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Comparative analysis of applications supporting the self-control process of anticoagulation therapy

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Abstract

The effectiveness of self-monitoring in anticoagulation therapy often depends on the quality of mobile applications used by patients. This paper presents a comparison of four such apps to determine how their design impacts practical usability. The analysis combined an eye-tracking study with 15 users to evaluate interface intuitiveness, technical performance tests (CPU/RAM usage), and an analysis of notification systems. The results reveal major differences in usability, where clear interfaces led to better user performance. The study concludes that an application's design is a critical factor that can directly support or worsen the effectiveness of patient therapy.

Keywords: medical applications; self-control process of therapy; anticoagulation therapy; user intuitiveness

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1. Introduction

Modern medicine increasingly relies on advanced technologies to improve treatment effectiveness and patient engagement. One of the key areas where technology plays a crucial role is the self-management of anticoagulant therapy. This type of treatment requires regular monitoring of blood coagulation parameters, strict adherence to medical recommendations, and systematic medication intake. Improper management may lead to serious consequences, such as an increased risk of thromboembolic or hemorrhagic events.

The dynamic growth of the mobile application market and health self-monitoring systems has provided patients with access to numerous tools that facilitate the process of self-management. These applications offer a wide range of functions, including medication reminders, result tracking, and health parameter analysis. However, despite the large number of available solutions, existing applications differ significantly in terms of user intuitiveness, interface ergonomics, and the scope of provided features. Some of them are linked to specific medical devices, which limits their accessibility for a broader group of patients, while others require paid subscriptions to unlock full functionality.

With the growing number of patients requiring long-term anticoagulant therapy and the diversity of available applications, it has become increasingly important to investigate their functionality and impact on the effectiveness of treatment self-management. This article presents a comparative analysis of mobile applications supporting anticoagulant therapy self-management, with particular emphasis on their functionality, user-friendliness, and influence on adherence to therapeutic recommendations.

The conducted analysis aims to provide a deeper understanding of current trends and to identify directions for the optimization of medical applications, which may ultimately contribute to improving the quality of anticoagulant therapy self-management and increasing patient safety.

2. Literature review

Scientific literature extensively discusses the use of applications and technologies that support patient self-management across various therapies, including anticoagulant treatment.

Årsand et al. [1] analyzed mobile health applications for diabetes patients, emphasizing the importance of personalized features and intuitive navigation. They also highlighted the role of involving users in the design process, which may also be relevant for anticoagulation applications.

Baig et al. [2] demonstrated the potential of sensors and IoT technologies to improve the quality of life for older adults, while also pointing out challenges in usability and integration.

Bevan et al. [3] discussed the evolution of usability standards in interactive systems. They emphasized the importance of intuitiveness, efficiency, and user satisfaction – factors that are crucial for applications supporting chronically ill patients.

Carter et al. [4] compared the use of mobile apps, websites, and paper diaries in weight loss. They showed that mobile applications engaged users more effectively, leading to better weight reduction outcomes.

Edwards et al. [5] explored the use of gamification in health applications, highlighting the role of challenges, rewards, and leaderboards in motivating users to adopt healthy behaviors.

Giordan, Ronto, and Chau [6] conducted a qualitative study on applications supporting heart failure management. They pointed out the importance of simple interfaces and medical staff support, which is also applicable in anticoagulant therapy applications.

The report „mHealth Apps Market Size, Share & Trends Analysis Report" presents growth forecasts for the health applications market for 2024–2030, underlining their availability across different platforms and their wide range of functionalities [7].

Hirschey et al. [8] stressed the importance of clear interfaces and ease of use in applications designed for patients with atrial fibrillation. Improved navigation encourages regular use of such applications.

Kassavou, Wang, and Mirzaei [9] analyzed the impact of mobile applications on blood pressure control, noting the importance of patient motivation and reminders for measurements. Similar mechanisms may also support anticoagulant therapy.

Kebede and Pischke [10] demonstrated that regular app use improves self-management in diabetic patients. They also emphasized the significance of social features in such applications.

Yuan et al. [11] developed an AI-assisted mobile app for anticoagulation after valve replacement; users rated usability highly, but the study highlights needs for better dose accuracy, privacy safeguards and family support.

Jang [12] systematically reviewed mobile education programs for warfarin and found that apps generally improve knowledge, adherence and satisfaction, yet interventions require larger, more rigorous trials.

