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Review

Poor replicability of recommended exercise interventions for knee osteoarthritis: a descriptive analysis of evidence informing current guidelines and recommendations

C. Bartholdy † ‡, S.M. Nielsen †, S. Warming ‡, D.J. Hunter §, R. Christensen † ||, M. Henriksen † ‡ *

† *The Parker Institute, Copenhagen University Hospital Bispebjerg and Frederiksberg, 2000 Copenhagen, Denmark*
‡ *Department of Physical and Occupational Therapy, Copenhagen University Hospital Bispebjerg and Frederiksberg, 2400 Copenhagen, Denmark*
§ *Rheumatology Department, Royal North Shore Hospital and Institute of Bone and Joint Research, Kolling Institute, University of Sydney, Sydney, NSW, Australia*
|| *Department of Rheumatology, Odense University Hospital, Denmark*

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SUMMARY

Objective: To examine the reporting completeness of exercise-based interventions for knee osteoarthritis (OA) in studies that form the basis of current clinical guidelines, and examine if the clinical benefit (pain and disability) from exercise is associated with the intervention reporting completeness.
Design: Review of clinical OA guidelines
Methods: We searched MEDLINE and EMBASE for guidelines published between 2006 and 2016 including recommendations about exercise for knee OA. The studies used to inform a recommendation were reviewed for exercise reporting completeness. Reporting completeness was evaluated using a 12-item checklist; a combination of the Template for Intervention Description and Replication (TIDieR) and Consensus on Exercise Reporting Template (CERT). Each item was scored 'YES' or 'NO' and summarized as a proportion of interventions with complete descriptions and each intervention's completeness was summarized as the percentage of completely described items. The association between intervention description completeness score and clinical benefits was analyzed with a multilevel meta-regression.
Results: From 10 clinical guidelines, we identified 103 original studies of which 100 were retrievable (including 133 interventions with 6,926 patients). No interventions were completely described on all 12 items (median 33% of items complete; range 17–75%). The meta-regression analysis indicated that poorer reporting was associated with greater effects on pain and no association with effects on disability.
Conclusion: The inadequate description of recommended interventions for knee OA is a serious problem that precludes replication of effective interventions in clinical practice. By consequence, the relevance and usability of clinical guideline documents and original study reports are diminished.
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Introduction

Osteoarthritis (OA) of the knee is a very common condition and one of the major contributors to the global burden of musculoskeletal diseases[1]. Knee OA is an age-related disease, and with the predicted increase in the aging population the burden of OA on the health system will increase[2]. Many health professionals attend to this common condition every day, to provide pain relief and improvement of physical function. Current clinical guidelines for the management of knee OA recommend exercise among the primary treatments[3–5]. These recommendations are supported by several systematic reviews and meta-analyses of randomised controlled trials[6–9] that all conclude that exercise interventions are effective for pain reduction and functional improvement. Indeed the body of evidence is so extensive that the most recent Cochrane Review on exercise for knee OA concluded that further research is unlikely to

* Address correspondence and reprint requests to: Marius Henriksen, The Parker Institute, Copenhagen University Hospital Bispebjerg and Frederiksberg, Copenhagen, Denmark. Tel.: 45-38164160.
E-mail addresses: Cecilie.roedgaard.bartholdy@regionh.dk (C. Bartholdy), sabrina.mai.nielsen@regionh.dk (S.M. Nielsen), susan.warming@regionh.dk (S. Warming), david.hunter@sydney.edu.au (D.J. Hunter), robin.christensen@regionh.dk (R. Christensen), marius.henriksen@regionh.dk (M. Henriksen).

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change the estimated effectiveness[8]. However, the existence of research evidence of effectiveness and clinical guideline recommendations is not a guarantee of informed healthcare delivery.

To implement evidence into practice, clinicians need to have sufficient information about the details of the exercise interventions including specificity about dose, frequency, and intensity. This requires clear, complete, and accessible reports of all components of the exercise interventions that have been tested in the research studies that form the base of the clinical guidelines.

Previous work has highlighted deficiencies in the reporting of non-pharmacological interventions[10]. This led to the development of a reporting checklist entitled Template for Intervention Description and Replication (TIDieR)[11], which is an extension of item 5 of the CONSORT 2010 statement[12] and item 11 of the SPIRIT 2013 statement[13]. Subsequently, assessments of reporting completeness of various non-pharmacological interventions have been performed by use of the TIDieR checklist[14–17], further highlighting the extent of the problem. Recently a checklist specific for the reporting of exercise intervention studies has been developed (Consensus on Exercise Reporting Template; CERT)[18].

Exercise interventions are often complex and multifaceted, which places a significant obligation on researchers to provide clear, complete, and replicable details of their study interventions. If the reporting lacks important details, replicability and implementation are impeded. Indeed, the most recent Cochrane review[8] alludes to the problem by stating that the evidence is insufficient to allow for specific recommendations regarding exercise dosage.

Clinical guidelines and recommendation documents are systematically developed statements that assist practitioners' and patients' decisions about appropriate health care for specific circumstances. While exercise is unanimously recommended as the treatment of choice for knee OA, the guidelines lack specificity and specific recommendations about the exercise type, duration, frequency, intensity, etc. This renders the guidance less useful and decreases the potential impact of research studies on clinical practice. Indeed, studies suggest that the uptake and use of clinical guidelines in daily practice are suboptimal[19,20], possibly attributable to the lack of specificity of the recommendations.

The completeness and quality of the reporting of exercise interventions for the management of knee OA have not been evaluated before. It, therefore, stands to reason to assess current replicability of the exercise interventions being recommended. In this review, we first examined the completeness of reporting of the exercise interventions that form the evidence base of current international clinical guidelines on the management of knee OA. We took the clinicians point of entry by reviewing the studies underlying clinical guidelines and recommendations. Secondly, we used meta-analysis methods to evaluate whether the apparent effect of exercise on pain and disability is associated with the reporting completeness of the exercise intervention.

Methods

A protocol specifying study selection, assessments of eligibility criteria, data extraction and statistical method was developed and registered before commencing the study (PROSPERO: CRD42016039742); protocol in Supplementary File 1. The study was reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[22]; checklist as Supplementary File 2.

Information sources and search strategy

This systematic review and meta-analysis included studies that formed the recommendations in current clinical guidelines on the management of knee OA. Hence, we searched for published clinical guidelines or recommendations for management of knee OA. Guidelines were eligible if they were current (within the last decade; published 2006–2016), included guidance or recommendations about exercise for adult patients with knee OA, were written in English and had been peer-reviewed before publication.

To identify guidelines/recommendations, a systematic literature search was performed in MEDLINE (via PubMed) and EMBASE (via Ovid) on June 7, 2016, using the terms 'osteoarthritis', 'knee', 'guideline', and 'practice guideline' with relevant combinations of MeSH terms. Supplementary File 3 shows the search strategies. Besides the database searches, the reference lists of the guidelines/recommendations were screened for other guidelines/recommendations.

Eligibility criteria

Assessment of eligibility of the identified guidelines/recommendations was performed independently by two reviewers (CB and SW). Firstly, titles and abstracts were screened with a subsequent retrieval of the full-text documents if it was judged potentially eligible by at least one reviewer. The same reviewers assessed the eligibility of the retrieved full-text documents independently. Disagreements were resolved by discussion, if an agreement could not be reached, a third reviewer (MH) would make the final decision.

From the included guidelines/recommendations the original intervention studies used to form the recommendations of exercise for knee OA were located. The only individual study eligibility criterion was that a study was used to inform the systematic review or guideline/recommendation on exercise in the published source document. Hence, we included all referenced studies irrespective of the study design (e.g., randomised or observational), study population (knee OA only or mixed diagnoses), or study duration. If the guideline/recommendation used published systematic review/meta-analyses as evidence for a recommendation, these were then used as the source of original intervention studies.

Data collection process

The data collection was completed in two steps, with data extraction sheets developed in Microsoft Excel. The first extraction focused on exercise intervention description, and the second data extraction focused on the extraction of effect estimates.

Exercise intervention description completeness

For the assessment of exercise intervention description completeness, we used a combination of the TIDieR[11] and the CERT[18] checklists (see Supplementary File 4). A total of 12 items was assessed: (1) Name; (2) Why; (3) What (materials); (4) What (procedure); (5) Who provided; (6) How; (7) Where; (8) When and how much (dose); (9) Tailoring/Progression; (10) Modifications; (11) How well (planned); (12) How well (actual). Item 6 and 8 addressed in their sub-components essential elements of exercise delivery and dose. Item 6 included the following sub-components: (6a) Whether exercise was performed as an individual or in a group; (6b) Whether exercises were supervised or unsupervised; (6c) Measurement and reporting of adherence to exercise; (6d) Decision rules for progressing the exercise program; (6e) Each exercise was described so that it can be replicated; (6f) Content of any home program component. Item 8 included following sub-components: (8a) Intensity; (8b) Frequency; (8c) Session time; (8d) Overall duration.

Each item was scored 'YES' or 'NO' for each individual exercise intervention independently by two reviewers (CB and SW) and any

disagreement was resolved by discussion. An item was scored 'NO' if the item was missing or lacked sufficient detail to be replicated (i.e., was not described completely). Items 6 and 8 were considered complete only if all subcomponents were considered complete.

Only published information on the exercise description was extracted; no attempts to retrieve further information from the authors were made. However, additional information on the individual exercise intervention was explored by checking links to Supplementary Material in the article and reference list, and if any relevant information was readily available, data was extracted.

