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on behalf of the American Heart Association Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention of the Council on Clinical Cardiology, Council on Lifestyle and Cardiometabolic Health, Council on Epidemiology and Prevention, and Council on Cardiovascular and Stroke Nursing

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Supervision of Exercise Testing by Nonphysicians A Scientific Statement From the American Heart Association

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on Exercise, Cardiac Rehabilitation, and Prevention of the Council on Clinical Cardiology, Council on
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The standard exercise test is a well-established procedure that has been widely used in cardiovascular medicine for many decades, with staffing issues that have changed over time. The test is frequently considered the “gatekeeper” to more expensive and/or invasive procedures since it is often the first diagnostic evaluation when coronary artery disease (CAD) is suspected. Thus, it is used to help guide decisions regarding diagnosis and/or medical and interventional management. Moreover, the prognostic value of aerobic capacity and other variables obtained during exercise is firmly established in those who are apparently healthy and in virtually all patient populations.^{1,2} Generally, peak or symptom-limited exercise testing is used to detect signs or symptoms of myocardial ischemia and to discern fundamental information on exercise capacity, exercise hemodynamics, dysrhythmias, oxygenation, neuroautonomic health, symptoms, and other physiological responses. In most instances, peak effort entails at least brief periods of high-intensity exercise, and evidence suggests that such vigorous physical exertion may cause a transient increase in the risk of cardiovascular events in high-risk individuals.^{3,4} Because the exercise test is typically performed in patients with known or suspected cardiovascular disease, guidelines and scientific statements on exercise testing have historically recommended physician presence for supervision as a means both to optimize functional and diagnostic testing decisions and safety and to administer emergency treatment should complications occur. However, systematic surveys of

multiple centers and reports from individual clinical exercise laboratories have shown that contemporary exercise tests are often conducted and supervised by nonphysicians (eg, exercise physiologists, nurses, physical therapists [PTs], physician assistants [PAs]). These reports and empirical evidence suggest that testing efficacy and safety are similar in laboratories where tests are directly supervised by physicians and those where nonphysicians administer testing under theegis of a physician supervisor.⁵⁻¹¹ This issue has been the topic of significant debate in the past, and there are currently no consistent or widely accepted standards on exercise test supervision.

To some extent, staffing shifts in exercise testing laboratories have been motivated by growing priorities for cost containment and greater efficiencies of medical care. Nonphysician care providers often now conduct the mechanics of exercise testing under a physician’s supervision at less cost than testing performed directly by physicians. Although the details of supervision and physician proximity vary between individuals and institutions, the key point is that direct physician contact with the patient has diminished⁵⁻¹² while involvement by allied healthcare providers has expanded. A premise of this scientific statement is to characterize testing strategies that center attention on quality compared with cost. Nonphysicians may even provide some advantages in regard to patient care but not as surrogates for physicians’ clinical skills and medical knowledge.

Previous statements are related to physician qualifications for the supervision of exercise testing from the American

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Heart Association (AHA)/American College of Cardiology (ACC) and the American College of Physicians.^{13,14} Performance criteria and personnel certification programs have been available from the American College of Sports Medicine (ACSM) for >30 years, but AHA/American College of Physicians statements in this area have been directed at the physician. However, in contemporary exercise laboratories, physicians often provide supervision or oversight but are less frequently physically present for testing. "Supervision" has been interpreted in different ways, and for the purposes of this document, 3 categories of physician supervision are used, depending on the type of patient being tested¹³: (1) personal supervision, requiring a physician's presence in the room; (2) direct supervision, requiring a physician to be in the immediate vicinity or on the premises or the floor and available for emergencies (explicitly defined as the ability to be in the testing room within 30 seconds of notification); and (3) general supervision, requiring the physician to be available by phone or by page (generally appropriate for healthy, asymptomatic individuals). The present statement responds to the need to specify the appropriate education, training, experience, and cognitive and procedural skills necessary for nonphysicians to conduct exercise testing and to delineate standards that maintain patient safety. This statement also responds to the need to provide physicians with guidance in terms of cognitive and procedural skills that strengthen their ability to supervise nonphysician health professionals who perform exercise testing.

Key principles endorsed by this statement include recognition that proficiency and quality of exercise testing can be achieved by nonphysician health professionals but that physician participation also remains indispensable. Ideally, exercise testing entails a team approach. Nonphysician health professionals may administer and even supervise exercise testing independently, but physician involvement is essential with respect to delineation of testing policies/standards, medical safety standards and monitoring, physical proximity in emergent situations, and direct participation for patients at high risk.

The necessity for this statement also evolves from changes in clinical practice patterns in regard to exercise testing in which many exercise tests—in some centers, most exercise tests—are administered by nonphysicians,^{5–12} including those in low- to high-risk patients. As these changes have evolved, ambiguity about the physician's role relative to the nonphysician has been increasingly common. Other AHA scientific statements address cardiopulmonary exercise testing and exercise and pharmacological imaging procedures specifically, each of which has its own unique set of cognitive and procedural skills.^{15–17} This document is intended to complement a previous ACC/AHA statement on clinical competence on exercise testing for physicians¹³ and to extend previous AHA scientific statements related to exercise testing.^{12,13,16–19} The writing group has considered current practice patterns; studies on risks associated with exercise testing; efforts by the ACSM and other organizations to formulate knowledge, skills, and abilities for conducting clinical exercise testing; legal implications; and the recognized scope of responsibilities for nonphysician health professionals who might perform exercise testing. Competence is a complex issue, and by its nature, an evidence basis for recommendations is not always

available; when this is the case, the writing group has used consensus opinion to formulate recommendations.

Continued Relevance of the Exercise Test

Publication of this document on exercise test supervision is in the context of a broader debate on the utility and application of functional and diagnostic testing. Whereas exercise testing was originally based on the assumption that cardiac risk was determined primarily by obstructive CAD, which could be reliably detected by provocative testing,¹⁶ coronary risk is now attributed more to inflammatory processes, plaque stability, or the nature of coronary lesions.²⁰ Therefore, many now regard biomarkers as superior gauges of risk and imaging as a preferred methodology to quantify or characterize plaque, calcium, or other pertinent anatomic lesions.

Nonetheless, this statement presumes an enduring and unambiguous value of exercise testing. For ischemic heart disease, exercise testing yields a physiological perspective on plaque burden and is a pertinent gauge of hemodynamics, arrhythmias, symptoms, and other indexes that provide independent and additive information to inflammatory and other biopeptide markers, adding critical perspectives on prognostic evaluation and management choices.² Moreover, exercise testing has substantive value as a means to delineate ischemic ECG, angina thresholds, and other abnormal physiological responses during activity, as well as facilitating pertinent assessments in heart failure, valvular heart disease, arrhythmias (supraventricular and ventricular), conduction disease, peripheral arterial disease, pulmonary hypertension, chronic obstructive pulmonary disease, and other subclinical disease processes that are increasingly prevalent in an aging population prone to chronic diseases and multimorbidity.² Functional quantification is a key end point for all these conditions, and this measurement is enriched when integrated with hemodynamics, heart rate changes, conduction changes, and symptoms, as well as in combination with myocardial perfusion imaging,²¹ gas exchange,¹⁷ and associated metabolic parameters.²² Decisions about patient selection, type of test, and which end points are to be prioritized require sophistication and expertise.

