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Peter Ronai
Sacred Heart University, ronaip@sacredheart.edu

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Exercise Recommendations for Cardiac Patients with Chronic Nonspecific Low Back Pain

Peter Ronai, MS, RCEP, CEP, EP-C, EIM III, FACSM[1]

ABSTRACT

Musculoskeletal comorbidities (MSKCs) are the most frequent cause of activity limitations in persons with cardiovascular disease (CVD) and affect as many as 70% of this population. It has been observed that over 50% of new outpatient cardiac rehabilitation participants experience some musculoskeletal pain, with back pain reported by up to 38% of cardiac rehabilitation patients. Back pain can limit performance of activities of daily living (ADLs) and reduce exercise tolerance and compliance during outpatient cardiac rehabilitation (CR). This article will describe ways to facilitate CR exercise participation in patients who have comorbid, chronic nonspecific low back pain (CNSLBP) and have been medically cleared to exercise. *Journal of Clinical Exercise Physiology*. 2019;8(4):144–156.

Keywords: nonspecific low back pain, exercise, cardiac rehabilitation

INTRODUCTION

Aerobic endurance training (AT), musculoskeletal strength (resistance) training (RT), and flexibility training (FT) are recommended as complementary forms of training for patients participating in outpatient cardiac rehabilitation (CR) exercise programs (1). These recommendations are consistent with and resemble those from the American College of Sports Medicine (ACSM) and the United States Department of Health and Human Services (USDHHS) for persons with and without chronic diseases and health disorders (2–6).

It is estimated that over half of patients hospitalized for coronary artery disease (CAD) suffer from comorbid musculoskeletal conditions (MSKCs) (7). While CAD is the leading cause of death globally, MSKCs result in the most global disability (8–14) and are the most frequent cause of activity limitations in persons with cardiovascular disease (CVD), affecting as much as 70% of this population (15). Knee and low back pain (LBP), most frequently attributed to arthritis and strains and sprains, are the two most reported MSKCs in cardiac rehabilitation (CR) programs (7,15–17). Patients who reported MSKCs at entry to outpatient CR had a poorer health profile than those without MSKCs, including lower levels of physical activity (PA) and cardiovascular fitness, and unfavorable anthropometric measures (16). Back pain has been reported in as many as 38% of CR patients. Low back pain can limit performance of activities of daily living (ADLs) and reduce exercise tolerance and compliance during outpatient CR. Low back pain is associated with cardiovascular illness, other musculoskeletal conditions, and poorer general health (7,8,15–18). Therefore, an individualized approach is warranted to prescribing and modifying exercises to limit pain and reduce the risk of injury (5,19–25).

This article will describe ways to facilitate safe, effective CR exercise participation in patients who have comorbid, chronic, nonspecific LBP (CNSLBP) and who have been medically cleared for exercise. Examples of appropriate modifications to and substitutions for some exercises commonly performed during outpatient CR workout sessions will be provided.

[1]Center for Healthcare Education, Sacred Heart University, Fairfield, CT 06825 USA

Address for correspondence: Peter Ronai, Sacred Heart University, Center for Healthcare Education, Dept. of Exercise Science, 5151 Park Avenue, Fairfield, CT 06825-1000; (203) 416-3935; e-mail: ronaip@sacredheart.edu.

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Please note that this article is not intended to help readers diagnose, evaluate, or treat low back pain or any musculoskeletal injury or disorder. Exercise professionals are encouraged to terminate exercise sessions and notify the patient's physician if new or worsening symptoms occur. For the purpose of this article, it is assumed that patients have already been medically cleared to participate in a supervised CR exercise program with their pre-existing, comorbid CNSLBP.

Scope

Musculoskeletal diseases affect more than one out of every two persons in the United States over the age of 18, and nearly three out of four persons aged 65 and over. LBP is one of the most common reasons for physician visits (26–30).

In any given year, between 12% and 14% of the US adult population will visit their primary care physician with a complaint of back pain (31). LBP is the leading cause of disability and years living with disability throughout the world. More than 540 million people have been affected by activity-limiting LBP (9–14,32). The burden from LBP has doubled in the last 25 years, and the prevalence of the condition is expected to continue to increase with an aging and increasingly obese population (9). In the United States, LBP accounts for more lost workdays than any other musculoskeletal condition (31). Data from a recent investigation in Australia indicate that there is a moderate to high level of comorbidity amongst LBP patients; diabetes, arthritis, hyperlipidemia, osteoporosis, and coronary artery disease are within the top 10 most frequently reported comorbidities (18). LBP is the leading chronic health problem forcing older Australian workers to retire prematurely (33). While LBP is the most common cause in Europe of medically certified sick leave and early retirement, occurrence rates vary substantially among European countries (34). LBP affects between 49% and 70% of persons living in westernized countries and 70% and 85% of persons living in the United States in their lifetimes; it is the fifth most common reason for physician visits (28,29). Specific causes of LBP are often unknown and, in approximately 80% to 90% of afflicted patients, a specific pain source and cause cannot be identified (9,10,12,27–29,32,36). A number of investigators conclude that persons with CNSLBP experience PA intolerance, lower levels of physical fitness and function (37–42), increased disability (42,43), PA avoidance (due to fear of increased pain with activity) (9,12,32,44–47), lower PA participation levels (48,49), and reduced health-related quality of life (43). An association exists between CNSLBP and obesity (9,50–53), smoking (9,54), and sedentary lifestyle (9). A recent cross-sectional analysis of data from the National Health and Nutrition Examination Survey (NHANES) found that women participating twice weekly in musculoskeletal exercise training activities had significantly reduced odds of self-reported LBP (55).

