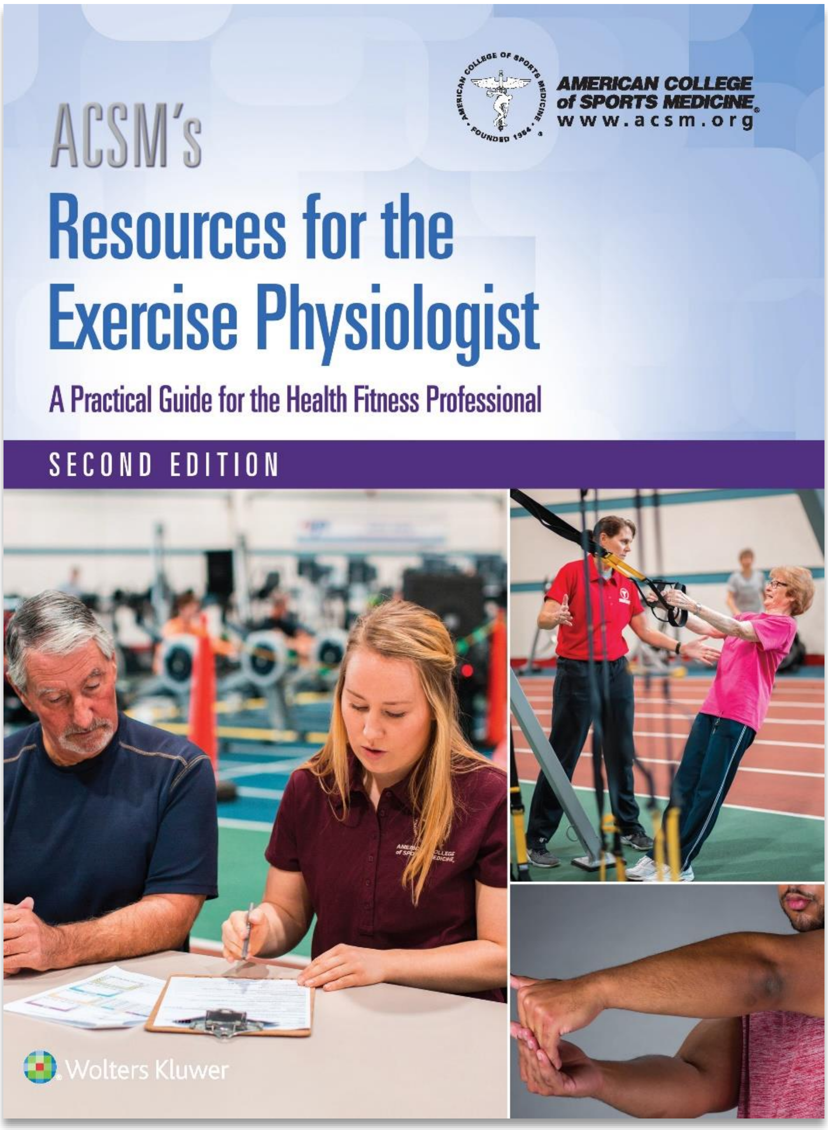

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CHAPTER 5

Flexibility Assessments and Exercise Programming for Apparently Healthy Participants

OBJECTIVES

- To understand the context of flexibility as it relates to health and wellness.
- To describe the basic anatomy and physiology of the musculoskeletal system related to flexibility.
- To differentiate modes of range of motion exercises and their strengths and weaknesses.
- To select appropriate assessment protocols for flexibility and analyze the results of those assessments.
- To formulate appropriate programs for development of whole body flexibility.

