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Osteoarthritis (L King, Section Editor)

Tailored Interventions for Supporting Physical Activity Participation in People with Arthritis and Related Conditions: a Systematic Review

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Abstract

Purpose of Review To summarize both the research on and effects of physical activity tailoring in people with arthritis.

Recent Findings Physical activity is an essential disease management strategy for people with arthritis. However, participation rates are low which may be due to generalized approaches to supporting physical activity behavior change. Tailored physical activity approaches involve the use of assessment to shape individualized intervention strategies to change physical activity. The effectiveness of tailored physical activity interventions in the general population is mixed, likely as a result of suboptimal tailoring methods, and the effectiveness in arthritis populations is unknown.

Summary We identified 24 unique assessment factors and 23 intervention strategies used in tailored physical activity interventions for people with osteoarthritis, inflammatory arthritis, or fibromyalgia. Health professionals should conduct comprehensive patient characteristics, physical, and psychosocial assessments to select the optimal physical activity prescription and strategies to deliver it. While more research is needed to refine methods for optimal tailoring of physical activity interventions for people with arthritis, health professionals should familiarize themselves with factors to consider for tailoring, collaborate with their patients on decisions about tailoring their physical activity, and adapt tailoring approaches as required over time to optimize physical activity participation.

Introduction

Physical activity, defined as any voluntary bodily movement that is produced by skeletal muscles and requires energy expenditure [1], is an essential component of successful disease self-management in people with arthritis. Extant research shows that it can improve pain, function, and quality of life [2, 3], and is safe for people with osteoarthritis (OA) and inflammatory arthritis (IA) [4]. Six million people currently live with arthritis in Canada, and this number is projected to reach 10.4 million by 2042 [5]. Among older adults, arthritis often coexists with frailty, which poses a greater risk of falls [6, 7], increased morbidity, physical dependence, and hospitalization [8, 9]. Physical activity can prevent the progression of frailty [10, 11], partly by mitigating the effects of arthritis [2, 3] and the progression of concomitant conditions such as cardiovascular disease [12] and type 2 diabetes [13].

Physical activity is beneficial during all phases of chronic disease management, from primary prevention through rehabilitation and ongoing care. However, only 49% of adults aged 18–79 in Canada engage in enough physical activity to meet the World Health Organization recommendations [14]. Among people with arthritis, physical activity participation is even lower than the general population [15–17]. Introducing physical activity to this population is challenging as their ability to engage in activities can be affected by their symptoms, their health status (including comorbidities), or other external factors. Both clinicians and academics have identified the lack of precision in physical activity prescription and promotion as a limitation to supporting health behavior change. In a cohort of 172 people with OA and IA who were eligible for physical activity intervention studies [18, 19], Feehan et al. [20•] identified four distinct activity profiles based on the average time participants spent daily sleeping, sitting, and walking in different intensities. Their findings suggest that a range of individualized strategies may be required to help people achieve their optimal balance between activity and rest [21•].

Physical Activity Tailoring

If we want to improve physical activity participation among people with arthritis, we need to move away from a one-size-fits-all approach and toward a personalized approach. We define "physical activity tailoring" as a process whereby health professionals use patient assessments to shape a personalized strategy to support an active lifestyle [22•], taking into account the patient's characteristics, preferences, needs, and context [23]. When a health professional is tailoring physical activity interventions, they assess individual factors (e.g., physical activity history, fitness, psychosocial factors) and health status (e.g., disease activity, symptoms) by inquiry, observation, physical examination, and/or monitoring. They then use this information to design the "what" (e.g., activity type, frequency, and intensity) and "how" to deliver the prescription (e.g., a combination of behavior change techniques (BCT), who delivers, using what mode of delivery) [24] to support individuals to engage in those activities. The purpose of this review is to first summarize the research on the use of physical activity tailoring in people with OA, IA, and related conditions (e.g., fibromyalgia). Secondly, we report the effectiveness of different tailoring strategies on physical activity behavior in this population.

Methods

Search Strategy and Literature Screening

The systematic review protocol has been registered at PROSPERO (https://www.crd.york.ac.uk/prospero/; Registration CRD42020215513). We followed the PRISMA guidelines and searched the PROSPERO database for similar reviews before commencing this review. This review was co-developed with people living with arthritis and health professionals (KT, AMH). We also consulted with the Arthritis Patient Advisory Board, a group of advocates who bring their personal experiences and expertise with arthritis to research decision-making. Their involvement included shaping the research question, refining the data extraction, reviewing the findings, and identifying priority topics for discussion.

The search strategy was developed with an experienced research librarian. The search was conducted in June 2020 and updated in May 2022. We searched five electronic bibliographic databases including PubMed, PsycINFO, CINAHL, Embase (Ovid), and MEDLINE (Ovid). Our search included terms for tailoring, physical activity, and arthritis. See Online Resource: Fig. 1 for a sample search strategy. In addition, we hand-searched reference lists of included articles and conducted forward citation searching.

Eligible articles (1) were original studies, (2) included people with arthritis and related conditions, (3) included a tailored intervention to promote physical activity participation, and (4) included a measure of physical activity behavior. Articles were excluded when either (1) the intervention did not include an assessment or a form of assessment for tailoring, and (2) the article was written in a language other than English.

We transferred all the retrieved articles from each bibliographic database to Covidence (www.covidence.org; Veritas Health Innovation, Melbourne, Australia) for screening, and removed all duplicate articles. Two reviewers (SR, AS) screened all articles by their titles and abstracts and then reviewed the full articles for those that appeared to be eligible. A third reviewer (JM) mediated any discrepancies. JM and DH completed the updated search following the same procedure.