Pathophysiology

Low back pain is considered a symptom rather than a disease and reflects many heterogeneous disorders and causes (9,10,12,14,32,35,56). As people age, LBP is accompanied by numerous activity limitations (10). Low back pain is often attributed to either nociceptive (sensitization of pain receptors in spinal/mechanical structures and fascial tissues), neuropathic (radicular or nerve related pain), or central (sensitization within the brain) sources (56). Traditionally, LBP is categorized by its etiology (causes), location, and duration of symptoms. Classifications are noted in Box 1.

> **BOX 1: CLASSIFICATIONS OF LOW BACK PAIN ETIOLOGY**
>
> Etiology
>
> - Specific: pain caused by unique or unusual pathophysiologic mechanisms (disc herniation, infection, tumor, ankylosing spondylitis, fracture, osteoporosis, arthritis, diseases, trauma, inflammatory process, radicular symptoms or cauda equine syndrome, or spinal pathology)
> - Nonspecific: pain not caused by a specific disease or spine pathology
>
> Timeline or Duration of Symptoms
>
> - Acute: pain lasting less than 6 weeks
> - Sub-acute: pain lasting 6 to 12 weeks
> - Chronic: pain lasting longer than 12 weeks (11,12, 27,30,32,36,56).

In 80% to 90% of cases, a specific pathoanatomical cause of LBP cannot be determined; therefore, the majority of LBP is considered to be nonspecific low back pain (NSLBP) (9,10,12,27–29,32,35,36). This article primarily addresses this population. Chronic low back pain is described as discomfort and pain, localized below the costal margin and above the inferior gluteal folds, with or without leg pain, that has been present for 3 months or longer (11,12,27,30,36,56,57). Chronic nonspecific low back pain (CNSLBP) is further defined as chronic low back pain not attributed to recognizable, known, specific pathology (e.g., infection, tumor, osteoporosis, ankylosing spondylitis, fracture, inflammatory process, radicular syndrome, or cauda equina syndrome) (9,10,12,27–29,32,35,36). During medical examinations of patients with LBP, physicians or qualified healthcare providers (HCP) conduct screening procedures to "rule in" or "rule out" more severe pathology.

"Red Flags" are symptoms or conditions experienced by patients with LBP that may warrant further medical evaluation (9,11,12,27,32,35,58–62). Their presence or absence can determine whether physicians and HCPs clear patients with CNSLBP for—or exclude them from—exercise participation. Although worldwide agreement on a uniform list is lacking, some generally recognized Red Flags exist and are provided in Box 2.

To reiterate, persons with CNSLBP experience PA intolerance, decreased neuromuscular function, strength, and lower levels of physical fitness (37–42,64–70), PA avoidance (due to fear of increased pain with activity)

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BOX 2: RED FLAGS—SIGNS AND SYMPTOMS OF LOW BACK PAIN

- Onset <20 or >55 years
- Non-mechanical pain (unrelated to time or activity)
- Previous history of carcinomas, steroids, or human immune deficiency syndrome (HIV)
- Feeling "unwell"
- Unexplained weight loss
- Widespread neurological symptoms (including saddle area numbness)
- Structural spinal deformity
- Spontaneous or persistent pain at night or pain while lying supine
- Indications for nerve root problems
- Unilateral leg pain greater than LBP
- Radiating pain to foot or toes
- Numbness and paresthesias in the same sensory distribution
- Straight leg raise test induces increasing leg pain
- Localized neurology (pain/symptoms limited to one nerve) (9,11,12,27,32,35,58–62).

(9,12,32,44–47) and are more sedentary than age- and sex-matched persons without CNSLBP (48,49). An association exists between CNSLBP and obesity (9,50–53), smoking (9,54) and sedentary lifestyle (9). Some investigators found delayed onset of activation in the transversus abdominus muscles and deficits in motor control in persons experiencing CNSLBP (64). Changes in size, composition and fiber typing of the multifidus, erector spinae, and other paraspinal muscles have been considered potential factors in the etiology and/or recurrence of pain symptoms and their effects on muscle strength and endurance (36,65–70). Gluteus medius weakness and gluteal muscle tenderness are common symptoms (70), and CNSLBP can also contribute reduced health-related quality of life (HRQOL) (43).