INTRODUCTION

Development and maintenance of flexibility has long been a recommended component of health-related fitness (24). The President's Council on Physical Fitness and Sports was in part prompted by the report of Kraus and Hirschland (56) indicating American children performed poorly compared with European children in a fitness assessment, especially on flexibility. The American College of Sports Medicine (ACSM) released its first position stand on cardiorespiratory and muscular fitness in 1981; however, it didn't include recommendations for flexibility exercises until 1998 (1). Similar to other components of fitness, it is important to maintain an adequate range of motion (ROM) necessary for activities of daily living. However, this increase in ROM through flexibility training does not seem to decrease the incidence of low back pain or muscle soreness (38,82,99), and it has not been shown to improve athletic performance. In some cases, it actually has been shown to decrease performance (7,52,54,55,106). Flexibility requirements are specific to the demands of individual activities, with some activities requiring more than average ROM at particular joints (*e.g.*, gymnastics and ballet) (28,71).

Basic Principles of Flexibility

Flexibility is defined as ROM of a joint or group of joints, as per the skeletal muscles and not any external forces (40). The flexibility of any given movable joint includes both static and dynamic components. Static flexibility is the full ROM of a given joint because of external forces. It can be achieved by the use of gravitational force, a partner, or specific exercise equipment (3). In contrast, dynamic flexibility is the full ROM of a given joint achieved by the voluntary use of skeletal muscles in combination with external forces (91). Although it is recognized that dynamic flexibility is greater than static flexibility for a given joint, the two may be independent of each other (43). Each movable joint has its own anatomical structure that helps define the ROM in which that joint can move. Due to this joint specificity, the ROM of one particular joint may not predict the ROM of other joints, although individuals participating in a full-body ROM program or performing activities that move several joints through their full ROM will generally have a greater full-body flexibility (32).

Visit thePoint to watch video 5.1, which demonstrates dynamic arm circles.

Factors Affecting Flexibility

ROM of a given joint is determined by several factors, including muscle properties, physical activity and exercise, anatomical structure, age, and gender.

Muscle properties: The inherent properties of muscle tissue play a major role in the ROM of a given joint. Skeletal muscles, when stretched, exhibit both viscous and elastic properties (viscoelastic properties), which allow them to extend through the process of creep and stress relaxation (78). In addition, research has suggested that the viscoelastic properties of skeletal muscle may be altered and lead to an increase in ROM by either an external thermal modality (*i.e.*, heat pad) or a physically active warm-up (79,89,90,96). Nevertheless, this finding is not well documented in humans, and therefore, more research is needed to further validate these findings (31,32).

Physical activity and exercise: Both single and multiple bouts of physical activity can lead to greater flexibility of the affected joints, primarily by moving joints through a fuller ROM during exercise

Visit thePoint to watch video 5.2, which demonstrates the soldier walk.

than would normally occur (26,43,86). In addition, resistance training programs that incorporate full ROM exercises may also increase flexibility of the affected joints (59,97), assuming both agonist and antagonist muscles around the joint are being trained (12). For instance, pull-ups or chin-ups move the shoulder through a ROM not normally encountered in day-to-day activities, thereby increasing shoulder ROM. Furthermore, athletes who regularly perform ROM exercise during aerobic, resistance, or flexibility exercise improve performance, at least in part, through an enhanced level of flexibility (44,50,108). Nonetheless, discrepancies exist in the level of flexibility necessary for a variety of activities (28), such as athletes in the same sport but at different competitive levels (collegiate vs. professional) (95) and athletes in the same sport but in a different position (27,80). Additionally, there is also a difference in the level of flexibility between dominant and non-dominant limbs in athletes who participate in sports that involve bilateral asymmetrical motions such as tennis and baseball (21,62).

Anatomical structures: The ROM of a given joint is influenced by its structure and the anatomical structures surrounding it. Freely moveable joints (synovial) may be classified into one of six groups, each with a specific permissible plane or planes of movement (Fig. 5.1) (32,105). Furthermore, joint flexibility is not affected equally by connective tissues around joints. Johns and Wright (48) demonstrated that relative contributions of various soft tissues to joint stiffness are as follows: joint capsule (47%), muscles (41%), tendons (10%), and the skin (2%). In addition, soft tissue bulk including muscle and subcutaneous fat tissues may affect joint flexibility because of potential movement restriction (16,105).

