REVIEW / SYNTHÈSE

Evidence-based risk assessment and recommendations for physical activity: arthritis, osteoporosis, and low back pain[1]

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Abstract: We systematically reviewed the safety of physical activity (PA) for people with arthritis, osteoporosis, and low back pain. We searched PubMed, MEDLINE, Sport Discus, and the Cochrane Central Register of Controlled Trials (1966 through March 2008) for relevant articles on PA and adverse events. A total of 111 articles met our inclusion criteria. The incidence for adverse events during PA was 3.4%–11% (0.06%–2.4% serious adverse events) and included increased joint pain, fracture, and back pain for those with arthritis, osteoporosis, and low back pain, respectively. Recommendations were based on the Appraisal of Guidelines for Research and Evaluation, which applies Levels of Evidence based on type of study ranging from high-quality randomized controlled trials (Level 1) to anecdotal evidence (Level 4) and Grades from A (strong) to C (weak). Our main recommendations are that (*i*) arthritic patients with highly progressed forms of disease should avoid heavy load-bearing activities, but should participate in non-weight-bearing activities (Level 2, Grade A); and (*ii*) patients with osteoporosis should avoid trunk flexion (Level 2, Grade A) and powerful twisting of the trunk (Level 3, Grade C); (*iii*) patients with acute low back pain can safely do preference-based PA (i.e., PA that does not induce pain), including low back extension and flexion (Level 2, Grade B); (*iv*) arthritic patients with stable disease without progressive joint damage and patients with stable osteoporosis or low back pain can safely perform a variety of progressive aerobic or resistance-training PAs (Level 2, Grades A and B). Overall, the adverse event incidence from reviewed studies was low. PA can safely be done by most individuals with musculoskeletal conditions.

Key words: adverse events, side effects, adverse effects, exercise.

Résumé : Cette étude présente une analyse documentaire systématique concernant l'aspect sécuritaire de la pratique de l'activité physique (PA) chez les personnes souffrant d'arthrite, d'ostéoporose ou de lombalgie. Nous avons répertorié les études pertinentes portant sur la PA et les événements nocifs dans les bases de données suivantes : PubMed, MEDLINE, Sport Discus, et Cochrane Central Register of Controlled Trials (de 1966 à mars 2008). Cent onze articles répondent aux critères d'inclusion. La fréquence des événements nocifs pendant la PA est de 3,4 % – 11 % (0,06 % – 2,4 % des événements nocifs graves) et consiste en des douleurs articulaires accrues, des fractures et des douleurs au dos chez les personnes affligées par l'arthrite, l'ostéoporose ou la lombalgie, respectivement. Les recommandations sont basées sur la Grille d'évaluation de la qualité des recommandations pour la pratique clinique; selon cette grille, le niveau des preuves est une fonction du type d'études et s'échelonne de la façon suivante : du niveau 1 pour les essais cliniques aléatoires de grande qualité jusqu'au niveau 4 pour les preuves anecdotiques; on distingue aussi des degrés, depuis A pour fort jusqu'à C pour faible. Nos principales recommandations sont que (*i*) les patients arthritiques présentant des formes évolutives de la maladie devraient éviter les exercices de prise en charge lourde, mais devraient faire des exercices sans mise en charge (niveau 2, degré A); et (*ii*) les patients souffrant d'ostéoporose devraient s'abstenir de flexion du tronc (niveau 2, degré A) et de forte torsion du tronc (niveau 3, degré C); (*iii*) les patients souffrant de lombalgie aigüe peuvent en toute sécurité pratiquer des PA de leur choix (pourvu que cela ne suscite pas de douleur) et s'adonner à des flexions et extensions du bas du dos (niveau 2, degré B); (*iv*) les patients arthritiques de condition stable et sans progression des lésions articulaires et les patients ostéoporotiques de condition stable et les lombalgiques peuvent en toute sécurité s'adonner à une variété de PA d'intensité progressive à caractère aérobie et contre résistance (niveau 2, degrés A et B). Dans l'ensemble, la fréquence des événements nocifs dans les

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études recensées est faible. La majorité des personnes présentant des troubles musculosquelettiques peuvent s'adonner en toute sécurité à la pratique de l'activité physique.

Mots-clés : événements nocifs, effets secondaires, effets nocifs, exercice physique.

[Traduit par la Rédaction]

Introduction

This systematic review is one of a series of reviews on the safety of physical activity (PA) for patients with different health conditions. These reviews have the overall purpose of revising forms that are currently used to screen people who may be at risk during participation of PA (i.e., the Physical Activity Readiness Questionnaire, or PAR-Q, and the Physical Activity Readiness Medical Evaluation, or PARmed-X; described in detail below). The focus of this systematic review was to determine the nature of the adverse events that are associated with exercise interventions for people with musculoskeletal conditions, specifically arthritis, osteoporosis, and low back pain; to develop recommendations for safe exercise prescriptions; and to suggest revisions to the sections of the PAR-Q and PARmed-X pertaining to these patients.

Arthritis, low back pain, and osteoporosis affect a large number of Canadians. Arthritis is caused by inflammation of a joint due to infectious, metabolic, or constitutional changes. The self-reported diagnosis of arthritis in Canada by physicians was 13.7% of the population in 2005 (Statistics Canada 2005). Of the aforementioned incidence of arthritis, 62% of cases occur in females. In Canada, arthritis accounted for approximately $5.9 billion in direct and indirect costs in 1994 (Coyte et al. 1998). Adjusted relative to gross domestic product, the cost today would be approximately $11 billion per year. The most prevalent types of arthritis include osteoarthritis and rheumatoid arthritis. Osteoarthritis is a degenerative disorder of one or more joints manifested as hypertrophic changes in subchondral bone and loss of articular cartilage. Osteoarthritis is characterized by a progressive wearing away of opposing joint surfaces with a distortion of the joint position but absence of bone growth that results in joint immobility. Osteoarthritis is the most common type of arthritis and is most prevalent from middle age onward (Veje et al. 2002). Individuals with osteoarthritis will usually first experience pain when loading and moving the affected joint, with pain at rest exhibiting itself later in the disease. Radiographic evidence of joint narrowing does not become evident until later in the disease. Usually, PA is restricted in individuals with osteoarthritis, as it produces painful symptoms that lead to progressive loss of strength and muscle mass around the affected joint (Pedersen and Saltin 2006). There is no evidence for a beneficial effect of PA on the pathogenesis of osteoarthritis, but improving strength around the affected joint will have a beneficial effect on quality of life and likely reduce symptoms associated with the disease (Fransen et al. 2003, 2009; Bartels et al. 2007). A recent summary of systematic reviews concluded that there is strong evidence for beneficial effects of PA in patients with osteoarthritis (Taylor et al. 2007).

Rheumatoid arthritis is a chronic inflammatory disease of unknown etiology and is considered an autoimmune disease. Rheumatoid arthritis is characterized by pain, stiffness, inflammation, swelling, and sometimes destruction of joints due to bony growth and cartilage destruction. Rheumatoid arthritis usually affects the peripheral joints, such as the knees, ankles, feet, elbows, and wrists. Rheumatoid arthritis is more prevalent in females than in males (79% of patients in Canada are female; Sokka et al. 2009) and is characterized by a chronic systemic inflammatory response that usually presents with symmetric polyarthritis (i.e., arthritis that affects 5 or more joints) (Pedersen and Saltin 2006). Individuals diagnosed with rheumatoid arthritis usually have reduced muscle strength and endurance, mostly due to a decrease in PA levels as a result of joint pain, stiffness, altered mobility, and general fatigue. PA has no known effect on the pathogenesis of rheumatoid arthritis, but it can likely improve quality of life and most certainly will improve physical fitness and strength (Hurkmans et al. 2009). Another type of autoimmune arthritis is ankylosing spondylitis, a chronic inflammatory form of arthritis of unknown etiology that mainly affects the joints of the sacroiliac and spine but may affect the shoulders, hips, knees, and ankles. In contrast to rheumatoid arthritis, ankylosing spondylitis is diagnosed more frequently in males (75% of patients are male; van der Horst-Bruinsma et al. 2009). PA is highly recommended in ankylosing spondylitis, as it is beneficial for maintaining the mobility of the spine and reducing comorbidities associated with the disease (Dagfinrud et al. 2008). Juvenile idiopathic arthritis is a type of arthritis that affects children under the age of 16. It commonly affects the joints of the hands, feet, wrist, ankles, and knees, but may present in any joint. The most common clinical feature is swelling of the affected joint, and children affected by the disease will display fatigue and lethargy. PA does not seem to have any positive or negative effects on disease progression, but is recommended for maintenance and development of fitness (Takken et al. 2008).

Osteoporosis is a systemic skeletal disorder characterized by low bone mass and microarchitectural corrosion of bone resulting in an increased risk of fractures (World Health Organization 1994). Canadian guidelines for 10-year risk of fracture place patients over the age of 50 years into categories of low (<10% risk), moderate (10%–20% risk), and high (>20%) risk based on the bone mineral density T-score (i.e., the standard deviation units that your bone mineral density differs from the young adult mean) from the femoral neck (as assessed by dual-energy X-ray absorptiometry) and their age and sex (Papaioannou et al. 2010). If the patient has suffered a fragility fracture after the age of 40 years or has recently used systematic glucocorticoid therapy (i.e., at least a 3-month cumulative dose for the preceding year at a prednisone-equivalent dose ≥7.5 mg daily), then the patient is moved up one risk category (i.e., from low to moderate or from moderate to high). If a patient has suffered a fragility fracture after the age of 40 years and has used systematic glucocorticoid therapy as defined above, they are automati-

cally considered high risk, independent of their bone mineral density reading. Older guidelines for the diagnosis of osteoporosis are outlined below, because most of the journal articles for this review defined osteoporosis based on these guidelines. Older guidelines are based on bone mineral density measurements using dual-energy X-ray absorptiometry (Boonen et al. 2008). The World Health Organization defined osteoporosis as bone density 2.5 standard deviation units below the mean for young adults of the same gender (NIH Consensus Development Panel on Osteoporosis Prevention, Diagnosis, and Therapy 2001; North American Menopause Society 2006). The occurrence of a fragility fracture was also used for diagnosis (Boonen et al. 2008). Osteopenia is a condition where bone mineral density is low enough to cause a significant increase in risk of fracture and is defined under the older guidelines as a bone mineral density 1.0 standard deviation unit below the young adult mean. Approximately 1 in 4 women and 1 in 8 men in Canada have osteoporosis (Brown and Josse 2002). The majority of osteoporosis cases are among postmenopausal women. A woman's risk of suffering a hip fracture is equivalent to her combined risk of developing breast, uterine, and ovarian cancer (Kelley and Kelley 2006). In Canada, osteoporosis treatment accounts for about $ 0.9 billion in direct and indirect costs per year (Osteoporosis Canada 2009). PA is beneficial for increasing bone mineral density, reducing risk of falls, and reducing risk of fracture (Chilibeck et al. 1995; Bonaiuti et al. 2002; Sinaki et al. 2002; Kohrt et al. 2004).

Chronic low back pain is reported by 20.6% of Canadians, with rates increasing up to the age of 35 years and then levelling off (Lim et al. 2006). More women than men report chronic low back pain (55% vs. 45% of cases). In Canada, back pain accounted for $8.1 billion in direct and indirect costs per year or 1.1% of the gross domestic product in 1994 (Coyte et al. 1998). Assuming the cost is the same percentage of today's gross domestic product, the cost of low back pain would be approximately $15.2 billion. Causes of back pain have been linked to both biomechanical and psychological factors (McGill 2007). Systematic reviews and clinical practice guidelines indicate that PA is beneficial for reducing pain and improving function in patients with chronic low back pain, but less effective for acute low back pain (Hayden et al. 2005; Chou et al. 2007; Ferreira et al. 2007); however, advice to stay physically active is more beneficial than forced bed rest for alleviating acute low back pain, improving functional status, and reducing sick leave duration (Hagen et al. 2004; van Tulder et al. 2006*a*, 2006*b*). Stabilizing exercise programs, although not immediately effective for alleviating acute low back pain, are effective for reducing recurrence of low back pain (Rackwitz et al. 2006). PA programs improve functional status and return to work after lumbar disc surgery without affecting reoperative rate (Ostelo et al. 2008). Most systematic reviews and clinical guidelines favour strengthening or stabilizing and flexibility exercises as the most important exercises for patients with low back pain (Philadelphia Panel 2001; Liddle et al. 2004; Hayden et al. 2005; Chou et al. 2007), while others suggest corrective and stabilizing exercise and muscular endurance exercise as the most important exercises to give to patients initially (McGill 2007).

The main objective of our review was to determine the nature of adverse events that occur during exercise training in people with arthritis, osteoporosis, or low back pain; to develop safe PA recommendations; and to revise sections of screening tools used for people with these conditions who wish to engage in PA. These screening tools (the PAR-Q and PARmed-X) are described in detail below.

Consensus panel statement

The following section was written by the consensus panel that guided the overall revision of the PA clearance process. This information is reprinted in each of the systematic review papers so that these reviews can stand alone from the paper describing the overall consensus process (Jamnik et al. 2011).

PA participation is recommended and beneficial for all asymptomatic persons and for persons with chronic diseases (Warburton et al. 2006, 2007). However, the PA participation of persons with certain chronic disease conditions or constraints may need to be restricted. The PAR-Q is a screening tool completed by persons who plan to undergo a fitness assessment or to become "much more physically active"; for example, when initiating PA participation that is beyond a person's habitual daily activity level or when beginning a structured PA or exercise program. Screening is also recommended when a person is joining a health club, commencing a training program with a fitness professional, or joining a sports team. If a person provides a positive response to any question on the PAR-Q, he or she is directed to consult with his or her physician for clearance to engage in either unrestricted or restricted PA.

The PARmed-X is a screening tool developed for use by physicians to assist them in addressing medical concerns regarding PA participation that were identified by the PAR-Q. Recent feedback from PA participants, fitness professionals, and physicians has brought to light substantial limitations to the utility and effectiveness of PA participation screening by the PAR-Q and PARmed-X. In short, the exercise clearance process is not working as intended and at times is a barrier to PA participation for those persons who may be most in need of increased PA. An important objective of this project is to provide evidence-based support for the revision of the screening process to be used by university-educated and qualified exercise professionals in the exercise clearance process. An expert panel was convened to conduct a series of systematic reviews that would be used to revise and increase the effectiveness of the PAR-Q and PARmed-X using an evidence-based consensus approach that adheres to the established Appraisal of Guidelines for Research and Evaluation (AGREE Collaboration 2001, 2003).

