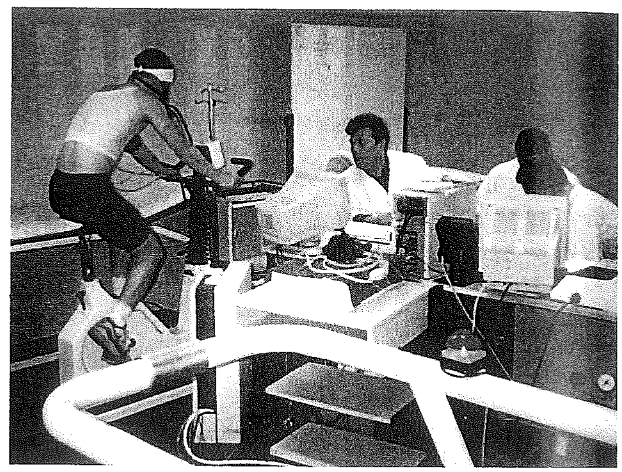
Assessing Physical Fitness

Attaining and maintaining a high level of physical fitness has various documented benefits that support leading an active lifestyle. This has led many people to begin exercise programs directed at improving their strength, endurance, agility, flexibility, body composition, and general quality of life. But how do you accurately determine your level of fitness? You may have seen, or experienced firsthand, fitness appraisals being done at health clubs or universities involving step tests or treadmills for endurance, grip strength tests, and sit-and-reach tests for flexibility, for example. But what do these tests actually measure? Do they provide you with an accurate indication of your actual level of physical fitness? It's important to set goals for yourself that make sense for you – fitness appraisals can be beneficial in this respect. This section will help you become more familiar with the various ways fitness is measured, how you can use the results of these tests to make personal changes in your life, and how you can administer these tests in a reliable and valid manner. Understanding the components of physical fitness (see Chapter 9) and how they can be measured will go a long way in assisting you in your own pursuit of physical fitness and health.

Measuring Aerobic Capacity

Cardiorespiratory endurance is a key component of physical fitness. It is what we are usually referring to when we say that someone is in "good shape" or "physically fit." The concept of cardiorespiratory endurance reflects an individual's aerobic capacity or aerobic power – in other words, the ability to supply oxygen to working muscles during physical exertion (see Chapter 5).

The most accurate and reliable measure of cardiorespiratory function is **maximal oxygen consumption** or **$\dot{V}O_2$max**, which is a measure of the amount of oxygen consumed per kilogram of body weight per minute of exercise. Measurement of aerobic capacity in the laboratory often involves a maximal exercise test on an ergometer (usually a treadmill or stationary cycle) in which the subject works at progressively increasing loads (intensity) until reaching exhaustion. Other reliable and valid testing protocols have been developed for estimating (predicting) $\dot{V}O_2$max; they are calculated from measurements of maximal or submaximal exercise performance, or submaximal heart rate. These **laboratory tests**, however, are rigorous and time consuming, and they often require expensive equipment such as gas analyzers, ergometers, and computerized metabolic systems. This puts lab testing of aerobic power out of reach for most schools.



Other simpler and more practical **field tests** have been devised to measure cardiorespiratory function. Popular field tests include running and step tests. **Running tests** require subjects to run a prescribed distance or run for a predetermined length of time; the time required to cover the distance and the distance covered in the allotted time, respectively, are the measurements used to evaluate aerobic capacity. The **step tests** involve stepping up and down steps of a certain height at a particular rate for an established period of time. Aerobic capacity is then estimated from the heart rate response or recovery heart rate following the activity – an individual with high aerobic power will return more quickly to a lower heart rate than a less "fit" individual. Make note of the fact that many step tests were devised for use by individuals of college age or above.

It is important when using field tests to employ standard distances, timers, and recording procedures for the most accurate results.

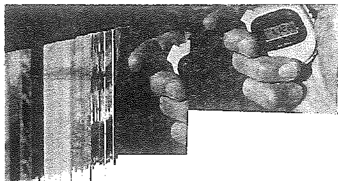
12-Minute Run–Walk Test

This test is satisfactory for both males and females from junior high school to college. Little equipment is required – a stopwatch, whistle, and distance markers are really all you need to complete the test. However, a course of specified distance will make counting the number of laps completed an easier task; the number of laps can then be easily multiplied by the course distance. Distance markers can also be used effectively to divide the course into quarters or eighths so that the tester can quickly and accurately determine the distance covered after 12 minutes have elapsed.

The goal of the test is simply to run or walk (or both) around the course as many times as possible in 12 minutes following the starting signal from behind a designated starting line. A spotter assigned to each runner should maintain an accurate count of each lap completed by the subject until the stop signal is given after 12 minutes. The runner should keep track of laps as well. The distance covered is calculated by multiplying the number of laps completed by the distance of each lap (including the incomplete lap). Spotter and subject can then reverse roles to complete the testing. If 12 minutes seems too long for a particular age level, 9-minute run–walk tests may also be appropriate. Evaluative norms for the 12-minute run are presented in Table 10.1.

Table 10.1 Fitness classifications based on distance covered (km) in the 12-minute run–walk test.

Fitness Category		Distance Covered by Age (years)		
		13 – 19	20 – 29	30 – 39
Superior	males	≥ 3.01	≥ 2.85	≥ 2.74
	females	≥ 2.45	≥ 2.35	≥ 2.25
Excellent	males	2.78 – 3.00	2.66 – 2.84	2.53 – 2.73
	females	2.32 – 2.44	2.17 – 2.34	2.09 – 2.24
Good	males	2.53 – 2.77	2.41 – 2.65	2.35 – 2.52
	females	2.09 – 2.31	1.98 – 2.16	1.92 – 2.08
Fair	males	2.22 – 2.52	2.12 – 2.40	2.11 – 2.34
	females	1.92 – 2.08	1.80 – 1.97	1.71 – 1.91
Poor	males	2.09 – 2.21	1.96 – 2.11	1.91 – 2.10
	females	1.61 – 1.91	1.54 – 1.79	1.53 – 1.70
Very Poor	males	≤ 2.08	≤ 1.95	≤ 1.90
	females	≤ 1.60	≤ 1.53	≤ 1.52



2,400-Metre Endurance Run

Participants are encouraged to complete the 2,400 metre distance in the shortest possible time. They should be informed that they may walk or stop and rest at any time if necessary.

