

Health Technology In The Management Of Rheumatoid Arthritis – A Systematic Review.

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Abstract

Background: Rheumatoid Arthritis (RA) is a chronic autoimmune disease that prevails in approximately one percent of the global population. RA manifests as joint inflammation, pain, swelling, and stiffness and its management burden disease significantly affects the quality of life, and economic costs. Due to its chronic and continuing nature coupled with the complexity of the disease, its diagnosis, treatment and rehabilitation requires the effort of a team of healthcare professionals.

Objective: This systematic review seeks to understand the Health Technology in the enhancement of RA care; including early diagnosis, care and rehabilitation. Wearable technologies, mHealth, telemedicine and artificial intelligence are assessed in terms of how far they can support care pathways.

Methods: A PubMed, Cochrane Library, Embase and Scopus was performed to source all research articles reported within the last 10 years. Key terms were ‘Rheumatoid Arthritis’, ‘health technology’, ‘diagnosis’ ‘management’ ‘rehabilitation’ ‘telemedicine’, ‘mHealth’, ‘wearable’, and ‘eHealth’. The eligibility criteria comprised of studies with RA that used health technology; Studies with the health technology were included but those that focused on other conditions apart from RA were Assessment of the bias risk and quality in the data were done utilizing the Cochrane Risk of Bias and the Newcastle Ottawa Scales respectively.

Results: Health technologies contribute to a higher accuracy when diagnosing RA and enhance practical patient

care through continuous monitoring and unique customise treatment approaches and exceptional rehabilitation options. Such are the current achievements found in the literature, although there are barriers that include data privacy, user compliance, and integration with healthcare systems.

Conclusion: There is good potential for health technology to significantly redefine the current setting in the RA preventive measures. Coh pioneered, this systematic review lays the background for future progresses for enhancing these technologies to address their current limitations. Due to the description of various elements of RA care, the review contributes to the creation of more effective and efficient care strategies for RA among healthcare professionals, researchers, and policymakers.

Key words : *Rheumatoid Arthritis, Health Technology, Telemedicine, Mobile Health Applications*

Introduction:

Rheumatoid Arthritis (RA) is an autoimmune condition that causes joint inflammation or thickening of joint capsules in the body, which in turn brings symptoms like pain, stiffness, warmth and swelling of the affected joints and finally loss of joint function. Involving about one percent of the world's population, RA is a disabling disease that reduces the life's quality and imposes a massive economic cost to individuals and states.[1] Due to the nature of RA, interventions in its diagnosis, management and rehabilitation are best made by a team with professionals from different fields to reduce the effect on joints.

Some issues still remain with regards to the usage of medications and the control of the disease and also the management of the physical, emotional and social effects of RA. Older approaches to diagnose, monitor, and manage RA include numerous face-to-face appointments, paper-based record keeping, and infrequent/reactionary modifications, which may further impair the timely, patient-centred care.[2,3] In this context, there is a pressing need to incorporate innovative approaches that will provide more accurate, faster, and patient-centred care paths.

Health technology has redefined the approach to treat chronic diseases, including RA in the past few years. Wearable devices, mobile health, telemedicine, and artificial intelligence are the four main categories of technologies that are changing the face of healthcare through possibilities of real-time monitoring, remote consultation, individualized management and planning, and prediction. [4,5] These technologies are expected to afford better diagnosis, management of disease, rehabilitation, and in general, a better quality of life for those diagnosed with the RA.

Due to the continuous development and increasing use of health technology a systematic review is necessary to consolidate the available body of knowledge on how effective HTM is in managing RA. The intended purpose of this review is to sum up the results of various researches, define the advantages and disadvantages of different health technologies, and recognize the lack of issues in the current state of research. In the light of this, this review aims at assist the HCPs, researchers and policy makers by offering a detailed insight on the discovery of health technology in enhancing RA diagnosis, management and rehabilitation in an efficient manner.

Methodology:

An extensive and proofed approach would be used to search through PubMed, Cochrane Library, EBSCO host and scopus. Original research reports, peer reviewed journals, as well as grey literature will be included in order to conduct a comprehensive review of the literature. On this blog, we will use the following tags: Rheumatoid Arthritis, Health Technology, Diagnosis, Management, Rehabilitation, Telemedicine, Mobile Health (mHealth),

Wearable devices, eHealth.

