# Predictors of adherence to prescribed exercise programs for older adults with non-musculoskeletal indications for exercise: a systematic review

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# Abstract

**BACKGROUND AND OBJECTIVES:** Prescribed exercise to treat medical conditions and to prepare for surgery is a promising intervention to prevent adverse health outcomes for older adults; however, adherence to exercise programs may be low. Our objective was to identify and grade the quality of predictors of adherence to prescribed exercise in older adults.

**METHODS:** After registration (CRD42018108242), prospective experimental studies were identified using a peer-reviewed search strategy applied to MEDLINE, EMBASE, Cochrane and CINAHL from inception until April 23, 2019. Following independent and duplicate review of titles, abstracts and full texts, we included prospective studies with an average population age ≥65 years, where exercise was formally prescribed for a medical or surgical condition. We excluded studies where exercise was prescribed for a chronic musculoskeletal condition. Risk of bias was assessed using the Quality in Prognostic studies tool or Cochrane risk of bias tool, as appropriate. Predictors of adherence were identified, pooled, and graded for quality using an adaptation of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework for predictor studies.

**RESULTS:** We included 19 observational studies and 4 randomized controlled trials (n=5785) Indications for exercise included cardiac (n=6), pulmonary rehabilitation (n=7), or other (n=10; surgical, medical, and neurologic). Overall adherence rate was reported in 20 studies (range 21%-93%; mean 68%, standard deviation 23%). Moderate-quality evidence suggested that positive predictors of adherence were self-efficacy and good self-rated mental health; negative predictors were depression (high quality) and distance from the exercise facility. Moderate-quality evidence suggested that comorbidity and age were not predictive of adherence.

**CONCLUSIONS:** These findings can inform design of future exercise programs as well as identification of individuals who may require extra support to benefit from prescribed exercise.


# Background

Western populations are aging at a rapid rate; it is estimated that by 2050, seniors could account for up to 30% of our population.(1) The declining physical function that accompanies older age is associated with increased disability, institutionalisation, and mortality.(2) Additionally, frailty, a multidimensional syndrome related to age- and disease-related deficits, increases in prevalence with age and results in vulnerability to stressors and adverse health outcomes.(3,4) Therefore, a large proportion of older individuals facing physiologic stressors, such as surgery or chronic medical conditions, are at risk of suffering worse outcomes compared to those who are more physically fit.

Older individuals preparing for major interventions or who have medical problems may benefit from interventions that target increasing their physical reserve to improve outcomes. Exercise has been identified as a promising perioperative intervention to improve postoperative outcomes in vulnerable older adults having surgery,(5) and has been shown to reduce mortality after cardiac events.(6) While exercise shows encouraging results for the treatment and prevention of adverse health outcomes in older adults, participants must adhere to the prescribed program in order to benefit from the exercise intervention. However, it is well-documented that older adults' adherence to prescribed exercise programs is low, especially in those with complex health conditions.(7) To support successful implementation of exercise programs for older adults, we must first identify what factors influence adherence to these programs to ensure that participants are willing and able to comply. To our knowledge, no studies have synthesized and graded the strength of evidence for patient- and program-level factors that predict exercise adherence.

To address this gap in the literature, our objective was to identify and grade the quality of predictors of adherence to prescribed exercise in older adults with either a medical or surgical indication. This systematic review will provide knowledge to inform current care and future research regarding the implementation and design of exercise programs for older adults with medical and surgical indications for physical activity.

# Methods

### *Design*

This was a systematic review that followed best practice recommendations from the Cochrane Collaboration(8) and for systematic reviews of observational and prognostic studies.(9,10) We pre-registered our protocol (PROSPERO 2018 CRD42018108242) and reported findings using the Preferred Reporting Items for Systematic reviews and Meta Analyses guidelines.(11) All stages of the review were conducted using Distiller SR (Evidence Partners, Ottawa, Canada), a cloud-based systematic review platform.

### *Search strategy*

A search strategy was developed in consultation with an information specialist (Supplementary Table S1) and peer-reviewed.(12) Citations in English or French were extracted from MEDLINE, Embase, Cochrane and CINAHL from inception until March 2018.

