Guidelines for implementing exercise programs for cancer patients

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Introduction

These guidelines are intended for use by health professionals, specifically Exercise Physiologists and Physiotherapists. Other health professionals, including General Practitioners, Oncologists and Occupational Therapists, may find the guidelines useful when considering an exercise program for patients. Finally, patients with a particular interest in exercise science may find these guidelines to be a useful resource.

The guidelines are supported by the Cancer Council Western Australia's patient booklet, *Exercise for people living with cancer*. Health professionals and patients can obtain this booklet from the Cancer Council Helpline 13 11 20.

Using these guidelines

The purposes of the guidelines for implementing exercise programs for cancer patients are:

1) To present background information on exercise prescription including modes of exercise, program variables and principles related to training that are critical to induce exercise adaptation.

2) To examine specific issues that may influence a cancer patient's capacity to exercise during and after treatment and provide the latest available scientific evidence to address these issues.

3) To provide a generic (home-based and clinic-based) exercise program for cancer patients. The program has largely been developed based on the research and the successful cancer survivor program at the Vario Health Institute, Edith Cowan University.

4) To assist with the administration of such a program including examples of general forms for GP clearance of exercise participation, health and medical history questionnaires and training log formats.

Cancer Council Western Australia

The Cancer Council WA is a community-based and community-funded organisation that aims to minimise the effect of cancer on our community through research and education, as well as by providing patient and family support to enhance the quality of life for people living with cancer.

The Cancer Council WA head office is located in West Perth. We have regional staff around the state including Midland, Geraldton, Albany, Bunbury and Kalgoorlie.

Community services that the Cancer Council WA offers include:

- Education programs for the community, workplaces and educational institutions.

- Provision of information through brochures, posters, videos and publications.

- The Cancer Council Helpline – a telephone information service for people living with cancer, friends, families, health professionals and others. The Cancer Council Helpline is staffed from 8 am to 8 pm on weekdays. It is available state-wide by calling 13 11 20 for the cost of a local call.

- Counselling and support services – contact the Cancer Council Helpline 13 11 20 for more information

- Support groups for cancer patients and their families.
- Complementary therapy and physical activity programs for cancer patients.
- Crawford Lodge and Milroy Lodge, purpose built facilities that provide accommodation for country people attending any of Perth's cancer treatment centres.

The Cancer Council WA has a range of resources including several resource kits on other cancer topics. An affordable range of sun protection products are also available from our Subiaco shop, or online at cancerwa.asn.au/shop/.

Exercise programs for cancer patients

Clinic-based programs

Ideally patients should attend a supervised clinic or gym for an individualised exercise program. The best results are obtained in a safe and supervised environment. It is important that patients carefully choose the clinic or gym that they attend and assess the credentials of those supervising the program. Programs that are run by an Exercise Physiologist or Physiotherapist are preferable. Many programs work closely with GPs too.

Home-based programs

Depending on the patient's circumstances, a home-based exercise program is an important addition to clinic exercise and in some cases might be the only choice. For example, patients in rural and remote settings might have no option but to perform a home-based program. Even urban patients with access to clinic facilities may have to consider a home-based program if transport, mobility and/or cost is a barrier, or they are feeling too unwell to come into the gym or clinic. A home-based program is recommended so that some amount of work can be performed away from the gym or clinic.

The home-based program should be instructed initially and then reinforced for the patient. In most cases it should be customised based on equipment availability and environment. For example, if the patient lives near a walking track, this exercise mode could form the basis of the exercise program with supplemental anabolic exercise.

Resources for patients

The Cancer Council Western Australia produces an accompanying patient publication, *Exercise for people living with cancer*. This booklet has been specially written for people undergoing cancer treatment. It is based on these guidelines and includes a sample home-based exercise program. The Cancer Council Western Australia also produces the complementary booklet, *Nutrition for people living with cancer*, which your patients may find helpful. These resources, and a range of others, are available from the Cancer Council Helpline 13 11 20.

Components of an exercise session for cancer patients

Warm-up phase

Warm-up facilitates the transition from rest to exercise and may reduce the susceptibility to musculoskeletal injury by improving joint range of motion.[1]

Regardless of training mode, exercise sessions should start with a 5-10 minute low-intensity exercise incorporating light stretching exercises. This should be followed by warming up for the specific exercise to be undertaken. For example, participants that use 20kg in a chest press exercise for 12 repetitions might have a warm-up set using 5-10kg for 15 repetitions before initiating this particular exercise. Similarly, participants who use brisk walking or jogging might conduct a warm-up phase gradually increasing from a slow walk before initiating the training program.

Specific phase

Aerobic exercises:
Aerobic training includes 30-60 minutes of continuous or intermittent (minimum of 10-minute bouts accumulated during the day) of aerobic activity training at 50-90% HR_{max} or 40-85% HRR.[2]

Resistance exercises:
Anabolic resistance exercises include performing 1-4 sets per muscle group training at 50-80% of 1RM or 6-10RM. The session should include 6-9 different exercises, with 60-90 seconds recovery between sets.[2]

Anabolic exercises should generally follow these rules in terms of ordering:

- Large muscle groups first (eg legs)
- Multi-joint exercises (eg bench press) before single joint (eg elbow extension)
- Abdominal and lower back exercises after whole-body ground-based exercises such as squat, dead-lift, bench press etc. This is to avoid fatiguing the muscle groups that stabilise and support the trunk. It is also important NOT to always program abdominal and lower back exercises last as the patient may be getting tired or bored and drop them from the program. These exercises are very important for posture and stability and should be completed at each session.

Flexibility exercises:
Flexibility (range-of-motion) exercises include performing 2-4 sets per muscle group at 15-30 seconds stretching time.[2]

Cool-down

This phase provides a gradual recovery from the specific activity performed and includes exercises using lower intensities. The cool-down allows appropriate circulatory adjustment of heart rate and blood pressure to near resting values, facilitates dissipation of heat, reduces potential post exercise hypotension and promotes removal of lactic acid. [1] For example, participants can use slow walking when completing higher intensity aerobic activity or light stretching when completing a resistance training session.

Sample clinic-based program

Warm-up phase

- There is much less discomfort and a reduced risk of injury if the patient transitions from rest gradually.
- 5-10 minutes of low-intensity aerobic activity.
  Walking, cycling, or rowing is recommended.
  Aerobic exercises, page 53.
- Incorporate light stretching, concentrating on the muscles and joints involved in the training program.
  Appendix one: Flexibility exercises, page 41.

Note: if the specific phase includes resistance exercises, it is also recommended to include a warm-up set for the first upper and lower body exercise to specifically prepare the muscles and joints.

Specific phase

Aerobic exercises:

- 4-7 times per week.
- 30-60 minutes of walking, cycling, or rowing at:
  - 50-90% maximum heart rate (HR_{max}), or
  - 40-85% heart rate reserve (HRR).
- Exercise can be continuous or intermittent (minimum of 10-minute bouts).

Note: if 10-minute exercise bouts remain too intense, exercise time has to be adjusted to each individual. It can be reduced to as little as a few minutes of activity with a progression plan to increase exercise duration, as tolerated, in subsequent sessions.

Resistance exercises:

- Exercises should target major functional muscles of the upper and lower limbs, and trunk.
  Resistance exercises, page 9.
- Ensure correct technique.
- 6-9 different exercises, with 60-90 seconds recovery between sets.
- 1-4 sets per muscle group, training at:
  - 50-80% of 1RM, or
  - 6-10RM
- Program should be incremented as patients improve to maximise training response:
  - Increase number of repetitions, from 6 to 12; then
  - Increase number of sets, from 1 to 4, dropping the number of repetitions back to 6 each time a set is added; then
  - Increase the *load* or *resistance* and reduce the number of repetitions and sets.

Resistance exercise combination program to be performed 2-3 times per week, on non-consecutives days:

- Chest press
- Lat pull-down
- Squat or leg press
- Leg extension
- Shoulder press or lateral arm raise
- Leg curl
- Seated row
- Triceps extension
- Biceps curl
- Core stability exercises

Resistance exercise combination to be performed 3-4 times per week, altering routine A & B:

Routine A:
- Chest press
- Lat pull-down
- Shoulder press
- Lateral arm raise
- Seated row
- Biceps curl
- Triceps extension

Routine B:
- Leg press or squat
- Leg extension
- Leg curl
- Hip extension
- Calf raise
- Core stability exercises

Flexibility exercises
- 3-4 times per week
- 2-4 sets per muscle group at 15-30 seconds stretching time.
- Upper, lower and trunk flexibility exercises
  Flexibility exercises, page 41.

Cool-down phase
- Slow walking when completing higher intensity aerobic activity, or
- Light stretching when completing a resistance training session can be incorporated in this phase.

Sample home-based program

Warm-up phase

- There is much less discomfort and a reduced risk of injury if the patient transitions from rest gradually.
- 5-10 minutes of low-intensity aerobic activity.
  Walking, cycling, or rowing is recommended.
  Aerobic exercises, page 53.
- Incorporate light stretching, concentrating on the muscles and joints involved in the training program.
  Flexibility exercises, page 41.

Note: if the specific phase includes resistance exercises, it is also recommended to include a warm-up set for the first upper and lower body exercise to specifically prepare the muscles and joints.

Specific phase

Aerobic exercises:

- 4-7 times per week.
- 30-60 minutes of walking, cycling, or rowing at:
  - 50-90% maximum heart rate (HR_{max}), or
  - 40-85% heart rate reserve (HRR).
- Exercise can be continuous or intermittent (minimum of 10-minute bouts accumulated during the day).

Note: if 10-minute exercise bouts remain too intense, exercise time has to be adjusted to each individual. It can be reduced to as little as a few minutes of activity with a progression plan to increase exercise duration, as tolerated, in subsequent sessions.

Resistance exercises:

- Exercises should target major functional muscles of the upper and lower limbs, and trunk.
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- 1-4 sets per muscle group, training at:
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- Program should be incremented as patients improve to maximise training response:
  - Increase number of repetitions, from 6 to 12; then
  - Increase number of sets, from 1 to 4, dropping the number of repetitions back to 6 each time a set is added; then
  - Increase the *load* or *resistance* and reduce the number of repetitions and sets.

Resistance exercise combination program to be performed 2-3 times per week, on non-consecutives days:

- Chest press
- Standing row
- Squat (or chair rise)
- Shoulder press or lateral arm raise
- Leg curl
- Triceps extension
- Biceps curl
- Core stability exercises

Resistance exercise combination to be performed 3-4 times per week, altering routine A & B:

Routine A:

- Chest press
- Standing row
- Shoulder press or lateral arm raise
- Biceps curl
- Triceps extension

Routine B:

- Squat (or chair rise)
- Leg curl
- Hip extension
- Calf raise
- Core stability exercises

Flexibility exercises

- 3-4 times per week
- 2-4 sets per muscle group at 15-30 seconds stretching time.
- Upper, lower and trunk flexibility exercises
  Flexibility exercises, page 41.

Cool-down phase

- Slow walking when completing higher intensity aerobic activity, or
- Light stretching when completing a resistance training session can be incorporated in this phase.

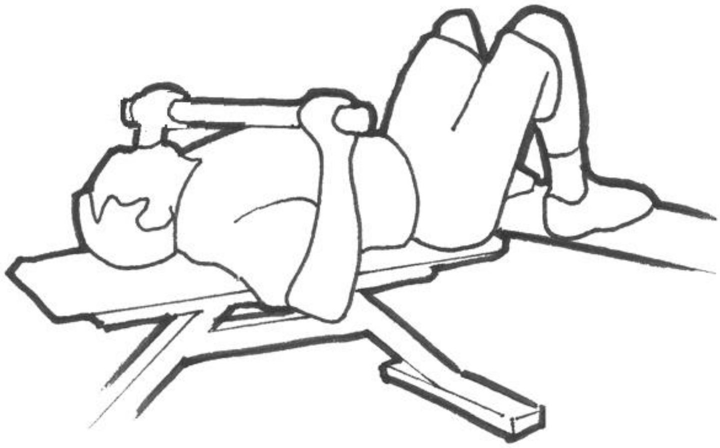
Resistance exercises: Upper body

1. Bench press

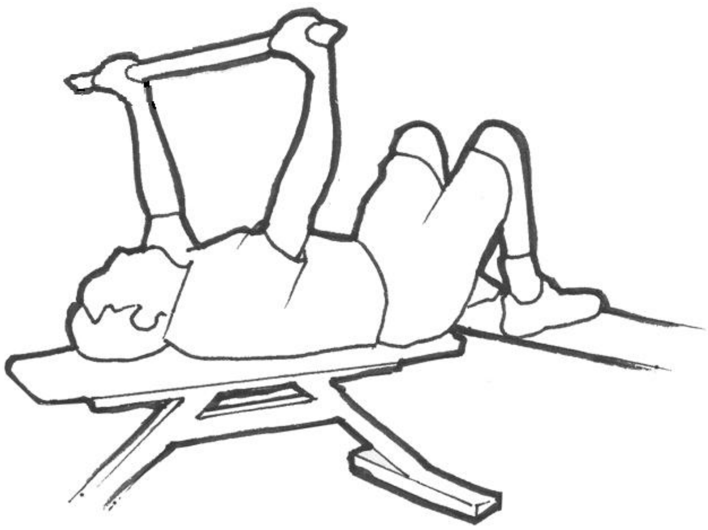
Region: Chest and arms

Major muscles: Pectoralis major, anterior deltoids, triceps brachii

Description: Extension of elbows and horizontal adduction of shoulder by pushing the resistance up and controlling the return



Starting position:
Align elbows just below shoulder line and maintain approximately 90 degrees of elbow flexion at starting position.