DIAGNOSIS SCREENING AND MANAGEMENT

Current treatment guidelines for CNSLBP recommend prudent use of imaging (magnetic resonance imaging [MRI], Computed Tomography [CT] scans, and others), surgery and medications (11,12,58,71,72). When any serious pathology is ruled out, HCPs should treat patients with CNSLBP-related symptoms with non-pharmacological methods, promote self-management of pain, and encourage patients to become and remain physically active and avoid bed rest (9,11,12,27,45,71). If pain medications are necessary, HCPs are encouraged to prescribe the lowest effective dosage of non-steroidal anti-inflammatory (NSAID) medications as a first line treatment for pain. They are also urged not to routinely offer opioids, paracetamol (acetaminophen) alone, selective serotonin reuptake inhibitors, serotonin–norepinephrine reuptake inhibitors, tricyclic antidepressants or anticonvulsants for managing LBP (11,12). Exercise, regardless of type, is recommended for reducing pain and improving function in patients with CNSLBP (21,36,60,72,74).

BOX 3: MOVEMENTS THAT MAY CAUSE OR WORSEN FLEXION INTOLERANT LOW BACK PAIN

- Seated upper and lower body ergometry
- Inclined treadmill walking (secondary to compensatory forward leaning)
- Seated/recumbent cycle or step ergometry
- Rowing ergometry
- Strength training exercises from a sitting or a bent position (rows, leg presses, deadlifts, knee extensions, hamstring curls)
- Strength training or trunk/core conditioning exercises from the supine position (curl-ups, crunches, full sit-ups)
- Flexibility and range of motion exercises requiring bending and twisting (seated hamstring stretches, toe touches, windmills)

Effects on the Exercise Response

Physical activity tolerance and exercise responses may be negatively affected by pain severity, location, physical fitness, strength, and body positions required during exercise testing and CR exercise training. Some individuals with CNSLBP are intolerant of motions such as trunk flexion or extension. In this case, positions such as prolonged standing, sitting, leaning, and reaching forward can cause discomfort, preventing CR patients from achieving their best exercise or testing efforts and results (3,5,6,22,23,25,75–77).

Patients who are flexion intolerant generally experience pain, discomfort, and fatigue when doing exercises requiring frequent bending at the waist, leaning forward, or prolonged sitting. Box 3 provides movements in which pain and discomfort may occur or worsen.

Patients who are extension intolerant generally experience pain, discomfort, and fatigue when performing exercises requiring frequent standing, backward bending, overhead reaching/lifting, and spinal hyperextension. Box 4 presents movement in which pain and discomfort may occur or worsen.

Regardless of whether or not a CR patient has a movement directional preference, the clinical exercise physiologist (CEP) should select warm-up, ET, RT, and flexibility exercise variations that CR patients can comfortably perform during their workout sessions. (19,20,22,23,25,75–77).

Examples of appropriate exercise modifications for CR patients with CNSLBP who have movement directional preferences are provided in Table 1. Exercise modifications to help CR patients with CNSLBP induced movement intolerance are addressed in a subsequent section.

Exercise Benefits

A variety of exercise interventions (including but not limited to yoga, AT, RT, and FT) have been shown to reduce pain

BOX 4: MOVEMENTS IN WHICH PAIN MAY OCCUR OR WORSEN IN EXTENSION INTOLERANT LOW BACK PAIN

- Treadmill walking
- Stair climbing
- Elliptical step ergometry
- Standing strength training exercises and overhead lifting (shoulder press, squats, rows, biceps curls, triceps extensions, dumbbell shoulder raises)
- Strength training or trunk/core conditioning exercises in the prone position (superman, swimmers, back hyperextensions)
- Flexibility and range of motion exercises requiring spinal extension/hyperextension (cobra, back bends, overhead reaches) (5,6,22–25,75,76).

and improve physical function in persons with CNSLBP, yet there is no consensus on the most effective form of exercise (21,36,60,72–74). Commonly reported benefits of AT and RT include:

- Increased physical activity tolerance
- Increased range of motion
- Increased physical fitness and strength
- Increased health-related quality of life
- Increased pain tolerance
- Increased functional capacity
- Increased overall physical activity participation levels (21, 36,60,73,74).

A recent systematic review and meta-analysis assessed the effects of resistance, endurance, and flexibility exercise in population-based interventions to prevent LBP and associated disability (78). They reported exercise reduced the risk of LBP by 33% and that severity and disability from

TABLE 1. Exercise modifications for patients with chronic nonspecific low back pain (CNSLBP) and movement directional preferences.