The AGREE Instrument was developed by a group of researchers from 13 countries to provide a systematic framework for assessing the quality and impact on medical care of clinical practice guidelines (AGREE Collaboration 2001, 2003). The AGREE Collaboration published the rigorous development process and associated reliability and validity data of the AGREE Instrument based on a large-scale study focusing primarily on clinical practice guidelines (AGREE Collaboration 2001, 2003). The AGREE Instrument is now a commonly used tool for assessing clinical practice guidelines and other health management guidelines (Lau 2007). The AGREE guidelines were applied in the present project with systematic reviews of adverse events to assess the formulation of risk stratification and PA participation clearance rec-

ommendations for each of the following critical chronic diseases: arthritis, osteoporosis, and low back pain.

In addition to adhering to the AGREE process, the Level of Evidence (1 = randomized controlled trials; 2 = randomized controlled trials with limitations or observational trials with overwhelming evidence; 3 = observational studies; 4 = anecdotal evidence) supporting each PA participation clearance recommendation and the Grade (A = strong; B = intermediate; C = weak) of the PA participation clearance recommendation was assigned by applying the standardized Level and Grade of Evidence detailed in the consensus document (Warburton et al. 2011).

In this series of articles, each chronic disease condition was considered in reference to a continuum of risk, from lower risk to intermediate (moderate) and higher risk categories. Particular attention was paid to the short-term (acute) risks of PA and exercise versus the long-term (chronic) benefits of exercise for the individuals with the chronic disease. PA participation may transiently increase the risk while leading to physiological and psychological adaptations that markedly reduce the long-term risk. Adverse events were considered as any adverse change in health status or a side effect that occurred as a result of PA or exercise participation.

Review questions

The purpose of this review was to evaluate adverse event reporting in studies involving PA for individuals with arthritis, osteoporosis, or low back pain. From this, we developed recommendations for relative and absolute contraindications to PA as part of the series of papers tasked with reevaluating the PAR-Q and PARmed-X. Other purposes of the review were to recommend changes to the PAR-Q and PARmed-X and to develop decision trees for PA prescription by qualified exercise professionals based on levels of severity of arthritis, osteoporosis, or low back pain. It was hypothesized that there would be a low number of adverse events and therefore minimal relative or absolute contraindications to PA prescription in individuals diagnosed with musculoskeletal conditions. Our specific review questions were as follows:

1. What PAs are associated with adverse events in individuals with arthritis, osteoporosis, or low back pain?
2. What are the differences in the characteristics of studies reporting adverse events versus those reporting no adverse events from PA?
3. How can the PAR-Q and PARmed-X be altered to reflect the literature on adverse events in people with arthritis, osteoporosis, or low back pain participating in PA?
4. What decision trees can be developed to assist qualified exercise professionals in prescribing PA to individuals with arthritis, osteoporosis, or low back pain, based on severity of the condition?

Methods

Identification of studies

The review team consisted of 5 researchers. S. Charlesworth conducted the literature search; P.D. Chilibeck, S.M. Cornish, H. Vatanparast, and S. Abeysekara were involved in the review process and manuscript writing. To conduct a comprehensive literature review, we defined search terms in 2 categories, "disease" and "exercise". The search included various terms and MESH words to identify the disease of interest (i.e., arthritis, osteoporosis, low back pain), its complications, and exercise. Those terms alone and in combination were searched in PubMed, MEDLINE, Sport Discus, and the Cochrane Central Register of Controlled Trials (1966 through March 2008). The search was limited to human subjects and the English language. Reference lists of systematic reviews, relevant journals, and primary studies were also hand searched.

To identify original articles, we used the following search terms: exercise or exercise therapy or sports or physical activity or physical fitness or physiotherapy or physical therapy or rehabilitation, or vigorous or intensity or intense or walking or physical exercise or aerobic fitness or leisure time physical activity or occupational physical activity or energy expenditure and terms specific for each musculoskeletal condition. The terms specific to the arthritis category included arthritis, osteoarthritis, rheumatoid arthritis, ankylosing spondylitis, septic arthritis, lupus, psoriatic arthritis, gout or pseudogout, knee or hip or shoulder. Terms specific to osteoporosis included osteoporosis, fracture, bone density, bone, or osteopenia. Terms specific to low back pain included lumbago, acute low back pain, chronic low back pain, backache, sciatica, or sciatalgia.

Study selection: inclusion and exclusion criteria

The population we reviewed included any patients with arthritis, osteoporosis or osteopenia, or low back pain, with no age restrictions. The interventions included any exercise or PA intervention. The comparators were not restricted. For example, we included studies where the comparator was "no exercise," studies where one type of exercise was compared with another, and studies where there was PA or exercise by itself with no comparator. The outcomes we assessed were adverse events from PA. We included all adverse events and attempted to classify these as nonserious and serious adverse events. We used the World Health Organization criteria for defining serious adverse events as those that resulted in death, disability, or hospitalization (Centre for Reviews and Dissemination 2009). We also evaluated whether adverse events resulted in withdrawal of the patient from the study. Studies were included only if they explicitly stated that adverse events were monitored. Outcomes also included characteristics of studies that reported an adverse event (i.e., study design, age of participants, exercise screening procedures, and types of exercise testing and monitoring). We included all study designs. Although randomized controlled trials are the best types of studies to include when looking at outcomes related to efficacy, they might not be generalizable, because they often exclude patients at high or medium risk of experiencing adverse events and they are often underpowered to detect adverse events (Centre for Reviews and Dissemination 2009). Observational studies provide data that are more generalizable and often include higher numbers of patients.

Data extraction

In the first step of the screening process, titles and abstracts of each article were read by 2 reviewers to determine whether they included one of the relevant musculoskeletal

conditions (i.e., arthritis, osteoporosis, or low back pain). Articles were marked as "yes" or "no". If the article was marked as "yes" by both reviewers, the article went to the next screening step. If there was a disagreement, the article was sent to a third reviewer to determine whether the article should be included in the next screening step. The inclusion criteria for the second step were as follows: Participants were diagnosed with the disease of interest and enrolled in exercise training of any duration. All study designs were included. Related systematic reviews and clinical practice guidelines were included in this step as well. The exclusion criteria were as follows: no direct relation with disease of interest (for example, if the study involved prevention of the disease of interest rather than participants with the disease of interest), indirectly related to PA (for example, community-based health promotion with an exercise component), duplicate study, and review article only. The final screening step involved a review of a hard copy of the article and whether adverse event reporting was included.

All data were collected on extraction forms that were modified after pilot testing. Information that was extracted from each study included the primary outcomes, study design, participant characteristics (i.e., type of disease, disease subtype, disease duration, age, sex, medication use), number of participants included in the exercise group, date of publication, country of publication, exclusion criteria, individual who screened participants, type of exercise test, individual who performed exercise testing, characteristics of the exercise intervention (i.e., type of exercise, frequency, duration of each exercise session, intensity, length of the intervention, whether the exercise was supervised or unsupervised), exercise safety monitoring, and the Level and Grade of Evidence according to the AGREE Instrument (AGREE Collaboration 2001, 2003). Four individuals performed extractions, with at least 2 individuals performing extractions for each disease condition. When consensus was not met on an extraction, the 2 individuals met to resolve the differences. If the differences were not resolved, then a third person reviewed the extraction. All data were entered into Excel spreadsheets, which allowed data to be pooled and entered into tables, as presented in the Results.

Quality assessment

We assessed studies based on the quality assessment tool designed by Jadad et al. (1996). This tool scores trials based on proper randomization procedures, proper double-blinding, and proper description of withdrawals and dropouts. This review instrument is primarily used for randomized controlled trials focusing on efficacy variables. We also performed a quality assessment based on suggestions from the Centre for Reviews and Dissemination (2009) (pp. 187–188) for studies that assess adverse events. This includes the following questions: (*i*) Are measurement instruments for adverse event reporting described? (*ii*) Was a standardized or validated measurement instrument used? (*iii*) Was it identified that the harm was related to the intervention? (*iv*) Was the person who made the attribution identified? (*v*) Was this person blinded to the assigned treatment? (*vi*) Was there a description of how the severity of adverse events was determined?

Data synthesis

Percentage of adverse events or serious adverse events of PA for each disease were calculated as the number of adverse events across studies divided by the total number of participants included in exercise groups, multiplied by 100. All results are expressed as means and SD.

Results

Figure 1 shows a flow chart for the screening processes for articles related to each disease condition. At the end of the screening, 20 articles (18 randomized controlled trials and 2 prospective trials) were included for arthritis, 39 articles (23 randomized controlled trials, 13 prospective trials, and 3 case reports) were included for osteoporosis, and 52 articles (33 randomized controlled trials, 12 prospective trials with an intervention, 1 prospective trial without intervention, 2 cross-sectional studies, 2 retrospective studies, and 2 case reports) were included for back pain. A list of articles that were excluded at the full-text stage of the review (i.e., step 4 in Fig. 1) is available from the authors by request.

Study characteristics

The characteristics of the studies are presented in Table 1 for arthritis, osteoporosis, and low back pain, respectively. For arthritis, the 20 studies that were included in the analysis contained 2472 patients. The mean age was 53 (SD 17) years with the majority of participants being female (74%). The bulk of the studies were published after 2001 in either the USA or Europe. Most of the studies included patients with osteoarthritis or rheumatoid arthritis (80%). The majority of studies reported the type of drug treatment and disease duration but failed to report disease classification of patients. Also, there is a paucity of research on the effects of exercise training in patients with highly progressed forms of arthritis (such as stage III or IV rheumatoid arthritis); therefore, generalizing to this patient population needs to be done with caution.

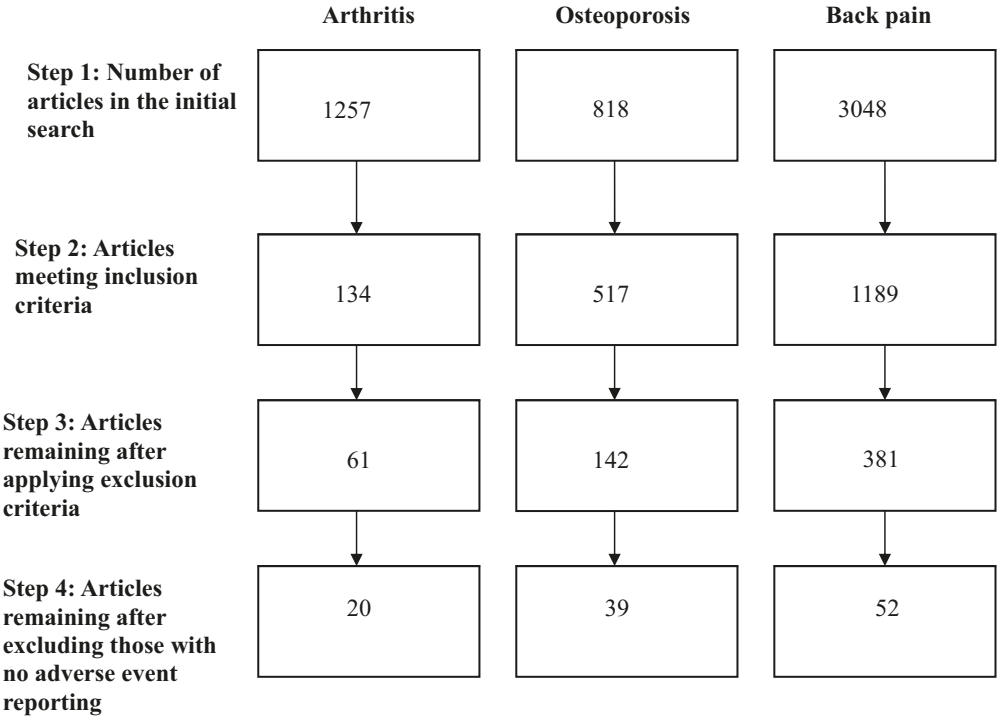
For osteoporosis, the 39 studies that were included in the analysis contained 2397 patients enrolled in exercise. The mean age was 67 $\pm$ 18 years, with the majority of participants being female (87%). Most of the studies were published after 2001 in Europe, Canada, or the United States. Most of the studies included patients with osteoporosis or osteopenia, with 15 studies done on patients recovering from hip or lumbar spine fracture.

For low back pain, the 52 studies that were included in the analysis contained 9664 patients enrolled in exercise. The mean age was 41 $\pm$ 11 years, with the majority of patients being female (55%). Most of the studies were published after 2001 in Europe or the United States. Most of the studies included patients with chronic low back pain, with a few studies on acute low back pain, subacute low back pain, back pain during pregnancy, patients after disc herniation surgery, and 1 study each on patients with spondylolisthesis, spondylolysis, and sciatica.

Study methodology characteristics

Table 2 presents the information for prestudy exercise screening. For the studies on arthritis, most had more than 1 exclusion criteria, and the majority included cardiovascular or

Fig. 1. Study selection flow chart.



pulmonary disease as a main exclusion to study participation. The majority of studies evaluated the changes in patients' cardiopulmonary function or muscle strength with the intervention. Exercise testing was done utilizing cardiovascular exercise equipment, a walking test, or a form of muscle strength measurement. The majority of studies did not report the use of exercise monitoring devices (such as heart rate monitors, electrocardiograms, blood pressure etc.) during the testing session. No studies utilized the PAR-Q or PARmed-X as part of the screening for exercise testing or training.

For osteoporosis, most studies had defined exclusion criteria, with the main ones being cardiovascular disease or impaired cognitive function. Half the studies did not report screening procedures. In about one-quarter of the studies, a physician was responsible for screening. Strength testing, balance testing, and treadmill or walking tests were the dominant exercise test modalities. Most studies did not state that exercise test monitoring was performed. In 30% of studies an exercise physiologist or physiotherapist monitored the exercise test. No studies utilized the PAR-Q or PARmed-X as part of the screening for exercise testing or training.

For low back pain studies, the main exclusion criteria were cardiovascular disease, cancer, arthritis or inflammation, pregnancy, older age, and serious back conditions, such as recent surgery, fracture, and nerve root compression or neurological symptoms. The lower mean age across studies for low back pain may be associated with the exclusion of patients with other largely age-related chronic diseases such as arthritis and osteoporosis. Most studies used physicians or physiotherapists for screening. The main exercise tests were for muscular strength or endurance and range of motion; however, close to half the studies had no exercise testing. Most studies did not report the use of an exercise monitoring device. Most studies used physiotherapists to monitor exercise testing and training. No studies utilized the PAR-Q or PARmed-X as part of the screening for exercise testing or training.

