PROJECT DEMONSTRATING EXCELLENCE

CRITERION VALIDITY OF A COMPUTER-BASED TUTORIAL FOR TEACHING WAIST CIRCUMFERENCE SELF-MEASUREMENT

by

William Leland Elliott

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Core Faculty Advisor: Peter Fenner, Ph.D.

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by

William Leland Elliott (Learner ID #: 24718)

B.S., California State University at Hayward, 1992

M.B.S., University of Colorado at Colorado Springs, 2000

A Project Demonstrating Excellence approved on: ______ (Date)

by the following Doctoral Committee members:

	Name	Signature	Date
First Core Advisor	Peter Fenner, Ph.D.	____________________	______
Second Core Reader	H. Ira Fritz, Ph.D.	____________________	______
Adjunct Member	Jacqueline R. Berning, Ph.D.	____________________	______
Adjunct Member	Deborah F. Tate, Ph.D.	____________________	______
Peer Member	Donald B. Ardell, Ph.D.	____________________	______
Peer Member	William S. Spees, Ph.D.	____________________	______

by the Dean of the Graduate College:

Dean	________________________	____________________	______

Graduate College

Union Institute & University

Cincinnati, Ohio

ABSTRACT

Human waist circumference (WC) is strongly linked to morbidity and mortality associated with many of today's lifestyle diseases. Health organizations and lifestyle assessment programs are commonly using the WC as a predictor of health risks. Knowing one's WC is a primary step in assessing lifestyle diseases. One concern, however, is the accuracy with which WC measurements are taken. This is especially true if individuals are self-measuring their WC. This study attempted to determine the effectiveness of a computer-based tutorial (CBT) in teaching previously untrained individuals to properly measure the circumference of their waist. This is the first study to test the validity of a computer-based method of teaching WC measurement. To test the efficacy of the computer-based multimedia tutorial in teaching WC self-measurement, eighty-three subjects were recruited from the student population at the University of Colorado at Colorado Springs (UCCS). Subjects used the CBT to learn WC self-measurement techniques. Upon completion of the tutorial, each subject attempted to perform WC self-measurement. Subjects' measurements were duplicated by a traditionally trained and experienced tester. Validity of the subjects' measurements was determined by comparing their measurements to those of the experienced tester's. Bland-Altman and box-whisker comparisons revealed an average 1.57 cm bias in the subjects' WC measurements. Bland-Altman bias plots illustrated agreement between the subjects' and experienced tester's measurements. Pearson correlation (r=0.97) showed no significant (p<0.0001) difference between the two groups of measurements. The results of this experiment suggest that the tested CBT is efficacious in teaching waist circumference self-measurement to untrained subjects, as determined by comparison of their measurement results to a traditionally trained and experienced tester's performance. The tested CBT holds the potential to teach the general population (*i.e.*, nonprofessionals) to properly perform WC self-measurement. The tutorial could be used in the area of health assessment, biomedical education, and scholarly research. The CBT could also be used as a standardized way of instructing individuals in learning WC self-measurement and maintaining this skill. Key Words: ANTHROPOMETRY, BODY COMPOSITION, COMPUTER-BASED TUTORIAL (CBT), MEASUREMENT, OBESITY, WAIST CIRCUMFERENCE (WC)

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TABLE OF CONTENTS

INTRODUCTION

"The measurement of body fat will become the new standard for assessing disease risk in adults. As such, it is of vital public health significance. It may also serve to replace the American obsession with body weight with a more appropriate measure of good health."

~ Dr. C. Everett Koop, Former U.S. Surgeon General (2000)

Statement of the Research Problem

Experts in the area of anthropometry and human health have demonstrated that waist circumference (WC) is the best simple anthropometric measure of total body fat, the best simple indicator of intra-abdominal fat mass, and is superior to the currently used overweight and obesity standard of body mass index (BMI) (Lean & Han, 2002). One reason for this is that the BMI is simply a metric of height and weight (calculated by dividing an individual's weight by the square of her or his height). The BMI is not a measure of an individual's relative fat mass, nor is it an indicator of regional adiposity. Additionally, the BMI does not account for relative amounts lean body mass (primarily muscle tissue). This means that two individuals could have the same BMI and yet have a greatly different fat mass to fat-free mass ratio (*e.g.*, 10% *vs.* 30% body fat), which is an independent health risk (Heyward & Wagner, 2004; Heymsfield, Lohman, Wang, & Going, 2005). While the BMI exhibits a somewhat higher, yet still moderate, association with body fat and disease risk than estimates of stature and body mass alone, the BMI has limitations as an indicator of health status (McArdle, Katch, & Katch, 2007). This is especially true in a time when individuals are being advised to exercise more (specifically where the exercise leads to any increase in lean body mass). This makes the BMI inappropriate to use with many athletic populations (Maud & Foster, 2006; Hoffman, 2006). Additionally, current classification standards for overweight and obesity assume the same relationship for percent body fat and BMI across gender, age, ethnic, and race groups. However, this is not the case. For example, for a given BMI, Asians possess a higher level of body fat than Caucasians, and Hispanic American women possess a higher level of body fat than European American and African American women (Bouchard, Blair, & Haskell, 2007; McArdle, Katch, & Katch, 2005).