### *Eligibility criteria*

Studies were eligible for inclusion if the following criteria were met: (1) average age of participants ³65 years; (2) participants had a medical or surgical condition as an indication for exercise; and (3) participants were prescribed or recommended a formal exercise program. Prior to beginning our review, we recognized that exercise programs for chronic musculoskeletal conditions (e.g., low back pain or chronic joint pain or arthritis) *versus* other indications would be a primary source of heterogeneity. We also identified several syntheses of adherence in chronic musculoskeletal conditions that were already available,(13–17) therefore, we excluded studies where chronic musculoskeletal conditions were the indication for exercise. Study designs were limited to prospective experimental studies (to minimize the effects of misclassification bias and measurement error) and effect estimates predictive of adherence were limited to those that underwent multivariable adjustment (to minimize confounding bias), as recommended by best practice guidelines.(10) This meant that we included 1) adjusted associations between participant or program characteristics and adherence reported from prospective cohort studies or the experimental arm of randomized trials of prescribed exercise, 2) or the effect estimate from a randomized trial if it compared the effect of two different program features on adherence.

### *Study selection and data extraction*

Title and abstract screening was performed in duplicate; any studies reviewed as 'yes' or 'unsure' by either reviewer were advanced to full-text review (agreement between both reviewers was required to exclude a study). Full-text articles were also assessed in duplicate and reasons for exclusion at this stage were recorded and categorized (wrong age group, no exercise program, no predictors of adherence, no medical or surgical condition, wrong study design, and other). Disagreements between reviewers during full-text review were resolved by consensus after discussion with the senior author (DIM).

A unique data extraction form was created for this study. The form was piloted in a sample of 8 studies by two extractors, which were then reviewed with the senior author. Following piloting, data was extracted by one reviewer and independently reviewed and checked for accuracy by a second reviewer. Extracted data included publication details (author, year), study design, sample size, average age, medical/surgical condition indicating exercise, and whether frailty status was assessed. We also extracted characteristics at the exercise program level, including inpatient/outpatient, supervised/unsupervised, and type of program (i.e., cardiac rehabilitation, pulmonary rehabilitation or other). Our primary outcome, program adherence, was recorded, including the definition used to quantify adherence and the overall adherence rate reported.

### *Risk of bias assessment*

Two reviewers independently evaluated risk of bias, and disagreements were resolved through discussion with a senior author. Randomized controlled trials were assessed using the Cochrane risk of bias tool(8) while observational studies were assessed using the Quality in Prognostic Studies (QUIPS) tool.(18)

### *Synthesis of results and analysis*

Our primary analysis was structured to support the Grading of Recommendations Assessment, Development and Evaluation (GRADE) adaptation for prognostic factor research framework.(19)

First, we categorized studies based on the indication for exercise (cardiac rehabilitation, pulmonary rehabilitation, and other). Next, prognostic factors were identified and categorized within themes (based on a consensus meeting within the investigative team). Where a prognostic factor was reported by two or more studies, the strength and quality of the association of the predictive factor with adherence was assigned using the GRADE framework. This process applies 8 criteria that can upgrade or downgrade the quality of evidence supporting a prognostic factor, and allows for evidence of a review of prognostic factors to be efficiently summarized for end-users.(19)

We also calculated descriptive statistics for the overall collection of included studies, as well as by indication for exercise. Overall adherence rates were calculated and averaged across all studies, as well as by exercise indication category. Adherence measures were separated based on measurement on a continuous scale (i.e., proportion of prescribed exercise completed) or as binary measurements (i.e., adherent vs not adherent).

## Results

### *Study selection*

The search strategy identified 982 records; 970 remained after duplicates were removed. Following title and abstract screening, 247 full text articles were assessed for eligibility and 23 were included. Study selection and reasons for exclusion are presented in Figure 1.

### *Study characteristics*

Study characteristics are presented in Table 1. Nineteen observational studies and 4 randomized controlled trials were included. A total of 5785 individuals were prescribed exercise across all studies (sample sizes ranged from 23-1218 participants) and average age ranged from 66-79 years. Indications for exercise included cardiac rehabilitation (n=6), pulmonary rehabilitation (n=7), and other (n=10; including surgical, medical and neurologic indications). Most (20/23 (87%)) exercise programs were supervised.

