



## Review

# Measuring adherence to unsupervised, conservative treatment for knee osteoarthritis: A systematic review



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## ABSTRACT

**Objective:** To describe the measurement of adherence to unsupervised, conservative treatments for knee osteoarthritis (OA), including the methods of adherence measurement, parameters for assessing adherence and any values used to quantify adherence.

**Methods:** A systematic review with search terms related to knee OA, conservative treatments and adherence was conducted. The protocol was registered with the International Prospective Register of Systematic Reviews (registration number CRD42020158188). Seven electronic databases (MEDLINE, AMED, EMBASE, CINAHL, SportDiscus, PsychINFO, PEDro) were searched from inception to February 02, 2021. Studies that included unsupervised, conservative treatment(s) for knee OA measuring adherence were eligible. Studies were independently screened for inclusion by two researchers. Data was extracted by one researcher and verified by a second researcher. Extracted data included: study type, population, type of treatment, adherence measurement methods, time-points, recall, parameters and values used to quantify adherence.

**Results:** Of 5033 references identified, 242 studies comprising of 261 treatments were included in the review. The majority of studies were randomised controlled trials investigating therapeutic exercise ( $n = 107$ , 41.0%). The most common adherence measurement across all treatments was through self-reported diary ( $n = 137$ , 52.5%) and the most common parameter was assessing the frequency of the treatment ( $n = 79$ , 30.3%). Only a small number of studies provided values for quantifying satisfactory adherence ( $n = 26$ , 9.3%).

**Conclusion:** There is a wide variety in the reporting of adherence to conservative treatments for knee OA and standardised methods for measuring and reporting adherence are needed. Developing a tool to measure adherence to conservative treatments for knee OA is a priority.

## 1. Introduction

Osteoarthritis (OA) is a major cause of disability worldwide and carries a large economic burden [1]. Of the joints affected, OA of the knee is the most frequent cause of mobility impairment and reduced quality of life [2]. Clinically, those suffering from knee OA report joint pain, stiffness and limitations in movement [3] and disability [4]. Conservative treatment which includes exercise, education and weight management [5], should be the first line of treatment for persons with knee OA. These

core treatments are recommended by guidelines for all individuals regardless of the severity of their knee OA or functional limitations [5–7].

However, for conservative treatments to benefit people with knee OA, adherence is important. Higher adherence to treatments such as exercise has been identified as a predictor of better long term outcomes among people with hip and/or knee OA [8]. The World Health Organisation (WHO) defined adherence as “the extent to which a person’s behaviour – taking medication, following a diet and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider”

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[9]. Maximising adherence can greatly dictate the success of the treatment and the implementation of strategies to improve and maintain adherence are recommended [8].

Currently, there are a variety of methods used to measure treatment adherence ranging from self-reported measures, objective measures, numerical rating scales or patient interview. Recent systematic reviews investigating the measurement of adherence to exercise and self-management for musculoskeletal pain have been inconclusive in determining a reliable method of measuring adherence [10–13]. The treatment for OA is multi-faceted [5,7] and to our knowledge, no review investigating measurement of adherence to all types of conservative treatments for knee OA exists. This review will focus on the measurement of adherence to unsupervised, conservative treatments for knee OA, as maintenance of behaviour and lifestyle changes is of particular challenge, especially in an unsupervised setting. In order to establish dimensions of measuring adherence, this review aims to describe methods of adherence measurement, parameters for assessing adherence and values used to quantify adherence. Findings of this review will inform guidance for clinicians and researchers measuring adherence among people with knee osteoarthritis, and the development of new measurement tools.

The objectives of this systematic review were to: (1) describe how adherence to conservative treatments is being measured (2) describe parameters of assessing adherence (i.e., any numerical or measurable factor used); and (3) describe values used to quantify satisfactory adherence to unsupervised, conservative treatments in adults diagnosed with knee OA.

## 2. Materials and methods

### 2.1. Protocol and registration

The protocol for this review was registered with the International Prospective Register of Systematic Reviews (PROSPERO) (registration number CRD42020158188). This review is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [14].

### 2.2. Search strategy

The search strategy was developed in consultation with an academic librarian. Three search strings were combined, including medical subject headings (MeSH) and text words related to knee OA, conservative therapies and treatment adherence. Seven electronic databases were searched from inception to November 25, 2019: MEDLINE, AMED, EMBASE, CINAHL, SportDiscus, PsycINFO and PEDro. The search was updated on February 02, 2021. The MEDLINE strategy is presented in [Appendix 1](#). The MEDLINE search strategy was adapted to the syntax and subject headings of the remaining six databases.

### 2.3. Eligibility criteria

For the purposes of this review, we were interested in adherence to conservative knee OA treatments which are unsupervised. Adherence to study protocols (such as the number of dropouts) and session attendance were not included.