The blend of physician and nonphysician personnel adds to the potential for excellence and efficiency. The range of clinical needs and testing modalities implies the need for a variety of testing expertise, with physicians often benefitting from complementary skill sets of allied providers. Therefore, instead of focusing on exercise testing personnel as a single prototype with redundant roles, it is important to identify where physicians and nonphysicians overlap and where they differ and thus how they can best complement one another to optimize test performance and safety.

Evolution of Exercise Test Supervision

Over the past 30 years since the AHA released its first set of standards for adult exercise testing laboratories,²³ the role of the physician in ensuring that the exercise laboratory is properly equipped and appropriately staffed with qualified personnel who adhere to a written set of policies and procedures specific to that laboratory has not changed. However, the issue of whether all exercise tests should be directly and personally supervised by a physician has evolved over time, as has the

range of patients being tested. In 1979, the AHA stated that “a physician must be immediately available, but may delegate the actual conduct of the test where he has determined it can be safely performed by experienced paramedical personnel.”²³ Since that time, the AHA, ACC, ACSM, and American Association of Cardiovascular and Pulmonary Rehabilitation have consistently addressed this issue in subsequent iterations of their respective guidelines.^{12,16,24,25} In 2000, the ACC/AHA/American College of Physicians–American College of Internal Medicine Competency Task Force focused its efforts on outlining the specific cognitive and training requirements for those personnel involved with the supervision and interpretation of exercise ECG testing and with stress imaging tests administered to adults, children, and adolescents. That seminal document was the first to look beyond the specific professional type (eg, physician, nurse, exercise physiologist) and focus on specific competencies of the individual staff member.¹³ Detailed recommendations of the most recent version of professional guidelines are provided in Table 1.^{12,13,16,24,25} Common to each of the published guidelines are several key recommendations: Patients are screened before exercise testing to identify the most appropriate personnel to supervise the test; exercise testing may be supervised by nonphysician staff who are deemed competent according to the criteria as outlined in the ACC/AHA statement¹³; a physician is always immediately available to assist as needed (ie, to provide direct supervision as defined in Table 1); and in high-risk patients, the physician personally supervises the test (as defined in Table 1).

A critical component common to each of these previous recommendations is that patients are screened before the exercise test to identify when direct physician presence is necessary. Therefore, the nonphysician staff should be able to distinguish when physician supervision is indicated. Furthermore, if this decision is unclear, the nonphysician staff should have the experience and judgment to defer to the physician directing the exercise laboratory. Screening should include cardiovascular history, general medical conditions and circumstances, and signs or symptoms that warrant direct physician supervision. Recommendations for key types of patients who require direct physician supervision (physically present in the room) are outlined in Table 2. This is not an evidenced-based list (general Level of Evidence, C) but represents a guideline based on judgment of the writing group in response to greater aggregate patient risks.

Risk of Exercise Testing by Physician and Nonphysician Healthcare Providers

Pathophysiological evidence suggests that the increased cardiac demands of vigorous to maximal exercise may precipitate cardiovascular events or other clinical instability in individuals with known or occult heart disease and other pertinent diseases, particularly among habitually sedentary people performing unaccustomed, high-intensity physical activity.⁴ Vigorous physical activity can provoke plaque rupture and thrombotic occlusion of a coronary vessel, presumably as a result of the associated abrupt increases in heart rate and blood pressure, induced coronary artery spasm in diseased artery segments, or twisting of the epicardial coronary arteries.²⁶ An increase in platelet activation and hyperreactivity, which

could contribute to (or even trigger) coronary thrombosis, has also been reported in habitually sedentary subjects who engaged in sporadic strenuous exercise but not in physically trained individuals.²⁷ Symptomatic or silent myocardial ischemia, sodium-potassium imbalance, increased catecholamine excretion, circulating free fatty acids, and decreased coronary perfusion resulting from abrupt cessation of maximal exercise may also be arrhythmogenic. Other complications that may be induced by exercise testing include hemodynamic (especially among patients with structural heart disease) and conduction perturbations, bronchospasm (especially among patients with chronic obstructive pulmonary disease), and hypoglycemia, all increasingly common among the wide range of patients now routinely referred to many exercise testing laboratories.

In 1971, Rochmis and Blackburn²⁸ published results of a survey on the procedures, safety, and litigation experience in $\approx 170\,000$ exercise tests performed in 73 medical centers, a time when testing focused primarily on CAD patients. The overall mortality rate from these centers was 0.10 deaths per 1000 tests (0.01%), and the combined morbidity and mortality (total complications) rate was 0.34 per 1000 tests (0.034%). Another widely quoted survey of 518 448 exercise tests conducted in 1375 centers revealed a 50% lower mortality rate, 0.05 deaths per 1000 tests (0.005%), but a higher combined complication rate, 0.89 per 1000 tests (0.089%).²⁹ However, application of these often-cited survey results to contemporary exercise laboratories is tenuous at best because of the varied testing modalities, protocols and end points used, as well as the mix of submaximal and maximal tests, differences in exclusion criteria and types of patients studied, expanded role of cardiopulmonary exercise testing in functional assessment and risk stratification, and gradual shift in direct physician supervision of these tests to highly trained nonphysician health professionals. Current emergent revascularization procedures (which markedly decrease early postinfarction mortality), cardioprotective pharmacotherapies (eg, aspirin, statins, antiarrhythmic and β -adrenergic blocking agents, angiotensin-converting enzyme inhibitors), and the increasing number of middle-aged and older adults with pacemakers or implantable cardioverter-defibrillators may also reduce the risk of exercise testing in specific patient subsets.