Exercise Type	Flexion Intolerance and Extension Movement Bias-Basic	Flexion Intolerance and Extension Movement Bias- Advanced	Extension Intolerance With a Flexion Movement Bias-Basic	Extension Intolerance With a Flexion Movement Bias-Advanced
Aerobic/endurance	Treadmill or over ground walking-level, *UBE-standing, walking in water, treading water	Elliptical trainer, stair climber, jogging-level, deep water running, swimming with a mask	**Nu-Step, *UBE-seated, recumbent bike, water walking	Swimming on back, walking w/incline, upright stationary bike, treading deep water treading/ jogging, swimming, rowing ergometry (without extension)
Resistance training/ upper body	Standing or Prone with external support chest press, row, Lat pull-down triceps push down, reverse shoulder (rear) fly, bicep curl w/adjustable cable column or tubing	Assisted, Body Weight or TRX/Suspension: Pushups, pull-ups, inverted rows, Free Weight, chest press, prone on bench row, reverse shoulder fly, Smith Machine shoulder press, Dumbbell biceps curl w/ stability ball support (against wall)	Seated Machine, Cable or Supine: Row, chest press, lateral shoulder raise, reverse/rear fly, Lat pull-down, triceps push-down, bicep curl	Seated: Machine or cable exercises weight/dumbbell exercises
Resistance training/ lower body	Chair/potty squat, wall squat with a stability ball, mini-lunge	Low height bench step-up, body weight squat, horizontal machine leg press, squat wearing a lightweight vest	Supine gluteal bridges, seated leg press, knee extension, knee flexion,	Machine horizontal or 45° leg press, chair/potty squats, wall squats with a stability ball
Trunk/core conditioning	Hip hinge, standing wall hip extension, standing wall shoulder flexion, quadruped “cat and camel,” standing wall abdominal plank	Bird dog, stability ball back extension without trunk flexion, standing trunk de-rotation, standing back extensions, hip hinging, Paloff presses (multiple positions/angles), single leg bridges, “stirring the pot”/sawing w/stability ball	Abdominal “bracing,” dead bug progression, press, gluteal bridge	Abdominal curl-up, bird-dog
Cautions (limit or avoid)	Bending at the waist, sitting, leaning forward and twisting/rotating	Bending at the waist, sitting, leaning forward and twisting/rotating	Arching or hyperextending the spine, prolonged standing, overhead reaching and lifting and exercising in the prone position	Arching or hyperextending the spine, prolonged standing, overhead reaching and lifting and exercising in the prone position

*Upper body ergometry **Upper/lower body recumbent step ergometer, adapted from 5,6,24,77

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LBP were lower in exercise training versus control groups. It was concluded that a combination of strengthening exercise with either stretching or aerobic exercise performed 2 to 3 times per week can be reasonably recommended for the prevention of LBP in the general population (78). Other well-tolerated and effective programs include periodized RT programs which improve strength and physical activity participation levels, as well as reduce disability levels in both sedentary and athletic populations with CNSLBP (79–84).

Exercise and Physical Activity Recommendations

These recommendations for persons with CNSLBP are consistent with those from the American College of Sports Medicine (ACSM) and the United States Department of Health and Human Services (USDHHS). They are consistent with those for patients participating in outpatient CR exercise programs, who are healthy, and do not have CNSLBP (1–6).

Common exercise program goals for persons with CNSLBP and patients in outpatient CR are similar and emphasize the importance of:

- Improving health and well-being
- Improving exercise tolerance
- Improving functional capacity
- Improving HRQoL
- Resuming vocational and recreational pursuits (1–4).

Aside from performing structured exercise, persons with CNSLBP should adopt an active lifestyle and add routine PA breaks when periods of sitting cannot be avoided (1–6).

Components of a comprehensive exercise program should include RT, ET, flexibility, and neuromotor training (2,3,5,6,36,73,74,85). The compendium of physical activities can serve as a resource for assisting CR patients with CNSLBP to find additional leisure time and recreational activities they can perform comfortably (86). Table 2 provides a general summary of exercise guidelines and PA recommendations for CR patients with CNSLBP.

Exercise and Functional Testing

Prior to performing exercise or functional performance tests, CEPs should discuss appropriate individualized protocol selections with the patient's physicians and HCPs. They should perform exercise and functional tests that CR patients with CNSLBP can complete comfortably (5,6).

As an example, patients who experience pain with trunk flexion may be more comfortable and perform better when standing while patients who experience pain when in trunk extension or have difficulty standing might be more comfortable and perform better when seated or recumbent (22–24,77,87).

Treadmill tests using low-level protocols such as the Modified Naughton or ramp or discontinuous protocols, along with the field-based 6-minute walk test can reduce compensatory trunk flexion due to less reliance on elevation. Each of these tests is appropriate for patients with flexion intolerance. Lower body cycle ergometer or recumbent cycle or step ergometer protocols are appropriate for CR patients with extension intolerance (3,5,6). Muscle strength testing using a multiple repetition maximum is well tolerated and an effective tool for measuring current strength levels, determining training loads, and measuring post-program strength increases in clients with CNSLBP and are an acceptable alternative to one-repetition maximum (1-RM) testing (81–83).