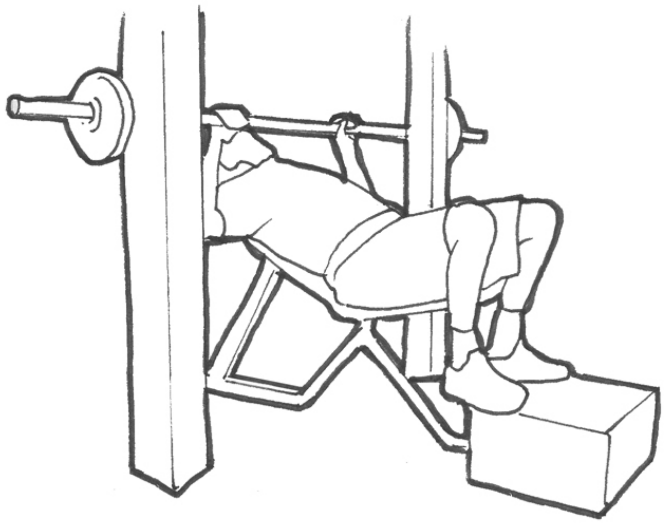
Final position:
Fully extend elbow joint, breathing out during the lift. Maintain legs in a raised position to provide better support for the back (flat lower back position).

2. Incline bench press

Region: Chest and arms

Major muscles: Pectoralis major, anterior deltoids, triceps brachii

Description: Extension of elbows and horizontal adduction of shoulder by pushing the resistance up and controlling the return



Starting position:

Align shoulders just below elbows and maintain approximately 90 degrees of elbow flexion at starting position.

Final position:

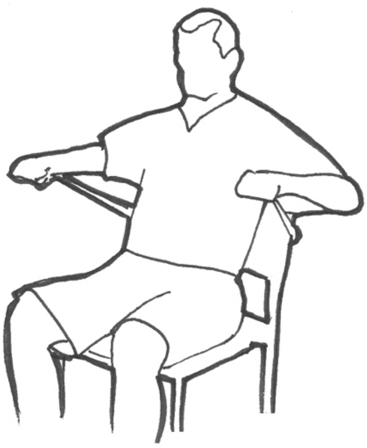
Fully extend the elbow joint, breathing out when lifting the resistance (extension of arms). Maintain legs raised (bench or box) to provide a better support for back (flat lower back position).

3. Seated chest press

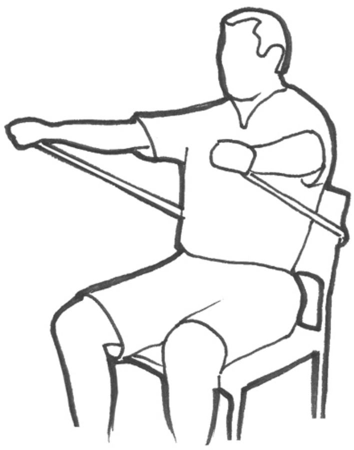
Region: Chest and arms

Major muscles: Pectoralis major, anterior deltoids, triceps brachii

Description: Extension of elbows and horizontal adduction of shoulder by pushing the resistance out and controlling the return



Starting position:
Align elbows with shoulders and maintain approximately 90 degrees of elbow flexion at starting position.



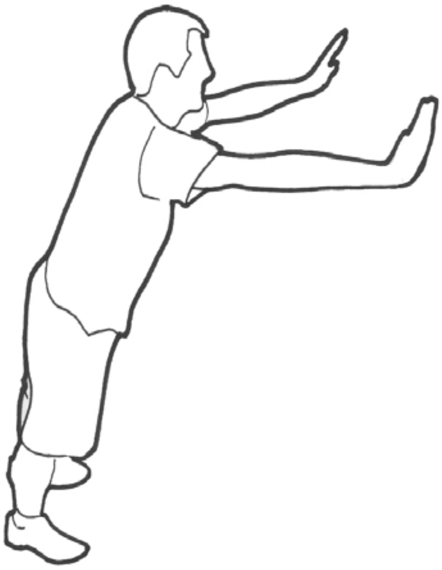
Final position:
Fully extend the elbow joint, breathing out during the push (extension of arms). Maintain back flat against chair for proper support.

4. Standing push-up

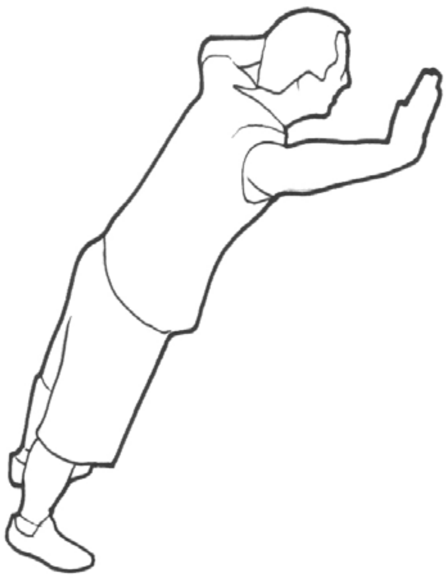
Region: Chest, back and arms

Major muscles: Pectoralis major, anterior deltoids, triceps brachii

Description: Extension of elbows and horizontal adduction of shoulder by pushing the body up and controlling the return



Starting position:
Standing, feet shoulder-width apart, leaning slightly on the wall with outstretched arms.



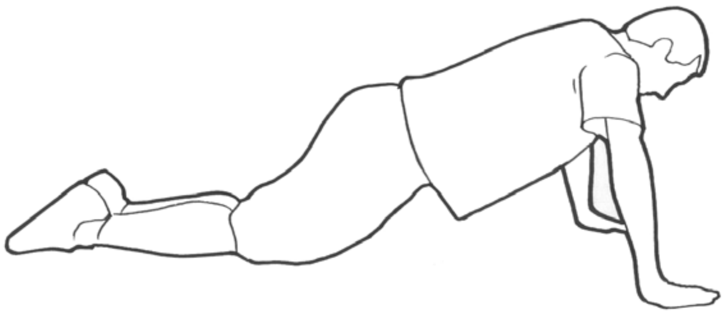
Final position:
Move the body slowly towards the wall, bending the arms at the elbow, and then push out the body (bodyweight resistance). Breathe out when pushing the resistance up.

5. Modified push-up

Region: Chest, back and arms

Major muscles: Pectoralis major, anterior deltoids, triceps brachii

Description: Extension of elbows and horizontal adduction of shoulder by pushing the body up and controlling the return



Starting position:
Knees and hands on the floor.

Final position:
Lower the trunk slowly, and then push up the body (bodyweight resistance). Breathe out when pushing the resistance up. Maintain a straight back.

6. Standing shoulder press

Region: Shoulders and arms

Major muscles: Deltoids, triceps brachii, latissimus dorsi and biceps brachii

Description: Shoulder flexion/abduction and elbow extension

Starting position:
Standing, feet shoulder-width apart. Holding the weight with elbows almost at full flexion (almost touching trunk).

Final position:
Full extension of elbows and shoulder flexion. Breathe out during the lift and maintain good posture at all times.

7. Seated shoulder press

Region: Shoulders and arms

Major muscles: Deltoids and triceps brachii

Description: Shoulder flexion/abduction and elbow extension

Starting position:
Seated, with back rest slightly off vertical. Maintain back flat against the support. Elbows flexed, holding the resistance.

Final position:
Fully extend elbows with shoulders flexion/abduction. Breathe out during the lift.

8. Lat pull down

Region: Upper and lower back, and arms

Major muscles: Latissimus dorsi and biceps brachii

Description: Adduction of shoulders and flexion of elbows

Starting position:
Seated, with hands holding the bar and knees firmly under the support..

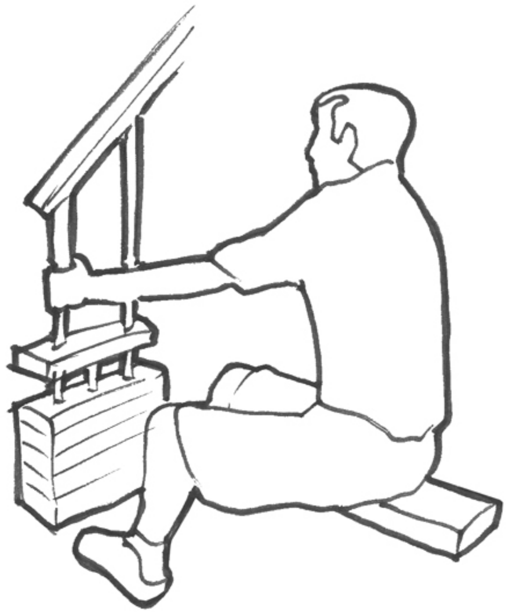
Final position:
Extend shoulders and flex elbows, breathing out when pulling the resistance. Maintain a straight back.

9. Seated row

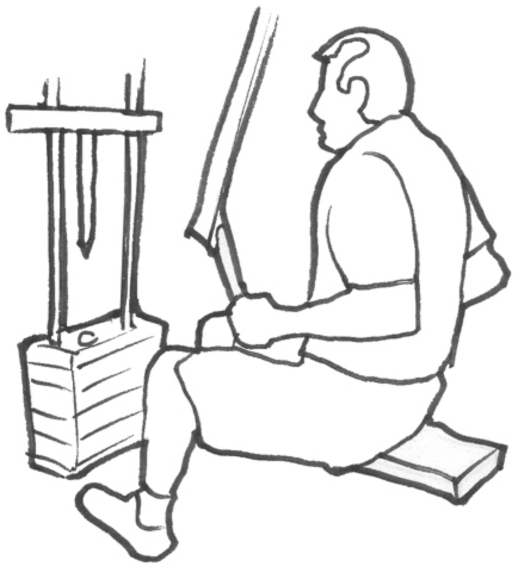
Region: Upper and lower back

Major muscles: Latissimus dorsi and biceps brachii

Description: Extension of shoulders and flexion of elbows



Starting position:
Seated, with flexed shoulders and extended elbows.



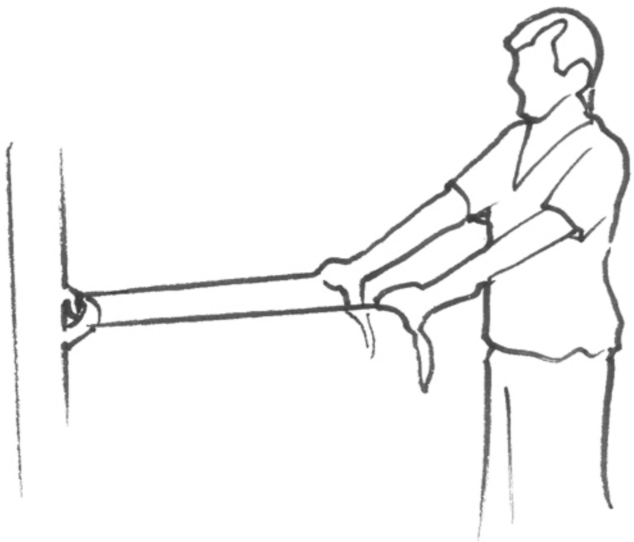
Final position:
Extend shoulders and flex elbows, breathing out when pulling the resistance and maintaining a straight back.

10. Standing row

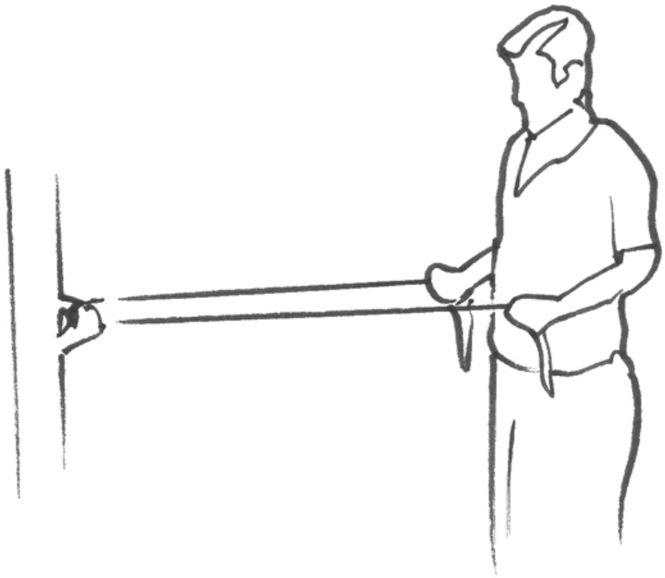
Region: Upper and lower back

Major muscles: Latissimus dorsi and biceps brachii

Description: Extension of shoulders and flexion of elbows



Starting position:
Standing, with flexed shoulders and extended elbows.



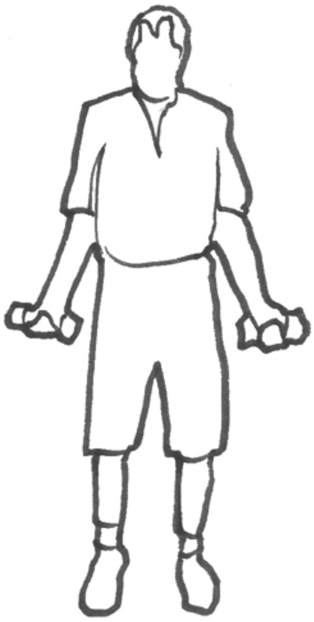
Final position:
Extend shoulders and flex elbows breathing out when pulling the resistance.
Ensure the trunk does not move.