**Table 1. Study Characteristics**

| Author | Year | Design | *N* | Average age | Medical indication | Exercise program | Adherence | Adherence definition |
|---|---|---|---|---|---|---|---|---|
| Ades et al.(33) | 1992 | OBS | 226 | 70 | MI or CABG | CR[a] | 21%[c] | Entry into the CR |
| Aherne et al.(46) | 2017 | OBS | 98 | 69 | PVD | Other[a] | N/A[b] | Number of sessions attended |
| Brown et al.(34) | 2016 | OBS | 440 | 66 | COPD | PR[a] | 52%[c] | Number of sessions attended |
| Casey et al.(20) | 2008 | OBS | 600 | 66 | CVD | CR[a] | 78%[c] | Staff judgement |
| Covey et al.(47) | 2014 | RCT | 113 | 68 | COPD | PR[a] | 93%[b] | Percent of exercise completed |
| Cox et al.(35) | 2013 | OBS | 85 | 68 | Cognitive impairment | Other | 78%[b] | Self-reported |
| Craike et al.(21) | 2016 | OBS | 52 | 67 | Prostate cancer | Other[a] | 80%[b] | Number of sessions attended |
| Fan et al.(22) | 2008 | OBS | 1218 | 67 | COPD | PR[a] | 79%[b] | Number of sessions attended |
| Gallagher et al.(23) | 2003 | OBS | 196 | 67 | CVD | CR[a] | 32%[c] | Number of sessions attended |
| Hogg et al.(24) | 2012 | OBS | 812 | > 65 | COPD | PR[a] | 54%[c] | Number of sessions attended |
| Jensen et al.(25) | 2016 | OBS | 50 | 69 | Bladder cancer | Other | 66%[c] | Self-reported |
| Mangione et al.(48) | 2005 | RCT | 23 | 79 | Hip fracture | Other[a] | 98%[b] | Number of sessions attended |
| Messer et al.(36) | 2007 | OBS | 164 | 66 | Incontinence | Other[a] | 70%[c] | Self-reported |
| Mudge et al.(26) | 2013 | OBS | 140 | > 65 | CVD, pulmonary disease | Other[a] | 42%[b] | Number of sessions attended |
| Pakzad et al.(27) | 2013 | OBS | 30 | 66 | CVD | CR[a] | N/A[b] | Number of sessions attended |
| Pandey et al.(37) | 2017 | RCT | 40 | 67 | Diabetes | Other[a] | 70%[b] | Self-reported |
| Pickering et al.(28) | 2013 | OBS | 70 | 73 | Parkinson's disease | Other[a] | 79%[b] | Percent of exercise completed |
| Rizk et al.(38) | 2015 | RCT | 35 | 67 | COPD | PR[a] | 75%[b] | Percent of exercise completed |
| Selzler et al.(29) | 2016 | OBS | 64 | 69 | COPD | PR[a] | 81%[b] | Number of sessions attended |
| Selzler et al.(30) | 2012 | OBS | 814 | 68 | COPD | PR[a] | 83%[b] | Number of sessions attended |
| Tiedemann et al.(39) | 2012 | OBS | 76 | 67 | Stroke | Other[a] | 60%[b] | Number of sessions attended |
| Tooth et al.(31) | 1993 | OBS | 30 | 66 | MI | CR | 93%[bf], 87%[bg] | Percent of exercise completed |
| van Montfort et al.(32) | 2016 | OBS | 409 | 66 | PCI | CR[a] | N/A[b] | Number of sessions attended |

CABG = coronary artery bypass graft; COPD = chronic obstructive pulmonary disease; CR = cardiac rehabilitation; CVD = cardiovascular disease; FEV1 = forced expiratory volume in 1 second; HADS = Hospital Anxiety and Depression Scale; HDL = high density lipoprotein; IMD = Index of Multiple Deprivation; MI = myocardial infarction; MRC = Medical Research Council; OBS = observational; PCI = primary coronary intervention; PR = pulmonary rehabilitation; PVD = peripheral vascular disease; RCT = randomized controlled trial; a = supervised exercise program; b = adherence as a continuous measure, c = adherence as a categorical threshold; d = % participation; e = % completion; f = % duration; g = % frequency

### *Adherence to prescribed exercise rates*

Exercise adherence was measured as a continuous variable in 16 studies and as a categorical outcome with a specified cut-off (demarking adherent vs not) in the remaining 7 studies. Overall adherence rate was reported in 20 studies and ranged from 21% to 93% (mean 68%, standard deviation (SD) 23%). Adherence was highest for pulmonary rehabilitation (71%, SD 15%), and other indications (74%, SD 13%); cardiac rehabilitation had lower rates (55%, SD 33%). However, lack of variance measures around adherence estimates limited our ability to perform formal comparative meta-analysis or meta-regression.

