine to generate sufficient cell energy to meet most, if not all, metabolic requirements. The two energy pathways are aerobic and water respiration, which can operate simultaneously but supply different forms of energy for different metabolic activities [1].

At the individual scale, energy balance is defined as the daily balance of calories consumed through eating and drinking (energy in) compared to calories burned daily (energy out). Energy balance assumes that aerobic respiration generates enough energy to meet *all* metabolic at the individual scale. Energy homeostasis is the biological process coordinating the homeostatic regulation of energy generation and expenditure. This broad definition of energy homeostasis implies that other biology-based energy sources can contribute to the cumulative energy input [1]. Research has proposed alternative methods of cell energy generation that act as secondary energy sources to meet *all* the energy requirements needed to maintain healthy cells [91-95]. One such energy generation source involves water respiration [1, 93-94]. Ramsey [1] published a comprehensive review of the interactions between BSW water and water respiration.

This review by Ramsey [1-3] summarized important concepts involving the relationships between BSW water and bioenergetics. Bioenergetics research investigates how BSW water captures and transforms low-grade, biologically-based energy sources into higher-grade energy forms, such as energized BSW water, which is then released in the water respiration

pathway [1-2]. Water respiration in biology is the slow combustion of water, which has two phases. The first phase involves the self-assembly and energizing of BSW water on cell surfaces as conceptualized by Preparata, Del Giudice, and their colleagues [90-96]. The second phase is the respiration of BSW water, as conceptualized by Voeikov and Ho [97-103]. Water respiration under biological limits requires that BSW water must be energized before it can be respired or reduced back to O₂ and H₂O. The papers by Del Giudice and others [90 -96] utilize the Quantum Electrodynamics (QED) theory to propose that BSW water can be energized up to 12.06 eV, which is only 0.54 mV below the ionization threshold of water molecules (12.6 eV). In other words, BSW water captures low-grade energy in the form of heat or far infrared energy (FIR) and converts it into high-grade energy in the form of energized BSW water [90-96]. BSW water converts the heat generated from the mitochondria (FIR energy) into energized BSW water up to 12.06 eV, which is just 0.54 mV under the ionization threshold of water [90-96]. The FIR wavelengths emitted during aerobic respiration in mitochondria excite the quasi-free π electrons that orbit around each hexagonal ring in BSW water. As the π electrons absorb the FIR energy, they enter the energized orbits, thereby energizing BSW water continuously [1-2].

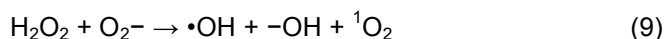
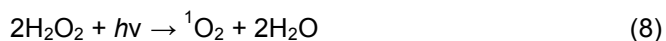
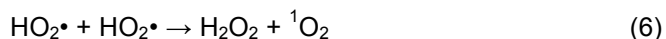
The second phase of water respiration occurs under mild biological conditions due to the low energy inputs needed to split energized BSW water. The energy of infrared wavelengths ranges from 1.24mV to 1.7 V, which is far more than the 0.54 mV needed to split BSW water. The high-grade energy in BSW water is released in a series of electron transfer reactions when the water ionization threshold of 12.6 eV is reached. BSW water ionization [97-103] occurs in the following reaction:



This first reaction of water respiration splits water into H₂ and triplet-state oxygen (³O₂). Molecular hydrogen and oxygen can be “activated” under normal physiological conditions. Molecular oxygen (O₂) exists in a triplet state, where it is most stable and is generally biologically un reactive. However, triplet state ³O₂ can be converted to singlet oxygen (¹O₂), where all the electrons are spin-paired [104-106]. Singlet oxygen (¹O₂), also known as “activated oxygen,” is much more reactive than triplet oxygen and can initiate a myriad of redox reactions. Molecular O₂ can be converted into

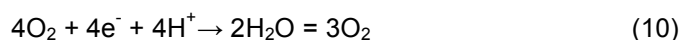
activated oxygen ($^1\text{O}_2$) when exposed to red and infrared radiation in mitochondria and other biological sites [107-109]. Mitochondria research shows that the temperature of human mitochondria averages about 53-54 C [110-111]. Temperature converts to energy in the infrared spectrum, i.e., a temperature of 53-54 C is equivalent to a long wavelength infrared spectrum (8,000 to 15,000 nm) with a temperature range of 89 to-80 C [112]. Aerobic respiration in mitochondria generates enough heat in the far infrared (FIR) spectral band to convert triplet oxygen (O_2) to singlet oxygen ($^1\text{O}_2$) under mild biological conditions. Exposure to infrared wavelengths converts molecular oxygen into singlet oxygen, which activates the redox cascade back to water and molecular oxygen.