11. Biceps curl

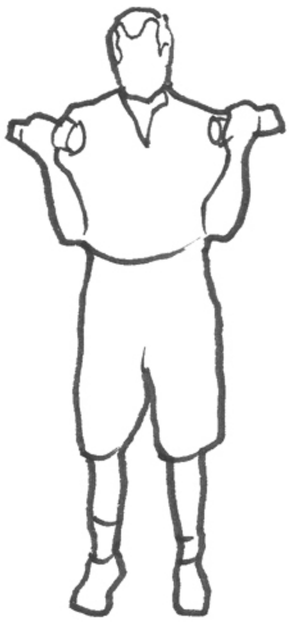
Region: Arms

Major muscles: Biceps brachii, brachialis

Description: Elbow flexion



Starting position:
Standing, with elbows extended by the side of the trunk.



Final position:
Fully flex both elbows, breathing out during the lift. Ensure trunk does not move.

12. Unilateral triceps extension

Region: Arms

Major muscles: Triceps brachii

Description: Extension of elbow with shoulder flexion.

Starting position:
Standing, with shoulders flexed. Resistance on the exercising arm and other arm acting as support.

Final position:
Fully extend the elbow, breathing out when lifting the resistance.

13. Triceps extension

Region: Arms

Major muscles: Triceps brachii

Description: Extension of elbows

Starting position:
Standing, with elbows flexed.

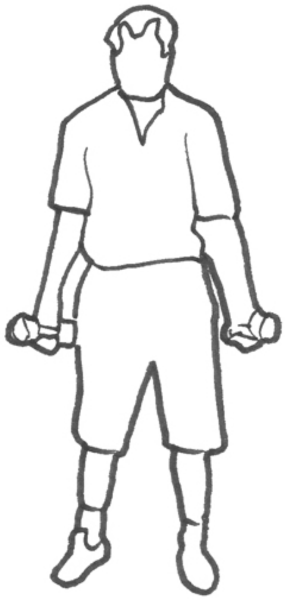
Final position:
Fully extend elbows, breathing out when pushing the resistance down.

14. Lateral arm raise

Region: Shoulders

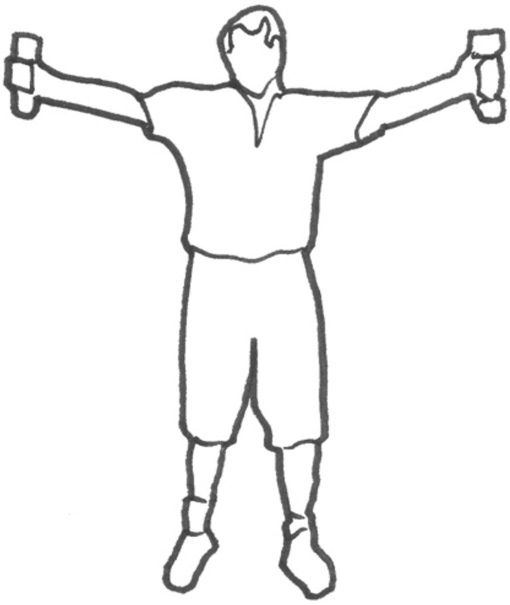
Major muscles: Deltoids

Description: Abduction of shoulder with external rotation of humerus



Starting position:

Standing, holding dumbbells with an external rotation of humerus (wrists pointing forward).



Final position:

Abduct shoulders until horizontal. Breathe out when lifting the resistance. Maintain head and neck position, looking straight ahead.

Resistance exercises: Lower body

15. Leg extension

Region: Anterior portion of legs

Major muscles: Quadriceps

Description: Extension of knees

Starting position:

Knees at approximately 90 degrees of flexion with ankle in dorsi flexion (at 90 degrees). Hold support to maintain trunk and back support during the lift.

Final position:

Extend knees (to full range of motion if possible) maintaining ankle in dorsi flexion (90 degrees). Breathe out during the lift.

16. Leg curl

Region: Posterior portion of legs

Major muscles: Hamstring

Description: Flexion of knees at approximately 90 degrees

Starting position:
Knee fully extended (if possible) with ankle dorsi flexion (90 degrees). Hold support and maintain back flat against support.

Final position:
Flex knees to 90 degrees (approximately) maintaining back flat against support. Breathe out during knee flexion.

17. Standing leg curl

Region: Legs

Major muscles: Hamstrings

Description: Flexion of knee

Starting position:

Standing, with feet shoulder-width apart, close to a wall in case of support. Alternatively, hold a chair for support.

Final position:

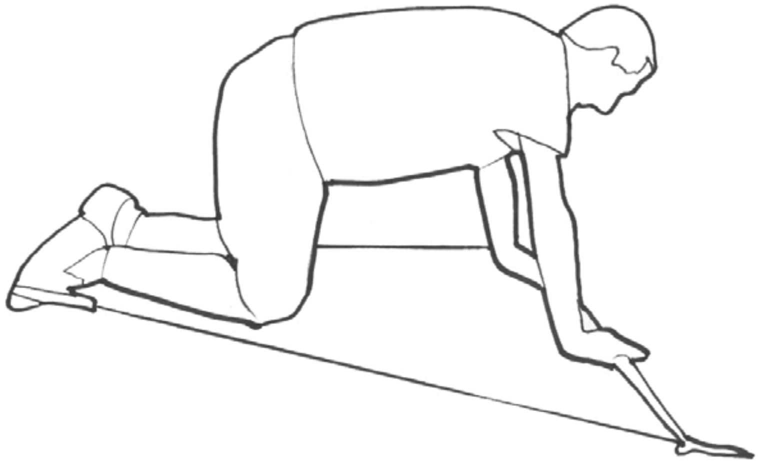
Flex one knee to approximately 90 degrees. Breathe out when lifting the leg.

18. Kneeling leg extension

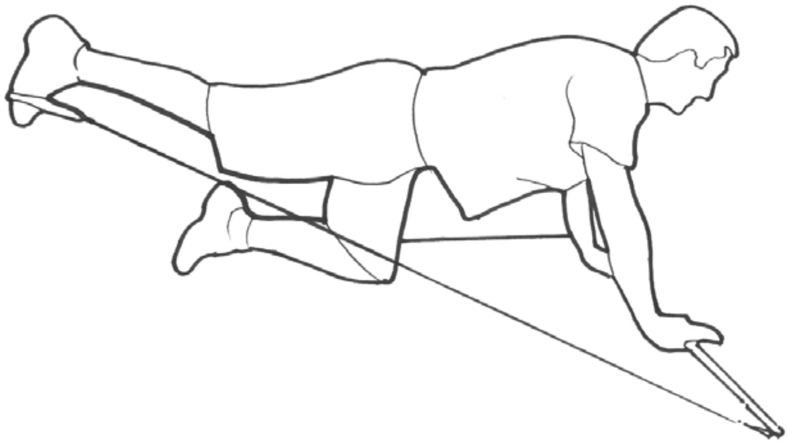
Region: Legs and gluteus

Major muscles: Quadriceps, hamstrings, gluteus and gastrocnemius

Description: Hip and knee extension



Starting position:
On all-fours, with knees at approximately 90 degrees and arms shoulder-width apart.



Final position:
Alternate extension of the knee (without locking the knee) on each leg. Breathe out during extension.

19. Incline leg press

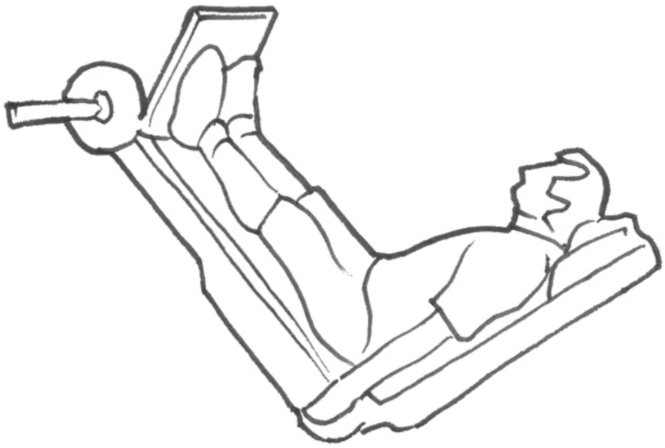
Region: Legs and gluteus

Major muscles: Quadriceps, hamstrings, gluteus and gastrocnemius

Description: Hip and knee extension

Starting position:

Flex knees at approximately 90 degrees (if possible) with back flat and feet separated, shoulder-width apart.



Final position:

Extend the knees (without locking the knees). Breathe out and maintain the feet flat on the platform.

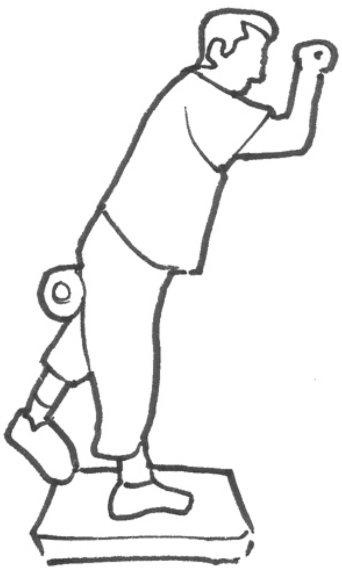
20. Hip extension

Region: Hip

Major muscles: Gluteus and hamstrings

Description: Unilateral hip extension

Starting position:
Stand upright, above supporting leg. Opposite leg flexed, at approximately 90 degrees, with ankle dorsi flexed (at approximately 90 degrees). Machine should not be under load at starting position.



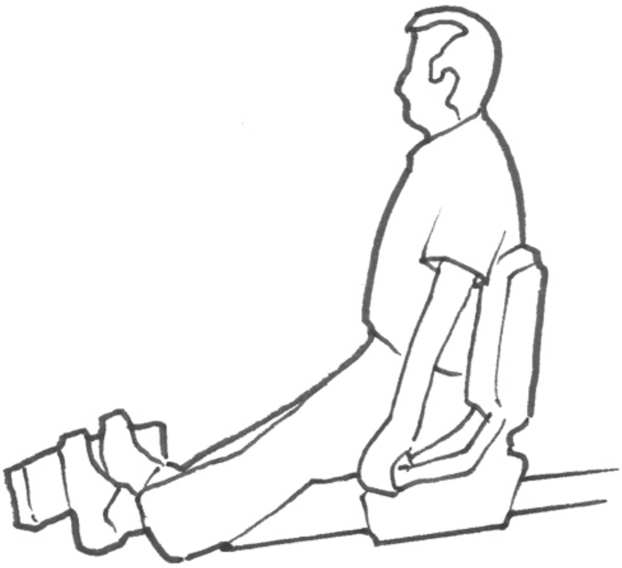
Final position:
Fully extend hip and knee, maintaining body position aligned with supported leg. Breathe out during extension (pushing leg back).

21. Seated calf raise

Region: Legs

Major muscles: Gastrocnemius and soleus (triceps surae)

Description: Extend the feet and point the toes (plantar flexion)



Starting position:
Dorsi flexion of ankle (approximately 90 degrees), maintaining back flat against the support.

Final position:
Extend the feet (plantar flexion) and point the toes while breathing out.

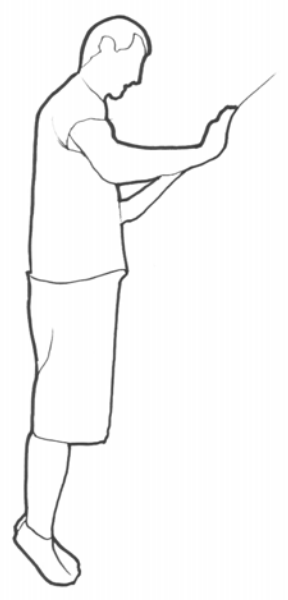
22. Calf raise

Region: Legs

Major muscles: Gastrocnemius and soleus (triceps surae)

Description: Extend the feet and point the toes (plantar flexion)

Starting position:
Standing on a step with a wall as support, dorsi flexion of ankle (approximately 90 degrees), with body upright.



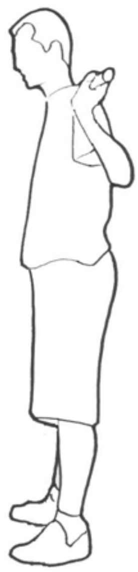
Final position:
Extend the feet (plantar flexion) and point the toes while breathing out.

23. Squat

Region: Legs and gluteus

Major muscles: Quadriceps, hamstrings, gluteus and gastrocnemius

Description: Hip and knee extension



Starting position:

Stand upright with bar just above the scapulas (just below shoulders). Feet flat on the floor, shoulder-width apart.

Final position:

Flexion of knees and hip at no more than 90 degrees. Return to starting position by extending knee and hip (breathing out) on the way up.

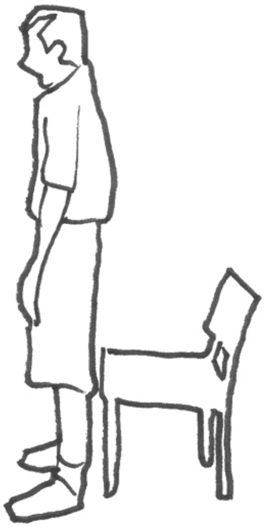
24. Chair rise

Region: Legs

Major muscles: Quadriceps, hamstrings and gluteus

Description: Knee and hip extension.

Starting position:
Seated, with hands on knees. Progress to arms across chest.



Final position:
Stand, by extending hip and knees, with assistance of hands on knees. Progress to standing without assistance. Breathe out when standing.