Effect estimates

The second data extraction sheet contained the following items: author, year of publication, journal, number of participants allocated to the exercise intervention, gender, age, baseline and follow-up outcome on patient-reported pain and disability (function). Both numeric and graphical data was extracted. Data were extracted by two independent reviewers (SW and SMN) and any disagreement was resolved by discussion, with a third reviewer as arbiter (MH). Mean at baseline and follow-up on patient reported pain and disability with the corresponding standard deviation (SD), or mean change with corresponding SD_{change}, were extracted. If no SD_{change} was available, and this could not be calculated from other measures, then, if possible, the SD_{change} was calculated from SD for baseline and follow-up means, using the correlation coefficients 0.475 and 0.682 for pain and disability, respectively, both calculated based on data from the other included studies. If data on pain or disability was available for more than one scale a predefined hierarchy (described in the protocol; Supplementary File 1) was used to decide which outcome score to include. If more than one patient reported outcome was relevant and not on the list, which to include was resolved by discussion between two reviewers (CB and MH). Only data on the exercise intervention arm(s) were extracted as the identified studies included both uncontrolled cohorts and controlled trials.

Summary measures

To assess the completeness of the exercise intervention description, each description item was summarised across the included interventions as the proportion (%) of interventions with complete description. Each intervention's description completeness was summarized across the 12 items as a percentage of completely described items. The sub-components of item 6 and 8, were also summarised separately.

To analyse the association between the completeness of the intervention description and the study outcomes in patient-reported pain and disability, a standardised mean change (SMC) with corresponding variance (V) was calculated for each intervention outcome as $SMC = D_i/SD_{Di}$, where D_i is the mean change for the i'th study arm, and SD_{Di} is the SD of the mean change, and $V_{SMC} = (1/n)\cdot([n-1]/[n-3])\cdot(1 + n\cdot SMC^2) - SMC^2/(c[df])^2$, where n is the number of patients in the group[23]; c(df) is the bias function and the approximation of $c(df) = 1 - 3/(4\ df - 1)$[24] was used, where $df = n - 1$. From the unadjusted SMC, a corrected SMC, SMC_c was calculated as $SMC_c = c(df)\cdot SMC$. A negative SMC for the calculated scores indicates a positive effect on the pain outcome and the disability outcome.

Synthesis of results

The main analyses were based on stratified meta-analysis according to complete reporting score of each item. Restricted maximum likelihood (REML) based random-effects was used as default option[25], and fixed-effect analysis was applied for sensitivity analysis.

The association between intervention description completeness score for each item and clinical benefits (pain and function) was analyzed with a multilevel meta-regression model[26] with intervention description item completeness as a predictor and SMC for pain or disability as the dependent variable, in addition to study as a random effect, intervention arm and publication as covariates. To enable interpretation of SMC's into (Cohen like) effect sizes, an SMD was calculated from $SMC_{complete} - SMC_{incomplete}$, by assuming $SD_{complete} \approx SD_{incomplete}$ and the confidence intervals were calculated as $SMD \pm 1.96\ SE_{SMD}$, where $SE_{SMD} = \sqrt{(SE^2_{SMC.complete} + SE^2_{SMC.incomplete})}$[27].

Inconsistency was assessed by use of the I^2 "inconsistency index", which traditionally is interpreted as the proportion of total variance in study estimate due to heterogeneity rather than sampling error[28]. In the case of multilevel models, two separate estimated variance components, $\widehat{\sigma}^2_1$ and $\widehat{\sigma}^2_2$ (i.e., the between study variance and the within-study, i.e., between observation, variance) and two separate inconsistency indices, I^2_1 and I^2_2 (the between-study inconsistency and the within-study, i.e., between observation, inconsistency) was calculated[29]. These were summed to $\widehat{\sigma}^2_T$ and I^2_T. In the case of moderators, the decrease in $\widehat{\sigma}^2_T$ and I^2_T from the model without the moderator to the model with the moderator, was considered indicative of how much of the heterogeneity that can be explained by the moderator (covariate).

Meta-regression analyses (Bubble plots) were constructed for pain and disability with SMC plotted against intervention description completeness (number of complete items) with the area of each circle being equal to the inverse variance; i.e., the areas are proportional to the precision of each efficacy estimate. The slopes with corresponding *P*-values were estimated based on the multilevel meta-regression model with intervention description item completeness as a predictor and SMC for pain or disability as the dependent variable, in addition to study as a random effect, with intervention arm and publication as covariates.

All analyses were performed using the statistical software R version 3.3.3[30] using the function rma.mv() from the package metafor[31].

Quality assessment

The methodological quality of the included guidelines/recommendations was not assessed as we wanted to ascertain the information available to clinicians and decision makers. Also, the individual original studies were not assessed for methodological quality based on the assumption that the working groups behind the guidelines/recommendations have been thorough and systematic and formulated their recommendations based on a careful evaluation of the quality of evidence.

Results

Guideline selection

Figure 1 illustrates the flow of selected studies. After removal of duplicates, abstract screening, and full-text review, a total of 10 guidelines/recommendation documents were included. The included guidelines represent global guidance and recommendations from the major organisations and authorities operating in the field of knee OA research and management[3–6,21,32–36]. The included guidelines align with a previous guideline review within knee OA[37] and the authors' knowledge about existing guidelines. The guidelines unanimously recommended exercise as a central treatment/management option for knee OA. However, the recommendations

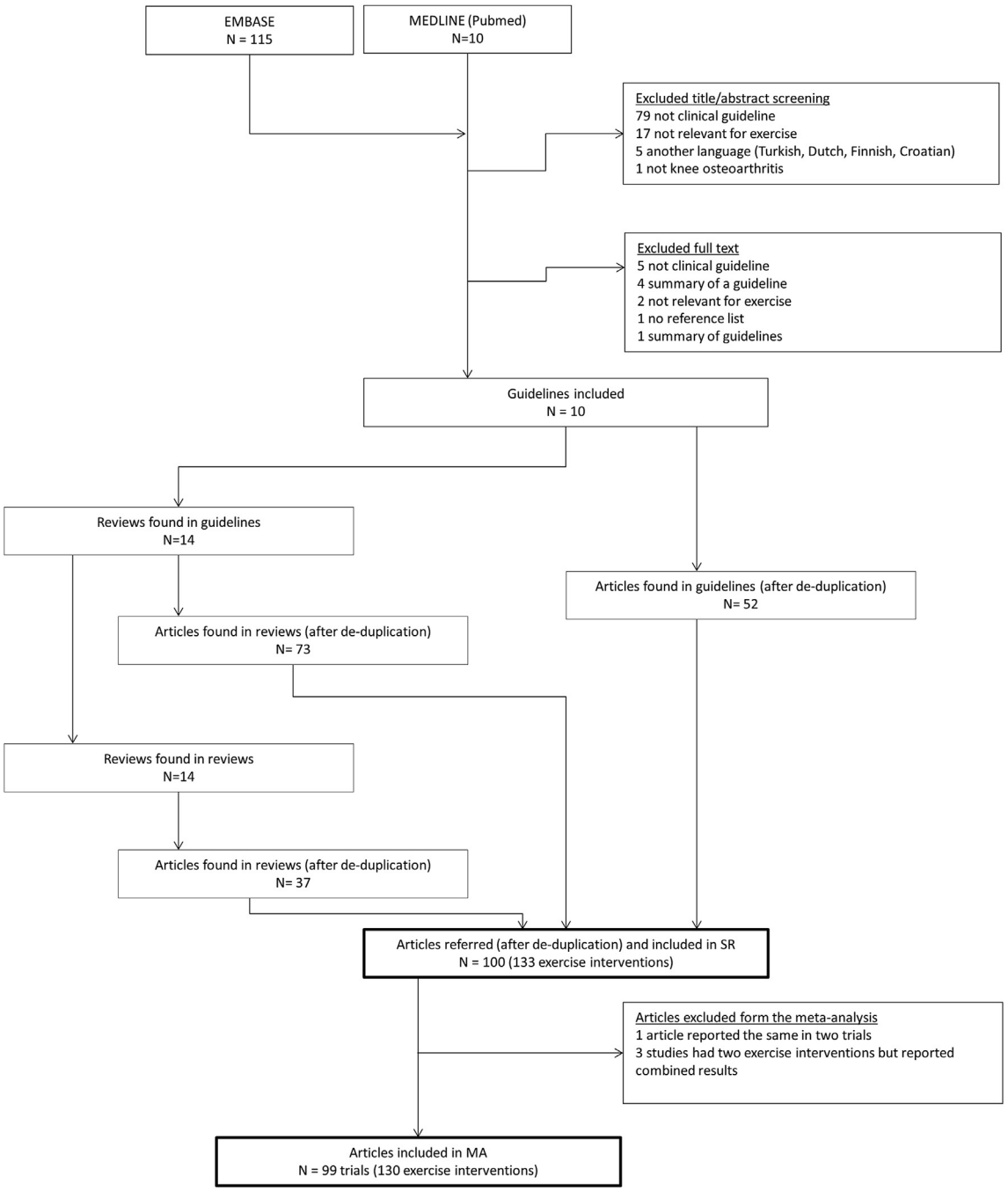

Fig. 1. Flow chart of the identification and inclusion of guidelines and original studies.

were non-specific in terms of type, dose, frequency, intensity, setting, duration, and other details of the recommended intervention. Table I summarises exercise recommendations and any specifications related to the recommended exercise in the included guidelines/recommendation documents.

Study selection

Reference lists of the 10 guidelines/recommendations were then screened for studies used to form the exercise recommendations for knee OA resulting in a total of 103 identified publications on exercise for knee OA. Of these, three could not be retrieved resulting in a total of 100 included publications[38–137]. Thirteen publications were secondary or long-term follow-up publications[40,52,78,98,100,103,107,111–113,122,130,134] (but were counted as individual interventions as they were referenced independently in guideline/recommendation). In total 133 individual exercise interventions were included in our systematic review.

The studies were published between 1982 and 2012 and included between 5 and 550 participants in the studied exercise interventions. Table II describes the characteristics of the included publications.

