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Online physical activity resources for individuals with rheumatoid arthritis: An environmental scan and quality appraisal

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Article Title

Online physical activity resources for individuals with rheumatoid arthritis: An environmental scan and quality appraisal

Abstract

Objectives: To review publicly available physical activity (PA) resources for individuals with rheumatoid arthritis (RA). Aims were to find online print and audiovisual resources, review their characteristics, and critically examine their quality from medical, exercise, and behavioral science perspectives.

Design: An environmental scan was completed using the Google search engine, with combinations of terms for RA and PA. The first 5 pages of results were reviewed for RA-specific PA resources that were free, written in English, and included PA recommendations.

Outcomes: After screening, resources underwent a medical review for safety and appropriateness. After extracting data on the resource characteristics, resources were evaluated for readability, understandability, actionability, exercise recommendations, and behavior change techniques.

Results: The search yielded 23 RA-specific PA resources, 17 of which passed the medical review. All 10 print resources and 7 audiovisual resources were created in English-speaking countries. The mean reading grade was 9.0±1.5. Print resources had mean understandability of 80.0±9.8% and actionability of 60.0±27.7%. Audiovisual materials had mean understandability of 86.0±9.2% and actionability of 86.9±22.9%. The quality of exercise recommendations was low. Only 1 resource provided comprehensive cardiovascular exercise advice, and 2 resources provided comprehensive strength exercise advice. 3-14 behavior change technique groups were featured in each resource. The most common groups were “shaping knowledge” and “natural consequences”.

Conclusions: The quality of RA-specific PA resources is variable. Some high-quality resources exist that provide actionable exercise behavior change advice. Healthcare teams may refer patients to these resources. However, more work is needed to improve the overall quality of resources. Co-development with patients,

providers, and exercise behavior change experts is recommended, ensuring resources are actionable, contain clear exercise recommendations, and promote behavior change.

Strengths and limitations of this study

- The study provides a comprehensive overview and critical appraisal of publicly available physical activity resources for individuals with rheumatoid arthritis.
- A critical appraisal was completed by a rheumatologist, patient partners with lived experiences of rheumatoid arthritis, researchers, and an exercise and behavior change expert.
- All resources were evaluated using standard measures for readability, understandability, actionability, exercise recommendations, and behavior change techniques.
- Due to the inherent subjectivity of the tool used to assess understandability and actionability, triplicate ratings were completed for each resource to minimize subjective biases.
- Patient partners were individuals with high health literacy and personal engagement with their health, which may impact certain scores and their generalizability to the broader RA population.

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Declaration of competing interests

The authors have no conflicts of interest to declare.

Abbreviations

DMARDs = Disease-Modifying Anti-Rheumatic Drugs

FITT = Frequency, Intensity, Time, Type

HCP = Healthcare Provider

PA = Physical Activity

PEMAT = Patient Education Materials Assessment Tool

RA = Rheumatoid Arthritis

1.0 Introduction

Rheumatoid arthritis (RA) is a chronic autoimmune inflammatory disease affecting around one percent of Canadians [1]. Chronic inflammation of the joints and throughout the body leads to systemic problems, compromised function, and reduced quality of life [2]. Despite significant improvements in RA treatment due to the emergence of new classes of disease-modifying anti-rheumatic drugs (DMARDs), individuals living with RA continue to face daily challenges [3-5]. These challenges include unpredictable disease flare ups, changes in disease activity, debilitating chronic fatigue and pain, and significant psychological distress [5].

Effective disease self-management (or self-care, as preferred by patients) between regularly scheduled follow-up appointments is critical to quality RA care. Indeed, major international rheumatology associations such as the European League Against Rheumatology (EULAR) recommend the implementation of self-management strategies for RA care [6]. Recommended strategies include patient education, goal setting and problem solving, lifestyle advice, and connecting patients to resources [6].

Physical activity is strongly recommended as part of effective RA self-management [6-8]. Regular physical activity can positively impact many disease-related and general health outcomes among RA populations [7-13]. For example, physical activity can significantly reduce fatigue, pain, and inflammation while improving functional ability and body composition [9-11]. It is positively associated with better strength and cardiorespiratory fitness and enhanced quality of life, while reducing the risk of cardiovascular disease and all-cause mortality [9, 12, 13]. The health benefits of regular physical activity can also reduce individual- and system-level healthcare costs [14]. Unfortunately, individuals with RA report lower than average physical activity levels, and physical activity support in routine RA clinical care remains limited [9, 15].

Greater efforts are needed to help individuals with RA become and stay physically active as part of their day-to-day disease self-management. Individuals with RA lack disease-specific physical activity resources, express doubts about the safety and effectiveness of physical activity, and rarely receive physical activity advice from their care team [16]. Publicly available, RA-specific physical activity resources may be helpful for addressing these problems. However, the quality of online health information is highly variable, and individuals with

chronic conditions struggle to find suitable, credible high-quality resources [17, 18]. They may also find it difficult to discern what recommendations are appropriate given their current concerns.

Therefore, we completed an environmental scan of publicly available physical activity resources for individuals living with RA. Specific goals were to identify available resources, provide an overview of their characteristics, and critically examine their quality. High-quality resources identified herein can serve as a foundation for patients and providers to improve physical activity behavior change as part of RA self-management. Meanwhile, the shortcomings among existing resources can inform future research and development.

2.0 Materials and methods

We completed an environmental scan and critical appraisal of publicly available online resources on physical activity for individuals living with rheumatoid arthritis.

2.1 Patient and public involvement

Patient partners with lived experiences of RA were involved throughout the study. The study was conducted in direct response to conversations with patient partners and reports in the literature that indicate challenges with accessing high-quality information on physical activity. Their opinions informed the study design, including the search strategy and selection of measures for critical appraisal. Furthermore, three patient partners were involved in assessing understandability and actionability of the included resources. They will also be involved in sharing lay summaries of our findings with patient organizations.

2.2 Search Strategy

An online search was carried out using the Google search engine from January-April 2024. The search strategy was developed, tested, and refined by three members of the research team (ME, SZ, CB). Searches were repeated using various combinations of search terms related to rheumatoid arthritis, physical activity, and program or resource. Search terms were obtained from existing patient materials and relevant scientific literature. Additional searches were completed after adding a term for the major countries contributing to English language patient resources (e.g. United States, United Kingdom, Canada, Australia). The complete list of search terms used for each concept is presented in the online Supplementary File 1. As research suggests

that most online search traffic is on the first two results pages, all links on these pages were reviewed [19]. Authors also screened the results on pages 3-5 to make sure no relevant resources were missed. To be included in the environmental scan, resources had to meet the following inclusion criteria: (1) freely available, (2) written in English, (3) developed specifically for individuals living with rheumatoid arthritis, and (4) containing at least 1 recommendation for physical activity. Resources were excluded based on the following criteria: (1) payment required to access, (2) presence of predatory advertising (3) intended for healthcare professionals or researchers, (4) information not specific to rheumatoid arthritis, and (5) absence of physical activity recommendations (e.g. sign-up page for a physical activity program). During the medical safety review (described below), any resources deemed unsafe or inappropriate by a rheumatologist were also excluded (see medical safety review).

2.3 Data Extraction

A data extraction spreadsheet was used to record resource characteristics including URL, title, organization, country of origin, date created or last updated, format (print, audiovisual), type (e.g. blog post, slideshow, PDF handout, video), and interactivity. A resource was deemed to be interactive if it prompted the user to complete an action or answer a question while viewing the content. If reported, additional data was recorded on the availability of translated versions of the resource, as well as the involvement of healthcare professionals or patient partners in resource development.

2.4 Critical Appraisal

The included resources underwent a comprehensive critical appraisal for medical safety, readability, understandability, actionability, quality of exercise recommendations, and use of behavior change techniques.

2.4.1 Medical Safety Review

The medical safety review was completed by a rheumatologist (CB) on the research team. Each resource was reviewed to ensure that the content was safe and appropriate for patients with RA in the opinion of a rheumatologist. Factors considered included (1) whether information provided in the resource about RA and its management was medically accurate, as well as, (2) whether the exercise recommendations would be safe

from a medical perspective for patients with RA. Each resource received a yes/no rating along with additional comments for consideration by the research co-lead (ME). Only resources that had no concerns across both factors were approved as safe for the general population of RA patients, based on clinical experience. Resources with any concerns were deemed unsafe and excluded from further review.

2.4.2 Readability

The validated and widely used Flesch-Kincaid Reading Grade score was used to assess readability [20]. Document text was copied into Microsoft Word and the Flesch-Kincaid Reading Grade score was calculated using the automated proofreading tools in Microsoft Word.

2.4.3 Understandability and Actionability

Understandability and actionability were assessed using the Patient Education Materials Assessment Tool (PEMAT) [21]. This tool has demonstrated strong internal consistency and reliability, can be used by both researchers and patient partners, and can be used for both print (PEMAT-P, 24 items) and audio-visual (PEMAT-A/V, 17 items) resources. The understandability domain includes evaluation of 6 sub-domains for content, word choice and style, use of numbers, organization, layout and design, and use of visual aids. Actionability measures the degree to which a resource provides specific actionable steps for patients using the provided information (e.g. feasibility, specificity, relevance). The PEMAT user guide includes specific instructions for the rating of each item as 1 (agree), 0 (disagree), or not applicable [22].

All assessors adhered closely to the PEMAT user guide for rating each resource [22]. To ensure consistency, each resource was reviewed by 3 assessors: 2 researchers (ME and KD) and 1 patient partner (AM, CG, or GL). Discrepancies for one or more items between the researcher ratings were resolved by open discussion to obtain a consensus researcher rating. Understandability and actionability scores, as well as overall PEMAT scores, were calculated for each resource according to the PEMAT scoring guidelines. To calculate scores, the sum for each domain was divided by the total sum of possible points in that domain and converted to a percentage, where 100% indicates that the resource received a rating of 1 (agree) on all applicable items in

that domain. Mean scores were calculated using equal weights for the researcher consensus score and the patient partner score. A higher percentage indicates better understandability or actionability.

Patient partners were recruited from existing relationships with patients involved in a larger project being conducted by the research team on improving physical activity support for individuals living with rheumatoid arthritis. Individuals with prior experience using the PEMAT from a previous project [23] were invited to participate by email. The email included a brief overview of the study objectives and explained the purpose of patient partner involvement with the critical appraisal of resources. All invitations included the option to decline participation. Researchers and patient partners were trained using the PEMAT user guide PDF and a virtual 1:1 session with a member of the research team (KD) as needed [22]. Those with no prior PEMAT experience (ME) completed a practice session with an experienced PEMAT rater (KD) to ensure consistency.

2.4.4 Exercise Recommendations Review

The exercise review was completed by a clinical exercise specialist (ME) on the research team. Each resource was reviewed in detail to assess the presence of exercise recommendations, exercise cautions, specific and actionable exercise tips, and tailored exercise advice for rheumatoid arthritis. This information was recorded using a standard data extraction spreadsheet, with separate sections for cardiovascular, strength, balance, and stretching exercise. Exercise types that were not mentioned at all were left blank in the data extraction spreadsheet. Meanwhile, missing information was noted as “not specified”. Recommendations to consult with a healthcare professional or qualified exercise professional were recorded.

2.4.5 Behavior Change Techniques Review

The behavioral review was completed by a physical activity behavior change expert (ME) on the research team. To assess the use of behavior change techniques, each resource was reviewed using a standard data extraction spreadsheet based on the behavior change technique taxonomy [24]. This taxonomy is the gold standard for classifying behavior change techniques in physical activity behavior change research. The presence of behavior change techniques was recorded across the 16 groups from the behavior change

technique taxonomy. Groups were either considered present, if one or more techniques from that group were identified, or absent, if none of the techniques were used.

3.0 Results

An overview of the environmental scan phases is shown in Figure 1. Our initial search yielded 33 potential resources. After screening the resources, 10 of them were excluded as they did not meet our inclusion criteria. Eight of these were landing pages for in-person or online exercise programs. One was not available in English, and another was not intended for rheumatoid arthritis. Twenty-three resources were included in the data extraction and critical appraisal phases.