Several runners may be timed at the same time by one timer. The time is recorded for each participant to the nearest second. Evaluative norms are presented in Table 10.2.

YMCA 3-Minute Step Test

All that is required for this simple test is a bench that is 12 inches in height, a metronome set at 96 beats per minute, and a watch or timer. It is an ideal test for testing large groups of people, particularly for the initial testing of unfit subjects. The subject should first listen to the metronome to become accustomed to the rhythmic beat. After becoming familiar with the beat and practicing the steps, the subject then begins the test. He or she steps to a rhythm of 96 beats per minute following an "up–up, down–down" pattern, which results in 24 steps per minute. This continues for three minutes, after which time the subject steps down and sits down in order that a tester can record the heart rate over one minute. This one-minute recovery heart rate is the score for the test.

Table 10.2 Norms (min:sec) for the 2,400-metre run for boys and girls, 14-17 years old.

Percentile	Boys				Girls			
	14	15	16	17	14	15	16	17
95	9:57	9:38	9:18	9:29	12:02	12:17	11:58	11:14
90	10:21	9:59	9:49	9:45	12:43	12:57	12:24	12:24
85	10:43	10:23	10:08	10:08	13:28	13:31	12:38	12:45
80	11:00	10:39	10:25	10:21	13:51	14:01	13:09	13:06
75	11:09	10:50	10:42	10:32	14:16	14:19	13:22	13:31
70	11:22	11:02	10:50	10:42	14:34	14:36	13:41	13:57
65	11:34	11:15	11:03	10:50	14:49	14:56	14:21	14:11
60	11:50	11:25	11:10	11:02	15:05	15:17	14:47	14:28
55	12:08	11:36	11:21	11:05	15:30	15:38	15:15	14:50
50	12:16	11:51	11:32	11:16	15:51	16:02	15:44	15:13
45	12:29	12:04	11:50	11:29	16:07	16:10	16:02	15:39
40	12:40	12:23	12:02	11:52	16:32	16:37	16:26	15:58
35	13:03	12:36	12:20	12:07	16:50	16:55	16:44	16:20
30	13:25	12:51	12:36	12:26	17:07	17:21	17:06	16:45
25	13:51	13:16	13:05	12:40	17:32	17:31	17:37	17:31
20	14:11	14:03	13:15	13:06	17:59	18:20	17:56	18:05
15	14:40	14:46	14:08	13:33	18:51	18:58	18:37	18:53
10	15:26	15:45	14:57	14:27	19:22	19:58	19:33	19:39
5	16:38	17:03	16:10	16:40	20:41	21:29	21:15	22:15

Queen's College Step Test

This test is satisfactory for males and females of college age or above. Bleachers or any stepping bench at a height of 16-17 inches is appropriate. A metronome and stopwatch are also needed to administer the test. Divide the group into pairs, with one partner being tested and the other counting the pulse rate. Before beginning, partners should familiarize themselves with pulse-counting procedures in order to perform properly (see Chapter 6).

Subjects step to a four-beat rhythm (up–up, down–down) for three minutes (Figure 10.4). Males step at 96 beats per minute (24 steps/min), while females step at 88 beats per minute (22 steps/min). After demonstrating and practicing at the required beat for about 15 seconds, begin testing. At the completion of the exercise, the subject remains standing and a heart rate is taken for a 15-second period (5 seconds after exercise). Recovery heart rates are converted into beats per minute (bpm) (15-second heart rate x 4). The following equations can then be used to predict $\dot{V}O_2max$ (ml/kg/min).

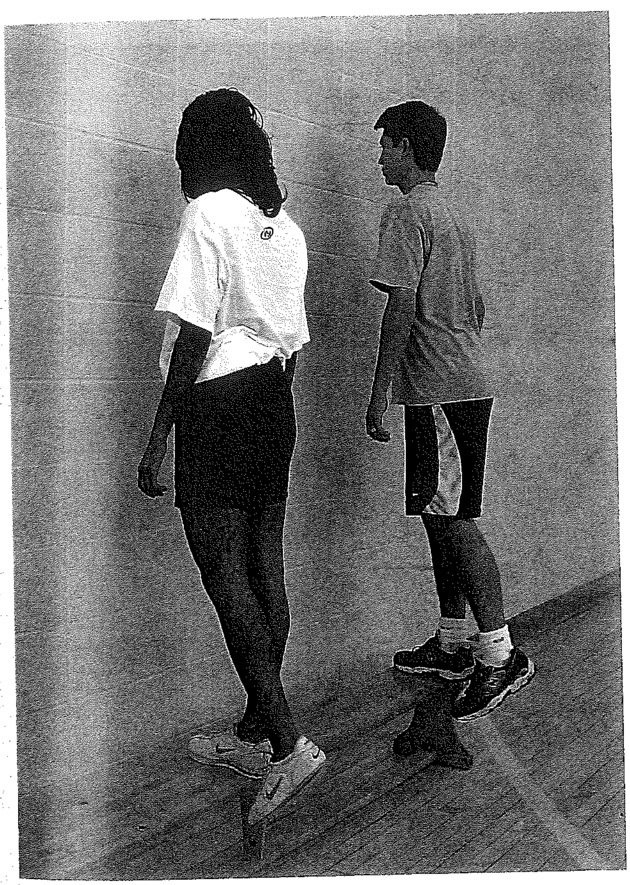


Figure 10.4 Participants follow an "up–up, down–down" stepping pattern for the step test.

$\dot{V}O_2max$ (males) = 111.33 – .42 (pulse rate in beats/min)

$\dot{V}O_2max$ (females) = 65.81 – .185 (pulse rate in beats/min)

In terms of accuracy of prediction, one can be 95 percent confident that the predicted value will be within 16 percent of the subject's true $\dot{V}O_2max$. Predicted $\dot{V}O_2max$ values can be obtained from Table 10.3.