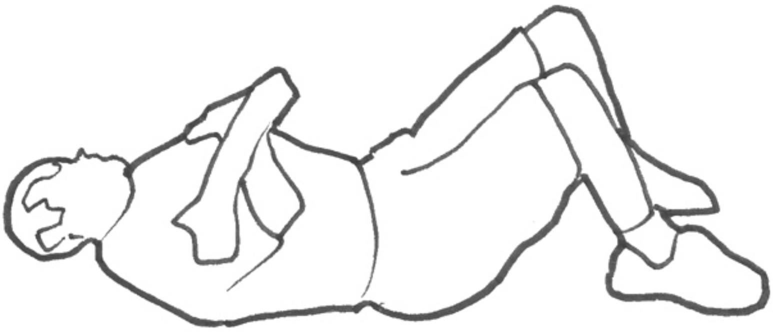
Resistance exercises: Core stability

25. Abdominal crunch (difficult 1)

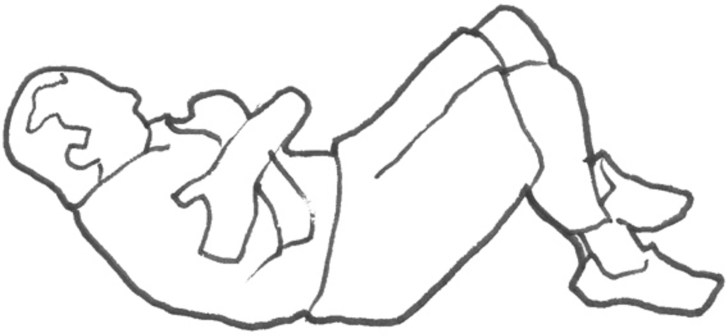
Region: Trunk

Major muscles: Rectus abdominis, internal and external oblique

Description: Partial flexion of trunk



Starting position:
Hip and knee flexion with arms crossed together over the trunk. Lower back flat on the floor. For increased difficulty place hands on head.



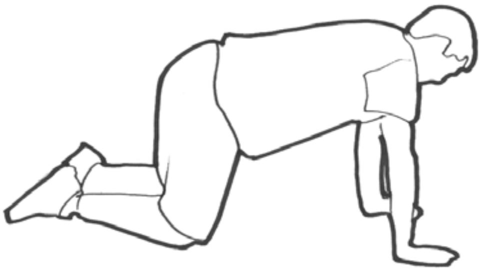
Final position:
Partially flex the trunk, maintaining the lower back flat on the floor during the lift. Breathe out on the way up and then return to starting position.

26. Bird-cat

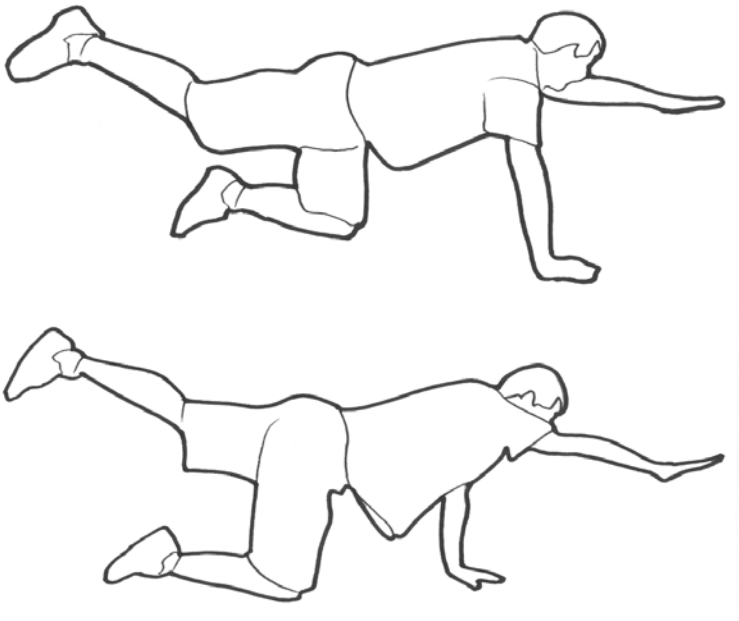
Region: Trunk

Major muscles: Rectus abdominis, internal and external obliques, and erector muscles of the spine

Description: Hip extension and opposite shoulder extension



Starting position:
Start on all fours and then extend one leg while supporting the trunk with both arms on the floor.



Final position:
Partially lower the leg and extend opposite arm. Maintain the position for a few seconds (< 5 seconds). Change sides and repeat the same position. Maintain normal breathing.

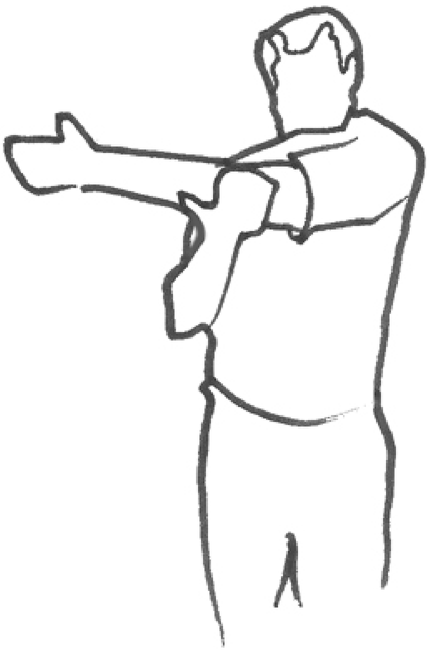
Flexibility exercises

27. Shoulder stretch

Region: Arms

Major muscles: Deltoids

Description: Unilateral adduction of shoulders



Technique:
Pull arm across chest, elbow just below shoulder line. Hold the position for several seconds (15-30 seconds). Perform the exercise for both sides.

28. Triceps stretch

Region: Arms

Major muscles: Triceps brachii

Description: Shoulder extension and elbow flexion

Technique:

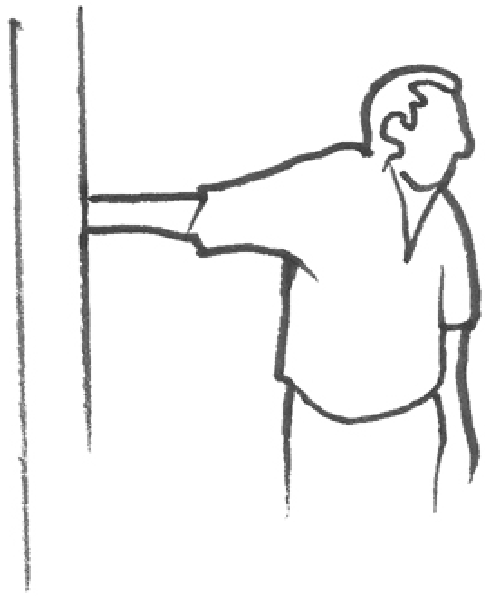
Raise arm, bend elbow and point forearm down the back. Pull arm, using elbow, down the back. Hold stretch for 15-30 seconds. Perform the exercise for both sides.

29. Pectoral and biceps stretch

Region: Upper body

Major muscles: Pectoralis major and biceps brachii

Description: Unilateral abduction of shoulder and elbow extension.



Technique:

Abduction of shoulder with a straight or bent arm at shoulder height. Partially rotate trunk and neck to the opposite side. Hold stretch for 15-30 seconds. Perform for both sides.

30. Quadriceps stretch

Region: Legs

Major muscles: Quadriceps

Description: Knee flexion

Technique:

Hold foot (with opposite arm of stretching leg) by flexing the knee and maintaining trunk straight. Hold stretch for 15-30 seconds. Perform for both sides.

31. Calf stretch

Region: Legs

Major muscles: Gastrocnemius and soleus

Description: Ankle dorsi flexion

Technique:

Pushing wall or fixed support with front knee partially flexed and back leg (stretching leg) completely extended. Perform for both sides.

32. Hamstrings and lower back stretch

Region: Legs and trunk

Major muscles: Hamstrings and lower back

Description: Hip flexion, knee extension and trunk flexion

Technique:

Sit with one leg on bench (knee extended). Pull the elastic, tight, around foot, maintaining the trunk upright and straight. Loosen the elastic band by flexing the trunk forward. Hold position for 15-30 seconds. Perform on both sides.

33. Lower back stretch

Region: Trunk

Major muscles: Lower back and hamstrings

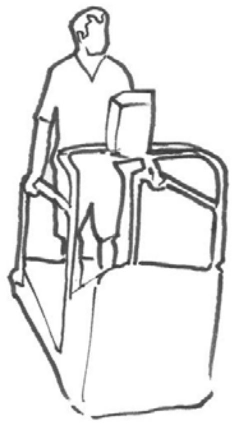
Description: Seated trunk flexion

Technique:

Sit with feet on the ground and knees partially bent. Curl (flex) the trunk forward and hold for 15-30 seconds.

Aerobic exercises

34. Aerobic exercises



Exercise and cancer treatment

Why physical activity for cancer patients?

The number of people being diagnosed, treated for and surviving cancer is increasing in Australia.[3] In Australia it was estimated that there were 106,000 new cases of cancer diagnosed in 2006.[3]

The five leading cancers by incidence – prostate, bowel, breast, melanoma and lung – account for more than half (50 per cent) of all cancers diagnosed in Australia (Figure 1).[3] Five-year survival for lung cancer remains poor (11-14 per cent), but for the other common sites prognosis is relatively good. In the case of breast (84 per cent), prostate (83 per cent) and melanoma (90-95 per cent) five-year survival exceeds eighty per cent.[4]

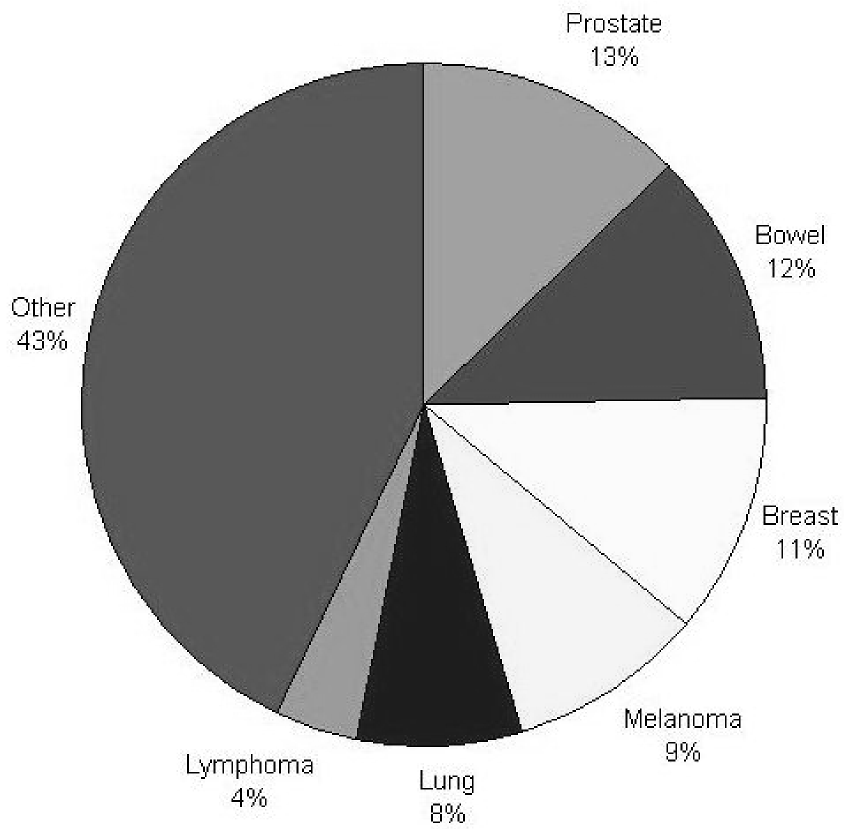


Figure 1: Cancer Incidence, Australia 2003[3]

While improvements in the treatments for cancer (including surgery, chemotherapy and radiation therapy) have led to better prognosis, fatigue during treatment remains a concern.[5] Fatigue affects the majority of patients during radiation therapy and/or chemotherapy and reduces physical function and quality of life.[5, 6] It is now understood that a lack of physical activity before and during treatment contributes to the fatigue observed at this time (Figure 2).[7-10]

Several studies have demonstrated the benefits of physical activity during and after cancer treatment. Positive outcomes include an amelioration of fatigue as well as improving physical performance and quality of life.[8, 10]

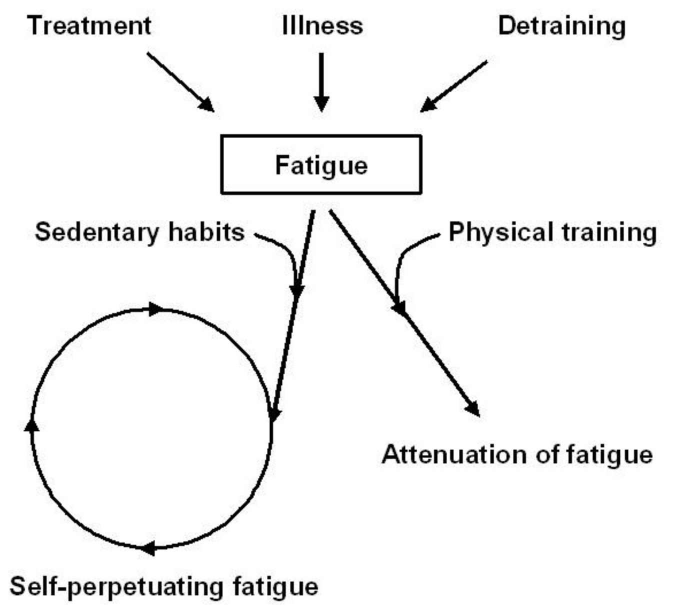


Figure 2: Physical activity and the cycle of fatigue[9]

The majority of the exercise intervention studies undertaken with cancer patients have focused on aerobic training, with few studies using the combination of aerobic and resistance exercises or resistance exercise alone.[2] Importantly, most of the experimental exercise studies undertaken with cancer patients have targeted those with breast cancer, with few studies focusing specifically on other types of cancer.[2]

Recent studies and reviews have suggested the importance of resistance exercise on counteracting the changes in body composition and long-term loss of bone-mass that accompany cancer and traditional treatments.[2, 8] The term *anabolic exercise* is also often used when referring to resistance training to better reflect the aim of the exercise prescription. That is, exercise designed to maximise the benefits on muscle, bone and the immune, endocrine and nervous systems.