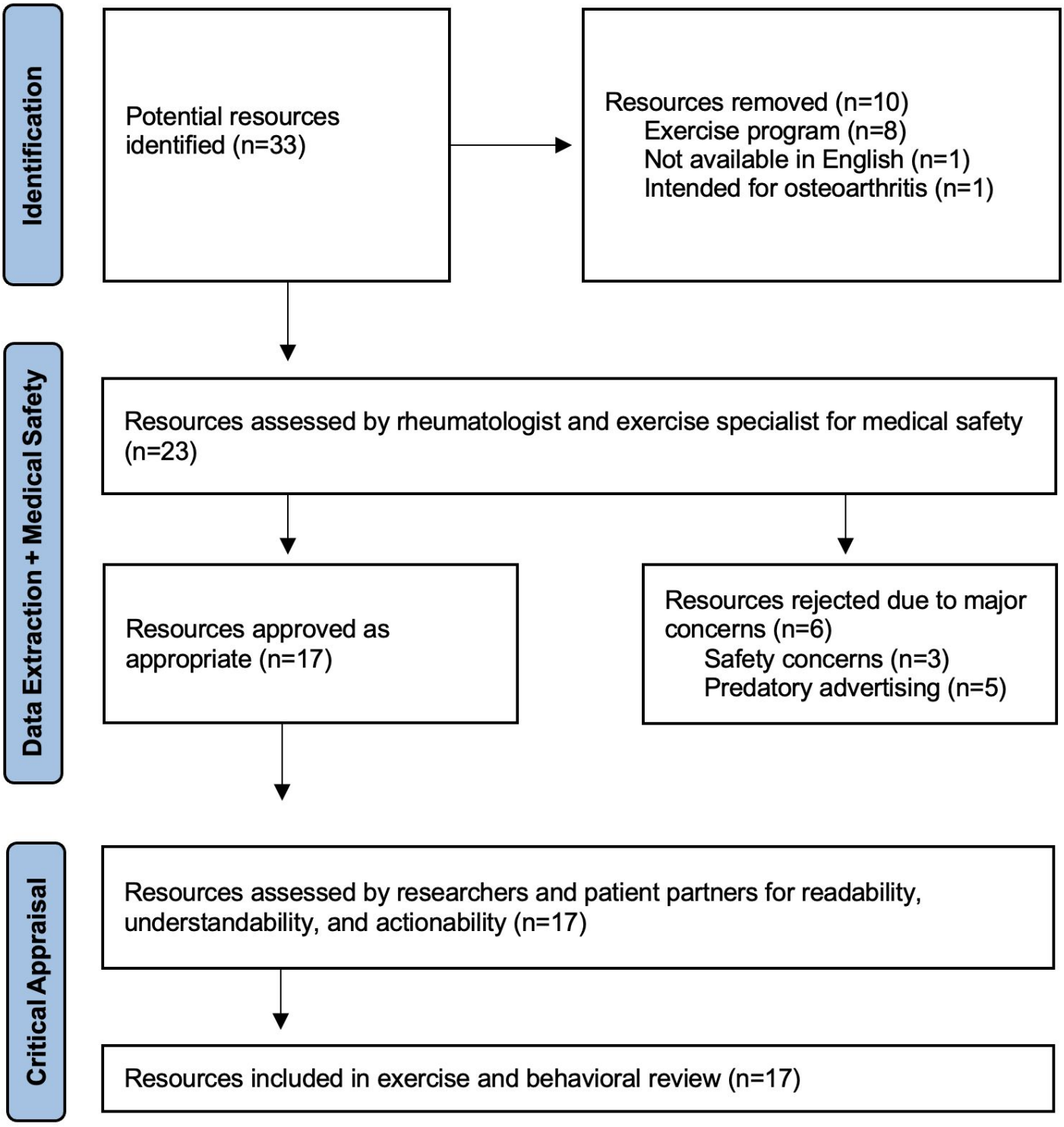

Figure 1: Flow diagram of environmental scan and critical appraisal of physical activity resources for individuals with rheumatoid arthritis.

3.1 Medical safety review

After completing the medical safety review, 17 resources were approved as safe and appropriate for individuals with RA [25-41]. Six resources were excluded due to concerns about safety (1/23), predatory

advertising (2/23), or both (3/23). Notable safety concerns among the excluded resources were the recommendation of unsafe exercises (e.g. push-ups, sit-ups, and other challenging exercises that load the hands and wrists) without sufficient modification for RA patients with joint symptoms, as well as blanket statements to avoid certain exercises (e.g. high impact, high intensity), which may still be suitable for individuals with well-controlled RA. In contrast, another resource wrote that "exercise is uncomfortable for 85% of people with RA". The statement was not supported by scientific evidence and may discourage physical activity engagement despite its many benefits. Some resources were deemed inappropriate due to predatory advertisements (e.g. weight loss medications) and stock images (e.g. able-bodied, younger white women) that are not representative of the RA population. The critical appraisal was completed only for the 17 resources that passed the medical safety review.

3.2 Resource characteristics

Of these 17 resources, 14 were created or updated between 2020-2024 (Table 1). All resources originated from English-speaking countries, including the USA (n=3), Canada (n=8), UK (n=5), and Australia (n=1). Ten resources were print materials of various formats (Blog post, brief article, slideshow, PDF), whereas the remainder were audiovisual resources (e.g. videos, multimedia materials). Only 6 resources included an interactive component. The involvement of healthcare professionals and patient partners was documented in 14 and 8 resources, respectively. A single resource was available in Spanish and English. All others were only available in English. Table 1 presents the characteristics for each resource.

Title	Organization	Country	Date Created or Updated	Type	Interactive	Language	HCPs Involved	Patients Involved
Print Resources								
Exercise and RA	Arthritis Australia	Australia	June 2024	Brief article	No	English	Unclear	Unclear
At home exercise guide	Arthritis Research Canada	Canada	July 2022	Brief article	No	English	Yes	Yes

30-Day Exercise Challenge for Arthritis	Arthritis Research Canada	Canada	January 2020	PDF workbook	Yes	English	Yes	Unclear
Exercise for RA	Health Link BC	Canada	September 2022	Brief article	No	English	Yes	Unclear
I START Toolkit (quick guide fact sheet)	University of British Columbia	Canada	2023	PDF handout	No	English	Yes	Yes
I START Toolkit (website)	University of British Columbia	Canada	2023	Brief article	No	English	Yes	Yes
Let's Move with Leon activity tracker	Versus Arthritis	UK	2024	PDF workbook	Yes	English	Yes	Unclear
Best Exercises for RA	Arthritis Foundation	USA	Unknown	Slideshow	No	English	Unclear	Unclear
EIM Rx for Health Rheumatoid Arthritis	Exercise is Medicine	USA	2021	PDF handout	No	English, Spanish	Unclear	Unclear
Exercise can ease RA pain	Harvard Health Publishing	USA	May 2023	Blog post	No	English	Yes	Unclear
Audiovisual Resources								
How to stay active at home during COVID-19 (Arthritis at Home)	Arthritis Consumer Experts	Canada	April 2020	Video	No	English	Yes	Unclear
Indoor Exercise Snacks (Arthritis At Home Ep.16)	Arthritis Consumer Experts	Canada	May 2020	Video	Yes	English	Yes	Unclear
Strong with Arthritis (Arthritis Research Education Series)	Arthritis Research Canada	Canada	March 2023	Video	No	English	Yes	Yes
Exercise Videos	National Rheumatoid Arthritis Society	UK	October 2017	Video series	No	English	Yes	Yes
Importance of physical activity and exercise (SMILE-RA)	National Rheumatoid Arthritis Society	UK	September 2021	Interactive platform	Yes	English	Yes	Yes
Yoga Exercises (SMILE-RA)	National Rheumatoid Arthritis Society	UK	September 2021	Video	Yes	English	Yes	Yes

Let's Move with Leon	Versus Arthritis	UK	2024	Video series	Yes	English	Yes	Yes

Table 1: Characteristics of the 17 included physical activity resources for individuals with rheumatoid arthritis. HCP = Healthcare provider.

3.3 Readability

The readability, understandability, and actionability scores of the included physical activity resources is summarized in Table 2. The mean reading grade level of the 10 print resources was grade 9.0±1.5. Only one resource was written at or below a sixth-grade level [33]. A second resource fell within the seventh-grade range [31]. All other print resources required a reading level of grade 9 or higher.

Print Resources			**FK Reading Grade**	**PEMAT**	**PEMAT**
Article	**Organization**	**Country**	**Readability**	**Understandability**	**Actionability**
Exercise and RA	Arthritis Australia	Australia	10	80.1%	57.5%
At home exercise guide	Arthritis Research Canada	Canada	8.6	92.3%	50.0%
30-Day Exercise Challenge for Arthritis	Arthritis Research Canada	Canada	8.9	84.0%	91.7%
Exercise for RA	Health Link BC	Canada	9.8	71.5%	30.0%
I START Toolkit: Quick guide fact sheet	University of British Columbia	Canada	8.9	82.6%	70.0%
I START Toolkit: Website	University of British Columbia	Canada	9.9	62.5%	73.3%
Let's Move with Leon activity tracker	Versus Arthritis	UK	7.0	91.2%	100.0%
Best Exercises for RA	Arthritis Foundation	USA	9.2	76.0%	28.3%

EIM Rx for Health Rheumatoid Arthritis	Exercise is Medicine	USA	6.4	89.4%	80.0%
Exercise can ease RA pain	Harvard Health Publishing	USA	11.5	70.8%	20.0%
	Mean (SD)		9.0 (1.5)	80.0 (9.8)%	60.0 (27.7)%
Audiovisual Resources			**FK Reading Grade**	**PEMAT**	**PEMAT**
Article	**Organization**	**Country**	**Readability**	**Understandability**	**Actionability**
How to stay active and exercise at home during COVID-19 (Arthritis At Home)	Arthritis Consumer Experts	Canada	N/A	84.3%	87.5%
Indoor Exercise Snacks Higher Intensity (Arthritis At Home)	Arthritis Consumer Experts	Canada	N/A	79.4%	100.0%
Strong with Arthritis Webinar (Arthritis Research Education Series)	University of British Columbia	Canada	N/A	71.5%	37.5%
Exercise Videos	National Rheumatoid Arthritis Society	UK	N/A	90.9%	83.3%
Importance of physical activity and exercise (SMILE-RA)	National Rheumatoid Arthritis Society	UK	N/A	91.3%	100.0%
Yoga Exercises (SMILE-RA)	National Rheumatoid Arthritis Society	UK	N/A	84.7%	100.0%
Let's Move with Leon	Versus Arthritis	UK	N/A	100.0%	100.0%
	Mean (SD)			**86.0 (9.2)%**	**86.9 (22.9)%**

Table 2: Readability, understandability, and actionability of the included physical activity resources. FK = Flesch-Kincaid. PEMAT = Patient Education Materials Assessment Tool.

3.4 Understandability and actionability

After being assessed by both researchers and patient partners, the mean understandability ratings were 80.0±9.8% for print materials and 86.0±9.2% for audiovisual materials (Table 2). Actionability ratings were lower for print materials (60.0±27.7%) than audiovisual materials (86.9±22.9%). Whereas all resources scored

above 60% for understandability, 50.0% (5/10) of the included print resources and 14.3% (1/7) of the audiovisual resources had actionability ratings below 60%. The highest scoring print resources were the "Let's move with Leon" PDF activity tracker workbook from Versus Arthritis, the "Rx for Health Rheumatoid Arthritis" PDF information sheet from Exercise is Medicine, and the "30-day Exercise Challenge for Arthritis" from Arthritis Research Canada [27, 31, 33]. All three scored above 80% for understandability and actionability. Meanwhile, the highest scoring audiovisual resources were the "Let's move with Leon" video series from Versus Arthritis and the "Importance of physical activity and exercise" interactive module on the National Rheumatoid Arthritis Society's "SMILE-RA" online learning platform [39, 41]. These two scored above 90% for understandability and actionability. Individual ratings for each resource are displayed in Table 2.

3.5 Exercise review

The quality of exercise recommendations provided was highly variable across the resources, as shown in Table 3. Specific exercise recommendations in at least one domain (e.g. cardiovascular, strength, balance, flexibility) were included in 14/17 (82.4%) resources. Most resources recommended professional help from a doctor (11/14, 78.6%) and exercise professional (14/14, 100%) for starting or resuming exercise after being diagnosed with RA. Of the 14 resources with exercise recommendations, 13 (92.9%) provided cardiovascular exercise recommendations, 13 (92.9%) provided strength exercise recommendations, 6 (42.9%) provided flexibility exercise recommendations, and 5 (35.7%) provided balance exercise recommendations.

Cardiovascular exercise was defined in lay terms in 5/14 (38.5%) of resources that recommended it. A complete (i.e. specific details for all four variables: frequency, intensity, time, and type) prescription for cardiovascular exercise was included in only 1/13 (7.7%) of these resources. The remaining resources provided either a partial (i.e. specific details missing for one or more variables) prescription (6/13, 46.2%) or none (6/13, 46.2%). Details for how to progress exercise gradually (6/13, 46.2%) and RA-specific exercise tailoring (i.e. exercise adaptations and/or cautions for common RA symptoms) (8/13, 61.5%) were present in more than half of these resources. Four (30.8%) resources did not provide any RA-specific tailoring for cardiovascular exercise.