Studies were eligible if they included all of the following:

1. Adults  $\geq 18$  years, diagnosed with knee OA. If the population was heterogeneous, studies were included if a description for the knee OA treatment was provided.
2. An unsupervised, conservative treatment or combination of treatments for knee OA. If a conservative treatment was compared to a surgical or pharmacological treatment, the study was included if a description for the conservative treatment was provided. For studies including a supervised and unsupervised component, the study was included if a measurement method to the unsupervised component

was provided. Treatments were classified into the following categories: therapeutic exercise; physical activity; dietary; biomechanical; supplements; educational; electrotherapy and other.

3. A description of how adherence to the treatment or component of the treatment was assessed (or planned to be assessed for study protocols).
4. Published in English or in a language that we were able to obtain a full translation for (Spanish, German, Portuguese and Chinese).

Studies were excluded if they:

1. Involved treatment for persons without OA or only involved OA in other joints, such as hand or hip OA.
2. Were supervised treatments, such as attendance at an exercise class or provided by a therapist, such as acupuncture.
3. Only included surgical or pharmacological treatment.
4. Were case studies, reviews, qualitative studies or published as conference proceedings or abstracts only.
5. Measured adherence to supervised treatment only

### 2.4. Data collection process

The citations and full-text articles from the search results were uploaded into the Covidence software (Veritas Health Innovation, Melbourne, Australia, [www.covidence.org](http://www.covidence.org)). Covidence is an online software used for collaboration among reviewers during the study screening process [15]. Titles and abstracts were first screened against the inclusion and exclusion criteria by two independent reviewers (VD and PN), followed by full-text screening. In the case of any discrepancies regarding any potentially eligible studies, the two reviewers resolved this through discussion. A third reviewer (MF) was consulted if needed.

### 2.5. Data items/extraction

A data extraction form (in Microsoft Excel) was developed and independently piloted by two authors (VD and PN). Data was extracted by one reviewer (VD) and verified by a second reviewer (PN, NW, MD). Any discrepancies were discussed, and a third reviewer was consulted (MF) if necessary. Data extracted included study details (design, country, setting), treatment type and details, adherence measurement method(s), adherence measurement time-point(s), recall period, parameters of assessing adherence, reliability/validity of adherence measures and any values used to quantify adherence. When multiple papers arose from the same study, data was extracted from the primary paper and additional papers were checked for further details.

### 2.6. Assessment of methodological quality

The methodological quality of the experimental trials was assessed using pre-existing scores from the Physiotherapy Evidence Database (PEDro) [16], if available. PEDro is a database developed by physiotherapists for physiotherapists which provides access to clinical research such as randomised-clinical trials, systematic reviews and practice guidelines relevant to physiotherapy. If the PEDro score was not available, the study was assessed by two reviewers (CGF, MF) with any discrepancies discussed ([Appendix 3](#)). Each trial in PEDro is rated on the PEDro scale. The PEDro scale is an 11-item scale with a maximum score of 10. A score  $\geq 6$  indicates “good” quality [17,18]. The Newcastle-Ottawa Scale (NOS) [19] was used to evaluate the quality of the cohort studies at the outcome level (adherence). The NOS judges studies on three broad criteria (selection of study groups, comparability of groups and outcome of interest). In order to receive a “good” rating, studies must fulfil 3–4 of the criteria for selection, 1–2 of the criteria for comparability and 2–3 of the criteria for outcomes. A maximum score for the NOS is 8 points, however, one criterion was irrelevant to our review and therefore, we presumed the maximum score to be 7 points. Scoring

was completed by one reviewer (VD) and verified by a second reviewer (MF) (Appendix 4). Protocols of trials were not assessed for methodological quality.

## 2.7. Data synthesis and analysis

The primary outcome was the method/s for measuring adherence to unsupervised, conservative treatments for knee OA. Secondary outcomes were parameters for assessing adherence and values used to quantify adherence. Data were summarised in tables and synthesised using a narrative format. Treatments were subdivided by category, and results were reported descriptively. Parameters of adherence measurement were classified by treatment and summarised in tables. Values quantifying adherence were converted to percentages when possible and reported as ranges. Where there was more than one component of a treatment, such as treatments comprising of diet and exercise, adherence to each component was reported separately if sufficient data was available.

## 3. Results

A total of 5033 references were identified, of which 3888 titles and abstracts were screened after duplicates were excluded (Fig. 1). A total of 1124 full-text papers were assessed against the inclusion and exclusion criteria. The main reason for excluding papers at full-text review was failure to report how adherence to the treatment was measured. A total of 242 studies (reported in 292 papers) were included in the review. From the 242 studies, a total of 261 treatments were included in the data extraction as 20 studies measured adherence to a combination of treatments.