In Australia, cancer is predominantly a disease of older adults, with 78 per cent of cancers in 2003 occurring in people over 55 years of age.[11] There is extensive scientific evidence supporting the benefits of physical activity for older adults.[12-16] Anabolic exercise is the most effective method available for improving muscle strength and increasing lean tissue mass in different populations, including frail older adults.[15, 17, 18] Anabolic exercise can also counteract the side-effects of cancer therapy (eg Androgen Deprivation Therapy [ADT] for prostate cancer) by increasing muscle function, lean tissue mass and bone mineral density with subsequent reduction in levels of fatigue.[15, 17, 19]

Generally, exercise prescription involves the modification of training variables, including:[1]

- Mode – aerobic, resistance or flexibility.
- Frequency – how many times, usually in a week, the activity is done.
- Intensity – how hard the activity is.
- Duration – time spent doing the activity.

In addition, resistance training has a number of specific training variables, including:[1, 18]

- Repetitions – number times, in each set, the weight is lifted
- Sets – number of times each exercise is done (eg three sets of eight repetitions)
- Volume – a function of the intensity (weight), repetitions and sets performed.
- Rest – time between sets
- Velocity – speed of each repetition

Currently, only scant information on these program variables is available for cancer patients undertaking exercise programs.[20] Some of these training variables have been examined in untrained older adults. Favourable responses in strength and function result from a variety of training regimens; even those at relatively low- to moderate-intensity, frequency and volume.[13, 15, 18]

Considering the detrained state and high levels of fatigue of many cancer patients, it is likely that resistance training would be beneficial.[8] Even a training program consisting of low- to moderate-intensity, volume and frequency exercise will lead to beneficial physiological and psychological adaptations for most patients.[8] Physical activity, of any type, has been demonstrated to lead to improvements in fatigue, functional capacity, quality of life and perhaps even survivability for cancer patients.[8, 10]

Exercise as part of cancer treatment

Most of the research on physical activity and cancer has been focused on prevention or reduction of risk. Evidence on the effectiveness of exercise programs for cancer patients is a new and active area of researched. Even with incomplete evidence, healthcare providers may reasonably conclude that exercise and physical activity has a beneficial role in cancer treatment.[8] Exercise and physical activity should be seen as a complementary and self-empowering intervention that needs to be incorporated into the treatment and support of cancer patients.

Three phases may be considered when contemplating exercise or nutrition prescription in cancer patients and survivors. Phase one is diagnosis, treatment and recovery; phase two is life after recovery and, unfortunately some patients enter phase three, living with advanced cancer.[8]

Treatment and recovery

During treatment, body-weight control and energy-balance stability are important. A number of studies, mainly with breast cancer or bone marrow transplant patients, have shown that exercise enhances the physical wellbeing, functional capacity and quality of life for cancer patients.[21] A principal ethos underlying the Hippocratic approach to medicine is *primum non nocere*, or first do no harm. There is no biological evidence to date to support any concerns. The evidence shows that there is neither additional risk of harm to the patient nor any adverse interactions with treatment when exercise is individually prescribed and supervised.[8]

People actively engaged in physical activity or exercise prior to diagnosis should be encouraged to continue as much as possible, within the limitations of the treatment plan. Previously sedentary patients should be encouraged to commence slowly and progress steadily under a supervised exercise program. With older patients care should be taken to avoid interaction or increasing risk of compounding chronic illnesses such as arthritis, cardiovascular disease, osteoporosis or falls. The vast majority of research has reported very positive outcomes for these illnesses even in the very old as a result of exercise.

Fatigue is usually the biggest barrier to patient participation in an exercise program. Excessive fatigue may be cancer related or treatment related and is a commonly reported symptom of treatment.[5, 6] Regular goal setting and adjustment of the intensity and frequency of the exercise prescription should be considered when fatigue is evident. Monitoring of the patient for changes in levels of fatigue or indicators of lethargy is fundamental.

Post-recovery

Once clinical treatment is complete many patients are regarded as either stable or disease-free. After cessation of treatment however, patients are at increased risk of recurrence, second cancers and the side-effects of treatment.[22] Cancer survivors are also at additional risk of other chronic conditions such as cardiovascular disease and type 2 diabetes.[22] Most cancer patients experience significant life changes during and after treatment. These changes impact on future healthcare needs and their personal lives.[23] Despite this, cancer survivors display similar health behaviours to the general population.[24]

The focus of exercise after cancer treatment is lifestyle and long-term behaviour change. Benefits such as improved cardio-respiratory fitness, strength and functional capacity, quality of life, enhanced mood states and self-esteem are as important for cancer survivors as for patients.[8] Accordingly, weight management, improving and maintaining body composition, and retaining functional capacity are the goals of a physical activity program in this group. The reduction of risk for cardiovascular diseases, diabetes, and secondary cancer are important benefits of participation in exercise and physical activity for cancer survivors. Survivors in this stage may benefit from the professional help of an exercise professional, Dietitian and/or a General Practitioner to oversee the transition to a healthier lifestyle.

Evidence is emerging that physical and emotional wellbeing, as an outcome of exercise prescription, may improve overall survival.[8] Quality of life and improvements in wellbeing may be the best markers of the benefits of an exercise program in cancer survivorship.

Advanced cancer and palliation

People living with advanced cancer frequently experience problems with inadequate nutrition, loss of functional capacity and difficulty maintaining lean body mass (cachexia). Even for patients with advanced cancers, a mild physical activity or exercise program can assist in improving appetite, reducing nausea and combating constipation and dehydration. An effective stretching or range-of-motion program can help to maintain body function and resistance exercises minimise muscle wasting, or loss of lean body mass, and have a positive impact on function. Exercise also benefits psychosocial health by improving quality of life and self-efficacy.[8]

Palliative patients can also benefit from an exercise program with the greatest benefits being the slowing of functional losses and retention quality of life.[8]

Role of the health professional

When faced with the task of designing an exercise program for a cancer patient a health professional may feel daunted by the scope of medical possibilities. This is not unreasonable given the shear size of the field referred to as 'cancer'.[20] The variability in cancer sites and treatments as well as individual side-effects means that a simple dose-response to exercise prescription is not only unlikely, but would also have limited benefit for the patient. A close collaboration between the exercise provider and medical, nursing and allied health staff is essential in effective exercise prescription for each individual.

> *"Given the number of cancer types and the wide variance in treatments for each type, it may not be reasonable to expect that 'overall' evidence-based guidelines for cancer patients can be developed"*.[20]

Patients and Oncologists often have different concerns and priorities about the management of treatment-related side-effects. Effective management of fatigue is considered important by patients and health professionals.[25]

Oncologists

Whilst in treatment or lead-up, the senior clinician is the Oncologist. Any exercise prescription should be discussed with the Oncologist, particularly any potential for conflict between an exercise plan and the treatment plan. The Oncologist is responsible for providing medical consent and, as part of the treatment team, outlining any potential complications. The inclusion of an exercise professional into the care team is likely to be met with a generally positive outlook by both Oncologists and patients.[26]

General Practitioners (GPs)

The majority of participants in an exercise program will be patients who are no longer receiving active treatment. For these patients their GP may be best placed to provide medical consent, medical and family history and advice on potential complications. The GP should be involved in the exercise prescription for the cancer patient from the beginning. Exercise counselling conducted by GPs reinforces the belief that physical activity is beneficial. Patients show better compliance and adherence to programs and are more likely start a program that has GP support.[27-29]

Exercise and treatment side-effects

There do not appear to be any specific negative interactions between exercise and treatment outcomes in cancer patients. Treatment-related side-effects, such as fatigue, anaemia and lymphoedema will influence a patient's participation in an exercise program, but should not exclude them. It is recommended that exercise professionals proceed with caution and maintain a close association with each patient's Oncologist and/or GP to manage potential interactions.

Lymphoedema

Stretching programs and range-of-motion (ROM) exercises are recommended in the presence of any lymphoedema.[8] Recent studies, though small in size, show that aerobic exercise and resistance training do not increase lymphoedema and that early inclusion of exercise in recovery may lower the risk and/or severity of lymphoedema experienced.[8]

Anaemia

Anaemia is another common side-effect of cancer treatment. [30] Monitoring of haemoglobin and/or ferritin levels is usually done by the treating Oncologist or GP. If anaemia is severe (≤ 80 g/L), it is recommended that exercise is delayed.[9] For less severe anaemia (> 80 g/L), it may be wise to delay or reduce volume and intensity of exercise prescribed until anaemia is corrected. Aerobic activity has been shown to be a potent stimulus for red blood cell production, which may improve anaemia. It is important to ensure the patient is eating a nutritious diet to supply all the necessary nutrients.

Compromised immunity

Some cancers and treatments have a negative impact on the immune system. Lymphoma, chemotherapy and bone marrow transplant all directly impact on the lymphatic and immune systems. When the immune system is compromised there is an increased risk of infection. Good hygiene is important.

It may be necessary to allow up to twelve months following bone marrow transplant before exposure to public training venues. If the patient is neutropaenic avoid public gymnasiums and training venues. When leukocyte (white blood cell) count is low it is important to reduce the risk of cross-infection by limiting physical interpersonal contact and cleaning any equipment prior to use.

Lowering the intensity and volume of the exercise program is a good way to allow the patient to maintain some physical activity without overloading the immune system. Ongoing training can improve immunity and lymphatic circulation.

Radiation therapy

Patients who are currently undergoing radiation therapy should avoid water-based exercise programs. Radiation sites can be extremely sensitive or burned. Select specific activities that limit abrasion or rubbing of clothing around affected sites. Consider and test for skin sensitivity if any form of massage is incorporated into the exercise program.

Fatigue

Fatigue is one of the most frequently reported side-effect of all cancer treatments.[5] Fatigue can be managed and accommodated in an exercise regime by careful monitoring of the patient's condition.[9] Individual adjustment of the exercise intensity and volume encourages the patient to continue to participate. Stretching, range-of-motion (ROM), yoga and tai chi style activities all serve to enhance functional capacity and maintain strength whilst avoiding excessive fatigue during the exercise program (Figure 3).[10]

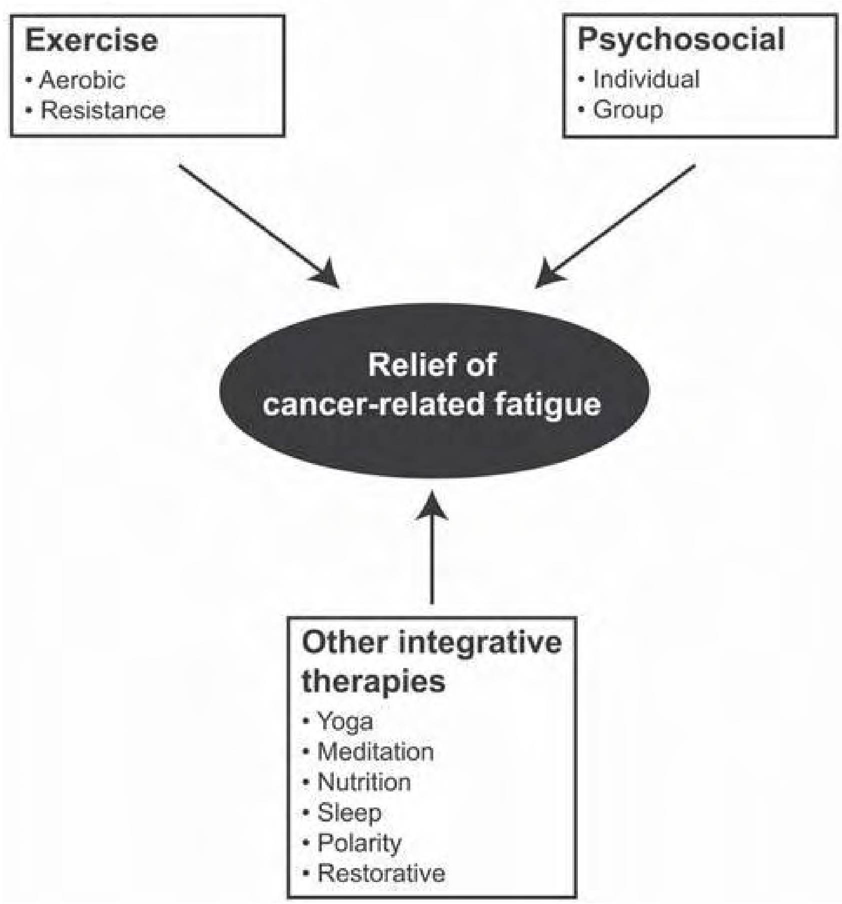


Figure 3: Management of cancer-related fatigue.[10]

To effectively combat fatigue, an exercise program should include aerobic, flexibility and resistance training components. Patients may tolerate resistance training better and, if fatigue is severe, resistance training may be more effective because of the shorter time.