Since the publication of these early survey data, numerous investigators have reported the cardiovascular complication rates of exercise testing using direct supervision by either physicians (generally cardiologists or internal medicine specialists) or highly trained nonphysician health professionals with a physician available in the immediate area for pretest evaluation of selected patients and to assist in the event of complications. A summary of 19 different reports (1971–2012) involving >2.1 million exercise tests is given in Table 3, with specific reference to year of publication, morbidity and mortality rates, total complications, and direct supervision (ie, physician versus nonphysician).^{5–9,11,28–40} Subjects included apparently healthy individuals and adults with known or suspected cardiovascular disease, athletes, and patients with a history of high-risk cardiac conditions, including chronic heart failure (ie, New York Heart Association class II–IV heart failure caused by left ventricular systolic dysfunction), hypertrophic cardiomyopathy, pulmonary hypertension, aortic

Table 1. Summary of Guideline Recommendations for Nonphysician Supervision of Exercise Tests

Organization	Guideline /Year	Recommendation
AHA/ACC	"Clinical Competence Statement on Stress Testing" ¹³ /2000 (PMID 11015355)	In most patients, exercise testing can be safely supervised by properly trained nurses, physician assistants, exercise physiologists, physical therapists, or medical technicians working under the direct supervision of the physician, who should be in the immediate vicinity or on the premises or the floor and available in case of emergency situations. It is recommended that nonphysicians who supervise the actual exercise test have certain cognitive skills (as outlined in this document) and that they be certified in exercise testing by organizations such as the ACSM. In general, the physician should be present to observe the patient continuously (ie, personally supervise) when the test is performed on a patient with a recent (within 7–10 d) history of documented acute coronary syndrome, severe left ventricular dysfunction, severe valvular stenosis (eg, aortic stenosis), or complex arrhythmia. In all instances, the healthcare provider should screen the patient for indications and contraindications immediately before the test.*
AHA	"Recommendations for Clinical Exercise Laboratories" ¹² /2009 (PMID 19487589)	These guidelines call for risk stratification of people to be tested to determine the appropriate level of medical supervision needed during testing. The use of specially trained nonphysician healthcare professionals is appropriate to supervise clinical exercise testing if the individual supervising the test meets competency requirements for exercise test supervision, is fully trained in cardiopulmonary resuscitation, and is supervised by a physician skilled in exercise testing, who is immediately available and later reads over the test results. These nonphysician health professionals typically include exercise physiologists, nurses, nurse practitioners, and physician assistants but may include other health professionals. This practice should be compatible with state licensure regulations and statutory definitions for the practice of medicine before it is implemented.
AHA	"Exercise Standards for Testing and Training" ¹⁹ /2013	Exercise testing should be conducted only by well-trained personnel with sufficient knowledge of exercise physiology and ability to recognize important changes in rhythm and repolarization on the ECG. The degree of subject supervision needed during a test can be determined by the clinical status of the subject being tested. This determination is made by the physician or physician's designated staff member, who asks pertinent questions about the subject's medical history, performs a brief physical examination, and reviews the standard 12-lead ECG performed immediately before testing. Supervision can be assigned to a properly trained nonphysician (ie, a nurse, physician assistant, or exercise physiologist or specialist) for testing apparently healthy younger people (<40 y of age) and those with stable chest pain syndromes with additional flexibility. Possibly with the exception of young, apparently healthy individuals (eg, exercise testing of athletes), a physician should be immediately available during all exercise tests. The ACC/AHA/ACP document on clinical competence in stress testing provides additional details on the supervision and interpretation of exercise tests. ¹³
ACSM	"Guidelines for Exercise Testing and Prescription" ²⁴ /2010	Individuals who supervise exercise tests must have the cognitive and technical skills necessary to be competent to do so as are outlined in the ACC/AHA/ACP document on clinical competence in stress testing. ¹³ In most cases, clinical exercise tests can be supervised by properly trained exercise physiologists, physical therapists, nurses, physician assistants, or medical technicians who are working under the direct supervision of a physician.* In situations in which the patient is deemed to be at increased risk for an adverse event during exercise testing, the physician should be physically present in the exercise testing room to personally supervise the test.
AACVPR	"Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs" ²⁵ /2013	The level of supervision depends primarily on the type of patients being tested. For patients who are at higher risk (eg, those with recent myocardial infarction, heart failure, or arrhythmia), the supervising physician should determine the necessity for direct physician monitoring of the test.* In other cases, properly trained nonphysician healthcare professionals may conduct the test and directly monitor patient status throughout testing and recovery, provided that they have been deemed competent by the physician supervisor as per established guidelines. ¹³ In all cases, the supervising physician must be immediately available to respond.

AACVPR indicates American Association of Cardiovascular and Pulmonary Rehabilitation; ACC, American College of Cardiology; ACP, American College of Physicians; ACSM, American College of Sports Medicine; AHA, American Heart Association; and PMID, PubMed Identifier.

*Three levels of supervision for diagnostic tests as follows: (1) personal supervision requires a physician's presence in the room; (2) direct supervision requires a physician to be in the immediate vicinity or on the premises or the floor and available for emergencies; and (3) general supervision requires the physician to be available by phone or by page.¹³

stenosis, malignant ventricular arrhythmias, or combinations thereof. Complications were defined primarily as the occurrence of acute myocardial infarction or exercise-induced threatening arrhythmias (ventricular tachycardia, ventricular

fibrillation, or marked bradycardia) that mandated immediate medical treatment. However, other complications were broadly reported in some studies and included supraventricular tachycardias, atrial fibrillation, stroke, transient ischemic attack,

Table 2. Recommendations for Patients Requiring Personal Physician Supervision Based on Clinical Safety Criteria*

Moderate to severe aortic stenosis in an asymptomatic or questionably symptomatic patient
Moderate to severe mitral stenosis in an asymptomatic or questionably symptomatic patient
Hypertrophic cardiomyopathy: risk stratification and exercise gradient assessment
History of malignant or exertional arrhythmias, sudden cardiac death
History of exertional syncope or presyncope
Intracardiac shunts
Genetic channelopathies
Within 7 d of myocardial infarction or other acute coronary syndrome
New York Heart Association class III heart failure
Severe left ventricular dysfunction (particularly patients whose clinical status has recently deteriorated and those who have never undergone prior exercise testing)
Severe pulmonary arterial hypertension
Broader context of potential instability resulting from noncardiovascular comorbidities, (eg, frailty, dehydration, orthopedic limitations, chronic obstructive lung disease)

*Personal supervision defined as physical presence in the room.

nonsustained ventricular tachycardia, syncope, implantable cardioverter-defibrillator discharges requiring hospitalization, and vasovagal episodes, resulting in considerable variation in the associated test morbidity and total complications.

