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Systematic Review of Online Photoplethysmography (PPG) Tool Kits

Mohammad Monjurul Haque Fahim[1]

[1]Department of Information Engineering Università Politecnica Delle Marche, Ancona, Italy

[1]ORCID: https://orcid.org/0009-0004-8602-670X

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Abstract: Photoplethysmography (PPG) is a non-invasive optical sensing technique commonly utilized for cardiovascular monitoring and biomedical research. As the need for customisable and easy-to-use signal-processing tools grows, many PPG tool kits have appeared online. This systematic review examines online PPG software tool kits released from 2015 to 2025. A PRISMA compliant methodology was utilized to search, screen, and identify pertinent toolkits from scientific databases and open-source repositories. Six tool kits were included and carefully looked at in terms of their features, ease of use, documentation, and limitations. Open-source tool kits like HeartPy, BioSPPy, and NeuroKit2 are great for academic research. On the other hand, commercial platforms like Lab Chart have advanced clinical-level features. This review offers a comprehensive guide for choosing the best PPG analysis tool kits for research, teaching, or clinical use.

Keywords: *Biomedical Signal Processing, Open-Source Libraries, Software Tool Kits, PRISMA, Physiological Signals, and Photoplethysmography (PPG).*

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I. INTRODUCTION

Photoplethysmography (PPG) is a non-invasive optical technique used to measure variations in blood volume within the microvascular bed of biological tissue. Owing to its simplicity, low cost, and compatibility with wearable sensors, PPG has become a widely adopted method for heart rate (HR) monitoring, heart rate variability (HRV) analysis, pulse oximetry, and vascular assessment in both research and practical applications [1], [3].

With the rapid growth of open-source platforms and online repositories, a variety of software tool kits dedicated to PPG signal processing have emerged. These tool kits provide functionalities such as signal filtering, artefact correction, feature extraction, and data visualization, thereby enabling researchers and students to analyze PPG signals efficiently without developing algorithms from scratch [1]–[5]. However, the available PPG tool kits differ substantially where the finding term is functionality, documentation quality, ease of use, and intended application domain, which makes the selection of an appropriate solution non-trivial.

To fill this gap, the current study uses the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method to do a systematic review of online PPG software tool kits.[7].

II. METHODS

This systematic review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to guarantee a transparent and reproducible methodology.

➢ *Search Strategy*

The following platforms were used to search:

- Google Scholar
- ResearchGate
- PubMed
- IEEE Xplore

The search query used (“Photoplethysmography” or “PPG”) AND (“Toolkit” OR “Software” OR “Analysis tool” OR “Open Source”), and was applied across Google Scholar, PubMed, IEEE Xplore, and ResearchGate. “The search included studies published in English between 2015 and 2025.”

➢ *Inclusion and Exclusion Criteria*

- Online software tool kits (open-source, free, or commercial).
- Made for processing or analyzing PPG.
- Enough documentation or activity in the repository.

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- Solutions that only use hardware.
- The projects that are no longer active, are no longer supported, or have no documentation.

✓ *Study Selection:*

The study looked through the records by title, abstract, and full text/repository content. There were no duplicate entries. Inclusion criteria were used to decide who was eligible. A PRISMA flow diagram shows a summary of the selection process.

III. RESULTS

Figure 1 shows how the study selection process based on PRISMA works. After removing duplicates, 38 unique records were screened from the 52 records that were first identified. A full-text review was done on 18 reports, but 12 were left out for reasons that were already set. This systematic review ultimately incorporated and examined 6 studies.

