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Ultraviolet to Visible Spectrophotometry Observation to Find Appropriate Wavelength for Non-Invasive Blood Glucose Level Measurement Optical Device

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Abstract. The wavelength convention for non-invasive blood glucose measurement remains inconclusive. Objective. We have done this experimental observation to find the appropriate wavelength candidate for non-invasive blood glucose level measurement optical device in 190 nm to 900 nm range. We run this observation in Prodia Kedoya and Biochemistry Lab, Universitas Krida Wacana, West Jakarta July 2019. We have obtained fasting, 15 mnt postprandial, and 30 mnt postprandial blood sample from 10 randomly selected consenting non blinded healthy adult subjects between 18 years old to 60 years old. We have diluted each blood samples 400 times in double distilled water before spectrophotometric measurement. We have measured the spectrophotometric absorbance of each blood sample. We then compared it to blood glucose level by standard gold measurement. We have compared the Pearson correlation, and the standard deviation of all samples to then-existing wavelength source LED provided by Thorlabs. We have found that the smallest standard deviation is at 510 nm, and the highest Pearson correlation is at 511 nm. There is low UV-VIS absorption value at 490 nm, 505 nm, and 525 nm wavelength. We did not find a severe adverse effect from each participant. Discussion and Conclusion. The 490 nm, 505 nm, and 525 nm wavelength may appropriate for non-invasive blood glucose level measurement optical device. Further research should confirm this trial with human observation. **Ethical Clearance**. 076/IT3.KEPMSM-IPB/SK/2018. **Grant**. PRJ-78/LPDP/2019, 2 December 2019.

INTRODUCTION

A non-invasive "needle-less" blood-glucose-level measurement device is still heavily researched, as people already familiar with the general risk own conventional phlebotomy-based method [1–3]. We have done a review on wavelength for non-invasive blood glucose level measurement optical device using bioassayed blood control sample. We have confirmed the wavelength using real human blood in the near-infrared range. However, we have not surveyed the ultraviolet to the visible range for human blood [4,5]. The appropriate wavelengths are essential for the device development [4–9], As they determine the general accuracy of the measurement device [10,11], As well as the potential machine learning algorithm to use [12,13]. We have done this experimental observation to find the appropriate wavelength candidate for non-invasive blood glucose level measurement optical device in 190 nm to 900 nm range.

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MATERIAL AND METHODS

General Methods

This manuscript describes a quantitative experimental observation of wavelength absorbance for human blood between 200 nm to 900 nm, taking account the change in blood glucose level. Human Research Ethical Committee of IPB University has approved this research under ethical clearance 076/IT3.KEPMSM-IPB/SK/2018. Lembaga Pengelola Dana Pendidikan has supported this study using Riset Inovatif Produktif Invitasi with grant number PRJ-78/LPDP/2019, 2 December 2019. This research protocol is a modification from our previous research, adapted to live human blood sample in visible wavelength range [4,5,8]. We have used CONSORT reporting guidelines [14–17], Docear [18], and Zotero [19] for this manuscript preparation.

Blood Sample Procurement

We have done the blood sample procurement in Prodia Office in Kedoya, which near Universitas Kristen Krida Wacana, in July 2019. There are ten volunteers for this study that already read the research information the day before, and they sign the informed consent before participating in this study. The Volunteers are not randomised nor blinded for this study purpose. Subjects are male or female between 18 years to 60 years old and did not under glucose disorder medication. They are also not pregnant nor breastfeeding in the duration of this observation. Subjects have undergone eight hours of fasting before blood taking procedure. The blood taking procedure is done three times, at fasting state and 15 minutes and 30 minutes postprandial. The Subjects are taking 75 mg of pure glucose in 200 ml water solution after first blood taking session. Each blood taking procedure yields 3 ml of the blood sample, and the whole procedure yields 30 samples, which would enough for typical spectral observation study.

Blood Observation

We did the blood sample observation in Biochemistry Laboratory of Universitas Kristen Krida Wacana in July 2019, within four hours after the blood sample procurement. We have diluted Each blood samples 400 times using double distilled water before spectrophotometric measurement using UV-VIS Biochrom Libra S22 (Biochrom, Ltd, United Kingdom). We then calculate the Pearson correlation and standard deviation of all samples to then-existing wavelength source LED provided by Thorlabs (Thorlabs, USA). We have used R [20], Rkward [21], and Rstudio [22,23] for data analysis in this study.

RESULT AND DISCUSSION

We have included all ten subjects data in this data analysis. We have done each data blood sample procurement and blood observation procedure within four hours. The whole event was taking two days. We stop the procedure after we have taken and observed all sample. We did not find a severe adverse effect from each participant

The highest correlation value is in the wavelength range of 190-200 nm. However, developers probably could not use the correlation value in the 190-250 nm wavelength range because there is noise. The highest correlation value used is in the wavelength range of 490-527 nm, precisely at a wavelength of 511 nm with a value of 0.37822 (1).