Quality of the included studies

Table 3 provides a checklist for the quality of all studies included in our review. It is difficult to blind participants to an exercise intervention; therefore, most studies did not involve blinding. The 2 studies that were able to blind participants used an exercise program involving electrical stimulation and had a "stimulation placebo" (Herman et al. 1994; Lamb et al. 2002). Most of the studies were described as "randomized" but did not describe appropriate randomization procedures (i.e., random number table, computerized randomization). Most studies gave a proper description of participants who withdrew from the study (i.e., number of participants who withdrew and their reasons). Few studies on arthritis and osteoporosis described the use of a validated instrument used for assessment of adverse events, whether adverse events were related to the intervention, the person who made the attribution, whether they were blinded to the groups, and how the severity of adverse events was determined. The majority of studies on back pain included a validated instrument for assessment of adverse events and whether the adverse event was related to the intervention. The adverse event instrument most commonly used in studies of back pain interventions were pain-related questionnaires.

Adverse events during PA

Table 4 and Table 5 report the information pertaining to adverse events during PA in patients with arthritis, osteoporosis, and low back pain, respectively. The total number of adverse events reported in PA studies on arthritis was 83 in a total of 2472 patients (3.4% incidence rate). The majority of adverse events were increased joint pain or inflammation

Table 1. Arthritis, osteoporosis, and low back pain study characteristics.

Characteristic	No. (%)
Arthritis studies (n = 20)	
Year of publication	
≤2001	9 (45)
>2001	11 (55)
Country of publication	
USA	5 (25)
Europe	7 (35)
Canada	3 (15)
UK	2 (10)
Other	3 (15)
No. of subjects	2472
Mean±SD	123±109
Age (y)	
Mean±SD	53±17
Mean age range across studies	8.7–71.0
Sex	
Male	633 (26)
Female	1839 (74)
Type of arthritis	
Osteoarthritis	5 (25)
Rheumatoid arthritis	11 (55)
Juvenile idiopathic arthritis	2 (10)
Mixed (≥2 types of arthritis)	2 (10)
Disease stage or functional classification	
I–II	2 (10)
II–III	2 (10)
III–IV	0 (0)
Mixed	5 (20)
Not reported	11 (60)
Arthritis treatment or medication	
Disease modifying antirheumatic drugs	1 (5)
Prednisone or corticosteroid	1 (5)
Nonsteroidal anti-inflammatory drugs	2 (10)
Mixed drug treatment	13 (65)
Other	1 (5)
Not reported	2 (10)
Osteoporosis studies (n = 39)	
Year of publication	
≤2001	16 (41)
>2001	23 (59)
Country of publication	
USA	17 (44)
Europe	8 (21)
Canada	7 (18)
Asia	4 (10)
Other	3 (8)
No. of subjects	2397
Mean±SD	60±110
Age (y)	
Mean±SD	67±18
Mean age range across studies	8.5–83.4
Sex	
Male	292 (13)
Female	1908 (87)
Type of disease, studies on	
Osteopenic subjects	4 (10)
Osteoporotic subjects	15 (38)
Subjects with osteoporotic fracture	15 (38)
Mixed	5(13)
Low back pain studies (n = 52)	
Year of publication	
≤2001	23 (44)
>2001	29 (56)
Country of publication	
United States	15 (29)
Europe	16 (31)
Canada	3 (6)
United Kingdom	7 (13)
Asia	2 (4)
Other	9 (17)
No. of subjects	9664
Mean±SD	186±311
Age (y)	
Mean±SD	41±11
Mean age range across studies	13.1–72.0
Sex	
Male	3348 (45)
Female	4165 (55)
Type of low back pain	
Nonspecific chronic	32 (62)
Nonspecific acute	3 (6)
Nonspecific subacute	3 (6)
Sciatica	1 (2)
Postdisc herniation surgery	4 (8)
During pregnancy	3 (6)
Spondylolisthesis	1 (2)
Spondylolysis	1 (2)
Mixed (≥2 types)	4 (8)
Back pain treatment or medication	
Anti-inflammatories	6 (12)
Analgesics	6 (12)
Muscle relaxants	1 (2)
Not reported	39 (75)

(75%), while increased space narrowing or bone loss or erosion (i.e., joint damage) was observed in 13% of the trials reporting adverse events. Considering increased joint damage and fracture (n = 3) as serious adverse events, the serious adverse event rate was about 0.6%. The most common type of PA reported to result in joint pain or inflammation was pool- or land-based joint mobility and muscle strength training and Tai Chi. Joint damage was associated with combined bicycle training, strength training circuit, and sport or game with impact loading (i.e., jumping). Fractures occurred from falls during aerobic training (n = 2, hip fracture) or dropping a dumbbell on the foot (n = 1, fracture of a toe). Of the 83 reported adverse events, 25 resulted in the participant dropping out of the intervention. Trials that included patients with rheumatoid arthritis accounted for 59% of the adverse events reported, while those with osteoarthritis represented 29% of the adverse events. The age of subjects in studies that reported adverse events was higher than that of studies not reporting adverse events (55 ± 15 years vs. 41 ± 29 years, respectively).

Table 2. Preexercise training and testing screening in arthritis, osteoporosis, and low back pain studies.

	No. (%)
Arthritis (n = 20)	
Reason for patient exclusion	
Heart disease	10 (16)
Hypertension	2 (3)
Physically active	2 (3)
Cognitive dysfunction	5 (8)
Pulmonary dysfunction	8 (13)
Cancer	1 (2)
Type II diabetes	4 (6)
Recent surgery or joint replacement	7 (11)
Uncontrollable or acute exacerbation of arthritis	3 (5)
Unstable drug treatment	5 (8)
Pregnancy	1 (2)
No exclusion criteria listed	2 (3)
Other	12 (19)
Study screening procedures	
Physician clearance	6 (30)
Physiotherapist clearance	2 (10)
PAR-Q or PARmed-X	0 (0)
Not stated	12 (60)
Type of exercise test	
Maximal, cardiopulmonary exercise test	4 (12)
Maximal without expired gas	1 (3)
Submaximal, age-predicted heart rate test	4 (12)
Submaximal, 6 or 12 min walk test	4 (12)
Muscle strength testing	12 (36)
Muscle endurance testing	1 (3)
Range of motion testing	2 (6)
Other	5 (15)
Exercise test modality	
Cycle ergometer	7 (21)
Treadmill	3 (9)
Walk test	6 (18)
Isokinetic dynamometer	9 (26)
Strength equipment	3 (9)
Strain gauge	1 (3)
Other	5 (15)
Exercise test monitoring	
Physician monitored	3 (10)
Exercise physiologist monitored	3 (10)
Physiotherapist monitored	7 (24)
Electrocardiogram	1 (3)
Blood pressure	2 (7)
Heart rate	3 (10)
Rate of perceived exertion	3 (10)
Not stated	7 (24)
Osteoporosis (n = 39)	
Reason for patient exclusion	
Heart disease	14 (36)
Hypertension	7 (18)
Physically active	3 (8)
Cognitive dysfunction	10 (26)
Pulmonary dysfunction	7 (18)
Cancer	4 (10)
Type II diabetes	1 (3)
Recent surgery	2 (5)
Osteoporotic fracture or orthopaedic disability	14 (36)
No exclusion criteria listed	3 (8)
Other	17 (44)
Study screening procedures	
Physician clearance	10 (26)
Physiotherapist clearance	6 (15)
Exercise physiologist clearance	0 (0)
PAR-Q or PARmed-X	0 (0)
Not stated	21 (54)
Type of exercise test	
Maximal, cardiopulmonary exercise test	2 (5)
Maximal without expired gas	0 (0)
Submaximal, age-predicted heart rate test	1 (3)
Submaximal, walk test	12 (31)
Submaximal, other	2 (5)
Muscle strength testing	17 (44)
Muscle endurance testing	3 (8)
Range of motion testing	3 (8)
Balance test	10 (26)
Other	5 (13)
No testing stated	10 (26)
Exercise test modality	
Cycle ergometer	0 (0)
Treadmill	3 (8)
Walk test	11 (28)
Isokinetic dynamometer	6 (15)
Strength equipment	7 (18)
Strain gauge	7 (18)
Other	7 (18)
Not listed	9 (23)
Exercise test monitoring	
Physician monitored	3 (8)
Exercise physiologist monitored	6 (15)
Physiotherapist monitored	6 (15)
Electrocardiogram	0 (0)
Blood pressure	1 (3)
Heart rate	1 (3)
Rating of perceived exertion	0 (0)
Not stated	27 (69)
Low back pain (n = 52)	
Reason for patient exclusion	
Heart disease	17 (33)
Hypertension	7 (14)
Physically active	3 (6)
Pulmonary dysfunction	2 (4)
Cancer	18 (35)
Type II diabetes	5 (10)
Previous back surgery	20 (38)
Neurological symptoms	12 (23)
Osteoporosis	10 (19)
Pregnancy	21 (40)
Fracture	15 (29)
Recent direct trauma	2 (4)
Spondylolisthesis	11 (21)
Spondylolysis	5 (10)
Ankylosing spondylitis	7 (13)
Cauda equina syndrome	3 (6)

Table 2 (*concluded*).

	No. (%)
Nerve root compression	10 (19)
Disc herniation	7 (13)
Spinal stenosis	3 (6)
Inflammatory joint disease, rheumatic disease, or arthritis	18 (35)
Psychiatric problem	12 (23)
Obese	5 (10)
Fibromyalgia	3 (6)
Scoliosis	2 (4)
Age	
>55 y	5 (10)
>60 y	4 (8)
>65 y	8 (15)
No exclusion criteria listed	3 (6)
Study screening procedures	
Physician clearance	27 (52)
Physiotherapist clearance	10 (19)
Chiropractor	1 (2)
Ergonomist	1 (2)
PAR-Q or PARmed-X	0 (0)
Not stated	13 (25)
Type of exercise test	
Maximal, cardiopulmonary exercise test	3 (6)
Submaximal, age-predicted heart rate test	3 (6)
Submaximal, walk test	2 (4)
Muscle strength testing	13 (25)
Muscle endurance testing	7 (13)
Range of motion testing	10 (19)
Stair climbing	1 (2)
None	23 (44)
Exercise test modality	
Cycle ergometer	6 (12)
Walk test	3 (6)
Treadmill	1 (2)
Isokinetic dynamometer	2 (4)
Strength equipment	6 (12)
Strain gauge	2 (4)
Other	6 (12)
Exercise test monitoring	
Physician monitored	2 (4)
Exercise physiologist monitored	3 (6)
Physiotherapist monitored	14 (27)
Electrocardiogram	1 (2)
Heart rate	4 (8)
Blood pressure	1 (2)
Rating of perceived exertion	1 (2)
Not stated	13 (25)

Note: Studies could report more than 1 criterion.

The total number of adverse events in exercise studies of osteoporosis was 264 in 2397 patients (11% incidence rate). General musculoskeletal pain was the most frequent adverse event, followed by fracture and orthopaedic complications. The largest percentage of fractures was reported in interventions that included trunk forward flexion. Pain was reported during a variety of exercises (resistance training, stretching, and aerobics). Orthopaedic complications occurred mainly during aggressive mobilization exercises after surgery for hip fracture and during lower-body resistance training. Considering fractures and a proportion of the orthopaedic complications (i.e., 10 cases of screw penetration or hip dislocation after surgery for hip fracture) as serious adverse events, the serious adverse event rate was about 2.4%. Of the 264 adverse events reported, 48 resulted in the participant dropping out of the intervention.

The total number of adverse events in exercise studies of lower back pain was 467 in 6680 patients (7% incidence rate). Increased back or leg pain and back stiffness were the most common adverse events. This type of adverse event was reported across a variety of PAs (i.e., resistance training, aerobic endurance training, and stretching). Fracture ($n = 1$) and disc herniation ($n = 3$) were considered serious adverse events, and therefore the serious adverse event rate was about 0.06%. Of the 467 reported adverse events, 108 resulted in the patient dropping out of the intervention. The age of subjects in studies that reported adverse events was slightly higher than that in studies not reporting adverse events (42 ± 13 years vs. 38 ± 8 years, respectively).

Discussion

The overall adverse event rate for individuals with arthritis, osteoporosis, and low back pain during exercise training ranged from 3.4% to 11%. The rate of serious adverse events (i.e., joint damage, fractures, orthopaedic complications, herniated discs) ranged from 0.06% to 2.4%. The majority of the adverse events reported for arthritis were exacerbated joint inflammation and pain. The majority of adverse events for patients with osteoporosis were general musculoskeletal pain, and for patients with low back pain most adverse events were due to increased pain. The reporting of exercise testing and training screening criteria as well as the reporting of adverse events was poor across most of the studies reviewed. Many of the studies reviewed excluded potential subjects with preexisting cardiovascular or cardiopulmonary disease. Thus, the generalizability of the results of this review is largely directed only towards those afflicted with musculoskeletal disorders without significant comorbidities. It is possible that the number of adverse events would increase in those individuals with one or more comorbid conditions should they partake in exercise testing or training, especially without proper supervision and guidance.

Appropriateness of PAR-Q and PARmed-X for screening patients with musculoskeletal conditions

The current PARmed-X does not have any absolute or relative contraindications to PA for patients with musculoskeletal conditions, but question 5 of the PAR-Q specifically asks respondents to identify whether they "have a bone or joint problem that could be made worse by a change in physical activity". Currently, if respondents were to answer "yes" to this question, they would be asked to see their primary care physician, who would complete a PARmed-X. The PARmed-X has 3 special prescriptive conditions for an arthritis diagnosis. The first is for acute arthritis (including infective, rheumatoid, or gout) and the prescription is for "treatment, plus judicious blend of rest, splinting, and gentle movement"; the second recommendation is for subacute arthritis, which recommends a "progressive increase of active exercise ther-

Table 3. Quality assessment of included studies on patients with arthritis, osteoporosis, and low back pain.