Measuring Body Composition

Because obesity is a risk factor for various health conditions such as high blood pressure (hypertension), coronary heart disease (CHD), cancer, and Type II (adult onset) diabetes, the accurate assessment of body composition is an important measurement goal. Many people today are concerned with their total body weight; however, the focus should be on losing excessive body fat rather than on total weight alone. Although numerous height–weight tables and indexes are used to assess body composition (e.g., BMI, see Chapter 12), you must be careful when interpreting information from such sources. An athlete who is well-muscled, for example, may be considered overweight on a height–weight table even though he or she is actually quite lean. Indexes such as the BMI do not directly measure body fatness.

True measures of body composition (lean versus fat mass) involve the estimation of an individual's body fat percentage, requiring the determination of body density. A lean individual at a fixed body weight will have a higher body density (lower percent body fat) when compared to a fatter person

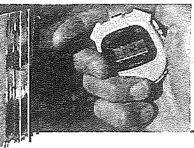
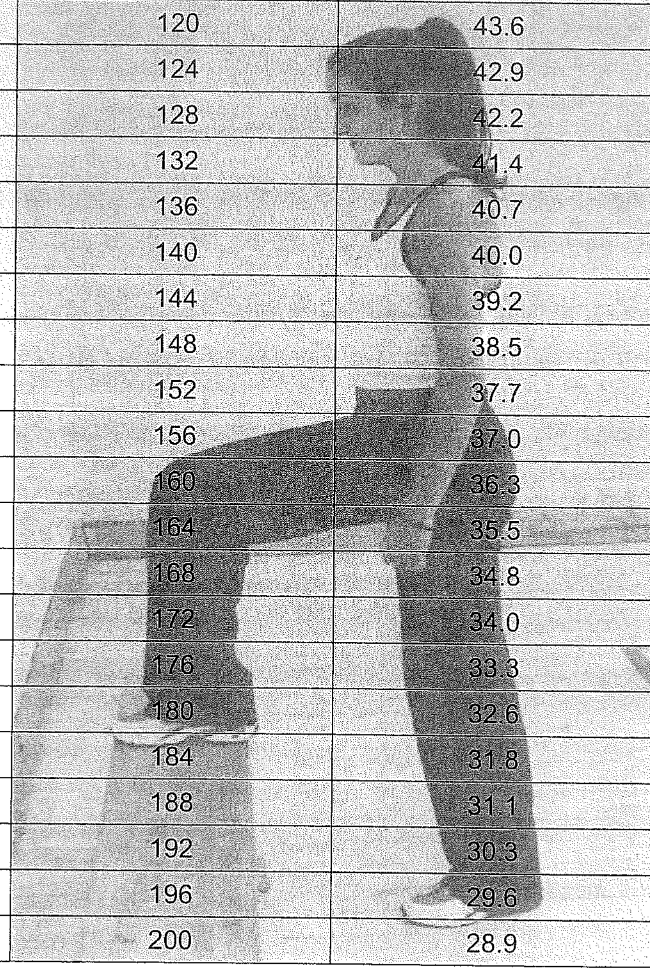


Table 10.3 Predicted maximal oxygen uptake ($\dot{V}O_2max$) for the step test (ml/kg/min).



15-Second Heart Rate	Heart Rate (bpm)	$\dot{V}O_2max$ – Females	$\dot{V}O_2max$ – Males
30	120	43.6	60.9
31	124	42.9	59.3
32	128	42.2	57.6
33	132	41.4	55.9
34	136	40.7	54.2
35	140	40.0	52.5
36	144	39.2	50.9
37	148	38.5	49.2
38	152	37.7	47.5
39	156	37.0	45.8
40	160	36.3	44.1
41	164	35.5	42.5
42	168	34.8	40.8
43	172	34.0	39.1
44	176	33.3	37.4
45	180	32.6	35.7
46	184	31.8	34.1
47	188	31.1	32.4
48	192	30.3	30.7
49	196	29.6	29.0
50	200	28.9	27.3

of the same weight. Many methods of measuring body density and body fat percentage exist, including chemical analysis of human cadavers, hydrostatic weighing, volumetry (body volume), total body water, total body electrical conductivity (TBEC), and radiographic (x-ray) analysis. Most of these methods are obviously not feasible for most schools or individuals for measuring body composition, as they require special apparatus and/or complex procedures.

Skinfold measurements are one of the most feasible, reliable, valid, and popular methods used for estimating body composition. These tests involve measuring skinfolds (actually "fat folds") at particular sites on the body with special calipers (Figure 10.5). These measurements of

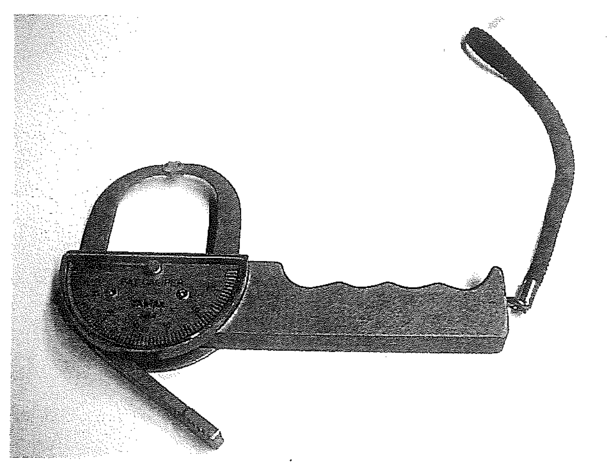
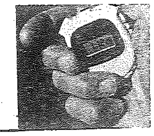


Figure 10.5 Skinfold calipers range in price, but more affordable plastic varieties are available for schools or organizations with limited budgets.



subcutaneous fat are based on the relationship that exists between fat located directly beneath the skin, and internal fat and body density. The sum of a set of skinfolds can be used as an indication of the relative degree of fatness among individuals.

