The Cardiac Society of Australia and New Zealand

Position Statement
Clinical Exercise Stress Testing in Adults

This document was originally developed by Prof Ben Freedman and members of the Rehabilitation, Exercise and Prevention Working Group. The Position Statement was reviewed by a Working Group chaired by A/Prof David Colquhoun. None of the reviewers have a conflict of interest to declare.

The revised Statement was considered by the Continuing Education and Recertification Committee and ratified at the CSANZ Board meeting held on 1st August 2014.

SUMMARY

1. Exercise testing is generally safe but has a small but definite risk of fatal and non-fatal cardiac events.
2. Testing should be supervised by a medical practitioner capable of recognising symptoms and signs of cardiac disease. The practitioner should have training in exercise testing and be capable of interpreting the exercise test findings. The practitioner should either be present in the room, or if the test is conducted by an appropriately trained healthcare professional, should be in close proximity and easily accessible during the exercise test.
3. The test can be conducted by a healthcare professional who has trained in a related health area, has appropriate training in the supervision of exercise stress tests, and is capable of performing cardio-pulmonary resuscitation.
4. For optimal patient safety, two persons should ideally be present in the exercise room during exercise stress testing at all times. Both persons should be trained in cardiopulmonary resuscitation. If two persons are not present in the room, a mechanism for an emergency call must be in place and there must always be an appropriately trained person who can respond immediately.
5. Testing should be performed on a treadmill or cycle ergometer. These pieces of equipment should be calibrated regularly.
6. Electrocardiographic monitoring should be performed with a three channel ECG and a 12 lead electrocardiogram should be recorded at rest, periodically during the test and in the recovery period. Blood pressure measurement should be recorded at least every three minutes during the test.
7. Symptoms should be monitored during the test to assess the development of angina or angina equivalent.
8. Resuscitation equipment should be immediately available and include a defibrillator, suction, airway, oxygen and appropriate drugs.
9. A written emergency plan should be developed and rehearsed on a regular basis with all personnel to ensure effective responses.
10. All clinical exercise stress laboratories should be equipped with a mechanism so that the help of nearby personnel can be summoned speedily.
11. For billing purposes MBS requirements include the continuous presence of a medical practitioner for at least 20 minutes. Nurse supervised tests are not subsidized.

1. PREAMBLE

Clinical exercise testing has wide application in medicine, including the assessment of functional capacity, ventilatory function, gas exchange, muscle function, endocrine and metabolic assessments, and as a test for claudication in peripheral vascular disease. The major use of clinical exercise testing, however, is as a stress test in patients with known or suspected coronary artery disease. This paper will limit its comments on safety and performance guidelines to clinical exercise stress testing with electrocardiography, although many of the safety guidelines are common to the other types of exercise tests, particularly exercise stress scintigraphy and echocardiography.

Clinical exercise stress tests utilizing exercise electrocardiography are usually performed in patients with known or suspected coronary artery disease. Accordingly there is a small but definite risk of death, approximating 1 in 10,000 stress tests, while 2 to 3 in 10,000 tests result in a major morbid event such as myocardial infarction, major arrhythmia requiring resuscitation, severe hypotension, and the development of either severe heart failure or unstable angina pectoris. In some laboratories complication rates are somewhat higher, approximating a 1 in 1000 incidence of severe hypotension, or arrhythmia requiring cardioversion, and this is probably related to the mix of referred patients. Because of these risks it is important that the personnel engaged in clinical exercise stress testing have the required skills and equipment to recognise and deal effectively with complications. Personnel should also have the clinical skills to be able to recognise patients who might be at increased risk of these complications and thereby exclude them from stress testing. It is also desirable that personnel obtain appropriate consent from the patient before performing the stress test. This document provides guidelines on the minimum requirements of both personnel and equipment for the safe performance of clinical exercise electrocardiography, and for the adequate interpretation and assessment of results.