In the meta-analysis, one publication[120] was excluded because identical data was reported in a previous report of the same study[121]. Three publications had two exercise interventions but only data from the combined groups was reported[66,80,125]. One

Table I
Overview of included clinical guidelines and their recommendations regarding exercise for knee osteoarthritis

Guideline/recommendation title and issuing authority/organisation	Year	Country/region	Recommendation pertaining to exercise	Intervention specification, if any
OARSI recommendations for the management of hip and knee osteoarthritis, Part II: OARSI evidence-based, expert consensus guidelines[6] Issued by: Osteoarthritis Research Society International (OARSI)	2008	Global	*"Patients with hip and knee OA should be encouraged to undertake, and continue to undertake, regular aerobic, muscle strengthening and range of motion exercises"*	*"…patients with OA knee should be encouraged to undertake regular aerobic walking exercises and home-based quadriceps muscle strengthening exercises…"*
Guideline for the non-surgical management of hip and knee osteoarthritis[34] Issued by: The Royal Australian College of General Practitioners (RACGP)	2009	Australia	*"There is good evidence to support GPs recommending land based exercise for people with OA of the hip and knee"*	*"Exercise programs should be individualised to the patient's specific needs, abilities and preferences and implemented by an appropriately trained health care provider."* *"Physical exercise of a light to moderate intensity increases muscle strength as well as range of motion, aerobic capacity, and endurance that contributes to improved physical functioning and pain reduction. A range of both supervised and home based exercise programs are available for patients with OA, including quadriceps muscle strengthening, resistance training, aerobic exercise, and flexibility exercises. Various programs offer different benefits and no specific type of exercise regimen has been shown to be superior"*
KNGF Guideline for Physical Therapy in patients with Osteoarthritis of the hip and knee[36] Issued by: Royal Dutch Society for Physical Therapy (KNGF)	2010	The Netherlands	*"…the Guideline Development Committee recommends the use of exercise therapy to alleviate pain and improve physical performance."*	*"…recommends supervised exercise therapy"* *"…cannot recommend specific types of exercises or intensities"* *"…recommends that an exercise program needs to include at least muscle strengthening, exercises to increase aerobic capacity, walking exercises and functional exercises, whether or not in combinations"* *"…recommends that the content and intensity of the exercise program be tailored to the patient's individual goals in terms of limitations of activity and restrictions of participation"* *"…recommends spreading the treatment sessions over longer periods with lower frequencies in the later stages of the exercise program"* *"…recommends that after a period of supervised exercise, patients should be referred to regular community exercise and sports activities"*
Physiotherapy in hip and knee osteoarthritis: Development of a practice guide line concerning initial assessment, treatment and evaluation[35] Published by: The authors of KNGF Guideline (above)	2011	The Netherlands	*"(Supervised) Exercise therapy aimed at reducing pain and improving physical functioning should be applied during the physiotherapy treatment of hkoa patients"*	*"There are no recommendations on intensity, specific exercise forms, number of treatment or follow up sessions, and supervision."*
Ottawa Panel Evidence-Based Clinical Practice Guidelines for Aerobic Walking Programs in the Management of Osteoarthritis[32] Issued by: Ottawa Panel	2012	Canada	*"The Ottawa Panel concluded that aerobic walking combined with stretching and strengthening exercises, education, and/or behaviour programs are recommended to improve pain relief, functional status, and QOL of adult individuals with OA."*	No intervention specification besides brief summaries of all reviewed studies.
American College of Rheumatology 2012 Recommendations for the Use of Nonpharmacologic and Pharmacologic Therapies in Osteoarthritis of the Hand, Hip, and Knee[5] Issued by: American College of Rheumatology (ACR)	2012	USA	*"We strongly recommend that patients with knee OA should do the following:* *Participate in cardiovascular (aerobic) and/or resistance land-based exercise* *Participate in aquatic exercise"*	*"The TEP expressed no preference for aquatic exercises as opposed to land-based exercises based on benefits or safety…. For example, a patient who is aerobically deconditioned should initially participate in an aquatic exercise program in order to improve their aerobic capacity. Once this is accomplished, they can progress to a land-based program and choose, in conjunction with their health care provider, an aerobic conditioning or strengthening program or both."*
EULAR recommendations for the non-pharmacological core management of hip and knee osteoarthritis[3] Issued by: European League Against Rheumatism (EULAR)	2013	Europe	*All people with knee/hip OA should receive an individualised management plan (a package of care) that includes the core non-pharmacological approaches, specifically:* *… addressing a regular individualised exercise regimen …"*	*"…the optimal exercise 'dosage' and rate of progression remain uncertain…"* *"This recommendation suggests the need for an increase in the intensity and/or duration of exercise over time."* *"General recommendations for dosage and progression of exercise in older people and people with chronic disease are aerobic moderate-intensity training for at least* 30 min/*day or up to* 60 min *for greater benefit, and progressive strength training involving the major muscle groups at least 2*

(*continued on next page*)

Table I (*continued*)

Guideline/recommendation title and issuing authority/organisation	Year	Country/region	Recommendation pertaining to exercise	Intervention specification, if any
				days/week at a level of moderate to vigorous intensity (60–80% of one repetition maximum) for 8–12 repetitions." *"The group reached consensus that mixed programmes should be recommended"* *"Twelve or more directly supervised sessions have been shown to be more effective than a smaller number on pain … and physical function"* No intervention specification besides brief summaries of all reviewed studies.
Treatment of osteoarthritis of the knee. Evidence-based guideline 2nd edition[33] Issued by: American Academy of Orthopaedic Surgeons (AAOS)	2013	USA	*"We recommend that patients with symptomatic osteoarthritis of the knee participate in …, strengthening, low-impact aerobic exercises, and neuromuscular education;… ".*	
Osteoarthritis. Care and management in adults[21] Issued by: National Institute for Health and Care Excellence (NICE)	2014	UK	*Advise people with osteoarthritis to exercise as a core treatment, irrespective of age, comorbidity, pain severity or disability. Exercise should include:* • local muscle strengthening and • general aerobic fitness.	*"Exercise in this context included aerobic walking, home quadriceps exercise, strengthening and home exercise, aerobic exercise with weight training, and diet with aerobic and resisted exercise."* *"There is limited evidence for the benefits of one type of exercise over another but delivery of exercise in a class setting supplemented by home exercise may be superior to home exercise alone"*
OARSI guidelines for the non-surgical management of knee osteoarthritis[4] Issued by: Osteoarthritis Research Society International (OARSI)	2014	Global	*"Appropriate treatment modalities for all individuals with knee OA included … exercise (land-based and water-based), …, strength training, …."*	*"The duration and type of exercise programs included in these meta-analyses varied widely, but interventions included a combination of elements including strength training, active range of motion exercise, and aerobic activity."* *"Strength training programs primarily incorporate resistance-based lower limb and quadriceps strengthening exercises. Both weight-bearing and non-weight-bearing interventions were included, as well as group and individual programs."*

publication had one exercise intervention but reported data for two subgroups[90]. The meta-analysis, therefore, contains a total of 130 exercise interventions (99 publications).

For the analyses of pain, 78 publications were included[38–41,43–51,53,57,59–63,65–78,80,83–86,88–91,93–102,104–106,108–110,113,115–117,119,120,122,124–135,137] describing 72 studies, each including one to three exercise intervention arms, and contributing to a total of 100 observations. For the analyses of disability, 63 publications were included[38–41,43–46,48,50,53–55,57,61–63,65–67,69–73,77–84,86,87,89–93,95–97,99–102,104–106,108–110,113,115,120,122,126–135,137] describing 57 studies, each including one to two exercise intervention arms, and contributing to a total of 78 observations.

The most common pain outcome was WOMAC pain and the most common reported disability outcome was WOMAC function (see Table II).

Description of exercise interventions

No intervention (0%) was completely described on all 12 items (median 33% of items complete; range 17–75%). Name and rationale of intervention (items 1 and 2) were most consistently reported (complete for 98% and 99% of the interventions, respectively) and general procedures (item 4) were completely described in 80% of interventions (Fig. 2). Between 8% and 40% of the interventions had complete reporting of items 3, 5, 7, 9, 10, 11, and 12 (Fig. 2).

Complete descriptions of essential elements of exercise delivery and dose (items 6 and 8) were missing in 97% and 84% of interventions, respectively (Fig. 3). The subcomponents of item 6 (mode of delivery) were completely described in 26–75% of the interventions, resulting in only 3% of the interventions being adequately described regarding mode of exercise delivery. The subcomponents of item 8 (dosage) were completely described in 30–100% of the interventions, with overall intervention duration being completely described in all studies. The resulting total of complete reporting related to item 8 was 16%.

Association between completeness of intervention description and changes in pain

Based on the multilevel meta-regression model, it is suggested that a relationship between pain and number of completed items exists with a slope estimate of 0.123 indicating that studies with less complete intervention descriptions report higher effect size. However, this relationship did not quite reach statistical significance ($P = 0.073$) [Fig. 4(A)].

The associations between complete reporting of each reporting item and reported effects on pain are presented in details in Supplementary File 5. An association between description completeness of item 6a (group or individual training) and change in pain was found with an SMD of 0.52 (95% CI 0.10 to 0.93; $P = 0.010$) in favor of studies with an incomplete description of item 6a. Descriptions of item 11 (how well planned) were also significantly associated with change in pain, with an SMD of 0.58 (95% CI 0.03 to 1.13; $P = 0.036$) in favor of studies with an incomplete description of item 11. The heterogeneity was generally very high.

Association between completeness of intervention description and changes in disability

Based on the multilevel meta-regression model, no relationship was found between self-reported disability and number of completed items with a slope estimate of −0.078 ($P = 0.257$) [Fig. 4(B)].