A review of these separate studies (Table 3) shows that 16 of the 19 reports included complication rates derived from >1000 exercise tests. The reported death rate for testing, which generally included a follow-up period to capture patients hospitalized as a result of a documented adverse event (ie, death within 48 hours of the exercise test), ranged between 0 and 0.25 per 1000 tests. In the same populations, the combined rates for morbidity and mortality (total complications) were between 0 and 78.0 events per 1000 tests. However, the latter complication rate (78.0 events per 1000 tests) was derived from 5 reported cases of sustained ventricular tachycardia in 64 exercise tests in patients with a history of life-threatening ventricular arrhythmias.³⁵ Similarly, in a series of 263 patients with a history of malignant ventricular arrhythmias who underwent a total of 1377 peak or sign- or symptom-limited exercise tests, investigators reported 32 episodes of sustained ventricular tachycardia, ventricular fibrillation, or profound bradycardia mandating immediate medical treatment.³² Although no deaths or myocardial infarctions were noted in either report,^{32,35} combining these 2 studies of high-risk patients yields an alarming complication rate, 25.7 per 1000 tests. If these 2 reports involving small numbers of extremely high-risk patients are excluded from Table 3, the total complication rate ranges from 0 to 3.46 events per 1000 tests. Although it is not possible from these data to stratify risk by population or testing method, the rate of total complications appears higher in populations who are undergoing diagnostic exercise testing, including patients with chronic heart failure, impaired left ventricular function, or threatening ventricular arrhythmias, compared with young adults being tested for athletics or as part of a preventive medical examination.

Although the current treatment era includes many patients who are complex and potentially at higher risk for an adverse event, given the evolution in cardiovascular management with respect to procedures, implantable cardioverter-defibrillators, chronic resynchronization therapy devices, and medications, many of these older surveys may provide an overestimation of risk in contemporary clinical practice.

Required Training and Demonstrated Competencies

There are several nonphysician health professions for which the academic training creates the foundation to achieve the level of competence required to independently supervise clinical exercise tests. These include nurses, nurse practitioners (NPs), PAs, clinical exercise physiologists (CEPs), and PTs. However, it should not be assumed that the academic training of any of these health professions provides the necessary educational experiences without proper vetting for a given individual. Thus, requirements for academic training and experiences focus on universally required educational experiences and competencies rather than a specific nonphysician health profession. Although numerous nonphysician health professionals function in a clinical exercise testing laboratory with varied responsibilities,^{12,18} the following sections describe the knowledge requirements and demonstrated competencies needed to operate autonomously, running day-to-day operations under the guidance of the physician director of the laboratory who must also be highly knowledgeable and proficient in all of these areas. The demonstrated cognitive and practical experiences and skills and abilities needed to independently supervise clinical exercise tests are summarized in Table 4. Although some of the skills described below and in Table 4 may be delegated to support personnel, the nonphysician health professional granted the ability to independently conduct the exercise test must demonstrate proficiency in all these areas.

Cognitive and Practical Skills Required to Conduct Exercise Testing

The ability to achieve diagnostic accuracy and to maintain a high degree of safety depends on understanding and identifying test indications and contraindications, selecting an appropriate incremental protocol (with respect to both mode and intensity), knowing when to terminate the test, and being prepared for and rapidly responding to any emergencies that may arise. Although most exercise testing guidelines have been written oriented to CAD, the population of patients considered for exercise tests has expanded. Clinical sophistication in terms of CAD, heart failure, structural heart disease, conduction disease, aortic stenosis and other valvular diseases, diabetes mellitus, pulmonary hypertension, and interstitial pulmonary disease is pertinent for safe and effective testing in most contemporary exercise testing laboratories. Insights pertaining to age, obesity, sex, and frailty are also relevant. These include knowing the normal and abnormal ECG and hemodynamic responses to different types and intensities of exercise, the associated adverse signs and symptoms and their pathophysiological implications, and the potential impact of the patient's prescribed medications on these parameters. Accordingly, physicians and nonphysicians who directly

Table 3. Complication Rates of Exercise Testing (1971–2012)

Reference	Year	Tests, n	Morbidity Rate, n per 1000	Mortality Rate, n per 1000	Total Complications, n per 1000	Physician Supervised?
Rochmis and Blackburn ²⁸	1971	≈170 000	0.24	0.10	0.34	Yes*
Scherer and Kaltenbach ³⁰	1979	353 638†	0	0	0	Yes*
		712 285‡	0.14	0.02	0.16	Yes*
Atterhog et al ³¹	1979	50 000	0.52	0.04	0.56	Yes*
Stuart and Ellestad ²⁹	1980	518 448	0.84	0.05	0.89	Yes*
Young et al ³²	1984	1377§	23.2	0	23.2	Yes*
Lem et al ³³	1985	4050	0.03	0	0.03	No
Cahalin et al ⁹	1987	18 707	0.38	0.09	0.47	No
DeBusk ³⁴	1988	>12 000	NR	0.25	NR	No
Allen et al ³⁵	1988	64	78.0	0	78.0	Yes
Gibbons et al ³⁶	1989	71 914	0.07	0.01	0.08	Yes*
Knight et al ⁸	1995	28 133	0.32	0	0.32	No
Franklin et al ⁵	1997	58 047	0.21	0.03	0.24	No
Ilija and Gueron ³⁷	1997	38 970	1.10	0	1.10	Yes
Squires et al ⁷	1999	289	3.46	0	3.46	No
Myers et al ⁶	2000	75 828	0.12	0	0.12	Yes*
Scardovi et al ³⁸	2007	395	2.53	0	2.53	NR
Kane et al ³⁹	2008	8592	0.93	0	0.93	No
Keteyian et al ⁴⁰	2009	4411	0.45	0	0.45	Yes/No¶
Skalski et al ¹¹	2012	5060	1.58	0	1.58	No

NR indicates not reported.

*The majority of these tests (73% to >85%) were directly supervised by physicians.

†Athletes.

‡Coronary patients.

§Patients with a history of malignant ventricular arrhythmias; complications (morbidity rate) were defined as the occurrence of serious arrhythmias during exercise testing (ie, ventricular fibrillation, ventricular tachycardia, or bradycardia) that mandated immediate medical treatment (cardioversion/defibrillation, use of intravenous drugs, or closed-chest compression).

||"No" signifies that these tests were directly supervised by a specially trained/certified allied health professional (eg, clinical exercise physiologist, nurse, physical therapist) with a physician available in the immediate area for pretest evaluation of selected patients and to assist in the event of an emergency.

¶All exercise tests were directly supervised by a physician or an allied health professional (eg, clinical exercise physiologist or nurse) with medical supervision in close proximity.

supervise exercise tests must have the necessary cognitive and technical skills as delineated in the competency statement of the ACC/AHA/American College of Physicians,¹³ experience in exercise testing as outlined in the ACC Foundation Task Force on Training in Electrocardiography and Exercise Testing⁴¹ (requiring a minimum of 200 tests for level 1 proficiency), and an understanding of the standards of practice and research-based guidelines from other professional organizations involved in the training/certification of these individuals, including the ACSM²⁴ (Table 1). The expanded range of patients undergoing exercise testing underlies one of the strong priorities of continued physician involvement even in a staff accustomed to routine exercise testing.

