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Review Article

Research Progress on the Implementation of the FHIR Framework in Sports Medicine Applications

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Abstract

Understanding the current status of Fast Healthcare Interoperability Resources (FHIR) applications in the real world would be beneficial for sports medicine research and rehabilitation studies. It would further promote the development of the athlete ecosystem. This paper examines the applications and research progress of the FHIR framework in the field of sports medicine applications at home and abroad in recent years, compares and analyzes the similarities and differences between CardinalKit FHIR and different frameworks, discusses the opportunities and challenges faced by FHIR currently, and constructs interoperable sports medicine applications using FHIR and CardinalKit FHIR. CardinalKit FHIR is a helpful framework for any developer wishing to build innovative medical solutions using FHIR. Developers can break down data silos, improve athlete injury care, enhance performance monitoring, simplify management tasks, and pave the way for the future of Internet medicine.

Keywords: Artificial Intelligence in Sports, Sports Medicine, Application Programming Interface (API), Fast Healthcare Interoperability Resources (FHIR).

1. INTRODUCTION

Although there is a wealth of data in the athlete's physical data ecosystem, there is a lack of data that is findable, accessible, interoperable, and reusable. The difficulty in finding, using, analyzing, and sharing health and training data persists. Traditional sports medicine software traditionally lacks sharing and standardization. Patient records and data are locked in proprietary systems, making sharing impossible among stakeholders, such as athletes, coaches, physiotherapists, and doctors. The lack of sharing between healthcare and training research often hinders research using existing data sources. As more and more people seek ways to improve fitness, track exercise, and prevent injuries, sports medicine applications have become increasingly popular.

Fast Healthcare Interoperability Resources (FHIR) is changing this situation. FHIR is a standard for health information technology introduced by the Health Level Seven International (HL7) organization in 2011. FHIR builds upon previous HL7 standards (HL7 versions 2 and 3 as well as Clinical Document Architecture) and combines their strengths with existing modern web technologies such as Representational State Transfer (REST) architecture, Application Programming Interfaces (APIs), XML and JSON formats, and authorization tools (OAuth). In FHIR, all exchangeable content is defined by different fundamental building blocks called resources, which represent the content and structure of information and can reference each other using reference mechanisms.

Therefore, this paper reviews the concept of sports medicine management software, the functionalities and content of existing sports medicine self-management software, and the existing shortcomings. It aims to provide a reference for improving and applying self-management for athletes and the management system of sports training for coaches.

2. Overview of the FHIR Standard Framework for Sports Medicine

FHIR provides a highly suitable standard for managing and exchanging medical data in sports medicine. FHIR (Fast *et al*., Resources) and CardinalKit FHIR are two commonly used technologies in sports medicine applications that assist users in managing their health data and making informed decisions about their exercise habits. The basic framework of FHIR provides a set of resources for representing and exchanging clinical data, such as patient demographics, clinical observations, and medication instructions. FHIR's design features flexibility and scalability, making it well-suited for various healthcare applications, including sports medicine applications.

Standard implementations of FHIR include the following:

- HAPI FHIR: HL7 FHIR's Java API is widely used in many production healthcare systems.
- FHIR .NET API: Used for building FHIR servers and clients. NET.
- Simple FHIR Client: Aiding in building FHIR applications and integrations in Python.
- FHIR-kit-client: A FHIR client written in Kotlin for Android and Java platforms, easing the development of Android medical applications based on FHIR.
- Ruby FHIR: An open-source library facilitating FHIR usage in Ruby projects.
- FHIR Inspector: A Chrome browser extension for quickly exploring FHIR specifications and testing FHIR APIs.
- Postman FHIR Toolkit: Simplifying the building and testing of FHIR APIs in Postman's popular API testing tool.

CardinalKit FHIR is an open-source software development kit (SDK) providing a framework for building health applications based on FHIR. It includes pre-built components for creating applications that collect, manage, and analyze health data.

The FHIR standard offers data models directly mappable to sports medicine concepts, such as:

- Subject: Represents an athlete.
- Episode: Tracks assessments, treatments, and visits for athletes.
- Condition: Represents injuries, illnesses, and other health issues.
- Procedure: Represents surgeries, treatments, and other procedures applicable to athletes.
- Observation: Captures measurements, scores, and other vital signs related to athlete health and performance.
- Questionnaire: Digitizes sports medicine assessments and forms.

2.1 Sharing Athlete Data Using FHIR

FHIR readily shares athlete health records among various systems and stakeholders through standard REST APIs. For example, it includes sharing injury records and status between coaches and doctors, exchanging post-operative physical therapy notes between surgeons and physical therapists, allowing athletes to access their health data via mobile applications, and aggregating athlete health data from different sources for population health analytics.

2.2 Building Sports Medicine Applications Using CardinalKit FHIR

CardinalKit FHIR reflects the complexity of using FHIR in Swift. It allows developers to represent FHIR resources (such as patients, conditions, and observations) as native Swift objects, validate resources to ensure they comply with the FHIR specification, make API calls to FHIR servers to create, read, update, and delete resources, and cache resources locally for improved performance. It is a pure Swift framework for handling FHIR. It is targeted towards iOS, macOS, tvOS, and watchOS. CardinalKit FHIR can be obtained via Swift Package Manager, CocoaPods, and Carthage. The framework comprises multiple modules showcasing application instances of CardinalKit FHIR, including primary FHIR client, management of patient and observation resources, local caching of resources, and authorization using SMART on FHIR.