Praus et al. [13] performed a scoping review of smartphone apps for antithrombotic therapy, showing available tools for warfarin self-management, adherence and clinician support, but noting gaps in coverage, evidence and regulatory clarity.

In summary, the scientific literature identifies several key factors, including interface intuitiveness, personalization of features, integration of IoT technologies, and availability across different platforms. In addition, educational functions play a vital role in the effectiveness of applications supporting self-management, as they help patients better understand disease mechanisms and adhere to therapeutic recommendations. These factors are essential for the success of self-management applications in anticoagulant therapy and provide a basis for further research and optimization of these tools.

3. Materials and methods

3.1. Research aim and research object

The aim of this work is a comparative analysis of the functionalities of mobile applications supporting self-management of anticoagulant therapy, as well as an assessment of how interface intuitiveness affects the effectiveness of therapy self-monitoring by patients. The research seeks to identify interface elements and application mechanisms that improve treatment monitoring efficiency and to formulate practical recommendations for the design of health applications.

The analysis covers four Android-based mobile applications: the CardioGo app (developed previously in the author's engineering thesis; version 1.0.0, proprietary, not published on Google Play), Kardiometr [14] (version 1.6.6), MyTherapy [15] (version 3.241.0) and OMRON Connect [16] (version 8.0.0). Four key areas were examined: application functionality, quality and layout of the user interface and its intuitiveness, effectiveness of reminder mechanisms in supporting self-management, and application performance measured by resource consumption (CPU, RAM).

The research problem was formulated as follows: "Can differences in the intuitiveness of using applications for anticoagulant therapy self-management affect the effectiveness of patient self-monitoring?".

3.2. Sample

The research sample consisted of four mobile applications supporting self-management of anticoagulant therapy: the proprietary CardioGo app, Kardiometr, MyTherapy: Medication Reminders, and OMRON Connect.

The applications were selected based on predefined criteria:

1. Availability on the Android platform,
2. Specialization in anticoagulant therapy,
3. More than 10000 downloads (excluding the proprietary app),
4. Average rating above 4.5 in Google Play (excluding the proprietary app, verification date: 11.12.2024).

3.3. Tools and research setup

To ensure repeatability and to minimise external influences, the experimental setup and device configuration were standardised across all methods. The following tools and hardware were used: Gazepoint GP3 HD (eyetracker), iMotions 9.1 (calibration, data collection and visualization), Perfetto (system trace analysis), Android Debug Bridge (dumpsys meminfo reports), test device Xiaomi Redmi Note 10 Pro (8-core CPU, 6 GB RAM, Android 13), and Python (Pandas, Matplotlib) for data processing and visualization. The test device remained connected to a power supply, automatic updates were disabled, and the system was restored to a clean state before each series of performance measurements. Ambient lighting was kept neutral and stable, participants sat on a stable chair with comfortable posture, the distance to the eyetracker was set to 65 cm (standard calibration distance). The research stand and software environment were prepared to minimise interference and ensure repeatability.

Before any notification analysis, Android system-level notification settings were unified for all tested applications: full permissions to display (lock screen + banner) were granted, sound and vibration were enabled, hiding content on the lock screen was disabled, and notification dots were activated. This ensured that any observed differences in notification behaviour resulted from application logic rather than OS-level restrictions.

3.4. Research methods

Three complementary research methods were applied: eye-tracking analysis, performance analysis, and analysis of notification systems. Each provided insights into different aspects of application operation on the Android platform.

The results of these methods were combined for comparative purposes. The comparative analysis was not a separate method but rather a way of interpreting data, allowing identification of similarities and differences in intuitiveness, performance, and reminder effectiveness.

3.4.1. Eye-tracking

Eye-tracking tests were carried out using a Gazepoint GP3 HD eye tracker integrated with the iMotions 9.1 platform. The experiment was conducted in the laboratory of the Department of Computer Science at the Lublin University of Technology, which was prepared to minimise external disturbances (stable, neutral lighting and comfortable seating). Each session involved one participant and a moderator supervising the procedure, assisting with calibration and ensuring consistent testing conditions.

Standardized screenshots of the tested applications were presented to participants. This approach was chosen to guarantee identical visual stimuli for all respondents, to eliminate variability due to user accounts, dynamic content or device-dependent behaviour. Using screenshots ensured that AOIs and task targets remained constant across participants, which improves comparability of eye-tracking metrics.