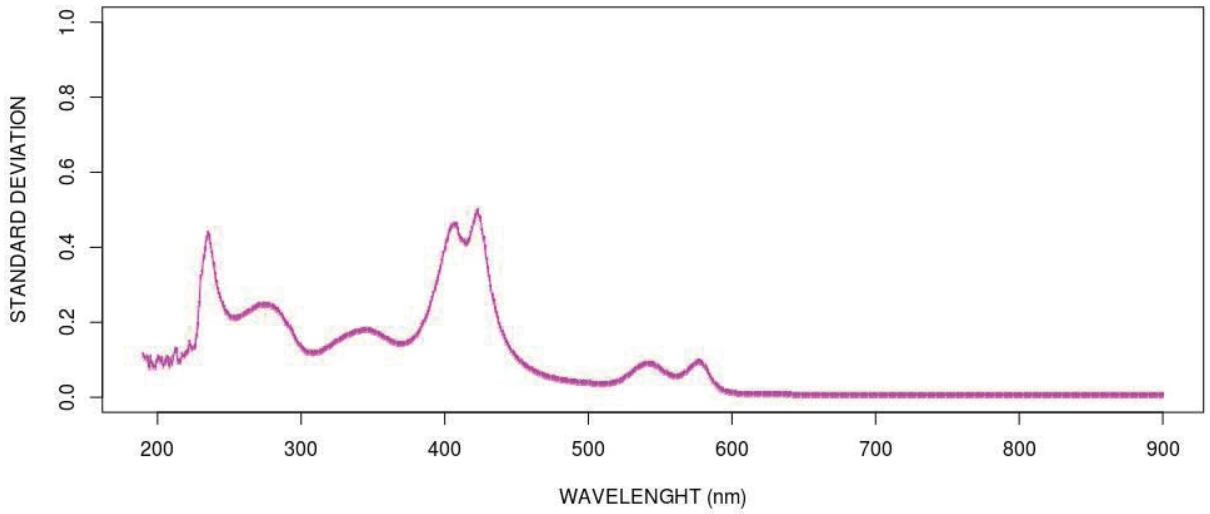

FIGURE 1. This figure shows the standard deviation value at the 190 nm - 900 nm wavelength variation of the entire sample.

The highest correlation value is in the wavelength range of 190-200 nm. However, the Developer would not be able to use the correlation value in the 190-250 nm wavelength range because there is noise. The highest correlation value used is in the wavelength range of 490-527 nm, precisely at a wavelength of 511 nm with a value of 0.37822 (2).

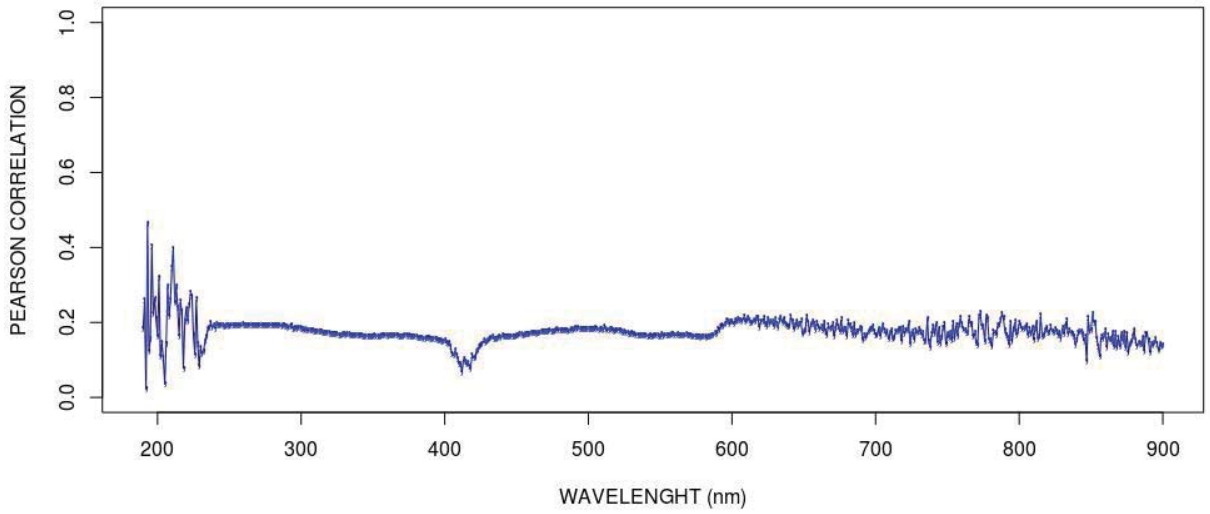

FIGURE 2. This figure shows the Pearson correlation values over the wavelength range of 190-900 nm of the entire sample.