Data Extraction and Analysis

We developed a data extraction form in consultation with Arthritis Patient Advisory Board members. Two reviewers (SR and AS) were trained by an experienced researcher (JM) and pilot-tested the data extraction with 10% of the papers for calibration. One reviewer (SR) extracted data from the remaining articles and a second reviewer (AS) checked them. The following information was extracted: study details, intervention details, change in physical activity behavior, and tailoring factors (timing, frequency, and content of assessments, who or what conducted the assessment and delivered intervention components, which assessments were explicitly paired with tailored intervention components).

We summarized the study and intervention characteristics in descriptive statistics. For each included study, we mapped the assessment and tailoring strategies used (Fig. 1). One experienced reviewer (JM) coded the tailored intervention strategies for BCTs using the 93 Behaviour Change Technique Taxonomy version 1 (BCTTv1) [24]. The BCTTv1 has previously demonstrated support for good inter-coder and test–retest reliability [25].

Appraisal of the Evidence

We assessed the quality of the studies with the Cochrane Risk of Bias (ROB) tool (for randomized controlled trials, RCTs) [26], and the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I; for non-RCTs) [27]. When interpreting overall risk of bias for randomized controlled trials, we did not consider blinding of participants given the challenge of blinding in a physical activity intervention. Random sequence generation, blinding of outcome assessment, incomplete outcome data, and other bias domains were prioritized in the overall Cochrane ROB appraisal.

Results

The systematic search retrieved 2121 records; of those, 257 passed the title and abstract screening. After the full-text screening, 78 articles (from 39 studies) were included (Online Resource File 1: List of Included Studies), with a total of 13,626 participants (individual study sample size varied from 3 to 8894 participants) (Online Resource Fig. 2: PRISMA Flow Diagram). The primary reasons for exclusion were (1) not an original article ($n = 99$), (2)

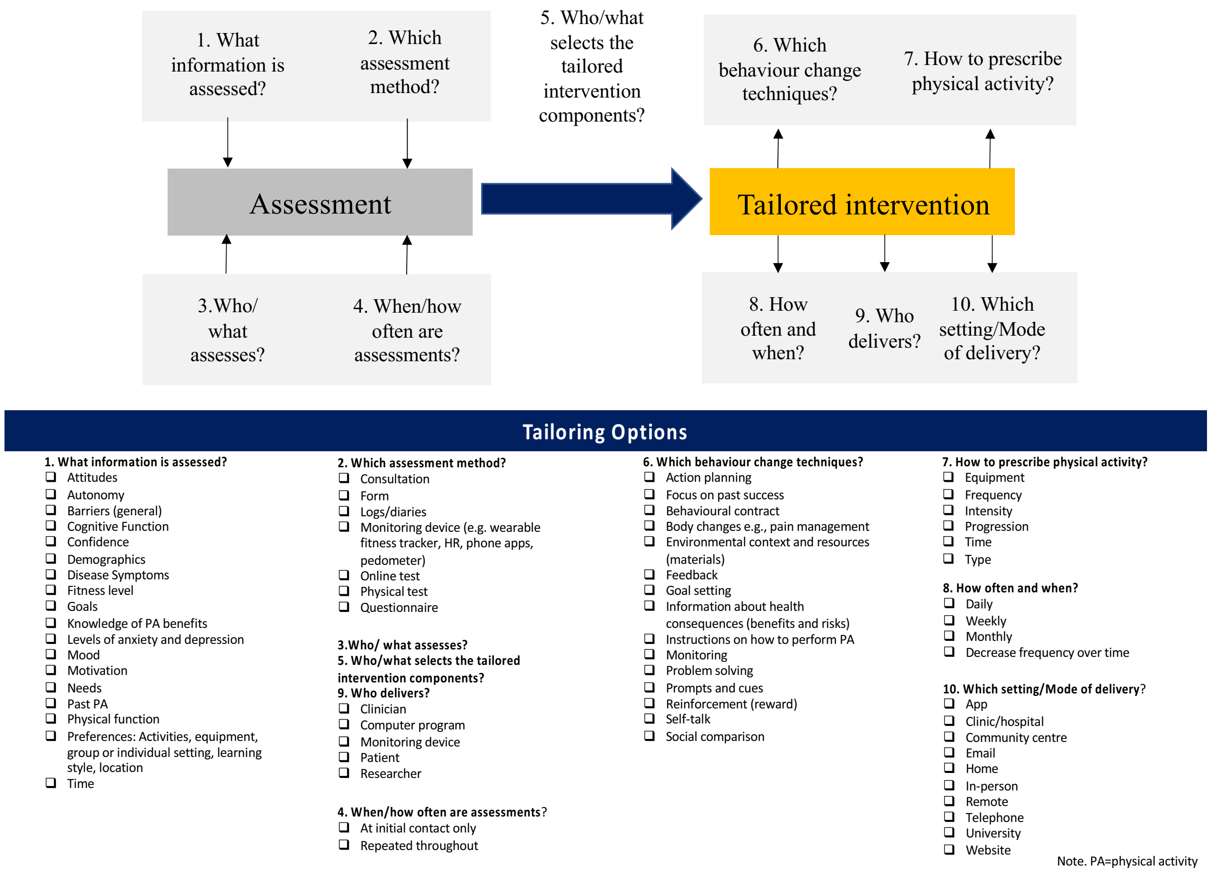

Fig. 1 Tailoring checklist: summary of tailoring methods and considerations used across studies

did not measure physical activity behavior ($n=30$), and (3) did not conduct a tailored intervention ($n=13$). For the complete data extraction, see Open Science Framework Repository: https://osf.io/t7ybv/.