Table II
Details and reporting completeness of the identified studies

Author year	Guideline	N (intervention)	Duration	Pain scale extracted	Function scale extracted	Items of complete reporting																							
						1	2	3	4	5	6							7	8						9	10	11	12	TOT
											a	b	c	d	e	f	a-f		a	b	c	d	a-d					
Adler, 2007[38]	RACGP, EULAR, OARSI	8	10 w	WOMAC pain	LLFDI (functional component)	+	+	−	+	+	+	+	+	+	−	−	−	+	−	+	+	+	−	−	+	−	+	7
Aglamis, 2008[39]	KNGF	17	12 w	VAS (during walking)	SF-36 (physical function)	+	+	−	+	−	−	+	−	+	−	+	−	−	+	+	−	+	−	−	−	−	−	3
Aglamis, 2009[40]	EULAR	17	12 w	WOMAC pain	WOMAC function	+	+	−	+	−	−	+	−	+	−	+	−	−	+	+	−	+	−	−	−	−	−	3
An, 2008[41]	EULAR	14	8 w	WOMAC pain	WOMAC function	+	+	−	+	+	−	+	−	−	+	+	−	−	−	+	+	+	−	+	−	−	−	5
Azad, 2011[42]	AAOS	52	6 w	NA	NA	+	+	−	+	−	−	+	−	−	−	+	−	−	−	+	−	+	−	−	−	−	−	3
Baker, 2001[43]	ACR, RACGP, EULAR, KNGF, KNGF2011, NICE, OARSI08, OARSI	23	4 m	WOMAC pain	WOMAC function	+	+	+	+	−	+	+	+	+	−	+	−	+	+	+	−	+	−	+	−	−	+	7
Bautch, 1997[44]	Ottawa, ACR, RACGP, EULAR, KNGF, KNGF2011, NICE, OARSI08, OARSI	6	12 w	VAS	AIMS	+	+	−	+	−	+	+	−	−	−	+	−	−	−	+	+	+	−	−	−	−	−	3
Bennell, 2005[45]	AAOS	45	24 w	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	+	−	−	−	−	+	−	+	−	+	−	−	−	−	+	6
Bennell, 2010[46]	AAOS, ACR, EULAR, KNGF, KNGF11, OARSI	73	12 w	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	−	−	−	−	−	−	−	+	−	+	−	−	−	−	+	5
Börjesson, 1996[47]	NICE, AAOS, EULAR, OARSI	34	5 w	NRS pain during walking	NA	−	+	−	+	−	+	+	−	+	−	+	−	−	+	+	+	+	+	+	−	−	−	4
Brismee, 2007[48]	NICE, OARSI	22	12 w	WOMAC pain	WOMAC function	+	+	−	+	−	+	+	+	+	−	+	−	−	+	+	+	+	+	−	−	−	+	5
Callaghan, 1995[49] (supervised)	EULAR, OARSI08, OARSI	8	4 w	VAS	NA	−	+	−	−	−	+	+	−	−	−	+	−	+	−	+	+	+	−	−	−	−	−	2
Callaghan, 1995[49] (home)	EULAR, OARSI08, OARSI	10	4 w	NA	NA	−	+	−	−	−	−	−	−	−	−	+	−	+	−	+	−	+	−	−	−	−	−	2
Chamberlain, 1982[50]	OARSI08	20	12 w	VAS	Function (walking, stairs, kneeling, use of stick)	+	+	+	−	−	−	+	+	−	−	−	−	+	−	+	−	+	−	−	−	−	−	4
Cheing, 2002[51]	RACGP, EULAR, KNGF	15	4 w	VAS	NA	+	+	−	+	−	−	−	−	−	+	+	−	−	+	+	+	+	+	−	−	−	−	4
Cheing, 2004[52]	RACGP, KNGF	15	4 w	NA	NA	+	+	−	+	−	−	−	−	−	+	+	−	−	+	+	+	+	+	−	−	−	−	4
Cochrane, 2005[53]	NICE, OARSI08, RACGP, EULAR, KNGF, OARSI	153	1 year	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	+	−	−	+	−	+	−	+	+	+	−	−	−	+	−	6
Deyle, 2000[54]	AAOS, ACR, RACGP, EULAR, KNGF, KNGF2011, OARSI	33	4 w	NA	NA	+	+	−	+	−	−	+	+	+	−	+	−	−	−	+	−	+	−	+	−	−	+	5
Deyle, 2005[55] (supervised)	KNGF	66	4 w	NA	WOMAC total	+	+	−	+	−	−	+	−	+	+	+	−	+	−	+	−	+	−	+	−	−	−	5
Deyle, 2005[55] (home)	KNGF	68	4 w	NA	WOMAC total	+	+	−	+	−	+	+	−	+	+	+	−	+	−	+	−	+	−	+	−	−	−	5
Dias, 2003[56]	ottawa	24	12 w	NA	SF-36 (physical function)	+	+	−	+	−	−	+	−	−	−	−	−	−	−	+	−	+	−	−	−	−	−	3
Doi, 2008[57]	KNGF	72	8 w	NA	WOMAC total	+	+	−	+	+	+	+	+	−	−	+	−	+	−	+	−	+	−	−	−	+	−	6
Duracoglu, 2005[58] (kinesthesia)	AAOS, KNGF	33	8 w	NA	WOMAC function	+	+	−	+	−	+	+	−	−	−	+	−	−	−	+	−	+	−	−	−	−	+	4
Duracoglu, 2005[58] (strength)	AAOS, KNGF	33	8 w	VAS	WOMAC function	+	+	−	+	−	+	+	−	−	−	+	−	−	−	+	−	+	−	−	−	−	+	4
Ebnezar, 2012[59]	AAOS	125	3 m	NRS rest	NA	+	+	−	+	−	−	+	−	−	−	−	−	−	−	+	+	+	−	−	−	−	−	3
Ettinger, 1997[60] (FAST, aerobic)	AAOS, OARSI08, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	144	18 m	Knee pain scale	Physical disability	+	+	−	+	−	+	+	+	−	−	−	−	−	+	+	+	+	+	+	−	+	+	7
Ettinger 1997[60] (FAST, strength)	AAOS, OARSI08, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	146	18 m	Knee pain scale	Physical disability	+	+	−	+	−	+	+	+	+	−	−	−	−	−	+	+	+	−	+	−	+	+	6
Evcik, 2002[61] (home)	ottawa, RACGP, EULAR, KNGF	27	3 m	WOMAC pain	WOMAC function	+	+	−	+	−	+	+	−	−	+	+	−	−	−	+	−	+	−	−	−	+	−	4
Evcik 2002[61] (walking)	ottawa, RACGP, EULAR, KNGF	28	3 m	WOMAC pain	WOMAC function	+	+	−	−	−	−	−	−	−	−	+	−	−	−	+	+	+	−	−	−	+	−	3
Eyigor, 2004[62] (cybex)	NICE	21	6 w	WOMAC pain	WOMAC function	+	+	−	+	−	−	+	−	+	+	+	−	−	+	+	−	+	−	+	−	−	−	4
Eyigor, 2004[62] (De Lormé)	NICE	18	6 w	WOMAC pain	WOMAC function	+	+	−	+	−	−	+	−	+	+	+	−	−	+	+	−	+	−	+	−	−	−	4
Fitzgerald, 2011[63] (agility)	AAOS	91	6 m	NRS 24h	WOMAC function	+	+	+	+	+	−	+	+	+	+	+	−	+	+	Y	−	+	−	−	+	+	+	9
Fitzgerald, 2011[63] (stretching and strengthening)	AAOS	92	6 m	NRS 24h	WOMAC function	+	+	+	+	+	−	+	+	+	+	+	−	+	+	+	−	+	−	−	+	+	+	9
Focht, 2005[64]	NICE, AAOS	80	18 m	NA	NA	+	+	−	+	−	−	+	+	−	−	−	−	−	−	+	+	+	−	−	−	+	−	4
Foley, 2003[65] (Hydrotherapi)	NICE, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	35	6 w	WOMAC pain	WOMAC function	+	+	−	+	−	−	−	+	+	−	+	−	+	−	+	+	+	−	+	−	−	−	5
Foley, 2003[65] (Strength)	NICE, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	35	6 w	WOMAC pain	WOMAC function	+	+	−	+	−	−	−	+	+	−	+	−	+	−	+	+	+	−	+	−	−	−	5

(*continued on next page*)

Table II (*continued*)