In this document, the word "clinical" has been used to qualify exercise stress testing to differentiate such tests from those performed by non-medical personnel - e.g. gymnasium assessments prior to taking up a fitness programme. Such non-clinical exercise tests are beyond the scope of this document and will not be considered in the recommendations.

This document will not review the indications and contra-indications for clinical exercise stress testing nor the diagnostic criteria for exercise electrocardiography. These matters have been well reviewed by the task force of the American College of Cardiology and the American Heart Association. The most recent update on standards for Exercise Testing of AHA was published in Circulation 2013;128:873-934. The Cardiac Society supports the principles contained in these papers.

2. EQUIPMENT

a) Physical Environment

The principal requirement for the room where clinical exercise stress tests are performed is the availability of sufficient space to cope with complications. Any of the major complications resulting in syncope and requiring resuscitation can only be handled adequately if there is sufficient space for the patient to be removed from the treadmill or cycle ergometer and to be placed on the ground for resuscitation. The resuscitation and exercise equipment must be arranged so as to facilitate cardiopulmonary resuscitation in the space immediately adjacent to the exercise equipment. The room and building (if applicable) where the exercise testing is being performed should allow for the easy access of a patient trolley and monitoring equipment, should a patient require emergency transportation to an intensive care facility. At the time the exercise room and equipment are being set up every laboratory performing clinical exercise stress testing should plan for the eventuality of cardiopulmonary resuscitation. A controlled temperature and humidity environment is recommended.

b) Exercise Equipment

The general requirements for exercise equipment are that maximum exercise stress can be reliably and safely reproduced in the laboratory by a machine which can be calibrated to estimate external work (energy expenditure), and to minimise upper body movement. Energy expenditure is best quantified by measurement of oxygen consumption (VO_2) during exercise. This is the most precise measurement of metabolic load, and therefore cardiovascular load, and can vary considerably between individuals with

differing exercise efficiency working at the same treadmill or cycle ergometer setting. (VO_2) is not usually measured directly in clinical exercise stress testing. Nomograms to estimate energy expenditure in METS (multiples of basal oxygen consumption) are available for the commonly used exercise protocols (Appendix 1), and assume that energy expenditure can be quantified as watts (cycle ergometer) or as speed and grade (treadmill) as well as assuming a constant basal oxygen consumption.

These requirements are usually achieved by a motorised treadmill or cycle ergometer. Treadmills should be capable of providing measured increases in the speed and gradient at periods throughout the protocol. Cycle ergometers should be of a variety that can quantify the external workload in watts. Both motorised treadmills and braked cycle ergometers should be serviced on a regular basis according to the manufacturers' instructions to ensure performance within specifications. The treadmill speed can be easily checked by measuring the visible length of belt, multiplying by 2, and multiplying this by manually counted belt revolutions/minute to give km/hour. Treadmill inclination can be checked by a protractor. Cycle ergometers for which the workload cannot be varied or where the variable workload cannot be quantified are not adequate for clinical exercise stress testing, and non-motorised or non-calibrated treadmills are similarly unsuitable. Masters two-step or other simple step devices are not considered adequate for clinical exercise stress testing, nor is any other form of non-quantified and unmonitored exercise.

c) Electrocardiographic Recording Device and Hard Copy

In all cases a standard 12-lead electrocardiogram (patient supine, limb leads placed on the limbs) should be recorded on a 3-channel ECG printing device with adequate low frequency and phase response for accurate reproduction of the electrocardiogram. An additional supine 12-lead electrocardiogram should be recorded if limb electrodes are placed on the torso, as is common practice during exercise. Further modified 12-lead electrocardiograms should be recorded with the patient upright, and during each stage of exercise, or at least at 3-minute intervals during exercise. Additional modified12-lead electrocardiograms should be recorded at peak exercise, immediately upon cessation of exercise, and at least twice during the post exercise period. Devices capable of recording only one or three ECG leads, even if these are bipolar chest leads, are not adequate for clinical exercise electrocardiography. Where electrocardiographic recording devices have the facility to provide computer averaged complexes, raw ECG traces should also be inspected at the intervals specified in the guidelines. This is required to prevent incorrect interpretation of computer averaged electrocardiograms when these are influenced by noise or artefact.