3. FHIR Management and Applications

3.1 Characteristics of CardinalKit FHIR in Sports Medicine Applications

Storing Athlete Health Records: FHIR resources such as patients, conditions, procedures, and observations can be used to keep athletes' electronic health records. These records may include information about injuries, treatments, vital signs, etc.

Data Sharing Between Systems: If clients have multiple systems for managing athlete health data, such as tracking athlete injuries or physical therapy, data can be shared using FHIR APIs. FHIR provides a standardized data model for medical data, ensuring that systems use the same health data structure and definitions as other healthcare institutions. Client applications can be developed for athletes, coaches, physiotherapists, etc., using the FHIR API in the system to view and input health data.

An example of a sports medicine application using FHIR and CardinalKit FHIR is MyFitnessPal, which allows users to track their workouts, monitor their calorie intake, and set fitness goals. The application also integrates with other health and fitness applications, such as Fitbit and Apple Health, to provide users with a comprehensive view of their health data.

Another application is Strava, a popular application among runners and cyclists. Strava uses FHIR to allow users to import and export their workout data, such as distance, speed, and heart rate, to and from other fitness applications. This enables users to track their progress and share their achievements with friends and other users.

Recent advancements include the experimental iOS application HealthGPT, which analyzes user health data stored in "Apple Health" using natural language processing. HealthGPT is built on the in-house CardinalKit framework (for rapid development of health-related apps). The application also leverages the OpenAI API, meaning OpenAI provides conclusions drawn from health data. The application features user-friendly interaction using natural language, integration with the native Apple Health app, customizability, and out-of-the-box usability.

3.2 Characteristics of Projects Facilitating the Development of Sports Medicine Using FHIR

Data Sharing: Traditionally, medical data has been locked in proprietary formats and exists separately in servers, making it unshareable. FHIR provides a common standard for data that can be shared across systems, platforms, and vendors. This breaks down data silos and limitations, enabling access to a patient's entire medical data when needed.

Patient Access: FHIR enables patients or athletes to easily access their health records and share them with any medical service providers, fitness trainers, physiotherapists, etc., of their choice. This free flow of access and information empowers patients to control their care.

Coordinated Care: When medical service providers can access a patient's complete medical history and records from other clinicians, they can offer higher-quality coordinated care. There will be no cases of lost information or duplicated tests and services.

Analysis and Population Health: FHIR aggregation tools can extract patient or athlete data from various systems to enable powerful analytics, reporting, and population health management tools. Trends can be identified, and preventive interventions can target high-risk populations.

Cost and Error Reduction: Lack of data interoperability can lead to repeated tests, medical errors, and unnecessary procedures, increasing operational costs. FHIR helps mitigate these drawbacks by making data accessible when athletes need care.

Therefore, FHIR enables true interoperability of medical and sports training data, reducing costs, improving athlete health, enhancing access for athletes or coaches, and establishing a new sports medicine application ecosystem. These applications also allow users to easily share their data with medical service providers, improving the accuracy and efficiency of diagnosis and treatment. This system also provides users with a more comprehensive view of their health data, enabling them to make wiser decisions regarding their exercise programs.

4. RESEARCH CONCLUSIONS AND RECOMMENDATIONS

4.1 FHIR provides a standardized API ecosystem, allowing third-party applications and services to build data around athletes or patients. This application ecosystem can provide value-added services for patients, equipment suppliers, and administrative management systems.

4.2 The use of FHIR as a standard for health research still needs to be widespread. To more effectively utilize existing data sources for health research, the operability of data sharing becomes increasingly important. FHIR provides solutions for application scenarios in sports medicine by offering resources in public health, research, and evidence-based medicine while utilizing established network technologies. Therefore, FHIR can help standardize data from different sources and improve the operability of sharing in health research.

5. Existing Problems and Challenges

Compared to traditional HTML5 or native mobile applications, CardinalKit FHIR offers many unique advantages in speed, reliability, accuracy, and extensive device support. For example, it can create highly accurate 3D models, provide precise measurements and tracking capabilities, and overlay digital assets directly onto the real world, providing excellent opportunities for innovative approaches to physical training, coach assessment, ergonomics optimization, and even musculoskeletal model analysis to improve injury prediction or surgical planning schemes. Additionally, seamless integration between AR and VR experiences facilitated by close connections between ARKit/ArCore SDKs can enhance user engagement in post-operative therapy sessions or psychological recovery exercises. Therefore, the array of notable features of CardinalKit FHIR offers imaginative sports medicine professionals new perspectives who are willing to embrace cutting-edge possibilities.

It is important to note that while CardinalKit FHIR holds excellent potential for transformative improvements, some limitations still need to be considered. Firstly, ensuring approval in medical ethics is essential, as is handling sensitive biometric indicators across different modules or requiring multiple rounds of systematic review before implementation. Secondly, proper validation and reliability testing must be extensively evaluated across various athlete use cases to ensure maximum safety for all athletes using CardinalKit FHIR services, guarantee reliable results, and avoid erroneous recommendations that could lead to harmful consequences. Thirdly, considering the importance of accessible user interface elements in our diverse society is still crucial. Lastly, implementing scalable backend architecture to efficiently handle large volumes of sports performance processes, medical examinations, or psychological developments is necessary. The accuracy of data collected by these applications may be affected by various factors such as user error and limitations of devices online. For users, it is essential to carefully review the privacy policies of these applications to ensure that their data usage and storage are secure.

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