Despite the advantages of the WC metric, many problems in the area of WC measurement exist. While WC holds great value for current and future use in the areas of health assessment and scholarly research, few individuals are properly trained in the area of WC *self-measurement*. Even health professionals are often unclear on how to correctly measure WC. According to one study, there were at least 14 different descriptions for identifying the measurement site (Wang et al., 2003).

Measuring the WC would not be a problem if the human body was a perfectly rigid, symmetrical, cylinder. However, the body is a compressible, dynamic (changing form with different phases of the respiratory cycle), asymmetrical, structure with multidirectional curvilinearity. That is, most individuals are shaped like apples (android body type) or pears (gynoid body type). This makes measuring a specific cross-section of the waist more challenging. The task can be an even greater challenge when an individual attempts to self-measure WC.

Since WC is closely related to mortality and various morbidities (*e.g.*, diabetes, hypertension, hyperlipidemia, and coronary heart disease), it is important that individuals are able to acquire an accurate measure of it. Ideally, individuals should be able to properly measure their own WC in order to benefit from the valuable health information that the measurement can provide. While it is assumed that individuals can be taught to correctly perform this measurement on themselves through personal instruction from a trained professional, there is no research on this subject. Even if individuals can learn this skill in person from an experienced teacher, such a process is time consuming and limited in its potential to teach the majority of the public. Furthermore, there is no scientifically tested, standardized way of instructing individuals in learning WC self-measurement and maintaining the skill. Standardized instruction is important for developing reference points in order to make sense of changes that take place over time. A CBT, such as the one tested in this study, could serve as a standardized means of teaching WC self-measurement.

Computers have been effectively used as a means of teaching skills that are similar to those involved in WC self-measurement (*e.g.*, anatomy, clinical procedures, diagnostic guidelines, and medical problem-solving strategies) (Berner, 1999; Norris, 2002; Coiera, 1997; Slack, 2001; Shortliffe & Perreault, 2001). Some of the benefits of computer-based learning include: self-paced learning, takes advantage of technology to educate large populations, individuals can learn at a distance, an instructor does not have to be directly involved in the learning process, and it provides a consistency of instructional technique over time (Gardner, von Ingersleben, Heyano, & Chesnut, 2001).

The aforementioned benefits of computer-based learning give it potential to be used as a tool to assist individuals in learning to accurately self-measure WC. The fact that computers are able to incorporate audio, video, and onscreen written instructions, should be helpful in teaching individuals the nuances involved in performing WC self-measurement (*e.g.*, locating the appropriate anatomical landmarks and proper tape placement). Accordingly, the author/principal investigator of the present study developed the Waist Circumference Self-Measurement Computer-Based Tutorial (WCSM-CBT) as a standardized means of low-cost instruction that can be used to educate the masses.

Purpose Statement

Purpose: This study attempted to determine the effectiveness of the WCSM-CBT in teaching previously untrained individuals to properly measure the circumference of their waist. This is the first known study to investigate a method of teaching WC measurement technique(s).

Research Question and Hypothesis

Research Question: How effective is a computer-based tutorial in teaching waist circumference self-measurement to untrained subjects, as determined by comparison of subjects' measurements (once computer trained) to a traditionally trained and experienced tester's measurement?

Null Hypothesis (H_O): There is no significant skill difference* ($p \leq 0.05$) in waist circumference measurements performed by computer trained testers compared to a traditionally trained and experienced tester.

Alternative Hypothesis (H_A): There is a significant skill difference ($p \geq 0.05$) in waist circumference measurements performed by computer trained testers compared to a traditionally trained and experienced tester.

* Skill difference is the difference between subjects' measurements (once computer trained) to a traditionally trained and experienced tester's measurement.

Variables in the Research Problem

Independent variable: The method of learning WC measurement (*i.e.*, the expert [the gold standard] was traditionally trained [via books, classes, and laboratory instruction], and the subjects were computer trained) is the independent variable.

Dependent variable: The measure of the waist circumference is the dependent variable.

LITERATURE REVIEW

This literature review contains five subsections. The first subsection, Human Body Composition in General, is intended to provide background information on concepts related to the composition of the human body. The second subsection, Body Composition Measurement, presents information related to the measurement of human body composition. The Body Composition Self-Assessment subsection analyzes methods of body composition self-measurement. The Waist Circumference section discusses theories and research studies that surround WC. The final subsection of the review presents and analyzes studies related to methods of instruction related to body composition and other motor skill-oriented tasks.

