

The GH-Method

Relationship between Sleep Quality & Overall Sleep Score versus Fasting Plasma Glucose Value Based on GH-Method: Math-Physical Medicine (No. 766)

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Abstract

Based on ~60,000 data collected over the past ~3 years, the curve similarity between sleep quality scores from Oura ring hardware versus fasting plasma glucose (FPG) values has a quite high correlation of 55% to 57%. This means that his FPG value would be lower when he falls into a “deep sleep” state and vice versa. In addition, the correlation of his overall sleep scores from chronic software versus FPG values over 8 years is very high at 68%. Examining these diagrams in more detail, his FPG curve looks like a big salad bowl with two higher “edges” and a central lower “bottom”. Within the sleep window between 04:00 and 07:00, the “flattening” sleep curve versus the “increasing” FPG curve has reduced his higher

correlation down to around 57%. Within the period from November 2020 to November 2022, his overall Chronic sleep score becomes lower due to his increased sleeping hours to 8+ hours with an averaged urination time of less than 1 which then reduces his FPG to ~90 mg/dL. In summary, diabetes patients having FPG fluctuation during the night sleep hours are mainly influenced by the health state of their pancreatic beta cells, and sleep is only a secondary influential factor. However, FPG indeed has a direct connection with sleep quality - more occurrences of “deep sleep” state would result in lower FPG values. Furthermore, more sleep hours with a higher quality of sleep will definitely bring FPG values downward.

Keywords: Diabetes; Sleep; Fasting plasma glucose; Sleep score

Abbreviations: PPG: postprandial plasma glucose; FPG: fasting plasma glucose

1. INTRODUCTION

Two kinds of medical studies are interrelated but with different emphases. The first or popular one focuses on “germs theory (microscopic bacterias, viruses)” and “treatment of diseases” via medications, surgeries, and/or other therapies. This approach is extremely important because it directly saves a patient’s life; however, the burden of disease treatment is on the shoulder of clinical doctors. The second or less emphasized one concentrates on the “body’s natural defense mechanism” and “prevention of diseases” via metabolism improvement and immunity strengthening through daily lifestyle management. This approach is effective in preventing various diseases from occurring in the first place, but the burden of disease prevention is mainly on the patient. The main driven force behind the treatment approach is by and large related to the “financial considerations in the capitalistic society” starting around 1922. However, this subject is neither the intention of the author nor the scope of this research. There is no need to have a theoretical debate regarding which route is right or wrong, easier or better. Both approaches have their intrinsic values, are correct in their own ways, and both are important. Developing good skills for clinical doctors take many years of studying, training, and practicing. Equally, possessing sufficient knowledge of preventive medicine through lifestyle also requires considerable studies and learning efforts on lifestyle, psychology, and biomedicine. It should be noted that these preventive measurements also involve a patient’s willpower, focus, and persistence which belongs to the subject of “personality and behavior psychology”.

The analogy of lifestyle management can be explained using a rectangular table. The table top carries the weight of health which is supported by 4 table legs: diet, exercise, sleep, and stress. These 4 subjects also require great effort to learn to maintain their supporting strength and durability. When these 4 table legs become weak, both metabolism and immunity get affected; then germs (bacteria and viruses) can invade our bodies to do damage and kill. These damages translate into various health problems which appear as excessive body weight and cause problems with glucose, blood pressure, and

cholesterol. Body weight is the most important biophysical signal and also the first sign of health problems. After that, being overweight or having obesity usually lead to other 3 interrelated metabolic conditions. Among these 3 blood-related metabolic conditions, blood sugar (glucose) is the most critical one and it behaves like a double-edged sword. Glucose provides necessary nutrition to our body, yet too much blood sugar (hyperglycemia) would damage the structural integrity of the blood vessels (both macro-vessels in the heart or brain and micro-vessels in the kidney and other organs), nerves, hormonal balance, etc. Besides, sugar also supplies needed nutrition for the growth and spread of cancer cells. The situation of glucose and blood vessels is similar to the analogy of acid and metal pipes. After the blood vessel’s structural integrity is weakened by high glucose (hyperglycemia), then high blood pressure (causing rupture of blood vessels) and high cholesterol (causing blockage of blood vessel) will perform the “final killing” actions which lead to many serious medical conditions, such as heart attacks, strokes, kidney failure, neuropathy, retinopathy, etc. The above descriptions are just simple explanations of the complex biomedical health scenario using plain English to avoid medical jargon for patients without medical training.