### *Predictors of exercise adherence*

Predictors of exercise adherence were grouped into the following clusters: demographic, psychological, program-related, medical condition severity, comorbidities, and other (see Supplementary Tables S1, S2, S3; Additional Files 1, 2, 3). Demographic factors were evaluated by 13 studies(20,21,30–32,22–29) (Table 2), psychological factors by 14 studies(20,21,32–36,22–24,27–31) (Table 3), program-related factors by 2 studies,(37,38) medical condition severity by 11 studies,(21,22,39,23,24,28–32,34) comorbidities by 8 studies(20,25,27,29–31,34,35) and other predictors by 5 studies.(24,26,31,33,39)

**Table 2. Demographic Predictors of Exercise Adherence**

| Study | Predictors | Direction | Theme |
|---|---|---|---|
| Casey et al. (2008)(20) | Age (years) | + | Age |
| | Employed (vs not employed/retired) | 0 | Employment |
| | Gender (male vs female) | 0 | Sex |
| Craike et al. (2016)(21) | Highest level of education (less than university degree vs university degree or higher) | 0 | Education |
| Fan et al. (2008)(49) | Age (per 1 year change) | 0 | Age |
| | Female gender | 0 | Sex |
| | Education reference: < high school | | Education |
| | High school | + | |
| | Some college | + | |
| | > College | + | |
| Gallagher et al. (2003)(23) | Unemployed or retired (vs employed) | - | Employment |
| | Age > 70 (vs 55–70) | - | Age |
| Hogg et al. (2012)(24) | Deprivation quintile (IMD score) reference: IMD 6.86-28.1 | | Social status |
| | IMD 28.11–35.02 | 0 | |
| | IMD 35.03–39.57 | 0 | |
| | IMD 39.58–43.85 | - | |
| | IMD 43.86–60.41 | - | |
| Jensen et al. (2016)(25) | Gender (women vs men) | 0 | Sex |
| | Age (<70 vs ≥70) | 0 | Age |
| Mudge et al. (2013)(26) | Retired from workforce (vs "working" and "not working") | + | Employment |
| | Age <65 vs 65+ | 0 | Age |
| | Sex (male vs female) | 0 | Sex |
| | Living alone vs living with family/others | 0 | Living status |
| Pakzad et al. (2013)(27) | Identity | 0 | |
| Pickering et al. (2013)(28) | Gender (male vs female) | 0 | Sex |
| | Living status (alone vs partner vs family/friends vs other) | 0 | Living status |
| | Age multiplicative decrease per 10 years | - | Age |
| Selzler et al. (2016)(29) | Age (years) | 0 | Age |
| Selzler et al. (2012)(30) | Age (years) | + | Age |
| Tooth et al. (1992)(31) | Scale of Status and Prestige (high score = lower social standing) | - | Social status |
| | Age (years) | 0 | Age |
| | Education (years) | 0 | Education |
| van Montfort et al. (2016)(32) | Female sex (vs male) | 0 | Sex |
| | Age (years) | 0 | Age |

IMD = Index of Multiple Deprivation (0, the least deprived, to 86, the most deprived); Scale of Status and Prestige (1 to 7, where 1 represents occupations of the highest social standing); + = significant positive effect; 0 = no significant effect; **-** = significant negative effect

**Table 3. Psychological Predictors of Exercise Adherence**

| Study | Predictors | Direction | Theme |
|---|---|---|---|
| Ades et al. (1992)(33) | Presence of depression before hospitalization | - | Depression |
| Brown et al. (2016)(34) | Beck Depression Index | 0 | Depression |
| Casey et al. (2008)(20) | Beck Depression Index (high scores, more depressed) | - | Depression |
| Cox et al. (2013)(35) | Baseline self-efficacy (higher) | + | Self-efficacy |
| Craike et al. (2016)(21) | Role functioning (higher) | + | |
| | Sexual activity | 0 | |
| Fan et al. (2008)(22) | State-Trait Anxiety Index ≥ 36 | - | Anxiety |
| | Beck Depression Index ≥ 5 | - | Depression |
| Gallagher et al. (2003)(23) | Perceived control | 0 | Control |
| | Personal stressful event | - | |
| Hogg et al. (2012)(24) | Hospital Anxiety and Depression Score "Not depressed" 0-7 | reference | Depression |
| | “Risk of depression” 8-10 | 0 | |
| | “Depressed” 11 | - | |
| Messer et al. (2007)(36) | Task self-efficacy summary scores (higher) | + | Self-efficacy |
| | Regulatory self-efficacy summary scores (higher) | + | |
| | Knowledge self-efficacy | 0 | |
| van Montfort et al. (2016)(32) | Positive affect | 0 | |
| Pakzad et al. (2013)(27) | State-Trait Anxiety Index (higher) | + | Anxiety |
| | Consequences | 0 | |
| | Chronology (acute/chronic) | 0 | |
| | Treatment control | 0 | |
| | Personal control | 0 | |
| Pickering et al. (2013)(28) | EQ-5D state of health thermometer | + | |
| | EQ-5D No pain/discomfort | reference | |
| | EQ-5D Moderate pain/discomfort | 0 | |
| | EQ-5D Extreme pain/discomfort | - | |
| | EQ-5D Not anxious/depressed | reference | Anxiety, Depression |
| | EQ-5D Moderate anxious/depressed | - | |
| | EQ-5D Extreme anxious/depressed | - | |
| | Mental health problem (self-reported) | - | Mental health |
| Selzler et al. (2012)(30) | Social functioning (36-Item Short Form Survey) | + | |
| | Mental health (36-Item Short Form Survey) | + | Mental health |
| | Role emotional (36-Item Short Form Survey) | + | |
| Selzler et al. (2016)(29) | Task self-efficacy | + | Self-efficacy |
| | Coping self-efficacy | 0 | |