Common RA-specific advice included exercising more when RA symptoms are lowest, resting if symptoms are too high, choosing lower impact exercise types (e.g. swimming) to reduce stress on joints, focusing on less-affected areas of the body when flaring, using appropriate footwear to minimize pain, ensuring a gradual warm-up and cool-down, and starting slow before progressing exercise frequency, intensity, or time. Resources cautioned individuals with RA to avoid exercise during flare ups, reduce intensity or time if exercise leads to unexpected pain, avoid vigorous or high impact exercises at affected joints, and return slowly to cardiovascular exercise after flares or other medical events.

Strength exercise was defined in lay terms in 8/13 (61.5%) of resources that recommended it. These resources provided either a complete (2/13, 15.4%) or partial (4/13, 30.8%) strength exercise prescription. Seven (53.8%) resources did not provide any prescription. Information was provided on gradual exercise progression (4/13, 30.8%) and RA-specific exercise tailoring (8/13, 61.5%) for strength exercise. Four (30.8%) resources did not provide any RA-specific tailoring for strength exercise.

RA-specific strength training recommendations included planning strength training when symptoms are lowest, using water aerobics to reduce strain on joints, strengthening muscles around affected joints, using resistance bands and wrapping them around wrists if grip strength is limited, using padded gloves and shoes for extra comfort, reducing weights and duration when symptoms are worse. Resources cautioned against intense strength exercise during flares and suggested using braces and professional supervision to minimize injury risk. Further details on the cardiovascular and strength exercise prescriptions and RA-specific advice provided by each resource can be found in the Supplementary File 2.

Title	Professional Help		Cardiovascular Exercise Recommendation				Strength Exercise Recommendation				Balance	Flexibility
	Doctor	Exercise Professional	Definition provided	FITT Rx	Progression	Tailored to RA	Definition Provided	FITT Rx	Progression	Tailored to RA		
Exercise and RA	X	X		Partial	X	X	X	None				

30-Day Exercise Challenge for Arthritis		X		Partial	X			Complete	X	X		
At home exercise guide	X	X	X	Partial		X	X	None		X	X	
Exercise for RA	X	X		None			X	None				X
I START Toolkit (quick guide fact sheet)	X	X		None			X	None		X		
I START Toolkit (website)		X		None				None				
Strong with Arthritis (Arthritis Research Webinar)	X	X					X	Partial	X	X		
Exercise Videos	X	X		None		X	X	Partial		X		
Importance of physical activity and exercise (SMILE-RA)	X	X		Partial	X	X						
Let's Move with Leon (Activity Tracker)	X	X	X	Partial	X	X		Partial	X	X	X	X
Let's Move with Leon (Videos)	X	X	X	Partial	X	X		Partial	X	X	X	X
Best Exercises for RA	X	X		None				None				X
Rx for Health Rheumatoid Arthritis	X	X	X	Complete	X	X	X	Complete		X	X	X

Exercise can ease RA pain		X		X		None			X		X		None				X		X

Table 3: Summary of exercise recommendations provided by the included physical activity resources. FITT = frequency, intensity, time, type.

3.6

Behavior Change Techniques review

Table 4 presents the groups of behavior change techniques used in each resource. Out of 16 possible groups, the mean number of behavior change groups used was 9.0±4.4 for PDF resources, 5.7±2.1 for websites, and 6.3±4.5 for audiovisual resources. Five (29.4%) resources used 8 or more (i.e. over 50%) of the behavior change groups. The resources with the highest number of behavior change groups used were the "Let's move with Leon" PDF workbook and video series from Versus Arthritis (14 behavior change groups used in both resources) and the "Importance of physical activity and exercise" module within the National Rheumatoid Arthritis Society's SMILE-RA interactive learning platform (11 behavior change groups used) [31, 39]. All 16 behavior change groups were used in at least one resource. The least common behavior change groups used were "identity" (Group 13), "scheduled consequences" (Group 14), and "covert learning" (Group 16), each appearing in only 2 resources. In contrast, "shaping knowledge" (Group 4) and "natural consequences" (Group 5) were the most common, appearing in 17/17 (100%) and 13/17 (76.5%) resources, respectively.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total /16**
Print (PDF)															**Mean (SD)**		**9.0 (4.4)**
I START Toolkit: Quick guide fact sheet	**X**	**X**	**X**	**X**	**X**						**X**						6
Let's Move with Leon Activity Tracker	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**		14
Rx for Health Rheumatoid Arthritis	**X**		**X**	**X**	**X**			**X**	**X**		**X**						7
Print (Website)															**Mean (SD)**		**5.7 (2.1)**

Exercise and RA			X	X	X			X	X								5
30-Day Exercise Challenge for Arthritis	X	X		X		X		X	X		X	X			X		9
At home exercise guide			X	X	X			X	X		X	X				X	8
Exercise for RA				X	X				X								3
I START Toolkit: Website	X		X	X	X	X						X					6
Best Exercises for RA			X	X	X			X	X								5
Exercise can ease RA pain			X	X	X				X								4
Audiovisual															**Mean (SD)**		**6.3 (4.5)**
How to stay active and exercise at home during COVID-19	X	X		X			X										4
Indoor Exercise Snacks Higher Intensity				X		X		X									3
I START Toolkit: strength training for RA		X		X	X			X	X		X						6
SMILE-RA: Importance of physical activity and exercise	X	X	X	X	X	X		X	X	X					X	X	11
Exercise Videos				X	X	X			X								4
SMILE-RA: Yoga exercises				X		X											2
Let's Move with Leon Exercise Program	X	X	X	X	X	X	X	X	X	X		X	X	X	X		14
Total (N)	8	7	10	17	13	8	3	10	12	3	5	5	2	2	4	2	
Total (%)	47.1	41.2	58.8	100	76.5	47.1	17.6	58.8	70.6	17.6	29.4	29.4	11.8	11.8	23.5	11.8	

Table 4: Overview of behavior change techniques identified in the included resources. 1 = Goals and planning. 2 = Feedback and monitoring. 3 = Social support. 4 = Shaping knowledge. 5 = Natural consequences. 6 = Comparison of behavior. 7 = Associations. 8 = Repetition and substitution. 9 = Comparison of outcomes. 10 = Reward and threat. 11 = Regulation. 12 = Antecedents. 13 = Identity. 14 = Scheduled consequences. 15 = Self-belief. 16 = Covert learning.

4.0 Discussion

4.1 Principal findings

Physical activity is internationally recommended as a key component of RA care, contributing to improved overall health and quality of life [7-15]. Patient-facing online resources may help individuals with RA become and stay physically active. Through our environmental scan of online RA-specific physical activity resources, we identified 23 resources, 6 of which were excluded due to predatory advertising or medical safety concerns [25-41]. A comprehensive critical appraisal of the 17 remaining resources, 10 print and 7 audiovisual, highlighted high overall understandability. Several resources stood out for having high actionability that was supported by detailed exercise recommendations and strong use of behavior change techniques. Audiovisual resources had higher average actionability than print resources. However, many resources left room for improvement with regards to readability and actionability. These concerns were often compounded by incomplete exercise recommendations and behavior change support, reducing the potential impact of these resources on physical activity behavior change.

4.2 Study meaning in relation to related research

Medical safety concerns continue to be a weakness among online patient resources. Alongside the present study, where 26% of the resources were excluded due to concerns, a recent environmental scan of flare self-management resources excluded 32% of resources for inappropriate advertisements or medical concerns [23]. Weight loss medications and programs were commonly advertised and often included stigmatizing language, which could be harmful to patients. In prior work, patients expressed concerns about the poor quality of patient materials, causing them to distrust online information [18]. Physical activity resources should always

be reviewed by rheumatologists, exercise professionals, and patients to ensure safety prior to publication. Furthermore, caution must be taken to ensure that advertisements, if present, are appropriate for the target population. This can be challenging for YouTube and other social media platforms where additional recommendations and advertisements are automated. Some resources were flagged during expert review for their negative tone and advanced exercise examples. To ensure that future resources empower, rather than discourage, physical activity behavior change, emphasis on positive messaging and gradual progression is preferable.

Certain resources stood out during the critical appraisal. These resources had high understandability and actionability scores, as well as detailed exercise and behavior change content [27, 31, 38, 39, 41]. Notable differences between these and other resources were the presence of interactive components (e.g. follow-along exercises, goal-setting prompts, self-monitoring tools) and the involvement of healthcare teams, exercise professionals, and patients in resource development. In line with evidence-based best practices for creating patient materials, these findings further emphasize the importance of co-development with relevant partners [42, 43]. For physical activity resources, this may include members of the target population (e.g. individuals with RA), healthcare providers, exercise professionals, and behavior change experts.

Whereas understandability was generally acceptable across the physical activity resources, more work is needed to improve their readability and actionability. The average reading level in both the present work and prior studies is often above 8th grade, with little or no patient materials meeting the recommended level of grade 6 or lower [44, 45]. Adding to this challenge is the limited translation of patient materials, despite the high prevalence of non-native English speakers in Canada and other English-speaking countries [46]. A common shortcoming among patient materials, noted above and across the literature, is a lack of actionability [23]. Specific actionable steps are key to eliciting physical activity behavior change among RA populations [47-49]. Close collaboration with patient partners is required to ensure that written and audiovisual content is actionable. The PEMAT emphasizes the importance of including clear actions, manageable steps, tools to support action, and visual aids to enhance actionability [21]. We noted that audiovisual content across the

reviewed resources featured either stock images of healthy, younger adults or white women with RA without apparent physical limitations. More representative content is warranted to encourage physical activity behavior change across the range of ages, ethnicities, and physical abilities of RA patients.

Comprehensive exercise recommendations are essential to physical activity promotion as part of RA management. First, individuals with RA need specific information on the frequency, intensity, time, and type (or FITT) of physical activity to address lack of knowledge, a common physical activity barrier in this population [47-49]. The reviewed RA-specific physical activity resources rarely provided complete FITT recommendations or covered all 4 key domains of physical fitness: cardiovascular, strength, balance, and flexibility. Future resources should aim to address this shortcoming. Second, individuals with RA may be unsure how to continue being physically active after an RA diagnosis, with fears about exacerbating RA symptoms [16]. While many resources provided some RA-specific suggestions for tailoring and progressing exercise, physical activity promotion efforts in this population could benefit from standardized physical activity guidelines. Relevant tailoring factors may include RA history and medications, joint damage and active inflammation, joint replacement precautions, and other health concerns impacting physical activity tolerance. Such guidelines are common for chronic conditions such as cancer and cardiovascular disease [50, 51]. Due to the breadth of important information related to the 4 physical fitness domains and RA-specific tailoring, resource developers may purposefully select content that aligns with specific aims for a patient resource.

However, physical activity information alone does not necessarily lead to behavior change. Only some of the included patient resources placed a strong emphasis on behavior change. These resources leveraged evidence-based behavior change techniques such as goal-setting and self-monitoring, which have been shown to support physical activity behavior change [52]. Many of the resources, however, focused on educating individuals with RA about the importance of physical activity but did not provide sufficient tools for helping them become and stay active. A lack of actionable behavior change advice is likely to limit the potential positive impact of these resources in RA care. Consultation with a behavior change specialist is recommended for future physical activity resources. Importantly, online resources alone may not be sufficient to promote

lasting physical activity behavior change among many individuals with RA. Work is needed to integrate further physical activity behavior change support into RA care pathways.

4.3 Clinical implications

For rheumatology care providers, our findings have important clinical implications. The list of RA-specific physical activity resources reviewed can serve as a useful starting point for supporting patients to set, meet, and adjust their physical activity goals. Providers are encouraged to keep a list of available resources to refer patients to, including information on the characteristics of the resources as well as the quality of content within them. Notably, the resources varied widely with respect to their purpose, content, format, complexity, and actionability. For example, resources covered one or more of the following domains: education on why to exercise, demonstration of how to exercise, guidance on talking about exercise with a care provider, tips for adopting and maintaining exercise habits, and more. This variety should be seen as a strength. Different content and delivery modes may work better for different patients. Optimal physical activity behavior change support should begin with a patient-led discussion around needs, preferences, available time and resources, motivation, and other relevant factors [53]. The provider can then use this information to provide tailored recommendations to available resources or additional support as part of a "personalized medicine" approach to physical activity.