YMCA Skinfold Test

This test requires skinfold calipers. The process involves taking skinfolds at the abdomen, suprailium (crest of the hip bone), triceps (Figure 10.6), and thigh. The following steps should be followed when taking skinfold measurements:

(1) lift skinfolds two or three times before placing the calipers for a measurement;

(2) place the calipers below the thumb and fingers and perpendicular to the fold to allow easy reading of the measurement; completely release the caliper grip before reading the dial 1-2 seconds later;

(3) repeat this procedure three times; the measurements should not vary by more than 1 mm; use the median value and allow at least 15 seconds between each measurement.

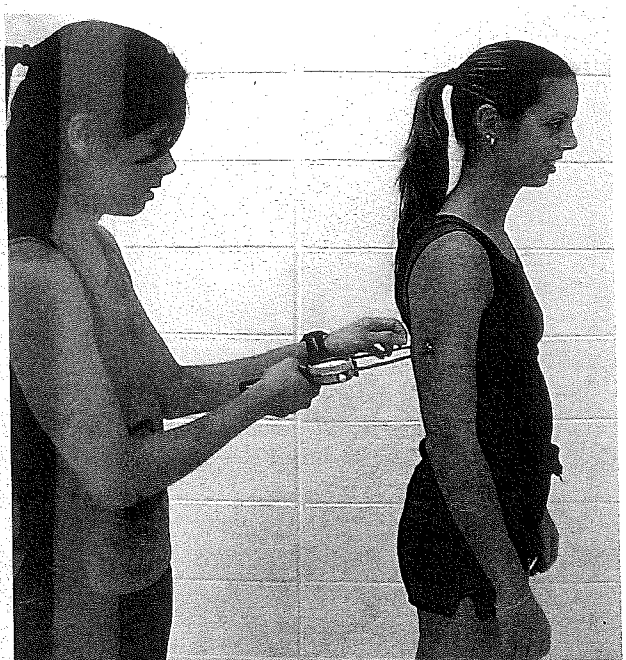


Figure 10.6 Caliper placement for measuring the triceps skinfold.

You must be aware that plenty of practice is required to obtain reliable and consistent results. You can convert the skinfold measures to percent body fat by using the following equations.

Four sites: abdomen, suprailium, triceps, and thigh:

Males

% fat $= .29288 \times (\text{sum of } 4) - .0005 \times (\text{sum of } 4)^2 + .15845 \times (\text{age}) - 5.76377$

Females

% fat $= .29669 \times (\text{sum of } 4) - .00043 \times (\text{sum of } 4)^2 + .02963 \times (\text{age}) + 1.4172$

Your body fat percentage can then be compared to norms for percent body fat (Table 10.4). However, in calculating your percent body fat, be aware that a standard error of estimate of up to 3.98 percent exists. Thus, a calculated percentage of 16 may actually range from 15.4 to 16.6.

Circumference (Girth) Measurements

The girth of various body segments can also be used to assess body composition. Using a cloth measuring tape, measurements must be made carefully at the correct sites and at right angles to the long axis of the body or specific body segment being measured (Figure 10.7). Plenty of practice is required to become an efficient tester.

Because obesity is characterized by large abdominal and hip girths in relation to chest circumference, these are particularly useful circumference measures to use. Some of the body sites most frequently measured include the:

- **neck** – immediately below the larynx;
- **chest** – in males, at nipple level; in females, measures are taken sometimes at the level of just above or just below the breasts (all measures of chest circumference should be taken at the end of an expiration);
- **hips** – from the maximal protrusion of the buttocks to the symphysis pubis;

Table 10.4 Norms for percent body fat in males and females.

Rating	Males		Females	
	18 – 25	26 – 35	18 – 25	26 – 35
Very lean	4 – 7	8 – 12	13 – 17	13 – 18
Lean	8 – 10	13 – 15	18 – 20	19 – 21
Leaner than average	11 – 13	16 – 18	21 – 23	22 – 23
Average	14 – 16	19 – 21	24 – 25	24 – 26
Fatter than average	17 – 20	22 – 24	26 – 28	27 – 30
Fat	21 – 26	25 – 28	29 – 31	31 – 35
Overfat	27 – 37	29 – 37	32 – 43	36 – 48

- **thigh** – the point of maximal thigh girth;
- **calf** – the point of maximal calf girth;
- **biceps** – the point of maximal circumference when the arm is (1) fully flexed and muscles fully contracted, and (2) fully extended and muscles fully contracted; and
- **abdomen** – measurements have been taken at different sites:

(1) at the level of the umbilicus (belly button) ar iliac crests;

(2) at the point of minimal girth, half way be tween umbilicus and xiphoid process of ster num; and

(3) at the point of maximal abdominal girth; in women, about 5 cm below umbilicus.