Author year	Guideline	N (intervention)	Duration	Pain scale extracted	Function scale extracted	Items of complete reporting																					
						1	2	3	4	5	6							7	8					9	10	11	12	TOT
											a	b	c	d	e	f	a-f		a	b	c	d	a-d				
Fransen, 2001[66] (individual)	ACR, RACGP, EULAR, KNGF, KNGF11, OARSI08, OARSI	43	8 w	WOMAC pain	WOMAC function	+	+	−	−	−	+	+	−	−	−	−	−	−	−	+	+	+	−	+	−	−	−	3
Fransen, 2001[66] (group)	ACR, RACGP, EULAR, KNGF, KNGF11, OARSI08, OARSI	40	8 w	WOMAC pain	WOMAC function	+	+	−	+	−	+	+	−	−	−	+	−	−	−	+	+	+	−	+	−	−	−	4
Fransen, 2007[67] (Hydrotherapi)	KNGF, NICE, AAOS, ACR, EULAR, KNGF2011, OARSI	55	12 w	WOMAC pain	WOMAC function	+	+	−	+	−	+	+	+	−	+	−	−	−	−	+	+	+	−	−	−	−	+	4
Fransen, 2007[67] (Tai Chi)	KNGF, NICE, AAOS, ACR, EULAR, KNGF2011, OARSI	56	12 w	WOMAC pain	WOMAC function	+	+	−	−	+	+	+	+	−	−	−	−	−	−	+	+	+	−	−	−	−	+	4
Gur, 2002[68] (concentric)	ACR, EULAR, KNGF, KNGF11, OARSI08, OARSI	8	8 w	NRS standing	NA	+	+	−	+	−	−	+	+	+	−	+	−	−	+	+	−	+	−	+	−	−	+	5
Gur, 2002[68] (concentric-eccentric)	ACR, EULAR, KNGF, KNGF11, OARSI08, OARSI	9	8 w	NRS standing	NA	+	+	−	+	−	−	+	+	+	−	+	−	−	+	+	−	+	−	+	−	−	+	5
Halbert, 2001[69]	RACGP, EULAR, KNGF, OARSI08	37	12 m	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	+	−	−	−	−	−	−	−	+	+	+	−	−	−	−	4
Hartman, 2000[70]	RACGP, OARSI	18	12 w	ASE pain	ASE function	+	+	−−	+	+	−	+	+	−	−	−	−	−	−	−	+	+	+	−	−	−	+	5
Hay, 2006[71]	NICE, ACR, EULAR, KNGF, KNGF11, OARSI	109	10 w	WOMAC pain	WOMAC function	+	+	−	+	+	−	+	−	−	−	−	−	−	−	−	−	+	+	−	−	+	−	−	5
Hinman, 2007[72]	KNGF, NICE, EULAR	36	6 w	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	+	−	+	+	−	−	−	−	+	+	+	−	+	−	−	+	6
Hopman-Rock, 2000[73]	ACR, RACGP, EULAR, KNGF, KNGF11, OARSI08, OARSI	56	6 w	IRGL pain	IRGL mobility	+	+	−	+	−	+	+	−	−	−	−	−	−	−	−	+	+	+	−	−	−	−	−	3
Huang, 2003[74] (isokinetic)	NICE, AAOS, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	33	8 w	VAS after walking 5min	NA	+	+	−	+	−	−	−	+	+	−	−	−	−	+	+	−	+	−	+	−	−	+	5
Huang, 2003[74] (isotonic)	NICE, AAOS, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	33	8 w	VAS after walking 5min	NA	+	+	−	+	−	−	−	+	+	−	−	−	−	+	+	−	+	−	+	−	−	+	5
Huang, 2003[74] (isometric)	NICE, AAOS, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	33	8 w	VAS after walking 5min	NA	+	+	−	+	−	−	−	+	+	−	−	−	−	−	+	−	+	−	−	−	−	+	4
Huang, 2005[75]	RACGP, EULAR, KNGF	30	8 w	VAS after walking 5min	NA	+	+	−	−	−	−	−	+	+	−	−	−	−	+	+	−	+	−	−	−	−	+	3
Huang, 2005[76]	ACR, EULAR, KNGF, KNGF11, OARSI	35	8 w	VAS after walking 5min	NA	+	+	−	−	−	−	−	+	+	−	−	−	−	+	+	−	+	−	−	−	−	+	3
Hughes, 2004[77]	ACR, RACGP, EULAR, KNGF, KNGF11, OARSI08, OARSI	80	8 w	WOMAC pain	WOMAC function	+	+	+	+	−	+	+	+	−	−	+	−	−	−	+	+	+	−	+	−	+	−	6
Hughes, 2006[78]	EULAR, OARSI	80	8 w	WOMAC pain	WOMAC function	+	+	+	+	−	+	+	+	−	−	+	−	−	−	+	+	+	−	+	−	+	−	6
Hurley, 1998[79]	RACGP, EULAR, KNGF, OARSI08	60	5 w	NA	Lequesne Index, total	+	+	−	+	−	+	+	−	−	−	+	−	−	−	+	+	+	−	−	−	−	−	3
Hurley, 2007[80] (individual)	NICE, AAOS	146	6 w	WOMAC Pain	WOMAC function	+	+	−	+	+	+	+	+	+	+	+	+	−	−	+	+	+	−	−	−	−	−	5
Hurley, 2007[80] (group)	NICE, AAOS	132	6 w	WOMAC Pain	WOMAC function	+	+	−	+	+	+	+	+	+	+	+	+	−	−	+	+	+	−	−	−	−	−	5
Jan, 2008[81] (jospt)	EULAR, AAOS, KNGF11, KNGF	20	6 w	NA	FIS (Bandi)	+	+	−	+	+	−	+	+	+	+	+	−	−	+	+	+	+	+	+	−	−	+	7
Jan, 2008[83] (high resistance)	KNGF11, KNGF	34	8 w	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	−	+	+	+	−	−	+	+	+	+	+	−	+	−	−	6
Jan, 2008[83] (low resistance)	KNGF11, KNGF	34	8 w	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	−	+	+	+	−	−	+	+	+	+	+	−	+	−	−	6
Jan, 2009[82] (weight baring)	AAOS	36	8 w	NA	WOMAC function	+	+	−	+	−	−	−	−	+	+	+	−	−	+	+	−	+	−	−	+	−	−	4
Jan, 2009[82] (non-weight baring)	AAOS	35	8 w	NA	WOMAC function	+	+	−	+	−	−	−	−	+	+	+	−	−	+	+	−	+	−	−	+	−	−	4
Jessep, 2009[84] (physiotherapy)	EULAR	35	5 w	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	+	+	+	+	+	−	−	+	+	+	−	−	−	−	+	6
Jessep, 2009[84] (escape)	EULAR	29	5 w	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	+	+	+	+	+	−	−	+	+	+	−	−	−	−	+	6
Karatosun, 2006[131]	EULAR	53	6 w	HSS Pain during activity	NA	+	+	−	+	−	+	+	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	3
Keefe, 2004[85]	NICE, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	16	12 w	AIMS pain	NA	+	+	+	+	+	+	+	+	+	−	+	−	−	+	+	+	+	+	−	−	−	−	6
Kovar, 1992[86]	ottawa, AAOS, ACR, RACGP, EULAR, KNGF, KNGF11, NICE, OARSI08, OARSI	52	8 w	AIMS pain	AIMS physical activity	+	+	−	+	−	+	+	−	−	−	−	−	−	−	−	+	+	+	−	−	−	+	4
Kreindler, 1989[87] (strength)	EULAR	5	6 w	NA	NA	+	+	−	−	−	−	−	−	+	−	−	−	−	−	−	+	−	+	−	−	+	−	−	3
Kreindler, 1989[87] (kinetron)	EULAR	10	6 w	NA	NA	+	+	−	−	−	−	−	−	+	−	−	−	−	−	−	+	−	+	−	−	+	−	−	3
Kreindler, 1989[87] (cybex)	EULAR	9	6 w	NA	NA	+	+	−	+	−	−	−	−	+	+	−	−	−	−	−	+	−	+	−	−	+	−	−	4
Kuptniratsaikul, 2002[88]	RACGP, KNGF, OARSI08	199	8 w	Pain score	NA	+	+	−	−	−	−	+	+	−	−	−	−	−	−	−	+	+	+	−	−	−	−	−	2
Lee, 2009[89]	EULAR,OARSI	29	8 w	WOMAC pain	WOMAC function	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−	+	+	+	−	−	−	−	−	3