4.4 Study strengths and limitations

The strengths of our work include the involvement of patient partners to assess understandability and actionability, the use of a search strategy that mimicked a real-world scenario of patients searching for resources, and the in-depth critical appraisal from patient, medical, exercise, and behavioral science perspectives. A limitation to the use of the PEMAT is its inherent subjectivity. To counteract this, we completed triplicate ratings for all resources. The search strategy may have led to some resources being missed. However, resources not identified in the first 5 pages of Google search results are unlikely to be found by patients themselves [19]. The lack of a validated measure for assessing exercise and behavior change components of patient materials is also a limitation. Work is needed to develop such measures that can guide

development and evaluation. Lastly, our patient partner team featured individuals with high health literacy and personal engagement in their health. This may have impacted the resultant PEMAT scores, limiting generalizability to all RA populations.

5.0 Conclusion

Our environmental scan of publicly available physical activity resources for individuals with RA identified 17 appropriate resources. Several resources, usually developed in collaboration with healthcare teams and patient partners, stood out as highly actionable, with clear exercise recommendations and behavior change tips. Others had significant gaps with regards to actionability and lacked clear physical activity behavior change advice. Overall, there is a need for more high-quality physical activity resources for RA populations. Wherever possible, resources should be developed with patient partners and content experts to optimize actionability. More work is needed to create resources that provide complete FITT recommendations for exercise and go beyond providing knowledge to truly empowering behavior change. To address health inequities, efforts must be made to create accessible resources for underserved populations. The use of more diverse audiovisual content and translation into other languages represent two steps in the right direction. A bigger library of excellent physical activity resources will better support the different needs, capabilities, and considerations of individuals with RA. Further research is also needed to develop and implement more intensive physical activity interventions for patients where resources alone are insufficient to promote behavior change.

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Author contributions

ME: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, supervision, visualization, writing – original draft, writing – reviewing and editing.

SZ: Data curation, formal analysis, methodology, writing – reviewing and editing. KD: Data curation, formal analysis, investigation, project administration, resources, writing – reviewing and editing. AMH: Conceptualization, methodology, resources, writing – reviewing and editing. CG: Data curation, formal analysis, investigation, writing – reviewing and editing. AM: Data curation, formal analysis, investigation, writing – reviewing and editing. CB: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, resources, supervision, writing – original draft, writing – reviewing and editing.

Data availability

The data is available from the corresponding author upon reasonable request.

Supplementary material

Supplementary File 1: Complete list of search terms for the environmental scan of publicly available online physical activity resources for individuals with rheumatoid arthritis.

Supplementary File 2: Detailed exercise recommendations provided by each included resource.

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Tables and Figures

Figure 1: Flow diagram of environmental scan and critical appraisal of physical activity resources for individuals with rheumatoid arthritis.

Table 1: Characteristics of the 17 included physical activity resources for individuals with rheumatoid arthritis. HCP = Healthcare provider.

Table 2: Readability, understandability, and actionability of the included physical activity resources. SD = Standard deviation. FK = Flesch-Kincaid. PEMAT = Patient Education Materials Assessment Tool.

Table 3: Summary of exercise recommendations provided by the included physical activity resources. FITT = frequency, intensity, time, type.

Table 4: Overview of behavior change techniques identified in the included resources. SD = Standard deviation. 1 = Goals and planning. 2 = Feedback and monitoring. 3 = Social support. 4 = Shaping knowledge. 5 = Natural consequences. 6 = Comparison of behavior. 7 = Associations. 8 = Repetition and substitution. 9 = Comparison of outcomes. 10 = Reward and threat. 11 = Regulation. 12 = Antecedents. 13 = Identity. 14 = Scheduled consequences. 15 = Self-belief. 16 = Covert learning.

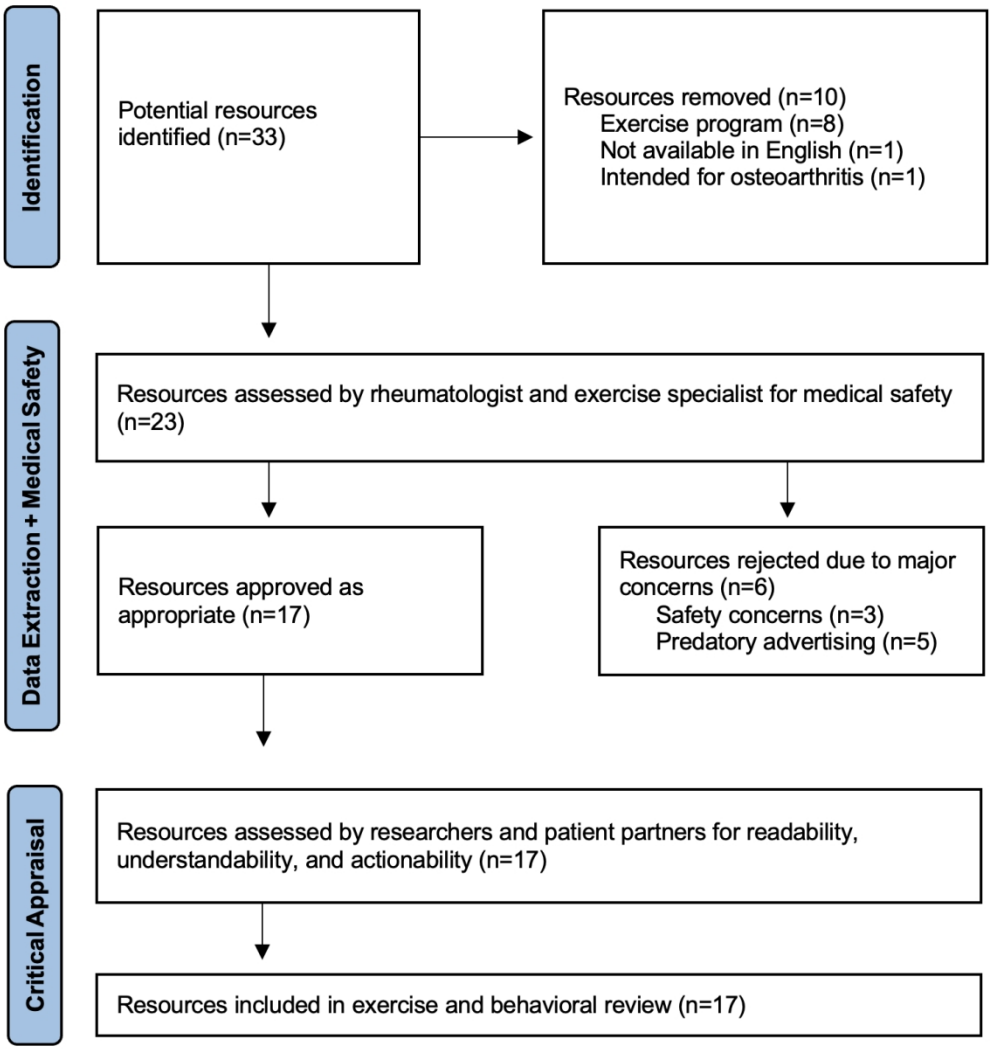

Figure 1: Flow diagram of environmental scan and critical appraisal of physical activity resources for individuals with rheumatoid arthritis.

265x279mm (144 x 144 DPI)

Supplementary File 1

Complete list of search terms for the environmental scan of publicly available online physical activity resources for individuals with rheumatoid arthritis.

Rheumatoid Arthritis	Physical Activity	Additional Descriptors
Rheumatoid arthritis	Physical activity	Resource
Rheumatology	Exercise	Handout
Arthritis	Sports	Program
Inflammatory arthritis	Movement	Group
	Fitness	Manual
	Exercising	Canada
	Strength exercise	US
	Cardio exercise	UK
	Exercise training	Europe
		Australia

Supplementary File 2

Detailed exercise recommendations provided by each included resource.

Title	Organization	Professional Help			Cardiovascular/Aerobic Exercise Recommendations							Strength/Resistance Exercise Recommendations							Other recommendat	
		Doctor	Exercise Professional	Personal Trainer	Definition provided	Frequency (weekly)	Intensity	Time (minutes)	Types	Progression	Tailored to RA	Definition Provided	Frequency (weekly)	Intensity	Time (sets/reps)	Types	Progression	Tailored to RA	Balance	Stretching
Exercising with Rheumatoid Arthritis	Exercise is Medicine	Y	Y	N	N	3-4	M-V	75-150 /week	Water; Activities you enjoy; variety	Y	Y	N	2-3	L-M	3 sets 10-15 reps	All major muscle groups; water; machines; free weights; body weight	N	Y	N	Y
Best Exercises for RA	Arthritis Foundation	Y	Y	N	N	N/S	N/S	N/S	Walking; Water; Biking	N	N	N	N/S	N/S	N/S	Water; Weight training	N	N	N	Y
30-Day Exercise Challenge for Arthritis	Arthritis Research Canada	N	Y	N	N	3-5	N/S	30/day	Walking; Biking; Water; Zumba; Golf; Gardening; Dancing; Exercise Games; Outdoor; Cardio Machines	Y	N	N	2-3	6-7/10 RPE	2-3 sets 8-12 reps	Resistance bands; free weights;	Y	Y	N	N
9 Best Excercises for RA pain	Medical News Today	Y	Y	N	N	N/S	N/S	N/S	Walking; Water; Biking	Y	Y	N	N/S	N/S	N/S	Resistance bands; grip strength (hands, wrists)	N	N	N	Y
Exercise can ease RA pain	Harvard Health Publishing	N	Y	N	Y	N/S	N/S	N/S	Walking; Water; Biking	N	Y	Y	N/S	N/S	N/S	Isometrics; free weights; weight machines	N	N	Y	Y
Make an Exercise Plan for RA	WebMD	Y	Y	Y	Y	5	N/S	30/day	Walking; biking; water; dance;	Y	Y	N	N/S	N/S	N/S	Free weights; resistance bands	N	N	N	Y
Exercise for RA	Health Link BC	Y	Y	N	N	N/S	N/S	N/S	Walking	N	N	Y	N/S	N/S	N/S	N/S	N	N	N	Y
Exercise helps ease arthritis pain and stiffness	MayoClinic	Y	Y	N	Y	Most days	Somewhat hard	150/week	Walking; water; biking	Y	Y	Y	2+	N/S	N/S	All major muscle groups; resistance bands; free weights; weight machines	N	N	N	Y
Exercise and RA	Arthritis Australia	Y	Y	N	N	N/S	N/S	N/S	Water;	Y	Y	Y	N/S	N/S	N/S	Free weights; weight machines; resistance bands; bodyweight	N	N	N	N
RA Exercises that are easy on your joints	WebMD	Y	Y	Y	N	Most days	M	30-60 /day	Stair climbing; walking; dancing; cardio machines; water	Y	Y	N	2-3	N/S	N/S	Free weights; weight machines; resistance bands; isometrics	N	Y	N	Y
7 Essential Everyday Exercises to Manage RA Pain	Healthline	Y	N	Y	N	N/S	N/S	N/S	Water; Biking; walking; cardio machines;	N	Y	N	2-3	N/S	N/S	Free weights; resistance bands	N	Y	N	Y
I START Toolkit (quick guide fact sheet)	University of British Columbia	Y	Y	N	N	N/S	N/S	N/S	N/S	N	N	Y	N/S	N/S	N/S	Resistance bands; free weights; body weight	N	Y	N	N
I START Toolkit (website)	University of British Columbia	N	Y	N	N	N/S	N/S	N/S	N/S	N	N	N	N/S	N/S	N/S	N/S	N	N	N	N
Rx for Health Rheumatoid Arthritis	Exercise is Medicine	Y	Y	N	Y	3-5	M-V; Somewhat hard	75-150 /week	Walking; biking; elliptical; rowing; water	Y	Y	Y	2-3	M-V (start light)	2-3 sets 10-15 reps	Free weights; resistance bands; weight machines; body weight; all major muscle groups	N	Y	Y	Y
At home exercise guide	Arthritis Research Canada	Y	Y	N	Y	N/S	M; Talk but not sing	N/S	Dance; stair climbing; walking; boxing/martial arts; intervals	N	Y	Y	N/S	N/S	N/S	Body weight; resistance bands; free weights; weight machines; household items	N	Y	Y	N
Let's Move with Leon (Activity Tracker)	Versus Arthritis	Y	Y	N	Y	N/S	M-V	75-150 /week	M: brisk walk, swim, cycle; V: climb stairs, run, sports	Y	Y	N	2	N/S	N/S	Gym (specific upper, lower, and core exercises); yoga; heavy carrying	Y	Y	Y	Y
Let's Move with Leon (Videos)	Versus Arthritis	Y	Y	N	Y	N/S	M-V	75-150 /week	M: brisk walk, swim, cycle; V: climb stairs, run, sports	Y	Y	N	2	N/S	N/S	Gym (specific upper, lower, and core exercises); yoga; heavy carrying	Y	Y	Y	Y
Exercise Videos	National Rheumatoid Arthritis Society	Y	Y	N	N	N/S	N/S	N/S	N/S	N	Y	Y	N/S	N/S	N/S	Arm raises; sit to stand; wrist alphabet; seated leg and feet exercises; grip strength; supported lunge; chair push up	N	Y	N	N
Strong with Arthritis Webinar (Arthritis Research Education Series Ep.9)	University of British Columbia	Y	Y	N								Y	N/S	6-8/10 RPE	2-3 sets 10-15 reps	Body weight; resistance bands; weight training machines; push, pull, squat/lunge, hinge, lateral, rotation	Y	Y	N	N
Importance of physical activity and exercise (SMILE-RA)	National Rheumatoid Arthritis Society	Y	Y	N	N	N/S	N/S	N/S	Low impact; swimming; walking; cycling; return to regular activities;	Y	Y								N	N

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Online physical activity resources for individuals with rheumatoid arthritis: An environmental scan and quality appraisal

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Article Title

Online physical activity resources for individuals with rheumatoid arthritis: An environmental scan and quality appraisal

Abstract

Objectives: To review publicly available physical activity (PA) resources for individuals with rheumatoid arthritis (RA). Aims were to find online print and audiovisual resources, review their characteristics, and critically examine their quality from medical, exercise, and behavioral science perspectives.