The standard Borg rating of perceived exertion (RPE) or the OMNI Resistance Exercise Scale (OMNI RES) scales can approximate intensity of patient effort during muscular strength testing and training (3,88,89).

The multiple repetition sit-to-stand test, 30-second arm curl, and handgrip strength test are viable instruments for measuring muscular strength in patients with CNSLBP who are ≥60 years old (3,90,91).

After a cardiac event, patients are at risk for deficits in mobility and function due to extended periods of inactivity (e.g., bed rest) (91). Gait speed, the 5 times sit-to-stand (STS), and handgrip strength tests are reliable and responsive measures for patients in CR and typically tolerated by those with CNSLBP (91).

Other acceptable tests that assess neuromotor function and balance include the timed up and go (TUG), 5-minute walk, and stair climb tests (3,6,26).

Exercise Program Recommendations for CNSLBP

An individualized approach to exercise program development that addresses all health-related fitness variables is appropriate when working with patients who have CNSLBP. The CR program should help to enhance functional performance and HRQOL (1–6,21,74,73,85). Components of a comprehensive exercise program for CR patients with CNSLBP should include AT, RT, FT, and neuromotor training (1–6,12,21,74,77,81–83,85). Due to potential physical deconditioning and pain in some patients who have CNSLBP, a slower rate of exercise program progression, volume, and intensity may be warranted (3,5).

Aerobic endurance training (AT) is generally well-tolerated by patients with CNSLBP (80). An appropriate goal for CR patients with comorbid CNSLBP is to accumulate ≥30 min of moderate intensity AT on most (≥5) days of the week (2–6). Initial AT bouts of ≤10 min repeated 2 to 3 times per day might be best tolerated in deconditioned CR patients. Total daily time during a single AT bout can be increased gradually to meet or exceed the 30 min goal (3–5). It is prudent to increase exercise duration gradually so longer, continuous AT exercise bouts can be tolerated (5). An initial AT intensity equivalent to an RPE of between 12 and 13 and progressing to 16 out of 20 over time is appropriate (1–3,5). If heart rate-guided, then maintaining exercise within the target heart rate range is appropriate but may start at a lower (50%-60%) level and progress to higher percentages (60%-80%). Walking, upright and recumbent cycling, step ergometry, elliptical, seated, and recumbent stepping, rowing, swimming, and aquatic exercises are all acceptable forms of

TABLE 2. Physical activity and exercise recommendations for persons with chronic nonspecific low back pain.

FIIT-VP Variable	Cardiorespiratory Fitness Training	Muscular Strength/ Endurance Training	Flexibility Training	Neuromotor Training
Frequency	≥5days/week^{-1} of moderate or ≥3 days/week^{-1} of vigorous, or a combination of moderate and vigorous exercise on ≥3-5 days/ week^{-1}	8-10 exercises for each major muscle group 2-3 days/week^{-1} with 2-3 minute rest intervals between sets and ≥48 h of recovery per muscle group between sessions	2-3 days/week^{-1} for major muscle groups including (chest, anterior shoulders, hip flexors, hamstrings, gastrocnemius/soleus	≥2-3 days/week^{-1}
Intensity	Moderate (RPE of 12-13) or 40%-59% of either $V0_{2r}$ or HRR to Vigorous, RPE of ≥14 or ≥60% of either $V0_2R$ or HRR	60%-70% 1-RM intensity for most participants; 40%-50% 1-RM intensity for novice, deconditioned or elderly participants	Stretch to a point of slight discomfort	An effective intensity has not been determined
Time	≥30 minutes/day^{-1} of continuous or accumulated exercise		10-30 seconds for most or 30-60 seconds for older participants respectively	≥20-30 minutes/day^{-1} may be needed
Type	Aerobic endurance	Multi-joint and single-joint resistance exercises addressing all major muscle groups and with a variety of exercise equipment and/or body weight	Dynamic warm-up activities followed by either static or proprioceptive neuromuscular facilitation stretching	Multifaceted activities involving balance, coordination, agility and gait to reduce fall risk in older persons
Volume	≥150 minutes/week^{-1} or 500-1,000 MET-minutes/ week^{-1}	N/A	A total time of 60 seconds per each flexibility exercise	An optimal volume is not known
Progression	Gradually increase exercise volume and use a “start low and go slow” approach	A gradual progression of greater resistance, repetitions and/or sets	Unknown at this time	Unknown at this time
Sets	N/A	2-4 per major muscle group; a single set can be effective for older, novice participants	2-4 sets per flexibility exercise	
Repetitions	N/A	8-12, 10-15 for middle-aged, older or de-conditioned patients	N/A	N/A
Special considerations	Participants should exercise in body positions best tolerated	Participants should exercise in body positions best tolerated	Participants should exercise in body positions best tolerated	Participants should exercise in body positions best tolerated