	Question*									
Study	1	2	3	4	5	6	7	8	9	10
Arthritis										
Bearne et al. 2002	No	Yes	No	Yes	No	No	No	No	No	No
Bilberg et al. 2005	No	Yes	No	Yes	No	No	No	No	No	No
Callahan et al. 2008	No	Yes	Yes	Yes	No	No	No	No	No	No
de Jong et al. 2003	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Ettinger et al. 1997	No	Yes	Yes	Yes	No	No	No	No	No	No
Eversden et al. 2007	No	Yes	Yes	Yes	No	No	No	No	No	No
Foley et al. 2003	No	Yes	No	Yes	No	No	No	No	No	No
Fransen et al. 2007	No	Yes	Yes	Yes	No	No	No	No	No	No
Häkkinen et al. 1994	No	Yes	No	Yes	No	No	No	No	No	No
Häkkinen et al. 2003	No	Yes	No	Yes	No	No	No	No	No	No
Kirsteins et al. 1991	No	Yes	No	Yes	No	No	No	No	No	No
Komatireddy et al. 1997	No	Yes	No	Yes	No	No	No	No	No	No
Kovar et al. 1992	No	Yes	No	Yes	No	No	No	No	No	No
Péloquin et al. 1999	No	Yes	Yes	Yes	No	No	No	No	No	No
Singh-Grewal et al. 2007	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Takken et al. 2003	No	Yes	No	Yes	No	No	No	No	No	No
van den Ende et al. 1996	No	Yes	No	Yes	No	No	No	No	No	No
van den Ende et al. 2000	No	Yes	No	Yes	No	No	No	No	No	No
Westby et al. 2000	No	Yes	No	Yes	No	No	No	No	No	No
Yang et al. 2005	No	Yes	No	No	No	No	No	No	No	No
Osteoporosis										
Binder et al. 2004	No	Yes	Yes	Yes	No	No	Yes	No	No	No
Bloomfield et al. 1996	No	No	No	Yes	No	No	Yes	No	No	No
Bravo et al. 1996	No	Yes	Yes	No	Yes	Yes	No	No	No	Yes
Carter et al. 2002	No	Yes	No	No	No	No	Yes	No	No	No
Chien et al. 2000	No	No	No	No	No	No	Yes	No	No	No
Chien et al. 2005	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Ekin and Sinaki 1993	No	No	No	No	No	No	Yes	No	No	No
Giangregorio et al. 2006	No	No	No	Yes	No	No	Yes	No	No	No
Gold et al. 2004	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Hans et al. 2002	No	Yes	No	Yes	No	No	Yes	No	No	No
Harrison et al. 1993	No	No	No	Yes	Yes	No	No	No	No	No
Hartkopp et al. 1998	No	No	No	No	No	No	Yes	No	No	No
Hauer et al. 2001	No	Yes	No	Yes	No	No	Yes	No	No	No
Hongo et al. 2007	No	Yes	No	Yes	No	No	Yes	No	No	No
Huntoon et al. 2008	No	No	No	No	Yes	No	No	No	No	No
Johnston et al. 2008	No	No	No	No	Yes	No	No	No	No	No
Jones et al. 2006	No	No	No	Yes	No	No	Yes	No	No	No
Judge et al. 2005	No	Yes	Yes	Yes	No	No	No	No	No	No
Kemmler et al. 2003	No	No	No	Yes	No	No	No	No	No	No
Kerschan-Schindl et al. 2000	No	No	No	Yes	No	No	No	No	No	No
Kita et al. 2007	No	No	No	Yes	No	No	No	Yes	No	No
Lamb et al. 2002	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No
Lauridsen et al. 2002	No	Yes	No	No	No	No	No	No	No	No
Liu-Ambrose et al. 2004	No	Yes	Yes	Yes	Yes	No	No	No	No	No
Malmros et al. 1998	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes
Mangione et al. 2005	No	Yes	Yes	Yes	No	No	Yes	No	No	No
Mendelsohn et al. 2008	No	Yes	Yes	Yes	No	No	No	No	No	No
Needham-Shropshire et al. 1997	No	No	No	No	No	No	Yes	No	No	No
Papaioannou et al. 2003	No	Yes	No	Yes	No	No	No	No	No	No
Rodgers et al. 1991	No	No	No	No	No	No	Yes	No	No	No
Sherrington and Lord 1997	No	Yes	No	Yes	No	No	Yes	No	No	No
Sherrington et al. 2003	No	Yes	Yes	Yes	No	No	Yes	No	No	No
Sherrington et al. 2004	No	Yes	Yes	Yes	No	No	Yes	No	No	No
Sinaki and Mikkelsen 1984	No	No	No	No	No	No	No	No	No	No

Table 3 (*continued*).

Study	Question* 1	2	3	4	5	6	7	8	9	10
Sinaki and Lynn 2002	No	Yes	No	No	Yes	No	No	No	No	Yes
Stengel et al. 2005	No	Yes	No	Yes	Yes	Yes	No	No	No	No
Tinetti et al. 1999	No	Yes	No	Yes	No	No	Yes	Yes	Yes	No
Tsauo et al. 2005	No	Yes	No	No	Yes	Yes	No	No	No	No
Valayer-Chaleat et al. 1998	No	No	No	No	No	No	Yes	No	No	No
Low back pain										
Alaranta et al. 1994	No	Yes	No	No	Yes	Yes	No	No	No	No
Anema et al. 2007	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Bendix et al. 1998	No	Yes	No	Yes	No	No	No	No	No	No
Bronfort et al. 1996	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Brox et al. 2006	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Burns 2006	No	No	No	No	No	No	No	No	No	No
Capaci et al. 2002	No	No	No	No	Yes	No	Yes	No	No	No
Djavid et al. 2007	No	Yes	No	No	Yes	Yes	Yes	No	No	No
El Rassi et al. 2005	No	No	No	No	Yes	Yes	Yes	No	No	Yes
Faas et al. 1995	No	Yes	No	Yes	Yes	Yes	No	No	No	No
Fairbank et al. 2005	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No
Ferreira et al. 2007	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No
Frost et al. 1998	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Glaser et al. 2001	No	Yes	No	Yes	Yes	Yes	No	No	No	No
Gudavalli et al. 2006	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Hansen et al. 1993	No	Yes	No	Yes	Yes	Yes	No	No	No	No
Hemmilä et al. 1997	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No
Herman et al. 1994	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Holmes et al. 1996	No	No	No	No	Yes	Yes	No	No	No	No
Iversen et al. 2003	No	No	No	Yes	No	No	Yes	No	No	No
Johannsen et al. 1995	No	Yes	No	Yes	Yes	Yes	No	No	No	No
Kääpä et al. 2006	No	Yes	Yes	No	Yes	Yes	No	No	No	No
Kihlstrand et al. 1999	No	Yes	No	Yes	Yes	Yes	No	No	No	No
Koumantakis et al. 2005	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Leggett et al. 1999	No	No	No	Yes	Yes	Yes	Yes	No	No	No
Long et al. 2004	No	Yes	No	Yes	Yes	Yes	No	No	No	No
Manniche et al. 1991	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Manniche et al. 1993	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Mayer et al. 2005	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
McDonald and Lundgren 1998	No	No	No	No	No	No	No	No	No	No
Miranda et al. 2002	No	No	No	No	Yes	No	Yes	No	No	No
Miranda et al. 2001	No	No	No	No	Yes	No	Yes	No	No	No
Möller and Hedlund 2000	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No
Mørkved et al. 2007	No	Yes	No	Yes	Yes	Yes	Yes	No	No	No
Moseley 2002	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
Nelson et al. 1995	No	No	No	Yes	No	No	Yes	No	No	No
Oldervoll et al. 2001	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No
Overman et al. 1988	No	No	No	No	Yes	No	No	No	No	No
Ozgen et al. 2007	No	No	No	No	No	No	No	No	No	No
Pengel et al. 2007	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No
Robert et al. 1995	No	No	No	Yes	No	No	No	No	No	No
Sherman et al. 2005	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Shirado et al. 2005	No	No	No	No	Yes	Yes	No	No	No	No
Sjogren et al. 1997	No	Yes	No	Yes	Yes	Yes	No	No	No	No
Skikić et al. 2004	No	No	No	No	Yes	Yes	Yes	No	No	No
Smeets et al. 2006	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Suputtitada et al. 2002	No	Yes	No	Yes	No	No	No	No	No	No
UK BEAM Trial Team 2004	No	Yes	No	No	Yes	Yes	Yes	No	No	ye
Underwood and Morgan 1998	No	Yes	No	Yes	Yes	Yes	Yes	No	No	No
Verbunt et al. 2003	No	No	No	Yes	Yes	Yes	Yes	No	No	No

Table 3 (*concluded*).

	Question*									
Study	1	2	3	4	5	6	7	8	9	10
Williams et al. 2005	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Yelland et al. 2004	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No

*Questions: (1) Was the study blinded? (2) Was the study randomized? (3) Was an appropriate randomization technique described? (4) Description of dropouts (i.e., number and reason) or statement that there were no dropouts. (5) Was an adverse event measurement instrument described? (6) Was the adverse event instrument validated? (7) Was the relationship of adverse events to exercise described? (8) Was the person who made the decision on the relationship identified? (9) Was this person blinded to groups? (10) Was the method for determining the severity of the adverse event described?

apy"; and the third is for chronic arthritis (including osteoarthritis), which recommends "maintenance of mobility and strength; non-weight-bearing exercises to minimize joint trauma (e.g., cycling, aquatic activity, etc.)". The PARmed-X has the following advice for patients with osteoporosis or low bone density: "Avoid exercise with high risk for fracture such as push-ups, curl-ups, vertical jump and trunk forward flexion: engage in low-impact weight-bearing activities and resistance training", and the following advice for patients with low back pain: "Avoid or minimize exercise that precipitates or exasperates, e.g., forced extreme flexion, extension, and violent twisting; correct posture, proper back exercises". All these recommendations seem prudent, but the evidence for the recommendations is lacking. As there was a low reported incidence of adverse events (3.4%–11%) found in this systematic review, the use of the PAR-Q and PARmed-X as tools that will effectively screen patients with musculoskeletal conditions requires evidence-based revisions. The next section suggests possible revisions to the PAR-Q and PARmed-X and clinical decision trees for screening by qualified exercise professionals based on the evidence reviewed.

Evidence-based absolute and relative contraindications to PA and clinical decision tree for arthritis patients

The studies evaluated in this systematic review did not demonstrate any evidence that absolute contraindications to PA are needed in individuals diagnosed with arthritis, but there are relative contraindications that should be considered (Kirsteins et al. 1991; Kovar et al. 1992; Häkkinen et al. 1994, 2003; Ettinger et al. 1997; Komatireddy et al. 1997; Péloquin et al. 1999; van den Ende et al. 1996, 2000; Westby et al. 2000; Bearne et al. 2002; de Jong et al. 2003, 2004*a*, 2004*b*; Foley et al. 2003; Takken et al. 2003; Bilberg et al. 2005; Munneke et al. 2005; van den Hout et al. 2005; Yang et al. 2005; Eversden et al. 2007; Fransen et al. 2007; Singh-Grewal et al. 2007; Callahan et al. 2008). The last recommendation of the current PARmed-X for chronic arthritis recommends "non-weight-bearing exercises to minimize joint trauma". Several publications contained within this review have evaluated this recommendation directly by assessing the effects of high-intensity, weight-bearing exercise on the progression of joint destruction in arthritis patients (van den Ende et al. 1996, 2000; de Jong et al. 2003, 2004*b*). The Rheumatoid Arthritis Patients in Training (RAPIT) trial was a 2-year randomized controlled trial where subjects with well-controlled rheumatoid arthritis participated in an exercise program 2 times per week, which included aerobic cycling (20 min), a circuit consisting of muscular strength and endurance exercises (20 min), and a sport or game (such as badminton or basketball for 20 min) as well as "impact loading" (i.e., jumping) (de Jong et al. 2003, 2004*b*). The results indicated no increase in joint damage in the exercise group when compared with the control; however, when the subjects were separated into those with and without severe joint damage at baseline, there was a greater progression of joint damage in those patients in the exercise group with more severe joint damage at baseline. This trial demonstrated that the high-intensity exercise was able to slow bone loss in individuals with rheumatoid arthritis (de Jong et al. 2004*a*). It is difficult for a practitioner to interpret these results, as it is unknown which type of PA utilized in the RAPIT trial would exacerbate joint damage. Likely, the high "impact loading" PA is the foremost candidate for increasing joint damage, although more research would be needed to confirm this.

Another study in rheumatoid arthritis patients whose disease was well controlled evaluated the effects of a high-intensity (high-pace dynamic weight-bearing activities and muscular strengthening combined with ergometer cycling at 70%–85% of maximal heart rate) and low-intensity (non-weight-bearing isometric muscle strengthening) exercise program on physical condition, muscle strength, joint mobility, daily functioning, and disease activity (van den Ende et al. 1996). The main results indicated greater improvements in aerobic capacity and joint range of motion in the high-intensity exercise group, with no harmful effect on self-reported disease activity or erythrocyte sedimentation rate. Later research from the same group evaluated the effects of intensive (70% of maximal voluntary contraction) isometric and isokinetic knee flexion and extension exercise on a dynamometer in patients with active rheumatoid arthritis (van den Ende et al. 2000). The authors concluded that the exercise intervention was more beneficial for increasing muscle strength than a conservative program of exercise while at the same time not magnifying disease activity. Further results from an 18-month study in elderly patients with knee osteoarthritis that compared aerobic training (walking at 50%–70% heart rate reserve, 3 sessions per week), resistance exercise training (2 sets × 12 reps of 9 exercises, 3 sessions per week), or health education found that the exercise interventions reduced disability and pain while improving performance scores and did not cause a change in X-ray scores (Ettinger et al. 1997). The cumulative results of this research provide evidence that the "non-weight-bearing exercises to minimize joint trauma" recommendation should be modified. Future clinical research in this patient population needs to ensure proper adverse event monitoring to ensure stronger conclusions can be made in regards to contraindications. Even though the evidence pre-

Table 4. Adverse events in clinical arthritis, osteoporosis, and low back pain physical activity research.