| | | |
|---|---|---|
| | Scheduling self-efficacy | 0 |
| Tooth et al. (1992)(31) | Expectations (higher) | + |
| | Psychological status (profile of mood states score) | 0 |

+ = significant positive effect; 0 = no significant effect; - = significant negative effect

*GRADE recommendations*

Prognostic factors, categorized by themes, reported by at least 2 observational studies were assessed using the GRADE framework (Table 4).

**Table 4. Grading of Recommendations Assessment, Development and Evaluation**

| Predictors | Participants | Studies | + | 0 | - | Phase | Limitations | Inconsistency | Indirectness | Imprecision | Publication bias | ↑ effect size | Do ef |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Demographic*** | | | | | | | | | | | | | |
| Age (older) | 3591 | 10 | 2 | 6 | 2 | 2 | ✓ | X | ✓ | ✓ | ✓ | Æ | Æ |
| Sex (male) | 2487 | 6 | | 6 | | 2 | ✓ | ✓ | ✓ | ✓ | ✓ | Æ | Æ |
| Employed | 936 | 3 | 1 | 1 | 1 | 2 | ✓ | X | ✓ | ✓ | X | Æ | Æ |
| More education | 1300 | 3 | 1 | 2 | | 2 | ✓ | X | ✓ | X | X | Æ | Æ |
| Living alone | 210 | 2 | | 2 | | 2 | ✓ | X | ✓ | ✓ | X | Æ | Æ |
| Lower SES | 842 | 2 | | | 2 | 2 | ✓ | ✓ | ✓ | X | X | Æ | Æ |
| ***Psychological*** | | | | | | | | | | | | | |
| Anxiety | 1318 | 3 | 1 | | 2 | 2 | ✓ | X | ✓ | ✓ | X | Æ | Æ |
| Depression | 3366 | 6 | | 1 | 5 | 2 | ✓ | ✓ | ✓ | ✓ | ✓ | Æ | D |
| Higher self-efficacy | 313 | 3 | 3 | | | 2 | ✓ | ✓ | ✓ | X | X | Æ | D |
| Higher control | 226 | 2 | | 2 | | 2 | ✓ | ✓ | ✓ | X | X | Æ | Æ |
| Good mental health | 884 | 2 | 2 | | | 2 | ✓ | ✓ | ✓ | ✓ | X | Æ | Æ |
| ***Comorbidities*** | | | | | | | | | | | | | |
| High BMI | 1848 | 3 | | 3 | | 2 | ✓ | ✓ | ✓ | ✓ | X | Æ | Æ |
| Smoker | 1446 | 5 | 1 | 2 | 2 | 2 | ✓ | X | ✓ | ✓ | X | Æ | Æ |
| High cholesterol | 158 | 3 | 1 | 2 | | 2 | ✓ | X | ✓ | X | X | Æ | Æ |
| Hypertension | 128 | 2 | | 2 | | 2 | ✓ | ✓ | ✓ | X | X | Æ | Æ |
| higher CCI | 1268 | 2 | | 2 | | 2 | ✓ | ✓ | ✓ | ✓ | X | Æ | Æ |
| ***Condition severity*** | | | | | | | | | | | | | |
| Better respiratory function | 878 | 2 | 1 | 1 | | 2 | ✓ | X | ✓ | ✓ | X | Æ | Æ |
| Higer FEV1 | 1658 | 2 | 1 | 1 | | 2 | ✓ | X | ✓ | ✓ | X | Æ | Æ |
| ***Program*** | | | | | | | | | | | | | |
| Farther distance | 1444 | 2 | | | 2 | 2 | ✓ | ✓ | ✓ | ✓ | X | Æ | Æ |
| Continuous exercise (vs intermittent) | 75 | 2* | 1 | | 1 | 2 | ✓ | X | ✓ | ✓ | X | Æ | Æ |
| ***Other*** | | | | | | | | | | | | | |
| Exercise history | 160 | 2 | 1 | 1 | | 2 | ✓ | X | ✓ | X | X | Æ | Æ |