Before each session the eye tracker was calibrated for the individual participant. The device configuration and iMotions settings were adjusted to provide tracking accuracy adequate for fixation and saccade analysis. During the experiment participants performed a sequence of tasks that modelled typical interactions in health apps (for example: find notification settings, open measurement history, add a new measurement). For each task a single screenshot with short written instruction was displayed. Participants searched for the requested information within the app view and then proceeded to the next task. The moderator recorded any task failures and ensured that technical conditions (distance to tracker, seating posture) remained stable.

Eye-tracking data were captured and processed in iMotions: heatmaps, fixation paths and AOI statistics were generated for each screenshot. The primary measured metrics used in the analysis were respondent ratio (percentage of participants who looked at an AOI), time to first fixation (TTFF), fixation count and average fixation duration. Exported data were later analysed with Python to produce aggregated statistics and visualisations used in the comparative analysis of the interfaces.

3.4.2. Performance analysis

The performance analysis aimed to compare applications in terms of system resource consumption in typical usage scenarios. Tests were performed on the single controlled Android device described above. Six scenarios reflecting typical user activities were prepared and executed manually and consistently for each app: launching and loading the main screen, entering and saving sample measurement data, navigating between sections, changing settings, exporting data, and running the app in the background.

Each scenario was repeated five times per application. Performance traces were collected using Perfetto and memory snapshots via Android Debug Bridge (ADB, dumpsys meminfo). Recording for each repetition was started at the moment the application began the scenario-specific processing activity (i.e. at the first observable increase in CPU usage related to the task) and stopped when the scenario completed (for instance when a save/export finished or when the app returned to an idle state). This rule ensured consistent measurement windows across apps and repetitions.

From raw traces per-repetition metrics were extracted such as mean CPU usage (%), peak CPU, mean memory (MB), peak memory, and the duration of the recorded activity. Perfetto traces and meminfo outputs were pre-processed with Python scripts to compute aggregated statistics (mean, median, standard deviation, min, max and quartiles) for each scenario and each application. Scenario-level comparisons were then used to identify differences in optimisation, responsiveness and resource demands across the tested apps.

3.4.3. Evaluation of notification systems

The notification system analysis was both qualitative and quantitative. Notification systems were assessed with respect to the number and frequency of reminders, degree of personalization, content, and presentation. This information enabled comparison of how well reminder mechanisms supported therapy self-management and which solutions offered advantages from the patient's perspective.

3.5. Methods of analysis

Data were processed and analyzed using both quantitative and qualitative methods. Eye-tracking exports from iMotions were parsed and aggregated in Python. Fixation detection and AOI metrics were taken from iMotions exports and then summarised (TTFF, average fixation duration, respondent ratio). Performance traces (Perfetto) and meminfo reports were pre-processed with Python scripts and aggregated per scenario (mean, median, std dev, min, max, quartiles). Notification features were compared across apps based on features presented. Results from the three methods were combined for comparative interpretation.

3.6. Interpretation of results

Interpretation was carried out in line with the study's objectives and research questions. The main areas of interpretation included:

- identifying the applications that best supported self-management (criteria: short time to locate key interface elements, high task success rate, stable and low resource consumption, and well-developed customizable reminders),
- highlighting interface elements that influenced intuitiveness (elements with high fixation counts and long completion times were considered potentially problematic),
- analyzing the impact of performance on user comfort,
- evaluating the effectiveness of notification systems.

Conclusions were drawn from comparisons of eye-tracking, performance, and reminder-related results. This made it possible to determine whether differences in application use could affect anticoagulant therapy self-management.

Limitations of the study that might affect interpretation of results were also taken into account.

4. Results

This chapter presents the results of the usability and intuitiveness studies of selected mobile applications related to anticoagulant therapy.

4.1. Eye-tracking results

4.1.1. Quantitative analysis

The quantitative analysis aimed to determine which interface elements users notice quickly and how fast they do so. The study relied on three eye-tracking metrics: the respondent ratio (the percentage of participants who looked at a given area of the interface), TTFF (Time To First Fixation), and average fixation duration. Five typical tasks were analyzed, e.g., locating the measurements chart, finding a medication, adding a measurement, and locating an entry with a specific date.