Design: An environmental scan was completed using the Google search engine, following a pragmatic approach to reviewing patient-facing self-care resources.

Data sources: We used combinations of common search terms for RA and PA. The first 5 pages of results were reviewed for patient-facing resources.

Eligibility criteria: Resources were included if they were (1) included RA-specific content, (2) provided specific PA recommendations, (3) written in English, and (4) freely available.

Data extraction and synthesis: Two independent experts completed a medical review of resources to ensure appropriateness for RA. Data was then extracted by two reviewers using a standardized template to record resource characteristics. Two research team members and two patient partners independently evaluated resources for readability, understandability, and actionability. Lastly, the quality of exercise recommendations and behavior change technique use was evaluated by an expert reviewer.

Results: The search yielded 23 RA-specific PA resources, 17 of which passed the medical review. All 10 print resources and 7 audiovisual resources were created in English-speaking countries. The mean reading grade was 9.0±1.5. Print resources had mean understandability of 80.0±9.8% and actionability of 60.0±27.7%. Audiovisual materials had mean understandability of 86.0±9.2% and actionability of 86.9±22.9%. The quality of exercise recommendations was low. Only 1 resource provided comprehensive cardiovascular exercise advice, and 2 resources provided comprehensive strength exercise advice. 3-14 behavior change technique groups

were featured in each resource. The most common groups were “shaping knowledge” and “natural consequences”.

Conclusions: The quality of RA-specific PA resources is variable. Some high-quality resources exist that provide actionable PA behavior change advice. Healthcare teams may refer patients to these resources. However, more work is needed to improve the overall quality of resources. Co-development with patients, providers, and exercise behavior change experts is recommended, ensuring resources are actionable, contain clear exercise recommendations, and promote behavior change.

Strengths and limitations of this study

- The study provides a comprehensive overview and critical appraisal of publicly available physical activity resources for individuals with rheumatoid arthritis.
- A critical appraisal was completed by a rheumatologist, patient partners with lived experiences of rheumatoid arthritis, researchers, and an exercise and behavior change expert.
- All resources were evaluated using standard measures for readability, understandability, actionability, exercise recommendations, and behavior change techniques.
- Due to the inherent subjectivity of the tool used to assess understandability and actionability, triplicate ratings were completed for each resource to minimize subjective biases.
- Patient partners were individuals with high health literacy and personal engagement with their health, which may impact certain scores and their generalizability to the broader RA population.

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Declaration of competing interests

The authors have no conflicts of interest to declare.

Abbreviations

DMARDs = Disease-Modifying Anti-Rheumatic Drugs

FITT = Frequency, Intensity, Time, Type

HCP = Healthcare Provider

PA = Physical Activity

PEMAT = Patient Education Materials Assessment Tool

RA = Rheumatoid Arthritis

1.0 Introduction

Rheumatoid arthritis (RA) is a chronic autoimmune inflammatory disease affecting around one percent of Canadians [1]. Chronic inflammation of the joints and throughout the body leads to systemic problems, compromised function, and reduced quality of life [2]. Despite significant improvements in RA treatment due to the emergence of new classes of disease-modifying anti-rheumatic drugs (DMARDs), individuals living with RA continue to face daily challenges [3-5]. These challenges include unpredictable disease flare ups, changes in disease activity, debilitating chronic fatigue and pain, and significant psychological distress [5].

Effective disease self-management (or self-care, as preferred by patients) between regularly scheduled follow-up appointments is critical to quality RA care. Indeed, major international rheumatology associations such as the European League Against Rheumatology (EULAR) recommend the implementation of self-management strategies for RA care [6]. Recommended strategies include patient education, goal setting and problem solving, lifestyle advice, and connecting patients to resources [6].

Physical activity is strongly recommended as part of effective RA self-management [6-8]. Regular physical activity can positively impact many disease-related and general health outcomes among RA populations [7-13]. For example, physical activity can significantly reduce fatigue, pain, and inflammation while improving functional ability and body composition [9-11]. It is positively associated with better strength and cardiorespiratory fitness and enhanced quality of life, while reducing the risk of cardiovascular disease and all-cause mortality [9, 12, 13]. The health benefits of regular physical activity can also reduce individual- and system-level healthcare costs [14]. Unfortunately, individuals with RA report lower than average physical activity levels, and physical activity support in routine RA clinical care remains limited [9, 15].

Greater efforts are needed to help individuals with RA become and stay physically active as part of their day-to-day disease self-management. Individuals with RA lack disease-specific physical activity resources, express doubts about the safety and effectiveness of physical activity, and rarely receive physical activity advice from their care team [16]. Publicly available, RA-specific physical activity resources may be helpful for addressing these problems. However, the quality of online health information is highly variable, and individuals with chronic conditions struggle to find suitable, credible high-quality resources [17, 18]. They may also find it difficult to discern what recommendations are appropriate given their current concerns.

Therefore, we completed an environmental scan of publicly available physical activity resources for individuals living with RA. Specific goals were to identify available resources, provide an overview of their characteristics, and critically examine their quality. High-quality resources identified herein can serve as a foundation for patients and providers to improve physical activity behavior change as part of RA self-management. Meanwhile, the shortcomings among existing resources can inform future research and development.

2.0 Materials and methods

We completed an environmental scan and critical appraisal of publicly available online resources on physical activity for individuals living with rheumatoid arthritis [19]. Environmental scans are a form of pragmatic content review that has been used extensively in healthcare to understand the quantity and quality of available health resources such as patient education materials [19].

2.1 Patient and public involvement

Patient partners with lived experiences of RA were involved throughout the study. The study was conducted in direct response to conversations with patient partners and reports in the literature that indicate challenges with accessing high-quality information on physical activity. Their opinions informed the study design, including the search strategy and selection of measures for critical appraisal. Furthermore, three patient partners were involved in assessing understandability and actionability of the included resources. Patient partners were recruited from existing relationships with patients involved in a larger project being conducted by the research team on improving physical activity support for individuals living with RA. Individuals with

prior experience reviewing patient-facing RA self-care resources [20] were invited to participate by email. The email included a brief overview of the study objectives and explained the purpose of patient partner involvement with the critical appraisal of resources. All invitations included the option to decline participation. Patient partners will also be involved in sharing lay summaries of our findings with patient organizations.

2.2 Search Strategy

An online search was carried out using the Google search engine from January-April 2024. The search strategy was developed, tested, and refined by three members of the research team (ME, SZ, CB). Searches were repeated using various combinations of search terms related to rheumatoid arthritis, physical activity, and program or resource. Search terms were obtained from existing patient materials and relevant scientific literature. Additional searches were completed after adding a term for the major countries contributing to English language patient resources (e.g. United States, United Kingdom, Canada, Australia). The complete list of search terms used for each concept is presented in the online Supplementary File 1. To reduce bias in search results due to prior search history, all searches were completed using Google Chrome's Incognito mode on a shared lab computer. As research suggests that most online search traffic is on the first two results pages, all links on these pages were reviewed [21]. Authors also screened the results on pages 3-5 to make sure no relevant resources were missed. To be included in the environmental scan, resources had to meet the following inclusion criteria: (1) freely available, (2) written in English, (3) developed specifically for individuals living with rheumatoid arthritis, and (4) containing at least 1 recommendation for physical activity. Resources were excluded based on the following criteria: (1) payment required to access, (2) presence of predatory advertising (3) intended for healthcare professionals or researchers, (4) information not specific to rheumatoid arthritis, and (5) absence of physical activity recommendations (e.g. sign-up page for a physical activity program). During the medical review (described below), any resources deemed unsafe or inappropriate by a rheumatologist were also excluded.

2.3 Data Extraction

A data extraction spreadsheet was used to record resource characteristics including URL, title, organization, country of origin, date created or last updated, format (print, audiovisual), type (e.g. blog post, slideshow, PDF handout, video), and interactivity. A resource was deemed to be interactive if it prompted the user to complete an action or answer a question while viewing the content. If reported, additional data was recorded on the availability of translated versions of the resource, as well as the involvement of healthcare professionals or patient partners in resource development.

2.4 Critical Appraisal

The included resources underwent a comprehensive critical appraisal for medical appropriateness, readability, understandability, actionability, quality of exercise recommendations, and use of behavior change techniques. While physical activity is any body movement that expends energy, exercise is a subset of structured, planned physical activity that aims to improve physical fitness [22]. The focus of the critical appraisal was specifically on exercise.

2.4.1 Medical Review

The medical review was completed by a rheumatologist (CB) on the research team, in collaboration with research co-lead (ME), an exercise specialist with a PhD in Kinesiology focusing on exercise psychology among individuals with chronic conditions. Each resource was reviewed to ensure that the content was safe and appropriate for patients with RA in the opinion of a rheumatologist. Factors considered included (1) whether information provided in the resource about RA and its management was medically accurate, as well as, (2) whether the exercise recommendations would be safe from a medical perspective for patients with RA. Each resource received a yes/no rating along with additional comments for consideration by the research co-lead (ME). Both team members met to discuss resources and achieve consensus on final decisions to include or exclude the resource. Only resources that had no concerns across both factors were approved as medically suitable for the general population of RA patients, based on clinical experience. Resources with any concerns were deemed unsuitable and excluded from further review.

2.4.2 Readability

The validated and widely used Flesch-Kincaid Reading Grade score was used to assess readability [23]. It has demonstrated both content- and criterion-related validity across various written materials. Document text was copied into Microsoft Word and the Flesch-Kincaid Reading Grade score was calculated using the automated proofreading tools in Microsoft Word. The formula used is 0.39*mean words per sentence + 11.8*mean syllables per word – 15.59. Numbers range from 1-18, corresponding to the United States school grade reading level required to understand the resource. Grade 1-5 is a primary school, grades 6-8 middle school, and grades 9-12 correspond to secondary/high school in this system. Scores of 13-15 are considered college reading level and 15-18 is considered post-graduate level.

2.4.3 Understandability and Actionability

Understandability and actionability were assessed using the Patient Education Materials Assessment Tool (PEMAT) [24]. This tool has demonstrated strong internal consistency and reliability, can be used by both researchers and patient partners, and can be used for both print (PEMAT-P, 24 items) and audio-visual (PEMAT-A/V, 17 items) resources. The understandability domain includes evaluation of 6 sub-domains for content, word choice and style, use of numbers, organization, layout and design, and use of visual aids. Actionability measures the degree to which a resource provides specific actionable steps for patients using the provided information (e.g. feasibility, specificity, relevance). The PEMAT user guide includes specific instructions for the rating of each item as 1 (agree), 0 (disagree), or not applicable [25]. All assessors adhered closely to the PEMAT user guide for rating each resource [25]. Researchers and patient partners were trained using the PEMAT user guide PDF and a virtual 1:1 session with a member of the research team (KD) as needed [25]. Those with no prior PEMAT experience (ME) completed a practice session with an experienced PEMAT rater (KD) to ensure consistency.