Inclusion Criteria:

1. Population: Research has to be carried out on patients with a confirmed Rheumatoid Arthritis diagnosis.
2. Interventions: Studies that will include use of any type of health technology like telemedicine, mHealth, wearables, and eHealth.
3. Comparators: RCTs of health technology interventions compared with traditional care are preferred but not required.
4. Outcomes: Outcomes pointed by articles include diagnosis accuracy, patient management (for example, following symptoms, medications compliance), rehabilitation efficacy.
5. Study Design: and Randomized controlled trials (RCTs), cohort studies, systematic reviews and meta analysis, feasibility studies and any case series irrespective of the publication language.
6. Time Frame: Peer review papers to warrant the most recent innovation within the last decade in health technology.

Exclusion Criteria:

1. Population: Research based on other diseases than RA or studies having combined data where separate RA data are not available.
2. Interventions: Clinical observational studies, patient satisfaction, qualitative studies or research manuscripts with no or limited relation to HT.
3. Outcomes: Papers that did not present results with respect to RA diagnosis, management, or rehabilitation.
4. Study Design: Newsletters, editorials, opinions, cases, and narratives, and non- systematic reviews.
5. Language: Even publications in other languages even without English equivalent
6. Data Extraction and Quality Assessment: Data Extraction and Quality Assessment:

Identified articles will be subjected to data abstraction on features of the study, population characteristics, the kind of health technologies applied, the comparators, the outcomes and the results. Quality assessment of the identified studies will be done using the Cochrane Risk of Bias tool for randomised controlled trials and the Newcastle-Ottawa Scale for cohort studies.

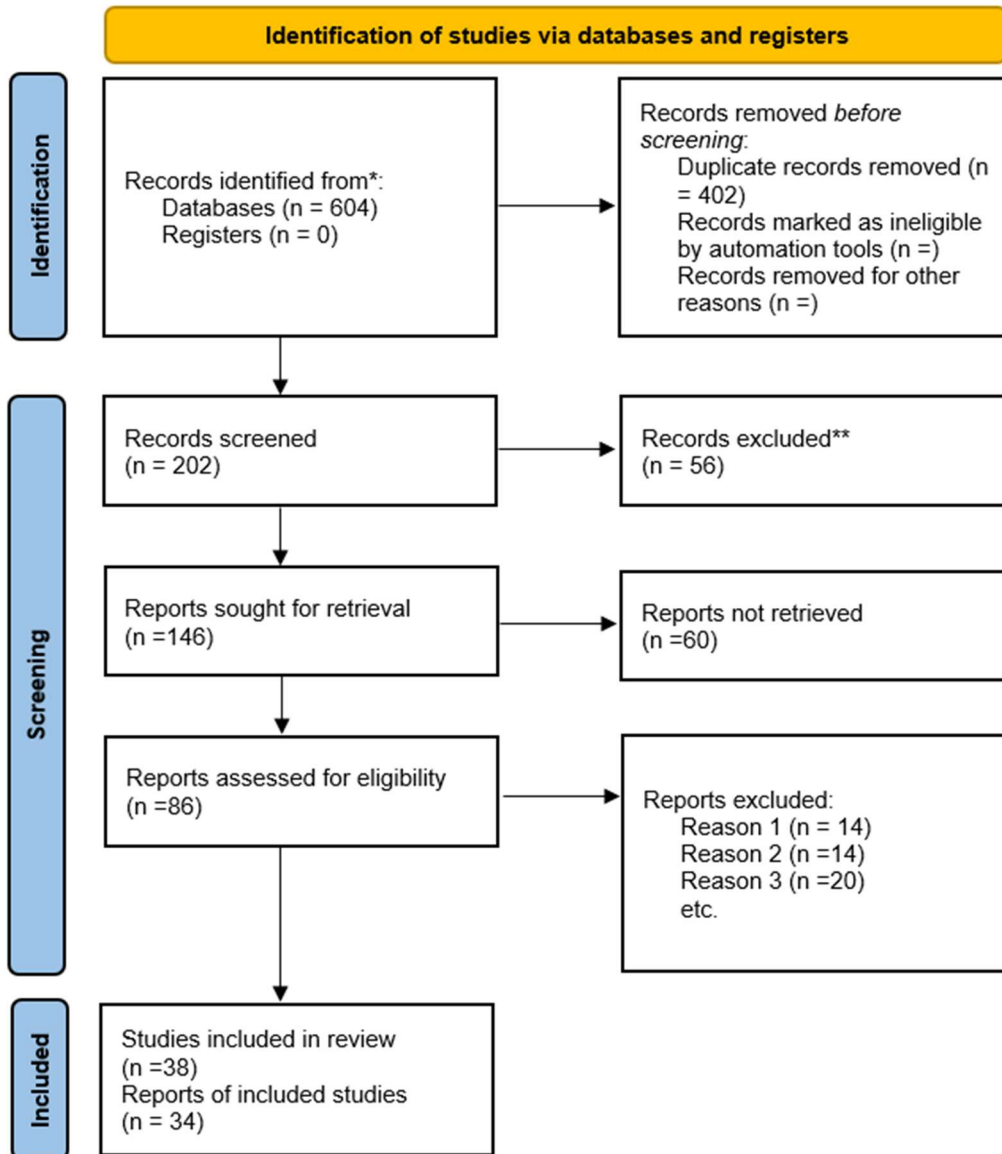
Data Synthesis:

Narrative synthesis and, where possible, meta-analysis will be conducted. The effects of health technology on diagnosis accuracy, patient management, and rehabilitation outcomes will be summarized and compared to traditional methods.

By employing this systematic methodology, the review aims to provide a robust analysis of the impact and effectiveness of health technology in managing Rheumatoid Arthritis.

The review was done according to Prisma guidelines. (Figure 1)

Figure 1 showing Prisma statement



Prospero registration:

The results can be analysed in three different angles, Diagnosis, Management and Rehabilitation.

Diagnosis:

Rheumatoid arthritis (RA) is an autoimmune disease where tissue that lines the joint is affected, resulting in inflammation, and the damage of the same joint. The aim of early and accurate diagnosis of RA is to start correct management to avoid the further deterioration of joint tissue which is characteristic for this disease. There is, therefore, the element of health technology that has proven vital in transforming diagnosis of rheumatoid arthritis as a friendly, real-time, non-invasive and more of analytical nature. In this expanded review, we will delve deeper into three main areas where health technology significantly impacts RA diagnosis: smart fashion

wearable devices, telemedicine, artificial intelligence (AI).

Wearable devices:

Smart apparel has been receiving a lot of focus in the healthcare industry given its capacity to measure several physiological signs in an invasive manner. In RA patients changes in daily activity levels, sleep patterns and heart rate variability suggesting inflammatory process are marginal [5]. Such changes are well sensed through wearable devices such as smartwatch and fitness tracker devices [6]. For example, with the help of wearables, it is possible to track levels of movements throughout a day, and, if these levels are lower than in the previous days, it is a sign of RA progression due to immobility or fatigue. In addition, the investigation of sleep pattern based on wearables has demonstrated the potential in the early identification of sleep disturbance related to RA inflammation [7]. Matching the values of the heart rate variability obtained with the help of these devices may also characterize the stuffer of the autonomic nervous system, a violation of which is observed in patients with RA [8,9].

Telemedicine:

Telemedicine platforms can be used in case of consultations and evaluation of the symptoms of RA and this minimizes face-to-face contact. However, with telemedicine, the healthcare professional can virtually, through an application offering face to face interaction diagnose patients symptoms [10]. This is especially good for patients who reside in the rural areas or those who have to sometime move around due to their ailment. In addition, telemedicine consultations facilitate follow-ups within the shortest time possible, meaning that changes in the disease management will be done at the right time thus enhancing the effectiveness of disease management. The use of telemedicine also mainly provide an ability to have a contact with specialists who may be located in different geographical zones and as a result, patient care is also improved [11].

Artificial intelligence- (AI)

Machine learning programs in diagnosing RA have been proved to have high rates of accuracy when integrated with other data sources like wearables and EHRs [12]. IBM Watson, for instance, is one of the tools based on machine learning algorithms that are employed to analyze the patient's information and records to enhance RA diagnosis [13]. Actually, the system accounts parameters such age, gender, symptoms, lab results, EHR data to make a prediction. Furthermore, AI makes it possible to perform diagnostic studies on large data samples of RA patients; thereby the diagnostician can single out minor variations in the patterns or biomarkers that may not be spotted by a traditional diagnostician [14]. Such an advancement in this AI technology looks very promising when it comes to increasing the chances of getting it right in diagnosing RA; at the same time, minimize on false positives as well as false negatives. The few of the tools of AI are described in the following lines:

- Predicting response to anti-TNF therapy.
- Predicting response to different biologic treatments
- Predicting future disease activity using EHR data
- Predicting difficult to treat RA (D2T RA)