Age and gender: Several studies have examined the relationship between the degree of flexibility within a given joint relative to age and gender. These studies have demonstrated that with aging, there is a reduction in collagen solubility, which may lead to increases in tendon rigidity and therefore reduction in joint ROM (81). This reduction may be further exacerbated by age-related conditions such as past injuries, degenerative joint disease, and decreased levels of physical activity) (42,81). Normative data collected on thousands of men and women at The Cooper Institute show that women consistently have greater ROM across almost all measured joints compared with men (100).

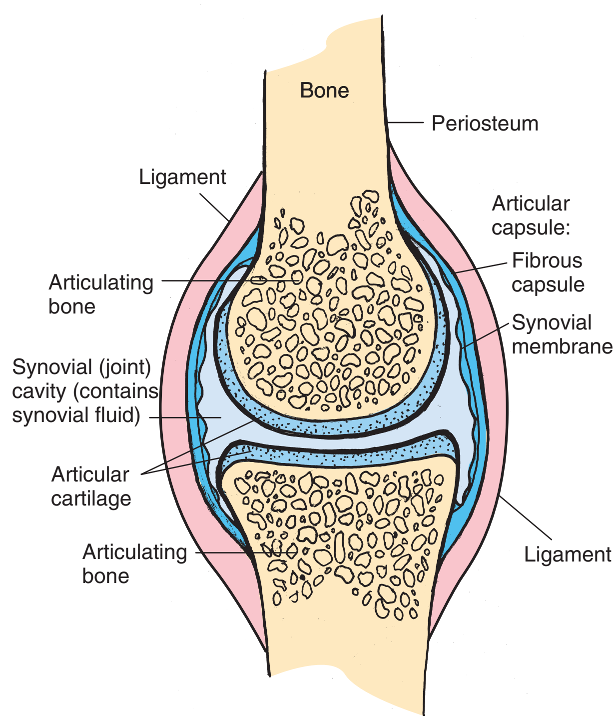

FIGURE 5.1. Classification of synovial joints. (From Bushman B, editor. *ACSM's Resources for the Personal Trainer*. 4th ed. Baltimore [MD]: Lippincott Williams & Wilkins; 2014. 592 p.)

Some of the reasons for increased female flexibility include smaller muscles and wider hips (60) and differences in hormonal levels (83). A study by Park et al. (83) has demonstrated that changes in estradiol and progesterone levels during ovulation led to a greater degree of knee joint laxity. Furthermore, it was also demonstrated that women have a more compliant Achilles tendon, resulting in greater ankle flexibility and lower muscle stiffness (49).

Modes of Flexibility Training

There are four types of flexibility training modes. Three of these modes — static, ballistic, and proprioceptive neuromuscular facilitation (PNF) — are considered "traditional" flexibility training modes (92). Dynamic flexibility training is becoming more common especially as part of the warm-up routine (31,66) to better prepare the body for competition (9). Of all the different modes, static flexibility training is most commonly utilized and can be further subdivided into three categories: (a) slow and constant stretch with a partner (passive), (b) slow and constant stretch without any assistance, or "self-stretching," and (c) slow and constant stretch against a stationary object (isometric) (95).

Static Flexibility

Static stretching is the most commonly used flexibility protocol of all due to the fact that it can be easily administered without assistance (95), and regardless of the type of static stretching, each involves a slow and constant motion that is held in the final position, or point of mild discomfort, for 15–30 seconds (1). To achieve an optimal degree of ROM, it is recommended to repeat each exercise no more than four times, because there are only minimal gains with additional repetitions (98). The advantage of using this method involves both relaxing and concurrent elongation of the stretched muscle without stimulation of the stretch reflex (78). Several studies have demonstrated that static stretching can lead to both short- and long-term gains in flexibility (4,19,67) through a decrease in muscle/tendon stiffness and viscoelastic stress relaxation (63,64). Although many researchers and practitioners view static stretching as effective and beneficial (4,5,19,78) (Fig. 5.2),