The author has monitored his glucose 4 times each day (1 FPG and 3 PPG) since 2012. Since 2018, after the FDC approved Libre sensor usage in the US, he measured 96 times each day at 15-minute intervals. By 2019, after collecting sufficient glucose data, he observed his FPG curve shape (i.e. waveform) looks like a salad bowl, starting higher value around midnight and continuously dropping to the bottom of the bowl around 3 am to 4 am, and then re-climbing up to another peak value around his wake-up moment at 7 am.

Since 2020, he started to wear several different health devices to collect a variety of his biomarker values and lifestyle data, including the Oura ring. Although results from these devices are not completely identical to each other, they still show similar data patterns and trends. Unfortunately, it is not easy for an ordinary patient to know how to extract those wearable device data and then combine them with other application software for further in-depth calculations and

complex data analyses. The author developed a software robot during 2002-2010 and then since 2010, further expanded his software tool into a customized health management APP known as “Chronic” on iPhone devices. He started to collect his vital biomarkers and lifestyle data using this Chronic APP in 2012. Thus far, he has already collected and processed 3+ million personal health data. In addition, he has also stored 6+ million nutritional data of restaurant dishes and food ingredients transformed from public domain into a cloud server for his immediate online access and data processing.

In November of 2022, he feels that he has already accumulated sufficient data via his personal wearable health devices. He then started to extract, organize, regroup, and calculate his sleep quality score from the Oura ring to compare them against his sensor FPG data and waveform.

In this article, he has not applied any fancy equations and difficult-to-understand mathematical physics theorems or advanced engineering research tools. Instead, he just uses simple statistical correlation coefficient calculation and visual examination of various curve shapes.

2. METHODS

2.1 Sleep

This particular paper focuses on investigating the relationship between sleep quality using the Oura ring (sleep score) and FPG using the Libre sensor within 7 hours of sleep at night between 00:00 and 07:00. The total ~60,000 data of both sleep and FPG are collected within nearly 3 years period from 1/18/2020 to 11/25/2022. It contains both Oura ring’s sleep quality score and FPG level at 15-minute time intervals. This time period matches with the COVID-19 pandemic period which is also his “COVID self-quarantined” period. Therefore, there are no traveling or other major events which disturbed his sleep quality.

The Oura-ring device has defined sleep quality into 4 stages or states of sleep, i.e. awake, REM, light, and deep, and their fluctuation by second. He has synthesized them into time interval of 15 minutes to match with his Libre sensor glucose device

record of FPG values. He further assigns the following score to each sleep quality state:

Awake = 1.0
REM sleep = 3.0
Light sleep = 4.0
Deep sleep = 5.0

As a result, he could calculate a total combined sleep quality score to compare with other devices, such as the Fitbit watch and Apple Health. However, all of those health devices, their shown sleep scores are “higher the better” which is different from the biomedical convention of “lower the better” (except for HDL). Therefore, he takes the value of (1 divided by the combined sleep quality) as his “sleep score” in this study.

Furthermore, he has included two data tables in Figure 1. The first data table uses 90 mg/dL as the normalization factor for FPG since he would like to see his FPG values fall below 90 mg/dL and above 70 mg/dL. The second data table uses 270 mg/dL as the normalization factor for FPG since he would like to be able to “eyeball” the “difference from direct comparison” of his sleep score curve against the FPG curve within a similar amplitude data range of the Y-axis in the same time domain chart.