Biochemistry, technology and rheumatoid arthritis:

Improved understanding of molecular pathways involved in RA has led to the development of targeted biologic therapies, such as TNF inhibitors and monoclonal antibodies, which specifically counteract inflammatory processes. Biochemical research has identified key molecular players and pathways, such as cytokines and

immune cell interactions, that drive RA's inflammatory processes. This knowledge has facilitated the development of targeted biologic treatments, like TNF inhibitors and JAK inhibitors, which specifically disrupt these pathways to mitigate inflammation and joint damage.[15]

Pain assessment:

Investment in health technology brings improvement in the evaluation of pain in Rheumatoid Arthritis through existing tools; mHealth, Wearable Devices, and Telemedicine. The above technologies allow faster evaluation, identification and monitoring of pain, collection of database, and further interaction, and provides personalized care regarding pain. Pain diaries may be created by using mobile apps where patients can report about the pain intensity, frequency and what triggers it, [16.17]while wearables can track physiological markers such as joint activity. Such a method enables the patients to convey the degree of suffering to the care givers often and therefore timely actions could be taken.

Management:

Rheumatoid Arthritis (RA) as an organic inflammatory-erosive disease presents clinically as an auto-immune one which necessitates constant follow-up and optimal psychosocial outcomes for the prevention of the progressive joint destruction and other clinical consequences. Telemedicine, wearables, and mobile applications have dramatically changed the different aspects of RA management, including teleconsultations, real-time monitoring of patients, medication compliance, and risk assessment [17]. In this expanded review, we will go deeper into four main areas where health technology has greatly enhanced RA management: , telemedicine, wearable technology, smart phones, and self-learning computer programs such as smart algorithms.

Telehealth Services:**Virtual Group Therapy Sessions.**

Telehealth services have emerged either as a critical approach in the modification of RA as patients benefit from the opportunity to access care from the comfort of their homes . This does not only make it efficient but also effective since those in wheel-chairs and other mobility disabled or those living in hard to reach areas benefit from the service. Telehealth services allow patients and healthcare professionals to connect to a site in real-time, thus permitting frequent assessment and/or, changes in the care plan and education. In addition, telehealth consultations are useful in delivering information about the necessary changes in patients' lifestyles, psychological assistance, and medication compliance.[18-21]

Telemedicine can be explained through clinical examples, which are as follows:

1. Remote Monitoring and Consultations

In one of the surveys, patients with Rheumatoid Arthritis (RA) of the Hospital for Special Surgery in New York relied on telemedicine for monitoring and follow-up. Patients daily input their symptoms, current medications intake, and exercise in a mobile app which automatically feed the healthcare provider console. [22] Teleconsultations by video call enabled rheumatologists to observe the deteriorating status of their patients, modify the medications and other necessary interventions as needed, in addition to giving advice on diet and physical activity to the patients. The study also noted an increase in patient satisfaction, decreased miles that patients had to travel and improved Disease Management.

Thus, the University of California, Los Angeles (UCLA) initiated a telemedicine programme that involved group therapy sessions for RA patients. These meetings encompass both PT exercises and protocolled lectures by medical practitioners and health related paraprofessionals as well as peer support talks. Often held via a

secure video conferencing software these sessions enabled the patients to attend from their homes, ensuring that they continued with their prescribed physiotherapy exercises and also insured that the patients formed communities. The examined program provided some evidence of a decrease in the self-reported pain levels and an increase in joint function in the participants.

3. Telehealth and AI Integration

Mobile Applications:

Mobile applications have become increasingly popular in managing RA, offering features such as medication tracking, side effect reporting, and educational resources (6). These applications allow patients to easily manage their medication schedules, set reminders, and track adherence levels. In Mayo Clinic, a pilot intervention integrated telemedicine coupled with AI with RA. Individuals employed a telemedicine application to file symptoms and share photos of affected joints, shot using the phone. [23] These inputs were then processed through an AI algorithm which recognised patterns of inflammation and disease activity. During teleconsultations, rheumatologists were looking at AI generated reports and this helped in early identification and treatment of patients. It showed that due to this intervention resource utilization has improved in terms of diagnostic acumen and minimizing of face to face attendances.