Electrocardiographic recordings during exercise require adequate electrode fixation by adhesive or continuous suction to ensure adequate skin contact during patient motion. Skin preparation prior to electrode placement is of utmost importance to provide artefact-free traces. To achieve this, oils should be removed from the skin by an alcohol solution, and abrasion of the horny layer of the epidermis should be performed with a disposable abrasive device. ECG leads should have good electrical contact with the ECG electrode (preferably silver-silver chloride) and be placed and secured in such a way as to minimise lead movement during exercise. The ECG should be inspected prior to exercise with the patient both supine and upright to ensure the trace is of a good quality, and to make the necessary electrode or lead adjustments if this is not the case.

d) Electrocardiographic Monitoring During Exercise

The electrocardiogram should be continuously monitored during the exercise period and for five minutes after the cessation of exercise. Continuous monitoring is required to detect arrhythmias and ischaemic ECG patterns. To adequately monitor for both indications requires a video display of at least two or three electrocardiographic leads, preferably selected to be semi-orthogonal. Leads would therefore include an inferior lead, lead V5, and V1 or V2. Monitoring devices should have a memory loop capable of providing hard copy or storing rhythm traces on request by the operator, in addition to producing rhythm traces in real-time. Monitoring of a single ECG lead during exercise is considered suboptimal for the continuous detection and recognition of arrhythmia or ischaemic patterns during exercise. Ideally ECG monitoring should include automatic arrhythmia detection algorithms.

e) Blood Pressure Measurement

A sphygmomanometer should be available for recording of blood pressures before, during, and after exercise. Ideally blood pressure measurements should be made every minute during exercise, but measurements should be made at least every 3 minutes during exercise, timed to coincide with each stage of exercise. If possible, a measurement should be made at peak exercise, and at least 2 measurements should be made in the post- exercise period. Additional measurements may be required depending on clinical circumstances, especially if there is an adverse blood pressure trend with levelling off or fall in systolic blood pressure. Automated BP measurements may replace manual methods for exercise testing, but automated BP devices should be validated against manual measurements in each laboratory before use, and abnormally high or low measurements before, during or after exercise testing should be checked by manual sphygmomanometry.

f) Recording of Symptoms and Documentation

The physician supervising the exercise test or the healthcare professional must monitor the development of significant symptoms such as angina, anginal equivalents, shortness of breath, presyncope, and claudication, by appropriate questioning of the patient during and after exercise. The major symptom which limits exercise should be identified, and the intensity of the symptom recorded at least descriptively, but ideally by use of a quantitative measure such as the Borg scale. If the physician is not in the room during the test, the presence and nature of symptoms including test angina should be verified at the conclusion of the test before the patient leaves.

The physician or healthcare professional should document the resting and peak heart rate and blood pressure, and any abnormalities of blood pressure or heart rate response. The peak rate-pressure product (heart rate x systolic blood pressure) should be calculated as this provides the best estimate of myocardial load. The symptoms recorded should also be documented, with the duration of exercise and the maximum workload achieved. The interpretation of the electrocardiogram and occurrence of arrhythmias should also be documented.

g) Post-Exercise Period

ECG monitoring should continue for at least 5 minutes, or longer if clinically indicated (e.g. prolonged symptoms or ECG changes). The duration of ECG monitoring may be abbreviated in special circumstances such as when imaging must commence as soon as possible after exercise. In such cases, the patient should be closely observed for the first 10 minutes post-exercise.

h) Resuscitation Equipment

All clinical exercise stress test laboratories must be adequately equipped to provide advanced life support in the event of a cardiac arrest. Such equipment includes the following:-

i) **Defibrillator.** This should conform to Australian/New Zealand standard A/NZS 3204 and should be maintained and tested on a regular basis as specified in A/NZS 3551 - "Procurement, acceptance, safety and functional testing of active medical devices". Electrogel or electrode pads must be readily available, and the defibrillator must physically be able to be manoeuvered into place for easy defibrillation within the exercise room.