### 3.1. Characteristics of included studies

Studies were published between 1997 and 2020. Studies originated from 32 countries, most commonly the United States of America ( $n = 79$ , 32.5%) or Australia ( $n = 35$ , 14.4%) (Appendix 5). The majority of included studies were randomised controlled trials ( $n = 208$ , 85.6%). Almost half of the included studies examined therapeutic exercise ( $n = 107$ , 40.8%) (Table 1). The majority of these studies included strengthening, stretching, neuromuscular and range of motion exercises. Other included studies investigated biomechanical treatments such as insoles and knee braces ( $n = 38$ , 14.5%), physical activity or aerobic exercise ( $n = 33$ , 12.6%), supplements ( $n = 23$ , 8.8%) or education ( $n = 23$ , 8.8%).

### 3.2. Methodological quality of included studies

The average quality of experimental trials was 6.2 on the PEDro scale (range 2–10,  $n = 192$ ), which corresponds to “good” methodological quality. The main methodological limitations were no blinding of participants ( $n = 150$ , 78.1%) or no blinding of therapists ( $n = 174$ ,  $n = 90.6\%$ ). The average quality of cohort studies ( $n = 30$ ) was 5.0 out of 7, (range 2–7). Just over half of the cohort studies were “poor” quality ( $n = 17$ , 56.6%) (Appendices 2–4). Generally, studies with a higher methodological quality score used objective measures of adherence, such as online monitoring or pedometers, rather than self-reported measures.

### 3.3. Methods used to measure adherence

Of the 261 included treatments, 189 (72.4%) used one measurement method, 54 (20.7%) used two methods and 18 used three methods (6.9%). Methods of adherence measurement varied (Table 1). For

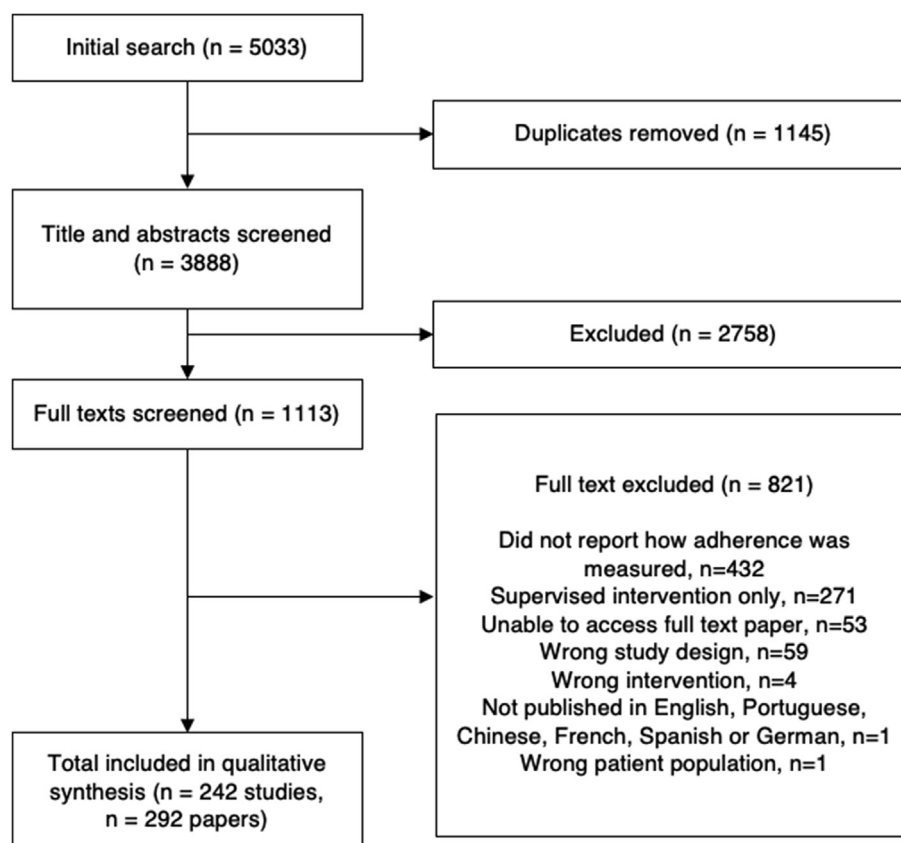


Fig. 1. PRISMA Flow Diagram.