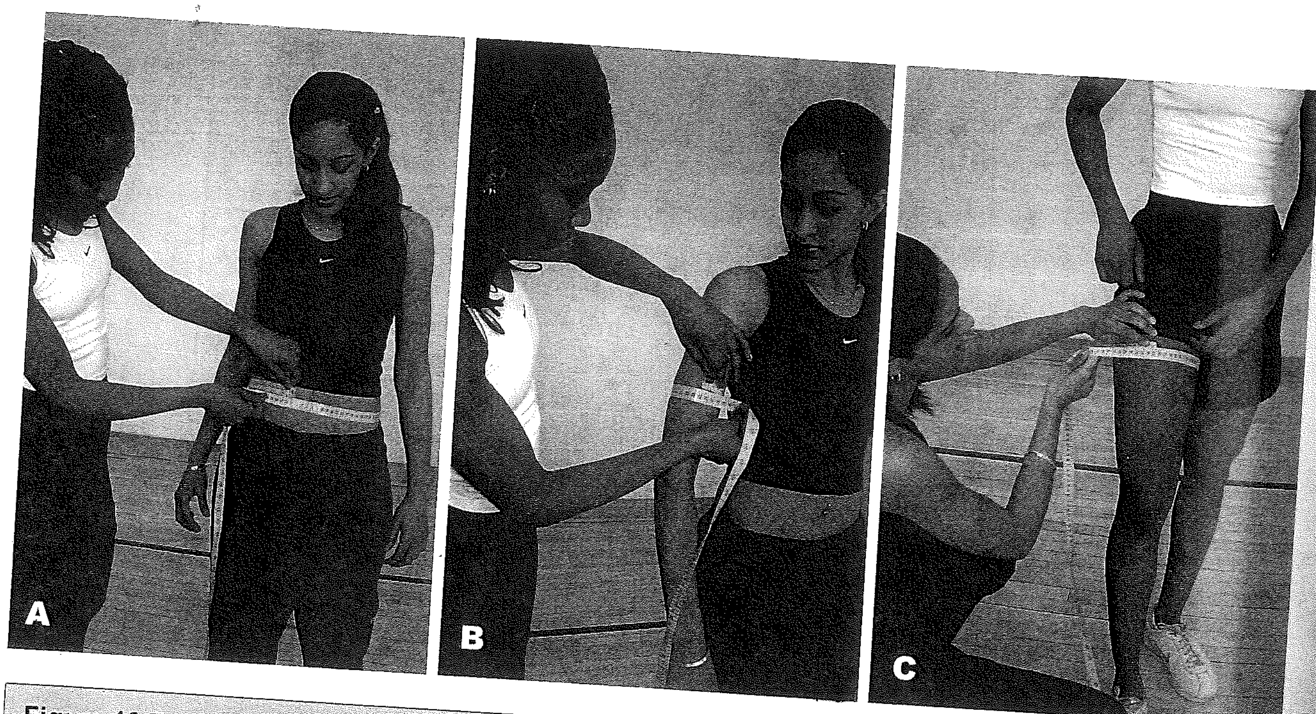
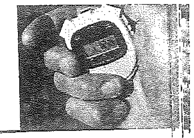


Figure 10.7 Common sites used for girth measurements. **A.** Abdomen. **B.** Biceps. **C.** Thigh.



Measuring Muscular Strength

Strength is recognized as an important factor in human performance, particularly in the execution of physical skills. It can be defined as the maximum force that muscle can generate during a brief contraction against a single rigid resistance. Measures of strength involve tests that require one maximal effort for a given movement, often lifting an external weight or contracting against external resistance. An individual's body weight, however, has an impact on how "strong" he or she is deemed to be. For example, a 64-kg man who lifts 75 kg (75/64 = 1.17) is stronger (relatively) than a 90-kg man who lifts 95 kg (95/90 = 1.05). But the 90-kg man still possesses more **absolute strength** because he is able to lift a larger absolute weight.

Again, laboratory tests used to assess muscular strength require sophisticated equipment such as computerized dynamometers. Such an apparatus allows detailed measures of work, power, etc., but can be quite expensive. Although lab tests can be quite useful for physiotherapists, clinicians, athletic trainers, and rehabilitation centres, field methods are far more feasible for the average individual.

Grip Dynamometer

This is an isometric strength test that measures strength with a **grip dynamometer**. It is used to measure the grip strength of the hand, but has correlated well with total body strength. It is adjustable to fit the size of any hand. A needle indicates scoring on the dial which is marked off in kilograms (0 to 100). The subject simply takes in a breath, and while exhaling, squeezes the device maximally to obtain a reading. This is completed three times to calculate an average score for each hand. Evaluative norms are presented in Table 10.5.

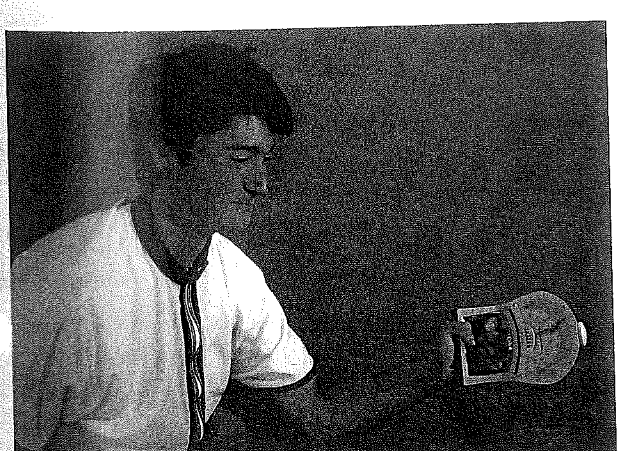


Table 10.5 Norms (kg) for grip strength of the dominant and non-dominant hands combined.

Performance Level	Grip Strength (Dominant and nondominant hands combined)	
	Males (15 – 19)	Females (15 – 19)
Excellent	113+	71+
Above Average	103 – 112	64 – 70
Average	95 – 102	59 – 63
Below Average	84 – 94	54 – 58
Needs Improvement	≤ 83	≤ 53

One Repetition Maximum (1RM)

One repetition maximum (1RM) refers to the maximum amount of weight an individual can lift just one time. 1RM tests can use values from the bench press or leg press. Dividing the 1RM values by the subjects' body weight allows you to make the strength measures equitable across weight classes. When testing for maximum strength, you must adhere to the following guidelines:

- have subjects warm up with stretching and light lifting;
- have subjects perform a lift below the maximum (a pre-test session may be useful);
- have subjects rest at least two minutes between lifts to prevent fatigue;

Maximal Strength – Muscular Endurance Relationship

It is neither necessary nor safe for an athlete or student to work against maximal resistance to calculate maximal strength capacity for a given exercise. Due to the close relationship between maximal strength and muscular endurance, determining an athlete's maximum number of repetitions against submaximal resistance will produce an accurate conclusion about maximal strength.

The relationship can be illustrated best with the following example. Student A is able to lift a 100-kg barbell, but partner B masters only 90 kg. If both students are challenged to clean and press a barbell of 85 kg as often as possible, student A will perform 7-8 repetitions and B only 2-3 repetitions. Using an 80-kg barbell, student A can do 10-12 repetitions and athlete B only 5-6 repetitions. This comparison shows that the number of repetitions against high resistance is dependent on the maximal strength of the athlete. The table below shows the maximal number of repetitions possible for load levels of different resistance.

