Smart Watch to Track the Levels of Vitamin D

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Abstract - *Vitamin D insufficiency affects almost 50% of the population worldwide. An estimated 1 billion people worldwide, across all ethnicities and age groups, have a vitamin D deficiency (VDD). This pandemic of hypovitaminosis D can mainly be attributed to lifestyle (for example, reduced outdoor activities) and environmental (for example, air pollution) factors that reduce exposure to sunlight, which is required for ultraviolet-B (UVB)-induced vitamin D production in the skin. Vitamin D can be synthesized in the skin upon exposure to UVB rays from the sun or obtained through dietary means. Vitamin D is essential for several reasons, including maintaining healthy bones and teeth. It may also protect against a range of diseases and conditions, such as type 1 diabetes. Although the body can create vitamin D, a deficiency can occur for many reasons. For example, darker skin and sunscreen, reduce the body's ability to absorb the ultraviolet radiation B (UVB) rays from the sun. People who live in northern latitudes or areas of high pollution, work night shifts, or are homebound may also be vitamin D deficient. So, to regulate the complication in the health, either by underdose or overdose, this paper introduces the development of smart watch which helps you monitor right amounts of vitamin D intake from sun, dietary intake or supplements. It also warns the user when exposed to harmful UVB rays and when exposed too much.*

***Key Words*:** NodeMCU, Smart watch, vitamin D, IOT, UV sensor, UVB, skin tone, sunlight

1. INTRODUCTION

Vitamin D deficiency arises from multiple causes including inadequate dietary intake and inadequate exposure to sunlight. About 50% to 90% of vitamin D is absorbed through the skin via sunlight while the rest comes from the diet. Twenty minutes of sunshine daily with over 40% of skin exposed is required to prevent vitamin D deficiency.[1]. It is important to note that vitamin D deficiency is a major global public health issue. About 1 billion people worldwide have vitamin D deficiency, while 50% of the population has vitamin D insufficiency.[2] The prevalence of patients with vitamin D deficiency is highest in the elderly, the obese patients, nursing home residents, and hospitalized patients. Prevalence of vitamin D deficiency was 35% higher in obese subjects irrespective of latitude and age.[3] In the United States, about 50% to 60% of nursing home residents and hospitalized patients had vitamin D deficiency.[4] [5]

Vitamin D deficiency may be related to populations who have higher skin melanin content and who use extensive skin coverage, particularly in Middle Eastern countries. In the United States, 47% of African American infants and 56% of Caucasian infants have vitamin D deficiency; while over 90% of infants in Iran, Turkey, and India have vitamin D deficiency. In the adult population, 35% of adults in the United States are vitamin D deficient whereas over 80% of adults in Pakistan, India, and Bangladesh are Vitamin D deficient. In the United States, 61% of the elderly population is vitamin D deficient whereas 90% in Turkey, 96% in India, 72% in Pakistan, and 67% in Iran were vitamin D deficient.[6]

1.1 Effects

Unfortunately, vitamin D trend isn't all blue skies. Some people are overdoing it with supplements. Researchers looking at national survey data gathered between 1999 and 2014 found 2.8% increase in the number of people taking potentially unsafe amounts of vitamin D.

Some people will benefit from taking vitamin D supplements, along with sufficient calcium intake, to promote their bone health. But they do not require large amounts of vitamin D to get the benefit. "More is not necessarily better. In fact, more can be worse," says Dr. Manson.[7] For example, a 2010 study published in *JAMA* showed that intake of very high doses of vitamin D in older women was associated with more falls and fractures. In addition, taking a supplement that contains too much vitamin D can be toxic in rare cases. It can lead to hypercalcemia, a condition in which too much calcium builds up in the blood, potentially forming deposits in the arteries or soft tissues. It may also predispose women to painful kidney stones.

If Vitamin D deficiency continues for long periods, it may result in complications, such as cardiovascular conditions, autoimmune problems, neurological diseases, infections, pregnancy complications, certain cancers, especially breast, prostate, and colon. Vitamin D toxicity is usually caused by mega doses of vitamin D supplements, which may result in Elevated Blood Levels, Elevated Blood Calcium Levels, Nausea, Vomiting and Poor Appetite, Stomach Pain, Constipation or Diarrhea, Bone Loss, Kidney Failure.