Visualisation and relaxation techniques should be incorporated into a comprehensive program. These complementary therapies allow the patient to develop a sense of body awareness and will help with the psychosocial components of cancer-related fatigue.[10]

Effectively combining exercise and treatment

Interactions between cancer treatment and exercise programs are unlikely; however individuals react differently to standard treatment regimes. It is preferable to be cautious and limit exercise frequency and intensity whilst in a specific treatment cycle. A great benefit of communication with the Oncologist is in determining start and end points of various treatment cycles. These allow for careful planning to prepare patients for treatment and identify windows of opportunity for exercise.

In this sample chemotherapy cycle (Figure 4), the patient is to undergo a three-cycle treatment regimen, consisting of one week of daily intravenous (IV) injections and two weeks of recovery, repeated three times. In the treatment week the patient may experience severe side-effects and will spend long periods in the hospital and therefore have limited time for exercise. This can be scheduled as exercise recovery. As the patient recovers from the worst side-effects of the treatment it may be possible to increase the intensity and/ or frequency of exercise. This example serves only to illustrate the need for the exercise professional to have communication with other care providers in order to adjust the exercise prescription in an individualised managed care plan.

Intensity	*Low*	*Mod*	*High*	*Low*	*Mod*	*High*	*Low*	*Mod*	*High*
Sessions	2	2	3	2	2	3	2	2	3
Treatment	*IV*	*Off*	*Off*	*IV*	*Off*	*Off*	*IV*	*Off*	*Off*

Figure 4: Sample weekly plan integrating exercise and treatment.

Principles of exercise prescription

The aim of this section is to provide patients and allied health professionals with knowledge of the basic principles of exercise prescription, and in particular resistance training. Exercise programs can be implemented in a range of settings and may not always have personnel with qualifications and experience in exercise physiology. This section is intended to provide a level of knowledge sufficient to understand the principles underlying the exercise programs presented.

Goals of exercise prescription

Adaptation

If an elevator in a building was required to lift its maximum capacity from the ground floor to the roof top each day it would not increase in its performance and be able to carry more people. It is more likely to deteriorate, its bearings will wear, the electric motor will become less efficient, and performance overall will decline. The human body is a very different machine because it has the ability to respond to a stimulus – such as the work of running or the stress of lifting weights – by altering its structure and function to be able to better perform that activity in the future. This is termed adaptation and it is the basis of physical training.

For adaptation to occur the body must have a biological mechanism enabling it to make the adaptation. For example, shortening the length of the bones of the upper arm and forearm would greatly increase the amount of weight that could be lifted in the bench press due to increased mechanical advantage but it is not a process of which the body is capable. Increasing the size of the muscles that perform the bench press would also allow the body to lift more weight and this is certainly an adaptation that is within our capabilities. Adaptation is very specific to the stimulus such that resistance training produces an increase in muscle size whereas swimming produces an increase in the heart's ability to pump blood.

Overload

A training adaptation occurs in response to an overload – a situation in which the body is required to perform work beyond which it is accustomed to or is normal. In terms of strength training this overload is the requirement of the neuromuscular system to exert forces that are more than that required during the activities of daily living. For aerobic training, it is an overload on the cardiopulmonary system which provides oxygen to working muscles. In general, the extent of the training adaptation is related to the degree of overload so greater overload results in more rapid and larger biological changes. Overload that is too great increases the risk of injury. It is important to find the overload that strikes a balance between optimal gain and risk of injury.

Modes of exercise

Aerobic exercises

Fitness, or cardiorespiratory capacity, relates to the ability to perform large-muscle dynamic, moderate-to-high-intensity exercise for prolonged periods.[1] Exercise prescription for cardiovascular fitness is based on the intensity, duration and frequency of the activity.[1] Activities prescribed most frequently include:

- Walking or hiking
- Cycling
- Jogging
- Running
- Rowing
- Swimming
- Ski paddling

It is recommended that individuals choose activities that they enjoy and are enthusiastic to continue.

Resistance exercises

Improvements, or maintenance, of muscular strength and endurance allows the activities of daily living to be performed with less physiological stress through the lifespan.[1] Muscle function, as well as bone density and connective tissue integrity, is improved by resistance (weight) training.[1] Common resistance exercises include:

- Upper body exercises
  - Chest press
  - Lat pull-down
  - Seated row
  - Shoulder press
  - Lateral arm raise
  - Biceps curl
  - Triceps extension
- Lower body exercises
  - Leg extension
  - Leg curl
  - Leg press
  - Squat
  - Calf raise
- Trunk exercises
  - Abdominal crunch
  - Back extension
  - Single leg raise
- Core stability exercises:
  - Bird-cat

Flexibility exercises

Maintaining maximal range-of-motion (ROM) in all joints is important for optimal musculoskeletal function.[1] A reduction in muscular strength and flexibility is a common cause of a loss of independence in elderly people. A comprehensive flexibility program, in combination with resistance and aerobic exercises, helps to improve or maintain normal activities of daily living. Common flexibility exercises include:

- Upper body and trunk stretches
  - Triceps
  - Biceps
  - Pectorals
  - Latissimus dorsi
  - Neck (cervical spine muscles)
  - Lower back
- Lower body stretches
  - Gluteus
  - Quadriceps
  - Hamstring
  - Calf

Exercise intensity

The intensity of an exercise session refers to how hard someone is pushing themself. Intensity and duration of exercise determine the total energy requirement of a training session.

Oxygen uptake (VO_2)

Maximal oxygen uptake (VO_{2max}) is accepted as the standard measure for aerobic fitness.[1] VO_{2max} is usually expressed in litres of oxygen per minute per kilogram of bodyweight ($L.min^{-1}.kg^{-1}$). It is a measure of the body's capacity to transport and utilize oxygen. As intensity increases, more oxygen is required by exercising muscle. The relative intensity of exercise can be expressed as a proportion of maximal oxygen uptake ($\%VO_{2max}$).

Heart rate (HR)

Heart rate is extensively used as a guide to monitor exercise intensity due to the close correlation with VO_{2max}.[1] The simplest and most often used heart rate assessment is the proportion of maximum heart rate ($\%HR_{max}$). Also used is per cent of heart rate reserve (%HRR).

$$HR_{max} = 220 - \text{age (in years)}$$
$$\%HRR = [(HR_{max} - HR_{rest}) \times \%Intensity] + HR_{rest}$$

The proposed intensity for cancer patients and survivors during aerobic activities is 60-90 per cent of HR_{max} (Figure 5)or 40-85 per cent of HRR.[2]

Target HR for cancer patients (60%–90%)

	AGE									
	20	25	30	35	40	45	50	55	65	70
100%	200	195	190	185	180	175	170	165	155	150
90%	180	176	171	167	1162	158	153	149	140	135
80%	160	156	152	148	144	140	136	132	124	120
70%	140	137	133	130	126	123	119	116	109	105
60%	120	117	114	111	108	105	102	99	93	90
50%	100	98	95	93	90	88	85	83	78	75

Figure 5: Target heart rate for cancer patients.[2]

It is important to monitor heart rate during the exercise sessions to ensure adequate intensity without working too hard. The simplest method is to measure the pulse rate at the wrist counting the number of beats for say 15 seconds and then multiplying by four to calculate beats per minute. Electronic heart monitors are convenient and relatively inexpensive. They are available from most sports shops.

Rating of perceived exertion (RPE)

Rating of perceived exertion allows individuals to subjectively rate intensity during exercise, taking into account fitness level, fatigue and environmental factors.[1] It is particularly valuable for assessing exercise intensity in individuals who have an altered heart rate responses to exercise (eg cardiac patients on β-Blockers).[1]

The best known and most established RPE scale is the Borg scale (Figure 6)[1].

6	No exertion at all	
7	Extremely light (7.5)	
8		
9	Very light	
10		
11	Light	
12		Target for cancer patients
13	Somewhat hard	
14		
15	Hard (heavy)	
16		
17	Very hard	
18		
19	Extremely hard	
20	Maximal exertion	

Figure 6: Borg's rating of perceived exertion scale.[1]

More recently the OMNI scale has been developed. It uses verbal and pictorial descriptors along a numerical scale of 0-10 to rate an individual's perceived exertion. This scale has been successfully validated with children and adults from both sexes during aerobic and resistance exercise (Figure 7) and may also be an option for exercise sessions with cancer patients (see page 101).[31-33]

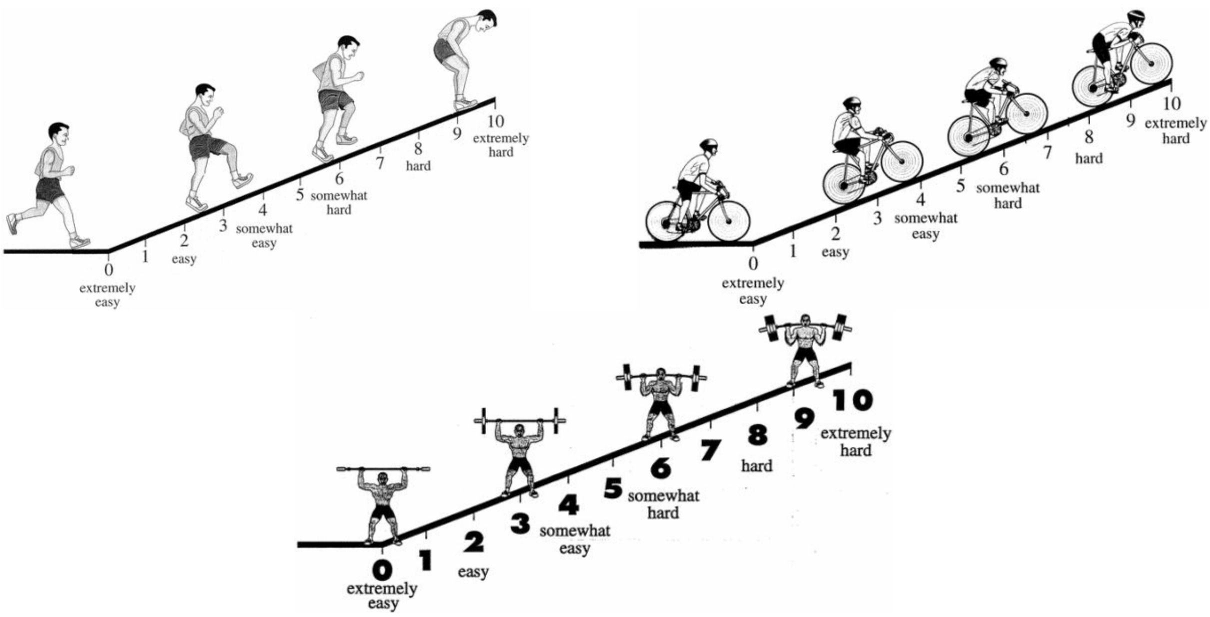


Figure 7: (Clockwise from top left) OMNI-walk/run, OMNI-cycle ergometer and OMNI-resistance.[31-33]

Repetition maximum (RM and %1RM)

Intensity during resistance training refers to the relative load or resistance that the muscle is working against. That is, the proportion of the muscle's maximum strength that is to be exerted during the each movement. One method of describing the intensity of resistance training is how many repetitions can be completed before muscular failure occurs and the load can not be lifted again (#RM). The maximum weight a person can lift only once is 1RM. It follows then that a 6RM load is a higher intensity (heavier) than a 10RM load. Another common method for prescribing the intensity of resistance exercise is as a proportion of the maximum load that the individual can lift only once (%1RM).

When training for strength there appears to be a minimum load below which no training adaptation will result. This varies depending on training state, muscle group and between individuals. The lifting of very light loads without maximal effort is ineffective for increasing strength and muscle power.

For cancer patients the intensity must be sufficient to produce structural and functional improvements or at least reduce the decline. Initially, for a patient who has not performed resistance training in the past 12 weeks (three months) intensity should be kept low to reduce muscle soreness. Intensity of 8-12 RM is appropriate, increasing over the first 4 weeks to an intensity of 6-10RM. For resistance training to be effective the intensity should be no lighter than 12RM.

Frequency

The number of training sessions completed each week is termed frequency. For resistance training, one session per week is not sufficient. The target should be a minimum of two sessions per week with a goal of three to four sessions of resistance training on non-consecutive days.[1]

The optimal training frequency for cardiorespiratory fitness in healthy adults is three to five times per week.[1] De-conditioned individuals are likely to improve their condition with lower training frequencies.[34]. The recommendations for cancer patients are consistent with the recommendations for healthy adults.[2]

Training volume

Training volume is the total amount of work that is completed during an exercise session. For resistance training, it is a function of the intensity (load), repetitions and sets. For aerobic training it is defined by the duration and the intensity.

Aerobic training volume

Aerobic training volume is commonly expressed as metabolic equivalents (METs), which is 4.184 $kJ.kg^{-1}.h^{-1}$.[35] One MET is equivalent to the resting metabolic rate obtained during quiet sitting.[35] Similar benefits from aerobic training can be derived from higher intensity and short duration activity or a lower intensity and longer duration program.[1] METs allow the easy comparison of different training regimens.

The duration and intensity of aerobic exercise recommended by the American College of Sports Medicine (ACSM) for healthy adults is also suitable for cancer patients. That is 20-60 minutes of continuous or intermittent (minimum of 10-minute bouts accumulated during the day) of aerobic exercise.[1, 2]

Resistance training volume

Many resistance program variables can be manipulated to provide various forms of overload and thus specific training adaptations.

Repetitions
The basic unit of a resistance training session is the *repetition*. For a given training movement a repetition is the completion of one complete cycle from the starting position, through the end of the movement and back to the start.