Wearable Devices:

Walking devices have particularly received much attention in the RA community based on the observation that such devices facilitate recording of the functional ability as well as disease progression. Such devices can be smart watches, fitness trackers or others particular devices used in the healthcare field. Wearable devices enable patients to know their activities for a day and likely detect trends of disease flare or disease exacerbation (vide supra). Also, in some of the wearables, different body signs including pulse rate and blood oxygen data, among others, can be checked to know individual's general health condition at any given time. [4,7] This information can be very useful to doctors to evaluate the efficacy of the existing therapies and redesign them in the event of inefficiency

Additionally, some mobile applications offer educational resources on disease management, providing patients with the knowledge and tools they need to manage their condition effectively

Some mobile apps used for managing Rheumatoid Arthritis:

MyRA, RheumaTrack, RA, ArthritisPower, MyPainLog, RA Monitor, Jointfully, MyArthritisRx, PainScale (figure 2)

These apps offer various features to help patients track their symptoms, medications, and overall disease management

Artificial Intelligence Algorithms:

It has been found in the study that AI algorithms use have promises in predicting disease flares in RA patients and analyzing trends of the patient data, which would lead to preventive interventions and enhanced care. These algorithms can measure large data sets of patient data such as the physiology, ambulations, medication compliance and lab data. AI can point out certain signs or changes in someone's behaviour that might be a sign of an upcoming flare and address them before they develop into something more serious. Besides, such algorithms can offer custom treatment regimen relying on the patient's information. Regarding the diagnosis and prediction of RA, various AI techniques have been designed. One such tool for instance is an automatic

tool used in identifying RA with the aid of hand radiographs, the sensitivity of which stands at 0.6818, specificity of 0.89, sensitivity of 0.7826 and accuracy of 0.7333 with an FI score of 0.7143. Another exciting application is concerned with employing appliances such as activity monitors for RA flare detection [24, 25] While this approach has not been corroborated yet, the mean sensitivity achieved is as high as 95 percent. 7% and mean sensitivity of 96.7%. Most of these techniques show how AI is useful in RA diagnosis and management even though they differ in the degree of accuracy; they are useful in enhancing clinical practice. Some of the AI tools are below. (figure 2)

- Automated diagnosis of RA using patient demographics and antibody profile
- Predicting synovial gene expression subtypes (high a and low b inflammatory groups) from histological data
- Automated RA flare detection using activity trackers
- Detecting synovitis from doppler ultrasound images

In conclusion, use of health technology in the optimisation of RA has led the delivery of remote consultations, constant monitoring of the patient's status, monitoring of medication intake, and development of means for evident prognosis. Telecare and telehealth enable follow-up and interactively assess patients, wearables offer essential information about functional capacity and the illness process, mHealth for medicines and side impact monitoring, and AI for flare risk assessment and individualised formulation. These technologies are expected to better the quality of life of those affected by RA, lower the total costs of healthcare, as well as get better quality patient outcomes.

Rehabilitation:

Rheumatoid arthritis (RA) is a long-term condition that generates inflammation of the joints with subsequent deterioration of the shafts and their functional abilities. The focus of the conventional methods of rehabilitation for RA, that has been ideal for a very long time, has been more on the utilization of long periods on hospital and subsequent rigorous therapy sessions. Yet, a new phenomenon termed as health technology has turned the tide in this sphere with better and individualised options for the patients. In this expanded review, we will go deeper into three main areas where health technology has significantly enhanced RA rehabilitation: specific categories of telerehabilitation programs, and uses of virtual reality in rehabilitation in addition to, turning therapy into games.

Telerehabilitation programs:

Telerehabilitation programs have gained significant traction in the field of rheumatoid arthritis rehabilitation due to their ability to enable patients to perform exercises at home using webcams and specialized equipment. These programs reduce the need for travel and provide greater flexibility, allowing patients to undergo therapy sessions at their own pace and convenience. Telerehabilitation programs can include a variety of interventions, such as physical therapy, occupational therapy, and speech-language therapy. For example, the "TeleREHAB" program at the University of Pittsburgh School of Health Sciences offers telerehabilitation services for patients who have rheumatoid arthritis, [26] which enables them to access personalized therapy sessions using webcams, exercise equipment and other specialized tools. (figure 2)

Virtual reality (VR) applications:

Virtual reality (VR) applications provide a safe place where individuals with rheumatoid arthritis (RA) can regain strength and flexibility. These applications simulate real-world environments that can be tailored

according to individual patient needs. VR therapy sessions may include exercises intended for improving balance, coordination or range of motion. One such system is the “Virtual Rehabilitation Environment for Stroke” (VRES),[27] which was developed by researchers at the University of Southern California using VR technology.