ii) **Suction.** Motor driven or gas cylinder (Venturi) devices for providing suction must be readily available at the position where the cardiac arrest is likely to be managed within the exercise room, and the appropriate plastic or metal suckers available to clear the airway.

iii) **Airway plus self-inflating bag.** A plastic or rubber airway and self-inflating bag should be available for maintenance of adequate airway and to ventilate the patient in the event of respiratory or cardiorespiratory arrest. Such equipment must be regularly inspected and maintained to ensure normal operation.

iv) **Oxygen.** Supplemental oxygen via cylinder or wall mounted device and appropriate masks should be available within easy access of the patient.

v) **Drugs and administration equipment.** Equipment for placing intravenous cannulae and appropriate giving sets should be available. The intravenous medications that should be readily available include Atropine, Lignocaine, Adrenaline, and Sotalol or Amiodarone. A beta-2 agonist spray such as salbutamol inhaler should be available for broncho-constriction. Short acting sublingual nitrates such as Glyceryl Trinitrate or Isosorbide Dinitrate or Glyceryl Trinitrate spray should be available in addition. All drugs must be in date and checked on a regular basis.

i) Emergencies: Emergency Mechanism and Emergency Plan

All clinical exercise stress laboratories should be equipped with some type of alarm so that the help of nearby personnel can be summoned speedily. A written emergency plan should be developed and rehearsed on a regular basis with all personnel to ensure effective responses. Plans should also describe the mode of rapid transfer of unstable patients to hospital emergency departments where tests are performed outside a hospital setting.

3. PERSONNEL

a) Supervision of Exercise Stress Test

Exercise stress testing should be performed by either a medical practitioner or an appropriately trained healthcare professional, as outlined in sections 3c and d. If a healthcare professional performs the test, they should be under the supervision of a medical practitioner who must be in close proximity and be easily accessible throughout the test should an urgent need arise. A history and examination should be taken before performance of the exercise stress test, and confirmation of the presence or absence of test angina or other symptoms should be made at the conclusion of the exercise test.

b) Number of Personnel Required

For optimal patient safety in clinical exercise stress testing, two persons should ideally be present in the exercise room during exercise stress testing at all times. Both persons should be trained in cardiopulmonary resuscitation. If two persons are not present in the room, a mechanism for an emergency call must be in place and there must always be an appropriately trained person who can respond immediately. The minimum requirements for training and experience of these personnel are detailed below.

c) Medical Practitioner

Referral for a clinical exercise test should include the history, diagnosis (known or suspected), indication for the test, and relevant medications.

The medical practitioner responsible for overseeing the clinical exercise stress test should take an appropriate history and examination to exclude significant unrecognised heart disease. The purpose of the history is to determine the nature of the symptoms that the individual is complaining of and in particular if an individual is complaining of chest pain, make an assessment as to the nature of the chest pain. Features of the history that suggest an unstable situation, where stress testing may be inappropriate, should be determined. The medical practitioner should examine the individual to determine whether or not there is unrecognised valvular disease or a heart failure. Prior to performing the exercise test the electrocardiogram should be examined to exclude features to suggest a recent acute cardiac event.

i) **Contraindications and indications for stress testing.** The medical practitioner must be competent and have the ability to recognize through history taking and physical examination whether there are any contraindications to clinical exercise stress testing. The practitioner should also be fully versed in the indications for clinical exercise stress testing and be able to evaluate these in the patient.

ii) **ECG interpretation.** The medical practitioner should be able to interpret all of the major abnormalities that can be detected on 12-lead electrocardiography, in particular those abnormalities associated with ischaemic heart disease. This includes knowledge of the ECG abnormalities likely to preclude interpretation of the exercise

electrocardiogram, and those abnormalities which might determine that exercise testing not be performed or be deferred. The practitioner should also be fully versed in the diagnosis of arrhythmias and should be able to rapidly determine the nature of the tachy and brady arrhythmias that may occur during exercise. The physician must also be able to diagnose ischaemic patterns as they occur, and to correctly interpret the exercise electrocardiogram for the presence or absence of ischaemia.