Sets
When strength training, a series of repetitions is normally completed and this is termed a *set*. During the set, the neuromuscular system will fatigue and performing the exercise will become more difficult. At the completion of the required number of repetitions or when the person is no longer able to complete any more repetitions, the set is completed. The person then waits until the neuromuscular system recovers and then completes further sets of exercise.

Recovery
The period between sets is called rest or *recovery* and is another important program variable which can be altered to achieve specific training goals.

Sessions
During an exercise *session* a series of sets of different exercises will be completed. The term session refers to the block of time devoted to the training.

For cancer patients, 2-4 sessions, on non-consecutive days are recommended. Each session should consist of 3-4 sets of 6-10RM for 6-9 different exercises, with 60-90 seconds recovery between sets. Lower training volumes are more appropriate during initial stages of training.[2]

Recommended training volumes for cancer patients

Aerobic exercises:
Aerobic training includes 20-60 minutes of continuous or intermittent (minimum of 10-minute bouts accumulated during the day) of aerobic activity training at 50-90% HR_{max} or 40-85% HRR.[2]

Resistance exercises:
Anabolic resistance exercises include performing 1-4 sets per muscle group training at 50-80% of 1-RM or 6-12RM.[2]

Aerobic exercise:
3-5 days/week for 20-60 continuous minutes at a moderate-intensity level (60-90% of maximal heart rate).

Resistance training specifics

Progressive resistance training

In order to stimulate an adaptation in the neuromuscular system, training must place the system under greater stress (load) than it is accustomed to. Overload is when the muscles of the body exert forces at, or near, their maximum potential. The neuromuscular system adapts to training with increases in muscle size, improvements in coordination, and better motor unit recruitment and firing efficiency. The end result is an increase in strength.

As strength increases, the initial overload becomes less relative to the increased maximal strength capability. The stimulus to adapt is declining if one continues to train with the same loads. To continue to elicit gains in muscle strength and power, the loads must be progressively increased so that the relative intensity remains high enough to provide an adequate overload. By expressing intensity as per cent of maximum (%1RM) or by specifying a load which can only be lifted a given number of times (6-12RM), the overload is progressive. As strength increases, so must the training loads to maintain relative intensity.

Window of adaptation

The degree of adaptation – increase in strength or aerobic capacity – that can be achieved from training is determined to a large extent by how well that particular physical characteristic is already developed in the individual. There are biological limits to how much the body can adapt and therefore how fit, strong or flexible a person can become. Adaptive capacity should be thought of as a continuum from someone with no exercise experience to an elite athlete.

For example, someone with no resistance training background the window of adaptation is quite large. Starting a training program will elicit large and rapid increases in muscle strength. As they become stronger and move towards their potential the window shrinks and gains will become harder to achieve.

The window of adaptation is important for a couple of reasons:

1. First, a beginner will increase in strength and power with even the most basic resistance training program. They will then plateau and gains will become harder to produce. Here, more innovative programming is required.
2. Second, after several years of resistance or aerobic training the person will adapt very quickly and with limited performance gains to a new training program and so variation in programming becomes much more important to maintain interest and any gains.

Specificity

Adaptations by the neuromuscular system and thus improvements in performance are specific to the resistance training performed. It is important to consider this when designing an exercise program for a cancer patient where maintenance of functional capacity is a primary goal for preserving the activities of daily living. Avoiding falls is another goal of the exercise program and should be considered during exercise prescription.

Muscle groups involved in the exercise
Generally strength will only increase in the muscle groups used in the training.

Movement pattern
A considerable part of strength adaptation is due to changes to the neural (nerve) activation of the muscles. Resistance exercises should reflect, as closely as possible, the specific movement that is the target of the exercise. The further the exercise deviates from the specific movement, the smaller the strength increases. This specificity relates to posture, timing of joint movement, and ranges of joint movement.

For example, it has been shown that performing the leg press exercise results in increased strength in that exercise but less strength gain when tested for squat strength which is a very similar but not identical exercise.

Joint ranges of motion
Any strength increases are specific to the joint movement during the exercise. Joint angle specificity is most evident during isometric (static) training. Performing isometric training at a particular angle, for example 90 degrees of elbow flexion, will result in increases in strength. These gains diminish at angles other than the training angle.

For example, quarter squats – where the squat is terminated at a shallow knee angle – will result in a strength increase after training; however the increases in strength diminish with deeper squats.

Velocity of contraction
Velocity specificity of resistance training is currently a contentious issue in resistance exercise. Studies have found that strength increases are specific to the velocity at which one trains. Training at slow movement velocity increases strength at that velocity, but strength at higher velocities, which are more common in sport, is not affected.

Contraction type
Strength increases are specific to type of contraction used during training. Isometric (static) training produces increases in isometric strength but, as mentioned previously, dynamic strength is not altered. Concentric (shortening under load) only training does not produce as large strength gains in eccentric (lengthening under load) strength as a program that includes both concentric and eccentric exercises.

Cross Transfer

In addition to the specific effects of training, there may be small increases in strength in untrained limbs. That is, performing exercises on one limb is associated with increased voluntary strength in the contralateral untrained limb. It appears that the increase in voluntary strength in the untrained limb is attributable to neural adaptation. This is supported by the observation that there is no increase in muscle size, muscle fibre size, or evoked contraction strength in the untrained limb. Interestingly there is an increase in strength in a contralateral limb after training by visualising (not completing) muscle contractions.

Reversal and maintenance

Just as the body adapts to overload by increasing performance it also down-regulates capacity in response to a decrease in physical activity. After the cessation of regular resistance training, strength levels gradually return similar levels from prior to commencement of the program. Importantly, the greater the strength gains attained from training then the longer it takes to return to pre-training levels. Further, one can reduce the amount of resistance training performed each week and still maintain strength at or near the level that was attained through training. In other words, the volume of training required for maintenance of strength is much less than that required achieving a given strength level.

Periodisation

Variation and specificity are two of the most important factors to consider when designing a resistance training program.

To continue to provide an overload, and thus stimulate the body to adapt, training must be novel. The more novel the task, the greater will be the changes in performance capacity towards the new task.

A simple exercise prescription may involve performing 3 sets of 6RM with 6 different exercises. As strength increases then the 6RM load lifted increases and thus the overload is maintained. Such a program however involves no variation and will not prove as effective as a varied program.

Periodisation adds variety, with changes in program characteristics to match changing program goals as well as to provide a change in stimulus for adaptation. The importance of variation in training for maintaining motivation should not be underestimated either. Making the program novel and varying the program parameters is important to avoid boredom and over-training.

Any of the program parameters can be modified to achieve variation in the training. Intensity and volume are obvious choices. It is standard that within each week there are heavy and light days. Also the volume should fluctuate over longer periods of 4-12 weeks or longer. Other subtle changes to exercise may include:

- Varying the depth of the squat or leg press exercise
- Performing explosive exercises
- Slowing the tempo down and using super-slow training
- Combining supersets, pre-fatigue, upper and lower body combinations
- Including heavy eccentric training

The key is to alter the nature of the overload to encourage the neuromuscular system to continue to adapt.

Physiology of exercise

The aim of this section is to provide patients and allied health professionals with knowledge of the basic physiology of exercise, in particular resistance training. Exercise programs are implemented in a range of settings and may not always have professionals with qualifications and experience in exercise physiology.

Muscle contraction types

Muscle tissue has the ability to contract in response to an electrical stimulus, usually carried by the nerves from the area of the brain that controls movement. When a muscle contracts, the force (pulling effect) it develops is applied to the bones it is attached to. The contraction results in a turning effect (or torque) at the joint between the bones. The movement that occurs is dependent on how strongly the muscle is stimulated and therefore how hard it contracts. There are three possible outcomes:

1. Isometric contraction: torque produced by the muscle is opposed by an equal resistance and the joint does not move.
2. Concentric contraction: torque produced by the muscle is more than the resistance to movement and the joint moves as the muscle shortens.
3. Eccentric contraction: torque produced by the muscle is less than the resistance to movement and the joint moves as the muscle lengthens.

Isometric actions are also termed static as no movement occurs. Concentric and eccentric actions are both termed dynamic because movement results.

Motor units

The basic functional unit of the neuromuscular system is the motor unit. A motor unit consists of a nerve and the muscle fibres it innervates. Each motor unit may consist of tens or even hundreds of muscle fibres, and each muscle might include many hundreds of motor units. The nerve running from the brain to the muscle splits once inside the muscle and connects to the surface of the muscle fibres. To produce a muscle contraction, the brain recruits, or activates, a certain proportion of the motor units contained in that muscle. One method of increasing or decreasing the force produced by the muscle is to recruit more or less motor units.

Not all of the motor units in a muscle have an equal chance of being activated during a contraction. Most muscles of the body have a mixture of different types of motor units with specific capabilities:

- Fast twitch motor units contain muscle fibres that are better suited to producing high forces at a fast rate.
- Slow twitch motor units have muscle fibres that are specialised for producing contractions repeatedly or over a long period of time.

Having a mixture of motor unit types in a muscle provides the muscle with both endurance and strength. The *size principle* explains that at low levels of contraction, only the slow motor units are recruited and as force of contraction increases more of the fast motor units are recruited.[36]

Fibre type

Muscle is composed of two broad categories of fibre type, making up the motor units. Classification of muscle fibre type is based on how fast they contract (twitch speed) and how much endurance they possess. The differences between fibre types result from differences in the proteins that make up the contractile machinery, the structures which activate their contraction and the enzymes that limit the chemical reaction. Fast twitch fibres can produce more force per cross-sectional area than slow twitch fibres and the difference in maximal power output is even greater. A person with a high proportion of fast twitch fibres in their muscles will be inherently stronger, faster and more powerful than a person who has predominantly slow twitch fibres.

Muscle cross-section

There is a clear positive relationship between the cross-sectional area of the muscle and the force that the muscle can produce. The larger the muscle then the stronger it is. For this reason, a goal of resistance training programs is to produce hypertrophy – an increase in muscle size.

Firing frequency

Muscle fibres are activated by electrical impulses transmitted down the nerve. The force produced by a single motor unit is increased by increasing the firing rate (frequency) of the impulses down the nerve.

Coordination

Strength is determined by the interaction between the muscles that produce the movement (agonists), muscles opposing the movement (antagonists) and muscles that stabilise (stabilisers) and prevent unwanted movement (synergists) involved in the joint movement. To produce force the agonist muscles must contract and there must be a complementary relaxation of the antagonists. Developing coordination is a learned skill and leads to increased strength. This is why there is often a rapid increase in strength when someone initiates a resistance training program. The nervous system adapts quickly but these large increases can only be achieved in the first few weeks.

The nervous system has a number of feedback mechanisms on muscle forces, joint position, and muscle length changes. These are necessary so movement can be monitored and to prevent injury by limiting the contraction force of the muscles. Resistance training acts to modify the influence of these reflexes and this contributes to strength increases.

Deconditioning

Conditioning is an indication of how adapted an individual is to a specific task. Put simply it indicates how able a person is to perform functional tasks. This term is often used in relation to athletes' aerobic or anabolic conditioning for a sport. In every day living each person also needs a certain level of conditioning, both aerobic and anabolic, in order to perform activities of daily living, work and leisure. Any drop in a person's ability to perform activities of daily living, or increased difficulty completing certain tasks, is an indication of deconditioning.

Rather than thinking of conditioning as a target to be achieved it is better to think of conditioning and deconditioning as a continuum. The continuum runs from health (conditioned) to illness (deconditioned). The goal of all exercise or training programs is to move an individual further up the continuum towards conditioning. As a person becomes less conditioned, whether through aging, inactivity or chronic illness (such as cancer) their ability to perform tasks is impaired. Seemingly simple tasks can be perceived as more stressful and fatiguing.[37]

Decondition can result from extended bed rest, inactivity, sedentary behaviours, or from chronic disease. Deconditioning is not a new concept, having been observed by Hippocrates more than two thousand years ago.[37] Deconditioning has a direct impact on cardiovascular function, respiratory capacity, muscle strength, fat-free mass, metabolic rate and applicable functional capacity.

Cancer, and its treatment, is known to have a negative effect on metabolic processes. A cancer diagnosis tends to lead to a reduction in physical activity. This can have a profound negative impact on the patient and often leads to an increase in bodyweight. Obese patients experience the greatest declines.

Reconditioning

The purpose of many complementary therapies, including a structured exercise program, is to restore the conditioning or functional ability of the individual. Reducing the side-effects of the cancer or treatments improves patient self-care and control, enhances wellbeing and quality of life, and reduces fear, distress, depression and anxiety.[38] A structured, progressive, exercise program can help do this. Further, a monitored exercise program is safe, non-invasive, inexpensive, easy to perform and can be tailored to each individual's lifestyle and circumstances.

Reconditioning may be best thought of as the process of improving or restoring an individual's functional capacity. This should include energetics, aerobic and anaerobic, as well as muscle strengthening and flexibility. In many rehabilitation programs the need to include strength conditioning and stretching is frequently overlooked. The key to a comprehensive rehabilitation program is incorporation of progressive resistance training and fundamental flexibility training.

Resistance exercise equipment

The variety of equipment developed for resistance training is remarkable. Equipment is designed to alter the direction of resistance and in some cases vary the magnitude of resistance through the range of movement. Most use gravity, but there are also machines that use elastic resistance, surface friction, hydraulic resistance, aerodynamic drag or pneumatic resistance. Biomechanical principles determine the interaction between the equipment and the human body.

Most exercise equipment is well designed however some do not incorporated good biomechanics. Poorly designed equipment can result in limited effectiveness or even injury risk. Understanding the mechanics underlying a piece of resistance training or conditioning equipment will assist initially with purchase decisions then with exercise selection and correct use.