Study Characteristics

Of the 39 total studies identified (Table 1), 31 were randomized controlled trials [18, 19, 28–56]. Twelve studies were categorized as low risk of bias [18, 39–41, 44, 49, 51, 52, 54, 55, 57, 58], 13 as moderate risk of bias [28–30, 32, 35, 37, 38, 42, 50, 53, 56, 59, 60], and 14 as high risk of bias [19, 31, 33, 34, 36, 43, 45–48, 61–64] (Online Resource: Table 1 and 2). The mean age of participants varied from 48 to 72 years old. Twenty-three studies reported on physical activity tailoring in participants with OA [19, 28, 29, 31, 34, 35, 37, 42–45, 47, 48, 50–53, 56–58, 62–64], 13 in participants with IA [18, 30, 32, 33, 38, 40, 41, 46, 49, 54, 55, 59, 60], and 3 in participants with fibromyalgia [36, 39, 61] (Table 1). The disease duration of study participants ranged from 1.75 to 20 years.

Table 1 Study characteristics

Author, year	Country	Population	Disease duration (years)	Study design	Sample size	Overall Cochrane ROB rating	Overall ROBINS risk of bias
1) Osteoarthritis							
Bossen, 2013a [28] Bossen, 2013b [75]	Netherlands	Knee/hip OA	NR	RCT	84	Moderate	
Allen, 2020 [57]	USA	Knee/hip OA	11.1	Pre-post test	53		Low
Allen, 2018 [29] Williams, 2015 [76]	USA	Knee OA	13.1	RCT	244	Moderate	
Brandes, 2018 [31]	Germany	Knee/hip OA	NR	RCT	23	High	
Gilbert, 2018 [34] Chang, 2014 [77] Ehrlich-Jones, 2010 [78]	USA	Knee OA RA	10.9 (knee OA) 13.2 (RA)	RCT	149	High	
Hinman, 2019 [35]; Hinman, 2017 [79]	Australia	Knee OA	9.5	RCT	87	Moderate	
O'Brien, 2016 [62]	England, UK	Knee/hip OA	2.25	Series of n-of-1 studies	3		Critical
Hoogeboom, 2010 [37]	Netherlands	OA	NR	RCT	10	Moderate	
Skou, 2017 [58] Skou, 2012 [80] Skou, 2014 [81]	Denmark	Knee/hip OA	NR	Registry-based study	8894		Low
Bennell, 2017b [42] Bennell, 2012 [82]	Australia	Knee OA	NR	RCT	72	Moderate	
Hoorntje, 2020 [43] Witjes, 2016 [83] Witjes, 2018 [84]	Netherlands	Knee OA	NR	RCT	46	High	
Skrepnik, 2017 [44]	USA	Knee OA	NR	RCT	104	Low	
Veenhof, 2006 [45] Veenhof, 2005 [85] Pisters, 2010 [86] Pisters, 2010b [87]	Netherlands	Knee/hip OA	NR	RCT	90	High	

Table 1 (continued)

Author, year	Country	Population	Disease duration (years)	Study design	Sample size	Overall Cochrane ROB rating	Overall ROBINS risk of bias
Talbot, 2003 [47]	USA	Knee OA	NR	RCT	17	High	
Hughes, 2004 [48]; Hughes, 2006 [88]; Hughes, 2010 [89]; Desai, 2014 [90]	USA	Knee/hip OA	NR	RCT	68	High	
Murphy, 2016 [50] Murphy, 2010 [91] Murphy 2011 [92] Murphy 2012 [93] Schepens, 2012 [94]	USA	Knee/hip OA	NR	RCT	49	Moderate	
Li, 2017 [51] Clayton, 2015 [95]	Canada	Knee OA	NR	RCT feasibility	17	Low	
Li, 2018 [52]	Canada	Knee OA	NR	RCT	29	Low	
Quicke, 2018 [53] Foster, 2014 [96]	UK	Knee OA	NR	RCT	N/A	Moderate	
Walker, 2018 [63]	UK	OA	NR	Pre-test post-test	498		Critical
Lee, 2016 [64]	China	Knee OA	8.97	Pre-test post-test	33		Serious
Li, 2020a [19]	Canada	Knee OA	NR	RCT	24	High	
Bendrik, 2021 [56]	Sweden	Knee/hip OA	1.75	RCT	120	Moderate	
2) Inflammatory arthritis							
Thomsen, 2017 [30] Esbensen, 2015 [97] Thomsen, 2016 [98] Thomsen, 2019 [99•]	Denmark	RA	15	RCT	75	Moderate	
Fenton, 2020 [32]; Rouse, 2014 [100]	UK	RA	7.8	RCT	32	Moderate	
Flint-Wagner, 2009 [33]	USA	RA	14	RCT	16	High	

Table 1 (continued)

Author, year	Country	Population	Disease duration (years)	Study design	Sample size	Overall Cochrane ROB rating	Overall ROBINS risk of bias
Brodin, 2008 [38] Sjoquist, 2010 [101] Sjoquist, 2011 [102]	Sweden	RA	1.75	RCT	77	Moderate	
O'Dwyer, 2017 [40]	Ireland	Ankylosing spondylitis	21	RCT	19	Low	
Nordgren, 2015 [59] Nordgren, 2012 [103]	Sweden	RA	12	Prospective observational study	194		Moderate
Habers, 2016 [41] Habers, 2012 [104]	Netherlands	Juvenile dermatomyositis	NR	RCT	14	Low	
Knittle, 2015 [46]	Netherlands	RA	NR	RCT	40	High	
Stavropoulos-Kalinoglou, 2013 [60]	UK	RA	6	Quasi-experimental	16		Moderate
Van den berg, 2006 [49] Van den Berg, 2007 [105] Hurksmans, 2010 [106]	Netherlands	RA	NR	RCT	77	Low	
Lamb, 2015 [54] Heine, 2012 [107] SARAH Trial Team, 2012 [108] Williams, 2015 [109]	England, UK	RA	10	RCT	224	Low	
Li, 2020b [18] Li, 2017 [110]	Canada	RA or SLE	NR	RCT	56	Low	
Veldhuijzen van Zanten, 2021 [55]	UK	RA	5.5	RCT	88	Low	
3) Fibromyalgia							
Camerini, 2010 [61]	Switzerland	Fibromyalgia	5.4	Post-test	157		Critical