Screening for indications and contraindications from the medical history and baseline 12-lead ECG can generally be achieved by highly trained nonphysician health professionals, provided that an appropriate physician staff member (eg, internal medicine, cardiology) is also available to evaluate selected

patients before testing. The nonphysician should bring questions related to appropriate use criteria to the attention of the physician. Decisions about the proper triaging of patients to appropriate levels of supervision during exercise testing are critical before the test (Table 2). Nonphysicians can also make a timely and accurate interpretation of the significance of evoked signs or symptoms, terminating an exercise test at an appropriate intensity level. Standardized methodological procedures and test termination criteria with a minimum of personal interpretation help preserve safety. Because all exercise testing staff should have current credentialing in basic life support and ideally advanced cardiac life support, complications should be appropriately managed in the interval before the designated covering physician or emergency response team arrives. A distinct, clearly audible, and easily activated emergency alarm system, specific to the testing room location where the complication has occurred, is strongly recommended for this purpose. Finally, several reports suggest that highly trained NPs, PAs,

Table 4. Demonstrated Cognitive and Practical Experiences and Skills and Abilities Needed to Independently Supervise Clinical Exercise Tests

	Essential Criteria	Where Obtained	How Assessed
Cognitive experiences	Exposure to and understanding of normal and abnormal resting and exertional physiology of the cardiovascular and pulmonary systems Exposure to clinical exercise testing principles Exposure to ECG interpretation during both rest and exertion.	Academic curricula, continuing education courses, and additional certifications	Academic transcripts, continuing education certificates, and documentation of certification credentials
Practical experiences	Previous time spent in a clinical exercise testing laboratory, either working independently or under supervision, during academic training or after graduation. Physicians and nonphysicians should meet level 1 Core Cardiology Training Symposium standard for conducting exercise testing, requiring a minimum of 200 tests. ⁴¹ A minimum of 50 tests per y should be performed to maintain competency.	Clinical exercise testing laboratory	Previous experience documented on curriculum vitae, letters of recommendation
Skills and abilities	Screens patients for the appropriate indication, type of test, and contraindications. Assesses patient history, symptoms, and signs that suggest increased risk so that the appropriate level of medical supervision is provided. Recognizes appropriate termination criteria for the clinical exercise test. Recognizes when baseline signs and symptoms indicate the clinical exercise test is not warranted. Effectively communicates with the patient about the reason for testing; obtains informed consent; selects appropriate exercise testing procedures; and prepares patient for the exercise test. Operates/maintains all clinical exercise testing equipment independently. Appropriately interprets clinical exercise testing data and generates appropriate reports, the parameters of which are defined by the laboratory medical director.	Clinical exercise testing laboratory	Direct supervision of nonphysician health professional conducting and interpreting clinical exercise tests by medical director or designee Clinical vignettes/written assessments Simulated ECG interpretation exercises

exercise physiologists, and technicians can provide an accurate preliminary interpretation of exercise test responses, in excellent agreement with attending physician or cardiology consult overreads.^{42–45} Thus, the nonphysician who meets the appropriate qualifications can provide a preliminary interpretation and discussion of the results to the patient.

An in-depth understanding of both resting and exertional cardiovascular and pulmonary physiology is perhaps the most important competency area for the nonphysician health professional supervising clinical exercise tests. The nonphysician health professional should be able to provide a detailed description of both normal and abnormal resting and exertional responses of these physiological systems. This understanding is needed to determine whether a clinical exercise test should be initiated and, if initiated, when the test should be terminated as a result of either abnormal signs or symptoms or an inappropriate physiological response. The

nonphysician health professional must be able to demonstrate his/her academic and experiential training by accurately interpreting resting and exertional cardiovascular and pulmonary responses. Ideally, these experiences should be reinforced by attending continuing education courses and independent reading of appropriate texts and journal articles. Numerous exercise testing guidelines, texts, and journal articles serve as invaluable resources in this regard^{12,16–19,24,46,47} (Table 1). In addition to demonstration of appropriate academic training, the nonphysician health professional must maintain, at a minimum, basic life support certification. There are additional certifications such as the ACSM Registered Clinical Exercise Physiologist and Certified Clinical Exercise Specialist (<http://certification.acsm.org/>) that the nonphysician health professional should be encouraged to obtain if eligible. Although highly recommended and possibly even required by specific exercise laboratories, these additional certifications are not

universally mandated for the ability to independently supervise clinical exercise tests.

The logistics of each clinical exercise test performed should account for characteristics of the individual patient undergoing the assessment. For example, patients who present with significant functional compromise (eg, New York Heart Association class III heart failure) would benefit from a conservative testing protocol. Likewise, older patients often benefit from lower-intensity protocols than those used in young adults. The nonphysician health professional must demonstrate an ability to make appropriate decisions about the mode of exercise and the protocol to use on a case-by-case basis. He/she must also demonstrate an ability to appropriately explain the rationale for exercise testing to the patient, to obtain informed consent, and to prepare the patient for the exercise test.

The nonphysician health professional, when hired in a given clinical exercise testing laboratory, should not be immediately granted the role to independently supervise clinical exercise tests, regardless of academic training, additional certifications, or previous experiences. The medical director of the laboratory should determine the proficiency of a staff member before he or she is granted the responsibility to conduct tests without direct supervision. Both physician and nonphysician personnel should meet the 2008 ACC Foundation Core Cardiology Training Task Force recommendation of a minimum of 200 tests for level 1 proficiency.⁴¹ A minimum of 50 tests per year should be performed to maintain proficiency. Previous experience in another clinical exercise testing laboratory where the nonphysician health professional conducted tests independently can be taken into consideration to reduce the number of tests that are directly supervised. In addition to direct observation, the medical director may choose to develop competency assessments in accordance with national standards and specific to that laboratory (eg, written clinical vignettes followed by a series of questions, real-time ECG analysis with a simulator).

Interpretation of exercise test data is ultimately the responsibility of the medical director overseeing the laboratory, including overreading of reports. The medical director may choose to delegate certain interpretation and report-generating responsibilities to nonphysician health professionals with appropriate medical sophistication, but final responsibility ultimately remains with the physician as a standard of care. Therefore, as determined by the clinical exercise testing laboratory medical director, the nonphysician health professional must demonstrate the ability to accurately interpret preliminary exercise testing data and to generate an appropriate report.

Ancillary Tests

Advanced clinical exercise testing laboratories typically include cardiac perfusion imaging and often have the ability to collect ventilatory expired gas analysis during testing. The utility of imaging is a key adjunctive technology to improve test sensitivity to diagnose CAD. In these settings, the nonphysician must have sophistication about the criteria for when imaging may be indicated and the requisite skills for completing the exercise testing protocols that are integrated with echocardiography and nuclear perfusion imaging techniques. This also entails the capacity for working with supplementary staff, including echocardiography sonographers and nuclear

perfusionists, and physicians (or nurses) in cases when echocardiographic contrast or pharmacological stress is indicated. Perhaps most important, nonphysician staff must have the insight and accessibility to the supervising physician to immediately share their impressions about which patients may benefit from imaging modalities.