To ensure consistency, each resource was reviewed by 3 assessors: 2 researchers (ME and KD) and 1 patient partner (Either AM, CG, or GL). Discrepancies between researcher ratings were resolved by open discussion to achieve a consensus researcher score. Understandability and actionability scores, as well as overall PEMAT scores, were calculated according to PEMAT scoring guidelines [24]. The percentage of possible points

achieved in each domain was calculated, where 100% indicates that the resource received a rating of 1 (agree) on all applicable items in that domain. Mean scores were calculated using equal weighting for the consensus researcher score and the patient partner score. A higher percentage indicates better understandability or actionability.

2.4.4 Exercise Recommendations Review

The exercise review was completed by a clinical exercise specialist (ME) on the research team. Each resource was reviewed in detail to assess the presence of exercise recommendations, exercise cautions, specific and actionable exercise tips, and tailored exercise advice for rheumatoid arthritis. This information was recorded using a standard data extraction spreadsheet, with separate sections for cardiovascular, strength, balance, and stretching exercise. Exercise types that were not mentioned at all were left blank in the data extraction spreadsheet. Meanwhile, missing information was noted as "not specified". Recommendations to consult with a healthcare professional or qualified exercise professional were recorded.

2.4.5 Behavior Change Techniques Review

The behavioral review was completed by a physical activity behavior change expert (ME) on the research team. To assess the use of behavior change techniques for physical activity behavior, each resource was reviewed using a standard data extraction spreadsheet based on the behavior change technique taxonomy [26]. This taxonomy is the gold standard for classifying behavior change techniques in physical activity behavior change research. The presence of behavior change techniques was recorded across the 16 groups from the behavior change technique taxonomy. Groups were either considered present, if one or more techniques from that group were identified, or absent, if none of the techniques were used.

3.0 Results

An overview of the environmental scan phases is shown in Figure 1. Our initial search yielded 33 potential resources. After screening the resources, 10 of them were excluded as they did not meet our inclusion criteria. Eight of these were landing pages for in-person or online exercise programs. One was not available in English,

and another was not intended for rheumatoid arthritis. Twenty-three resources were included in the data extraction and critical appraisal phases.

3.1 Medical review

After completing the medical review, 17 resources were approved as safe and appropriate for individuals with RA [27-43]. Six resources were excluded due to concerns about appropriateness for individuals with RA (1/23), predatory advertising (2/23), or both (3/23). Notable concerns among the excluded resources were the recommendation of potentially unsuitable weight-bearing exercises (e.g. push-ups and other exercises that load the hands and wrists) without sufficient modification for RA patients with joint symptoms, as well as blanket statements to avoid certain exercises (e.g. high impact, high intensity), which may still be suitable for individuals with well-controlled RA. In contrast, another resource wrote that “exercise is uncomfortable for 85% of people with RA”. The statement was not supported by scientific evidence and may discourage physical activity engagement despite its many benefits. Some resources were deemed inappropriate due to predatory advertisements (e.g. weight loss medications) and stock images (e.g. able-bodied, younger white women) that are not representative of the RA population. The critical appraisal was completed only for the 17 resources that passed the medical review.

3.2 Resource characteristics

Of these 17 resources, 14 were created or updated between 2020-2024 (Table 1). All resources originated from English-speaking countries, including the USA (n=3), Canada (n=8), UK (n=5), and Australia (n=1). Ten resources were print materials of various formats (Blog post, brief article, slideshow, PDF), whereas the remainder were audiovisual resources (e.g. videos, multimedia materials). Only 6 resources included an interactive component. The involvement of healthcare professionals and patient partners was documented in 14 and 8 resources, respectively. A single resource was available in Spanish and English. All others were only available in English. Table 1 presents the characteristics for each resource.

Title	Organization	Country	Date Created	Type	Interactive	Language	HCPs Involved	Patients Involved

			or Updated					
Print Resources								
Exercise and RA	Arthritis Australia	Australia	June 2024	Brief article	No	English	Unclear	Unclear
At home exercise guide	Arthritis Research Canada	Canada	July 2022	Brief article	No	English	Yes	Yes
30-Day Exercise Challenge for Arthritis	Arthritis Research Canada	Canada	January 2020	PDF workbook	Yes	English	Yes	Unclear
Exercise for RA	Health Link BC	Canada	September 2022	Brief article	No	English	Yes	Unclear
I START Toolkit (quick guide fact sheet)	University of British Columbia	Canada	2023	PDF handout	No	English	Yes	Yes
I START Toolkit (website)	University of British Columbia	Canada	2023	Brief article	No	English	Yes	Yes
Let's Move with Leon activity tracker	Versus Arthritis	UK	2024	PDF workbook	Yes	English	Yes	Unclear
Best Exercises for RA	Arthritis Foundation	USA	Unknown	Slideshow	No	English	Unclear	Unclear
EIM Rx for Health Rheumatoid Arthritis	Exercise is Medicine	USA	2021	PDF handout	No	English, Spanish	Unclear	Unclear
Exercise can ease RA pain	Harvard Health Publishing	USA	May 2023	Blog post	No	English	Yes	Unclear
Audiovisual Resources								
How to stay active at home during COVID-19 (Arthritis at Home)	Arthritis Consumer Experts	Canada	April 2020	Video	No	English	Yes	Unclear
Indoor Exercise Snacks (Arthritis At Home Ep.16)	Arthritis Consumer Experts	Canada	May 2020	Video	Yes	English	Yes	Unclear
Strong with Arthritis (Arthritis Research Education Series)	Arthritis Research Canada	Canada	March 2023	Video	No	English	Yes	Yes

Exercise Videos	National Rheumatoid Arthritis Society	UK	October 2017	Video series	No	English	Yes	Yes
Importance of physical activity and exercise (SMILE-RA)	National Rheumatoid Arthritis Society	UK	September 2021	Interactive platform	Yes	English	Yes	Yes
Yoga Exercises (SMILE-RA)	National Rheumatoid Arthritis Society	UK	September 2021	Video	Yes	English	Yes	Yes
Let's Move with Leon	Versus Arthritis	UK	2024	Video series	Yes	English	Yes	Yes

Table 1: Characteristics of the 17 included physical activity resources for individuals with rheumatoid arthritis. HCP = Healthcare provider.

3.3 Readability

The readability, understandability, and actionability scores of the included physical activity resources is summarized in Table 2. The mean reading grade level of the 10 print resources was grade 9.0±1.5. Only one resource was written at or below a sixth-grade level [35]. A second resource fell within the seventh-grade range [33]. All other print resources required a reading level of grade 9 or higher.

Print Resources			**FK Reading Grade**	**PEMAT**	**PEMAT**
Article	**Organization**	**Country**	**Readability**	**Understandability**	**Actionability**
Exercise and RA	Arthritis Australia	Australia	10	80.1%	57.5%
At home exercise guide	Arthritis Research Canada	Canada	8.6	92.3%	50.0%
30-Day Exercise Challenge for Arthritis	Arthritis Research Canada	Canada	8.9	84.0%	91.7%
Exercise for RA	Health Link BC	Canada	9.8	71.5%	30.0%
I START Toolkit: Quick guide fact sheet	University of British Columbia	Canada	8.9	82.6%	70.0%

I START Toolkit: Website	University of British Columbia	Canada	9.9	62.5%	73.3%
Let's Move with Leon activity tracker	Versus Arthritis	UK	7.0	91.2%	100.0%
Best Exercises for RA	Arthritis Foundation	USA	9.2	76.0%	28.3%
EIM Rx for Health Rheumatoid Arthritis	Exercise is Medicine	USA	6.4	89.4%	80.0%
Exercise can ease RA pain	Harvard Health Publishing	USA	11.5	70.8%	20.0%
	Mean (SD)		9.0 (1.5)	80.0 (9.8)%	60.0 (27.7)%
Audiovisual Resources			**FK Reading Grade**	**PEMAT**	**PEMAT**
Article	**Organization**	**Country**	**Readability**	**Understandability**	**Actionability**
How to stay active and exercise at home during COVID-19 (Arthritis At Home)	Arthritis Consumer Experts	Canada	N/A	84.3%	87.5%
Indoor Exercise Snacks Higher Intensity (Arthritis At Home)	Arthritis Consumer Experts	Canada	N/A	79.4%	100.0%
Strong with Arthritis Webinar (Arthritis Research Education Series)	University of British Columbia	Canada	N/A	71.5%	37.5%
Exercise Videos	National Rheumatoid Arthritis Society	UK	N/A	90.9%	83.3%
Importance of physical activity and exercise (SMILE-RA)	National Rheumatoid Arthritis Society	UK	N/A	91.3%	100.0%
Yoga Exercises (SMILE-RA)	National Rheumatoid Arthritis Society	UK	N/A	84.7%	100.0%
Let's Move with Leon	Versus Arthritis	UK	N/A	100.0%	100.0%
	Mean (SD)			**86.0 (9.2)%**	**86.9 (22.9)%**

Table 2: Readability, understandability, and actionability of the included physical activity resources. FK = Flesch-Kincaid. PEMAT = Patient Education Materials Assessment Tool.

3.4 Understandability and actionability

After being assessed by both researchers and patient partners, the mean understandability ratings were 80.0±9.8% for print materials and 86.0±9.2% for audiovisual materials (Table 2). Actionability ratings were lower for print materials (60.0±27.7%) than audiovisual materials (86.9±22.9%). Whereas all resources scored above 60% for understandability, 50.0% (5/10) of the included print resources and 14.3% (1/7) of the audiovisual resources had actionability ratings below 60%. The highest scoring print resources were the "Let's move with Leon" PDF activity tracker workbook from Versus Arthritis, the "Rx for Health Rheumatoid Arthritis" PDF information sheet from Exercise is Medicine, and the "30-day Exercise Challenge for Arthritis" from Arthritis Research Canada [29, 33, 35]. All three scored above 80% for understandability and actionability. Meanwhile, the highest scoring audiovisual resources were the "Let's move with Leon" video series from Versus Arthritis and the "Importance of physical activity and exercise" interactive module on the National Rheumatoid Arthritis Society's "SMILE-RA" online learning platform [41, 43]. These two scored above 90% for understandability and actionability. Individual ratings for each resource are displayed in Table 2.

3.5 Exercise review

The quality of exercise recommendations provided was highly variable across the resources, as shown in Table 3. Specific exercise recommendations in at least one domain (e.g. cardiovascular, strength, balance, flexibility) were included in 14/17 (82.4%) resources. Most resources recommended professional help from a doctor (11/14, 78.6%) and exercise professional (14/14, 100%) for starting or resuming exercise after being diagnosed with RA. Of the 14 resources with exercise recommendations, 13 (92.9%) provided cardiovascular exercise recommendations, 13 (92.9%) provided strength exercise recommendations, 6 (42.9%) provided flexibility exercise recommendations, and 5 (35.7%) provided balance exercise recommendations.

Cardiovascular exercise was defined in lay terms in 5/14 (38.5%) of resources that recommended it. A complete (i.e. specific details for all four variables: frequency, intensity, time, and type) prescription for

cardiovascular exercise was included in only 1/13 (7.7%) of these resources. The remaining resources provided either a partial (i.e. specific details missing for one or more variables) prescription (6/13, 46.2%) or none (6/13, 46.2%). Details for how to progress exercise gradually (6/13, 46.2%) and RA-specific exercise tailoring (i.e. exercise adaptations and/or cautions for common RA symptoms) (8/13, 61.5%) were present in more than half of these resources. Four (30.8%) resources did not provide any RA-specific tailoring for cardiovascular exercise.

Common RA-specific advice included exercising more when RA symptoms are lowest, resting if symptoms are too high, choosing lower impact exercise types (e.g. swimming) to reduce stress on joints, focusing on less-affected areas of the body when flaring, using appropriate footwear to minimize pain, ensuring a gradual warm-up and cool-down, and starting slow before progressing exercise frequency, intensity, or time. Resources cautioned individuals with RA to avoid exercise during flare ups, reduce intensity or time if exercise leads to unexpected pain, avoid vigorous or high impact exercises at affected joints, and return slowly to cardiovascular exercise after flares or other medical events.

Strength exercise was defined in lay terms in 8/13 (61.5%) of resources that recommended it. These resources provided either a complete (2/13, 15.4%) or partial (4/13, 30.8%) strength exercise prescription. Seven (53.8%) resources did not provide any prescription. Information was provided on gradual exercise progression (4/13, 30.8%) and RA-specific exercise tailoring (8/13, 61.5%) for strength exercise. Four (30.8%) resources did not provide any RA-specific tailoring for strength exercise.