**Table 1**  
Methods of measuring adherence.

Treatment (n = 261, %)	Measurement method	Number of studies using method (%)
Therapeutic exercise (n = 107, 41.0)	Self-reported diary	71 (66.4)
	Telephone call	21 (19.6)
	Self-developed question(s)	21 (19.6)
	Patient interview	11 (10.3)
	In-person demonstration	4 (3.7)
	Videotaping	4 (3.7)
	Home visit	3 (2.8)
	Verification from family member	2 (1.9)
	Existing questionnaire	2 (1.9)
	SMS message	1 (0.9)
Biomechanical (n = 38, 14.6)	Self-reported diary	23 (60.5)
	Telephone call	8 (20.1)
	Self-developed question(s)	5 (13.2)
	Inspection by researcher	5 (13.2)
	Patient interview	4 (10.5)
Physical activity (n = 33, 12.6)	Activity tracker (pedometer, accelerometer, heart rate monitor)	18 (54.5)
	Self-reported diary	14 (42.4)
	Self-developed question(s)	8 (24.2)
	Existing questionnaire	4 (12.1)
	Telephone call	4 (12.1)
	Patient interview	1 (2.6)
	Pill count	20 (90.0)
	Self-reported diary	6 (26.1)
	Patient interview	4 (7.4)
	Monitored online	13 (56.5)
Supplements (n = 23, 8.8)	Telephone call	5 (21.7)
	Self-developed question(s)	4 (17.4)
	Self-reported diary	4 (17.4)
	Existing questionnaire	1 (4.3)
	Accelerometer	1 (4.3)
Educational (n = 23, 8.8)	Email	1 (4.3)
	Self-reported diary	9 (64.3)
	Device counter	8 (57.1)
	Telephone call	1 (7.1)
	In-person demonstration	1 (7.1)
Diet (n = 12, 4.6)	Self-reported diary	9 (75.0)
	Body weight monitored	4 (33.3)
	Self-reported question	2 (16.7)
	Existing questionnaire	1 (8.3)
	Home visit	1 (8.3)
Magnetic (n = 3, 1.1)	Patient interview	1 (33.3)
	Self-developed question	1 (33.3)
	Self-report diary	1 (33.3)
Massage (n = 2, 0.8)	Telephone call	2 (100.0)
	Existing questionnaire	1 (50.0)
	Self-developed question	1 (50.0)
	In-person demonstration	1 (50.0)
Heat/cold pack (n = 2, 0.8)	Telephone call	2 (100.0)
Gait training (n = 2, 0.8)	Self-developed question	2 (100.0)
	Self-reported diary	1 (50.0)
	Accelerometer	1 (50.0)
Topical gel (n = 2, 0.8)	Gel tube count	1 (50.0)
	Volume measured	1 (50.0)

Some studies used multiple adherence measurement methods; therefore, some totals will not sum to 100%.

therapeutic exercise and biomechanical treatments, a self-reported diary or logbook (n = 71, 66.4%; n = 23, 60.5%) was most commonly used. For physical activity, the majority of studies used a wearable device such as a pedometer or accelerometer to measure activity levels (n = 18, 54.5%). Almost all studies investigating supplements used pill count to measure adherence (n = 20, 90.0%). Six of the supplement studies also used a secondary method such as patient interview or a self-reported diary (26.1%). The majority of studies investigating dietary treatment used self-reported diaries monitoring food intake (n = 9, 75.0%). Half of these (n = 6, 50.0%) were supplemented by a secondary measure such as body weight measurement. For electrotherapy treatment, adherence was most commonly measured by self-reported diary (n = 9, 64.3%) or an inbuilt

device counter (n = 8, 57.1%).

#### 3.4. Parameters for assessing adherence

Table 2 details parameters used to assess adherence by treatment type. This information was not reported for 32.6% of treatments (n = 85). Across all treatments and measurement methods, the most common parameter was frequency of treatment completion (n = 79, 30.3%). For therapeutic exercise adherence measured by self-reported diary, frequency of exercise was recorded throughout the week, whereas for the self-developed questions, developed by the study team, frequency was usually measured on a Likert scale. In two studies investigating yoga, participants were asked to videotape their home practice and the results were analysed qualitatively by the researchers [20,21]. Two studies used the Exercise Adherence Rating Scale (Section B), a validated scale for measuring exercise adherence [22,23]. One exercise treatment asked participants to record the mass of the weights used [24] and one asked participants to record the colour (difficulty) of the resistance band used [25]. For biomechanical treatments, the most common parameter was the number of hours the device was worn (n = 27, 71.1%). Five studies assessed the device (orthotic) for signs of wear (11.8%).

Physical activity assessed using activity trackers was most commonly measured by the number of steps taken (n = 9, 50%), or the intensity of activity (n = 7, 38.9%). Self-reported diaries for physical activity most commonly assessed duration of activity (n = 9, 64.3%), or frequency of activity (n = 6, 42.6%). Three existing validated questionnaires were used to measure physical activity; including the Short Questionnaire to Assess Health enhancing physical activity (SQUASH) [26,27], the Physical Activity Scale for the Elderly questionnaire (PASE) [28], and the Community Health Activities Model Program for Seniors (CHAMPS) [29].

For supplements, the most common parameter of assessing adherence was pill count, specifically, the number of pills/bottles or packets of the supplement returned (n = 20, 87.0%). When self-report diaries were used, the parameters for assessing adherence were time of ingestion (n = 2, 8.7%) and the number of capsules ingested (n = 1, 4.3%). For educational treatments delivered through a website, all except for one (n = 13, 93.0%) were monitored online. The main parameter for assessing adherence was the completion of educational modules or videos watched (n = 8, 61.5%).