+ = number of studies with a significant positive effect; 0 = number of studies with no significant effect; - = number of studies with a significant negative effe limitations; X = serious limitations; D = present; Æ = not present; * randomized controlled trials

*Demographics*

Demographic predictors included age, sex or gender, employment, education, social status and living situation. There was low-quality evidence that lower socioeconomic status predicted lower adherence. High-quality evidence suggested that sex was not predictive of adherence and moderate-quality evidence suggests that age does not predict adherence. Low, low and very low-quality evidence, respectively, suggested a lack of prediction of adherence for employment status, living status and education.

*Psychological factors*

Psychological predictors included anxiety, depression, self-efficacy, control, and self-rated mental health. High-quality evidence supported a negative association between the presence of depression and adherence. Individuals who had good self-rated mental health and who had good self-efficacy were more likely to be adherent (moderate-quality evidence). Low-quality evidence suggested that anxiety and perception of control did not predict adherence.

*Comorbidities*

Identified comorbidities reported as predictors of exercise adherence were Body Mass Index (BMI), smoking status, hypercholesterolemia, hypertension, and Charleston Comorbidity Index (CCI). None of these were predictive of exercise adherence, which was supported by moderate-quality evidence for BMI and CCI, low-quality evidence for smoking status and hypertension, and very low-quality evidence for hypercholesterolemia. Frailty was not assessed or reported in any of the studies.

*Medical condition severity*

Measures of respiratory disease severity were not found to be predictive of adherence, but this was only supported by low-quality evidence.

*Program factors*

The type of exercise program (continuous vs interval exercise) was evaluated by two randomized controlled trials. Although randomized trials are considered to provide high-quality evidence, we downgraded the evidence of no association to moderate quality, given that trial findings were contradictory (one trial reported better adherence to interval exercise, one reported better adherence with continuous exercise). Moderate-quality evidence suggests that living a further distance from the exercise facility decreased adherence.

*Other*

Low-quality evidence suggests that a history of exercise participation is not predictive of exercise adherence.

***Risk of bias within studies***

Nine observational studies were deemed to be at low risk of bias and 10 were at moderate risk of bias; no studies were at high risk of bias (Supplementary Table S5). Importantly, prognostic factor measurement and study confounding components of the tool scored low risk of bias across all studies. All four randomized trials were assessed as high risk of bias due to lack of blinding, however, this is recognizably difficult in exercise interventions (Supplementary Table S6). All other domains were low or unclear risk of bias.

## Discussion

In this systematic review of predictors of exercise adherence in older adults with non-musculoskeletal indications for prescribed exercise, we found that positive predictors of adherence, supported by moderate-quality evidence, were higher self-efficacy and good self-rated mental health. Negative predictors included depression (high-quality) and distance from the exercise facility (moderate quality). Comorbidity status, sex and age did not appear to be predictive of adherence, supported by moderate- to high-quality evidence. As prescribed exercise programs are less likely to be effective without high levels of adherence, these findings provide important insights into current practice and future research. In current practice, identification of negative predictors, with a particular focus on mental health, could allow for increased personalization and targeting of support. The small number of identified predictors with at least moderate-quality evidence and sparse data available for many predictors suggest that future research is needed to better understand and predict poor exercise adherence in older adults.

Numerous studies have estimated exercise adherence rates in a variety of populations, typically reporting similar or slightly higher adherence rates than those identified in our study. For example, Bullard et al.(40) reported a pooled adherence rate of 77% (95% CI 68%, 84%) across 30 studies of adults with cancer, cardiovascular disease or diabetes. However, few studies have evaluated what patient- and program-factors predict adherence, and to our knowledge, none have evaluated the strength of this evidence using a standard framework such as GRADE. Most available data currently focuses on program-related factors. Similar to our findings, Morgan et al.(41) identified program location as a barrier to participation and adherence, while Sheill et al.(42) found that difficulties travelling to exercise locations were a substantial barrier for individuals with advanced cancer. We found no evidence that the type of exercise program (i.e., interval vs continuous exercise) was predictive of adherence, which is consistent with recommendations that the act of engaging in exercise is likely of greater importance than the specific type of exercise performed.(40,42)