The maximal feasible number of repetitions of a particular load is referred to as the **repetition maximum (RM)**. If the RM of an exercise is 2-3, it can be deduced that an athlete can resist a force corresponding to approximately 95 percent of maximal strength capacity. If the athlete is able to perform maximally 7-8 repetitions with a particular weight, then this weight approximates 85 percent of his or her maximal strength capacity.

Maximum number of repetitions as a function of resistance.

Resistance Level	100%	95%	90%	85%	80%	75%
Repetition Maximum	1	2 – 3	5 – 6	7 – 8	approx. 10 – 12	approx. 12 – 16

- increase weight on subsequent lifts by small increments (2.5 or 5 kg);
- continue procedure until subjects fail to lift a particular weight;
- record the last weight successfully lifted as the 1RM;
- divide the subjects' 1RM by their body weight.

If it takes more than five lifts to determine a subject's 1RM, consider retesting the subject the next day with a heavier starting weight.

Measuring Muscular Power

The term **power** is often (incorrectly) used as a synonym for the term strength. However, power specifically refers to the ability to release maximum force in the shortest possible time. Indeed time is the element that really distinguishes the two concepts. Activities that involve rapid muscular contractions such as the vertical jump, shot put, and standing broad jump require power to execute movements explosively. Many tests of power are easy to administer and are very practical in terms of time, effort, and equipment.

Standing Long Jump

This simple test can be used for both males and females from age six and up. All that is needed for the test is a floor or mat, a tape measure, and a marking material (chalk or tape) to indicate the distance jumped. Actually, it has never been easier to measure an athlete's explosive power in the legs using the standing long jump. Special standing long jump test mats have been made to make the test even simpler to administer (Figure 10.8). The special mat eliminates taping down measuring tapes to the gym floor and eyeballing the distance jumped since the measuring tape (in cm and in) is printed directly on a thick, durable rubber material.

The goal of a two-footed long jump is to jump horizontally as far as possible from a standing

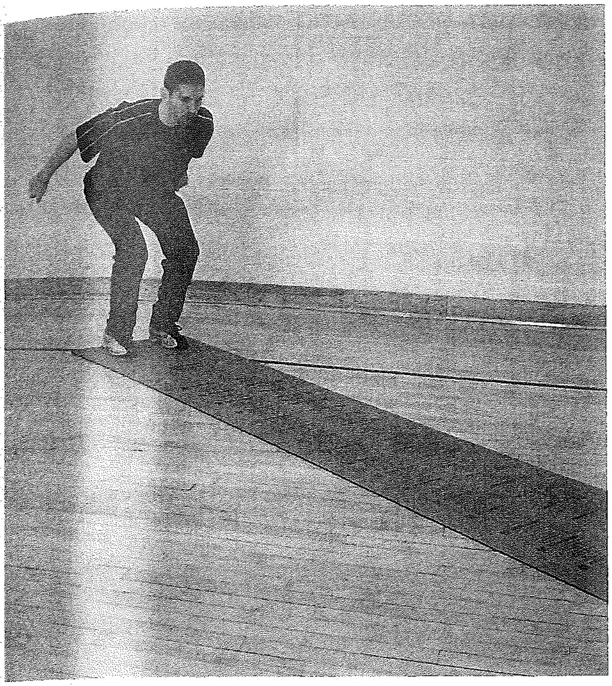


Figure 10.8 The rubber material of the mat provides excellent grip for take-off and effectively cushions landings, eliminating the fear that students may slip on a wooden floor or other slick surface.

start. Begin by standing with the feet about shoulder-width apart with the toes just behind the take-off line. Then bend the knees and swing the arms backwards and forwards in preparation for the jump.

After attaining a feel for the jump, extend the hips, knees, and ankles from a crouch position as a unit while simultaneously swinging the arms forward for the jump. In addition, the trunk should be leaning slightly forward at the instant of take-off and then upward as the arms swing in the direction of the jump. There should be no extra hop or step prior to the jump; it must be performed cleanly, with both feet entirely behind the take-off line. The key to a successful jump is coordinating all parts of the body during the jump – ankles, knees, hips, arms, and trunk.

The measurement of the jump is the distance between the take-off line and the heel touchdown (or other body part) closest to the take-off line. Accurate readings are quick and easy with a specialized test mat. Allow each student at least three trials to obtain an average score. Evaluative norms are presented in Table 10.6.

Vertical Jump (Sargent Jump)

Another simple test used to measure power in the legs is the vertical jump, satisfactory for males and females age nine and up. A measuring tape or yardstick, chalk, and a smooth wall at least 12 feet high is all that is required to complete the test. The subject simply stands sideways beside

Table 10.6 Norms (cm) for the standing long jump test.

Performance Level	Males			Females		
	Age (years)			Age (years)		
	15	16	17+	15	16	17+
Excellent	217 – 235	228 – 244	235 – 255	185 – 204	190 – 208	193 – 208
Above Average	206 – 216	217 – 227	223 – 234	173 – 184	177 – 189	178 – 192
Average	195 – 205	207 – 216	214 – 222	163 – 172	166 – 176	170 – 177
Below Average	176 – 194	196 – 206	200 – 213	150 – 162	153 – 165	157 – 169
Needs Improvement	131 – 175	169 – 195	168 – 199	124 – 149	121 – 152	128 – 156

the wall about an elbow's distance away (put the hand closest to the wall on your hip to determine this distance). Holding a small piece of chalk in the hand closest to the wall, the subject reaches up as high as possible with the heels on the floor and makes a mark on the wall (Figure 10.9 A). He or she then jumps as high as possible and makes another mark at the peak of the jump on the wall. It is important to bend the ankles, knees, and hips before explosively extending these joints from the crouch position for optimal power. Allow three trials of which the best score will count. The jump height is measured by subtracting the reach height from jump height.