RPE = rating of perceived exertion; $V0_2R$ = oxygen uptake reserve; HRR = heart rate reserve; MET-minutes/week^{-1} = metabolic equivalent minutes per week; 1-RM = one repetition maximum; N/A = does not apply. Adapted from 1–6,20,22,23,25,74–77,85,88,89,92

AT. For patients in CR, AT exercise selections should be dictated by their comfort and (if present) movement directional preferences. Exercises that are high-impact, like running, should be avoided or introduced gradually with caution (5). Figures 1, 2, and 3 depict recumbent combined arm and leg ergometry, treadmill walking, and upper body ergometry, three types of AT commonly prescribed during CR.

Cardiac rehabilitation patients with comorbid CNSLBP are encouraged to follow RT guidelines for apparently healthy sedentary adults without CNSLBP (3,5) and should complete RT workouts consisting of 8 to 10 exercises—all of which emphasize major muscle groups—on 2 to 3 nonconsecutive days of the week. A variety of modalities are appropriate and include: free weights, machines, elastic resistance tubing, and body weight exercises (1–3,92,93). Patient comfort and, if present, movement directional preferences should dictate the equipment and body position selected during all RT exercises. Standing exercises may be more comfortable for patients who experience pain with trunk flexion, while seated exercises may be more comfortable for patients who experience pain during prolonged standing or with trunk extension (3,5,6,22,23,75–77). Figures 4 through 7 depict the leg press, row, Lat pull-down, and chest press exercises commonly performed during CR.

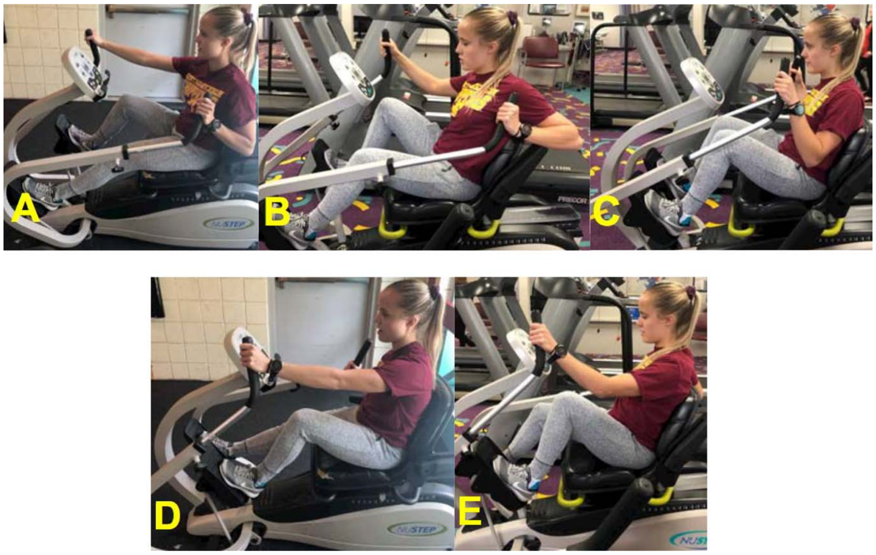

FIGURE 1. Recumbent arm/leg ergometry. (A-C) Overreaching with knee and elbow hyperextension (A) and hyperflexion (B and C) from improper seat adjustment of the recumbent arm/leg ergometer can exacerbate low back pain. (D-E) Proper positioning is demonstrated (D, starting and finish position; C, pulling motion).

FIGURE 2. Treadmill walking. (A) Pain can occur during inclined walking from compensatory trunk flexion in a person with flexion intolerance. (B) Pain during prolonged walking and compensatory trunk flexion in a person with extension intolerance. (C) Walking on a level surface may be best tolerated by persons with flexion intolerance. Those with extension intolerance may do better with some incline or, if necessary, by substituting seated or recumbent exercises for treadmill walking.

FIGURE 3. Upper body ergometry (A) can be performed seated for patients with extension intolerance, or (B) standing for patients with flexion intolerance.

FIGURE 4. Seated leg press is a well-tolerated multi-joint lower body strength exercise option for persons with extension intolerance. Improper seat positioning can worsen back pain. (A) Overextension of the knees and overreaching during the end of the pushing phase of the leg press can exacerbate low back pain in persons with extension intolerance. (B) The knee to chest position is a form of spinal flexion which might need to be modified for persons with flexion intolerance. (C) Sitting fully against the back seat pad will ensure vertical alignment of the head, neck, back, and hips, and support a more neutral spine. An alternative can be either a supine leg press (not shown) or (D) a standing wall squat, with or without a stability ball behind the back (D, proper alignment at the bottom position). The wall squat performed with a stability ball is an alternative to the leg press for persons with flexion intolerance.