Reduction of singlet oxygen flows down a redox cascade of reactions in the following sequence during the second phase of water respiration [113]



The cascade of redox reactions in the second phase of water respiration produces several Radical Oxygen Species (ROS), which could damage cell structures or biomolecules. However, recent quantum biology findings show that ROS species' lifetime is extremely short due to reactions occurring at ultra-fast or superconductive speeds [1, 114-117]. Therefore, redox reactions within the water respiration pathway react at quantum speeds without causing detectable ROS injury or damage to membranes or biomolecules [1].

The first reaction of the WR cycle occurs as molecular oxygen is exposed to light energy, which converts triplet ground state $^3\text{O}_2$ to an excited singlet state $^1\text{O}_2$ (Eq. 3) with an energy of 0.98 eV. The other reactive oxygen species (ROS) include the electronically excited radical anion O_2^- , electronically excited hydroperoxide radical $\text{HO}_2\cdot$, electronically excited hydroxyl radical $\text{HO}\cdot$, and hydrogen peroxide H_2O_2 . If the intermediate redox steps are ignored, the entire set of reactions can be summarized as follows [100]:



Reduction of four oxygen molecules (4O_2) into two water molecules ($2 \text{H}_2\text{O}$) releases approximately 180 KJ of energy per mole of O_2 [97]. Also, 1 ml H_2O contains 0.000045 mol O_2 , and 100 ml H_2O contains 0.0045 ml O_2 [44]. Therefore, 100 ml of water will produce 0.0045 mol O_2 , generating 0.81 kJ of energy, or 5.06×10^{15} MeV ($180\text{kJ/mol } \text{O}_2 \times 0.0045 \text{ mol } \text{O}_2$). This energy generation estimate assumes all 100 ml of H_2O dissociated into 0.0045 mol of O_2 that was converted back to H_2O . A review by Babcock [118] states that > 95% of consumed oxygen is utilized in the aerobic respiration pathway. A review of oxygen radicals by Checa *et al.* [119] states that about 1 to 2% of total oxygen consumption is composed of ROS species. However, if water respiration is a valid biological pathway for cellular energy generation, then total oxygen consumption would need to change its input components. Both molecular oxygen (O_2) and energized BSW water ($(\text{H}_2\text{O})_6$) would contribute to the total oxygen consumption rate. Therefore, energy balance estimates using indirect calorimetry, based on O_2 consumption rates, would not include oxygen derived from BSW water. It is likely that only intracellular water contributes to the BSW water respiration pathway.

During aerobic respiration in mitochondria, six moles of O_2 are consumed to convert one mole of glucose into water and carbon dioxide, which generates 2,870 kJ (686 kcal) of energy [120]. During water respiration, 1 ml of water splits into $^3\text{O}_2$ and 2H_2 (Eq. 2), followed by the redox cascade to recycle $^3\text{O}_2$ and 2H_2 (Eq. 2) back into $2\text{H}_2\text{O}$ and 3O_2 (Eq. 9) to generate 132 kJ of energy [119]. These respiration pathways are non-exclusive and could occur simultaneously. Water respiration only requires energized water that generates an adequate supply of $^3\text{O}_2$, which initiates the redox cascade after infrared light converts triplet oxygen to singlet oxygen $^1\text{O}_2$ (Eq. 3). Water respiration and aerobic respiration jointly generate cell energy when BSW water is at higher levels in humans up to age 40 to 50 years old [2]. As adults advance into their 60s and 70s, the levels of BSW water are reduced due to dehydration, which results in a concomitant reduction in water respiration rates [2]. If older adults drink SW water to replenish their BSW water levels, the role of BSW water as a secondary cellular energy source could be maintained well into their senior years. Maintaining BSW water in the elderly at the same levels as young adults would substantially relieve much

of the biological stress of depending on aerobic respiration as the sole energy source. Water respiration could also be a secondary or alternative energy source during resting or low-activity periods.

This study shows that SW water improved the five biomarkers after drinking SW water for 43 months. Two of these biomarkers (REE and VO₂) are associated with aerobic respiration, and there was a reduction in REE and VO₂ by 18.3 % and 21.6% after drinking SW water. The decrease in REE and VO₂ is linked to a similar reduction in aerobic respiration levels. Also, the improvement in the other three biomarkers (RHR, resting temperature, and percent blood oxygen) implies that water respiration rates were restored to levels putatively existing in middle-aged adults. The findings in this study suggest water respiration resumes its role as a secondary cell energy source in an elderly subject by drinking SW water. Restoration of water respiration rates relieves the stress of aerobic respiration, supplying all the cellular energy needs and a concomitant improvement in the other health biomarkers as well.