Event	No. (%)	Mode of exercise inducing adverse event
Arthritis (n = 20)		
Total no. of adverse events	83 (3.4)	
Total no. of individuals in all trials	2472	
Types of adverse events during exercise training		
Joint inflammation or pain exacerbation	63 (75)	n = 6 (6 DO) maximum voluntary contractions against strain gauge; n = 1 (1 DO) pool-based aerobic exercise; n = 23 (4 DO) pool- or land-based joint mobility and muscle strength training; n = 3 (3 DO) resistance training; n = 1 (1 DO) combined aerobic, resistance, and flexibility training; n = 2 (2 DO) isokinetic dynamometer training and aerobic cycling; n = 25 Tai Chi; n = 1 (1 DO) strength and endurance training; n = 1 (1 DO) aerobic water exercise
Fracture	3 (4)	n = 2 (2 DO) fall during aerobic walking training; n = 1 (1 DO) dropped dumbbell on foot
Low back pain	3 (4)	n = 1 hydrotherapy; n = 1 (1 DO) Tai Chi; n = 1 (1 DO) resistance training
Increased joint damage	11 (13)	n = 11 combined bicycle training, strength training circuit, and sport or game with impact loading (i.e., jumping)
Psychological strain	3 (4)	n = 2 (1 DO) combined isokinetic dynamometer training and aerobic cycling; n = 1 (1 DO) aerobic cycling and body weight strength exercises
Osteoporosis (n = 39)		
Total no. of adverse events	264 (11)	
Total no. of individuals in all trials	2397	
Types of adverse events during exercise training		
Orthopaedic complication	25 (9.5)	n = 10 (10 DO) (with redisplacement, screw penetration, or hip dislocation) during mobilization and exercise after surgical treatment of hip fracture; n = 11 (11 DO) with unclassified orthopaedic problems during moderate resistance training of lower body, n = 4 (4 DO) unclassified orthopaedic problems during moderate resistance training of upper body
Fracture	48 (18.2)	n = 1 (1 DO) hairline fracture of the os pubis in a fall during aerobic training; n = 6 new vertebral fractures in women with high risk of fracture under long-term home exercise program; n = 8, 4, 10 compression vertebral fracture during long-term flexion, extension, or combined flexion–extension exercise, respectively; n = 2 hip re-fracture in patients undergoing hip strengthening, stair climbing within 11 days of hip fracture; n = 1 rib fracture from fall during exercise, n = 2 metatarsal fractures during resistance training or testing; n = 2 rib fractures during prone exercise; n = 7 during back extension exercise; n = 2 femoral fractures in patients with spinal cord injury during maximal strength testing or unspecified exercise; n = 3 lumbar spine fracture during golf swing
General pain (sore neck, muscle soreness, unclassified)	172 (65)	n = 87 resistance training with rubber bands; n = 10 resistance training; n = 5 agility training; n = 10 (10 DO) stretching, strength, and aerobics; n = 7 (7 DO) general pain by daily balance and quadriceps femoris exercise; n = 52 during stepping exercise or strength exercises of the hip and knee; n = 1 back extension exercise
Knee pain	5 (1.9)	n = 4 (4 DO) step exercises, hip strengthening, and squats; n = 1 body-weight-supported exercise in patients with spinal cord injury
Hip pain	2 (0.8)	n = 2 during mobilization and exercise after surgical treatment of hip fracture
Back pain	7 (2.7)	n = 4 (1 DO) during back-strengthening exercise; n = 3 slight back discomfort during impact loading of the hip using Osteocare device
Autonomic dysreflexia (i.e., increased blood pressure during functional electrical stimulation)	4 (1.5)	n = 4 during functional electrical stimulation cycling in patients with spinal cord injury
Increased spasticity	1 (0.4)	n = 1 following functional electrical stimulation cycling in a patient with spinal cord injury
Low back pain (n = 52)		
Total no. of adverse events	467 (7)	
Total no. of individuals in all trials	6680	
Types of adverse events during exercise training		

Table 4 (*concluded*).

Event	No. (%)	Mode of exercise inducing adverse event
Increased back pain	323 (69)	$n = 11$ (9 DO) dynamic lumbar extension; $n = 1$ hydrotherapy and land exercises, trunk range of motion; $n = 1$ cycling; $n = 1$ aerobic and strength exercises for legs, hip, abdominal, back, and stretching; $n = 2$ (2 DO) flexion–extension exercises for strength, weight training, flexibility training, cardiovascular training, MacKenzie extension exercises; $n = 2$ (2 DO) isometric abdominal, spine extension, and spine flexion, hamstrings, illiopsoas, quadriceps stretching, cycling, light weights with arms, bridging, step-ups, bench press, jogging, walking, rope skipping; $n = 1$ (1 DO), light exercise of stretching, spine mobilization, deep trunk exercise, $n = 1$ (1 DO) biking, low-impact and step aerobics, walking, strengthening of trunk and lower limbs, mobility, stabilizing spine and hip extension, flexibility, balance; $n = 2$ soccer; $n = 1$ aerobics and stretching, $n = 1$ whole-body circuit dynamic strength training and stretching; $n = 2$ (2 DO) back extension, abdominal training (crunches), back, pelvic, leg stretches, trunk stabilization, stationary cycling, bridges from lying and lying on side; $n = 2$ (2 DO) cardiovascular endurance (games, hiking), maximal strength exercises, stretching; $n = 4$ intense sports; $n = 3$ Tai Chi; $n = 4$ stretching, mobility of spine and lower limbs, strengthening of abdominals, trunk extensors, upper and lower limbs, cycling; $n = 5$ treadmill walking, cycling, stairmaster, whole-body weight training; $n = 5$ (5 DO) trunk strength and flexibility exercises; $n = 6$ (6 DO) aerobic, muscle strength and endurance, stretching, ball games, swimming; $n = 8$ (1 DO) isometric trunk flexion and extension and lower body flexibility; $n = 7$ (1 DO) competitive swimming (kicking); $n = 4$ (4 DO) cycling, low back and abdominal muscular endurance, lat pull downs, hip abduction and adduction, knee extension muscular endurance, $n = 2$ (2 DO) light jogging, balance and stability training; $n = 1$ (1 DO) isometric back extension, sit ups, isometric abdominals, curl ups (knees to shoulders); $n = 2$ (2 DO) hip and spine full extension, prone with trunk over bench and with legs over bench, lat pulldown; $n = 5$ (5 DO) aerobic cycling; followed by leg and trunk stretching, leg extension while sitting on knees and hands, trunk lifting, lifting of legs while prone with pulley resistance; $n = 2$ (2 DO) prone back extension, prone hip extension, abdominal crunches (hip flexion), lat pulldown; $n = 4$ walking, cycling, stretches, trunk and limb strengthening; $n = 20$ (20 DO) multidirectional, mid-range lumbar exercises, hip and thigh stretches; $n = 16$ (16 DO) lumbar flex or extension (in the direction that caused pain); $n = 48$ from standing: hip extension and flexion to mid-range, and lumbar spine flexion; $n = 149$ general strengthening including lumbar extension with weight machine, cardiovascular exercises
Back stiffness	42 (9)	$n = 42$ from standing: hip extension and flexion, and lumbar spine flexion
Sciatica	24 (5)	$n = 3$ (3 DO) hip and spine extension, prone with trunk or legs over bench, lat pulldown; $n = 21$ jogging
Leg numbness	4 (1)	$n = 4$ walking, cycling, stretches, trunk and limb strengthening
Leg pain	38 (8)	$n = 5$ (5 DO) prone back extension, prone hip extension, abdominal crunches, lat pulldown; $n = 33$ from standing: hip extension and flexion, and lumbar spine flexion
Fracture	1 (0.2)	T-12 compression fracture; back flexion–extension exercises
Disc herniation	3 (0.6)	$n = 1$ (1 DO) cardiovascular endurance (games, hiking), maximal strength exercises, stretching; $n = 1$ (1 DO) aerobic cycling; leg extension, trunk lifting, and lifting of legs while prone using pulley resistance; $n = 1$ from standing: hip extension and flexion, and lumbar spine flexion
Muscle soreness	11 (2)	$n = 7$ trunk, leg, and abdomen strengthening; $n = 4$ walking, cycling, stretches, trunk and limb strengthening
Psychological strain	1 (0.2)	$n = 1$ (1 DO) Flexibility training for lumbar spine, isometric back and abdomen exercises
Dyspnea or dizziness	2 (0.4)	$n = 2$ (2 DO) prone back and hip extension, abdomen crunches, lat pulldown
Fatigue	5 (1)	$n = 1$ (1 DO) cycling, low back and abdomen muscular endurance, lat pulldowns, hip abduction and adduction, knee extension muscular endurance; $n = 4$ walking, cycling, stretches, trunk and limb strengthening
Bursitis	2 (0.4)	High-repetition exercise of hip and spine extension, prone with trunk or legs over bench, lat pulldown
Migraine headache	1 (0.2)	$n = 1$ (1 DO) induced during head-down pose in yoga
Knee or hip pain	3 (0.6)	$n = 4$ (1 DO knee pain, 1 DO vascular) aerobic cycling; leg extension
Vascular problems	1 (0.2)	trunk lifting, lifting of legs while prone, using pulley resistance
Nerve root irritation	7 (1)	$n = 7$ (7 DO) stretching, pelvic flexion, isometric abdominal exercises

Note: DO indicates the number of participants who dropped out of the study because of specific adverse events.

Table 5. Comparison of characteristics of adverse event reporting for arthritis, osteoporosis, and low back pain intervention studies.

Characteristic	Adverse events reported	No adverse events reported
Arthritis intervention studies (n = 20)		
No. studies	17	3
Study design		
Randomized controlled trial	15 (88)	3 (100)
Prospective intervention	2 (12)	0 (0)
No. of subjects	1945	527
Mean±SD	114±107	175±128
Age of subjects (y)		
Mean±SD	55±15	41±29
Type of arthritis		
Osteoarthritis	5 (29)	0 (0)
Rheumatoid arthritis	10 (59)	1 (0)
Juvenile idiopathic arthritis	1 (6)	1 (0)
Mixed	1 (6)	1 (17)
Study screening procedures		
Physician clearance	5 (29)	1 (0)
Physiotherapist clearance	2 (12)	0 (0)
PAR-Q or PARmed-X	0 (0)	0 (0)
Not stated	10 (59)	2 ()
Exercise test monitoring		
Physician monitored	3 (12)	0 (0)
Exercise physiologist monitored	3 (12)	0 (0)
Physiotherapist monitored	7 (28)	0 (0)
Electrocardiogram	0 (0)	1 (25)
Blood pressure	2 (8)	0 (0)
Heart rate	3 (12)	0 (0)
Rate of perceived exertion	2 (8)	1 (25)
Not stated	5 (20)	2 (50)
Osteoporosis intervention studies (n = 39)		
No. studies	25	14
Study design		
Randomized controlled trial	14 (56)	9 (64)
Prospective intervention	8 (32)	5 (36)
Case studies	3 (12)	
No. of subjects	1927	465
Mean±SD	88±141	33±35
Age of subjects (years)		
Mean±SD	66±20	67±13
Study screening procedures		
Physician clearance	8 (32)	4 (29)
Exercise physiologist	0 (0)	2 (14)
Physiotherapist clearance	5 (20)	2 (14)
PAR-Q or PARmed-X	0 (0)	0 (0)
Not stated	10 (40)	5 (36)
Exercise test monitoring		
Physician monitored	1 (4)	1 (7)
Exercise physiologist monitored	4 (16)	4 (29)
Physiotherapist monitored	5 (20)	2 (14)
Electrocardiogram	0 (0)	0 (0)
Blood pressure	1 (4)	0 (0)
Heart rate	1 (4)	1 (7)
Rate of perceived exertion	0 (0)	0 (0)
Not stated	13 (52)	8 (57)
Low back pain intervention studies (n = 52)		
No. studies	34	18

Table 5 (*concluded*).

Characteristic	Adverse events reported	No adverse events reported
Study design		
Randomized controlled trial	19 (56)	14 (78)
Prospective intervention	11 (32)	2 (11)
Case study		2 (11)
Cross-sectional	2 (6)	
Retrospective	2 (6)	
No. of subjects	5020	3888
Mean±SD	157±300	216±320
Age of subjects (y)		
Mean±SD	42±13	38±8
Type of low back pain		
Chronic	23 (68)	9 (50)
Acute	2 (6)	1 (6)
Subacute	2 (6)	1 (6)
Sciatica	1 (3)	0 (0)
After disc herniation surgery	2 (6)	2 (11)
Mixed	3 (9)	1 (6)
Caused by pregnancy	0 (0)	3 (17)
Spondylolisthesis	0 (0)	1 (6)
Spondylolysis	1 (3)	0 (0)
Study screening procedures		
Physician clearance	18 (53)	8 (44)
Physiotherapist clearance	4 (12)	4 (22)
Exercise specialist clearance	0 (0)	0 (0)
Ergonomist clearance	0 (0)	1 (6)
Chiropractor clearance	1 (3)	0 (0)
PAR-Q or PARmed-X	0 (0)	0 (0)
Not stated	6 (18)	5 (28)
Exercise test monitoring		
Physician	2 (6)	1 (6)
Exercise specialist	4 (12)	3 (17)
Physiotherapist	20 (59)	13 (72)
Occupational therapist	2 (6)	0 (0)
Electrocardiogram	1 (3)	0 (0)
Heart rate	5 (15)	0 (0)
Rate of perceived exertion	2 (6)	1 (6)
Blood pressure	1 (3)	0 (0)
Not stated	8 (24)	4 (22)

Note: Studies could report more than 1 criterion.

sented in this review suggests no absolute contraindications, individuals diagnosed with arthritis may have significant comorbid conditions (such as cardiovascular disease), and the other consensus papers for exercise testing and screening should be followed when individuals with arthritis present with other comorbidities.

There are some relative contraindications to PA in individuals with arthritis that should be considered based on the evidence presented in this review. Adverse events were more likely to be reported in studies with rheumatoid arthritis patients (59%), whereas patients with osteoarthritis (29%) had a lower incidence of adverse events. Rheumatoid arthritis is a systemic condition that may affect multiple organ systems as well as multiple joints and therefore is likely to manifest in more disease-related events and more instances of joint pain with activity. Patients with rheumatoid arthritis and osteoarthritis have a higher than usual risk of cardiovascular disease, even if they do not currently exhibit cardiovascular disease (Erb et al. 2004); therefore, there may be increased risk of adverse events due to exercise testing or training due to undiagnosed or unknown comorbidities such as cardiovascular disease.

Recommendation no. 1

The current PAR-Q is restricted to participants 15–69 years of age. We included studies of individuals with arthritis outside this age range (Table 1*a*); therefore, this age restriction is not required (Level 2, Grade A).

Recommendation no. 2

Arthritic patients with highly progressed forms of disease (stage III or IV) or severe radiological evidence of joint damage should participate in non-weight-bearing activities to maintain or improve mobility, strength, and cardiovascular

function. These patients should not participate in very high-intensity exercise such as those involving jumping or high-load-bearing activities (Level 2, Grade A).

Recommendation no. 3

Those individuals with recently diagnosed arthritic disease or those experiencing an acute flare of their disease should be prescribed PA that limits an exacerbation of disease activity such as light to moderate pool-based exercise (i.e., water aerobics) or light cycle ergometer activity (Level 3, Grade B).

Recommendation no. 4

Arthritis patients with stable, well-controlled disease without progressive joint damage may participate in a wide variety of PAs including weight-bearing and non-weight-bearing activities to maintain or improve mobility, strength, and cardiovascular function (Level 2, Grade A).

Clinical decision tree

A clinical decision tree for qualified exercise professionals, based on the above recommendations, is presented in Fig. 2. For all patients it is also recommended that, if possible, they consult a specialist to determine their biomechanical tolerance for specific PAs.