➢ *PRISMA Flow Diagram*

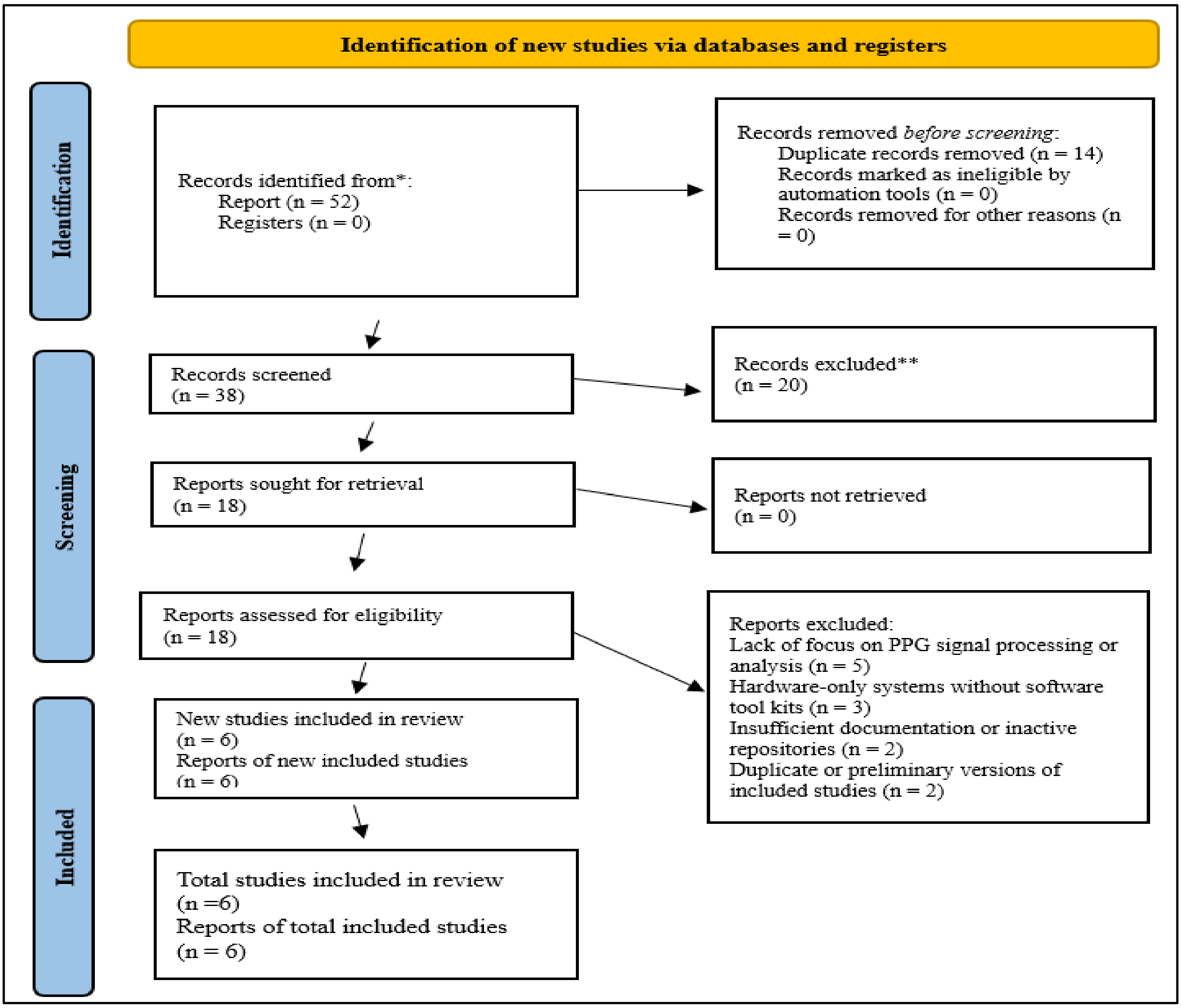

Fig 1 PRISMA Flow Diagram of Study Selection.

Table 1 Summary of Included PPG Tool Kits

Tool Kit	Type	Key Features	Strength	Limits
HeartPy	Open source (Python)	HR/HRV analysis, artifact detection	User-friendly, strong	Focused mainly on HR/HRV
BioSPPy	Open source (Python)	PPG/ECG/ EMG processing	Multi-modal, modular	Requires Programming expertise
NeuroKit2	Open source (Python)	Comprehensive bio signal framework	Large community, extensive features	Advanced functions complex