The HRR study by Sydó *et al.* [29] reveals that 60 to 69-year-old subjects have an HRR rate of 18.4 BPM when pulse rate is measured after a 60-second interval. The HRR test in this study found an HRR rate of 37 BPM when measured after a 60-second time interval for the 68-year-old subject after 11 months of drinking the SW water (Figure 9). These findings suggest that drinking the SW water for 11 months approximately doubled the HRR rate stated by Sydó *et al.* [29] for the elderly. Sydó *et al.* also found that the hazard ratio for HRR threshold level of < 13 BPM was significantly higher in adjusted models than HRR > 13 BPM. The adjusted models accounted for age, gender, diabetes, hypertension, obesity, smoking, and cardio respiratory fitness. A review by Dewar *et al.* [121] states that HRR is a simple, non-invasive biomarker that independently predicts mortality in humans with heart failure and coronary artery disease. A Lipinski *et al.* [122] study states that the HRR threshold for abnormal recovery rate should be increased to 22 BPM. Their study found that an abnormal recovery rate for HRR < 22 BPM was the best model parameter for human survival or predictor for longevity. These HRR studies [29, 121-123] state that abnormal HRR rates below either 13 or 22 BPM reliably predict the risk of mortality. These studies imply that survival rates increase as HRR rates increase above the abnormal

HRR threshold (13-22 BPM). In other words, these studies suggest a positive relationship between HRR and longevity in humans. The HRR rate in this treadmill study (37 BPM) is higher than the HRR abnormal threshold of 22 BPM used by Lipinski *et al.* [122] for predicting the risk of mortality.

A drinking water study by Matsiyevska [124] reports that human blood has a negative ORP varying from -100 to -200 mV. Pollack *et al.* [125-126] and Hwang *et al.* [127] state that the Exclusion Zone water (BSW water) has a negative charge. This negative charge originates from the quasi-free electrons that circle above and below each hexagonal-ringed water molecule that is the basic unit in EZ or BSW water [1]. BSW water with a negative ORP has a negative electrical charge that can be converted into energy (joules), which can be converted into electron numbers (coulomb charge/electron) [128]. Therefore, if one volt (1 V) has approximately 6.242×10^{18} electrons [128], human blood with an ORP of -100 mV has approximately $6,242 \times 10^{16}$ quasi-free electrons contributing to the negative ORP potential. These quasi-free electrons. The excellent antioxidant properties of BSW water are evident based on these estimates of the massive number of electrons that could be donated to quench free radicals.

White blood cell-based inflammatory biomarkers are blood cell count composites that can be calculated from an inflammatory blood panel test. The WBC inflammatory biomarker tests are low-cost and widely available at many commercial blood diagnostic clinics. Kotfis *et al.* [129] state that an increase in NLR levels was correlated with cerebrovascular and cardiovascular diseases, neuropsychiatric disorders (i.e., stroke, Alzheimer's disease, or schizophrenia), autoimmune diseases, and various malignant tumors. Fest *et al.* [130] developed a set of reference ranges for WBC-based biomarkers from the Rotterdam study that included 8,711 cohort subjects. They estimated reference ranges for the following WBC ratios: Neutrophil-to-lymphocyte ratio (NLR), Platelet-to-lymphocyte ratio (PLR), Lymphocyte-to-monocyte ratio (LMR), and Systemic inflammation index (SII). They found that the NLR and PLR means were 1.82 and 119, respectively, for the 65 to 74-year-old cohort [130]. In comparison, the NLR and PLR mean after drinking the SW water were 1.79 and 101 in this study (Table 3). In other words, the WBC-based biomarkers were at the low end of their reference ranges, indicating a low inflammation level after drinking SW water. The CRP

protein tests agree with the WBC-based biomarker results. The CRP biomarker was 1.1 mg/l after starting to drink the SW water. Nehring *et al.* [131] states that the reference range for CRP lies between 3 and 10 mg/l. The inflammatory biomarkers align with the calorimetry-based biomarkers, i.e., less O₂ consumption (lower VO₂) results in less ROS generation with less inflammation and lower WBC and CRP biomarker values in the elderly with reduced metabolism.