The results show that centrally placed and clearly highlighted elements are easy to notice. For the task involving the blood pressure chart, respondent ratios were high across all applications, confirming that large central components are intuitive. Figure 1 illustrates the comparison of respondent ratios between applications and tasks. When searching for the medication "Warfin," CardioGo achieved a high hit rate, while other applications performed worse, suggesting issues with the readability of medication lists or information overload.

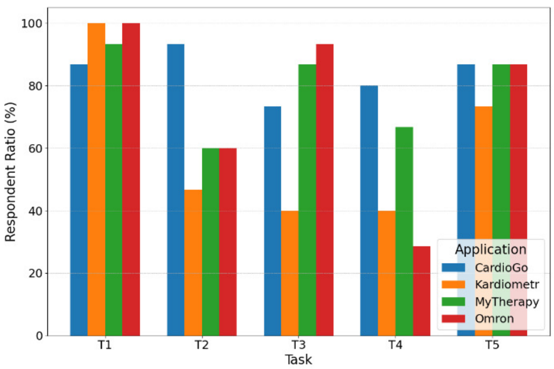

Figure 1: Percentage of respondents who completed the task.

The TTFF analysis confirms these observations and shows how quickly users orient themselves. The longest TTFFs occurred for the task of finding a specific date, with values reaching up to two seconds, aligning with low respondent ratios. Kardiometr revealed clear difficulties in locating functions: both the add-measurement and add-medication tasks were characterized by extended TTFFs. Figure 2 presents TTFF for all the applications and tasks.

This pattern suggests that users require additional visual cues to recognize interactive elements. Minor layout improvements, such as consistent button positioning and clearer iconography, could noticeably shorten search times and improve orientation efficiency.

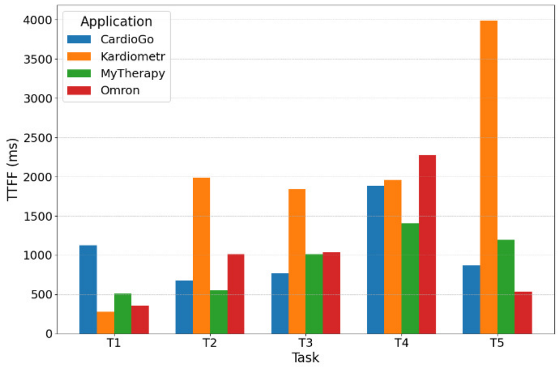

Figure 2: Time To First Fixation by application and task.

A practical conclusion is the need to better highlight key buttons and use unambiguous labeling. Clear element placement and readable names reduce TTFF and increase hit rates, which improves the convenience and effectiveness of applications supporting therapy self-management.

4.1.2. Qualitative analysis – heatmaps

The two heatmaps shown below were chosen as the most interesting examples from the full dataset. They illustrate contrasting interaction patterns: Figure 3 (OMRON Connect) shows a clear visual focus on a central call-to-action, while Figure 4 (Kardiometr) shows scattered gaze and confusion. Heatmaps for CardioGo and MyTherapy were also checked and support the same conclusions. The full set of heatmaps and the raw eye-tracking data are available from the authors on request.

The OMRON Connect start screen (Figure 3) is characterized by a clear concentration of gaze in the central area where the main "Add medication" button is located. Although a second, alternative option was available in the top-right corner, most users focused their attention on the central button, which suggests that a noticeably displayed element attracts attention far more effectively than options placed in standard navigation locations.

The heatmap shown in Figure 4 illustrates the Kardiometr screen and reveals problems with quickly locating the button for adding a medication. The gaze distribution pattern shows users' attention scattered across various interface elements and a relatively long time required to find the correct function. Intense focus was observed on areas related to physical activity ("Activity") and measurements ("BMI measurement"), which may indicate that users misinterpreted the available categories.

Figure 3: Heatmap for the OMRON Connect application.

Figure 4: Heatmap for the Kardiometr application.

An important factor contributing to the prolonged search time was poor-quality Polish localization: the button related to medications was imprecisely labeled, which misled users and hindered intuitive navigation. These results highlight the importance of high-quality localization in medical applications, where clear communication is critical for effective self-management of therapy.