Exercise testing, coupled with ventilatory expired gas analysis, is also indicated for specific test indications such as patients diagnosed with heart failure who are being considered for device implantation or transplantation and patients being assessed for unexplained exertional dyspnea.¹⁷ In these settings, the nonphysician health professional must also have the sophistication to identify appropriate patients and to be able to readily share this information with the supervising physician. Moreover, he/she must be able to independently operate this equipment, including calibration and collection of appropriate data during the exercise test.

Laboratory Maintenance

The nonphysician health professional must be able to manage all equipment housed within the clinical exercise testing laboratory. This equipment commonly includes a motorized treadmill, an electronically braked cycle ergometer, and blood pressure, ECG, and pulse oximetry monitoring equipment. A ventilatory expired gas analysis system may also be housed within the clinical exercise testing laboratory. The nonphysician health professional is typically responsible for the maintenance and upkeep of this equipment and for ensuring that all devices are properly calibrated to be able to collect valid and reliable data. The nonphysician health professional may have various degrees of ability in repairing equipment, and advanced skills in this area are not considered a requirement. However, this individual must be able to recognize when equipment is not working properly and contact external support staff to schedule repairs. Exercise testing laboratory standards have been detailed in previous AHA scientific statements.^{12,17}

Specific Roles and Responsibilities for Nonphysician Staff

A critical role of the nonphysician health professional is to triage patients into appropriate risk groups and to understand the level of physician oversight required for a given patient. Physicians are responsible for teaching their nonphysician staff which tests should be considered high risk, and the physician should be available to directly supervise those tests when they are identified by nonphysician support staff. As outlined in previous scientific statements related to exercise testing (Table 1), patients should be triaged into 3 categories by level of risk¹³ to determine the degree of physician supervision required. These levels are as follows: (1) personal supervision, requiring a physician's presence in the room (Table 2); (2) direct supervision, requiring a physician to be in the immediate vicinity or on the premises or the floor and available for emergencies (immediate vicinity is defined as the ability to physically enter the exercise testing room within 30 seconds of notification); and (3) general supervision, requiring the physician to be available by phone or by page.

Individuals who supervise and administer exercise tests, whatever their professional designation, must be highly

competent with specific clinical expertise and technical skills. These skills have been outlined by the ACC, AHA, ACSM, and others^{13,24} (Tables 1 and 4). Although all professionals supervising exercise tests must have a core set of skills, the considerable variation in educational preparation, certification, and licensing of these healthcare professionals underlies differences in their roles in the administration and supervision of exercise tests, although this may also vary from state to state and with the availability of professionals at a given institution. Suggested roles of nonphysicians working in exercise laboratories, including CEPs, nurses and NPs, PAs, and PTs, are outlined below.

Clinical Exercise Physiologist

The CEP is specifically trained to perform clinical exercise testing, write exercise prescriptions, and provide supervision, as well as health education and promotion.⁴⁸ The educational preparation of a CEP is a minimum of a bachelor degree in exercise science, exercise physiology, or kinesiology that includes courses covering exercise physiology, clinical exercise testing, exercise prescription, exercise training, and basic clinical assessment.⁴⁸ This specialized education, training, and certification prepares the CEP for a broad range of roles and responsibilities within the context of exercise test supervision, particularly in selecting exercise test protocols, monitoring hemodynamic responses to exercise, helping to determine test end points, and quantifying peak exercise workload to estimate the patient's functional capacity in metabolic equivalents.

Registered Nurses and NPs

Registered nurses are trained to perform physical examinations, to take health histories, to provide health education and counseling, to interpret patient information, and to make critical decisions about treatment strategies. They are licensed to administer medications and to perform a variety of medical procedures under the supervision or direction of a physician or person who is licensed to practice medicine.⁴⁹ NPs complete a course of advanced training (master's or doctorate degree) and are licensed (in most states) to diagnose and treat acute and chronic problems, to interpret test results, and to prescribe medications and other therapies.⁵⁰ To conduct exercise testing, registered nurses should have specific training and skills in cardiovascular disease assessment and rhythm management and should be certified in advanced cardiovascular life support. They should be well prepared to take the health history, to perform the physical examination before exercise testing, and to monitor the patient for adverse responses to incremental exercise, including the identification and treatment of serious arrhythmias. They may also help determine the end point of testing on the basis of the patient's symptoms, start intravenous medications, and deliver medications during life-threatening complications. Because of their advanced training, certification, and licensure, NPs may be able interpret test results and communicate them with referring physicians.

Physician Assistants

PAs complete training in an accredited PA program after having completed at least 2 years of undergraduate courses in basic and behavioral sciences. Although PAs receive a

broad-based medical education, they, like many health professionals, continue learning in the clinical work environment and through continuing medical education.⁵¹ Theoretically, their role in exercise testing may be interchangeable with that of registered nurses and NPs, depending on the specific training of individuals in each discipline.

Physical Therapists

PTs are trained to provide care to patients who have physical impairments, activity limitations, and participation restrictions as a result of musculoskeletal, neuromuscular, cardiovascular/pulmonary, or integumentary disorders.⁵² However, the educational background of PTs can include specialized training in cardiovascular and exercise physiology, potentially making their role in exercise testing similar to that of the CEP.

As a general rule, the relative areas of expertise of each of these disciplines overlap, but they are also distinctive. Nurses, NPs, and PAs have relatively more medical training and sophistication, but the degree of relevant cardiovascular, pulmonary, and exercise science background may vary. Likewise, CEPs and PTs may be similar in regard to their expertise in exercise science, but the overall skill set in relation to disease may vary from individual to individual, depending on the person's particular training and experience. Ideally, nonphysician personnel should work as a team rather than in a hierarchical manner.

Role of the Physician

Whereas the physician's role has gradually evolved from directly supervising exercise tests,²⁸ the contemporary physician now more typically oversees nonphysicians conducting these assessments. However, the physician is ultimately responsible for the quality and safety of all exercise tests done under his or her direct or indirect supervision, as well as the final interpretation of the findings. Referral for exercise testing and decisions about appropriate use criteria for standard exercise testing or stress imaging are under the purview of the physician. Therefore, high standards of time-sensitive communication, documentation, and coordination between physicians and nonphysicians are essential.

Competencies required to supervise exercise tests have been outlined previously by the ACC/AHA.^{13,41} Physicians supervising exercise tests must have cognitive skills including knowledge of indications and contraindications for testing, knowledge of basic cardiovascular and exercise physiology, and knowledge of testing protocols. Furthermore, they must have the skills necessary to interpret test results. Physicians who oversee exercise tests should meet proficiency standards outlined in the 2008 ACC Foundation Task Force 2 training statement, which require conducting a minimum of 200 exercise tests during training.⁴¹ This experience is frequently obtained during cardiology fellowship, during which tests are reviewed by faculty. During this period of training, the fellow should not be considered a surrogate for the attending physician. The attending physician has a supervising role in teaching the fellow and overreading the tests and to be present in the room when high-risk patients are undergoing testing (Table 2). To maintain competency, clinicians should perform at least 50 exercise tests per year (level 1, personally supervised) and should be certified in advanced cardiovascular life support.