Table 1 (continued)

Author, year	Country	Population	Disease duration (years)	Study design	Sample size	Overall Cochrane ROB rating	Overall ROBINS risk of bias
Ang, 2013 [36] Ang, 2011 [111] Kaleth, 2013 [112]	USA	Fibromyalgia	9	RCT	97	High	
Da Costa, 2005 [39] Dobkin, 2006 [113]	Canada	Fibromyalgia	10.8	RCT	33	Low	

Note: *OA*, osteoarthritis; *RA*, rheumatoid arthritis; *IG*, intervention group; *CG*, control group; *PA*, physical activity; *NR*, not reported; *RCT*, randomized controlled trial; *NR*, not reported; *SLE*, systemic lupus erythematosus

Intervention Details

The interventions employed in the studies lasted from 19 days to 2 years. Twenty-eight interventions were delivered in-person, while the rest (n=11) were delivered remotely (e.g., via app, telephone, website) (Table 2). Most interventions (n=31) were delivered by a health professional (physiotherapist, occupational therapist, nurse, physician, exercise physiologist). Providers who delivered interventions were variably trained in counseling, motivational interviewing, autonomy-supportive strategies, behavior change techniques, exercise prescription, stages of change, patient-practitioner collaboration, effective communication, and brief action planning.

Changes in Physical Activity Participation

Of the 39 studies, 27 demonstrated significant improvements in at least one measure of physical activity over time [18, 19, 28–32, 35, 36, 38, 40, 42–52, 55, 56, 58, 59, 63]. Sixteen interventions demonstrated significant improvements in physical activity in comparison to control groups [19, 28–30, 35, 40, 42, 44–52], though 4 of those interventions were appraised as having a high risk of bias.

Tailoring Methods

Figure 1 summarizes the tailoring methods and considerations used across the studies and provides a checklist to guide decision-making. The majority of studies conducted assessments throughout the intervention (n=29), at baseline only (n=2), or used both baseline and repeated assessments throughout the intervention (n=8). Assessment was conducted by a human (n=30), technology/device (n=5), both (n=3), or was not reported (n=1). Both the interventionist and participant (n=26), only the interventionist (n=9), technology/device and participant (n=3), or all of the above (n=1) decided which tailored intervention components were delivered based on the assessment.

Interventionists and patients shared decision-making responsibility for the tailoring of the intervention in 10/12 interventions that demonstrated significant differences between groups in favor of the tailored intervention in at least one outcome of physical activity behavior (excluding high risk of bias studies). In all the effective interventions, assessments to inform tailored approaches were reassessed at multiple time points. The remainder of tailoring methods did not demonstrate consistent patterns across effective, low-moderate risk studies. See Online Resource: Table 3 for the full tailoring characteristic data extraction.

Assessment Factors and Intervention Strategies used in Tailoring

Figure 1 contains a summary of assessment and intervention factors used for tailoring across the included studies (labeled as “tailoring options”).

Table 2 Intervention characteristics

Author, year	Mode of delivery	Provider	Setting	PA measure	Measurement time points	Specific information gathered paired with tailored intervention components Specific assessment paired with specific tailored content. Specify Baseline and/or FU	PA change—time**	PA change—group**
1) Osteoarthritis								
Bossen, 2013a [28] Bossen, 2013b [75]	Website for individual use	Joint2move web-based program	Remote	Physical Activity Scale for the Elderly ActiGraph GT3X triaxial accelerometers	9 weeks (+3 m and 12 m FU)	3-day self-test + short-term goal –> automatically generated weekly modules + activity progression guide Pain and performance evaluation –> text messages If module was missed due to physical complaints –> choice of module completion/modification	Y	Y
Allen, 2020 [57]	1) Telephone calls with individuals 2) Email	PA coach	N/A	ActiGraph GT3X+	3 m (+4 m FU)	Patient's stage of change for PA –> stage of change specific coaching Goals –> tailored emails Progress –> Longer term goals	N	N/A
Allen, 2018 [29] Williams, 2015 [76]	1) Website (IBET condition) OR 2) In-person individual sessions (PT condition)	Website or PT	Remote and/or PT clinic	Physical Activity Scale for the Elderly	4 m (+outcomes at 12 m)	*IBET* WOMAC (pain, function), current activity –> exercise level (baseline) WOMAC (pain, function) –> exercise routine + exercise progression (both) *PT* Shoe assessment –> shoe recommendations (1st visit) Patient's needs and functional limits –> # of PT visits	Y	Y
Brandes, 2018 [31]	In-person	Counselor	Rehabilitation center	Step Activity Monitor 3.0	Avg 19.4 days (+1 m and 6 m FU)	Step count of previous 3–4 days –> increase new step goal by 5% Walking pattern history –> strategies for meeting new step goal	Y	N
Gilbert, 2018 [34] Chang, 2014 [77] Ehrlich-Jones, 2010 [78]	Telephone sessions with individuals	Physician PA advocate (nurse or OT)	Clinic or home	GT1M ActiGraph accelerometer	24 months (+3 m, 6 m, 12 m, and 24 m FU)	ACTA –> personal short term goals + action plan/strategies to increase PA and monitor progress. (baseline) Assessment of achievement of short-term goals –> revision of goals (FU)	N	N
Hinman, 2019 [35]; Hinman, 2017 [79]	Telephone sessions with individuals	Nurse PT	Home	Physical Activity Scale for the Elderly Global change—increased activity	6 months (+6 m FU)	Pre-treatment survey + symptom irritability –> personalized self-management goals + home strengthening exercise program + PA plan (baseline + first call) Progress on program –> program/goal adjustment + increase participant knowledge + strategies for exercise pacing + motivation to be more active (subsequent calls)	Y	Y
O'Brien, 2016 [62]	Individual sessions	Researcher	Home	Step count—Omron HJ-113 Pedometer and electronic diary	6 weeks	All data measures were analyzed to determine if participant should receive the action planning or control cognition manipulation intervention (baseline data (weeks 0–6) were analyzed to identify the cognitions that were significantly correlated with walking—participants received an action planning or control cognition manipulation accordingly)	N	N/A