Some authors have advocated the identification of participant-level ‘red flags’ to adherence as a way to personalize exercise program design and support.(40) However, this approach requires a thorough understanding of what participant characteristics may act as red flags. At the participant level, consistent findings from our study and from others suggest that aspects of mental health are likely key predictors of adherence. Self-efficacy has previously been reported as a predictor of adherence in a systematic review of home-based physiotherapy,(43) which is consistent with our findings and aligns with other systematic reviews that have found one’s intentions to engage in health-changing behaviors to be strongly predictive of adherence.(44) We also found that the presence of depression was a strong predictor of poor adherence and the only predictor supported by high-quality evidence. The related concept of good self-rated mental health (to some degree the inverse of depression) had moderate quality evidence supporting its role as a positive predictor of adherence. Whether anxiety predicts adherence in older people remains to be determined; we found no clear evidence of an association, as the strength and quality of evidence was low and reflected findings from only 3 studies. Interestingly, we did not find evidence that comorbidities, sex, or age were important predictors of adherence, as none suggested a directional association. Obesity and multimorbidity were also the only comorbidities with at least moderate quality evidence. Many comorbidities were not assessed and the impact of frailty was not reported in any studies, suggesting a need for future research. Finally, absent from the literature and related reviews is the consideration that program factors may interact with participant factors when predicting adherence. Although we were unable to identify any evidence of this phenomenon in our review, future evaluation is likely warranted to understand how, for example, participant-level red flags such as poor mental health may potentially be modified by specifically targeted aspects of program design. Such efforts could lead to better personalization and potentially higher adherence in individuals at risk of poor participation.

***Strengths and limitations***

Our study's findings should be considered in the context of its strengths and limitations. First, we conducted our review according to best-practice methodologies, which included protocol pre-registration, peer-review of our search strategy, review of multiple databases, a focus on adjusted estimates and contextualisation of our findings within the GRADE strength of evidence framework. Furthermore, our results are based on identified studies that were generally at low or moderate risk of bias (apart from blinding issues in randomized trials, which is typical of exercise studies). However, despite pre-specifying a defined population of interest, included studies represented a somewhat heterogenous group of participants who engaged in exercise for cardiovascular, pulmonary and other indications. We were also unable to identify adequately homogenous data to support quantitative meta-analyses. This may, in part, reflect the number of largely unvalidated measures used to define exercise adherence in clinical research.(45) Accordingly, we classified our studies based on whether adherence was measured using a continuous or binary definition; however, this may not have completely captured the heterogeneity in underlying adherence measures.

## Conclusions

Design of prescribed exercise programs for older adults requires an understanding of how program and participant characteristics impact exercise adherence. Based on the GRADE Framework for prognostic research, mental health factors appear to be the most important patient-level predictors, while a longer distance from the exercise facility was the only clear program-related factor predicting adherence. These findings can help to inform the design of current programs and personalization of support for participants. Future research is needed to evaluate the impact of other patient- and program-level predictors.

## Abbreviations

QUIPS: Quality in Prognostic Studies; GRADE: Grading of Recommendations Assessment, Development and Evaluation; BMI: Body Mass Index; CCI: Charleston Comorbidity Index

## Declarations

**Ethics Approval and Consent to Participate:** Not applicable

**Consent for publication:** Not applicable

**Availability of Data and Materials:** Not applicable

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**Authors' Contributions:** All authors made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; drafting the manuscript or revising it critically for important intellectual content; and final approval of the version to be published.

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## Additional Files

Additional File 1.docx: Supplementary Table S1. Predictors of Exercise Adherence for Cardiac Rehabilitation

Additional File 2.docx : Supplementary Table S2. Predictors of Exercise Adherence for Pulmonary Rehabilitation

Additional File 3.docx : Supplementary Table S3. Predictors of Exercise Adherence for Other Exercise Programs

Additional File 4.docx : Supplementary Table S4. Risk of Bias Assessments for Observational Studies (QUIPS tool)

Additional File 5.docx : Supplementary Table S5 Risk of Bias Assessments for Randomized Controlled Trials (Cochrane Risk of Bias tool)