Vertical Jump Test Mat Another special device has been developed to measure vertical jump height and power. The key feature in the design of this vertical jump test is a measuring tape feeder mounted on a rubber mat. This feeder allows the measuring tape to be fed through with minimal resistance as the athlete jumps, but stops the tape once the apex of the jump is reached (Figure 10.9 B). The length of measuring tape pulled through the feeder indicates the height of the jump, which is clearly displayed for recording. Evaluative norms are presented in Table 10.7.

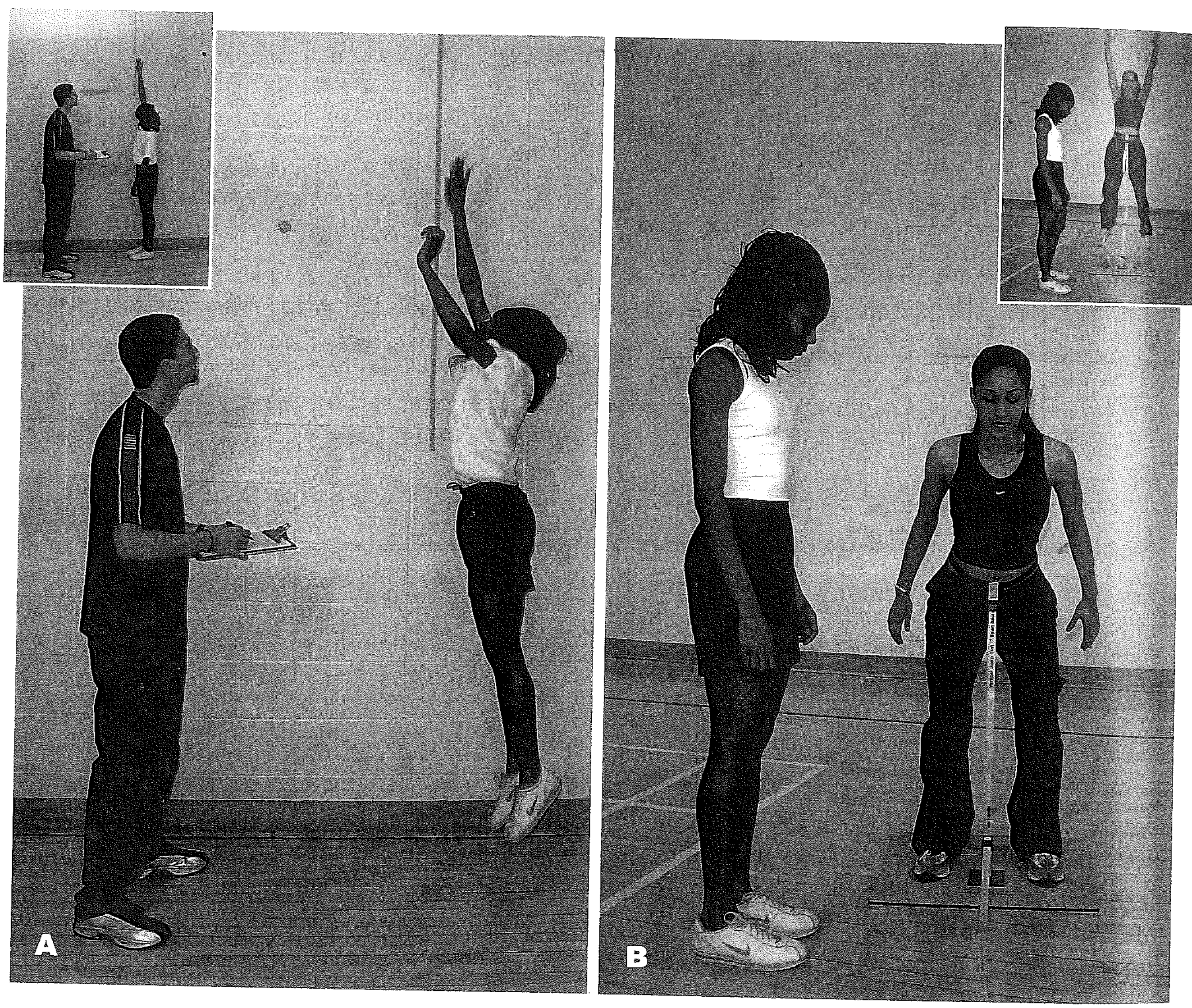


Figure 10.9 The vertical jump. **A.** Traditional sargent jump. **B.** Using a vertical jump test mat.

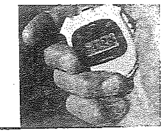


Table 10.7 Norms (cm) for the vertical jump test.

Performance Level	Males		Females	
	Age (years)		Age (years)	
	15 – 19	20 – 29	15 – 19	20 – 29
Excellent	≥ 51	≥ 56	≥ 37	≥ 40
Above Average	37 – 50	39 – 55	29 – 36	28 – 39
Average	27 – 36	30 – 38	22 – 28	20 – 27
Below Average	18 – 26	21 – 29	15 – 21	15 – 19
Needs Improvement	≤ 17	≤ 20	≤ 14	≤ 14

Measuring Muscular Endurance

Muscular endurance is characterized by the ability of muscle to maintain tension or to execute repeated movements versus submaximal resistance over time. Whether measures of endurance are static (e.g., flexed arm hang) or dynamic (e.g., pull-ups), most tests of muscular endurance are actually quite practical. The scoring for such tests usually involves recording the number of repetitions completed for a particular exercise, or the length of time tension is maintained. Whether the test involves push-ups, sit-ups, bench presses, or squats, the ability to sustain muscular tension with repeated movements is what is being tested. It is important to note the difference between cardiorespiratory and muscular endurance. Muscular endurance, unlike cardiorespiratory endurance discussed earlier, refers to the endurance of skeletal muscle involved in activities, not the efficiency of the heart and lungs.