Table 2 (continued)

Author, year	Mode of delivery	Provider	Setting	PA measure	Measurement time points	Specific information gathered paired with tailored intervention components Specific assessment paired with specific tailored content. Specify Baseline and/or FU	PA change—time**	PA change—group**
Hoogeboom, 2010 [37]	In-person	PT	Outpatient clinic	LASA Physical Activity Questionnaire	Varies; 3–6 weeks before surgery	Perceived rate of exertion –>exercise intensity	N	N
Skou, 2017 [58] Skou, 2012 [80] Skou, 2014 [81]	In-person group sessions	PT+expert patient (previous GLA:D participant)	University Home	Patient-reported PA	8 weeks (+3 m and 12 m FU)	Participant's choice –>mode of participation (throughout) Participant's function and pain levels –>exercise (throughout)	Y	N/A
Bennell, 2017b [42] Bennell, 2012 [82]	In-person individual sessions and telephone calls	PT Telephone coaches—nurses, OT, health psychologist	Remote PT clinics	Physical Activity Scale for the Elderly ActivPAL accelerometer	6 m (+12 m, 18 m FU)	*Both groups*: Participant's choice of location –>PT (baseline) PT assessment (muscle strength, the participant's pain and their perceived level of effort during performance of the exercise) –>exercise prescription (baseline?) PT assessment –>exercise progression (throughout) *IG=PT+coaching*: Participant's preference, confidence, and success in achieving behavior change –>optional up to 6 additional telephone coaching sessions (throughout) Individual barriers –>strategies to overcome barriers (throughout) Individual motivation levels –>techniques to help identify self-motivators (throughout)	Y	Y
Hoorntje, 2020 [43] Witjes, 2016 [83] Witjes, 2018 [84]	Individual sessions	PT	Unclear	Activ8 accelerometer	Individualized;~3–12 m (+6 m FU)	Baseline characteristics –>activity goals –>GAS scale and rehab schedule (baseline) Choice of GAS-trained PT –>PT assignment (baseline)	Y	N
Skrepnik, 2017 [44]	Mobile app, individual contact	N/A	Remote	Activity monitor Compliance Jasbonne UP 24 activity monitor	90 days (+180d FU)	Baseline step count –>daily step goal (baseline) OA GO app data –>summary of activity trends for review	Y	Y
Veenhof, 2006 [45] Veenhof, 2005 [85] Pisters, 2010 [86] Pisters, 2010b [87]	In-person individual sessions	PT	Home	Short QUestionnaire to ASsess Health Enhancing Physical Activity	12w+5–7 booster sessions in weeks 18, 25, 34, 42, and 55 (+13w, 39w, and 65w FU)	Participant's choice of problematic activities –>short-term and long-term goals Baseline values (pain tolerance to selected activities) –>individually based exercise plan (baseline) Participant behavior –>positive reinforcement (throughout)	Y	Y
Talbot, 2003 [47]	In-person	Registered nurse	Unclear	Tritrac-R3D pedometer Adherence	12w (+3 m FU)	Baseline step count –>daily step target and progression Pedometer logs –>review step goals and provide feedback	Y	Y

Table 2 (continued)

Author, year	Mode of delivery	Provider	Setting	PA measure	Measurement time points	Specific information gathered paired with tailored intervention components Specific assessment paired with specific tailored content. Specify Baseline and/or FU	PA change—time**	PA change—group**
Hughes, 2004 [48]; Hughes, 2006 [88]; Hughes, 2010 [89]; Desai, 2014 [90]	In-person individual and group sessions, and telephone calls	PT	Senior centers/residences Home	Exercise logs	8 weeks (+2 m and 6 m FU)	Progress made toward goals ->systematic feedback "what is the best regimen that this participant is likely to follow" ->regimen negotiation+problem solving ->increase self-efficacy for exercise adherence Functions/activities participants have trouble with+individual participant performance records ->skills and strategies to maintain adherence ->increase internal locus of control Participant's preference for exercising alone or in groups ->home-based program or community classes	Y	Y
Murphy, 2016 [50] Murphy, 2010 [91] Murphy 2011 [92] Murphy 2012 [93] Schepens, 2012 [94]	In-person individual sessions and telephone calls	OT	Unclear about OT sessions Home Clinic	Actiwatch accelerometer	10 weeks (+outcomes at 6 m)	Baseline PA and symptom data ->personalized report—>activity pacing recommendations using personalized examples->goals for pacing Barriers to using recommendations ->address barriers	Y	Y
Li, 2017 [51] Clayton, 2015 [95]	In-person individual and group sessions, and telephone calls	PT	Clinic or research center Remote	SenseWear Mini	5 weeks (+5w FU)	Barriers ->solutions (session 1) Avg baseline step count+activity goals+confidence levels ->action plans (session 1) Normal sitting time ->identify ways of breaking up sitting time (session 1) Fitbit data ->activity goal progression (throughout)	Y	Y
Li, 2018 [52]	In-person individual and group sessions, and telephone calls	PT	Clinic or research center Remote	SenseWear Mini	2 m (+4 m and 6 m FU)	Barriers ->solutions (session 1) Avg baseline step count+activity goals+confidence levels ->action plans (session 1) Normal sitting time ->identify ways of breaking up sitting time (session 1) Fitbit data ->activity goal progression (throughout)	Y	Y
Quicke, 2018 [53] Foster, 2014 [96]	*ITE* In-person individual sessions *TEA* In-person individual sessions and/or telephone	PT	Physiotherapy center Home	Physical Activity Scale for the Elderly	*Individually tailored exercise* 12 weeks (+3 m, 6 m, 18 m, and 36 m FU) *Targeted exercise adherence* 6 m (+3 m, 6 m, 18 m, and 36 m FU)	ITE: PT assessment ->exercise prescription and intensity progression+lower limb function goals+exercise goals+exercise targets *TEA*: *Same factors as ITE* Current PA levels+intentions to increase PA+attitudes to exercise+barriers and facilitators to exercise ->adherence enhancing toolkit Participant interests/suitability ->local PA opportunities	Unclear (statistical analyses nor reported)	N/A