Lim, 2008[90]	KNGF11, KNGF, NICE	53	12 w	WOMAC pain	WOMAC function	+	+	−	+	+	+	+	+	−	+	−	−	+	−	+	−	+	−	−	−	−	+	6
Lin, 2004[91]	EULAR	66	12 m	WOMAC pain	WOMAC function	+	+	−	−	−	+	+	+	+	−	+	−	+	−	+	+	+	−	−	−	−	+	4
Lin, 2007[92] (computerized proprioception facilitation)	EULAR	29	8 w	NA	WOMAC function	+	+	−	+	−	−	−	−	+	+	+	−	−	−	+	+	+	−	+	−	−	−	4
Lin, 2007[92] (closed kinetic chain)	EULAR	26	8 w	NA	WOMAC function	+	+	−	+	−	−	−	−	−	−	+	−	−	+	+	−	+	−	−	−	−	−	3
Lin, 2009[93] (proprioceptive)	AAOS, EULAR	36	8 w	WOMAC pain	WOMAC function	+	+	−	+	−	−	−	−	+	+	+	−	−	−	+	+	+	−	−	−	−	−	3
Lin, 2009[93] (strength)	AAOS, EULAR	36	8 w	WOMAC pain	WOMAC function	+	+	−	+	−	−	−	−	+	+	+	−	−	+	+	−	+	−	+	−	−	−	4
Lund, 2008[94] (aquatic)	KNGF	25	8 w	KOOS pain	NA	+	+	+	+	−	−	+	+	−	+	+	−	−	−	+	+	+	−	−	−	−	+	5
Lund, 2008[94] (land-based)	KNGF	27	8 w	KOOS pain	NA	+	+	+	+	−	−	+	+	−	+	+	−	−	−	+	+	+	−	−	−	−	+	5
Magione, 1999[95] (high intensity aerobic)	KNGF, KNGF11, NICE, RACGP, OARSI08, OARSI	19	10 w	AIMS2 pain	NA	+	+	−	+	−	−	−	+	+	+	+	−	−	+	+	+	+	+	+	−	−	+	6
Magione, 1999[95] (low intensity aerobic)	KNGF, KNGF11, NICE, RACGP, OARSI08, OARSI	20	10 w	AIMS2 pain	NA	+	+	−	+	−	−	−	+	+	+	+	−	−	+	+	+	+	+	+	−	−	+	6
Maurer, 1999[96]	AAOS, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI08, OARSI	57	8 w	WOMAC pain	WOMAC function	+	+	−	+	−	−	−	−	−	−	+	−	−	+	+	−	+	−	−	−	−	−	3
McCarthy, 2004[97] (home)	KNGF, NICE, AAOS, RACGP	103	12 m	WOMAC pain	WOMAC function	+	+	−	−	−	+	+	+	−	−	−	−	+	−	+	−	+	−	+	+	−	−	5
McCarthy, 2004[97] (home and class based)	KNGF, NICE, AAOS, RACGP	111	12 m	WOMAC pain	WOMAC function	+	+	−	−	+	+	+	+	−	−	−	−	−	−	+	−	+	−	+	+	−	−	5
Messier, 1997[98] (FAST, subgroup, aerobic)	NICE, ottawa, RACGP, EULAR, KNGF, OARSI	33	18 m	Likert scale walk and stair	NA	+	+	−	+	−	−	−	+	+	−	−	−	−	+	+	+	+	+	+	+	+	+	8
Messier, 1997[98] (FAST, subgroup, strength)	NICE, ottawa, RACGP, EULAR, KNGF, OARSI	34	18 m	Likert scale walk and stair	NA	+	+	−	+	−	−	−	+	+	−	−	−	−	−	+	−	+	−	+	+	+	+	7
Messier, 2000[99]	NICE, RACGP, KNGF	11	6 m	Likert scale walk and stair	Physical Performance Inventory	+	−	−	+	+	−	+	+	−	−	+	−	−	−	+	+	+	−	−	−	−	+	4
Messier, 2004[100] (ADAPT)	NICE, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI08, OARSI	80	18 m	WOMAC pain	WOMAC function	+	+	−	+	−	−	−	+	+	−	−	−	−	−	+	−	+	−	+	−	+	+	6
Mikesky, 2006[101]	ACR, EULAR, KNGF, KNGF11, OARSI	113	30 m	WOMAC pain	WOMAC function	+	+	−	+	−	+	+	+	+	−	−	−	−	−	+	−	+	−	+	+	+	+	7
Minor, 1989[102] (walking)	ottawa, ACR, RACGP, EULAR, KNGF, KNGF2011, OARSI08, OARSI	36	12 w	AIMS pain	AIMS physical activity	+	+	−	+	−	+	+	−	+	−	−	−	−	+	+	+	+	+	+	−	−	−	5
Minor, 1989[102] (aquatic)	ottawa, ACR, RACGP, EULAR, KNGF, KNGF2011, OARSI08, OARSI	47	12 w	AIMS pain	AIMS physical activity	+	+	−	+	−	+	+	−	+	−	−	−	+	+	+	+	+	+	+	−	−	−	6
Minor, 1993[103] (walking)	RACGP, EULAR, KNGF, OARSI	36	12 w	NA	NA	+	+	−	+	−	+	+	−	+	−	−	−	−	+	+	+	+	+	+	−	−	−	5
Minor, 1993[103] (aquatic)	RACGP, EULAR, KNGF, OARSI	47	12 w	NA	NA	+	+	−	+	−	+	+	−	+	−	−	−	+	+	+	+	+	+	+	−	−	−	6
Ni, 2010[104]	EULAR, OARSI	18	24 w	WOMAC pain	WOMAC function	+	+	−	−	+	−	+	−	+	−	+	−	−	−	+	+	+	−	−	−	−	−	3
O'Reilly, 1999[105]	OARSI08, AAOS, ACR, RACGP, EULAR, KNGF, KNGF11, NICE, OARSI	113	6 m	WOMAC pain	WOMAC function	+	+	−	+	−	+	+	−	−	−	+	−	+	−	+	−	+	−	−	−	−	−	4
Patrick, 2001[106]	RACGP, EULAR, KNGF, OARSI	125	20 w	HAQ pain	HAQ disability	+	+	−	−	−	+	+	+	−	−	+	−	−	−	+	+	+	−	−	−	−	−	2
Penninx, 2001[107] (FAST, aerobic)	NICE, ottawa, RACGP, EULAR, KNGF, OARSI	88	18 m	NA	NA	+	+	−	+	+	−	+	+	−	−	+	−	−	+	+	+	+	+	+	−	+	+	8
Penninx, 2001[107] (FAST, strength)	NICE, ottawa, RACGP, EULAR, KNGF, OARSI	82	18 m	NA	NA	+	+	−	+	+	−	+	+	−	−	−	−	−	−	+	−	+	−	+	−	+	+	7
Petrella, 2000[108]	ACR, RACGP, EULAR, KNGF, KNGF2011, NICE, OARSI08, OARSI	91	8 w	WOMAC Pain	WOMAC physical activity	+	+	−	+	−	+	+	−	+	+	+	−	+	−	+	−	+	−	−	−	−	−	4
Quilty, 2003[109]	KNGF2011, ACR, EULAR, KNGF, OARSI08, OARSI	43	10 w	VAS pain	WOMAC function	+	+	−	+	−	−	+	−	−	−	−	−	+	−	+	+	+	−	+	−	−	−	5
Ravaud, 2004[110]	OARSI08	550	6 m	VAS pain	WOMAC function	+	+	−	−	−	+	+	+	−	−	−	−	+	−	−	−	+	−	−	−	−	+	4
Rejeski, 1997[111] (FAST)	OARSI08, RACGP, EULAR, KNGF, OARSI	NA	16 m	NA	NA	+	+	−	+	−	−	+	+	−	−	−	−	−	−	+	+	+	−	+	−	+	−	5
Rejeski, 1998[112] (ADAPT)	EULAR	69	18 m	Knee pain scale (KPS)	NA	+	+	−	+	−	−	+	+	−	−	−	−	+	−	+	+	+	−	+	−	+	+	7
Rejeski, 2002[113] (ADAPT)	NICE, AAOS, RACGP, KNGF	69	18 m	SF-36 body pain	SF-36 physical functioning	+	+	−	+	−	−	−	−	−	−	−	−	−	−	+	+	+	−	+	−	+	−	5
Rodgers, 1998[114]	EULAR	10	6 w	NA	NA	+	+	−	+	−	−	+	−	−	−	+	−	−	−	+	−	+	−	−	−	−	−	3
Rooks, 2006[115]	EULAR	22	6 w	VAS weight bearing	WOMAC function	+	+	−	+	−	−	+	−	−	−	+	−	−	−	+	+	+	−	−	−	−	+	4
Røgind, 1998[116]	ACR, RACGP, EULAR, KNGF, KNGF11, OARSI08, OARSI	12	3 m	WOMAC pain	NA	+	+	−	+	−	+	+	+	−	−	−	−	−	−	+	−	+	−	−	−	−	+	4
Schilke, 1996[117]	ACR, RACGP, EULAR, KNGF, KNGF11, OARSI08, OARSI	10	8 w	OASI pain	NA	+	+	−	+	−	−	−	−	−	−	+	−	−	+	+	−	+	−	−	−	−	−	3

(continued on next page)

Table II (*continued*)

Author year	Guideline	N (intervention)	Duration	Pain scale extracted	Function scale extracted	Items of complete reporting																							
						1	2	3	4	5	6							7	8					9	10	11	12	TOT
											a	b	c	d	e	f	a-f		a	b	c	d	a-d					
Shakoor, 2010[118]	AAOS	64	6 w	NA	NA	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	2
Silva, 2008[119] (aquatic)	KNGF, AAOS	32	18 w	VAS pain (previous week)	NA	+	+	–	+	–	+	+	–	+	+	+	–	+	–	+	+	+	–	–	–	–	4
Silva, 2008[119] (land-based)	KNGF, AAOS	32	18 w	VAS pain (previous week)	NA	+	+	–	+	–	+	+	–	+	+	+	–	+	–	+	+	+	–	+	–	–	5
Song, 2003[120]	ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	22	12 w	WOMAC Pain	WOMAC Physical function	+	+	+	–	+	+	+	–	+	–	–	–	–	–	+	–	+	–	–	–	+	–	5
Song, 2007[121]	RACGP, EULAR	22	12 w	WOMAC Pain	WOMAC Physical function	+	+	+	–	+	+	+	–	+	–	–	–	–	–	+	–	+	–	–	–	+	–	5
Sullivan, 1998[122]	RACGP, KNGF	52	8 w	VAS pain	AIMS physical activity	+	+	–	+	–	+	+	–	–	–	–	–	–	–	+	+	+	–	–	–	–	–	3
Suomi, 1997[123]	RACGP, EULAR, KNGF	17	6 w	NA	NA	+	+	–	+	+	–	+	+	–	–	+	–	–	–	+	+	+	–	–	–	–	+	5
Talbot, 2003[124]	ACR, EULAR, KNGF, KNGF11, NICE, OARSI08, OARSI, ottawa	17	12 w	VAS present pain	NA	+	+	–	+	–	+	+	+	+	–	–	–	+	–	+	–	+	–	+	–	–	+	6
Thomas, 2002[125] (exercise)	OARSI08, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	235	2 years	WOMAC pain	NA	+	+	–	–	–	+	+	–	–	–	–	–	+	–	–	+	+	–	–	–	+	–	4
Thomas, 2002[125] (exercise and phone calls)	OARSI08, ACR, RACGP, EULAR, KNGF, KNGF11, OARSI	121	2 years	WOMAC pain	NA	+	+	–	–	–	+	+	–	–	–	–	–	+	–	–	+	+	–	–	–	+	–	4
Thorstensson, 2005[126]	NICE, ACR, EULAR, KNGF, KNGF11, OARSI	30	6 w	KOOS pain	KOOS ADL	+	+	–	+	–	+	+	+	–	–	–	–	–	+	+	+	+	+	+	–	–	+	6
Topp, 2002[127] (isometric)	AAOS, ACR, RACGP, EULAR, KNGF, KNGF11, NICE, OARSI08, OARSI	32	16 w	WOMAC pain	WOMAC function	+	+	–	+	–	+	+	–	+	+	–	–	–	+	+	+	+	+	–	–	–	–	4
Topp, 2002[127] (dynamic)	AAOS, ACR, RACGP, EULAR, KNGF, KNGF11, NICE, OARSI08, OARSI	35	16 w	WOMAC pain	WOMAC function	+	+	–	+	–	+	+	–	+	+	–	–	–	–	+	+	+	–	–	–	–	–	3
Tunay, 2010[128] (hospital based)	AAOS	30	6 w	VAS pain (climbing/ descending stairs)	NA	+	+	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–	–	–	2
Tunay, 2010[128] (home based)	AAOS	30	6 w	VAS pain (climbing/ descending stairs)	NA	+	+	–	–	–	+	+	–	–	–	–	–	+	–	+	–	+	–	–	–	–	–	3
Van Baar, 1998[129]	ACR, RACGP, EULAR, KNGF, KNGF11, OARSI08	98	12 w	VAS pain past week	Self-reported disability (IRGL questionnaire)	+	+	–	–	–	–	+	–	–	–	–	–	+	–	–	–	+	–	–	–	–	+	4
Van Baar, 2001[130]	NICE, RACGP, EULAR, KNGF	98	12 w	VAS pain past week	Self-reported disability (IRGL questionnaire)	+	+	–	–	–	–	+	–	–	–	–	–	+	–	–	–	+	–	–	–	–	+	4
Veenhof, 2006[132]	KNGF	97	12 w	WOMAC pain	WOMAC physical function	+	+	–	+	+	+	+	+	–	–	–	–	+	–	–	–	+	–	–	–	–	+	6
Wang, 2004[133]	RACGP, EULAR, KNGF, OARSI08	20	12 w	Pain intensity (0 −100)	Functional status (0−3)	+	+	–	+	+	+	+	+	–	–	+	–	–	+	+	+	+	+	+	–	+	+	8
Wang, 2007[134]	KNGF, EULAR	20	12 w	VAS bodily pain	Physical functioning (MDHAQ)	+	+	–	+	+	+	+	+	–	–	+	–	–	+	+	+	+	+	+	–	+	+	8
Wang, 2009[135]	EULAR	20	12 w	WOMAC pain	WOMAC physical function	+	+	–	+	+	–	+	+	–	–	–	–	–	–	+	+	+	–	–	–	+	+	6
Wyatt, 2001[136] (aquatic)	RACGP, EULAR, KNGF, OARSI08, OARSI	NA	6 w	NA	NA	+	+	–	+	–	–	–	–	–	–	+	–	–	–	+	–	+	–	–	–	–	–	3
Wyatt, 2001[136] (land based)	RACGP, EULAR, KNGF, OARSI08, OARSI	NA	6 w	NA	NA	+	+	–	+	–	–	–	–	–	–	+	–	–	–	+	–	+	–	–	–	–	–	3
Yip, 2007[137]	AAOS	88	16 w	VAS pain	Modified HAQ	+	+	–	+	–	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	3