Physicians are responsible for teaching their nonphysician staff which tests should be considered high risk and should be available to directly supervise those tests when identified by nonphysician support staff. Considerations for direct physician supervision include clinical history and presentation, baseline hemodynamics, and the resting ECG.¹² All people conducting exercise tests under the supervision of a physician should be competent in making these assessments. Because the criteria for tests requiring direct physician supervision may vary, depending on the individual interpretation of the patient's risk status, it appears prudent to err on the conservative side. Patients who have experienced a recent acute coronary syndrome or have severe valvular stenosis or complex arrhythmias should be supervised directly by physicians (Table 2).^{13,24} It is the physician's responsibility to be in the vicinity of the test and to be able to respond should the need arise.

Basic initial interpretation of exercise testing results may be done by a qualified nonphysician.¹² Evidence suggests a high level of agreement between results as interpreted by highly trained physicians and nonphysicians.⁴²⁻⁴⁵ However, physicians should overread all tests to provide a final report for the referring provider to ensure accuracy. Given the evolving reasons that patients are referred for exercise testing (valvular disease, heart failure, dyspnea assessment, arrhythmias, etc), the skills involved in the interpretation of testing are not routine. State-of-the-art interpretation by physicians and nonphysicians assumes an expansive knowledge base, with skills and insights that must be commensurate with the growing complexity of clinical circumstances/questions. It is the responsibility of the physician to keep interpretations of all providers up to date.

Physician's Elemental Role in the Exercise Testing Team

This document highlights the considerable expertise of highly trained nonphysician providers to administer exercise testing safely and effectively; it also affirms the physician's elemental role. Although this statement avoids direct focus on remuneration, it affirms the physician's elemental leadership role in an exercise testing team. Whereas the hands-on mechanics of exercise testing may be administered predominantly by CEPs, nurses, NPs, PTs, and PAs, an in-suite (readily available) physician remains essential, not merely for emergencies but also for clinical management, outcomes evaluations, data management and interpretation, and quality control. The physician is responsible for effective and safe exercise testing, as well as requisite coordination, communication, and testing techniques among all the team members, that is, skills that are increasingly relevant as patients and indications for testing become increasingly complex (patients who are older, frailer, with more comorbidities and more obesity). The physician also has a critical role in executive leadership.

Authority, Delegation, and Management

Implications of the Legal System

In the US legal system, the sources of law that regulate professions or affect relationships between individuals and entities are numerous, and their potential influences on health care can be complex. Examples of these sources include federal

regulations, state statutes, local laws, common laws, torts and contracts, laws related to malpractice and negligence actions, and criminal laws. A review of these foundations in relation to clinical exercise testing can be found elsewhere.^{53,54} Certain aspects of the law may be more likely to have implications for healthcare service delivery than others.

State statutes constitute one such area. Each state has enacted laws that define and regulate the practice of medicine and certain nonphysician healthcare professions. Those governing the practice of medicine are generally all encompassing. However, because the written provisions vary among states, court decisions in malpractice litigation in reference to the statutes can differ from one jurisdiction to another. Statutes and licensing boards also exist for certain nonphysician healthcare professions in different states. The scope of practice and specific licensing authorities for nonphysician healthcare providers also can differ between jurisdictions, but unlike statutes for licensed physicians, those established for nonphysician healthcare professions are almost always narrowly defined.

Complicating matters for both physicians and nonphysicians is the fact that statutes in some states proscribe physicians from assigning certain aspects of patient care to nonphysicians.²³ Given that many states have criminal statutes prohibiting the unauthorized practice of medicine, failing to adhere to statutory mandates can potentially lead to serious legal consequences. Evolution of healthcare reform has further complicated role delineation with regard to day-to-day delivery of patient care. Judicious use of paraprofessionals has helped contain costs while maintaining quality of care. To some extent, various states have undertaken an effort to expand nursing and other nonphysician healthcare provider practice laws, and this has facilitated physician delegation of appropriate responsibilities to nonphysicians.

Another important legal consideration is whether licensure or professional self-regulation of competency has different implications for legal risks associated with the nonphysician's role in clinical exercise testing. As an example, in the United States, Louisiana is currently the only state that licenses CEPs. By statute, CEPs in Louisiana may administer exercise tests to patients known to have ≥ 1 specific diseases and conditions. Even then, licensed CEPs in that state may provide exercise testing and exercise treatments only when acting under the direction, approval, and supervision of a licensed physician.⁵⁵ Advocacy groups have lobbied for licensure of CEPs in several other states, but these efforts have been unsuccessful.⁵⁶ Whether licensure enhances public safety beyond what professional self-regulation may accomplish is a complex issue that is difficult to resolve.

Demonstration of competency, established with reference to rigorous and relevant practice guidelines and recommendations, is an inherently effective means for reducing the risk of harm and legal risks in the delivery of healthcare services. With regard to clinical exercise testing, credentialing programs based on relevant knowledge, skills, and abilities have been developed by the ACSM to serve this purpose. The ACSM has established educational prerequisites and competency standards that individuals must meet to be credentialed to perform exercise testing and related exercise training in the clinical setting (Table 5). These credentials are based on

Table 5. Allocation of Responsibilities: Deciding Nonphysician Roles in Clinical Exercise ECG Tests**Medical director**

- Establishes and documents policies: provides standing orders to specify duties and limits of exercise testing responsibilities for each nonphysician delegate; specifies clinical risk categories of patients eligible to be tested. Does not delegate authorities reserved for licensed physicians
- Directly supervises sufficient tests with each nonphysician to confirm his/her competencies with clinical classes of patients to be tested; requires individual to be credentialed or provide alternative evidence of qualifications (ie, ACSM CES or RCEP credentials or equivalent)
- Establishes, regularly rehearses, and documents capability for emergency response; ensures capability for rapid activation of a physician-directed advanced cardiac life support team for all tests; requires each nonphysician delegate to maintain training in AHA BLS or equivalent and to participate in these emergency rehearsals
- Provides substantive physician oversight with regard to policy supervision for informed consent; indications/contraindications for testing; immediate pretest physical examination by a physician; confirmation of anticipated test end points; diagnosis, prognosis, or treatment decisions; final clinical interpretation; and report to referring physician
- Makes certain that provisions in the medical malpractice policy do not preclude insurance coverage for delegation of patient care duties to nonphysicians