Table 2 (continued)

Author, year	Mode of delivery	Provider	Setting	PA measure	Measurement time points	Specific information gathered paired with tailored intervention components Specific assessment paired with specific tailored content. Specify Baseline and/or FU	PA change—time**	PA change—group**
Walker, 2018 [63]	In-person individual sessions	PT	Unclear	Number of days walked > 20 min	6 m	Joint problems + physical function + general health and lifestyle + BMI + current PA behavior –> compare behavior to accepted norms for healthy lifestyle –> individualized care plan + goal setting + action and coping planning Progress of goals–> feedback + goal revisions	Y	N/A
Lee, 2016 [64]	In-person group sessions	Healthcare professional with special training on teaching exercise to older people	Community center	Diary entry	4 weeks (3 m FU)	Patient's physical capacity + mental capacity + living context –> exercise prescription Patient's time schedule + established peer support –> exercise class time Patient's learning style –> exercise content delivery method	N/A (adherence 91%)	N/A
Li, 2020 [19]	In-person individual and group sessions, and telephone calls	PT	Clinic or research center Remote	SenseWear Mini	12 weeks (+14w and 27w FU)	Barriers –> solutions (session 1) Avg baseline step count + participant's goals + confidence levels –> action plan –> PA parameters (baseline) Daily MVPA –> goal revision (throughout)	Y	Y
Bendrik, 2021 [56]	In-person individual sessions and telephone calls	PT	Community gym Remote	SenseWear Mini 7-day diary	6 months	Outcome and behavioral goals –> action planning and exercise prescription Physical activity preferences ⟶ exercise prescription Physical activity behavior –> new goals and activities	Y	N
2) Inflammatory arthritis								
Thomsen, 2017 [30] Esbensen, 2015 [97] Thomsen, 2016 [98] Thomsen, 2019 [99•]	In-person individual sessions	Nurse OT	University hospital	Physical Activity Scale 2.1 ActivPAL 3 Activity Monitor	4 months (+18 month FU)	Participants perceived barriers + resources –> catalog of ideas Behavioral goals –> number and timing of weekly SMS reminders	Y	Y
Fenton, 2021 [32]; Rouse, 2014 [100]	Telephone sessions with individuals	Counselor Gym instructor	Unclear	International Physical Activity Questionnaire	3 months	Subjects experience and emotions to PA + knowledge of PA benefits –> identify reasons for PA engagement Link between PA behavior and personal goals/events –> identify and internalize reasons for PA engagement Barriers to PA –> strategies to overcome them Perceived needs and capabilities –> revise goals	Y	N
Flint-Wagner, 2009 [33]	In-person individual and group sessions	Certified trainers	Unclear	Adherence	16 weeks	Preferred mode + presence of flare-up –> exercise mode Joint pain (if none) + perceived exertion (less than or equal to a 4) –> weight load	N/A (attendance = 82%)	Unclear

Table 2 (continued)

Author, year	Mode of delivery	Provider	Setting	PA measure	Measurement time points	Specific information gathered paired with tailored intervention components Specific assessment paired with specific tailored content. Specify Baseline and/or FU	PA change—time**	PA change—group**
Brodin, 2008 [38] Sjoquist, 2010 [101] Sjoquist, 2011 [102]	Telephone sessions with individuals	PT	Home	Self-reported questionnaire on the frequency of physical activity participation/week	12 m (+12 m FU)	Thoughts about body function+possibilities for PA –>individual coaching and PA goals Perceived obstacles to implementation –>problem solving strategies for barriers Body function tests –>oral and written feedback Activity log data –>goal evaluation and adjustment	Y	N
O'Dwyer, 2017 [40]	In-person individual sessions or telephone calls	PT	Exercise lab	ActiGraph GT3X accelerometers	3 months (+3 m FU)	Needs, ambitions, preferences, and available resources –>PA resources+PA goals and action plans (initial session) Barriers to goal achievement –>strategies to overcome PA barriers Participant's choice for FU sessions –>frequency and mode of FU sessions	Y	Y
Nordgren, 2015 [59] Nordgren, 2012 [103]	In-person individual and/or group sessions, and the use of a webpage	PT	Community center	1) International Physical Activity Questionnaire 2) Adherence	2 years	Participant's needs and preferences –>circuit training program (baseline) Knowledge, attitudes, and self-efficacy for HEPA based on participants' previous experiences –>goal setting (throughout) Performance –>feedback support group (throughout) HR –>feedback (PT) (throughout) Present and future barriers –>problem solving (throughout)	Y	N/A
Habers, 2016 [41] Habers, 2012 [104]	In-person individual sessions	Researcher	Home	Actical accelerometer	12 weeks	HR peak –>interval training intensity (baseline) Exercise performance –>strength training progression+training prescription adjustments (throughout) T1 measurements –>individual advice to stay fit	N	N
Knittle, 2015 [46]	In-person individual and group sessions, and telephone calls	PT Rheumatology nurse	University medical center Home	Short QUestionnaire to ASsess Health Enhancing Physical Activity	6 weeks (+32w FU)	Patients' pros and cons of (re-) engaging in PA –>long-term goals Exercise diary entry –>feedback on PA progress, short-term PA goals and action plans Barrier identification –>problem solving	Y	Y
Stavropoulos-Kalinoglou, 2013 [60]	In-person individual sessions	Exercise physiologist—researchers Resident exercise supervisor	Rehabilitation center Home	Exercise session attendance	6 m (+outcomes at 3 m and 6 m)	Cardiorespiratory status (exercise tolerance test+functional ability –>exercise prescription Issues from exercise sessions+heart rate –>exercise adjustment Patient's preference for exercise equipment+patient's perceived ability+researcher's assessment of patient's ability to attain training objectives –>choice of exercise equipment First resistance exercise session –>resistance training intensity prescription	N	N/A