Evidence-based absolute and relative contraindications to PA and clinical decision tree for patients with osteoporosis

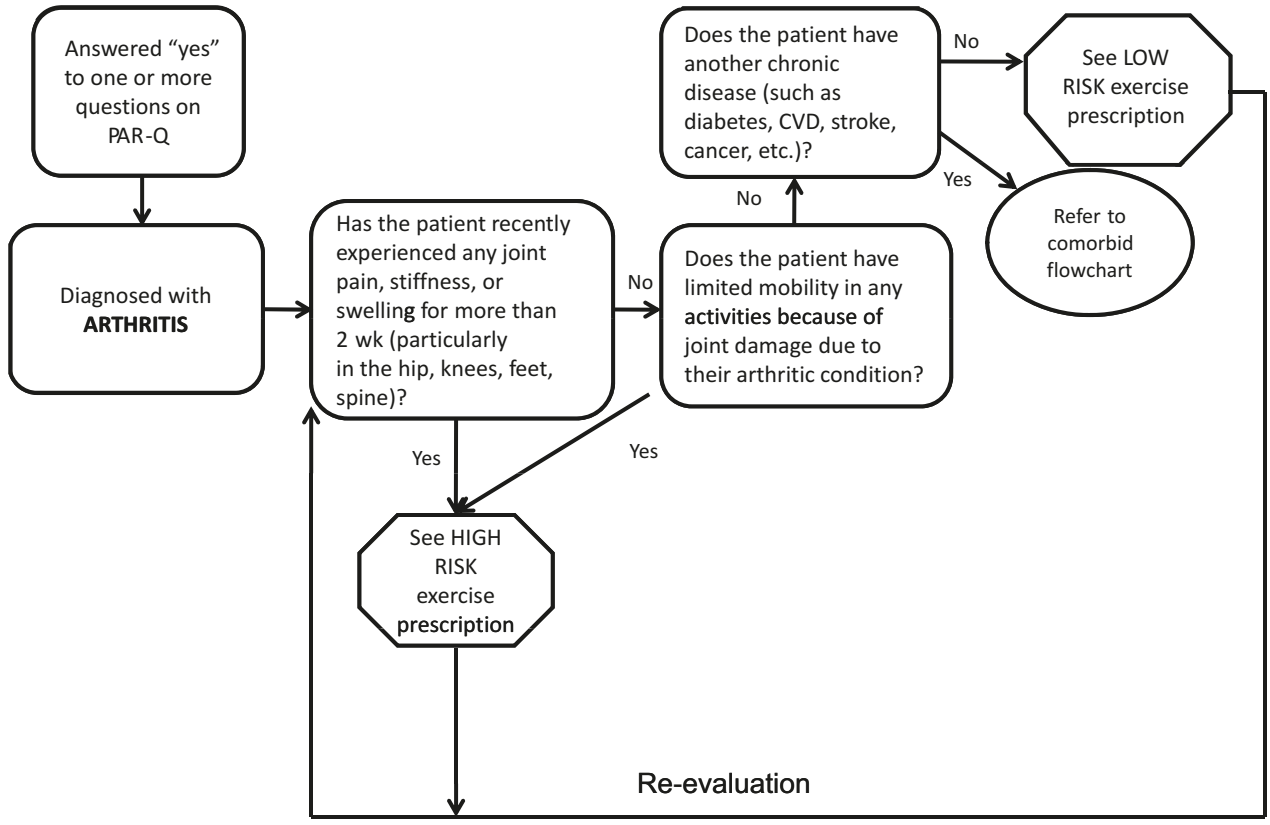
Most studies of exercise and osteoporosis reported few, mostly minor adverse events such as muscle soreness and general pain (Harrison et al. 1993; Bravo et al. 1996; Malmros et al. 1998; Chien et al. 2000, 2005; Carter et al. 2002; Hans et al. 2002; Sinaki and Lynn 2002; Papaioannou et al. 2003; Liu-Ambrose et al. 2004, 2005; Stengel et al. 2005; Hongo et al. 2007; Kita et al. 2007). We suggest 1 absolute contraindication for osteoporotic patients: trunk flexion exercises should not be prescribed to patients with osteoporosis who are at high risk of fracture (Papaioannou et al. 2010). This is based on a single early study (Sinaki and Mikkelsen 1984). This study assigned postmenopausal women with spinal osteoporosis and back pain to a treatment program that included lumbar extension exercises ($n = 25$), flexion exercises ($n = 9$), combined flexion and extension exercises ($n = 19$), or no exercises ($n = 6$). After 1–6 years of follow-up, 4 of 25 women in the extension group, 8 of 9 women in the flexion group, 10 of 19 women in the combined group, and 4 of 6 women in the no-exercise group had wedging or compression fractures of the spine. Extension exercises appear to be safe, and in a different study with 10 years of follow-up, the same researchers observed a lower number of fractures in women assigned to train with extension exercise versus no exercise (Sinaki et al. 2002). Adverse events listed in Table 4 include lumbar compression fractures incurred during a 12-month prospective study of lumbar extension exercises in women who had fractures at baseline; however, the fracture rate in the exercise-only group (1 of 20 women) was lower than in a group of women who underwent percutaneous vertebralplasty (15 of 20) and a group who underwent percutaneous vertebralplasty and participated in the exercise program (6 of 17) (Huntoon et al. 2008). One additional study of 94 women who were 6 months postvertebral fracture found no additional lumbar spine fractures during a program that involved trunk extension, abdominal stabilization, trapezius, hip abduction and extension, and shoulder flexion exercises (Gold et al. 2004). One woman fractured a costal cartilage while performing prone exercise, and 1 fractured a rib while rolling from supine to prone. One additional subject in this study suffered a metatarsal fracture during exercise testing when a weight fell on her toe. This study confirms that trunk extension exercises are safe and that abdominal muscles can be trained with stabilization exercises rather than trunk flexion. There was 1 other study that observed a relatively high number of vertebral fractures with exercise training (6 of 19 exercisers versus 0 of 6 in the nonexercise group with 10 years of follow-up); however, it is difficult to determine whether the exercises caused the fracture, as this was not stated. The home-based program included brisk walking or jogging, stretching, and back extensor and abdominal strengthening (i.e., trunk flexion) exercises (Kerschan-Schindl et al. 2000).

A number of studies have investigated exercise interventions to improve mobility after hip fracture surgery, and there is a recent systematic review on this topic (Handoll and Sherrington 2007). A variety of exercise programs, including progressive heavy resistance training of knee extensors and flexors, hip flexors, extensors, and abductors, semisquats, leg press, plantar flexors, bench press, row, biceps, and stepping exercises, appear to be safe, with only minor adverse events (i.e., pain, fatigue, muscle soreness) if initiated 79–210 days after hip fracture (Sherrington and Lord 1997; Tinetti et al. 1999; Binder et al. 2004; Sherrington et al. 2004; Mangione et al. 2005; Jones et al. 2006). Only 1 of these studies resulted in fracture during the exercise program; this involved a rib fracture and a metatarsal fracture in 2 of 46 patients who underwent progressive heavy resistance training 100 days after hip fracture (Binder et al. 2004).

A number of exercise interventions are safe when performed early after surgery for hip fracture. These include arm-crank ergometry (i.e., to maintain cardiovascular fitness) started 5 days after fracture (Mendelsohn et al. 2008), low-frequency electrical stimulation of the quadriceps started 7 days after surgery (Lamb et al. 2002), progressive weight-bearing exercise started 18 days after surgery (Sherrington et al. 2003), and progressive resistance training (leg press, hip abduction and extension, ankle plantar flexion) combined with balance training started 24 days after in-patient rehabilitation (Hauer et al. 2001). A program of resistance training (hip flexion, extension, abduction, and knee extension) combined with sit-to-stand exercises and stair climbing started 11 days after surgery resulted in 2 of 28 patients sustaining refracture of the hip (Tsauo et al. 2005). From the collective results of these studies we therefore recommend that progressive resistance training or aggressive weight-bearing exercise (i.e., stair climbing, sit to stand) should not be started until at least 24 days after in-patient rehabilitation following surgery.

Aggressive physical therapy immediately after recovery from hip fracture may result in increased serious adverse events (Lauridsen et al. 2002). This study randomly assigned patients to intensive ($n = 44$) versus regular ($n = 44$) physiotherapy after surgery (i.e., osteosynthesis or partial hip replacement) due to uncomplicated hip fracture. The regular

Fig. 2. Clinical decision tree for patients with arthritis. Note that there is no end point to the clinical decision tree because patients are to be continuously monitored and reevaluated, given that arthritis is often a progressive disease.



HIGH RISK exercise prescription

HIGH RISK

As a result of the patient's recent symptoms, it is recommended they get clearance from their physician before starting a physical activity program. If the patient has not yet had a specific diagnosis for the cause of their arthritic pain it is recommended, if possible, that they consult a specialist to determine the cause of their pain and their biomechanical tolerance for specific physical activities.

Once they receive clearance from their physician the qualified exercise personnel can prescribe physical activity with the following precautions:

•Avoid high impact exercise.
•Pool-based exercise or light cycle ergometer activity is recommended if the patient is experiencing an acute flare up or if they have been recently diagnosed with arthritis.
•If the patient has stage III or IV arthritis or severe joint damage then they should participate in non-weight bearing activities to maintain or improve mobility, strength and cardiovascular function.

LOW RISK exercise prescription

LOW RISK

If the patient has not yet had a specific diagnosis for the cause of their arthritic pain, it is recommended, if possible, that they consult a specialist to determine the cause of their pain and their biomechanical tolerance for specific physical activities.

The patient can begin a low- to moderate-intensity physical activity (<60%HRR) program with the goal of performing 150 min per week of accumulated activity. Resistance exercise should also be performed 3 times per week (1-3 sets, 8-12 reps, 50-70%1-RM).

If the patient has previously been inactive, they should avoid high intensity physical activity unless doing so under the supervision of a qualified exercise professional.

The patient may participate in a wide variety of physical activities, including weight-bearing and nonweight bearing activities to maintain or improve mobility, strength, and cardiovascular function.

physical therapy group performed 15–30 min exercise per day, 5 days per week (for approximately 2 h total per week), while the aggressive physical therapy group performed exercises 2 h per day, 3 days per week (i.e., 6 h total per week). Exercises included bench exercises (range of motion, strength, endurance, stretching, stabilizing), gait, balance, coordination, and stair climbing. Six of the patients in the more intense physical therapy group dropped out because of orthopaedic complications, and 2 dropped out because of increased pain, while 4 patients dropped out from the regular physical therapy group. The specific complications cited in the intense physical therapy group were fracture complications including redisplacement, screw penetration, and hip dislocation. We therefore recommend that patients recovering from hip fracture should partake in a progressive PA program, where time per session is limited initially to 15–30 min.

There were several additional case studies of osteoporotic fracture during PA. One involved 3 women with lumbar spine osteoporosis who experienced lumbar spine compression fractures during golf swings (Ekin and Sinaki 1993). We therefore recommend that patients with osteoporosis avoid powerful twisting movements of the trunk. There are case studies of patients with spinal cord injury accompanied by lower-limb paralysis and severe lower-limb osteoporosis who fractured their femur during PA. One study did not specify the type of PA (Valayer-Chaleat et al. 1998). The second study induced a femoral fracture while having the patient perform maximal knee extension exercise with high-frequency electrical stimulation (Hartkopp et al. 1998). We therefore recommend that individuals with spinal cord injury avoid strength training of the lower limbs involving maximal contractions induced by electrical stimulation. In several prospective nonrandomized interventions, osteoporotic or osteopenic patients with spinal cord injury who trained with progressive electrical stimulation knee extensor resistance exercise (Rodgers et al. 1991), functional electrical stimulation cycling (Bloomfield et al. 1996; Johnston et al. 2008), functional electrical stimulation ambulation (Needham-Shropshire et al. 1997), and body-weight-supported treadmill exercise (Giangregorio et al. 2006) experienced minimal adverse events. It should be noted, however, that these studies excluded patients who had suffered recent fragility fractures.

The current PARmed-X advises osteoporotic patients to avoid exercises such as push-ups, curl-ups, vertical jump, and trunk forward flexion and to engage in low-impact weight-bearing activities and resistance training. Based on our review, there is evidence that trunk forward flexion and curl-ups increase the risk of fracture in patients with lumbar spine osteoporosis (Sinaki and Mikkelsen 1984). The only study we reviewed that involved push-ups did not result in fracture (Judge et al. 2005). Likewise, vertical jumping (i.e., skipping) and higher-impact PA does not increase risk of fracture in itself; however, it may increase risk of falls (Kemmler et al. 2003; Liu-Ambrose et al. 2004). One of these falls resulted in a fracture of the os pubis (Kemmler et al. 2003). We would therefore recommend that these types of PAs be done under close supervision to avoid falls. Progressive high-intensity resistance training, likewise, appears to be safe for osteopenic or osteoporotic women. There were no serious adverse events when regular weight training was progressed from moderate loads using 50% 1RM to more intense loads of 85% 1RM over 6 months of training (Liu-Ambrose et al. 2004).

Recommendation no. 1

The current PAR-Q is restricted to individuals 69 years or younger. Our review included many studies of people over the age of 69 (Table 1*b*); therefore, there is no need for age restriction with the PAR-Q (Level 2, Grade A).

Recommendation no. 2

Patients with osteoporosis at high risk of fracture (i.e., those with previous fragility fractures or taking systemic corticosteroids for a cumulative period of 3 months or greater during the preceding year at a prednisone-equivalent dose ≥7.5 mg daily) should not perform trunk flexion exercises, as these increase risk of spine fracture. Trunk extension exercises and abdominal stabilization exercises can be done safely (Level 2, Grade A).

Recommendation no. 3

Patients recovering from hip fracture should not perform physical therapy exercises for more than 15–30 min per session early in the rehabilitation process, as this increases the risk of orthopaedic complications. Weight-bearing exercise can be started after 18 days, and higher-intensity exercises such as resistance training can be progressively implemented 1 month following in-patient rehabilitation (Level 2, Grade A).

Recommendation no. 4

Patients with osteoporosis can safely perform a variety of aerobic PAs or resistance training. Intensity of the exercise sessions should initially be light to moderate and progressively increased based on the individual's capability (Level 2, Grade A).

Recommendation no. 5

Individuals with osteoporosis should avoid powerful twisting movements of the trunk (Level 3, Grade C).

Recommendation no. 6

Individuals with spinal cord injury and osteoporosis of the lower limbs should avoid maximal-intensity PA (i.e., maximal strength testing) via electrical stimulation of the lower limbs (Level 3, Grade C). Progressive lower-limb resistance training, cycling, and ambulation (all assisted by electrical stimulation) or body-weight-supported treadmill training are safe forms of PA for individuals with spinal cord injury who do not have recent fragility fractures (Level 2, Grade A).