His self-developed Chronic software has a specific category of sleep. This sleep category contains the following 14 detailed sleep elements:

- Annoying issues before or in sleep
- Sleep hours
- Wake-up times (e.g. urination)
- Degree of freshness & restfulness
- Degree of dreams
- Environmental comfort degree
- Physical sickness degree
- Sleep pattern disturbance
- Itchy skin degree
- Numbness feeling of hands or feet
- Hungry feeling during sleep
- Leg cramp during sleep
- Cold feeling of legs and feet
- Snoring during sleep

The above 14 “subjective” sleep measurements receive a score from 1 to 5 by the user input which is quite different from those health device “objective” measurements, such as heart rate, HRV, blood oxygen level, etc. However, in his

biased opinion, his Chronic software measurements are broader in scope and more detailed in inputs than those hardware devices can provide. Actually, this is why a well-developed software product is usually more useful and offers wider coverage of applications than many hardware devices can do. Besides, the author can enhance his software product at anytime while a hardware product becomes somewhat “fixed” right after its release.

2.2 The author’s diabetes history

The author was a severe T2D patient since 1995. He weighed 220 lb. (100 kg) at that time. By 2010, he still weighed 198 lb. with an average daily glucose of 250 mg/dL (HbA1C at 10%). During that year, his triglycerides reached 1161 (high risk for CVD and stroke) and his albumin-creatinine ratio (ACR) at 116 (high risk for chronic kidney disease). He also suffered from five cardiac episodes within a decade. In 2010, three independent physicians warned him regarding the need for kidney dialysis treatment and the future high risk of dying from his severe diabetic complications.

In 2010, he decided to self-study endocrinology with an emphasis on diabetes and food nutrition. He spent the entire year of 2014 developing a metabolism index (MI) mathematical model. During 2015 and 2016, he developed four mathematical prediction models related to diabetes conditions: weight, PPG, FPG, and HbA1C (A1C). Through using his developed mathematical metabolism index (MI) model and the other four glucose prediction tools, by the end of 2016, his weight was reduced from 220 lbs. (100 kg) to 176 lbs. (89 kg), waistline from 44 inches (112 cm) to 33 inches (84 cm), average finger-piercing glucose from 250 mg/dL to 120 mg/dL, and A1C from 10% to ~6.5%. One of his major accomplishments is that he no longer takes any diabetes-related medications since 12/8/2015.

In 2017, he achieved excellent results on all fronts, especially his glucose control. However, during the pre-COVID period, including both 2018 and 2019, he traveled to ~50 international cities to attend 65+ medical conferences and made ~120 oral presentations. This hectic schedule inflicted damage to his diabetes control caused by stress, dining out frequently, post-meal

exercise disruption, and jet lag, along with the overall negative metabolic impact from the irregular life patterns; therefore, his glucose control was somewhat affected during the two-year traveling period of 2018-2019.

He started his COVID-19 self-quarantined life on 1/19/2020. By 10/16/2022, his weight was further reduced to ~164 lbs. (BMI 24.22) and his A1C was at 6.0% without any medication intervention or insulin injection. In fact, with the special COVID-19 quarantine lifestyle since early 2020, not only has he written and published ~500 new research articles in various medical and engineering journals, but he has also achieved his best health conditions for the past 27 years. These achievements have resulted from his non-traveling, low-stress, and regular daily life routines. Of course, his in-depth knowledge of chronic diseases, sufficient practical lifestyle management experiences, and his own developed high-tech tools have also contributed to his excellent health improvements.

On 5/5/2018, he applied a continuous glucose monitoring (CGM) sensor device on his upper arm and checked his glucose measurements every 5 minutes for a total of 288 times daily. Furthermore, he extracted the 5-minute intervals from every 15-minute interval for a total of 96 glucose data each day stored in his computer software.