Additional File 6.docx: Supplementary Table S6. Search Strategy

## Figures

**Figure 1. PRISMA Flow Diagram for Study Selection and Inclusion**

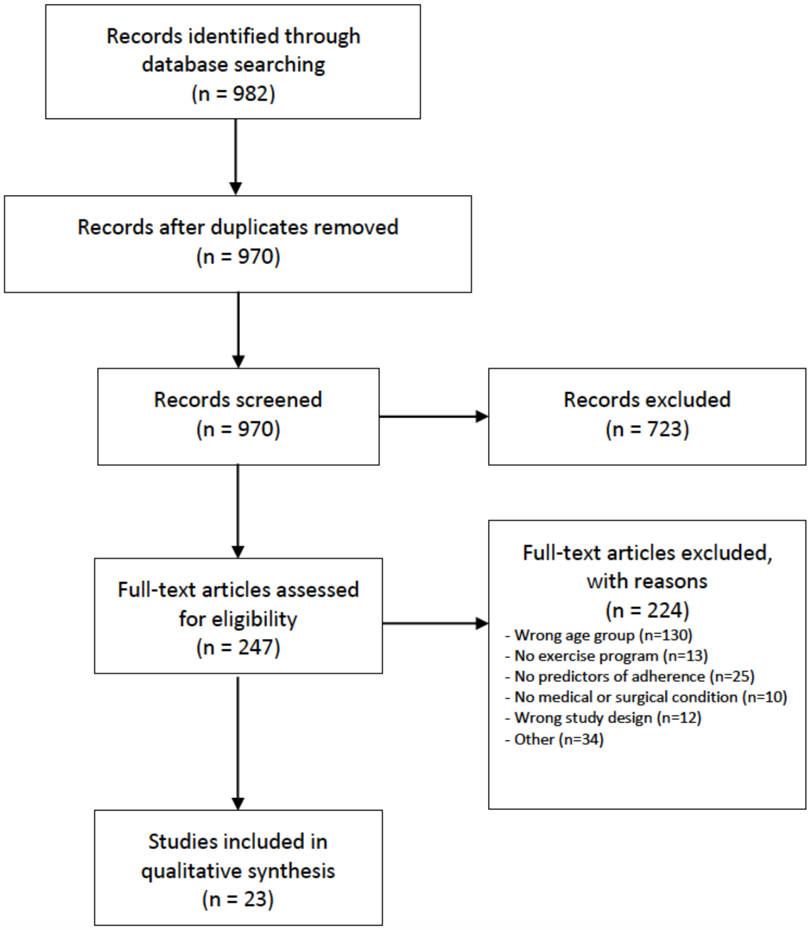


**Figure 1**

PRISMA Flow Diagram for Study Selection and Inclusion

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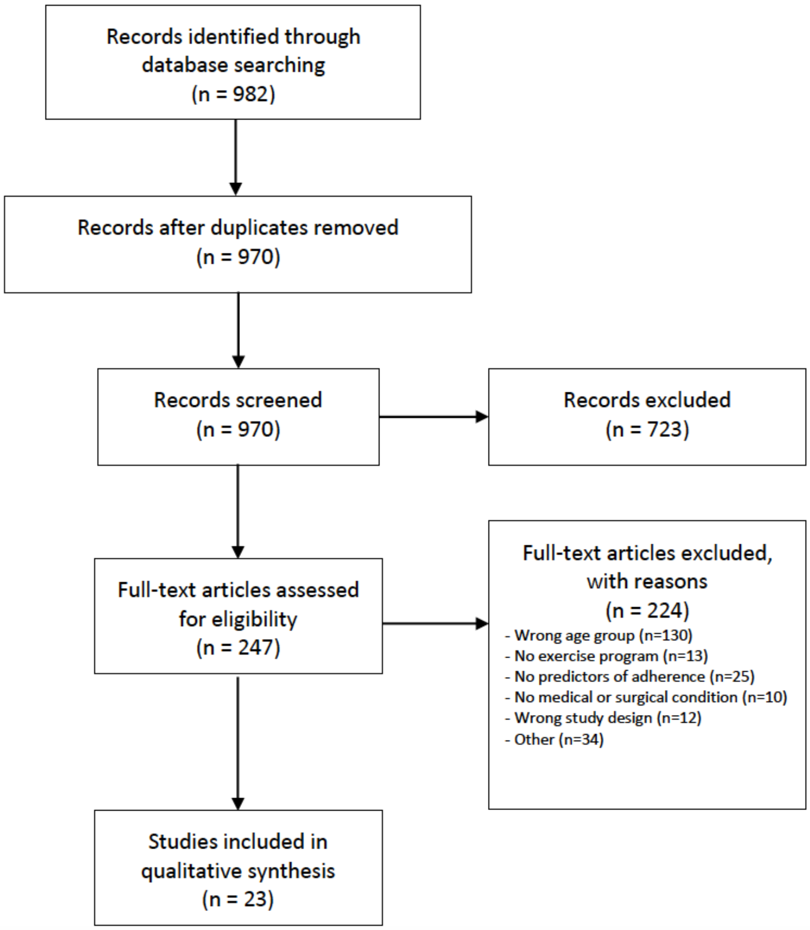


**Figure 1**

PRISMA Flow Diagram for Study Selection and Inclusion

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