4.2. Analysis of notification systems

To ensure comparability of notification modules across all tested applications, Android system settings were first unified (Figure 5). In each application's notification section full permissions to display (lock screen and banner) were granted, sound and vibration were enabled, and content hiding on the lock screen was disabled. Notification dots were enabled so the user immediately sees unread messages. This way, any differences arise solely from the applications' notification systems and not from operating system limitations.

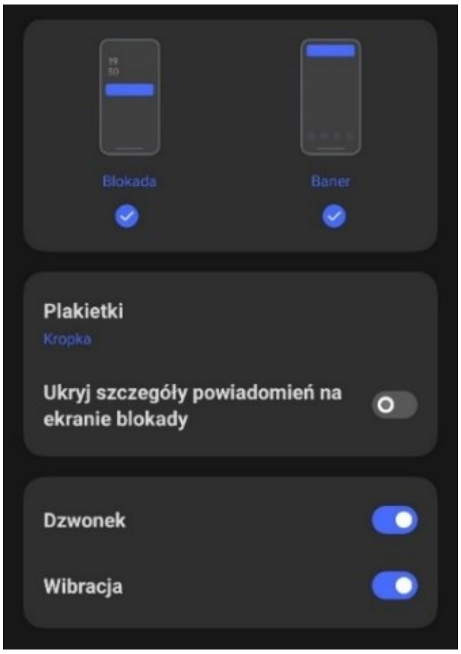

Figure 5: Unified Android notification settings.

The screenshots presented below (Figures 6–9) use Kardiometr as an illustrative example of how reminders were configured and how system notifications were evaluated. Kardiometr was chosen for the screenshots because its settings clearly expose the reminder types and the list management UI. Analogous screens for the other apps are available from the authors upon request. The short summary table below (Table 1) synthesizes the reminder capabilities observed in all four applications.

Table 1: Short summary of notification capabilities observed in the tested applications

App	Key strengths	Main limitation
CardioGo	Scheduling, editable medication schedules.	Reminders failed to be delivered.
Kardiometr	Categorized reminders, personalized push header, report scheduling (weekly / monthly).	Relies on Android global channel, no internal channel config.
MyTherapy	Very flexible: recurring, snooze/intervals, pop-ups, privacy modes, adherence tracking.	None, most feature-rich.
OMRON Connect	Simple and clear measurement reminders, integrates with Google Fit / Samsung Health.	Basic notifications (text only), limited advanced features.

In Kardiometr all reminder settings are managed globally in the Android system – the application does not provide its own channel configuration screen. In the "Reminders" tab (Figure 6) the user can add any reminder type: medication intake (e.g., Warfin), a measurement (blood pressure or BMI) or a scheduled physical activity (yoga, aerobics, etc.). For each entry the exact time and days of the week when the reminder should appear are defined. The list of active reminders allows previewing, editing or deleting each entry, and grouping by category ("Medication", "Measurements", "Activity", "BMI") facilitates finding a specific function under intensive use.

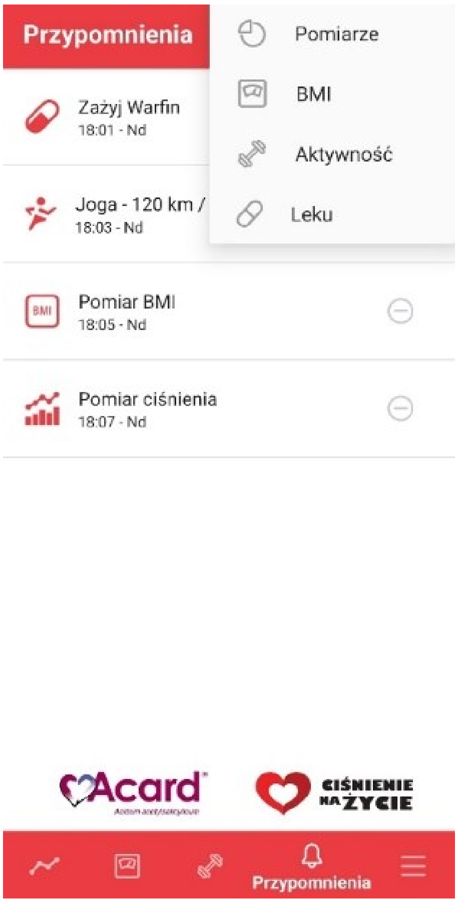

Figure 6: "Reminders" tab in the Kardiometr application.