AAOS: American Academy of Orthopedic Surgeons; **ACR**: American College of Rheumatology; **EULAR**: European League Against Rheumatism; **KNGF**: Koninklijk Nederlands Genootschap voor Fysiotherapi; **KNGF11**: Koninklijk Nederlands Genootschap voor Fysioterapi from 2011; **NICE**: National Institute for Health Excellence; **OARSI**: Osteoarthritis Research Society International; **OARSI08**: Osteoarthritis Research Society International from 2008; **Ottawa**: The Ottawa group; **RACGP**: The Royal Australian College of General Practitioners; (m): the MOVE consensus.
AIMS: Arthritis Impact Measurement Scales; **ASE**: Arthritis Self-Efficacy scale; **FIS**(bandi): Bandi's Functional Incapacity Score; **HAQ**: Health Assessments Questionnaire; **IRGL questionnaire**: Influence of Rheumatic Disease on General Health and Lifestyle;; **KOOS**: Knee injury and Osteoarthritis Outcome Score; **LLFDI**: Late-life Function and Disability Instrument; **MDHAQ**: Multidimensional Health Assessment Questionnaire; **NRS**: numeric rating scale; **OASI**: Osteoarthritis Screening Index; **SF-36**: Short Form 36 health survey questionnaire; **VAS**: Visual analogue scale; **WOMAC**: Western Ontario and McMaster Universities Osteoarthritis Index.
m = months; **w** = weeks.

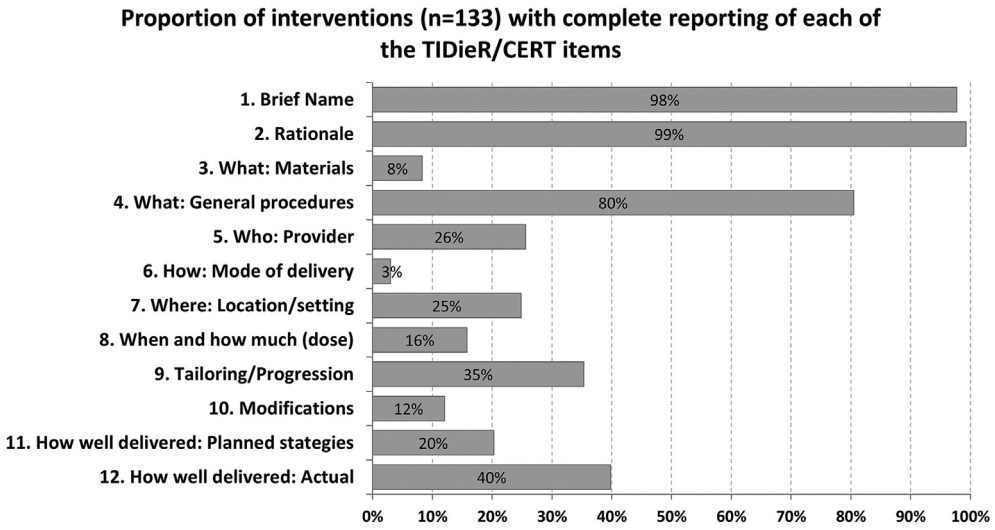

Fig. 2. Proportion of interventions ($n = 133$) with complete reporting of each of the 12 items on the TIDieR/CERT checklist.

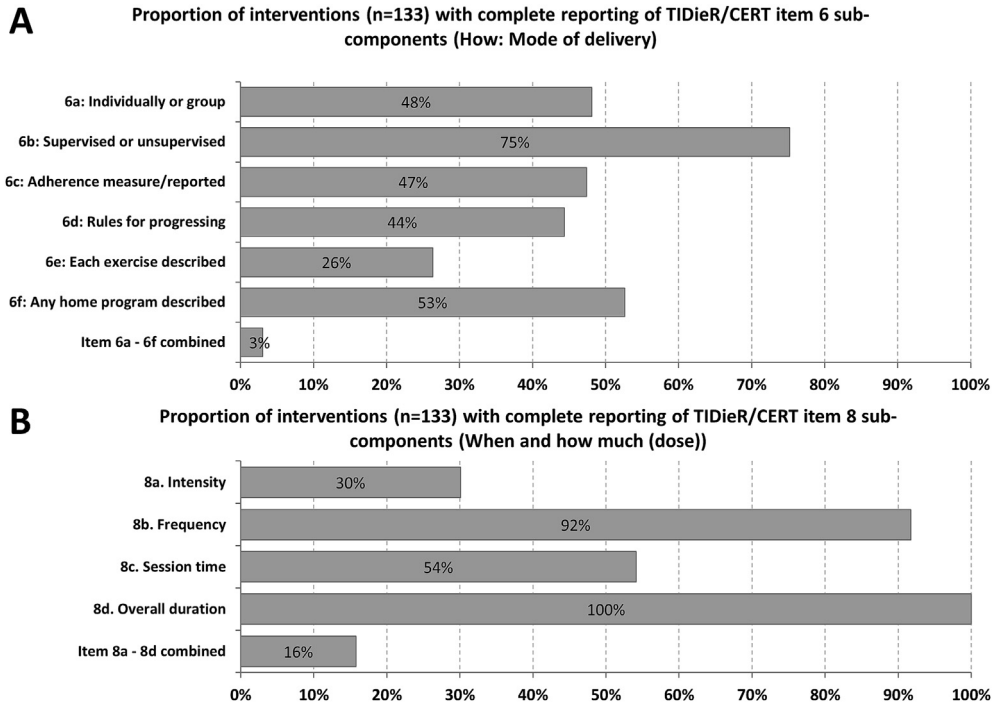

Fig. 3. Proportion of interventions ($n = 133$) with complete reporting of the sub-components of item number 6 (A) and 8 (B).

Associations between each item and self-reported disability are presented in Supplementary File 5. One item (7: Where) was significantly associated with disability with an SMD of 0.39 (95% CI −0.01 to 0.79; $P = 0.045$) in favor of incomplete reporting. The heterogeneity was generally very high.

Discussion

Knee OA is a common problem that in general is very poorly managed. Management is characterised by inappropriate care and high rates of referral for surgical intervention[19,138].

Guidelines recommend more conservative nonsurgical approaches. However, their implementation is limited by the lack of transparency around specifics for exercise prescription. The reporting of the exercise interventions in original studies that form the evidence base of recommendations in current international guidelines for knee OA management was remarkably incomplete. Essential details of the exercise programs necessary for replication in clinical practice, such as materials used, mode of delivery, and dosage, were missing or inadequately described in more than 80% of the studies. Missing information on almost every item across the original studies diminishes transparency and has series of serious implications.

Firstly, it makes it impossible for clinicians to replicate and utilize the exercise programs that have been proven effective, which renders the studies more or less unusable. By consequence, the current international clinical guidelines for knee OA management do not fulfil their purpose to assist practitioner and patient