Nonphysician test supervisor

- Demonstrates evidence of competency related clinical exercise testing (eg, appropriate credentialing and evidence of continuing education)
- Establishes and maintains competency for cardiovascular emergency response capability, AHA BLS, or equivalent
- Performs only procedures, supervisory duties, and initial interpretations as delegated and documented in written policies from the medical director of the testing facility
- Accepts only responsibilities consistent with competencies and credentialing
- Does not perform duties that might be characterized as the practice of medicine

Institutional administrator(s)

- Reviews institutional implications of nonphysician roles in clinical exercise testing relative to institutional liability insurance coverage, Medicare regulations and policies of private healthcare insurers that would affect eligibility for reimbursement of services, and the conduct of any clinical exercise testing performed as part of IRB authorized research

Legal counsel

- Provides guidance on framing policies and practices so that proposed practices will comply with federal and state statutes, local laws, and health insurance mandates

ACSM indicates American College of Sports Medicine; AHA, American Heart Association; BLS, basic life support training, including automated external defibrillator; CES, certified Clinical Exercise Specialist; IRB, Institutional Review Board; and RCEP, Registered Clinical Exercise Physiologist.

performance criteria derived from long-established and clinically relevant exercise testing and prescription guidelines²⁴ that meet independent accreditation standards. In addition, these ACSM guidelines and credentialing competencies are highly consistent with the current AHA recommendations for equipment, methods, protocols, and competencies needed to supervise clinical exercise testing.^{12,13,16} Thus, nonphysicians who directly perform clinical exercise tests under the direction of a physician, adhere to relevant practice guidelines, and

avoid engaging in activities reserved by law for the licensed physician should be less vulnerable to damage and loss in the event of legal claim and suit.

When malpractice or negligence lawsuits related to exercise testing in the healthcare setting have occurred, the contested issues are numerous and diverse and arise from patient insult, injuries, or deaths. Common allegations may include failures related to informed consent, devices, or performance of personnel who carried out the exercise test or related emergency cardiac care in ways that purportedly failed to meet applicable standards of care. Information resources needed to quantify the risk of litigation are not readily available. The reasons are 2-fold. First, legal databases that might be used to quantify incidents of litigation generally include only that fraction of cases that led to court-reported actions and resulted in legal opinions written to support research needs of attorneys. Thus, the presumably much larger number of cases settled confidentially are not included in these databases. Second, there is no available comprehensive database of medical exercise ECG tests performed in the United States that might be used as an index of exposure. The number of clinical exercise tests performed across the United States is believed to exceed 2 million annually. Yet, a recent search of the Thomas Reuters Westlaw Classic malpractice database yielded a total of only 482 opinions written in connection with federal or state court cases related to exercise tests in healthcare facilities in the United States over the past 66 years. Although these are inexact markers, they suggest that personal injury lawsuits related to exercise testing are uncommon. All healthcare providers and organizations should recognize that finite risks exist and develop effective risk mitigation strategies accordingly.

Recommendations

Table 5 presents the delineation of responsibilities that may contribute to fewer untoward outcomes with clinical exercise testing and simultaneously reduce risks for personal injury lawsuits or losses in the event of claim and suit. The medical director of the testing facility should lead in developing and implementing procedures that directly affect safety and the quality of patient care. Medical directors should possess the cognitive skills for exercise testing and should periodically reinforce these skills by supervising such tests, as recommended by the AHA.¹³ An emergency medical response plan, coupled with periodic emergency drills, is an invaluable way to maintain emergency readiness, particularly for nonphysician test supervisors who would necessarily be responsible for activating the emergency medical team if a physician was not immediately available in the testing room. Finally, the medical director or another designated physician should make all final decisions derived from the exercise test that might be regarded as part of the practice of medicine and should not permit them to be carried out by nonphysicians (Table 5 provides further suggestions). Documentation of these decisions in the patient record is equally important.

The qualified nonphysician exercise test supervisor should secure and strive to maintain competencies consistent with his/her assigned duties, education, and credentialing. Preferably, this may be accomplished by maintaining active status with an appropriate professional credential and engaging in continuing education activities. These individuals also should interact

with the medical director in jointly conducted clinical exercise tests and emergency drills. Maintenance of skills related to basic life support training also is essential, including use of an automated external defibrillator. The nonphysician delegate supervising any exercise test may be expected to activate a physician-directed emergency response when a need arises.

Institutional administrators and legal counsel should collaborate with the medical director to establish approaches to enable physician delegation of exercise testing duties to qualified nonphysicians. These should be consistent with providing safe and effective patient care and satisfying both insurance considerations and legal requirements.

Summary Recommendations

- In support of previously published guidelines¹³ and a recent AHA scientific statement,¹² it is the consensus of this writing group that, in most cases, clinical exercise tests can be safely supervised by properly trained non-physician health professionals if the individual supervising the test meets competency requirements for exercise test supervision, is fully trained in cardiopulmonary resuscitation, and is supported by a physician skilled in exercise testing or emergency medicine who is in close proximity for pretest assessments or complications that may arise.
- The attainment of advanced training/certification such as the ACSM Exercise Specialist or Registered Clinical Exercise Physiologist²⁴ and current competency certification via continuing education or the supervision of

a designated number of exercise tests annually are also advocated for exercise testing laboratory personnel.

- High-risk patients require that a physician be physically present (ie, in the room) during exercise testing (Table 2), and the physician responsible for supervising the test must meet established competency standards.^{13,24} Nonphysicians must be capable of screening for and identifying these high-risk patients and alerting the physician supervisor when appropriate. Such cases include patients with increased risk for CAD instability, moderate to severe valvular stenosis, a history of malignant ventricular arrhythmias,^{32,35} significant pulmonary arterial hypertension/secondary pulmonary hypertension, questionable conduction disease, or combinations thereof.
- An emergency medical response plan, coupled with periodic emergency drills, should be in place in any facility that conducts clinical exercise testing.
- This statement supports the nonphysician’s value not merely as a less expensive physician surrogate for exercise testing but also as a professional who brings skills that are complementary to those of the physician as part of an exercise testing team. The physician’s role as final authority for the safety and quality of testing interpretation remains paramount. Nonphysician health professionals bring different skills to exercise science and patient care that enhance testing efficiencies and performance. The training and expertise of each health-care professional must be acknowledged and optimally used within a contemporary exercise testing laboratory. Regular communication and cohesion are also fundamental for clinical excellence and safety.

Disclosures

Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives \$10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

Reviewer Disclosures

Reviewer	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
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Michael S. Lauer	NHLBI	None	None	None	None	None	None	None
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Todd Miller	Mayo Clinic	None	None	None	None	None	Astellas Pharma*	None

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*Modest.

†Significant.

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KEY WORDS: AHA Scientific Statements ■ exercise test ■ physical exertion ■ physician's role