The main parameter for electrotherapy treatment was the number of hours that the device was worn or used (n = 10, 71.4%). This was measured through either an in-built device counter or a self-report diary. Only one study assessed adherence by correct use of the device during an in-person demonstration. The majority of dietary treatments assessed adherence by food intake (n = 8, 87.5%), and a small number also monitored participant's body weight (n = 4, 30.0%). One study used a validated questionnaire to assess adherence to the prescribed diet [30].

#### 3.5. Values for quantifying adherence

Very few studies reported values for assessing satisfactory adherence to a treatment (n = 26, 10.0%) (Table 3). Of the 107 treatments included for therapeutic exercise, only 10 (9.3%) reported values for quantifying satisfactory adherence to the treatment. Most commonly studies reported a cut-off percentage or number of sessions/repetitions to be classified as adherent. Four studies defined adherence based on the overall completion of exercise. For example, Rattanachaiyanont et al. categorised adherence into "good", "fair" or "poor", depending on how many repetitions of exercise were completed each day and the frequency per week [31]. Another study reported adherence based on the self-reported questionnaires from the participant. The participant was considered adherent if they reported "often adherent" or "very often adherent" on their questionnaire, or non-adherent, if they reported "regularly adherent", "occasionally adherent" or "almost never adherent on their questionnaire" [27].

**Table 2**

Parameters used to measure adherence, presented by treatment type.

	Measurement method (n studies)	Parameter	No. Treatments using parameter (%)
Therapeutic exercise (n = 107 studies)	Self-reported diary (71)	Frequency	29 (42.6)
		Duration	11 (16.1)
		Number of repetitions completed	8 (11.8)
		Number of sets completed	5 (7.4)
		Specific exercises completed	5 (7.4)
		Equipment used	2 (2.9)
		Balance time	1 (1.5)
		Frequency	4 (19.0)
		Duration	2 (9.5)
		Frequency	14 (66.7)
	Telephone call (21)	Agreement with prescribed treatment	7 (33.3)
		Duration	2 (9.5)
		Quality of movement	1 (4.8)
		Frequency	4 (36.4)
	Patient interview (11)	Duration	2 (18.2)
		Specific exercises completed	1 (9.1)
		Number of exercises completed	1 (9.1)
		Agreement with prescribed treatment	1 (9.1)
	In-person demonstration (4)	Quality of movement (COEP scale)	1 (25.0)
		Duration	1 (33.3)
		Frequency	1 (33.3)
		Poses/sequences practiced	1 (33.3)
	Home visit (3)	Tools used	1 (33.3)
		Quality of movement	1 (33.3)
		Confirmation that exercises were completed	1 (50.0)
		Existing questionnaire (2)	Exercise Adherence Rating Scale
	SMS message (1)	Frequency of exercise	1 (100.0)
		Frequency of exercise	1 (100.0)
Biomechanical (n = 38)	Self-reported diary (23)	Duration worn	18 (78.3)
		Frequency worn	4 (17.4)
		Level of participation with device	1 (4.3)
		Duration worn	4 (57.1)
	Telephone call (8)	Frequency worn	3 (42.9)
		Duration worn	3 (60.0)
		Frequency worn	3 (60.0)
		Assessed for signs of wear	5 (100.0)
	Self-developed questions (5)	Duration	2 (50.1)
		Frequency	1 (25.0)
Physical activity (n = 33)	Inspection (5)	Steps taken	9 (50.0)
		Intensity	7 (38.9)
		Duration	3 (16.7)
		Intensity	9 (64.3)
	Self-reported diary (14)	Frequency	6 (42.9)
		Steps taken	4 (28.6)
		Type of activity	2 (14.3)
		Intensity	1 (7.1)
	Self-developed question(s) (8)	Frequency	5 (66.7)
		Duration	3 (50.0)