Since this study was focused on the relationship between a computer-based tutorial and the performance of a specific motor task, much of the cited literature was focused on the comparison of novice to expert performance of WC and other anthropometric measurements, which are motor skills. The study did not attempt to analyze the psychological aspects of computer-based learning and performing motor skills.

Human Body Composition in General

The human body may be measured in terms of its absolute and relative constituents (Marieb, 2004). The term body composition is used to describe these constituents, which can be separated into categorical groups in order to assess the body's makeup (Pietrobelli, Heymsfield, Wang, & Gallagher, 2001; Gallagher et al., 2000). One model commonly used to describe body composition, the two-component model, divides the body into fat mass (*i.e.*, the absolute amount of body fat) and fat-free mass (*e.g.*, muscle, bone, organs, and connective tissue) (Wilmore & Costill, 2004). Another way of looking at body composition is by analyzing its locational distribution in the human body (Heymsfield et al., 2005).

Research has associated fat mass (also known as FM, relative body fat, body fat percentage, and %BF), fat-free mass (FFM), and regional body composition, with various conditions of human health (Roche, Heymsfield, & Lohman, 1996; Heyward & Stolarczyk, 1996). Increased fat mass, for example, is associated with an increased risk of coronary artery disease (CAD), hypertension, stroke, type 2 diabetes, various cancers, osteoarthritis, degenerative joint disease, and abnormal blood lipid profiles (Howley & Franks, 2003). Low levels of FFM have been shown to contribute to osteoporosis, impaired functional capacity and reduced physical activity levels (Gartner, Maire, Kameli, Traissac, & Delpeuch, 2001; American College of Sports Medicine, 2006). Regional body composition has been linked to heart disease, stroke, diabetes mellitus, hypertension, endometrial cancer, peptic ulcers, non-alcoholic hepatitis, gall bladder disease, Cushing's syndrome, polycystic ovaries, menstrual disorders, Werner's syndrome, psychosocial problems, and other health risks (Lean, 2003; Janssen, Heymsfield, Allison, Kotler, & Ross, 2002). These established correlations are among the many good reasons to measure body composition.

Body Composition Measurement

There are many laboratory and field methods used to measure body composition. A few of these methods include densitometry, radiography, hydrometry (for measuring total body water), relative biochemical assessment (*e.g.*, potassium, 3-methylhistidine and urinary creatinine), photon absorptiometry, computerized tomography, dual-energy X-ray absorptiometry (DEXA), magnetic resonance imaging (MRI), neutron activation analysis, bioelectrical impedance analysis (BIA), infrared interactance, skinfold (SKF), and waist circumference (WC) measurement (Groff & Sareen, 2000; Spallholz, Boylan, & Driskell, 1999; Wilmore & Costill, 1999; American College of Sports Medicine, 2005; Heyward & Stolarczyk, 1996). While there are many methods used to measure body composition, each of them has its pros and cons. In general, laboratory techniques are costly and complicated, while field techniques (*e.g.*, SKF and WC) are simpler but potentially less accurate (Bray, 2003). There are a number of scholarly arguments surrounding this topic, which makes it one for advanced research (McArdle, Katch, & Katch, 2001; Heymsfield, Nunez, Testolin, & Gallagher, 2000).

Even complicated techniques that are often considered to be highly accurate may produce inaccurate results. For example, hydrostatic (underwater) weighing is considered the "gold standard" for determining body density and subsequently, %BF. This method is based on the fact that fat mass, with a density of ~0.90 g/ml, will float in water. FFM, on the other hand, with a density of ~1.10 g/ml, will sink in water (Powers & Howley, 2007). Thus, underwater weighing can be used to determine body volume, which can be used to determine an individual's body density. Despite the widely accepted use of hydrostatic weighing as the "gold standard" for determining body density and %BF, there are a number of factors that introduce error into this method. One is the fact that residual lung volume varies from individual to individual and is often inaccurately estimated. Another factor is that individuals may possess different volumes of buoyant gas in their gastrointestinal tracts, that aren't accounted for. These factors are compounded by how well an individual is able to repeatedly (*i.e.*, six to ten times) remain still on a scale while underwater, after completing a maximal exhalation. Additionally, the formulae commonly used in hydro densitometry are based on limited cadaver data. This means that unless the individual being measured has a body with exactly the same density as the cadavers used to develop the equations that derive body density, her or his calculated body density will be inaccurate.

While there are techniques that are less complex than hydrostatic weighing, that still give reasonable results, they are not necessarily simple to perform. For example, SKF techniques use a sum of sampled skinfold thicknesses to determine a "sum of skinfolds" which can be converted in to %BF through formulae derived from the relationship of the sum of skinfolds to a standard based on a particular body composition model. Several factors complicate SKF measurement. The person taking the measurement must be well trained at taking skinfold samples and locating anatomical measurement sites. Additionally, the most appropriate "populations specific" equation must be chosen for an individual being measured. Over 100 of such equations have been developed, which can create problems for individuals trying to find an equation that works best for individuals of different age, gender, race, ethnicity, *etc* (Powers & Howley, 2007; Kohlstadt, 2006).