Gamified Therapy Activities:

One original method for enhancing both patient motivation and engagement in the rehabilitation process is to apply gamification of therapy activities. These efforts have integrated game mechanics that most gaming nerds and aficionados are familiar with, such as points, badges/achievements and leader boards within archetype therapy exercises. GameReady Rehab, a platform created by Hocoma is one great evidence that offers gamified Therapy Activities aimed at the upper Limb functioning of RA Patients. [28,29]Competing against themselves or their peers, patients are financially rewarded for performance (ie., doing exercises) and progress is tracked over time.

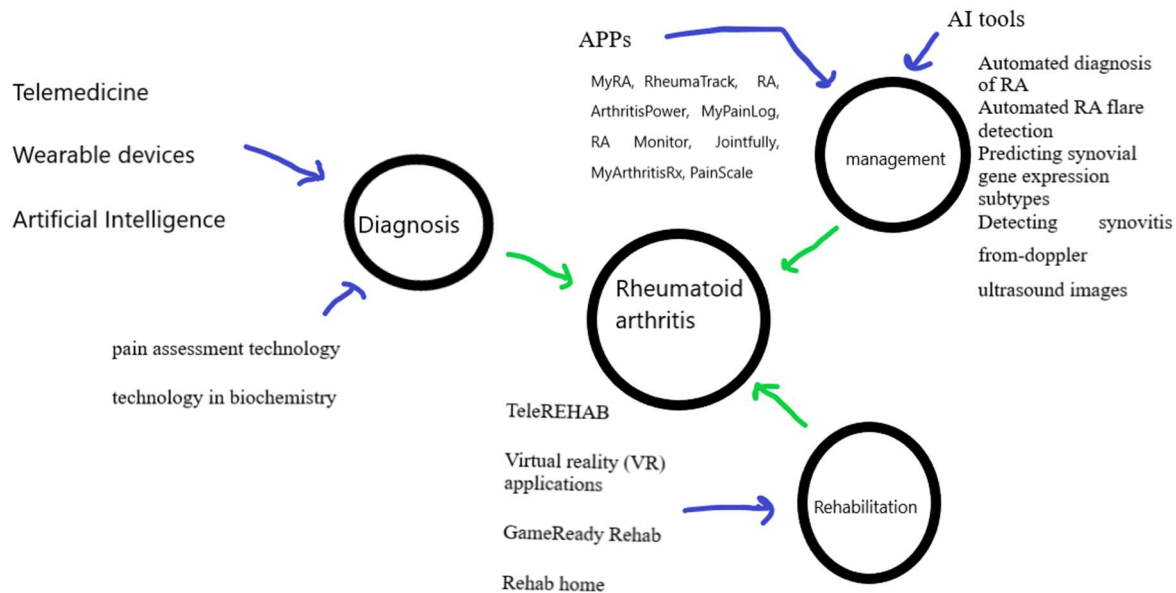
Clinical Examples:

a) Researchers at the University of California, Los Angeles use advanced telerehabilitation technology to tailor RA therapy sessions directly into patients' homes with their "REHAB at Home" program. The kit provided to patients includes a webcam, exercise equipment and instructions on how to perform the exercises at home. Therapy is conducted using video conferencing and patients can talk to a therapist in real time.

b) Researchers at the University of California, Irvine have also designed th "VirtualActive" system will use VR technology to create environments that are as immersive and realistic laboratory can simulate normal everyday lives for patients with RA. Patients wear head-mounted displays and complete exercises specifically designed to improve their mobility or something else about them.

c) "RehaCom" platform: A system based in gamification with its development associated to University of Duisburg-Essen researchers (Germany). Users can unlock points, badges and rewards for exercise completion as well as compete on a leaderboard. [30-33]

figure 2 abstracting the roles of health technology in Rheumatoid arthritis



Conclusion:

There are so many possibilities with health technology that could transform rehab for Rheumatoid Arthritis patients. Long-distance web-based tele-rehabilitation programs that allow patients to do rehab at home with a computer and state-of-the-art technology, avoiding travelling. Safe, Immersive Environments for Gaining Strength and Flexibility – VR applications used in therapy as a kind of strength-training coupled with gamification when updating physical therapy exercises, in which patients are expected to benefit due to stronger motivation and engagement. These advances really are game changing opportunities; the promise of significantly better patient outcomes and quality of life for all with less long hospital stays and intensive physiotherapy treatments with the colossal price-tag too.

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