Free weights

Working against the inertia of gravity of a freely moving mass, such as a dumbbell or barbell, is the simplest and most common form of resistance training. The biomechanics of free weights are similarly straightforward, with the resistance acting vertically downward at all times.

Gravitational machines

A disadvantage of free weights is that the resistance is always vertically downwards. A second problem is that the resistance (weight of the dumbbell or barbell) is constant. This is not consistent with the variations in strength required across the range of motion for each action. The total amount of weight that can be lifted is limited by weight that can successfully be moved through the *sticking region*. For example, in the bench press using free weights the load lifted is limited to what can be moved through the bottom part of the range (the sticking region). Once through the sticking region the effort required decreases and the neuromuscular system is not stressed as much.

To overcome this, several types of gravity-based machine have been developed to more closely match the strength curve for each movement.

Constant resistance machines

The most basic modification is to redirect the force of the weight. Early versions used standard weight plates and incorporated cables and pulleys to provide upward or horizontal resistance. Many of these machines now incorporate a weight stack, with a pin used to select the resistance. This improves ease of use, helps to keep the exercise area tidy, and reduces injury risk from lifting weight plates on and off the machines.

Variable resistance machines

Levers and cams allow the resistance profile to be matched more closely to the strength curve for each movement. To overcome limitations of the *sticking region*, there are a range of variable resistance devices.

Early designs use sliding levers. As the movement proceeds, the lever arm slides out and changes the application of the load from the weight stack. Later examples use variable radius cams to achieve the same result. In this case a cable or chain wraps around a cam with a changing radius and alters the resistance through the motion. The cams are designed to match the strength curve for each exercise, based on biomechanical principles.

Hydraulic machines

Hydraulic resistance devices depend on the resistance of oil (hydraulic fluid) being forced though a small aperture. It is important to note that hydraulic machines are passive and only provide a concentric contraction. This equipment has found a niche in circuit training program designs and also with special populations because there is reduced muscle soreness (no eccentric phase). It is easy to use and no momentum is built up so there is a reduced risk of injury.

Pneumatic machines

This equipment uses air (pneumatic) pressure to provide resistance to both concentric and eccentric exercise. A pneumatic ram is preloaded to a specific pressure using compressed air. The higher the pressure the greater the resistance provided. When the movement is performed the ram compresses the air and increases pressure, thus resistance. On the return movement the gas expands, allowing eccentric as well as concentric phases.

Elastic resistance

There are several examples of elastic resistance, ranging from simple elastic bands to devices that use spring or elastic cord. All use the resistance which is developed when an elastic material such as steel spring, rubber or bungy cord is stretched. Such devices also provide an ascending resistance curve because elastic tension is greater the more the material is deformed. They also allow for eccentric exercise as the muscles act to control the speed of elastic recoil.

Machines verus free weights

There are a number of advantages and disadvantages of machines when compared to free weights for resistance training. Each system has pros and cons. Budget and access to available equipment are important considerations. A simple understanding of the biomechanical principles that apply to each facilitates the selection of equipment and exercises appropriate to each individual.

Selecting and acquiring equipment

Home exercise equipment

An inexpensive exercise program can be undertaken at home with minimal equipment. A more sophisticated program can include a variety of home-based exercise equipment. There is a big market for home-based equipment.

Aerobic training equipment
Aerobic training only requires suitable footwear and clothing. Aerobic training ranges from simple exercises such as walking, jogging and stair-climbing to the use of sophisticated electronic equipment such as treadmills, cycles and rowers.

A 20-40cm bench for stepping exercises can be used for a very functional workout emphasising aerobic endurance. The height of the step chosen will reflect the fitness and functional ability of the participant. Suitable benches can be homemade or purchased from most sports and department stores.

Heart rate monitoring is an important measure of intensity. Heart rate can be measured with a watch by feeling the pulse at the wrist or neck. Electronic heart rate systems are now relatively inexpensive.

Resistance training equipment
A number of types of elastic band are available in rolls of different colours, with the colour indicating the resistance. Elastic bands are relatively inexpensive and handles can be added to increase comfort and grip. A wide variety of strength exercises can be performed with elastic. One problem is the lack of neuromuscular feedback leading to a reduction in motivation and compliance. Also, transfer to functional tasks is less than for weight training as movements against gravity are far more common than movement against an elastic resistance. Elastic bands can be purchased at many sports shops and pharmacies.

Dumbbells and barbells can be used in a wide range of resistance exercises or to increase intensity of aerobic exercise such as walking or bench stepping. Choosing the correct weight is an issue as different exercises will require different resistance depending on the patient's strength in that movement. Also, as the patient gets stronger they will need heavier barbells and dumbbells to maintain the same relative intensity. For this reason a good set of adjustable dumbbells and barbell where weight can be added or removed are preferable. Dumbbells and barbells can be purchased at most department or sports shops.

Padded benches can be used to perform some exercises in a more efficient or comfortable manner. For example, push-ups are an effective chest and arm exercise but with a bench and dumbbells, bench press is an alternative. Benches can also be used for seated and incline exercises. Benches can be purchased from most department and sports shops.

Pin-loaded, multi-station resistance training machines are available for home use and incorporate a wide range of different exercises. These machines are available from most department and sport shops, however expert advice is recommended prior to purchase.

Exercise clinic equipment

The exercise clinic should incorporate an appropriate balance of aerobic and resistance training equipment. Resistance training equipment should include free weights and machines – so that there is scope for progression – and ground-based exercises, requiring controlled stability, can be included in the programming. It is important to purchase any equipment from a reputable exercise equipment supplier.

Aerobic training equipment
Treadmills are good for low impact walking or jogging exercise in which the patient supports their bodyweight. This is important for maintaining gait capacity and also can be used to provide a good intensity of aerobic exercise. While home-use treadmills are relatively inexpensive they will not stand up to constant use in a clinic environment. Commercial standard treadmills are preferable.

Stationary cycles are also effective for aerobic exercise and may be better tolerated in patients with more marked deconditioning or for those that have orthopaedic problems in the lower extremities. The most basic cycles use a friction resistance system. Most commercial cycles now use some form of electronic resistance which can be controlled with various programs of speed and load.

Rowing ergometers provide a whole body aerobic overload. There may be issues related to skill and coordination but most people can perform the exercise with some practice.

Resistance training equipment
The cheapest and most versatile resistance training equipment is a series of dumbbells and barbells. A set of free weights can accommodate 10-20 people undertaking functional and effective exercises at the same time. Disadvantages include the time required to learn techniques and difficulty keeping the clinic tidy. Consider a range of dumbbells from 1-20 kg in 1 kg increments. A set of barbells of the fixed weight type from 5- 40kg in 2.5 or 5 kg increments is recommended.

A series of benches, some with adjustable back rests, is important. Benches are used for exercises such as bench press, incline press, shoulder press and bent over rowing. Use of benches increase the stability of the patient and may allow them to perform free weight exercises that they may not have the balance and trunk stability to perform in a standing position.

Pin-loaded exercise stations are relatively easy to use, allow a wide range of resistance settings and can accommodate people with little experience or even disability. There is a wide range of designs and exercises available but the key movements are:

- Leg press
- Bench press
- Seated row
- Shoulder press
- Lat pull-down

Cable machines that provide a range of additional exercises should be considered.

Layout of the exercise area

It is preferable to group similar equipment, for example aerobic equipment in one area and the resistance training equipment in another. Similarly, the stretching and cool-down area should also be set aside. Grouping equipment increases safety; it is best to keep the weight lifting away from where people might be stretching. Also, much of the aerobic equipment is electronic and so power outlets and cords can be confined to a designated area.

Strength training equipment should be arranged in logical order to make it easier for participants to progress around their workout. Often equipment is grouped according to body part, for example legs, chest, back, arms. This is more common in weight training facilities (gyms) rather than exercise clinics. A better arrangement would be according to a sequence of exercises that the participant can follow. One way to arrange this is as agonist and antagonist combinations, for example, the seated row located next to the bench press station. Another method is to alternate upper and lower body exercise stations as this provides good local muscle recovery between exercises. For example, leg press followed by bench press, followed by knee extension and then a seated row.

Additional resources

Vario Health Institute medical history questionnaire

Medical history questionnaire

Personal information

Name: ______________________________

Date of birth: ____________________ Sex: Male / Female

Address: ______________________________

Suburb: ____________________ Postcode: ____________

Phone: ____________________

Emergency contact

Name: ______________________________

Phone: ____________________

Medical contact

Doctor: ______________________________

Address: ______________________________

Suburb: ____________________ Postcode: ____________

Phone: ____________________

Health history

Smoking

- ☐ I have never smoked
- ☐ Former smoker:
  - Age started smoking: ________
  - Age quit smoking: ________
- ☐ Current smoker:
  - Age started smoking: ________
  - Number of cigarettes per day: ________

Alcohol use

- ☐ I have never used alcohol
- ☐ Former drinker:
  - Age stopped drinking: ________
- ☐ Current drinker:
  - Number of drinks per day: ________

Bodyweight

- ☐ My weight has fluctuated more than a 2-3 kilograms in the last 12 months?
  - How many kilograms: ________

Physical activity

Current level of physical activity:

- ☐ No physical activity
- ☐ Limited physical activity
- ☐ Regular physical activity:
  - Type of activity: Aerobic   Resistance   Flexibility
  - Duration: ____________________ minutes/session
  - Intensity: Low   Moderate   Vigorous
  - Frequency: ____________________ times/week

Medical history

Cancer diagnosis

When were you first diagnosed with cancer? ______________________

Primary cancer site: ______________________

Secondary cancer site(s): ______________________

Cancer treatments

Which cancer treatments have you had (please include details of each treatment)?

☐ Radiation therapy ______________________

☐ Chemotherapy ______________________

☐ Surgery: ______________________

☐ Blood transfusion: ______________________

☐ Other ______________________

Do you still have regular blood tests?

☐ Yes ☐ No

Has the doctor told you that you are neutropaenic or have a low white cell (leukocyte) count?

☐ Yes ☐ No

Has the doctor told you that you have anaemia?

☐ Yes ☐ No

Haemoglobin: ______________________

Other medical conditions

Do you experience shortness of breath while walking with others of your age?

☐ Yes ☐ No

Do you experience sudden tingling, numbness, or loss of feeling in arms, hands, legs, feet, or face?

☐ Yes ☐ No

Do you experience swelling of your feet and ankles?

☐ Yes ☐ No

Do you get pains or cramps in your legs?

☐ Yes ☐ No

Do you experience any discomfort in your chest?

☐ Yes ☐ No

Have you ever been told that your blood pressure was abnormal?

☐ Yes ☐ No

Medication(s) ______________________________

Have you ever been told that your serum cholesterol or triglyceride level was high?

☐ Yes ☐ No

Medication(s) ______________________________

Do you have diabetes?

☐ Yes ☐ No

Medication(s) ______________________________

Please describe any recent episodes of illness or infection.

____

____

____

____

Please list any current sites of pain and whether the pain is constant.

______________________________ ☐ Constant pain?

______________________________ ☐ Constant pain?

______________________________ ☐ Constant pain?

Please describe any other medical conditions you have.

____

____

____

____

Please describe any other medical conditions you have.

____

____

____

____

Please describe any other surgery you have had.

____

____

____

____

Falls history

Have you ever broken a bone as a result of a fall?

☐ Yes ☐ No

Details: ______________________________

Have you been tested for osteoporosis?

☐ Yes ☐ No

Bone density: Normal Osteopenia Osteoporosis

Medication(s): ______________________________

Has your doctor recommended you do anything else to improve your bone density?

____

____

____

____

Medication history

Please list any medications you are currently taking.

Medication	Dose	Reason

Sample medical clearance letter

Dear Doctor,

We provide exercise programs for cancer patients. Exercise programs have been demonstrated to improve function, reduce muscle and bone loss, reduce symptom experience and possibly increase survival rate for cancer patients. The exercise program includes high-intensity progressive resistance (strength/weight) training for the upper and lower body, and core. Patients also undertake aerobic exercise to maintain cardiovascular fitness and reduce or maintain body fat content. Relaxation and flexibility exercise are also included in the program.

Exercise sessions commence with a 10-minute warm-up of aerobic activity and conclude with a 10-minute cool-down period that includes exercises for core stability and stretching. All sessions are conducted in small groups of up to 6 participants under direct supervision by Exercise Physiologists and/or Physiotherapists to ensure proper technique and minimise the risk for injury. The total time to complete the exercise session is less than 60 minutes. In addition, patients are encouraged to complete a home exercise program that is provided.

Participants with any of the following conditions (tick all that apply) are not able to participate in the full program:

- ☐ Musculoskeletal or cardiovascular disorder that limits participation
- ☐ Bone metastases
- ☐ Severe anaemia (Hb < 80 g/L)
- ☐ Neutropaenia

Our concern is of past and/or present medical conditions that may compromise the patient's ability to participate in the program. This includes conditions that are musculoskeletal, neurological or cardiovascular in origin. For these reasons all potential participants have been asked to seek approval from their treating doctor prior to involvement in the program. Should you require further information, please feel free to contact us by phone or by e-mail.

Sincerely

Program Coordinator

Participant: ____

☐ Is able participate in the full exercise program.

☐ Is able to participate in a modified exercise program (please list restrictions on back of page)

☐ Is not able to participate in an exercise program

______________________________ ______________________

Doctor's signature Date

Resistance training log

Name: Week commencing

Date:																				
Sets*	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**

* Record as repetitions/weight (eg 6/15)

Rating of perceived exertion (RPE) scale

Rating of Perceived Exertion

Rating	Descriptor
0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	-
7	Very Hard
8	-
9	-
10	Maximal

Target zone

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