**Table 2 (continued)**

	Measurement method (n studies)	Parameter	No. Treatments using parameter (%)
Supplements (n = 23)	Existing questionnaire (4)	Agreement with prescribed treatment	1 (16.7)
		Intensity	2 (50.0)
		SQUASH	1 (25.0)
		PASE	1 (25.0)
	Telephone call (2)	CHAMPS	1 (25.0)
		Frequency	1 (50.0)
		Duration	1 (50.0)
		Number of pills returned	20 (100.0)
	Pill count (20)	Time of ingestion	2 (40.0)
		Number of capsules ingested	1 (20.0)
		Number of missed doses	1 (25.0)
		Module/video completion	8 (61.5)
	Self-reported diary (5)	Frequency of logins	1 (7.7)
		Duration of interaction with online content	1 (7.7)
		Number of times posting on feed	1 (7.7)
		Number of times contacting coach	1 (7.7)
	Patient interview (4)	Frequency of completing exercises	1 (7.7)
		Completion of assignment/task	2 (40.0)
		Self-reported exercise behaviour	2 (40.0)
		Frequency of prescribed treatment	1 (20.0)
Education (n = 23)	Monitored online (13)	No. Phone calls and duration	1 (20.0)
		Duration of exercise	2 (40.0)
		Type of exercise	1 (20.0)
		Body weight	1 (20.0)
	Self-developed question(s) (5)	Completion of exercises	1 (20.0)
		Module completion	1 (25.0)
		Compliance with pain coping	1 (25.0)
		Duration and frequency of planned activity	1 (25.0)
	Self-reported diary (4)	Body weight and duration of physical activity	1 (25.0)
		SQUASH	1 (100.0)
		Duration of moderate/vigorous physical activity	1 (100.0)
		Completion of weekly exercises	1 (100.0)
	Existing questionnaire (1)	Completion of weekly exercises	1 (100.0)
		Completion of weekly exercises	1 (100.0)
		Hours worn	4 (44.4)
		Device voltage settings	1 (11.1)
Electrotherapy (n = 14)	Email (1)	Hours worn	6 (75.0)
		Time the device was applied	2 (25.0)
		Intensity setting	1 (12.5)
		Proper use of the device	1 (100.0)
	Text message (1)	Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)
		Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)
	Self-reported diary (9)	Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)
		Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)
Diet (n = 12)	Self-reported diary (9)	Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)
		Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)
	Self-reported diary (9)	Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)
		Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)
	Self-reported diary (9)	Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)
		Food intake	8 (87.5)
		Number of sessions attended	1 (12.5)

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Table 2 (continued)

	Measurement method (n studies)	Parameter	No. Treatments using parameter (%)
	Body weight monitored (4)	Body weight monitored	4 (100.0)
	Self-reported question (2)	3-point Likert scale	1 (50.0)
		10-point numerical rating scale	1 (50.0)
Magnetic (n = 3)	Existing questionnaire (1)	110-item Block Food Frequency Questionnaire	1 (100.0)
	Patient interview (1)	Duration of use	1 (33.3)
	Self-developed question (1)	Visual analogue scale	1 (33.3)
Massage (n = 2)	Self-reported diary (1)	Hours worn	1 (33.3)
	Telephone call (2)	Rate of adhering to self-practice	1 (50.0)
	Existing questionnaire (1)	4-item scale from Medical Outcomes Study	1 (100.0)
Heat/cold pack (n = 2)	In-person demonstration (1)	Accurate location of 9 acupoints	1 (100.0)
	Telephone call (2)	Correct use of heat pack	1 (50.0)
Gait training (n = 2)	Self-developed question (2)	Confidence in maintaining gait	2 (100.0)
	Self-reported diary (1)	Duration of walking time	1 (100.0)
	Accelerometer (1)	Step count	1 (100.0)
Topical gel (n = 2)	Gel tube count (1)	Number of empty gel tubes returned	1 (100.0)
		Amount of volume returned	1 (100.0)
	Volume measured (1)		

SQUASH: Short QuesTionnaire to ASsess Health enhancing physical activity; PASE: Physical Activity Scale for the Elderly; CHAMPS: Community Healthy Activities Model Program for Seniors. Note: Some studies have used more than one parameter and method of measurement therefore, the percentages do not sum to 100%.

Only one biomechanical treatment (2.6%) reported values for assessing adherence, which was quantified as hours of wear. Five of the physical activity treatments (16.7%) specified a value of adherence assessment, this was reported as a percentage of completion of the program. The most commonly used cut-off value was  $\geq 75\%$ , which was used in two studies [17,32]. For supplements, seven of 22 studies (31.8%) reported what they considered to be satisfactory adherence. Six of these reported a minimum percentage, ranging between 70 and 90%. One study also expressed an upper limit of 130% [33]. The remaining study used a distribution of the participant's adherence data to assign a value: "poor compliance defined as those who failed to comply  $\geq 4$  days for 4 weeks at least once" [34].

For the educational treatments, three studies (14.2%) reported a value for assessing satisfactory adherence [26,35,36]. These were reported as a percentage of module/program completion of educational treatments delivered online, with the most common cut-off values between 75 and 99%. Of the fourteen electrotherapy studies, only one reported values for assessing adherence. These values were based off a combination of subjective (self-report diary) and objective (data from electrical stimulation device). Two of eight studies investigating dietary treatments reported values for assessing adherence. One of the studies quantified adherence in terms of adherence to the diet program [17], whereas the other study quantified this based on completion of the self-reported diaries [24]. There were no values assigned for massage, magnetic, heat/cold packs, gait training and topical gel treatments.

### 3.6. Adherence measurement recall, time-points and validity

Adherence measurement recall and time-points are presented in

Table 3

Values for quantifying satisfactory adherence.