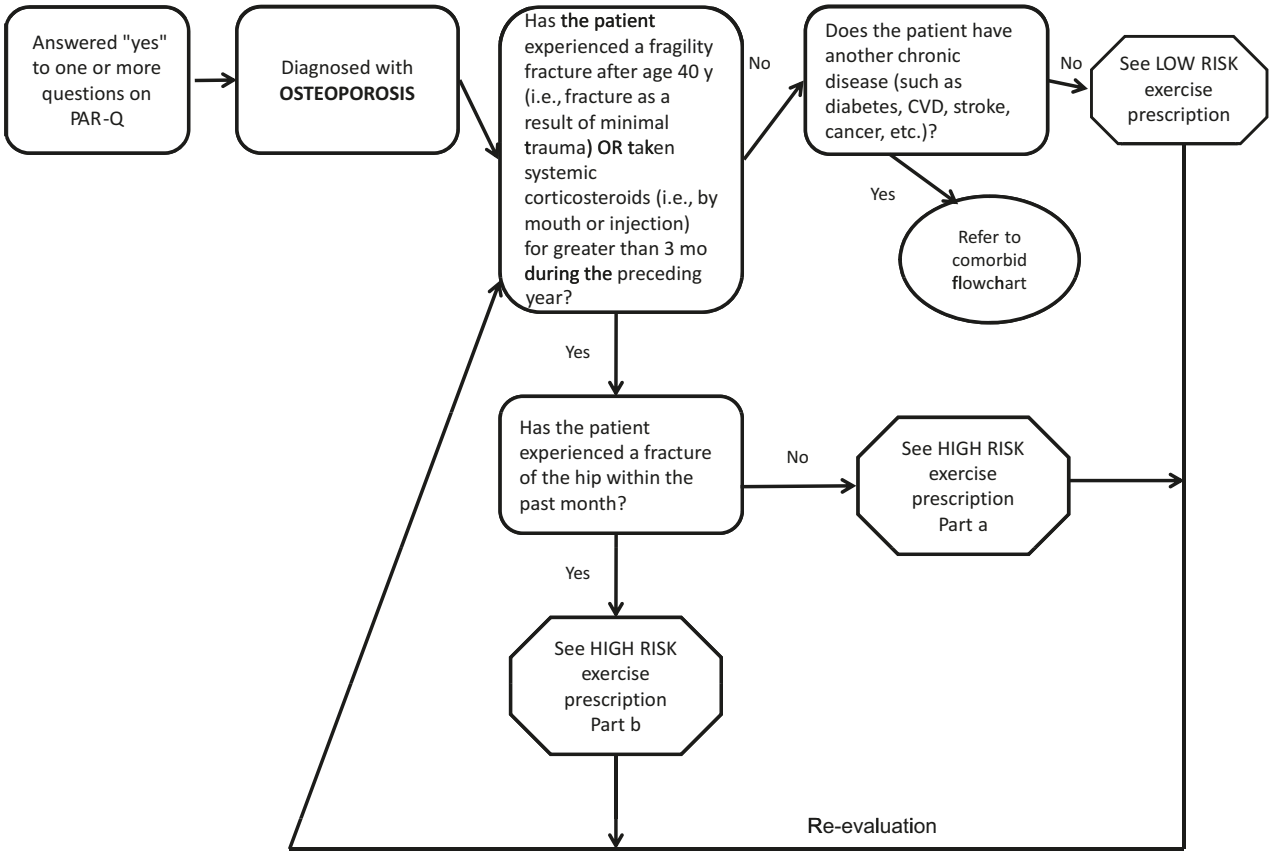
Clinical decision tree

A clinical decision tree for qualified exercise professionals, based on the above recommendations, is presented in Fig. 3. For all patients it is also recommended that, if possible, they consult a specialist to determine their biomechanical tolerance for specific PAs.

Evidence-based absolute and relative contraindications to PA and clinical decision tree for patients with low back pain

Previous recommendations for patients with low back pain are largely based on biomechanical analyses of PA. Many of

Fig. 3. Clinical decision tree for patients with osteoporosis. Note that there is no end point to the clinical decision tree because patients are to be continuously monitored and reevaluated, given that osteoporosis is often a progressive disease.



HIGH RISK exercise prescription

HIGH RISK

Part a

It is recommended that the patient consult their physician for permission to begin a physical activity program. It is also recommended, if possible, that they consult a specialist to determine their biomechanical tolerance for specific physical activities. The patient can safely perform trunk extension and exercises that involve abdominal stabilization (i.e., isometric exercises). Other resistance training or aerobic exercises can be progressively introduced (see low risk guidelines below).

Part b

As a result the patient's recent fracture, it is recommended that the patient consult their physician for permission to begin a physical activity program. It is also recommended, if possible, that they consult a specialist to determine their biomechanical tolerance for specific physical activities.

Once permission is given by the physician, the patient can perform upper-body exercise (i.e. arm crank ergometry) to maintain aerobic fitness 5 days after fracture repair. The patient can start a program of progressive weight-bearing exercise (i.e. walking progressing to stair climbing) 18 days after fracture repair. Progressive resistance training can be started a month after in-patient rehabilitation.

LOW RISK exercise prescription

LOW RISK

It is recommended, if possible, that the patient consult a specialist to determine their biomechanical tolerance for specific physical activities.

The patient can begin a low to moderate intensity physical activity (<60%HRR) program with the goal of performing 150 min per week of accumulated activity. Resistance exercise should also be performed 3 times per week (1-3 sets, 8-12 reps, 50-70%1 RM). Balance exercises and weight bearing activity (i.e. stepping, stair climbing) are of particular importance for those with osteoporosis.

PRECAUTIONS:

•Individuals with osteoporosis should not perform trunk flexion exercises as these increase risk of fracture. These patients should also avoid powerful twisting movements of the trunk.

•Individuals with spinal cord injury and osteoporosis of the lower limbs should avoid maximal intensity physical activity (i.e., maximal strength testing) via electrical stimulation of the lower limbs. Progressive lower-limb resistance training, cycling, and ambulation (all assisted by electrical stimulation) or body-weight supported treadmill training are safe forms of physical activity for individuals with spinal cord injury who do not have recent fragility fractures.

these are outlined in detail by McGill (2007) and are summarized briefly here. We have graded the following recommendations, taken from McGill (2007), as Level 3, Grade A evidence, unless otherwise indicated: (1) Patients with low back pain should avoid full sit-ups, as this places too much loading on the lumbar spine (Axler and McGill 1997); (2) stability training is recommended for patients with spondylolisthesis, rather than taking the spine through a full range of motion (Level 4, Grade C); (3) brisk walking is preferred over slow walking with minimal arm swing because it reduces the loading on the lumbar spine (Callaghan et al. 1999); (4) extensor exercise of the trunk, where musculature on one side of the spine is activated at a time (i.e., such as when kneeling on all fours and extending one leg at a time), is preferred over regular trunk extension exercise because it reduces lumbar spine loading (Callaghan et al. 1998); (5) avoid lumbar flexion exercises just after rising from bed, as intervetebral discs imbide fluid overnight, leaving them susceptible to higher stresses when loaded. When people with low back pain were instructed to avoid early-morning trunk flexion, their pain was reduced (Snook et al. 1998) (Level 2, Grade A); and (6) Avoid loading of the lumbar spine after long periods of sitting, as ligament laxity increases with long periods of sitting (McGill and Brown 1992).

From our systematic review, the incidence of adverse events during a wide variety of PAs for patients with chronic low back pain was low (Nelson et al. 1995; Robert et al. 1995; Bronfort et al. 1996; Holmes et al. 1996; Hemmilä et al. 1997; Sjogren et al. 1997; Bendix et al. 1998; Frost et al. 1998; McDonald and Lundgren 1998; Glaser et al. 2001; Oldervoll et al. 2001; Capaci et al. 2002; Moseley 2002; Iversen et al. 2003; Verbunt et al. 2003; Skikić et al. 2004; UK BEAM Trial Team 2004; Fairbank et al. 2005; Sherman et al. 2005; Shirado et al. 2005; Williams et al. 2005; Burns 2006; Gudavalli et al. 2006; Kääpä et al. 2006; Anema et al. 2007; Djavid et al. 2007; Ferreira et al. 2007). This is in agreement with previous systematic reviews that reported mainly mild adverse events such as increased low back pain and muscle soreness (Hayden et al. 2005; van Tulder et al. 2006*b*). The only systematic review to report the relative incidence of adverse events reported that 4.5% of patients experienced adverse events in interventions that included advice on PA (Liddle et al. 2007). Most studies we reviewed had overall benefits of reduced pain and disability, with an adverse event rate of 7%. Our adverse event rate is greater than that found by Liddle et al. (2007), because they included only randomized controlled trials in their review, whereas we included all types of studies. We have no absolute contraindications for patients with chronic low back pain. There were a number of studies that had a relatively high number of dropouts because of increased low back pain or sciatica (Manniche et al. 1991; Hansen et al. 1993; Johannsen et al. 1995; Leggett et al. 1999), and there were 3 studies that reported back injuries serious enough to require surgery (Alaranta et al. 1994; Yelland et al. 2004; Smeets et al. 2006). These studies included exercises requiring vigorous strength training, high-impact aerobics, or trunk flexion or extension to an extreme range of motion or with added resistance (i.e., pulley systems connected to weight stacks). One study had a high number of withdrawals from patients prescribed PA (i.e., trunk flexion, extension, or rotation) in a direction that induced pain, whereas those prescribed PA in a direction that decreased or centralized pain (i.e., pain retreated in a proximal direction towards the lumbar midline) had no adverse events and better outcome (Long et al. 2004). A prospective study found an increase in the severity of sciatica in those who jogged and had sciatica at baseline (Miranda et al. 2002). On the other hand, jogging prevented sciatica in those without sciatica at baseline. Brisk walking may also aggravate sciatica (Miranda et al. 2001). From these studies we recommend that patients with chronic low back pain not initially be prescribed high-intensity strength training, high-impact aerobics, or trunk exercises (flexion, extension, or rotation) that induce pain. One study reported a T-12 compression fracture detected after flexion–extension exercises; however, it was unknown whether the participant had this fracture upon entry into the study (Overman et al. 1988). Most of the studies on chronic, acute, or subacute low back pain excluded patients with serious spinal pathology (i.e., previous back surgery, spondylolysis, spondylolisthesis, neurological symptoms, inflammatory and infectious conditions, spinal fractures); therefore, our recommendations are restricted to patients without serious pathology. Most of the studies on low back pain classified the back pain as "nonspecific", and making recommendations for this heterogeneous condition is therefore difficult. Ideally, a patient should be subclassified to create homogenous subgroups so that more specific recommendations on safe exercise prescriptions can be made. For patients with serious pathology (as defined above), it would be highly recommended to refer the patient to a specialist who could determine their biomechanical tolerance for specific PAs. Given that most studies excluded patients with serious pathologies and did not classify patients into subgroups for different causes of back pain, we have assigned our recommendations a lower grade to indicate that these recommendations cannot apply to all patients with back pain (i.e., Grade B).

Three studies of patients with acute low back pain (i.e., back pain >2 days, <4 weeks) were included. Exercise performed in the preferred direction (i.e., trunk flexion and (or) extension that did not cause pain) combined with heat wrap was more beneficial for increasing function and reducing disability and pain than either therapy alone, with no adverse events reported (Mayer et al. 2005). We therefore recommend this type of PA for patients with acute low back pain. One study of patients with acute low back pain reported 1 adverse event (increased pain) with trunk extension exercises (Underwood and Morgan 1998), and another reported that 7 of 122 patients were removed from a PA program that included stretching, pelvic flexion, and isometric abdominal exercises because of signs of nerve root irritation (Faas et al. 1995). Several studies of subacute low back pain (4–8 weeks) had minimal adverse events with PAs that included walking, cycling, stretching, and trunk and limb strengthening (Herman et al. 1994; Koumantakis et al. 2005; Pengel et al. 2007). Patients with serious spinal pathologies were excluded from most of these studies; therefore, our recommendations are restricted to those without serious pathology.

There were 2 studies included on patients with spondylolysis or spondylolisthesis. Spondylolysis results from a stress fracture in a section of the lumbar vertebra called the pars interarticularis. Spondylolisthesis occurs when 1 lumbar verte-

brae has slipped forward, often because of a defect, such as a stress fracture, in the pars interarticularis. A case series was done on adolescent soccer players who had spondylolysis (El Rassi et al. 2005). Soccer players with spondylolysis who ceased playing soccer and wore an antilordotic thoracolumbosacral orthosis for 3 months had a better outcome than those who continued playing soccer. Specifically, 32 of 32 players who ceased sport participation for 3 months and took part in a rehabilitation program of abdominal strengthening, hamstring stretching, and pelvic tilt exercises after they became asymptomatic were able to return to sport pain-free. Two of the 25 players who did not cease sport participation experienced pain severe enough to preclude further sport performance. In a randomized controlled study of patients with spondylolisthesis, there were no complications from exercise training described as strength and postural training with emphasis on back and abdominal muscles (Möller and Hedlund 2000). We therefore recommend this type of training for patients with spondylolysis or spondylolisthesis with avoidance of sport activities until asymptomatic.

Two randomized controlled trials were performed on patients more than 1 year after surgery for lumbar disc herniation (Manniche et al. 1993; Brox et al. 2006). PAs included aquatic exercise, isometric abdominal and back exercise, and progressive PA involving back and hip extension, abdominal crunches, or lat pulldowns. The isometric abdominal and back exercises resulted in no adverse events. The other exercises caused 7 of 62 patients to drop out because of aggravated low back pain or worsening leg pain; however, all adverse events were resolved within days to weeks of stopping training with no changes in sensory or motor function. We therefore recommend PA that starts with isometric abdominal and back exercise, with progressive inclusion of the other PAs. We assigned this recommendation a lower grade based on the uncertainty of the benefit to risk ratio of the latter types of PA. An encouraging retrospective study in adolescents (13–17 years) who had surgery after disc herniation found that only 4 of 17 patients experienced mild pain upon resumption of intense sport or work-related activities (Ozgen et al. 2007).

There were 3 studies of PA involving pregnant women with low back pain that reported no adverse events (Kihlstrand et al. 1999; Suputtitada et al. 2002; Mørkved et al. 2007). Aquatic exercise, low-impact aerobics, and pelvic muscle exercises were effective for reducing pain, disability, and number of sick days. One recent set of clinical guidelines also suggested aquatic exercise for pregnant women (Burton et al. 2005).

Causes of back pain differ in younger versus older people, as disc problems are more likely the cause of back pain in younger individuals, and facet and sacroiliac joint pain is the main cause of back pain in older people (DePalma et al. 2011). Only 2 of the studies included in our review of low back pain had patients with mean ages older than 55 years. Holmes et al. (1996) determined that lumbar extension exercises with high repetitions (i.e., 15–20) on a weight machine 1–2 times per week for 97 days only slightly increased back pain (i.e., from 5 to 6 on a 10-point visual analog scale) in 1 of 18 women with a mean age of 63.2 years. This study included a range of different low back disorders, including degenerative disc disease and postsurgical fusion. Iversen et al. (2003) had patients with low back pain (19 women, 7 men, age 72 years) perform 12 weeks of cycle ergometer training, 3 times per week, for 20 min per session. Adverse events included knee and hip pain, but no participants experienced increased back pain and no participants dropped out of the program because of increased pain. Participants with previous low back surgery or fractures were excluded. Patients who were included had either back pain that was not specific or neurological claudication secondary to degenerative lumbar spine stenosis. Both these studies were small, nonrandomized prospective studies and excluded more serious causes of back pain; therefore, we have graded the recommendation for including older patients in the PAR-Q for low back pain as level 3, Grade B.