Blood biomarkers for inflammation levels serve as indicators for cell and tissue injury due to excessive concentrations of ROS free radicals [132-133]. White blood cell counts are correlated with free radical concentrations [134-135]. Maintaining the BSW water levels during aging also maintains the homeostasis balance in oxygen species and biological metabolic functions. Oxygen species play a role in signaling and immunity systems and cause cell and tissue injury when generated at excessive levels. Maintaining the oxygen species in the Goldilocks range allows effective signaling and crucial cell division activities [136]. The blood biomarker results for this study show low WBC and CRP values, indicating low inflammation levels and that the overall ROS levels in the blood and body were within the Goldilocks homeostasis range. In the elderly, dehydration and dysfunctional mitochondria produce excessive ROS concentrations that inhibit or disrupt signaling and cell division activities.

Energized BSW water is the first input or step in the respiration pathway [1]. With a minimum energy input (0.54 eV), two energized BSW water molecules split into two H₂ + O₂ or 2 H⁺ + 2 e⁻ + O [114, 119]. This reaction between energized BSW water and infrared energy generates a triplet state O₂ molecule, which has two electrons with the same spin value occupying two equivalent energy levels rather than pairing with opposite spins [137-138]. The triplet state O₂ molecule is a very stable, di-radical oxygen species with two unpaired electrons in the outer orbit. Triplet state O₂ is the same oxygen species that forms the molecular oxygen in humans' air. Triplet O₂ is a stable and non-reactive oxygen molecule that must be converted to singlet oxygen (¹O₂) in the next phase of the water respiration pathway. Singlet oxygen is generated by a number of methods, including photomodulation [139-140] and thermal, chemical, and neutrophils [140-142]. Singlet oxygen is not a radical ROS species but an excited state of O₂ in which the spin of one of the unpaired electrons is changed to yield two electrons with opposite spins [143]. An

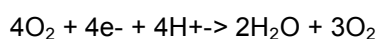
enzyme catalyst, NADH oxidase, triggers a type of WBC called neutrophils to generate a burst of ROS species to kill pathogens [143]. The burst of ROS species includes large amounts of hydrogen peroxide, which can be converted into singlet oxygen (¹O₂). Neutrophils, a type of phagocyte, make up about 50 to 60% of the total WBC count in humans. Hwang *et al.* [144] found that phagocytic activity increased twofold for a SW water treatment in macrophage cells. Drinking SW water may increase neutrophil activity up to 200%, which also increases the potential for increasing ROS bursts and subsequent generation of the long-lived singlet oxygen (¹O₂) molecule.

A literature review reveals several possible pathways for triplet-state oxygen to be energized into the singlet oxygen state under biological conditions [145-150]. However, how energy is transferred to triple O₂ to activate or energize O₂ to the singlet state is still a very active area of biological research. Recent advances and findings in quantum biology promise to open up new realms of research in biological reactions, such as energizing triplet O₂ to the singlet state. Could an as-of-yet-unknown quantum mechanism possibly convert triplet O₂ to its singlet stage that bypasses the quantum physics barrier (aka electron spin conservation barrier) that prevents energy transfers without first adding a photosensitizing molecule [151]? These findings suggest that drinking SW water may double the neutrophil count in humans, with a subsequent increase in ROS and singlet oxygen generation. The burst of ROS appears to have several possible functions, including the inactivation of pathogens or a large signaling burst to initiate inflammation that activates an immune response. Other roles for generating singlet oxygen include acting as a signaling agent for cell division and autophagy. Maintaining the level of BSW water in the blood may ensure that the signaling role of singlet oxygen is also maintained in the elderly, allowing cell division and autophagy to remain at optimal levels.

The BSW water review by Ramsey [1-3] attempted to explore the astonishing prospects of quantum biology in solving many biological problems and improbable biological reactions and activities. One such example is the biochemical reaction speeds of ROS species, which typically assume that excessive biological ROS concentrations would result in cell or tissue injury. However, quantum biology research suggests that protons and electrons can be transferred at superconducting rates under specific conditions [1, 4, 151-153]. Electron transfers at superconducting

speeds, instead of biochemical reaction speeds, would ensure immediate quenching of ROS species due to the antioxidant properties of BSW water [1]. Also, the super conduction of electrons in the electron transfer chains down a cascade of reducing reactions may occur so rapidly that biological injury from ROS species would be eliminated or minimized. Quantum behaviors such as tunneling and superconducting may eventually be proven to be ubiquitous or common in cellular activities under typical biological conditions. If quantum biology is ubiquitous and becomes the new frontier in biological science, then most assumptions about biological reaction kinetics and energy barriers or limitations should be reexamined under quantum principles [154-160].