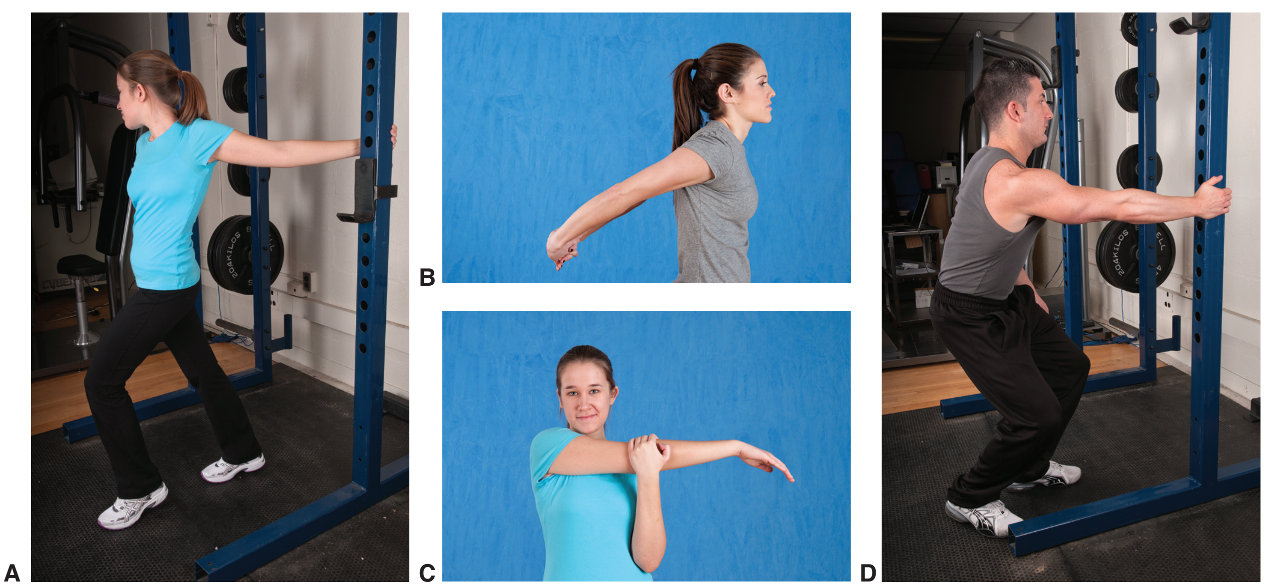

FIGURE 5.2. Examples of static stretches: **(A)** pectoral wall stretch, **(B)** posterior shoulder hyperextension, **(C)** anterior cross-arm stretch, and **(D)** lat stretch. (From Ratamess N. *ACSM's Foundations of Strength Training and Conditioning*. Baltimore [MD]: Lippincott Williams & Wilkins; 2012. 560 p.)

others have raised concerns. Because static stretching is slow and controlled, it does not provide an increase in muscle temperature and blood flow redistribution that is needed before exercise particularly prior to competitive sports performance (69,93,94). In addition, the view that static stretching may improve performance is ambiguous, with several studies reporting an increase (44,50,108), several reporting a decrease (8,17,67), and others reporting no changes (98,109) in performance.

Ballistic Flexibility

Ballistic stretching involves rapid and bouncing-like movements in which the resultant momentum of the body or body segments is used to extend the affected joint through the full ROM (32). This type of stretching technique, as opposed to static stretching and PNF, is no longer advocated as common practice for most individuals (57,102) to improve a joint's ROM. However, ballistic stretching is still used by some athletes and coaches to increase the blood flow to the muscle prior to competition or practice. Current research in this area indicates that properly performed ballistic stretching is equally as effective as static stretching in increasing joint ROM and may be considered for adults who engage in activities that involve ballistic movements such as basketball (25,107). However, given the nature of the movements, this type of stretching produces a rapid and high degree of tension inside the muscle, which may potentially lead to muscle and tendon injuries (78,79,92). The risk of injury may be further exacerbated by stimulating a myotatic reflex (also referred to as the stretch reflex), which is common with this mode of stretching (32). However, the hypothesis that ballistic stretching leads to muscle or connective tissue injury has never been supported by the scientific literature (76,103). In respect of the effectiveness of this technique and when compared with static stretching, ballistic stretching does not provide any added benefit (5,41,61). Thus, it is recommended to use techniques that are viewed as safer and may potentially be more effective such as static stretching, dynamic stretching, and PNF (31).