BIA is an example of a method of body composition measurement that gives reasonably accurate results and is easy to perform, but has a high potential for error. BIA involves passing a low level alternating current through the body, and measuring the opposition or impedance to the current flow. Since FM is less conductive than FFM, BIA can give an indication of the body's composition. The results of a BIA measurement can be equivocal for a number of reasons including: improper electrode positioning, body positioning, wearing clothing or jewelry, air and skin temperature, and any of the many things that can alter the body's electrolyte or fluid balance (*e.g.*, food intake, fluid intake, elimination status, and activity status) (Heymsfield et al., 2005; Cornish, 2006). Additionally, there is little if any standardization for BIA measurement techniques aside from how electrodes should be configured on the body (Heymsfield et al., 2005).

When measuring body composition, one must first decide which model to use in order to gain the specific information that is sought after. A central five level model provides a formal structure for developing appropriate body composition methods. The five levels in body composition research consist of the atomic, molecular, cellular, tissue-organ, and whole body, levels. The atomic level consists of hydrogen, carbon, oxygen, nitrogen and other elements. The molecular level is made up of minerals, protein, lipid, water; minerals, CHO, and other molecules. The cellular level consists of adipocytes, extracellular solids, body fluids, and body cell mass (excluding storage fat). The tissue-organ level is made up of visceral organs, bone, skeletal muscle, adipose, and other tissues. The whole body level consists of appendages, the trunk, and the head. An individual's body mass is considered to be the sum of all components at each of the five levels in this central model (Heymsfield et al., 2005). While all of the levels in this central model describe the human body, each level differs in its intricacies, and holds potential to reveal the state of the human body in a different way. The present study is primarily related to the whole body level. More specifically, the study is focused on the WC and its absolute measurement (*i.e.*, as opposed to the ability to convert absolute WC measurement into %BF) and how it relates to human health. The reason for this is that WC is highly reflective of dangerous visceral adipose tissue (VAT), and it has large population studies connecting it with morbidity and mortality. Furthermore, WC can be self-measured and is a metric that is commonly recommended by major health organizations as an index of obesity-related health (*e.g.*, the World Health Organization and the National Institutes of Health). In fact, the Disease Management Association of America (DMAA) recently published the first definition of obesity with co-morbidities, which states that, "Men with a waist circumference of 40 inches or greater, and women with a waist circumference of 35 inches or greater, are considered obese." (Disease Management Association of America, 2006)

While %BF is not the focus of this study, it should be noted that researchers have shown that a formulae developed to predict %BF calculated from using body density measured by hydrodensitometry from WC measurements alone, gave an equally good prediction of %BF when compared to other equations using more than one variable or measurement, including, Durnin and Womersley equations (Lean, Han, & Deurenberg, 1996). The formulae for converting WC measurements into %BF (from WC adjusted for age) are listed below. WCs were taken in the same manner described in the Methodology section of this study.

%BF for women = 0.439 WC (cm) + 0.221 age (y) – 9.4

%BF for men = 0.567 WC (cm) + 0.101 age (y) – 31.8

Body Composition Self-Assessment

Since human body composition is so closely related to health, it is important that individuals are able to easily acquire body composition measurements that provide them with meaningful information about their health status. The BMI is the most commonly used body composition-related metric for assessing overweight and obesity. Aside from the previously mentioned problems inherent in the BMI metric, research shows that BMI is often underestimated due to individuals over-reporting height and underreporting weight values (Ezzati, Martin, Skjold, Vander Hoorn, & Murray, 2006). Unless individual BMI values account for these biases, the BMI cannot be used as a valid self-assessment tool.

The abundant research linking health status to adiposity indicates a need for individuals to know how to accurately assess their own body composition. While body composition measurements may be taken by health and fitness professionals, in clinics or health clubs, self-assessment provides a more private, convenient and cost-effective alternative for individuals to attain such information (Eckerson et al., 1998). Unfortunately, few of the aforementioned techniques enable individuals to practically and accurately perform self-assessment. Three of the techniques that do allow an individual to self-assess body composition are BIA, SKF, and WC measurement.

In recent years, BIA has been offered as a non-invasive, fast and reliable way to measure body composition (Wit, Piechaczek, D. Blachnio, & Busko, 1998). While this method may be useful in assessing total body composition, it lacks the ability to assess regional body composition. The assessment of regional body composition (specifically, abdominal fat) is of significant importance because of its association with morbidity and mortality (Bray, 2003). Localized adiposity measurements reveal health information beyond what %BF reveals. Regional assessments of body composition also have implications for athletic performance and physical fitness (Sharkey, 2002). For example, judo athletes have more fat on their trunks than on their extremities (Pieter, Palabrica, & Bercades, 1998). While BIA cannot assess regional body composition, SKF and WC methods can.