If triplet stage O_2 is energized into the singlet stage, then it can be reduced in a series of ROS reactions, gaining four electrons and converting into H_2O and O_2 in the simplified reaction below [113]:



The generation of ROS species and their negative and positive roles in biology has been well researched. Other metabolic activities generate large amounts of ROS, which in turn contributes to cell injury or beneficial roles. However, under healthy metabolic conditions or under Goldilocks redox homeostasis, the final fate of ROS species is to be reduced to water and triplet-state oxygen [114]. However, triplet oxygen may not enter the ROS reduction pathway but instead become energized into the singlet state [161-163].

Singlet molecular oxygen is generated in biological systems using a combination of photosensitization, oxidative stress, UV radiation, lipid peroxidation, enzymatic reactions, end peroxides, and other chemical reactions [146-151]. Singlet oxygen has a long lifetime and can be quite stable in a cell, unlike most ROS species, and can diffuse across cell membranes. Also, 1O_2 is a strong oxidant and can oxidize such biomolecules as lipids, proteins, and nucleic acids [151]. Singlet oxygen is quenched by carotenoids such as lycopene, β -carotene, astaxanthin, and lutein that physically transfer the energy from 1O_2 to their molecular structure [164]. Other biomolecules such as quercetin, ascorbic acid, and α -tocopherol have electron-rich, double-bonded oxygen structures that react with 1O_2 [165]. Under biological conditions, singlet oxygen is generated and quenched to perform several important roles without causing excessive damage to healthy cells.

During aging, damaged and old cells start to accumulate as the immune system becomes less efficient in destroying and replacing the injured cells. As the damaged cells remain alive, they enter a senescence stage known as zombie cells. The senescent cells continue to release proteins that can cause inflammation and tissue degradation. When left untreated, these cells can accumulate in the body, leading to chronic inflammation and tissue disruption. [166]. Zombie cells have been associated with cataracts, diabetes, osteoporosis, Alzheimer's disease, cardiovascular disease, and muscle loss [167-168].

Due to its long life and membrane transport ability, 1O_2 is well-suited as a signaling agent that initiates the mitosis sequence in cell division [151, 168]. However, the role of 1O_2 in activating cell apoptosis and autophagy during the aging process cannot be overemphasized [169-174]. When singlet oxygen reaches high enough levels, it will react with proteins, lipids, and nucleic acids in zombie cells, which may result in sufficient damage that the cell enters apoptosis. By maintaining BSW water at healthy biological levels during aging, all the ROS species and singlet oxygen can remain in homeostasis and continue their specialized roles in metabolism, cell repair, and replacement. Middle-aged cells may only need worn-out organelles to be replaced with micro autophagy. However, older cells may succumb to the senescence process and become zombie cells. These cells can not divide anymore and are resistant to apoptosis, but are still releasing toxic chemicals that injure nearby healthy cells [167-168].

Singlet oxygen reactions may generate other ROS species that could bypass the natural resistance of zombie cells to enter apoptosis [175- 179]. The non-specificity of these ROS species results in damage to all proteins and lipids in cells, thereby inducing apoptosis after injury levels cross the cell viability threshold. For example, cross-reactivity between singlet oxygen (1O_2) and superoxide anion (O_2^-) could generate hydroxyl radicals (OH^\bullet), which are highly reactive and non-specific [169]. Hydroxyl radicals can cause extensive damage to any biomolecules and cellular components. This oxidative damage can trigger autophagy as a protective response to remove damaged components. Another ROS species, hydrogen peroxide, is one of the most abundant biological oxidants that is a by-product of aerobic respiration in mitochondria. It is a stable, non-radical oxidant that is able to cross cell membranes [169].

Ferrous iron (Fe^{2+}) will reduce H_2O_2 into hydroxyl anions (HO^-) and hydroxyl radicals ($\text{HO}\cdot$) using the Fenton reaction [177]. Another lesser-known set of reactions involves lactic acid, which can reduce ferric iron (Fe^{3+}) to ferrous iron, reducing H_2O_2 into hydroxyl radicals [170]. Also, superoxide ion ($\text{O}_2^{\cdot -}$) will reduce ferric ions to ferrous ions. Finally, hemoglobin in blood is a heme-based protein that contains Fe [171].