2. MEASURING EXPOSURE TIME

2.1 Spectrum of UV rays

Vitamin D is made when UV (more precisely, UVB rays) react with a compound (7-dehydrocholesterol) in the skin. The best rays for UV synthesis have wavelengths between 270–300 nm. These wavelengths are present when the UV index is greater than 3. The angle of the Sun above the horizon (at sea level) also affects the production of vitamin D because the atmosphere is thicker at lower angles and absorbs more UV. At angles greater than 45° above the horizon (at sea level), vitamin D production will be occurring, although some recent research suggests that vitamin D production may occur at angles as low as 30°. At higher altitudes, there is less (thinner) atmosphere to absorb UV from the Sun.

Fig -1: UV Index

2.2 Vitamin-D Measure

In general, the UV index is higher between 10:00 am and 4:00 pm, and during summer months. The recommendations in the below table assume that you are exposed to this amount of sunlight at least 3 times per week. Once the watch determines that the person had enough vitamin D through sun exposure, it recommends the individual to take shade and indicates his measurements. If not, he/she is asked to take food supplements.

	UV Index			
SKIN REACTION TO SUNLIGHT	**3-5**	**6-7**	**8-10**	**11+**
Skin type 1: Always burn, never tan	10-15 min	5-10 min	2-6 min	1-5 min
Skin type 2: Burn easily, rarely tan	15-20 min	10-15 min	5-10 min	2-8 min
Skin type 3: Occasionally burn, slowly tan	20-30 min	15-20 min	10-15 min	5-10 min
Skin type 4: rarely burn, rapidly tan	30-40 min	20-30 min	15-20 min	10-15 min
Skin type 5 & 6: very rarely burn, always dark	40-60 min	30-40 min	20-30 min	15-20 min

Table-1: Minutes of sun exposure

2.3 Skin Type Classification

The current Fitzpatrick skin type classification [9] denotes six different skin types, skin color, and reaction to sun exposure which ranges from very fair (skin type I) to very dark (skin type VI) depending upon whether the patient burns at the first average sun exposure or tans at the first average sun exposure [8]. The two main factors that influence skin type are: 1. Genetic disposition 2. Reaction to sun exposure and tanning habits

FITZPATRICK SKIN TYPE	SUNBURN	TAN	TEST SCORE
I	Always	Never	0 to 6
II	Always	Rarely	7 to 12
III	Sometimes	Sometimes	13 to 18
IV	Less likely	Likely	19 to 24
V	Rarely	Easily	25 to 30
VI	Very rarely	Yes	31 +

Table-2: Fitzpatrick skin types

2.3 Genetic disposition and reaction to sun exposure

Skin type is determined genetically and is one of the many aspects of the overall appearance, which also includes color of eyes and hair. The way skin reacts to sun exposure is another important factor in correctly assessing the skin type. Recent tanning (sunbathing, artificial tanning, or tanning creams) has a major impact on the evaluation of the skin color. The Fitzpatrick scale is a numerical classification scheme for determining the skin color based on a questionnaire related to an individual's genetic constitution, reaction to sun exposure, and tanning habits. The response to each question is measured on a scale of zero to four. The response for all the questions is added to get the final score corresponding to the Fitzpatrick skin type. The following questions are asked when the user starts using the application and hence determines the users skin type.

QUESTIONS	YOUR ANSWER	YOUR SCORE
1. What is your eye color?	Light blue, light gray or light green	0
	Blue, gray or green	1
	Hazel or light brown	2
	Dark brown	3
	Brownish black	4
2. What is your hair color?	Red or light blonde	0
	Blonde	1
	Dark blonde or light brown	2
	Dark brown	3
	Black	4
3. What is your skin color	Ivory white	0
	Fair or pale	1

before sun exposure?	Fair to beige, with golden undertone	2
	Olive or light brown	3
	Dark brown or black	4
4. How many freckles are there on the unexposed areas of your skin?	Many	0
	Several	1
	A few	2
	Very few	3
	None	4
5. How easily do you get skin burn by sun exposure?	Always burns, blisters and peels	0
	Often burns, blisters and peels	1
	Burns moderately	2
	Burns rarely, if at all	3
	Never burns	4
6. Does your skin tan by sun exposure?	Never	0
	Seldom	1
	Sometimes	2
	Often	3
	Always	4
7. How deeply do you tan?	Very little or Not at all	0
	Lightly	1
	Moderately	2
	Deeply	3
	Natural dark	4
8. How sensitive is your face to the sun?	Very sensitive	0
	Sensitive	1
	Normal	2
	Resistant	3
	Never had a problem	4