SKF measurements offer a good balance of affordability (compared to laboratory techniques) and accuracy. They also offer a direct and accurate assessment of subcutaneous fat (Howley & Franks, 2003). In fact, research has demonstrated that subcutaneous fat values obtained through SKF measurements at 12 sites are similar to values obtained from MRI (Heyward, 1998). This may be the most valuable benefit of SKF measurement; it can provide highly specific information about an individual's fat pattern, distribution of body fat and subsequently, health status. For example, the ratio of subscapular to triceps SKFs has been used to reflect the relative amounts of visceral *versus* peripheral fat in individuals (American College of Sports Medicine, 2001).

While individuals could benefit from the health-related information that SKF measurements provide, few have access to skinfold calipers and even fewer have the technical skills necessary to use them. Additionally, the most accurate formulas for measuring body fat require measurements that an individuals cannot take on themselves (*e.g.*, subscapular and triceps skinfold measurements). These factors present limitations for using SKF measurement as a viable method of body composition self-assessment.

While WC measurement is similar to SKF measurement in that it provides a means of estimating total and regional body fat (*i.e.*, abdominal fat in the case of WC measurement), WC measurement doesn't require access to skinfold calipers or the level of technical skill required in SKF measurement (Lean et al., 1996; Heyward & Stolarczyk, 1996). These qualities, as well as its affordability and convenience, make WC measurement a good method to use for body composition self-assessment (Rimm et al., 1990; Hall & Young, 1989; Han & Lean, 1998).

Waist Circumference

In addition to having qualities that make it a good choice for body composition self-assessment, WC measurement has a number of benefits that are closely related to human health status. According to Michael J. Lean and Thang S. Han, experts in the area of anthropometry and health, waist circumference is the best simple anthropometric measure of total body fat, the best simple indicator of intra-abdominal fat mass, and is better than the currently used obesity standard of BMI (Lean & Han, 2002). The benefits of WC measurement are well documented in the recent scientific literature (Heymsfield et al., 2005).

In 1995, Lean, Han, & Morrison tested the hypothesis that WC measurement might be used to identify individuals at health risk from being overweight and having a central fat distribution (Lean, Han, & Morrison, 1995). This research validated the use of WC as a single anthropometric measurement that can be used to alert the general public of health risks. Additionally, this study promoted the use of "action levels" to help individuals with various WC measurements to become involved in appropriate action-oriented interventions (*e.g.*, maintain weight, lose weight, seek professional help, *etc.*). These action levels have been adopted and endorsed by many public health organizations and have been used by the World Health Organization, the National Institutes of Health, and the National Heart Lung and Blood Institute, in establishing health-related cutoff levels for WC (Han, van Leer, Seidell, & Lean, 1995; Han & Lean, 1998; Janssen, Katzmarzyk, & Ross, 2002). The action levels are listed below and in the methodology section of this paper.

In the 1995 Lean, Han, & Morrison study, 1014 women and 904 men, from 25 to 74 years of age, were chosen from the general population of north Glasgow. Separately, 86 men and 202 women were recruited to test the proposed "action levels." (aka cutoff points for disease risk) derived in the determination study. Trained observers measured mass, stature, and waist circumference. The researchers performed cross tabulation between variables to determine the action levels for men and women. The results showed that a WC $\geq$ 88 cm for women and $\geq$ 102 cm for men identified subjects with a BMI $\geq$ 30 kg/m^2; and that a WC $\geq$ 80 cm for women and $\geq$ 94 cm for men identified subjects with a BMI $\geq$ 25 kg/m^2, with a sensitivity of >96% and specificity of >98%, with only ~2% of the sample being misclassified. The researchers concluded that a WC ≥ 80 cm for women and ≥ 94 cm for men should be used in health promotion programs as cutoff points to indicate that an individual should not gain any further weight. They also concluded that a WC ≥ 88 cm for women and ≥ 102 cm for men should be used in health promotion programs as cutoff points to indicate that an individual should seek professional help and make efforts to reduce her or his weight. This classic study also concluded that, "better information will be needed about possible self reporting bias and about ability to monitor changes with weight management" (Lean et al., 1995). The latter conclusion forms the basis for the present study.