Assuming that the water respiration pathway can generate energy from splitting energized BSW water into H_2O and O_2 , a simplified estimate of potential energy for humans can be estimated. Also, the potential energy estimates are based on the assumption that drinking SW water would replenish or maintain the BSW water levels in humans, typically lost due to dehydration during aging. Assuming that drinking from 100 to 200 ml of SW water would maintain BSW water at healthy levels, the water volume can be converted into energy equivalents. As previously mentioned, the reduction of four oxygen molecules (4 O_2) into two water molecules ($2 \text{ H}_2\text{O}$) releases approximately 180 kJ of energy per mole of O_2 [110]. Also, as previously mentioned, 100 or 200 ml H_2O contains 0.0045 and 0.009 mol O_2 [131]. Therefore, 100 ml of water will produce 0.0045 mol O_2 , generating 0.81 kJ (0.19 kcal), or 5.06×10^{15} MeV of energy ($180 \text{ kJ/mol O}_2 \times 0.0045 \text{ mol O}_2$). Drinking 200 ml of SW water could generate 0.009 mol O_2 , which would generate 1.62 kJ/mol O_2 (0.39 kcal), or 1.01×10^{16} MeV. This energy generation estimate assumes that all 100 or 200 ml of H_2O was dissociated into 0.0045 or 0.009 mol of O_2 , which was energized into singlet O_2 and converted back to H_2O . If these assumptions are valid, drinking a cup of SW water daily, or about 100-200 ml, can generate energy from 5.06×10^{15} MeV to 1.01×10^{16} MeV via the water respiration pathway. The REE findings show a reduction of 278 kcal/day (1.163 MJ/day), or 7.26×10^{18} MeV in Resting Energy Expenditure due to drinking SW water (Table 3). The potential chemical energy in 200 ml of H_2O (0.009 mol O_2) is about 10^2 MeV less than the reduction in REE energy supply, which suggests that the estimated energy in 200 ml of SW drinking water is somewhat comparable to the savings in REE energy.

These energy generation estimates from the water respiration pathway are based on the total sum of several reactions within the pathway. As electrons are exchanged to reduce the different oxygen species, quanta packets of energy (photons) are released

during each reaction as visible and non-visible wavelengths [180-186]. Research has proposed that BSW water (EZ water) can capture, store, and release biologically based energy to meet metabolic energy requirements [108-112, 187-194]. The energy generated from BSW water in the water respiration pathway would likely be captured, stored, and released from the estimated 20 l of BSW water within the cells of an adult male. This energy would supplement or combine with the energy generated by aerobic respiration, reducing the energy demands on mitochondria during aerobic respiration. Lower energy demand on mitochondria could also lower ROS generation and reduce stress levels for functional and dysfunctional mitochondria.

As mentioned in the water review by Ramsey [1], BSW water also contributes to cell energy supply by maintaining resting membrane potential by cell and tissue types. Also, BSW water creates membrane potentials on all organelle membrane surfaces, such as mitochondria membrane potentials. The cytosol within animal cells contains up to 60 to 70% BSW water [184]. Thus, all organelle surfaces within the cytosol are covered with a BSW water layer with openings for ion and water channels or wires and aquaporins. Resting membrane potential is created by the electrochemical charges between the negative charge of the BSW water layer and the free water layer with positively charged hydronium ions adjacent to the BSW layers [139-141]. The resting membrane potential can vary from -40 to -80 mV with an electrical field charge of up to 10 MeV across a membrane. The origin of the gradient in electrochemical charges is still uncertain due to two conflicting theories on the underlying mechanism. The most widely published concept is based on the membrane pump theory, which states that ion pumps transport cations across membranes to create a charge gradient across the membrane, with the inner cytoplasm more negative than outside the cell. The second theory is based on the electrochemical charges created by BSW water layers that cover all cell and organelle membranes. A review by Ling [195] offers a convincing rebuttal that several components within membrane pump theory have several flaws that nullify the overall premise that ion pumps create membrane potential. Pollack [125-127] agrees with Ling's findings that the membrane pump theory is too flawed to describe the mechanisms behind the charge gradient across membranes accurately. The ubiquitous nature and large total volume of BSW and free water as intracellular and

intercellular structures offer a more rational biological explanation for the charges across membranes. Thus, BSW water generates energy through both water respiration and resting membrane potential. These two energy inputs are then integrated with aerobic respiration energy generation to supply most of the energy requirements for the cell and functional needs at any higher biological scales.