The current PARmed-X advises people with low back conditions to avoid or minimize exercises that precipitates or exasperates low back pain (e.g., forced extreme flexion, extension, violent twisting) and includes correct posture and proper back exercises. Our review supports this advice; however, we provide more specific recommendations for different subgroups of patients with low back pain.

Recommendation no. 1

The current PAR-Q is restricted to people between the ages of 15 and 69 years. Only 1 study included in this review included participants older than 69 years; therefore, the recommendation of inclusion of people older than age 69 for screening by the PAR-Q receives a lower grade (Level 3, Grade B).

Recommendation no. 2

Persons with nonspecific chronic low back pain, without serious pathology (i.e., previous back surgery, spondylolysis, spondylolisthesis, neurological symptoms, inflammatory and infectious conditions, or spinal fractures), can safely perform a variety of PAs that are progressive in nature. However, they should initially avoid high-impact PA, heavy resistance training, or extreme trunk flexion, extension, or rotation in a direction that induces pain (Level 2, Grade B).

Recommendation no. 3

Persons with acute low back pain (>2 days, <4 weeks), without serious pathology, can safely perform direction, preference-based PA (i.e., movement in the direction that does not induce pain). These include low back extension and flexion or a combination of these movements. Pain relief and functional ability is enhanced if these are combined with heat-wrap treatment (Level 2, Grade B).

Recommendation no. 4

Persons with subacute low back pain (4–8 weeks duration), without serious pathology, can safely perform PAs consisting of walking, cycling, stretching, and trunk and limb strengthening, including progressive strength and postural training of the back and abdominals (Level 2, Grade B).

Recommendation no. 5

Persons with spondylolisthesis or spondylolysis can safely perform progressive strength and postural training of the back and abdominals (Level 2, Grade A). Athletes should cease strenuous sport participation for at least 3 months (Level 3, Grade A).

Recommendation no. 6

Persons who are more than 1 year postsurgery for disc herniation can safely perform isometric abdominal and back exercise and progressive PA involving aquatics (i.e., water aerobics) and dynamic back and hip extension and abdominal exercises (Level 2, Grade B).

Recommendation no. 7

Pregnant women with low back pain can safely perform aquatic exercise (i.e., water aerobics), low-impact aerobics, and pelvic muscle exercises (Level 2, Grade A).

Clinical decision tree

A clinical decision tree for qualified exercise professionals, based on the above recommendations, is presented in Fig. 4. This clinical decision tree includes recommendations for individuals with specific conditions (i.e., spondylolisthesis or spondylolysis) and recommends that individuals who have not had a diagnosis for the cause of their pain seek a thorough assessment to determine their biomechanical tolerance to specific exercises.

Drug interactions

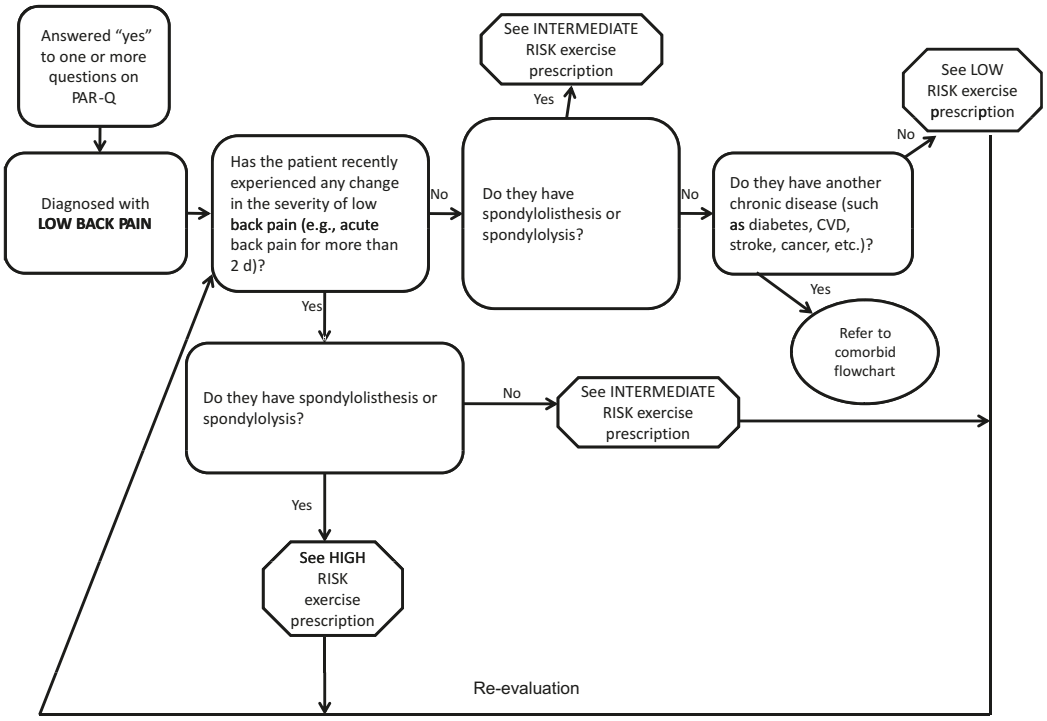
As many patients with musculoskeletal conditions are treated with a variety of pharmacological interventions, the effects of these drugs on exercising individuals is of interest to this review. Our review indicates that many of the individuals tested or trained were consuming some type of medication to help treat and control the disease. Nonsteroidal anti-inflammatory drugs (NSAIDs) are frequently prescribed for individuals with arthritis or back pain, as NSAIDs effectively reduce inflammation and control pain. High-dose NSAID use reduces muscle protein synthesis in young healthy individuals (Weinheimer et al. 2007) and reduces muscle regeneration in animal models (Bondesen et al. 2004, 2006), while a moderate dose of NSAIDs does not seem to affect muscle strength or hypertrophy during exercise training (Krentz et al. 2008). Research concerning the effect of NSAID use in exercising arthritic or back pain patients on muscle function, morphology, or protein synthesis is lacking; thus it merits further investigation.

Many patients with rheumatoid arthritis, ankylosing spondylitis, or juvenile idiopathic arthritis take disease-modifying antirheumatic drugs such as sulfasalazine, methotrexate, or azathioprine, which act as immunosuppressors. To our knowledge, the effects of these drugs on these patients when exercising have not been evaluated. One study in Duchenne muscular dystrophy patients found that azathioprine reduced the infiltration of leukocytes into skeletal muscle after a bout of exercise but demonstrated no improvement in clinical outcomes (Kissel et al. 1993). Prednisone or other oral corticosteroids are frequently used to reduce inflammation in individuals with arthritis, but it is also a drug known to have significant negative systemic side effects when used for a long period of time (e.g., bone loss, increased central adiposity, and decreased muscle mass). Some research on the effects of prednisone on muscle morphology in patients with rheumatoid arthritis indicated a reduced percentage of type I muscle fibres and a reduction in both type I and II muscle fibre area when compared with that of rheumatoid arthritis patients not taking prednisone (Danneskiold-Samsøe and Grimby 1986*a*). Further, muscle strength was reduced in the rheumatoid arthritis patients on prednisone compared with the strength of those not taking the drug (Danneskiold-Samsøe and Grimby 1986*b*). Thus, the interaction of drug use and exercise ability needs to be carefully considered before prescription of exercise training or exercise testing is carried out in individuals with arthritis. According to the Canadian guidelines for determination of fracture risk, patients who have taken systemic corticosteroids for a cumulative period >3 months during the preceding year (at a predinisone-equivalent dose ≥7.5 mg daily) should be placed into a higher risk category for bone fracture (Papaioannou et al. 2010). Patients with rheumatoid arthritis also have an elevated risk of osteoporosis, especially at the hip and wrist (Vosse and de Vlam 2009). Patients taking corticosteroids and those with rheumatoid arthritis should therefore be assessed for fracture risk (i.e., with dual-energy X-ray absorptiometry measurement of bone mineral density) to determine whether they fall into the high-risk category (Papaioannou et al. 2010). These individuals would then have to follow exercise recommendations for arthritis and osteoporosis. Recently, patients with rheumatoid arthritis, ankylosing spondylitis, or juvenile idiopathic arthritis have been prescribed biological therapy (anti-TNF-α) to control and reduce the severity of their diseases. There is 1 animal model reporting a positive effect of anti-TNF-α therapy in preserving body mass and attenuating the loss of skeletal muscle mass as a result of cardiac malfunction (Steffen et al. 2008), but more research is required on the effects of drug–PA interactions on the safety and efficacy of exercise training in arthritic individuals prescribed various medications. Many patients with osteoporosis will be taking bisphosphonates; however, these do not have negative effects on adaptations to exercise training (Chilibeck et al. 2002; Uusi-Rasi et al. 2003).

Limitations and future directions

While the primary intent of this review was to evaluate the evidence for relative and absolute contraindications to PA for individuals with musculoskeletal conditions, there are some limitations to the existing research that should be addressed. The low percentage of studies that screened or monitored clients during exercise testing and training suggests that more vigilance in these areas is required in future research trials to ensure that a correct conclusion can be drawn for the safety of PA. Overall, the effectiveness of PA for improving outcomes in individuals with musculoskeletal conditions has been addressed quite extensively, and PA is a safe and effective adjunct to typical medical and drug treatment. The prevalence of serious adverse events in exercising patients with musculoskeletal conditions is low (i.e., approximately 0.6%, 2.4%, and 0.06% in patients with arthritis, osteoporosis, and low back pain, respectively), and thus PA can be pursued quite safely. A limitation to the literature is a lack of studies including adverse event reporting (i.e., Hayden et al. 2005 reported that only 26% of studies monitored adverse events). While the quality of the study designs could be ranked as "moderate" (Table 3) according to the guidelines by Jadad et al. (1996), the quality of adverse event reporting, as evaluated by the guidelines from the Centre for Reviews and Dissemination (2009), was poor (Table 3). There is a relative paucity

Fig. 4. Clinical decision tree for patients with low back pain. Note that there is no end point to the clinical decision tree because patients are to be continuously monitored and reevaluated, given that back pain is often a progressive condition.



HIGH RISK exercise prescription

HIGH RISK

The patient should get permission from their physician to take part in a physical activity program. The patient should not participate in high-intensity sport activity for at least 3 months. The patient can participate in progressive strength and postural training of the back and abdominals.

INTERMEDIATE RISK exercise prescription

INTERMEDIATE RISK

If the patient has not yet had a specific diagnosis for the cause of their lower back pain, it is recommended, if possible, that they consult a specialist to determine the cause of their pain and their biomechanical tolerance for specific physical activities.

The patient should only take part in low-intensity physical activity until they get clearance from their physician OR they can be advised to exercise under the supervision of a qualified exercise professional. The following precautions should be implemented:

PRECAUTIONS:

- Persons with spondylolisthesis or spondylolysis can safely perform progressive strength and postural training of the back and abdominals
- Persons with nonspecific chronic low back pain, without serious pathology, should initially avoid high impact physical activity, heavy resistance training, or extreme trunk flexion, extension, or rotation in a direction that induces pain
- Persons with acute low back pain (>2 d, <4 weeks), without serious pathology, can safely perform direction preference based physical activity (i.e., in the direction that does not induce pain). These include low back extension and flexion, or a combination of these movements. Pain relief and functional ability is enhanced if these are combined with heat wrap treatment.
- Persons with sub-acute low back pain (4-8 weeks duration), without serious pathology, can safely perform physical activity consisting of walking, cycling, stretching, and trunk and limb strengthening, including progressive strength and postural training of the back and abdominals.
- Persons greater than 1 year after surgery for discherniation can safely perform isometric abdominal and back exercise and progressive physical activity involving aquatics, and dynamic back–hip extension and abdominal exercises
- Pregnant women with low back pain can safely perform aquatic exercise, low impact aerobics, and pelvic muscle exercises

LOW RISK Exercise prescription

LOW RISK

If the patient has not yet had a specific diagnosis for the cause of their lower back pain, it is recommended, if possible, that they consult a specialist to determine the cause of their pain and their biomechanical tolerance for specific physical activities.

It is safe for the patient to begin a physical activity program beginning with a low to moderate intensity physical activity (<60%HRR) with the goal of performing 150 minutes per week of accumulated activity. Resistance exercise should also be performed 3 times per week (1-3 sets, 8-12 reps, 50-70%1-RM).

PRECAUTIONS:

- Persons with nonspecific chronic low back pain, without serious pathology, should initially avoid high impact physical activity, heavy resistance training, or extreme trunk flexion, extension, or rotation in a direction that induces pain
- Persons with sub-acute low back pain (4-8 weeks duration), without serious pathology, can safely perform physical activity consisting of walking, cycling, stretching, and trunk and limb strengthening, including progressive strength and postural training of the back and abdominals.
- Persons greater than 1 year after surgery for discherniation can safely perform isometric abdominal and back exercise and progressive physical activity involving aquatics, and dynamic back/hip extension and abdominal exercises (start isometric and build to dynamic back–hip–abdominal exercise).
- Pregnant women with low back pain can safely perform aquatic exercise, low impact aerobics, and pelvic muscle exercises

of evidence surrounding the detrimental or beneficial effects of concurrent drug therapy and PA. This issue should be addressed, as there may be detrimental side effects of drug therapy that may contribute to comorbidities but could possibly be ameliorated by PA training. As this paper predominantly reviewed only rheumatoid arthritis and osteoarthritis, the generalization to other types of arthritis cannot be made. Individuals with systemic lupus erthyematosus, polymyositis, or polymyalgia rheumatica are all special cases of rheumatological diseases that may respond differently to exercise testing and training. Further research into the contraindications of PA in these diseases is warranted. Studies are also needed on whether the acute inflammatory reaction brought about by exercise exacerbates or ameliorates the inflammation associated with arthritis.

Many of the studies on exercise and osteoporosis would have avoided some of the exercises that are thought to be harmful to participants (i.e., trunk forward flexion, twisting), and therefore this reduces the ability to fully evaluate the safety of these exercises.

Most back pain studies excluded patients with more serious conditions (i.e., recent surgery, fracture, spondylolisthesis, spondylolysis, spinal stenosis, nerve root compression or neurological symptoms), and about half the studies excluded patients older than 65 years and pregnant women. Specific PA recommendations cannot be made for some of the more serious back disorders, and these patients should be closely monitored in conjunction with their physicians.

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