Notifications appear in the Android system notification center both as banners (when the screen is active) and as messages on the lock screen. Each contains a personalized header with the patient's name and a clear prompt (Figure 7).

This form of message, combining personalization with an explicit instruction, promotes higher engagement and better adherence to therapeutic recommendations. The message content is always short, organized by reminder category and easy to understand at a glance.

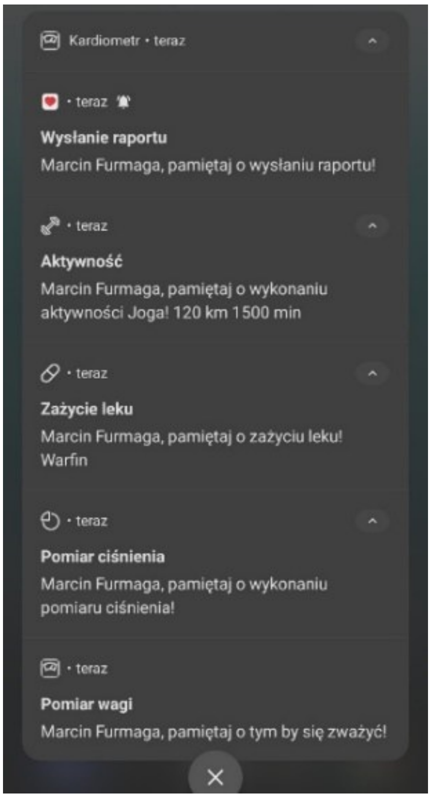

Figure 7: Push notifications from the Kardiometr application.

4.3. Performance study

The performance study included six prepared test scenarios covering typical user actions. In this article we present detailed results for the single scenario "Export data" because exporting forces a short but intensive burst of CPU and memory activity (data processing, graphic generation and compression). This makes the scenario particularly sensitive to implementation and optimisation differences between applications, so it serves as a representative stress test for comparative performance. Results from the other scenarios were recorded but are not reported here in full due to space constraints; summary observations are mentioned below and the raw traces are available from the authors on request.

Test procedure:

- Start the performance measurement.
- Select the "Export" option.
- Wait for the process to finish (appearance of file/notification).
- End measurement after the file is actually generated.

CPU and RAM usage were recorded in five repetitions for each case. Below is a summary of the statistics.

As shown in Table 2 and Figure 8, the highest CPU load was observed for CardioGo (mean 9.99%), MyTherapy (7.30%) and OMRON Connect (5.07%). Kardiometr, which generates reports in HTML, remained the lightest (1.85%).

Table 2: CPU usage during the "Export" scenario

Application	Mean (%)	Std. Dev. (%)	Min (%)	Max (%)
CardioGo	9.99	0.71	9.14	10.64
Kardiometr	1.85	0.25	1.52	2.05
MyTherapy	7.30	0.39	6.67	7.69
OMRON Connect	5.07	0.56	4.10	5.51

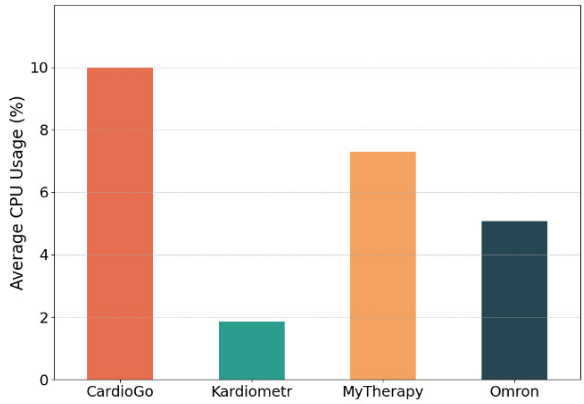

Figure 8: CPU resource usage during data export.

Analyzing RAM usage, OMRON Connect uses memory most intensively (249.7 MB), MyTherapy (198.9 MB) and CardioGo (166 MB) also show high values. Kardiometr again is the most economical (98.9 MB). Statistics and a visual representation of the results are presented in Table 3 and Figure 9.