According to Shi *et al.* [184], about 64% of the total water in the cytosol of a human cell is BSW water, which is close to the 70:30 ratio for BSW water to free water ratio stated by others. Suppose this ratio remains consistent within organelles such as mitochondria. In that case, BSW water is the primary water structure both inside the inner membrane and between the inner membrane and the outer membrane. Under these assumptions, the small percentage of free water (30%) is probably sandwiched between the BSW water crystalline layers on the inner and outer membrane surfaces. Research shows that hydrogen-bonded, interfacial water on surfaces (BSW water) has lateral proton superconductivity properties [196-201]. Also, there is evidence of mitochondrial aquaporins that can transport water and small neutral solutes such as hydrogen peroxide [202] or glycerol [203-206]. The inner and outer mitochondria membrane sare covered with BSW water, which maintains the membrane potential as proposed by Pollack [125-127]. Due to the negative properties of BSW water, free water adjacent to the interfacial water layer always contains hydronium ions (H_3O^+) [130- 132]. Mitochondria aquaporins or water channels form openings in the BSW water layer, allowing free water or hydronium ions (H_3O^+) movement into the inner mitochondria membranes. Hydronium ions may be an alternative source for protons to recycle the energy biomolecules NAD, FAD, and NADP.

A wealth of research on aquaporins reveals their astonishing significance for transporting water across cell and organelle membranes. A study by Ikaga *et al.* [204] investigated the effects of inhibiting or knocking down the activity of Aquaporin-8 (AQP8) in a cell culture. They found that inhibiting AQP8 in the inner membrane of the mitochondria in the cells reduced the maximum oxygen consumption rate by 30%, indicating a 30% reduction in aerobic respiration rates. Also, the inhibited AQP8 cells had an 85% reduction in ATP levels compared to the control cells. They conclude that inhibiting water transport in the AQP8 aquaporin resulted in mitochondrial dysfunction but did not result in loss of viability. A similar study by Marchissio *et al.*

[205] investigated the effects of the knockdown of AQP8 on cell culture mitochondria. They found that the inhibited AQP8 cells had a 40% reduction in ATP levels, along with an 80% decrease in the mitochondria membrane potential. They state that the inhibited AQP8 increased ROS levels, which led to membrane depolarization and mitochondrial dysfunction. These findings suggest that free water transport across the inner membrane of mitochondria is crucial to maintaining BSW and free water levels within the energy generation center of the mitochondria.

Other research shows that most aquaporin types are associated with cancer development in humans [206-210]. Reviews by Abir-Awan *et al.* [206] and Chow [207] found that over expression of aquaporins was associated with several cancers. His findings conflict with the general premise that aquaporins generally increase cell health due to adequate transport rates of free water into cells and organelles. However, the majority of aquaporin research fails to measure or quantify the total amount of BSW or free water at the intracellular or intercellular level or even quantify their general dehydration level. Human subjects in future aquaporin research should be monitored for dehydration levels, or better yet, use non-invasive terahertz scans to quantify their bound (BSW water) and free water levels before studying the effects of aquaporins on cancer development. The initial levels of BSW and free water in humans are highly associated with age-related diseases, including cancer [1-3, 211-216]. Dehydration should be included with age and gender as an adjustment factor in many age-related disease studies to adjust and account for inadequate intercellular and intracellular water levels.

Recently, research involving non-invasive terahertz wavelength scans has examined biological structure and properties [217-219]. However, terahertz wavelengths are within the far-infrared (FIR) spectrum. As mentioned in the BSW water review by Ramsey [2], the entire infrared spectral band increases BSW water levels due to the preferential absorption rates of this spectral band in water molecules. Also, the average penetration of FIR wavelengths into biological tissue is about 100 to 250 μm due to its longer wavelengths [220]. The energy of FIR wavelengths is readily absorbed by vibrating bonds within biomolecules and is preferentially absorbed before the shorter infrared wavelengths [220]. The lack of penetration depth into biological tissue by terahertz scans would prevent these scans from discerning or quantifying water structure properties in tissue below skin level.

These potential energy estimates from the water respiration pathway are based on several specific assumptions that may or may not be entirely valid. Such assumptions include drinking SW water daily and replenishing water losses due to dehydration and aging. Also, drinking high-quality SW water will efficiently convert it to BSW water under normal biological conditions. Finally, drinking SW water allows both aerobic and water respiration pathways to integrate and supply adequate cellular energy in the middle-aged and elderly to maintain all metabolic activities, including cell division, apoptosis, and autophagy at healthy levels.

The results from this case study support the Water Respiration theory postulated by several scientists, such as Voeikov, Del Giudice, Messori, and their colleagues [109-112, 185-190]. The concept of water respiration has an early history in Russian research but was first published by Voeikov and Del Giudice in 2009 as a complete theory with supporting evidence and earlier citations [190]. The BSW water review by Ramsey [1] further explored the concept of water respiration based on recent quantum biology and bioenergetics research. The recent focus on quantum tunneling, proton wires, and superconducting research in quantum biology adds much-needed support for water respiration. The basic properties and functions of BSW water can only be comprehended at the quantum level. There are still many unanswered questions involving the water respiration pathways and how energy and BSW water interact to complete the pathway cycle explored by Ramsey [1]. One of the more interesting questions is whether biological sources of near and short-wave infrared radiation can convert the stable form of triplet oxygen (O_2) into the radical oxygen species known as singlet oxygen (1O_2). This critical oxygen conversion reaction is essential to the water respiration pathway.