Treatment	Value for satisfactory adherence	Number of studies using this level (%)
Therapeutic exercise (n = 107)	100%	1 (0.9%)
	75%–99%	5 (4.7%)
	50%–74%	4 (3.7%)
	Insufficient information given to calculate	8 (7.5%)
Biomechanical (n = 38)	No value	89 (83.2%)
	100%	1 (2.6%)
	Insufficient information given to calculate	1 (2.6%)
	No value	36 (94.7%)
Physical activity (n = 33)	100%	2 (6.1%)
	75%–99%	2 (6.1%)
	Insufficient information given to calculate	2 (6.1%)
	No value	27 (81.8%)
Supplements (n = 23)	75%–99%	5 (21.7%)
	50%–74%	1 (4.3%)
	Insufficient information given to calculate	1 (4.3%)
	No value	16 (70.0%)
Educational (n = 23)	75%	1 (4.3%)
	50%–74%	2 (8.7%)
	No value	20 (87.0%)
	75%–99%	1 (7.1%)
Electrotherapy (n = 14)	No value	13 (92.9%)
	75%–99%	1 (8.3%)
	Insufficient information given to calculate	1 (8.3%)
Diet (n = 12)	75%–99%	1 (8.3%)
	No value	10 (83.3%)

Appendix 5. Adherence measurement recall periods varied from bidaily to weekly or monthly. There was also large variability in the time points at which adherence was measured, ranging from daily to 3 years. Only ten treatments (3.8%) reported any reliability or validity testing of the instrument they used to measure adherence (Table 4).

## 4. Discussion

We aimed to describe how adherence to conservative treatments are being measured, parameters of assessing adherence and values used to quantify adherence to unsupervised, conservative treatments in adults diagnosed with knee OA. The results of this review demonstrate that of the numerous studies investigating unsupervised, conservative treatments for knee OA, many (432/1113, 38.8%) did not report adherence. Amongst included studies, we found a wide variety of methods of adherence measurement and reporting. This finding is in accordance with previous reviews which concluded a lack of adherence measurements that have been robustly validated [10,12,13]. Overall, the quality of all included papers was fair. The average rating of the experimental trials was "good", with scores ranging from 2 to 10, corresponding to a rating of "poor" to "high" methodological quality. For the cohort studies, over half of the studies were rated as "poor". Most studies failed to use a valid measure of adherence, our outcome of interest and we overall observed large variability in the methodological quality of the included studies. We acknowledge that lack of blinding in pragmatic trials is impossible and that the methodological screening tools used may have introduced bias in scoring. The PEDdro scale penalises interventions which cannot be blinded, such as therapeutic exercise or physical activity and the NOS scale penalises studies for measuring outcomes using a self-reported measures which were generally used to measure adherence.

### 4.1. Methods used to measure adherence

The majority of studies which measured adherence related primarily to therapeutic exercise and physical activity. Most commonly, studies used only one method of adherence measurement. Several treatments

**Table 4**  
Reliability or validity of adherence measurement.

Treatment	Adherence measurement	Psychometric evaluation	Psychometric evaluation results
Therapeutic exercise	Self-reported exercise diary [41]	Internal consistency	$\alpha = 0.90$
	Correctness of Exercise Performance (COEP) scale [42]	Inter-observer agreement	Kappa coefficient of 0.88
Physical activity	PASE questionnaire [35]	Validated scale	$r = 0.75$ [43]
	CHAMPS questionnaire [44]	Reliability analyses	$\alpha = 0.72$
	Calendar format diary [38]	Validated instrument	$r = 0.77$ [45]
	Sense Wear accelerometer [46, 47]	Validated tool for estimating energy expenditure during daily activities for people with OA	Intraclass correlation coefficient = 0.72
	Actiwatch-Score [48]	Reliability and preliminary criterion validity	$r = 0.98$
	Pacing subscale of the Chronic Pain Coping Inventory (CPCI) [49]	Reliability (test-retest, internal consistency) and validity (construct, discriminant)	“Good” – data not reported
Education	Self-reported question – agreement with extent of completion of assigned treatment (1 = not at all to 5 = as advised) [50]	Internal consistency	$\alpha = 0.78$
Diet	110-item Block Food Frequency Questionnaire (FFQ) [30]	Validated instrument	$r = 0.5–0.6$ [51]

comprising of physical activity and online education modules used objective measures such as accelerometers or the number of website logins to measure adherence, which may provide a potentially novel way of validating other self-reported measurements methods. The nature of adherence is complex as it is influenced by many factors, which will vary considerably between and within individuals over time [9]. Therefore, using a “multimethod approach” of combining self-reported and objective measures [9,37] may capture more accurate and meaningful information. However, increasing the number of measurement methods also makes it difficult to make comparisons across studies, or to apply them in a clinical setting [10–13].

In addition to wide variability in adherence measurement methods, our results demonstrated that adherence measurement time-points varied greatly. As adherence levels fluctuate over time (12), it is important to measure adherence throughout various stages (i.e., at short-, medium- and long-term). This will allow researchers and clinicians to monitor adherence levels over time and intervene if adherence levels begin declining. This will also facilitate comparisons of efficacy of different treatments in both the short- and long-term.