Table 3: RAM usage during the "Export" scenario

Application	Mean (MB)	Std. Dev. (MB)	Min (MB)	Max (MB)
CardioGo	166.00	4.93	159.52	170.97
Kardiometr	98.87	22.31	73.62	125.22
MyTherapy	198.91	17.60	172.74	218.40
OMRON Connect	249.72	10.58	239.60	264.02

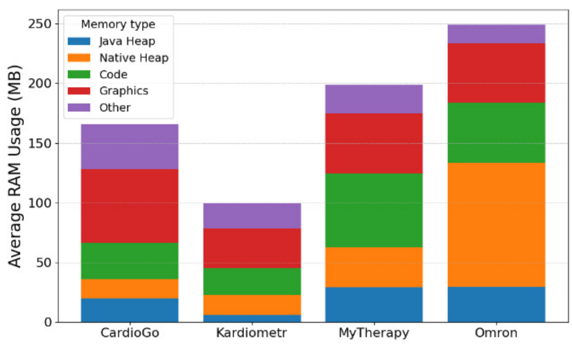

Figure 9: RAM resource usage during data export.

The performance measurements reveal differences in optimization among the tested applications. CardioGo and MyTherapy showed the highest average CPU usage during file export, while OMRON Connect recorded the highest memory consumption. High CPU and RAM usage can affect smooth operation on weaker devices and increase battery consumption, which in turn may reduce user comfort.

Note that Kardiometr produced the lightest results in this scenario in part because it generates reports in HTML rather than PDF. The other applications exported to PDF, which typically requires more processing for layout and compression and thus may increase CPU and memory use.

5. Discussion

The conducted studies provided consistent insights into how interface elements, technical performance, and notification systems influence the usability of applications supporting self-management of anticoagulant therapy. Eye-tracking data showed that applications with a logical and clear interface structure enable users to find key functions more quickly, with fewer fixations and shorter task completion times. In applications where labels were imprecise or important options were less noticeably displayed, users' gaze trajectories were dispersed and search times were extended, leading to greater cognitive load. These findings confirm that layout clarity and label readability are essential for effective interaction and, consequently, for the practical use of such applications by patients.

The performance analysis complemented the usability picture with a technical perspective. Differences in CPU and memory usage during resource-intensive operations indicate that some applications may run less smoothly on devices with lower specifications, reducing user comfort. At the same time, low resource consumption did not guarantee interface ergonomics – Kardiometr was technically efficient but less intuitive. This demonstrates that technical optimization is just as important as interface design.

An important part of the analysis concerned notification systems. Among the tested applications, MyTherapy stood out with the greatest flexibility and configurability of reminders, which supports regularity in therapy monitoring. OMRON Connect offered broad customization of notification attributes, Kardiometr provided only basic centralized control, while CardioGo in the tested version had a limited reminder mechanism. Since regular medication intake is crucial in anticoagulant therapy, differences in how reminders function have direct practical importance and affect the usability of the applications.

When interpreting the results, limitations of the study must be considered. The participant group, especially in the eye-tracking part, was small and consisted mainly of individuals with relatively high digital skills, limiting the generalizability of the findings to patients with more varied skill levels. Furthermore, performance measurements were carried out on a single device model under a specific system configuration; other hardware–software combinations may yield different results. Finally, subjective assessments by some participants may vary individually, also influencing the final conclusions.

6. Conclusions

Based on the collected data, several practical conclusions can be drawn. First, interface design quality has a direct impact on the effectiveness of therapy self-management: a clear layout, readable labels, and prominent functions shorten the time required to complete typical tasks and reduce user errors, thereby supporting self-care effectiveness. Second, the reminder system is a key element influencing the real usability of applications in anticoagulant therapy. Solutions allowing flexible notification configuration better support patient regularity. Third, application performance optimization is essential to ensure smooth operation across devices. High resource consumption may reduce comfort and lead to less frequent measurements or even abandonment of application use.

For developers, the recommendation is to focus on three areas: simplifying and structuring the interface, expanding and personalizing reminder mechanisms, and optimizing resource consumption. Usability tests should involve target patient groups to reflect their needs and limitations. Future studies should verify the long-term clinical impact of the observed differences and include larger and more diverse samples.

In summary, the results confirm the thesis that differences in intuitiveness and functionality of applications have real importance for the effectiveness of anticoagulant therapy self-management. Improving interface quality, enhancing reminder mechanisms, and optimizing performance may contribute to greater safety and effectiveness of treatment by better supporting patients in their daily therapy routines.

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