The calorimetry biomarkers selected for this study measured an essential metabolic input (O_2), which was then used to estimate the metabolic output in caloric terms (resting kcal/day). These calorimetry biomarkers are the essential input components needed to assess the resting energy balance in humans. Energy balance refers to the equilibrium between the energy inputs and outputs to sustain all metabolic activities in an organism. The concept of energy balance takes into account the amount of available energy, the rate at which it is acquired and metabolically transformed, and the capacity to store and utilize it efficiently [184-186].

Energy balance is achieved when energy intake equals energy expenditure. A positive energy balance occurs when energy intake exceeds energy expenditure, resulting in weight gain and possible increased energy storage in augmented cell membrane potential. A negative energy balance occurs when energy expenditure exceeds energy intake, leading to weight loss and stored energy utilization.

Maintaining a proper energy balance is crucial for an organism's health and well-being [221-222]. There may be a relatively easy method of testing the water respiration theory using basic aerobic respiration principles. Any decrease in the input variables, such as molecular oxygen (O_2) for aerobic respiration, can be attributed to increased efficiency or an alternative cell energy source added to balance the metabolic energy equation. Increased metabolic efficiency occurs when fewer resources are needed to achieve the same metabolic activity or output. Increased cell energy efficiency requires that several or all reactions in the metabolic energy pathway reduce waste or increase reaction yields. Adding supplemental or secondary cell energy sources or pathways is an alternative to increased efficiency. For example, adding the water generation pathway and cell membrane potential to the input side of the energy balance equation would maintain that balance even with a reduction in oxygen inputs to the aerobic respiration pathway. This study shows that adding the water respiration pathway as an energy input could compensate for a reduction in the VO_2 biomarker with a subsequent reduction in aerobic respiration. Combining the energy generation output with water respiration could maintain the cellular energy balance while simultaneously reducing the oxygen inputs for the aerobic respiration pathway.

A plant study by Ramsey [223-224] evaluated the effects of SW water on water-stressed legumes. The first article [223] reported the basic physiological and growth rates of water-stressed legumes. The second article [224] reported the same study but included additional gas exchange and mesophyll cell water content analysis that was not reported in the first article. Both articles indirectly validated the abovementioned conceptual principles for maintaining a biologically sustainable cellular energy balance. The results from this water stress plant study indicate that plant photosynthesis was not symmetrically correlated with SW water uptake. In other words, there was a significant reduction in photosynthetic rates but a much smaller reduction in oven-dry foliage biomass. The first

article [223] reported a 43% reduction in photosynthesis rates for the optimal SW treatment. However, this reduction in sugar production only resulted in a 5.4% reduction in the oven-dry, aboveground biomass. This asymmetric decrease in photosynthesis compared to foliage biomass reduction implies that plant efficiency and supplemental cell energy sources caused this asymmetric reduction results. The second article [224] reported the water vapor concentration (mmol H₂O/mol air) in the intercellular airspace among the spongy mesophyll cells for the SW-watered plants. The spongy mesophyll cells transpire liquid water from the cell membrane into the intercellular airspaces, and that phase changes into water vapor, which ultimately transpires to cool the foliage. Increased water vapor concentrations are correlated with increased liquid water (aka hydration levels) within the spongy mesophyll cells [225-227]. A review of the complexities and interconnections with water properties and temperature related to water vapor dynamics within leaves was published by Buckley and Sack [228]. Despite these complex relationships, the results from this study [224] show a 21.5% increase in water vapor concentration that transpired from the surface of the spongy mesophyll cells in the optimal SW-watered plants compared to the controls. These plant study results validate the biomonitoring results from this case study. Both studies suggest that energy inputs related to aerobic respiration can be reduced if there is a concomitant increase in alternative energy generation due to increased BSW water levels.

This case study presents preliminary but promising results, hopefully encouraging much larger studies using similar biomarker techniques. A rapidly expanding volume of clinical databases reliably correlates easy-to-measure biomarkers with health status and longevity. Short- and long-term personal health assessment is now possible for virtually everyone. Drinking SW water lowered most of the biomarkers, which is correlated with improved health and longevity. Future studies are needed to determine how drinking SW contributes to the biological processes involving cellular energy generation.

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