Initially, waist circumference was coupled with hip circumference in order to give a ratio (*i.e.*, waist-hip-ratio [WHR]) that was indicative of abdominal fat accumulation. Thus, WHR was the first anthropometric index of visceral adipose tissue (VAT), which is an important indicator of heart disease, diabetes mellitus, stroke, hypertension, endometrial cancer, peptic ulcers, non-alcoholic hepatitis, hirsutism, menstrual disorders, Cushing's syndrome, gall bladder disease, polycystic ovaries, Werner's syndrome, psychosocial problems, and other health risks (Lean, 2003; Janssen et al., 2002). Later research, however, supports the idea that WC alone is more closely related to VAT and health status than the WHR (McTiernan, 2006; Heymsfield et al., 2005). In fact, the WHR has been shown to be a poor estimator of VAT (Maud & Foster, 2006). The reason for this is that central fat distribution is associated with a greater number of metabolic complications than fat located on the hips or the legs, probably due exposure of the liver to excessive release of fatty acids from an expanded intraabdominal fat mass (Lean, 2003). The WC measurement is strongly associated with VAT (Bouchard et al., 2007; Schardt, 2006). Furthermore, changes in the WC reflect changes in abdominal obesity and risks for cardiovascular disease (Kohlstadt, 2006).

Some researchers and clinicians have suggested that measurement combinations other than waist and hip circumference measurements might provide the best indication of morbidity and mortality. For example, the ratio of waist to height (WHtR) has been suggested as a measure superior to WHR or waist circumference by itself (Ashwell, Lejeune, & McPherson, 1996). However, a study of 2183 men and 2698 women showed that WC bears little or no relation to height (Lean, 2003). In other words, tall and short people have essentially the same waist circumference. The conicity index (C-index) is another anthropometric measurement that has potential for predicting abdominal adiposity and subsequent health risk. The C-index combines WC with weight and height (Heyward & Stolarczyk, 1996). To date, no measurement combination has been shown to be more useful than WC alone. Furthermore, the use of ratios (*e.g.*, WHtR and WHR) in statistical analyses has been criticized because they are less sensitive to change, are more difficult to interpret biologically, and may be more prone to spurious results than single anthropometric variables (Heymsfield et al., 2005).

The fact that WC is an integral component of WHR, waist to height ratio, and the C-index, attests to its value in measuring human body composition. Ongoing research in the areas of anthropometry and of body composition continually shows that

WC is a very meaningful and useful index of human health, adiposity, and fitness. One reason for this is that WC is a, "straightforward measurement that relates to both body weight and the distribution of fat" (Pounder, Carson, Davison, & Orihara, 1998), p. 1428).

In the 1998 Pounder *et al.* study, researchers evaluated several measures of obesity by comparing them with levels of intra-abdominal fat during postmortem examination. A series of 100 men was investigated in this study. All cases of severe trauma, prolonged hospitalization, chronic wasting disease, and postmortem decomposition were eliminated from the study. Body mass was measured to within 1 kg, hip circumference was measured to within 1 cm, body length to within 1 cm, and WC to within 1 cm. The mean age at death was 52.8 years. The greater omentum and the pararenal fat was excised and weighed to the nearest 1 g. When using the mass of the intra-abdominal fat as the outcome, r^2 was 37% for BMI, 40% for body weight, 43% for WHR, 47% for hip circumference, 54% for WHtR, and 61% for WC. Additionally, WC was strongly correlated with BMI (r=0.90), body mass (r=0.90), and hip circumference (r=0.95). The researchers concluded that the WC correlates more strongly with intra-abdominal fat mass than any other suggested index, and that remains true across the range of BMI values (Pounder et al., 1998). This study was well done but was performed on cadavers which may not correspond exactly with *in vivo* clinical indices. However, such measurements cannot be measured in clinical practice so this study provides valuable information.

A summary of benefits of the WC measurement are listed below. The unique conjunction of these benefits is the reason that WC was chosen as the focal point of this study. No other health metric possesses all of these benefits:

• Can be self-measured;

• Can be used alone (*i.e.*, the raw WC measurement value in centimeters or inches) as a meaningful index of health status;

• Is a surrogate measure of visceral adipose tissue;

• Is commonly recommended by major health organizations as an index of obesity-related health (*e.g.*, the World Health Organization, the National Institutes of Health, and the National Heart Lung and Blood Institute);

• Has large epidemiological studies relating it to morbidity and mortality;

• Has researched health-related cutoff points that have been adopted by major health organizations (*e.g.*, the World Health Organization, the National Institutes of Health, and the National Heart Lung and Blood Institute);

• Is portable (*i.e.*, everything necessary to take the measurement can be easily moved between variable locale);

• Is quick (*i.e.*, time-efficient);

• Can be measured regardless of body or tissue size;

• Does not require expensive technical equipment.

Methods of Instruction

While WC measurement has been researched extensively and holds potential as a means of body composition self-assessment, there is little research on how accurately individuals can perform the measurement on themselves. The limited research in the area of WC self-assessment indirectly shows that various methods of instruction will teach individuals to perform WC self-assessment with varying degrees of accuracy (Rimm et al., 1990; Hall & Young, 1989; Han & Lean, 1998). However, these studies have not been focused on the efficacy of the method of instruction used in teaching individuals to perform the measurement. Instead, these studies have simply focused on comparing experienced technicians' measurements with those of untrained individuals. The present study places emphasis on the specific method used to instruct individuals in learning WC self-measurement, in an effort to help untrained individuals learn to perform the measurement as accurately as a trained and experienced technician.