YMCA 1-Minute Sit-ups Test

This test is appropriate for males and females of most ages and requires subjects simply to perform the maximum number of sit-ups possible in one minute. The test is to be performed with bent knees, the feet flat on the ground shoulder-width apart, and the fingers behind the head (Figure 10.10). A partner holds the subject's feet during the test as he or she performs sit-ups to alternate sides (i.e., left elbow to right knee, right elbow to left knee, etc.). The total number of sit-ups performed in one minute is recorded to measure trunk endurance; repetitions are not to be counted if the fingers lose contact with the head. Evaluative norms are shown in Table 10.8.

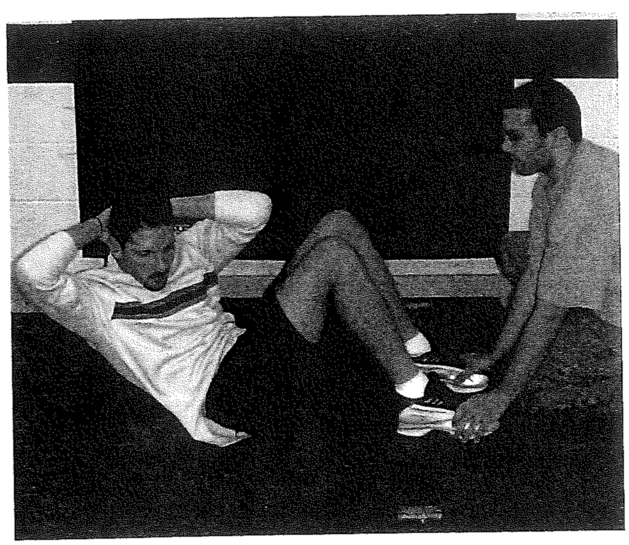


Figure 10.10 The YMCA sit-ups test.

Table 10.8 Norms (number of repetitions) for the YMCA sit-ups test.

Performance Level	Age and Sex			
	Males		Females	
	16	17	16	17
Excellent	49+	47+	44+	45+
Above Average	43 – 48	42 – 46	38 – 43	40 – 44
Average	40 – 42	39 – 41	33 – 37	34 – 39
Below Average	34 – 39	34 – 38	26 – 32	28 – 33
Needs Improvement	≤ 33	≤ 33	≤ 25	≤ 27

Pull-ups and Flexed Arm Hang

Pull-up tests are popular for testing upper body muscular endurance. All that is required is a horizontal bar high enough from the ground that the tallest subject cannot reach the ground with his or her feet. An overhand grip (palms facing away) must be used. The test begins with the subject maintaining a straight arm hang (Figure 10.11 A). The subject's task is simply to pull him or herself upwards until the chin is above the bar (Figure 10.11 B); after each chin-up, the subject is to return to the starting position. This sequence is repeated as many times as possible to test muscular endurance of the arms and shoulder girdle. Evaluative norms are presented in Table 10.9.

The flexed arm hang is another effective test of muscular endurance, especially for participants who cannot pull their own body weight. In this test, two spotters assist the subject in attaining a flexed arm position (palms facing in) so the eyes are level with the bar (Figure 10.11 C). The subject is to hold this position as long as possible,

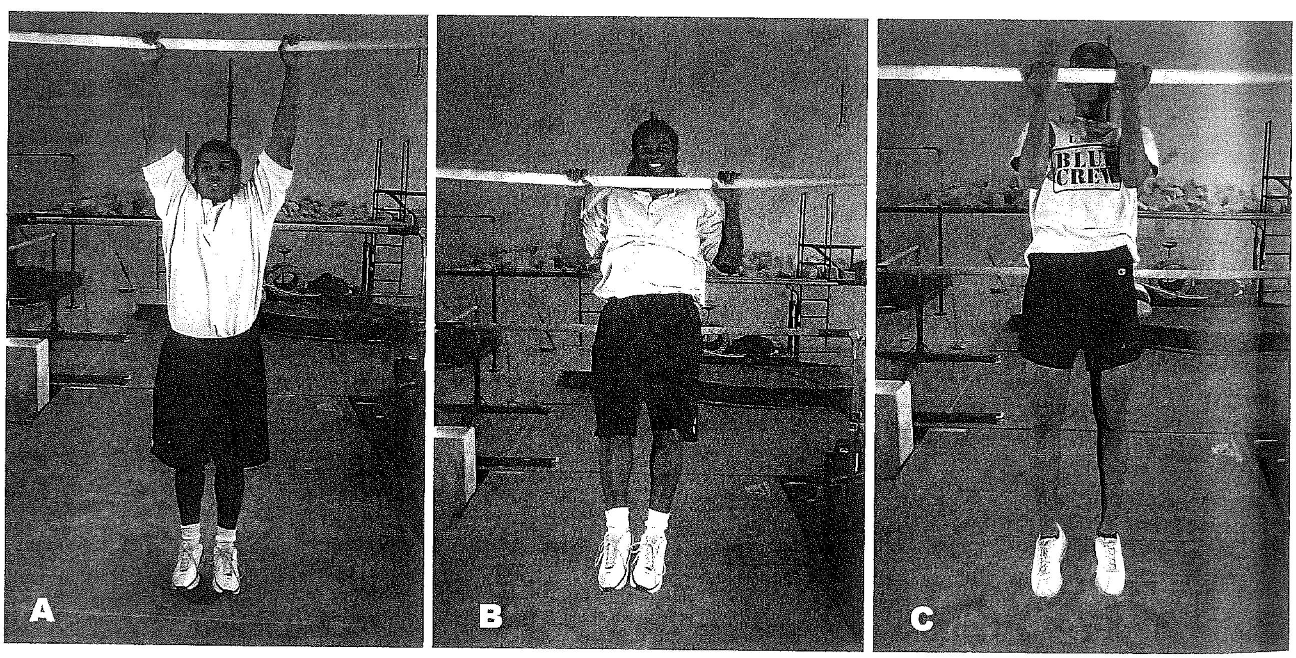


Figure 10.11 The pull-ups test. **A.** Starting position. **B.** Chin-up position. **C.** Flexed arm hang modification.