Table 2 (continued)

Author, year	Mode of delivery	Provider	Setting	PA measure	Measurement time points	Specific information gathered paired with tailored intervention components Specific assessment paired with specific tailored content. Specify Baseline and/or FU	PA change—time**	PA change—group**
Van den berg, 2006 [49] Van den Berg, 2007 [105] Hurksmans, 2010 [106]	1) Website (cyber-training.nl) 2) Email 3) In-person individual and group sessions	Website PT	Remote Unclear	Proportion of patients meeting the physical activity recommendations Actilog V3.0 PA website usage	12 m (+12 m FU)	Perceived rate of exertion (Borg)+Average heart rate –>cycling intensity and duration Patient's needs –>self-management strategies	Y	Y
Lamb, 2015 [54] Heine, 2012 [107] SARAH Trial Team, 2012 [108] Williams, 2015 [109]	In-person individual sessions	PT or OT	Outpatient clinics	5-item exercise compliance questionnaire	12 weeks (+outcomes at 4 m, 12 m)	Participant's strength, pain level, and flexibility –>exercise prescription (baseline and FU) Rate of perceived exertion (Borg scale), exercise diary –>exercise load/intensity (FU) Use same language* Participant's goal–>SMART goal (baseline and FU) Situational cue –>implementation intention Patient's self-efficacy to complete goal –>identification of barriers and facilitators –>identification of barriers and facilitators	Y (but statistical analysis not performed)	Unclear
Li, 2020b [18] Li, 2017 [110]	In-person individual and group sessions, and telephone calls	PT	Clinic or research center Remote	SenseWear Mini	8 weeks (+18w and 27w FU)	Barriers –>solutions (session 1) Avg baseline step count+participant's goals+confidence levels –>action plan –>PA parameters (baseline) Daily MVPA –>goal revision (throughout)	Y	N
Veldhuijzen van Zanten, 2021 [55]	In-person individual and group visits and telephone calls	Behavior change counselor	Healthcare center	International Physical Activity Questionnaire (IPAQ)	5 months (+7 m FU)	Participant experience and emotions to PA+knowledge of PA benefits –>discussion of benefits that are personally meaningful Cardiorespiratory fitness, disability, preferences for exercise→exercise program Barriers to PA –>strategies to overcome them Perceived needs and capabilities –>revise goals	Y	N
3) Fibromyalgia								
Camerini, 2010 [61]	Website for individual use	Tailored gymnasium Website	Remote	Time spent on the tailored gymnasium website	4 months	Available time, pain, time of day (level of fatigue), available tools, localization, level of difficulty, experience, user judgment –>exercise prescription	Unclear	N/A
Ang, 2013 [36] Ang, 2011 [111] Kaleth, 2013 [112]	Telephone sessions with individuals	MI-trained health practitioner	Remote	Community Health Activities Model Program for Seniors GT1M ActiGraph accelerometer	12 weeks (+3 m and 6 m FU)	Motivational statement assessment –>self-motivation statements HRR –>exercise prescription Behavioral indicators of motivation, responses to questions concerning reasons for making or maintaining changes, barriers to exercise adherence –>participant's commitment to exercise, praise and reinforce progress	Y	N

Table 2 (continued)

Author, year	Mode of delivery	Provider	Setting	PA measure	Measurement time points	Specific information gathered paired with tailored intervention components Specific assessment paired with specific tailored content. Specify Baseline and/or FU	PA change—time**	PA change—group**
Da Costa, 2005 [39] Dobkin, 2006 [113]	In-person individual sessions	Exercise physiologist	Unclear	Adherence	12 weeks (+3 m and 9 m FU)	Graded maximal exercise stress test + severity of FM, accessibility to equipment, time constraints and enjoyment of various activities –> individualized exercise prescription (baseline) Participant's adaptation to exercise –> exercise intensity progression (throughout)	N	N/A

Note. *Significant change in at least 1 outcome of physical activity over time in the tailored intervention group

**Significant change in at least 1 outcome of physical activity between groups in favor of tailored intervention group

ACTA, Arthritis Comprehensive Treatment Assessment; *BMI*, body mass index; *FU*, follow-up; *GAS*, Goal Attainment Scaling; GLA:D, Good Life with Arthritis: Denmark study; *HEPA*, health-enhancing physical activity; *HR*, heart rate; *HRR*, heart rate reserve; *IBET*, internet-based exercise training; *IG*, intervention group; *ITE*, individually tailored exercise; *MVPA*, moderate-to-vigorous physical activity; *N/A*, not available; *N*, no; *PA*, physical activity; *OT*, occupational therapist; *PT*, physical therapy; *SMS*, short message service; *TEA*, targeted exercise adherence; *WOMAC*, Western Ontario and McMaster Universities Osteoarthritis Index; *Y*, yes

Online Resource: Figs. 3 and 4 contain the assessment and intervention factors employed by each study. A total of 24 unique assessment factors and 23 intervention strategies for tailoring were used across the studies. The most commonly used assessment factors were past physical activity ($n = 22$), disease symptoms ($n = 16$), physical function ($n = 14$), fitness ($n = 14$), goals ($n = 14$), barriers ($n = 13$), and confidence ($n = 11$). The most commonly used tailored intervention strategies were goal setting ($n = 27$), physical activity prescription ($n = 24$), and problem solving ($n = 17$).