The low standard deviation value and high Pearson correlation value are in the range 477-527 nm. The vertical line that intersects the curve in the wavelength range is the vertical LED line (r) with a wavelength of 490 nm, (s) with a wavelength of 505 nm, and (t) with a wavelength of 525 nm. The peak of the 3rd graph with a wavelength of 430 nm has a functional group C = O. This means that the appropriate LED wavelength candidates can be determined. The candidates are LED (m) with a wavelength of 405 nm and LED (n) with a wavelength of 420 nm. Based on this, Developer can use LEDs with wavelengths of 405 nm, 420 nm, 490 nm, 505 nm, and 525 nm for the manufacture of non-invasive glucose measuring devices (3).

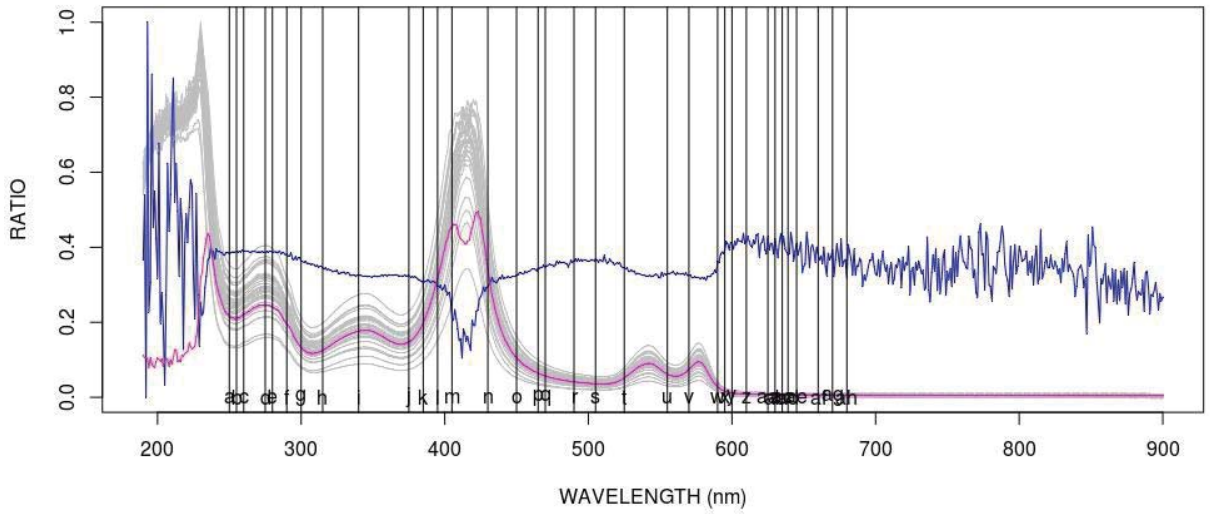

FIGURE 3. This figure shows the absorbance ratio, pearson correlation, standard deviation to the vertical line representing the wavelength of the LED (a) 250 nm, (b) 255 nm, (c) 260 nm, (d) 275 nm, (e) 280 nm, (f) 290 nm, (g) 300 nm, (h) 315 nm, (i) 340 nm, (j) 375 nm, (k) 385 nm, (l) 395 nm, (m) 405 nm, (n) 430 nm, (o) 450 nm, (p) 465 nm, (q) 470 nm), (r) 490 nm, (s) 505 nm, (t) 525 nm, (u) 555 nm, (v) 570 nm, (w) 590 nm, (x) 595 nm, (y) 600 nm, (z) 610 nm, (aa) 625 nm, (ab) 630 nm, (ac) 635 nm, (ad) 639 nm, (ae) 645 nm), (af) 660 nm, (ag) 670 nm, and (ah) 680 nm.

The study confirms our previous observation [4]. This result specifically confirms the result of Zalesskaya [24], Abdallah [25], Hu [26], McEwen [27], Rajan [28], Meshram [29], Wang [30], Clarke [31], and Momose [32].

We take the fact that the study was only taking account of healthy Subjects as a limitation. Further verification should include those with blood glucose level disorders. Some examples include hypoglycaemia or hyperglycaemia as well. We also plan to confirm this result using in vivo human observation.

CONCLUSION

The 490 nm, 505 nm, and 525 nm wavelength may appropriate for non-invasive blood glucose level measurement optical device. Further research should confirm this trial with human observation.

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