RA-specific strength training recommendations included planning strength training when symptoms are lowest, using water-based exercises to reduce strain on joints, strengthening muscles around affected joints, using resistance bands and wrapping them around wrists if grip strength is limited, using padded gloves and shoes for extra comfort, reducing weights and duration when symptoms are worse. Resources cautioned against intense strength exercise during flares and suggested using braces and professional supervision to minimize injury risk. Further details on the cardiovascular and strength exercise prescriptions and RA-specific advice provided by each resource can be found in the Supplementary File 2.

Title	Professional Help		Cardiovascular Exercise Recommendation				Strength Exercise Recommendation				Balance	Flexibility
	Doctor	Exercise Professional	Definition provided	FITT Rx	Progression	Tailored to RA	Definition Provided	FITT Rx	Progression	Tailored to RA		
Exercise and RA	X	X		Partial	X	X	X	None				
30-Day Exercise Challenge for Arthritis		X		Partial	X			Complete	X	X		
At home exercise guide	X	X	X	Partial		X	X	None		X	X	
Exercise for RA	X	X		None			X	None				X
I START Toolkit (quick guide fact sheet)	X	X		None			X	None		X		
I START Toolkit (website)		X		None				None				
Strong with Arthritis (Arthritis Research Webinar)	X	X					X	Partial	X	X		
Exercise Videos	X	X		None		X	X	Partial		X		
Importance of physical activity and exercise (SMILE-RA)	X	X		Partial	X	X						
Let's Move with Leon (Activity Tracker)	X	X	X	Partial	X	X		Partial	X	X	X	X
Let's Move with Leon (Videos)	X	X	X	Partial	X	X		Partial	X	X	X	X

Best Exercises for RA	X	X	None			None				X	
Rx for Health Rheumatoid Arthritis	X	X	X	Complete	X	X	X	Complete	X	X	X
Exercise can ease RA pain		X	X	None		X	X	None		X	X

Table 3: Summary of exercise recommendations provided by the included physical activity resources. FITT = frequency, intensity, time, type.

3.6

Behavior Change Techniques review

Supplementary File 3 presents the groups of behavior change techniques used in each resource. Out of 16 possible groups, the mean number of behavior change groups used was 9.0±4.4 for PDF resources, 5.7±2.1 for websites, and 6.3±4.5 for audiovisual resources. Five (29.4%) resources used 8 or more (i.e. over 50%) of the behavior change groups. The resources with the highest number of behavior change groups used were the "Let's move with Leon" PDF workbook and video series from Versus Arthritis (14 behavior change groups used in both resources) and the "Importance of physical activity and exercise" module within the National Rheumatoid Arthritis Society's SMILE-RA interactive learning platform (11 behavior change groups used) [33, 41]. All 16 behavior change groups were used in at least one resource. The least common behavior change groups used were "identity" (Group 13), "scheduled consequences" (Group 14), and "covert learning" (Group 16), each appearing in only 2 resources. In contrast, "shaping knowledge" (Group 4) and "natural consequences" (Group 5) were the most common, appearing in 17/17 (100%) and 13/17 (76.5%) resources, respectively.

4.0 Discussion

4.1 Principal findings

Physical activity is internationally recommended as a key component of RA care, contributing to improved overall health and quality of life [7-15]. Patient-facing online resources may help individuals with RA become and stay physically active. Through our environmental scan of online RA-specific physical activity resources, we identified 23 resources, 6 of which were excluded due to predatory advertising or medical concerns [27-43]. A comprehensive critical appraisal of the 17 remaining resources, 10 print and 7 audiovisual, highlighted high overall understandability. Several resources stood out for having high actionability that was supported by detailed exercise recommendations and strong use of behavior change techniques. Audiovisual resources had higher average actionability than print resources. However, many resources left room for improvement with regards to readability and actionability. These concerns were often compounded by incomplete exercise recommendations and behavior change support, reducing the potential impact of these resources on physical activity behavior change.

4.2 Study meaning in relation to related research

Medical appropriateness concerns for individuals with RA continue to be a weakness among online patient resources. Alongside the present study, where 26% of the resources were excluded due to concerns, a recent environmental scan of flare self-management resources excluded 32% of resources for inappropriate advertisements or medical concerns [20]. Weight loss medications and programs were commonly advertised and often included stigmatizing language, which could be harmful to patients. In prior work, patients expressed concerns about the poor quality of patient materials, causing them to distrust online information [18]. Physical activity resources should always be reviewed by rheumatologists, exercise professionals, and patients to ensure safety prior to publication. Furthermore, caution must be taken to ensure that advertisements, if present, are appropriate for the target population. This can be challenging for YouTube and other social media platforms where additional recommendations and advertisements are automated. Some resources were flagged during expert review for their negative tone and advanced exercise examples. To ensure that future resources empower, rather than discourage, physical activity behavior change, emphasis on positive messaging and gradual progression is preferable.

Certain resources stood out during the critical appraisal. These resources had high understandability and actionability scores, as well as detailed exercise and behavior change content [29, 33, 40, 41, 43]. Four of these resources were developed by organizations in the United Kingdom (Versus Arthritis [33, 43], National Rheumatoid Arthritis Society [40, 41]) and one was created in Canada (Arthritis Research Canada [29]). Notable differences between these and other resources were the presence of interactive components (e.g. follow-along exercises, goal-setting prompts, self-monitoring tools) and the involvement of healthcare teams, exercise professionals, and patients in resource development. In line with evidence-based best practices for creating patient materials, these findings further emphasize the importance of co-development with relevant partners [44, 45]. For physical activity resources, this may include members of the target population (e.g. individuals with RA), healthcare providers, exercise professionals, and behavior change experts.

Whereas understandability was generally acceptable across the physical activity resources, more work is needed to improve their readability and actionability. The average reading level in both the present work and prior studies is often above 8th grade, with little or no patient materials meeting the recommended level of grade 6 or lower [46, 47]. Adding to this challenge is the limited translation of patient materials, despite the high prevalence of non-native English speakers in Canada and other English-speaking countries [48]. Rapid improvements in automated translation through Google Translate and other artificial intelligence-based tools may help address this gap. A common shortcoming among patient materials, noted above and across the literature, is a lack of actionability [20]. Specific actionable steps are key to eliciting physical activity behavior change among RA populations [49-51]. Close collaboration with patient partners is required to ensure that written and audiovisual content is actionable. The PEMAT emphasizes the importance of including clear actions, manageable steps, tools to support action, and visual aids to enhance actionability [24]. We noted that audiovisual content across the reviewed resources featured either stock images of healthy, younger adults or white women with RA without apparent physical limitations. More representative content is warranted to encourage physical activity behavior change across the range of ages, ethnicities, and physical abilities of RA patients.

Comprehensive exercise recommendations are essential to physical activity promotion as part of RA management. First, individuals with RA need specific information on the frequency, intensity, time, and type (or FITT) of physical activity to address lack of knowledge, a common physical activity barrier in this population [49-51]. The reviewed RA-specific physical activity resources rarely provided complete FITT recommendations or covered all 4 key domains of physical fitness: cardiovascular, strength, balance, and flexibility. Future resources should aim to address this shortcoming. Second, individuals with RA may be unsure how to continue being physically active after an RA diagnosis, with fears about exacerbating RA symptoms [16]. While many resources provided some RA-specific suggestions for tailoring and progressing exercise, physical activity promotion efforts in this population could benefit from standardized physical activity guidelines. Relevant tailoring factors may include RA history and medications, joint damage and active inflammation, joint replacement precautions, and other health concerns impacting physical activity tolerance. Such guidelines are common for chronic conditions such as cancer and cardiovascular disease [52, 53]. Due to the breadth of important information related to the 4 physical fitness domains and RA-specific tailoring, resource developers may purposefully select content that aligns with specific aims for a patient resource.

However, physical activity information alone does not necessarily lead to behavior change. Only some of the included patient resources placed a strong emphasis on behavior change. These resources leveraged evidence-based behavior change techniques such as goal-setting and self-monitoring, which have been shown to support physical activity behavior change [54]. Many of the resources, however, focused on educating individuals with RA about the importance of physical activity but did not provide sufficient tools for helping them become and stay active. A lack of actionable behavior change advice is likely to limit the potential positive impact of these resources in RA care. Consultation with a behavior change specialist is recommended for future physical activity resources. Importantly, online resources alone may not be sufficient to promote lasting physical activity behavior change among many individuals with RA. Work is needed to integrate further physical activity behavior change support into RA care pathways.

4.3 Clinical implications

For rheumatology care providers, our findings have important clinical implications. The list of RA-specific physical activity resources reviewed can serve as a useful starting point for supporting patients to set, meet, and adjust their physical activity goals. Providers are encouraged to keep a list of available resources to refer patients to, including information on the characteristics of the resources as well as the quality of content within them. Notably, the resources varied widely with respect to their purpose, content, format, complexity, and actionability. For example, resources covered one or more of the following domains: education on why to exercise, demonstration of how to exercise, guidance on talking about exercise with a care provider, tips for adopting and maintaining exercise habits, and more. This variety should be seen as a strength. Different content and delivery modes may work better for different patients. Optimal physical activity behavior change support should begin with a patient-led discussion around needs, preferences, available time and resources, motivation, and other relevant factors [55]. The provider can then use this information to provide tailored recommendations to available resources or additional support as part of a "personalized medicine" approach to physical activity. In addition to patient-provider discussions and recommendation of high-quality physical activity resources, rheumatology care teams may want to leverage mobile health technologies or tailored group-based programs (online or in-person, where available). These approaches have shown promise for helping individuals with RA increase their physical activity [56, 57].

4.4 Study strengths and limitations

The strengths of our work include the involvement of patient partners to assess understandability and actionability, the use of a search strategy that mimicked a real-world scenario of patients searching for resources, and the in-depth critical appraisal from patient, medical, exercise, and behavioral science perspectives. While this pragmatic single search engine strategy may have led to some resources being missed, resources not identified in the first 5 pages of Google search results are unlikely to be found by patients themselves [21]. A limitation to the use of the PEMAT is its inherent subjectivity. To counteract this, we completed triplicate ratings for all resources. The lack of a validated measure for assessing exercise and behavior change components of patient materials is also a limitation. In addition, the exercise and behavioral

appraisal was completed by a single author, which may have led to some coding biases despite significant expertise in the topic areas. Work is needed to develop such measures that can guide development and evaluation. Lastly, our patient partner team featured individuals with high health literacy and personal engagement in their health. This may have impacted the resultant PEMAT scores, limiting generalizability to all RA populations.

5.0 Conclusion

Our environmental scan identified a need for more high-quality physical activity resources for RA populations, which should be developed with patient partners and content experts. More work is needed to create resources that provide complete FITT recommendations for exercise and go beyond providing knowledge to truly empowering behavior change. To address health inequities, efforts must be made to create accessible resources for underserved populations. The use of more diverse audiovisual content and translation into other languages represent two steps in the right direction. A bigger library of excellent physical activity resources will better support the different needs, capabilities, and considerations of individuals with RA. Further research is also needed to develop and implement more intensive physical activity interventions for patients where resources alone are insufficient to promote behavior change.

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Author contributions

ME: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, supervision, visualization, writing – original draft, writing – reviewing and editing, guarantor. SZ: Data curation, formal analysis, methodology, writing – reviewing and editing. KD: Data curation, formal analysis, investigation, project administration, resources, writing – reviewing and editing. AMH:

Conceptualization, methodology, resources, writing – reviewing and editing. CG: Data curation, formal analysis, investigation, writing – reviewing and editing. AM: Data curation, formal analysis, investigation, writing – reviewing and editing. CB: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, resources, supervision, writing – original draft, writing – reviewing and editing.

Data availability

The data is available from the corresponding author upon reasonable request.

Supplementary material

Supplementary File 1: Complete list of search terms for the environmental scan of publicly available online physical activity resources for individuals with rheumatoid arthritis.

Supplementary File 2: Detailed exercise recommendations provided by each included resource.

Supplementary File 3: Overview of behavior change techniques identified in the included resources.

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Tables and Figures

Figure 1: Flow diagram of environmental scan and critical appraisal of physical activity resources for individuals with rheumatoid arthritis.

Table 1: Characteristics of the 17 included physical activity resources for individuals with rheumatoid arthritis. HCP = Healthcare provider.

Table 2: Readability, understandability, and actionability of the included physical activity resources. SD = Standard deviation. FK = Flesch-Kincaid. PEMAT = Patient Education Materials Assessment Tool.

Table 3: Summary of exercise recommendations provided by the included physical activity resources. FITT = frequency, intensity, time, type.