The author has performed medical research work over 40,000 hours and read 4,000+ published medical papers online in the past 13 years. He discovered and became convinced that good life habits of not smoking, moderate or no alcohol intake, avoiding illicit drugs, eating the right food with well-balanced nutrition, persistent exercise, having a sufficient and good quality of sleep, reducing all kinds of unnecessary stress, maintaining a regular daily life routine contribute to the risk reduction of having many diseases, including CVD, stroke, kidney problems, micro blood vessels issues, peripheral nervous system problems, and even cancers and dementia. In addition, a long-term healthy lifestyle can even “repair” some damaged internal organs, with different required time-length depending on the particular organ’s cell lifespan. For example, he has “self-repaired” about 35% of

his damaged pancreatic beta cells during the past 10 years.

3. RESULTS

Figure 1 shows 2 data tables.

No.766	11/25/22				No.766	11/25/22			
Correlation	55%				Correlation	55% / 270			
Sleep vs. FPG	Sleep Score	FPG	Oura Sleep	Libre FPG	Sleep vs. FPG	Sleep Score	FPG	Oura Sleep	Libre FPG
00:00	0.27	1.21	3.74	108.70	00:00	0.27	0.40	3.74	108.70
00:15	0.53	1.20	1.89	107.92	00:15	0.53	0.40	1.89	107.92
00:30	0.62	1.20	1.62	107.84	00:30	0.62	0.40	1.62	107.84
00:45	0.44	1.17	2.25	105.33	00:45	0.44	0.39	2.25	105.33
01:00	0.31	1.16	3.25	104.68	01:00	0.31	0.39	3.25	104.68
01:15	0.31	1.13	3.20	101.55	01:15	0.31	0.38	3.20	101.55
01:30	0.35	1.11	2.89	100.05	01:30	0.35	0.37	2.89	100.05
01:45	0.34	1.09	2.91	97.99	01:45	0.34	0.36	2.91	97.99
02:00	0.33	1.09	3.05	97.82	02:00	0.33	0.36	3.05	97.82
02:15	0.32	1.06	3.16	95.09	02:15	0.32	0.35	3.16	95.09
02:30	0.32	1.04	3.10	93.94	02:30	0.32	0.35	3.10	93.94
02:45	0.34	1.03	2.94	92.70	02:45	0.34	0.34	2.94	92.70
03:00	0.34	1.03	2.92	93.07	03:00	0.34	0.34	2.92	93.07
03:15	0.33	1.02	3.00	91.47	03:15	0.33	0.34	3.00	91.47
03:30	0.31	1.01	3.18	91.09	03:30	0.31	0.34	3.18	91.09
03:45	0.30	1.01	3.28	90.88	03:45	0.30	0.34	3.28	90.88
04:00	0.30	1.02	3.28	91.79	04:00	0.30	0.34	3.28	91.79
04:15	0.31	1.01	3.23	90.53	04:15	0.31	0.34	3.23	90.53
04:30	0.31	1.01	3.18	90.58	04:30	0.31	0.34	3.18	90.58
04:45	0.31	1.00	3.21	90.38	04:45	0.31	0.33	3.21	90.38
05:00	0.30	1.02	3.33	92.08	05:00	0.30	0.34	3.33	92.08
05:15	0.29	1.01	3.48	91.16	05:15	0.29	0.34	3.48	91.16
05:30	0.29	1.02	3.48	91.48	05:30	0.29	0.34	3.48	91.48
05:45	0.29	1.03	3.49	92.31	05:45	0.29	0.34	3.49	92.31
06:00	0.29	1.05	3.49	94.07	06:00	0.29	0.35	3.49	94.07
06:15	0.29	1.04	3.47	93.98	06:15	0.29	0.35	3.47	93.98
06:30	0.28	1.06	3.58	95.42	06:30	0.28	0.35	3.58	95.42
06:45	0.27	1.09	3.64	98.50	06:45	0.27	0.36	3.64	98.50
07:00	0.27	1.12	3.69	100.74	07:00	0.27	0.37	3.69	100.74
Average	0.33	1.07	3.14	96.32	Average	0.33	0.36	3.14	96.32

Figure 1: 2 data tables.

Figure 2 depicts 3 time-domain diagrams of comparison between sleep score and FPG.