An initial training intensity that is equivalent with an RPE of 12 to 13 (out of 20) or 4 to 6 (out of 10) on the OMNI RES scale is appropriate and, if tolerated, may be progressed over time (1,3,5). Although single set RT programs have produced significant strength increases in sedentary, untrained individuals (92), progressing to a protocol consisting of 2 to 4 exercise sets per muscle group is recommended as tolerated (2,3,92). Periodized, progressive,

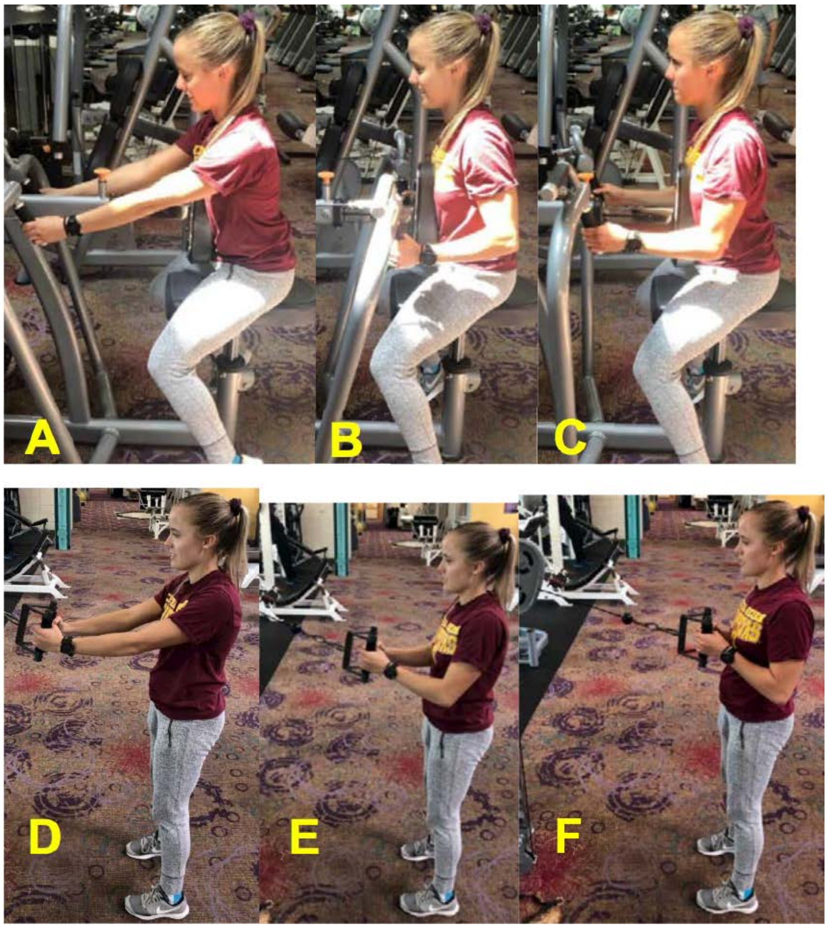

FIGURE 5. Rowing exercises can be modified to accommodate specific back movement limitations. (A-C) A version of a seated machine row for a person with extension intolerance (A, starting position; B, pulling motion; C, returning to starting position). (D-F) An adjustable cable column version of a standing row for persons with flexion intolerance (D, starting position; E, pulling motion; F, finish position).