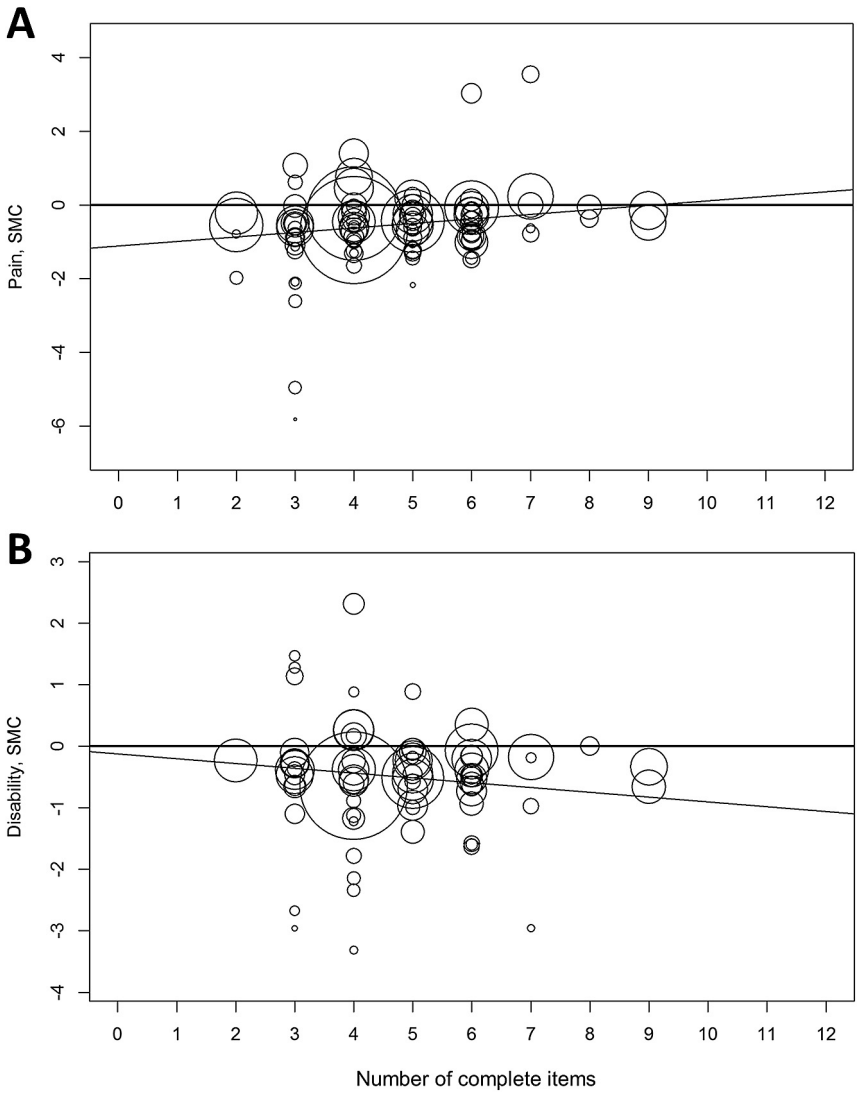

Fig. 4. Bubble plots representing results from a multilevel meta-regression model for change in pain (A) and disability (B) related to total number of complete reported items for each study. Bubble sizes are inversely proportional to the variance of the SMC in each study.

decisions about appropriate health care for specific circumstances. To make such specific recommendations, detailed knowledge about the components of the intervention is essential[139]. As knee OA is very common, the unanimous recommendation of exercise leads to provision of exercise to an extensive part of the knee OA population every day worldwide. When exercise is recommended to such large numbers of people, it is reasonable to demand that the recommended exercise programs meet the standards of evidence-based practice, including standardisation. However, the incomplete reporting prevents such standardisation and a highly likely consequence is that the exercise programs actually delivered in clinical practices around the world are just as elusive as the descriptions of the programs in the original studies. This means that there most likely are as many exercise programs being offered as there are providers of them. Such variance (even within small areas or regions) challenges the concept of evidence-based practice even further, as both all and none of the provided exercise programs can be claimed to be evidence based.

While the unanimity of the current guidelines leaves an impression of certainty, our results clearly suggest that clinical uncertainty is very likely to be present, which is the opposite of the intended outcome of a guideline and an important factor driving variations in clinical practice. Further, this vague concept of exercise for knee OA and variations in practice can augment inequity in the quality of delivery of exercise as the standard is unknown, and the skills of the individual exercise provider become too significant.

Another important consequence of the inadequate reporting of exercise programs is the impeded ability to inform new research based on existing evidence. The current evidence support exercise as beneficial, but across meta-analyses, the effect sizes are small-to-moderate[4,8,140]. Hence, there is a repeated call for research into the development of the optimal exercise program[7,8,140], preferably stratified or individualised to increase effectiveness. Also, there is a need to identify the underlying mechanisms, and endeavors in this area are currently ongoing[141]. However, it seems unachievable to build upon existing evidence when the essential “ingredients” of the proven exercise programs are unknown. The most recent Cochrane review concluded that there is no need for further trials to document efficacy of exercise for symptomatic benefits in knee OA[8]. However, the lack of proper reporting in the existing research literature creates a stalemate and there is a need to reproduce the evidence with a complete and adequate reporting of the exercise

programs under study. If research within the field of exercise for knee OA is to develop, transparency and mandatory reporting of minimum criteria seem to be essential elements in future research.

Our meta-analysis of the association between exercise description completeness and self-reported pain and disability showed variable results. The results indicate that studies with poor descriptions of how the exercise intervention was delivered and if it was delivered according to the planned strategy (items 6a and 11), reported greater effects of the exercise program on self-reported pain. Also, incomplete description of the location/setting (item 7) associated with a greater effect on self-reported disability. While the associations are few and unsystematic with high risk of multiplicity, the meta-regression analysis of overall intervention descriptions completeness and effects on pain suggests that a less rigid reporting of an intervention associates with a larger reported effect on self-reported pain. No such association was found in relation to disability. The implication of this could be that the reporting completeness of the exercise intervention should not only be considered when trying to replicate the interventions but also when interpreting the results. Similar associations are well-known within the domain of risk of bias[142], and our results support the notion that an article deprived of details is likely to report a greater effect.

The poor intervention reporting completeness is not a phenomenon related exclusively to knee OA exercise studies. The TIDieR checklist was developed based on systematic review of intervention reporting completeness in a random set of non-pharmacological studies[10]. The study demonstrated overall poor reporting, which resulted in the development of the TIDieR checklist[11]. Also, a random set of physiotherapy interventions were recently reviewed and a similar poor intervention reporting completeness was shown[14]. While the approach of these studies gives an overview, they do not describe the extent of the problem in a focused clinical research area in full. Such focus was taken within cardiac rehabilitation, where intervention description completeness in trials was reviewed[16]. In that study, even lower completeness than the generic (and random) approaches[10,14] were shown, even after contacting authors for further details. Also, intervention description completeness in RCTs related to exercise for patellofemoral pain has recently been shown to have similar shortcomings[143]. We also focused on a specific clinical research field within non-pharmacological treatments (exercise for knee OA) and we chose a slightly different approach, as we reviewed the research studies used to inform clinical guidelines. Thereby we took the clinicians point of entry and therefore we decided not to seek further information by contacting authors of the studies. While we expected shortcomings in the reporting, the incompleteness of the exercise interventions used in the studies that form international clinical guidelines was even worse than what has been reported in the above-mentioned studies[10,14,16].

Poor intervention reporting is not restricted to non-pharmacological intervention research. Indeed the problems also exist in studies of pharmacological interventions. A review of randomised controlled trials published in major oncology journals showed that essential therapeutic details necessary for translation of the findings to clinical practice were not consistently reported[144]. Nevertheless, in pharmacological research, some essential elements of a drug/compound and how it is administered (e.g., concentration, dosage, duration, mode of action, route of delivery, etc.) is often known from preclinical studies, and from labelling and product summaries. In fact, it is unimaginable that a drug is recommended in a clinical guideline as first/core treatment (not to mention approval) if such important information is unavailable. In analogy, if exercise for knee OA should be thought of as a drug there would be no clear knowledge about important details such as the active ingredient(s), how to administer it, at what dosage, how often it should be administered, or how to modify the delivery or dosage. From that perspective, it can be considered surprising that exercise is unanimously recommended as first-line treatment for knee OA in guidelines across the world.

The gaps in the intervention reporting are extensive and filling them seems unrealistic as it extents several decades back. The problem is highlighted in a recent systematic review attempting to identifying specific exercise dosing associated with improved outcomes in common knee disorders[145]. The results were vague and relate only to number of exercise sessions. This is most likely due to the limited information about the interventions as demonstrated in our results. Before adequate descriptions are available, systematic reviews on intervention details (such as dosing) should therefore not be viewed as solutions, but as suggestions.

The remarkable incompleteness of information necessary for intervention replication calls for actions. Researchers should already in the planning phase of a study describe their exercise intervention in rich detail to allow for adequate reporting of the study as well as ensuring consistent intervention delivery during a study. Researchers, authors, journal editors, and peer reviewers share the responsibility to ensure that the intervention descriptions are complete. The TIDieR and CERT checklists are easily accessible tools that aid complete reporting (and planning) of exercise interventions. Further, most scientific journals have entered the digital age that allows online supplements to overcome the typical word count limitations in main manuscripts. Electronic supplements opens a wide variety of possible intervention descriptions such as written manuals, videos, links to study websites, virtual reality participation in an exercise session, and more. The opportunities are many and the technological development constantly provides new avenues for information sharing. These should be exploited by all stakeholders in order to improve intervention descriptions and a consequently more evidence based clinical practice. Finally, authors of systematic reviews and meta-analyses should consider the intervention description completeness as important aspects when grading the usefulness of research evidence.

In our review, we only included studies referenced in the guidelines and recommendations and have therefore likely missed some studies on exercise for knee OA. However, this review is among the most inclusive as we included all study types. We included 100 studies which exceeds all of the clinical guidelines and the most recent Cochrane review. A review of the full body of studies may have changed our results slightly, but not to an extent that would mitigate the problems we have identified.

Conclusion

Despite ten international guidelines from around the world unanimously recommending exercise for knee OA, none of the interventions used to form the recommendations was completely reported to allow replication in clinical practice. This omission of essential information about exercise interventions for knee OA is quite troublesome and can result in significant clinical uncertainty, variability and limit implementation – despite united worldwide recommendations. There is a need to specify recommendations and replicate the original studies with close attention to intervention reporting. Future studies should prioritise adherence to minimum reporting standards to avoid research waste, and improve the quality of the clinical management of patients with knee OA.

Contributors

CB, SMN, SW, DJH, RC and MH were responsible for study concept and design, acquisition of data, and analysis and interpretation of

data. All authors drafted or wrote the manuscript and critically revised it for important intellectual content. MH, SMN and RC were responsible for statistical analysis. RC, DJH, and MH supervised the study. MH is guarantor. All authors approved the final version of the manuscript.

Competing interests

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no financial relationships with companies that might have an interest in the submitted work in the previous 3 years. RC declares involvement in many health-care initiatives and research that could benefit from wide uptake of this publication (including Cochrane, OMERACT, and the GRADE Working Group).

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Ethical approval

Not required.

Data sharing

No additional data available.

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Supplementary data

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