Only ten studies reported any reliability or validity testing of the instrument used to measure adherence. The majority of these studies assessed physical activity and used a validated questionnaire or an objective measure such as an accelerometer. One study reported the validity of an instrument that was tested in a different population, which is of limited meaning as it was not specific to an OA population [38]. Without a validated measure of adherence, the interpretation of study results and clinical monitoring remains questionable.

#### 4.2. Parameters for assessing adherence

The most common parameter for assessing adherence across all

treatments was frequency of completion. When used alone, this parameter is unable to provide valuable details such as the accuracy or quality of the movement (for therapeutic exercise) or information on the weight used (for treatments involving weights for resistance). Despite being a commonly used parameter in clinical practice [11], only two studies evaluated the accuracy or quality of movement which involved the clinician to observe the participant in-person. One reason for the limited use of this parameter may be due to the additional time and resources required for clinical trials. Some studies used multiple parameters of measurement within the same method. The vast number of adherence parameters used suggest that there are many relevant parameters of adherence measurement, but no consensus on which are of greater importance.

#### 4.3. Values for quantifying adherence

Overall, very few studies included values for quantifying satisfactory adherence. When adherence was quantified, different methods were used. For example, some studies used an arbitrary cut-off value, whereas others defined the values based on distribution methods, by comparing participants' performance to each other. Some studies reported values for satisfactory adherence but did not explicitly state in the methods the total amount that they expected the participant to complete. Therefore, we were unable to convert these values to percentages. The most commonly reported cut-off values were between 75% and 99%, suggesting that  $\geq 75\%$  may be a reasonable threshold value. This cut-off value is similar to that of a previous systematic review investigating adherence to therapeutic exercise [12]. Quantifying satisfactory adherence may allow researchers and clinicians to correlate this to pain and functional outcomes, allowing them to conclude whether unfavourable results were due to lack of adherence or an ineffective treatment. However, the analysis of adherence on a continuous scale should also be considered.

#### 4.4. Strengths and limitations

A strength of our review is that we used a broad search strategy, screening all potentially eligible studies regardless of whether they determined to explicitly measure adherence in the title. By doing so, we were able to include a comprehensive list of adherence measurement methods. We also presented a methodological appraisal of all 219 included studies (excluding RCT protocols). Another strength is the inclusion of all unsupervised, conservative treatments for knee OA. Previous studies investigating the measurement of adherence focused mainly on therapeutic exercise and self-management [10,12,13]. However, our review included all conservative treatments for knee OA, providing a more comprehensive overview of adherence measurement methods. Although the majority of papers concerned therapeutic exercise, physical activity or biomechanical treatments, the remaining treatments included in our review are still frequently used to manage OA. Therefore, the adherence measurement of these methods should be reviewed. The main limitation of our review was the inability to perform formal comparisons between different measurement methods for different treatments due to the wide variety in reporting adherence measurement outcomes. We were also unable to screen studies in all languages, and this may have induced a language bias.

#### 4.5. Research and clinical implications

Although valid and reliable measures of adherence do not yet exist, there is a need for improved clarity of reporting adherence, due to the multiple aspects of adherence that can be measured. This would allow improved comparison between different treatments and better allow clinicians to monitor adherence and correlate adherence to outcomes. For example, all treatments should include a clearly stated method and parameter of measuring adherence (measure of quality and/or frequency) with time-points and recall periods if applicable.

Currently, there is no validated measure of adherence, and developing a tool to measure adherence to conservative treatments for knee OA should be a priority. Guidelines for developing clinical measurement tools have been previously established [39]. However, due to the complexity of adherence, developing a tool which encompasses all adherence aspects will be a particular challenge. Input and collaboration from patients, clinicians, and researchers in the development of this future tool should be sought [40]. Ideally, the adherence measurement tool should be multi-faceted to focus on aspects such as frequency/duration of the treatment, as well as encompass a measure of accuracy/quality, which is particularly of importance for therapeutic exercise treatments and commonly used in clinical practice [11]. The tool should also focus on unsupervised, rather than supervised treatment as this is the most sustainable, long-term solution for those suffering of knee OA.

## 5. Contributions

VD, PN, MLF and DJH contributed to the study design. VD developed the search strategy and conducted the literature search. The title/abstract and full-text screening was performed by VD and PN. CGF and XW performed full-text screening for additional languages. VD performed the data extraction. Data extraction was verified by PN, MD and NW. Methodological quality assessment was performed by VD, CGF and MLF. All authors contributed to the interpretation of the data and VD wrote the first draft of the manuscript. All authors revised it critically for important intellectual content and read and approved the final manuscript.

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## Declaration of competing interest

DJH has received consulting fees from Pfizer, Merck Serono, Tissue-Gene, and TLC (less than \$10,000 each). No other disclosures relevant to this article are declared.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ocarto.2021.100171>.

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