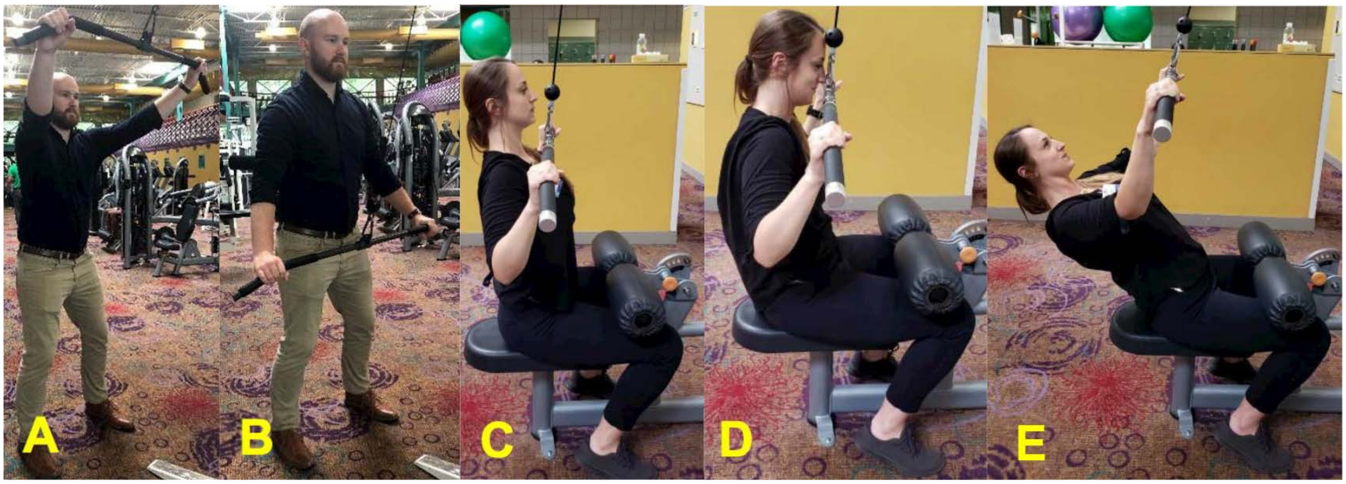

FIGURE 6. Lat pull-down exercise. The Lat pull-down can be performed (A-B) standing (A, start position; B, finish position) for those with flexion intolerance or (C) seated for persons with extension intolerance. (D) Excessive trunk flexion and (E) excessive trunk extension. (A) A straight arm Lat pull-down is depicted with a slightly wider than shoulder width grip.

multi-set RT programs have produced significant increases in strength in persons with CNSLBP who were comparable to those in apparently healthy individuals without CNSLBP (81–83). Intensity and loading of RT exercises should follow the "two for two" rule (increase the resistance after ≥2 repetitions more than the number prescribed during the last set of an exercise can be properly completed during two consecutive workouts) (92). Table 3 describes RT exercise program modifications for patients who have movement directional preferences and are either flexion or extension intolerant.

A discussion of trunk stability and core exercise training is beyond the scope of this article. For additional resources regarding back and core conditioning exercises and management of CNSLBP, refer to McGill (24,77).

Flexibility training should be preceded by light aerobic activity for approximately 8 to 10 min daily. Static, dynamic, and proprioceptive neuromuscular facilitation stretching are all acceptable as tolerated (2,3,5). Hip flexor, hamstring, anterior shoulder girdle, and calf muscle flexibility exercises should be emphasized (3,5). Clinical exercise physiologists should use caution if signs of new or worsening pain and fatigue occur during or after exercise sessions. Signs and symptoms warranting exercise termination and prompt communication with a physician or HCP are provided in Box 5. Physician or HCP clearance for patients to return to CR exercise sessions after symptom exacerbations and flare ups is prudent.

SUMMARY

Low back pain is a common musculoskeletal disorder affecting approximately 38% of new outpatient cardiac rehabilitation patients. The majority of LBP is considered chronic and nonspecific. Cardiac rehabilitation patients who have CNSLBP can obtain the same improvements in physical activity tolerance, physical function, and HRQoL as persons without CNSLBP. A comprehensive, individualized approach to developing exercise programs that

FIGURE 7. Chest press exercise can be modified to accommodate specific back movement limitations. (A-B) A version of a seated machine chest press for persons with extension intolerance (A, starting position; B, pushing motion). (C-D) An adjustable cable column version of a standing chest press exercise for persons with flexion intolerance (C, starting position; D, pushing motion).

TABLE 3. Sample machine-based resistance training exercises for flexion and extension intolerant patients.

Muscle Group(s)	Exercise(s) for Flexion Intolerance	Exercise(s) for Extension Intolerance
Gluteus maximus, quadriceps, hamstrings	Chair squat or wall squat with a stability ball	Seated or supine leg press (machine)
Quadriceps	Stair step-up	Seated leg extension (machine)
Hamstrings	Standing leg curl (machine)	Seated leg curl (machine)
Latissimus dorsi, teres major	Standing straight arm cable pull-down or Assisted pull-up (machine)	Seated Lat pull-down (machine)
Pectorals, deltoids, triceps	Standing cable or resistance tubing chest press	Seated chest press (machine)
Rhomboids, middle/lower Trapezius	Standing cable or resistance tubing scapular row	Seated scapular row (machine with a chest support pad)
Deltoids	Standing dumbbell shoulder press (alternating)	Seated lateral shoulder raise (machine)
Biceps	Standing biceps curl (dumbbell)	Seated biceps curl (machine)
Triceps	Standing triceps pushdown	Seated triceps push down or seated dip machine(s)

Adapted from 2,3,5

BOX 5: SIGNS AND SYMPTOMS REQUIRING EXERCISE TERMINATION AND PHYSICIAN ALERT IN THOSE WITH LOW BACK PAIN

- Pain severe enough to halt exercise
- Pain that persists for ≥3 h after exercise
- Pain resulting in several days of disability or sleep disturbances
- Pain that initiates, exacerbates or extends the distribution of radiating pain

accommodate patients' CNSLBP and (if present) their movement directional preferences is prudent and can enhance the benefits of participation in outpatient CR. Clinical exercise physiologists should monitor patients for new or worsening symptoms. New or worsening pain and fatigue warrant immediate exercise cessation and communication with a physician or HCP.

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