Among the low-moderate risk of bias interventions that demonstrated significant differences between groups' physical activity behavior in favor of the tailored intervention, the assessment factors were barriers, confidence, demographics, disease symptoms, fitness, goals, mood, motivation, needs, past physical activity, physical function, and preferences (activity type, setting, general/not defined). The tailored intervention strategies included behavior change techniques (action planning, body changes, goal setting, environmental context and resources, information about health consequences, instructions on how to perform the behavior, problem solving, reinforcement), intervention dose, provider, and physical activity equipment, options, and prescription.

Discussion

This review provides a summary of tailoring methods used to date in physical activity interventions for people with arthritis. The evidence suggests that assessments to guide tailoring should be made repeatedly over time and that the health professional and the patient should make decisions together about tailoring. Health professionals may be able to select more appropriately tailored intervention strategies if they assess factors such as patient characteristics (e.g., demographics, disease symptoms, physical function), barriers (e.g., needs, confidence, motivation), and physical activity readiness and preferences (e.g., physical activity history, fitness, goals). Such strategies may include tailoring behavior change techniques (e.g., action planning, problem solving, provision of resources), the frequency of using these techniques, exercise prescriptions, and who should deliver the intervention.

Are Tailored Physical Activity Interventions Effective for People with Arthritis?

Overall, tailored interventions appear to be effective in improving physical activity participation among people with arthritis. However, we were unable to determine whether they are more effective than generic interventions given the lack of studies comparing the use of these approaches in this population. Meta-analyses have shown that tailored interventions demonstrate only small effects [65] or have demonstrated smaller effects than generic interventions for changing physical activity behavior in the general population [66].

However, select reviews and randomized controlled trials have supported the use of tailored interventions in improving physical activity behavior and demonstrated medium- to large-sized effects [67]. Well-defined moderators of physical activity behavior also signal the value of tailored interventions [68, 69]. Taken together, we argue that comparing the effectiveness of tailored vs. non-tailored interventions is premature without evidence for optimizing tailoring methods [22•]. Our summary of tailoring methods used across studies and recommendations for effective strategies is a step toward improving our understanding of optimal tailoring approaches. Further research is needed to define how tailoring approaches can be refined before quantifying or comparing its value in physical activity interventions. Therefore, while it is unclear whether tailored physical activity interventions are more effective than generic interventions among people with arthritis, our review notes the common use of certain tailored approaches in studies with effective interventions, which may indicate the importance of taking into account a patient's characteristics, physical abilities, and psychosocial needs in client-centered care.

How do Health Professionals Learn to Tailor?

There is likely room for both systematic and humanistic approaches to tailoring. The Behaviour Change Wheel is one example of a systematic approach using evidence- and consensus-based links to tailor behavior change techniques to identified barriers [70]. The questions and checklist provided in this review may also help health professionals and researchers strategically plan tailoring in a systematic fashion. A key finding of this review is that a tailored physical activity intervention strategy has more chance of success if the health professional and patient collaborate on how to structure it. None of the included studies reported details of the decision-making process, possibly because the collaboration with patients was more intuitive than systematic (i.e., following a distinct procedure). Many health professionals are already tailoring strategies instinctively by employing aspects of motivational interviewing (compassion, acceptance, partnership, evocation) and principles of shared decision-making (e.g., situation diagnosis, option clarification, deliberation of patient preferences) [71, 72•]. Another point of consideration is that none of the included interventions mentioned self-tailoring, where patients alone decide on the intervention strategies and how they are tailored. Self-tailoring stems from the concept of self-management, whereby patients use self-management skills, decision-making skills, and problem-solving skills to apply knowledge to themselves as appropriate [73]. Collaborating with and equipping patients to self-tailor may be another tailoring strategy that benefits both health professionals' workload and patient outcomes. As the literature for optimal physical activity tailoring strategies among patients with arthritis builds, it is important to consider not only "what" we tailor, but "how" and "with whom" we tailor.

Limitations and Future Directions

We acknowledge that this review has certain limitations. First, most studies did not provide enough detail for their tailoring methods to be reproducible. Therefore, the coding we conducted produced broad categories for tailoring, but important nuances like specific questions to ask or specific assessment tools to use are missing. Second, the checklist in Fig. 1 is a compilation of tailoring options that were included across the studies in this review and is not an exhaustive list. Furthermore, it is challenging to single out effective components of complex interventions as they likely intertwine and overlap. We encourage researchers and health professionals to build on our list and use principles of evidence-informed practice to decide with their patients which tailoring options are best suited for them [74]. Lastly, given the heterogeneity of the included tailoring approaches and limitations in study reporting, we were unable to define explicit links between assessments and strategies (i.e., if X finding is determined from the assessment, then Y strategy should be implemented). In the future, the specific links between assessment factors and tailored intervention strategies should be explored and more clearly defined.

Conclusion

Physical activity is a complex behavior that is influenced by demographic, physical, and psychosocial factors. Health professionals and researchers who want to move beyond generic interventions and increase physical activity participation among people with arthritis may benefit from using tailored approaches that involve patients in the decision-making process, can adapt to each patient's changing needs over time, and are based on a broad range of relevant assessment factors. While much more work is needed to develop and refine methods for optimal tailoring, health professionals can start by familiarizing themselves with their options for tailoring and take a patient-centered approach to guide their decision-making and help more people with arthritis to be physically active.

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Declarations

Conflict of Interest
Jasmin K. Ma declares that she has no conflict of interest. Smruthi Ramachandran declares that she has no conflict of interest. Amrit Sandhu declares that she has no conflict of interest. Karen Tsui declares that she has no conflict of interest. Alison M. Hoens declares that she has no conflict of interest. Davin Hu declares that he has no conflict of interest. Linda C. Li declares that she has no conflict of interest.

Human and Animal Rights and Informed Consent
This article does not contain any studies with human or animal subjects performed by any of the authors.

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