In addition to not being focused on the method of instruction used to teach individuals WC self-measurement, many of the expert *vs.* novice studies that exist are flawed. For example, Rimm and colleagues (1990) compared self-reported WC measurements from mailed questionnaires from a population of 123 men (40-75 years old) and 140 women (41-66 years old) with WC measurements made by trained technicians. Crude Pearson correlations between technician-measured and self-reported WC measurements were 0.95 for men and 0.89 for women. The results of the study also showed that men significantly overestimated their WC measurements (.36"), and women reported measurements that were approximately the same as the true measurements. (Rimm et al., 1990). Although the subject and technician measurements seem close, there is a major flaw in this study. That is, the validating measurements (*i.e.*, the technician measurements) were taken six to nine months after the subjects took their measurements. The subjects' WCs could have significantly changed during this time period due to weight gain or loss. With such a massive span of time in between the two groups of measurements, it is difficult to derive any meaningful conclusions from this study.

While the Rimm *et al.* (1990) study is an older one. The most recent study of self-reported and technician-measured waist circumferences has the same flaw. In this study of 173 men and 235 women (after 8 subjects were excluded for missing self-reported WC values) researchers investigated agreement between 1.) technician-measured and self-reported waist circumference at the level of the umbilicus, 2.) technician-measured circumference at the natural waist and self-reported circumference at the level of the umbilicus, and 3.) circumference measured halfway between the lower rib and the iliac crest (the natural waist), and at the level of the umbilicus. The overall results of the study showed Spearman's correlation coefficients of 0.87 in men and 0.88 in women between self-reported and technician-measured WC values. On average, the participants underestimated their WC. The mean difference between the two groups was -2.41 cm. The study also showed that the WC at the level of the umbilicus was larger than the natural waist (+0.7 cm in men and +5.0 cm in women) (Bigaard, Spanggaard, Thomsen, Overvad, & Tjonneland, 2005). While this study seems to be well designed (*e.g.*, it is one of the few comparison studies that actually uses Bland-Altman plots to test for agreement between the two groups of measurements), having such a large span of time between subject and technician measurements renders the results of the study uninterpretable.

Another study of 101 men and 83 women (from age 28 to 67 years) compared self-reported home-assessed, self-measured (using a specialized measuring device called the "Waist Watcher" tape measure), and investigator measured (using a specialized measuring device called the Waist Watcher tape measure), WC measurements (Han & Lean, 1998). The mean errors for subjects' self-reported home-assessed WC was -4.3 cm in women and -6.7 cm in men, compared to investigator measurements. Mean errors for subjects' self-measured WC was -4 mm in women and -5 mm in men, compared to investigator measurements. There was a systematic bias in errors of self-reported WC in women (r=-0.41, P=<0.001) and in men (r=-0.58, P=<0.001) of different waist size. Subjects with a larger WCs tended to underestimate and subjects with smaller WCs tended to overestimate. There was also a systematic bias in errors of self-measured WC in men (r=-0.40, P=<0.01) of different WCs (*i.e.*, men with a larger WCs tended to underestimate and subjects with smaller WCs tended to overestimate). There was no systematic bias in errors of self-measured WC in women (r=0.04, P=<0.72) of different waist size. Subjects with a larger WCs tended to underestimate and subjects with smaller WCs tended to overestimate. The investigators concluded that, in general, people tend to underestimate their WC, and that the "Waist Watcher" tape measure offers advantages over self-reported home-assessed measurements. In general, this was a well designed study. However, as in the previously discussed studies, this study had a time gap (the duration was unmentioned) between the time that subjects self-measured their WCs at home and the time that their WCs were measured by the investigator at the validation site at the Royal Infirmary in

Glasgow, UK. Additionally, the fact that the validating measurements in this study used a specialized tool for measuring WC values, gives it less applicability for the general population who would most likely self-measure using a conventional measuring tape.

There are several studies in the area of SKF measurement that have given focus to the issue of efficacy of the method used to instruct the measurement (Oppliger, Clark, & Kuta, 1992; Kerr, Wilkerson, Bandy, & Ishee, 1994; Whitehead & Parker, 1993; Shaw, 1986). Methods that these studies compared include, training clinics, classroom/personalized instructions, written instructions, and video tape instructions. All of the studies compared novice testers to experienced testers.