iii) **Interpretation of Symptoms.** The medical practitioner should be able to recognize symptoms occurring during exercise, and be able to differentiate ischaemic from non-ischaemic symptoms.

iv) **Basic and Advanced Life Support.** The medical practitioner supervising clinical exercise stress tests must be fully versed in the techniques of basic and advanced life support (as defined by the Australian Resuscitation Council or as in New Zealand Standards and Guidelines on Basic Life Support) and be able to perform these techniques with skill in an emergency situation. These include the ability to diagnose the underlying problem, to apply early rapid defibrillation when required, to perform effective external cardiac massage, and to ventilate the patient using an airway and bag with mask.

v) **Experience in clinical exercise stress testing.** The medical practitioner should have observed exercise stress tests and performed tests under close supervision in a laboratory under the direction of a cardiologist, prior to undertaking clinical exercise stress testing. Such experience will enable the practitioner to determine which exercise protocol is appropriate for an individual patient, based on the clinical history, physical examination, and resting electrocardiogram. The number of tests to be observed and to be performed under supervision will vary according to the skills and training of the medical practitioner, and the back-up and support facilities available.

d) Healthcare Professional for Clinical Exercise Stress Test

The second person or healthcare professional for clinical exercise stress tests should be a person with appropriate training. There are three minimum training requirements for this healthcare professional:

1) ability to perform cardiopulmonary resuscitation;
2) ability to obtain a high quality ECG trace;
3) ability to recognise the major arrhythmic and ischaemic ECG and clinical manifestations likely to occur during clinical exercise stress testing.

For certain categories such as cardiopulmonary technologists, ECG technologists and coronary care or intensive care trained nurses, the above minimum training requirements would be covered during professional training. For other healthcare professionals, training in the above skills would be necessary prior to undertaking solo assistance in clinical exercise stress testing.

Personnel acting as an assistant for clinical exercise stress tests should also have observed exercise stress tests in a clinical exercise laboratory under the supervision of a an appropriately trained healthcare professional. They should also have performed exercise stress tests under close supervision of another healthcare professional in such a laboratory. The number of tests to be observed and performed under supervision will vary according to the training and skills of the assistant.

REFERENCES

Circulation 2000, 102:1726 (www.americanheart.org).

Circulation 2009, 119:3144

Circulation 2013; 1 28:873-934

Appendix 1

Exercise Standards for Testing and Training

A Scientific Statement from the American Heart Association

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FUNCTIONAL CLASS	CLINICAL STATUS	O_2 COST ml/kg/min	METS	BICYCLE ERGOMETER	TREADMILL PROTOCOLS						METS
					BRUCE MODIFIED 3 min Stages MPH %GR		BRUCE 3 min Stages MPH %GR		NAUGHTON		
				1 WATT = 6.1 Kpm/min							
				FOR 70 KG BODY WEIGHT Kpm/min	6.0	22	6.0	22			
					5.5	20	5.5	20			
NORMAL					5.0	18	5.0	18			
AND		56.0	16								16
		52.5	15								15
I		49.0	14								14
		45.5	13	1500	4.2	16	4.2	16			13
		42.0	12	1350							12
		38.5	11	1200	3.4	14	3.4	14	2 min Stages MPH %GR		11
		35.0	10	1050							10
		31.5	9	900					2	17.5	9
		28.0	8	750					2	14.0	8
		24.5	7		2.5	12	2.5	12			7
II		21.0	6	600					2	10.5	6
		17.5	5	450	1.7	10	1.7	10	2	7.0	5
III		14.0	4	300					2	3.5	4
		10.5	3		1.7	5			2	0	3
		7.0	2	150	1.7	0			1	0	2
IV		3.5	1								1

Oxygen requirement (expressed as METs or mL/kg/min) for various exercise tests using treadmill and cycle ergometer protocols.