Proprioceptive Neuromuscular Facilitation

PNF is a collection of stretching techniques combining passive stretch with isometric and concentric muscle actions designed to use the autogenic and reciprocal inhibition responses of the Golgi tendon organs (GTOs) (31,32). It is hypothesized that through the responses of the GTO, the muscle and tendon are able to elongate and achieve greater ROM and increasing neuromuscular efficiency (31,39). PNF stretching (Fig. 5.3) was first developed not only as a stretching technique but also as a strengthening technique through a series of diagonal patterns to help physical therapists treat patients with neuromuscular paralysis (51) and later adopted for use by athletes as a technique to increase ROM (91).

FIGURE 5.3. PNF stretching. (From Ratamess N. *ACSM's Foundations of Strength Training and Conditioning*. Baltimore [MD]: Lippincott Williams & Wilkins; 2012. 560 p.)

Visit thePoint to watch video 5.3, which demonstrates PNF stretching.

There are three types of PNF stretching techniques: (a) hold–relax, (b) hold–relax with antagonist contraction, and (c) agonist contraction (11,14,73,97). Of the three, the hold–relax and the hold–relax with antagonist contraction are most frequently used (39). Each technique comprises three phases: (a) a passive prestretch, (b) passive stretch, and (c) contractions (3). When PNF is compared with other stretching techniques with respect to effectiveness of improving ROM, the data are inconsistent. Some studies have demonstrated that PNF is superior to both static and ballistic stretching techniques (41,88,104), whereas others have found no difference (10,12,29,61). Despite the wide support that the PNF stretching has among researchers and practitioners, there are some limitations with these techniques such as the need for a trained partner and the potential risk for musculature injury (15,37).

EXERCISE IS MEDICINE CONNECTION

Moonaz S, Bingham C III, Wissow L, Bartlett S. Yoga in sedentary adults with arthritis: effects of a randomized controlled pragmatic trial. *J Rheumatol*. 2015:42(7);1194–202. (72)

Yoga has been used for more than 5,000 years around the world as a means of health improvement, with well-documented studies showing increased in flexibility and ROM, a key aspect of health-related fitness. Yoga's use has increased dramatically as a popular exercise modality in the United States in the recent past. It is estimated that the number of Americans that practice yoga increased by 29% between the years 2008 and 2012.

In addition to the benefits to flexibility, yoga has often been used to ease pain and dysfunction associated with arthritis, a debilitating condition that results in inflammation, stiffness, and pain at and around the joints and affects over 50 million Americans. Recent evidence suggested that yoga training may improve physical activity adherence and physical and psychological health.

Moonaz, Bingham, Wissow, and Bartlett randomly assigned 75 physically inactive adults with rheumatoid arthritis (RA) or knee osteoarthritis (OA) to an 8-week yoga program group or a control group. Per week, the yoga program group completed two 60-minute classes and one home practice. Outcome measures included physical and mental components representing health-related quality of life (HRQL) domains and disease activity. In the yoga group, the researchers followed the participants for an additional 9 months to examine the long-term effects of the program. The results of this study demonstrated that an 8-week yoga program led to improved physical and mental components, improved walking capacity, and reduced depressive symptoms. It was also demonstrated that most of these benefits were maintained 9 months after the cessation of the program.

In summary, appropriately designed yoga programs can be an effective treatment for improving physical and psychological health and physical abilities in patients with RA and OA.