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Pulse Sensor Play ground	Hardware–software	Real-time PPG acquisition	Educational, prototyping-friendly	Hardware dependent
WFDB Toolbox (PhysioNet)	MATLAB/ Python	Dataset access, signal processing	Validate Algorithms, rich datasets	Steeper learning curve
Lab Chart	Commercial	Advanced PPG analytics, reporting	Clinical-grade support	Costly, proprietary

➢ *Overview of Comparative Feature Analysis of the Selected PPG Tool Kits.*

Table 2 Feature Comparison of PPG Tool Kits

Toolkit	HR/HRV	Filtering	Feature Extension	Real-Time	Docs	Ease	Clinical Use
HeartPy	✓	✓	✓	✕	✓	✓	✕
BioSPPy	✓	✓	✓	✕	✓	▯	✕
NeuroKit2	✓	✓	✓	✕	✓	✓	✕
Pulse Sensor	✓	▯	▯	✓	▯	✓	✕
WFDB Toolbox	✓	✓	✓	✕	✓	✓	✓
Lab Chart	✓	✓	✓	✓	✓	✓	✓
Legend: ✓ = strong, ▯ = moderate, ✕ = limited							

IV. DISCUSSION

The findings of this systematic review highlight clear differences Between open-source and commercial photoplethysmography (PPG) software tool kits in terms of functionality, usability, and intended application domains.

HeartPy, BioSPPy, NeuroKit2, and Pulse Sensor Playground are all open-source tool kits that have a lot of benefits when it comes to being easy to use, customizable, and clear. These platforms let users look at and change signal-processing algorithms, which makes them especially useful for research in schools and colleges, as well as for early-stage prototyping. Community-driven documentation and open repositories make it easier to reproduce results and be flexible with methods, both of which are important parts of modern biomedical research.

However, the reviewed open-source solutions also present certain limitations. Most of them primarily focus on offline signal analysis and lack robust real-time processing capabilities. These technologies also demand programming skills, which may deter physicians and non-technical users. Advanced analytical features like motion-intensive artifact reduction or clinical-grade validation are sometimes restricted or lacking.

In contrast, commercial platforms such as Lab Chart are designed to meet the requirements, professional and clinical environments & these systems usually offer real-time acquisition, validated analysis pipelines, and compliance with rules set by the government. These qualities make them useful for clinical diagnostics, controlled experiments, and long-term patient monitoring. Having professional technical support also makes things easier for the people who use the product. Hence it is fact that commercial tool kits are proprietary and come with licensing fees can make them hard to get to, especially for students, teachers, and researchers who don't have a lot of resources. This is in addition to the fact that the algorithms aren't very clear. & may limit methodological experimentation and customization.

The situation in which you will use the PPG tool kit should assist to find out for choosing the right one. Open-source platforms are better for research, education, and exploration because they are flexible and open. However, commercial systems are better for clinical and professional uses that need reliability, compliance with rules, and full technical support.

V. LIMITATIONS AND FUTURE RESEARCH

This study only looks at online and publicly available PPG tool kits. The comparison is mostly based on reported capabilities and documented features, which is the result of indirect experiments.

Moreover, disparities in community engagement and updating frequency might influence the long-term reliability of certain tools. Subsequent research may focus on clinical robustness and real-time processing capabilities in realistic operational contexts, alongside standardized performance benchmarks employing shared datasets.

VI. CONCLUSION

This systematic review, in accordance with PRISMA guidelines, assessed six frequently employed online software toolkits for photoplethysmography (PPG) signal analysis. The study looked at both open-source and commercial solutions to meet different analytical needs and levels of user skill. The findings indicate that open-source platforms are adaptable, accessible, and user-friendly. They are great for doing research, teaching, and making early prototypes. They are better for exploration and methodological research because they have active communities and regular updates. Commercial systems' analytical tools, coordinated procedures, and technical support are useful in professional and clinical settings where reliability, standardization, and

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compliance are important. It must have a license to use these advanced, clinical-grade tools in high-fidelity healthcare settings.

This review provides a systematic comparison of presently available PPG toolkits and underscores the principal criteria that should inform tool selection, including application objectives, user proficiency, documentation quality, and computational demands. The study's goal is to help researchers, developers, and clinicians make smart choices about which PPG analysis software to use for their specific needs by putting all this information together.

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