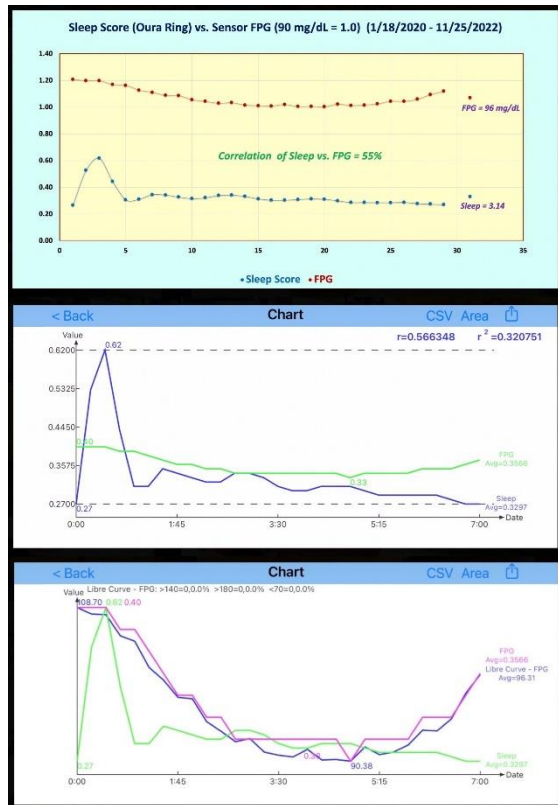


Figure 2: 3 time-domain diagrams of comparison between sleep score and FPG.

Figure 3 demonstrates his 90-day moving average overall Chronic sleep scores versus his FPG values over a long period of ~8 years.

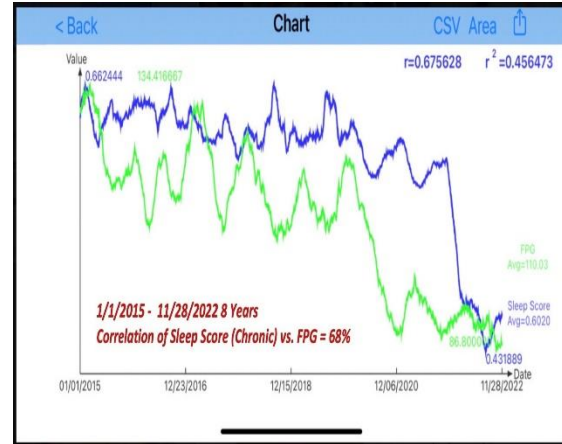


Figure 3: 90-day moving average overall chronic sleep scores versus his FPG values over a long period of 8 years.

4. CONCLUSION

Based on ~60,000 data collected over the past ~3 years, the curve similarity between sleep quality scores from Oura ring hardware versus fasting plasma glucose (FPG) values has a quite high correlation of 55% to 57%. This means that his FPG value would be lower when he falls into a “deep sleep” state and vice versa. In addition, the correlation of his overall sleep scores from Chronic software versus FPG values over 8 years is very high at 68%.

Examining these diagrams in more detail, his FPG curve looks like a big salad bowl with two higher “edges” and a central lower “bottom”. Within the sleep window between 04:00 and 07:00, the “flattening” sleep curve versus the “increasing” FPG curve has reduced his higher correlation down to around 57%. Within the period from November 2020 to November 2022, his overall Chronic sleep score becomes lower due to his increased sleeping hours to 8+ hours with an averaged urination time of less than 1 which then reduces his FPG to ~90 mg/dL.

In summary, diabetes patients having FPG fluctuation during the night sleep hours are mainly influenced by the health state of their pancreatic beta cells, and sleep is only a secondary influential factor. However, FPG indeed has a direct connection with sleep quality - more occurrences of “deep sleep” state would result in lower FPG values.

Furthermore, more sleep hours with a higher quality of sleep will definitely bring FPG values downward.

5. REFERENCES

For editing purposes, the majority of the references in this paper, which are self-references, have been removed. Only

references from other authors' published sources remain. The bibliography of the author's original self-references can be viewed at www.eclairemd.com.

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