Visit thePoint to watch videos 5.4 and 5.5, which demonstrate the kneeling cat and modified cobra positions.

Dynamic Flexibility

As opposed to the previously mentioned stretching techniques, dynamic flexibility uses slow and controlled, sport-specific movements that are designed to increase core temperature and enhance activity-related flexibility and balance (5,36,66). In view of the fact that these exercises are sport-specific, there is no comprehensive list of dynamic exercises. The design of such exercises is only limited by the knowledge and resourcefulness of the coach/trainer (36). In the past few years, several studies have examined the effectiveness of dynamic flexibility in relation to the degree of flexibility and athletic performance and the effects of preexercise static and dynamic stretches on anaerobic performance in different populations. One study has demonstrated that both static and dynamic stretches improve the ROM of the hamstring muscle; yet, static stretching was more effective (5). Furthermore, whereas some studies have demonstrated that a warm-up that included dynamic stretching was superior for improving sport performance to the one that included static stretching (70,74,101), others have failed to show those differences (13,33,103). Also related to dynamic stretching, eccentric training was recently introduced as a new technique that is designed to reduce the occurrence of injuries and improve flexibility and performance. Using this technique, the participant is instructed to resist a flexion in a given joint by eccentrically contracting the antagonist muscles during the entire ROM (76). Two studies examining this technique have demonstrated some merit when compared with static stretching (76,77). These recent findings emphasize the controversy that surrounds the issue of the usefulness of different stretching techniques.

Muscle and Tendon Proprioceptors

There are two types of sensory organs that provide muscular dynamic and limb movement information to the central nervous system (68). These sensors, muscle spindles (Fig. 5.4), and GTOs (Fig. 5.5) should be considered when discussing stretching and flexibility. Muscle spindles are a collection of 3–10 intrafusal, specialized muscle fibers that are innervated by gamma motor neurons and provide information about the rate of change in muscle length. The intrafusal muscle fibers run parallel to the extrafusal muscle fibers (regular muscle fibers), which are innervated by alpha motor neurons and are responsible for tension development (30,32) (see Fig. 5.4). When muscle

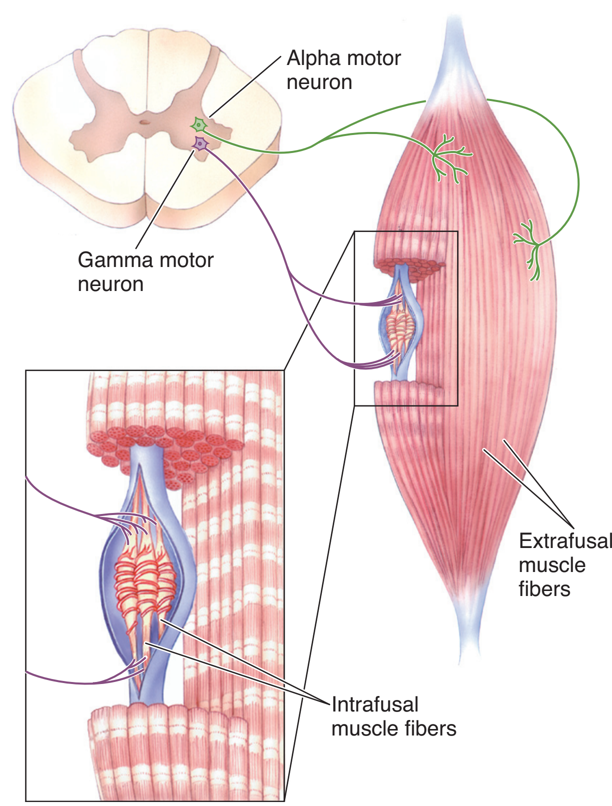

FIGURE 5.4. Structure and location of the muscle spindles. (From Bear MF, Connors BW, Parasido MA. *Neuroscience: Exploring the Brain*. 2nd ed. Philadelphia [PA]: Lippincott Williams & Wilkins; 2001. 855 p.)