Table-3: Testing scores

3. SYSTEM DESIGN

3.1 Hardware Components

A. NodeMCU

The NodeMCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features made it ideal for this project. NodeMCU can be powered using Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.

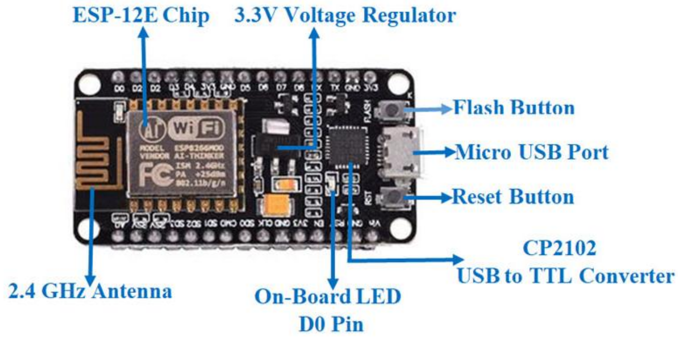

Fig -2: NodeMCU

B. UV Sensor

The ML8511 sensor breakout is an easy to use ultraviolet light sensor. The MP8511 UV Sensor outputs an analog signal in relation to the amount of UV light it detects. This sensor detects 280-390nm light most effectively. This is categorized as part of the UVB (burning rays) spectrum and most of the UVA (tanning rays) spectrum.

Fig -3: ML8511 UV sensor

3.1 Architecture

When the user starts using the application in an android device, will be asked to answer the questions mentioned in table 3. Depending on the answers, skin tone of the user is determined. Based on the skin tone and the time exposed, the application will determine how many minutes the user is supposed to be exposed to sun. Now the user is ready to use the smart watch. UV sensor in the smart watch determines the UV intensity and measures the amount of time the user should be exposed to the sun. Once the user exceeds the amount of time exposed to the sun, an alert is sent to the user interface. It also sends an alert if the user is exposed to very high UV index (8+ range). On completion of the day, it intimates the user about the levels vitamin D absorbed and recommends if any food supplements if necessary. This will reduce over intake of vitamin D and maintains right amounts of vitamin in the user's body. These messages are sent from NodeMCU to the user interface using the ThingSpeak cloud platform. User interface continuously listens from the cloud platform.

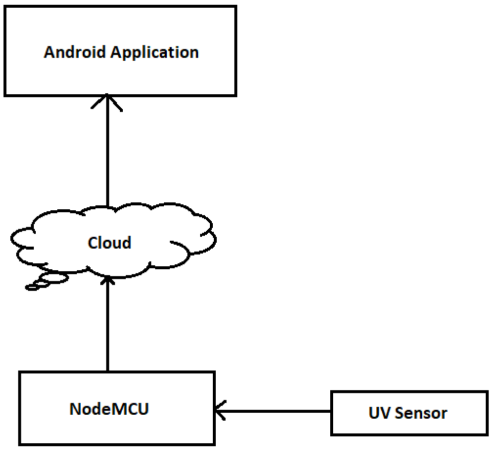

Fig -4: Architecture

4. CONCLUSION

From this proposed system, we can measure if the user has been exposed to the right UV radiation or not. It protects the user from harmful UV rays exposure while allowing the user to obtain vitamin D from the harmless rays. It also measures the amount of time the user should be exposed based on one's skin tone. At the end of the day the user can be intimated if the amount of vitamin D from the natural source(sun) is sufficient or must take supplements and thereby, protecting him from vitamin D overdosage. This application is helpful for most of the age groups irrespective of their work.

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