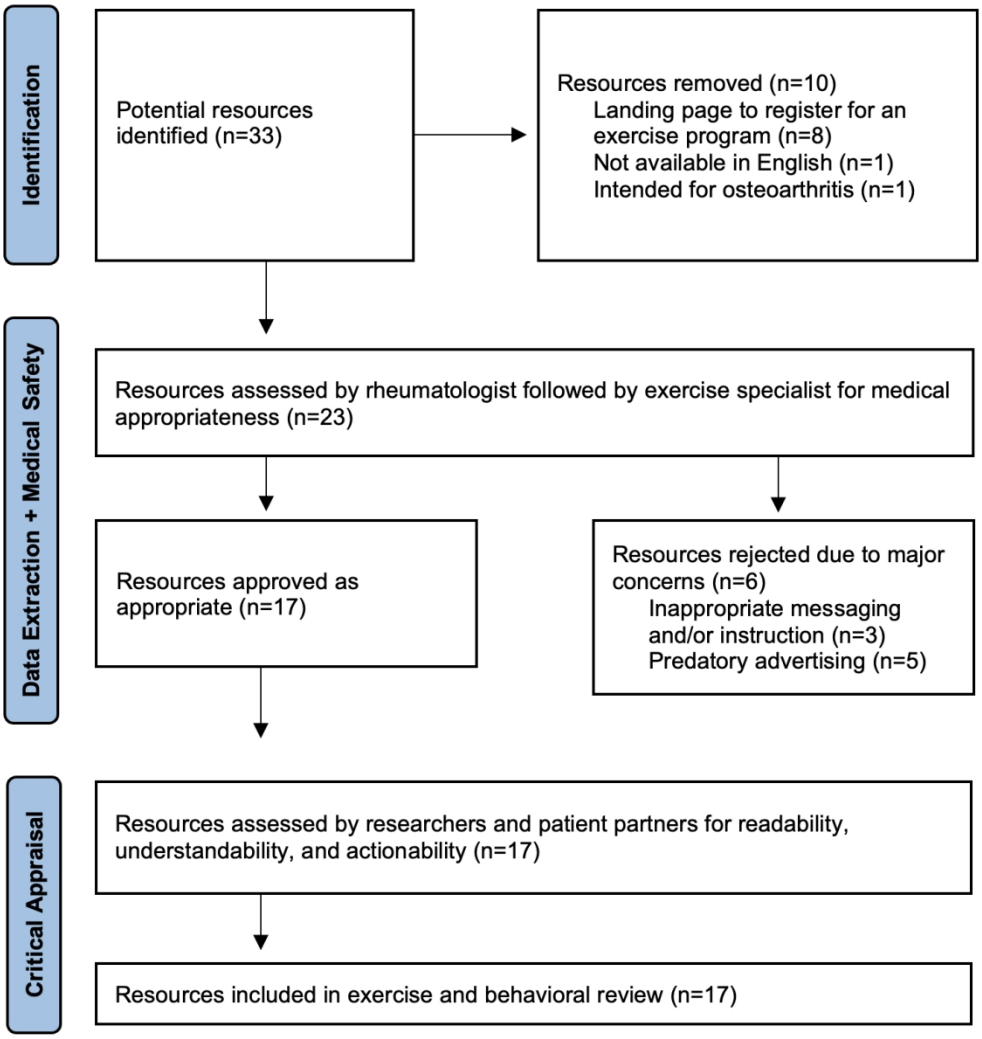

Figure 1: Flow diagram of environmental scan and critical appraisal of physical activity resources for individuals with rheumatoid arthritis.

262x275mm (144 x 144 DPI)

Supplementary File 1

Complete list of search terms for the environmental scan of publicly available online physical activity resources for individuals with rheumatoid arthritis.

Rheumatoid Arthritis	Physical Activity	Additional Descriptors
Rheumatoid arthritis	Physical activity	Resource
Rheumatology	Exercise	Handout
Arthritis	Sports	Program
Inflammatory arthritis	Movement	Group
	Fitness	Manual
	Exercising	Canada
	Strength exercise	US
	Cardio exercise	UK
	Exercise training	Europe
		Australia

Supplementary File 2

Detailed exercise recommendations provided by each included resource.

Title	Organization	Professional Help			Cardiovascular/Aerobic Exercise Recommendations							Strength/Resistance Exercise Recommendations							Other recommendat	
		Doctor	Exercise Professional	Personal Trainer	Definition provided	Frequency (weekly)	Intensity	Time (minutes)	Types	Progression	Tailored to RA	Definition Provided	Frequency (weekly)	Intensity	Time (sets/reps)	Types	Progression	Tailored to RA	Balance	Stretching
Exercising with Rheumatoid Arthritis	Exercise is Medicine	Y	Y	N	N	3-4	M-V	75-150 /week	Water; Activities you enjoy; variety	Y	Y	N	2-3	L-M	3 sets 10-15 reps	All major muscle groups; water; machines; free weights; body weight	N	Y	N	Y
Best Exercises for RA	Arthritis Foundation	Y	Y	N	N	N/S	N/S	N/S	Walking; Water; Biking	N	N	N	N/S	N/S	N/S	Water; Weight training	N	N	N	Y
30-Day Exercise Challenge for Arthritis	Arthritis Research Canada	N	Y	N	N	3-5	N/S	30/day	Walking; Biking; Water; Zumba; Golf; Gardening; Dancing; Exercise Games; Outdoor; Cardio Machines	Y	N	N	2-3	6-7/10 RPE	2-3 sets 8-12 reps	Resistance bands; free weights;	Y	Y	N	N
9 Best Excercises for RA pain	Medical News Today	Y	Y	N	N	N/S	N/S	N/S	Walking; Water; Biking	Y	Y	N	N/S	N/S	N/S	Resistance bands; grip strength (hands, wrists)	N	N	N	Y
Exercise can ease RA pain	Harvard Health Publishing	N	Y	N	Y	N/S	N/S	N/S	Walking; Water; Biking	N	Y	Y	N/S	N/S	N/S	Isometrics; free weights; weight machines	N	N	Y	Y
Make an Exercise Plan for RA	WebMD	Y	Y	Y	Y	5	N/S	30/day	Walking; biking; water; dance;	Y	Y	N	N/S	N/S	N/S	Free weights; resistance bands	N	N	N	Y
Exercise for RA	Health Link BC	Y	Y	N	N	N/S	N/S	N/S	Walking	N	N	Y	N/S	N/S	N/S	N/S	N	N	N	Y
Exercise helps ease arthritis pain and stiffness	MayoClinic	Y	Y	N	Y	Most days	Somewhat hard	150/week	Walking; water; biking	Y	Y	Y	2+	N/S	N/S	All major muscle groups; resistance bands; free weights; weight machines	N	N	N	Y
Exercise and RA	Arthritis Australia	Y	Y	N	N	N/S	N/S	N/S	Water;	Y	Y	Y	N/S	N/S	N/S	Free weights; weight machines; resistance bands; bodyweight	N	N	N	N
RA Exercises that are easy on your joints	WebMD	Y	Y	Y	N	Most days	M	30-60 /day	Stair climbing; walking; dancing; cardio machines; water	Y	Y	N	2-3	N/S	N/S	Free weights; weight machines; resistance bands; isometrics	N	Y	N	Y
7 Essential Everyday Exercises to Manage RA Pain	Healthline	Y	N	Y	N	N/S	N/S	N/S	Water; Biking; walking; cardio machines;	N	Y	N	2-3	N/S	N/S	Free weights; resistance bands	N	Y	N	Y
I START Toolkit (quick guide fact sheet)	University of British Columbia	Y	Y	N	N	N/S	N/S	N/S	N/S	N	N	Y	N/S	N/S	N/S	Resistance bands; free weights; body weight	N	Y	N	N
I START Toolkit (website)	University of British Columbia	N	Y	N	N	N/S	N/S	N/S	N/S	N	N	N	N/S	N/S	N/S	N/S	N	N	N	N
Rx for Health Rheumatoid Arthritis	Exercise is Medicine	Y	Y	N	Y	3-5	M-V; Somewhat hard	75-150 /week	Walking; biking; elliptical; rowing; water	Y	Y	Y	2-3	M-V (start light)	2-3 sets 8-15 reps	Free weights; resistance bands; weight machines; body weight; all major muscle groups	N	Y	Y	Y
At home exercise guide	Arthritis Research Canada	Y	Y	N	Y	N/S	M; Talk but not sing	N/S	Dance; stair climbing; walking; boxing/martial arts; intervals	N	Y	Y	N/S	N/S	N/S	Body weight; resistance bands; free weights; weight machines; household items	N	Y	Y	N
Let's Move with Leon (Activity Tracker)	Versus Arthritis	Y	Y	N	Y	N/S	M-V	75-150 /week	M: brisk walk, swim, cycle; V: climb stairs, run, sports	Y	Y	N	2	N/S	N/S	Gym (specific upper, lower, and core exercises); yoga; heavy carrying	Y	Y	Y	Y
Let's Move with Leon (Videos)	Versus Arthritis	Y	Y	N	Y	N/S	M-V	75-150 /week	M: brisk walk, swim, cycle; V: climb stairs, run, sports	Y	Y	N	2	N/S	N/S	Gym (specific upper, lower, and core exercises); yoga; heavy carrying	Y	Y	Y	Y
Exercise Videos	National Rheumatoid Arthritis Society	Y	Y	N	N	N/S	N/S	N/S	N/S	N	Y	Y	N/S	N/S	N/S	Arm raises; sit to stand; wrist alphabet; seated leg and feet exercises; grip strength; supported lunge; chair push up	N	Y	N	N
Strong with Arthritis Webinar (Arthritis Research Education Series Ep.9)	University of British Columbia	Y	Y	N								Y	N/S	6-8/10 RPE	2-3 sets 8-15 reps	Body weight; resistance bands; weight training machines; push, pull, squat/lunge, hinge, lateral, rotation	Y	Y	N	N
Importance of physical activity and exercise (SMILE-RA)	National Rheumatoid Arthritis Society	Y	Y	N	N	N/S	N/S	N/S	Low impact; swimming; walking; cycling; return to regular activities;	Y	Y								N	N

Supplementary File 3

Overview of behavior change techniques identified in the included resources.

One (1) = Goals and planning. Two (2) = Feedback and monitoring. Three (3) = Social support. Four (4) = Shaping knowledge. Five (5) = Natural consequences. Six (6) = Comparison of behavior. Seven (7) = Associations. Eight (8) = Repetition and substitution. Nine (9) = Comparison of outcomes. Ten (10) = Reward and threat. Eleven (11) = Regulation. Twelve (12) = Antecedents. Thirteen (13) = Identity. Fourteen (14) = Scheduled consequences. Fifteen (15) = Self-belief. Sixteen (16) = Covert learning.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total /16
Print (PDF)															**Mean (SD)**		**9.0 (4.4)**
I START Toolkit: Quick guide fact sheet	**X**	**X**	**X**	**X**	**X**						**X**						6
Let's Move with Leon Activity Tracker	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**		14
Rx for Health Rheumatoid Arthritis	**X**		**X**	**X**	**X**			**X**	**X**		**X**						7
Print (Website)															**Mean (SD)**		**5.7 (2.1)**
Exercise and RA			**X**	**X**	**X**			**X**	**X**								5
30-Day Exercise Challenge for Arthritis	**X**	**X**		**X**		**X**		**X**	**X**		**X**	**X**			**X**		9
At home exercise guide			**X**	**X**	**X**			**X**	**X**		**X**	**X**				**X**	8
Exercise for RA				**X**	**X**				**X**								3
I START Toolkit: Website	**X**		**X**	**X**	**X**	**X**						**X**					6
Best Exercises for RA			**X**	**X**	**X**			**X**	**X**								5

Exercise can ease RA pain			X	X	X				X								4
Audiovisual															**Mean (SD)**		**6.3 (4.5)**
How to stay active and exercise at home during COVID-19	X	X		X			X										4
Indoor Exercise Snacks Higher Intensity				X		X		X									3
I START Toolkit: strength training for RA		X		X	X			X	X		X						6
SMILE-RA: Importance of physical activity and exercise	X	X	X	X	X	X		X	X	X					X	X	11
Exercise Videos				X	X	X			X								4
SMILE-RA: Yoga exercises				X		X											2
Let's Move with Leon Exercise Program	X	X	X	X	X	X	X	X	X	X		X	X	X	X		14
Total (N)	8	7	10	17	13	8	3	10	12	3	5	5	2	2	4	2	
Total (%)	47.1	41.2	58.8	100	76.5	47.1	17.6	58.8	70.6	17.6	29.4	29.4	11.8	11.8	23.5	11.8	