The Cardiac Society of Australia and New Zealand

Patient Information for Exercise Stress Testing

On the basis of NHMRC guidelines for Medical Practitioners on Providing Information to Patients, the Council of the Cardiac Society feel that it is advisable to provide patients with a written information sheet prior to the performance of an exercise/pharmacological stress test. Different information documents should be available for stress echocardiography or nuclear imaging techniques and for pharmacological stress testing. In particular the pharmacological techniques will require information on the additional risks associated with the use of these agents (see Safety and Performance Guidelines for Pharmacological Stress Testing in conjunction with Clinical Cardiac Imaging Procedures 1998). The details of this sheet will obviously vary from practice to practice but should include some mention of the headings outlined below.

Council of the Cardiac Society does not feel that it is mandatory to obtain signed consent for an exercise stress test. It does, however, believe that obtaining consent does provide a valuable written record of the fact that suitable information has been provided to the patient concerning the test and that the patient has had the opportunity to ask questions prior to undergoing the investigations. If informed consent is not to be obtained, Council strongly advises that some form of documentation be included in the case record to the effect that oral information has been provided to the patient. Alternatively, a written information sheet could be handed to the patient prior to the stress test and its provision to the patient documented in the case record.

In the case of treadmill exercise stress testing the following document could serve as a patient information document if wished. Alternatively, a patient information document could be adapted along the lines outlined below.

Some states have legislation that mandates obtaining a written consent before performing a stress test.

INFORMATION/CONSENT FORM FOR TREADMILL EXERCISE TESTING

The purpose of the test: Exercise testing measures the performance and capacity of the heart, lungs and blood vessels. In many cases, the test is carried out to assist in making a diagnosis of coronary artery disease. Other uses of the test include evaluating a patient's capacity to undertake certain physical activities, the planning of an appropriate training program, assessment of prognosis in patients with heart disease and the effect of medical treatment, angioplasty or surgery on symptoms. Before being tested you will have been questioned and examined by a Doctor and a resting electrocardiogram will be recorded prior to performing exercise.

Testing consists of walking on a treadmill and the speed and gradient of the treadmill will be increased every three minutes. The test is eventually stopped if and when you develop symptoms such as fatigue, breathlessness, tired legs, chest pain or other symptoms. Throughout the test a doctor will be present and your pulse, blood pressure and electrocardiogram will be monitored. If there is any change in any of these observations, which concerns the Doctor, he or she may stop the test immediately. Your pulse, blood pressure and electrocardiogram will continue to be monitored for sometime after the test has been stopped.

If at any time during the test you are feeling unwell in any way, report the symptom immediately.

Risks: Clinical exercise stress testing is usually performed in patients with known or suspected coronary artery disease. While every effort is made to minimize the risks of the procedure, there is a small but definite risk of complications which you should be aware of. Be aware also that emergency equipment and trained personnel are available to deal with any complications that may arise.

Serious potential complications include the possibility of a major disturbance of heart rhythm requiring resuscitation, the development of heart failure or prolonged angina (heart pain), or the development of a heart attack. The risk of one of these occurring is approximately 2 or 3 in 10,000 tests. Unfortunately, there is also a very small risk of death occurring as a result of an exercise test. The chance of this in the average patient is approximately 1 in 10,000 although the risks both of complications and of death may be higher in patients who are already known to have severe coronary disease.

The doctor performing the test is well aware of these risks and will have taken them into account before deciding to recommend the study. Please feel free to discuss these issues prior to agreeing to undergo the exercise stress test.

Signed consent

Before proceeding with the test we need your signed consent. The signing of this form is voluntary and you are absolutely free to deny consent if you so desire, if so, the test will not be done. Before signing the consent form, please feel free to ask any questions you have about exercise stress testing and about any risks and benefits.

I have read this form and had the opportunity to ask questions. I understand the test which I will carry out and I have been made aware of the risks involved. I consent to participate in this stress test.

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Signature of patient Witness

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Date Date