For example, one study (Shaw, 1986) was designed to test the efficacy of two methods of teaching SKF measurement. The investigator used two groups in the study. One group was instructed to study written descriptions of the measurement procedure and photographs of the measurement sites (*i.e.*, the triceps and subscapular regions). Another group viewed a 22-minute video tape with step-by-step instructions for performing the measurement. In order to determine the validity of the two methods of instruction, the novice testers' measurements were compared to those of experienced testers'. The study showed similar results between the two groups of novice testers and significantly different results between the novice testers and the experienced testers. The alpha reliability coefficient was used to determine reliability estimates. Reliability coefficients ranged from .83 to .88 for the reading group and from .91 to .97 for the video tape group. Reliability coefficients were higher for the experienced testers than the novice testers. Coefficients for the experienced testers ranged from .95 to .98. The investigator concluded that better methods of SKF measurement training need to be developed. This is a good example of a study focused on the method of teaching how a measurement should be preformed. One drawback to this study is Bland-Altman plots were not used in the statistical analysis, which would have a given a better indication of agreement between the methods (Williams & Bale, 1998; Bland & Altman, 1986).

In addition to developing such training methods, researchers have mentioned the importance of testing them for validity (Morrow, Fridye, & Monaghen, 1986). The principal investigator of the current study suggested testing a computer-based tutorial to determine its efficacy as a method of teaching WC self-measurement. To date, this investigator has not found any published studies designed to test a computer-based method (*i.e.*, a method that can be delivered by means of a personal computer) of teaching this skill. However, studies that test computer-based methods of teaching similar skills have been conducted.

In a study conducted by Gardner *et al.*, the validity of a computer-based tutorial was tested for its efficacy in training technologists in vertebral morphometry. In this study, the technicians (novices) were compared to radiologists (experts) after learning fiducial point placement technique from an online tutorial. The technologists participating in the study had no prior experience in vertebral morphometry. The tutorial program consisted of four steps; 1.) utilizing the tutorial, 2.) reviewing the analyzed spine images, 3.) practicing fiducial point placement, and 4.) testing. The results of this study show that self-directed, tutorial-based training results in good inter-observer measurement precision between technologists showing mean coefficients of variation of 2.33% for anterior, 2.65% for posterior, and 2.87% for central vertebral heights. Comparisons between technicians and radiologists ranged from 2.19% to 3.18%. The researchers concluded that, "… self-directed tutorial-based training for spine image analyses is effective, resulting in good inter-observer measurement precision." Furthermore, they concluded that tutorial-based training provides standardized training methods and consistency of instruction over time (Gardner et al., 2001).

Similar studies have been used to validate the efficacy of computer-based tutorials in teaching other motor skill-oriented tasks such as microscopic examination of urine sediment (Kim, Schaad, Scott, Robins, & Astion, 2001; Phillips et al., 1998) and performance of cystoscopy techniques (Shah & Darzi, 2002). Currently, studies in this area are limited but researchers have expressed interest in using them to validate the use of computer-based instruction in teaching pulmonary auscultation, colonoscopy techniques, and other health and medical skills (Sedlack & Kolars, 2002; Mooney & Bligh, 1997; Mangione & Dennis, 1992). The present study is an example of this as it seeks to determine the efficacy of a computer-based multimedia tutorial in teaching WC self-measurement.

METHODOLOGY

Procedures

In order to test the efficacy of a computer-based multimedia tutorial (*i.e.*, the WCSM-CBT) in teaching WC self-measurement, eighty-three subjects were recruited from the student population at the University of Colorado at Colorado Springs (UCCS). The adult male and female subjects were chosen on the basis that they were not pregnant and had not been previously trained to measure WC.

After recruitment, and prior to participation in the experiment, all subjects were asked to read, consider, sign, and date, an informed consent form (Appendix A) and fill out the demographics portion of a data collection sheet (Appendix B). Experimentation took place at the Berning Laboratory in the Science building at UCCS. There, the recruited subjects used the WCSM-CBT to learn WC self-measurement techniques. Since the purpose of this study was to test the efficacy of the tutorial in teaching the subjects to properly self-measure WC, validity and reliability of the tutorial were determined by comparing the subjects' measurement results (after being tutorial trained) to a traditionally trained and experienced tester's measurement results. No additional skills or cognitive tests were performed.

The tutorial included audio, video, and onscreen written instructions for performing WC self-measurement. The written instructions were written at a high school reading level (*i.e.*, a Flesch-Kincaid Grade Level score of 11.8). The tutorial was designed to teach individuals the importance of WC measurement, proper tape placement (through finding appropriate anatomical landmarks, *etc.*), and the details of correctly self-measuring their WC. The tutorial consisted of five lessons and took approximately five minutes to complete. Please see “Appendix E: WCSM-CBT Lesson Screen Captures and Audio Scripts” for tutorial details.

Waist circumference was measured to the nearest 0.1 centimeter, with an inelastic (nonstretchable) fiberglass measuring tape (Item #BMS-8 from Creative Health Products Inc., Plymouth, MI), while the subject was standing erect with the weight evenly distributed over both feet, at a level midway between the lowest point of the ribs (lower rib margin) and the highest point of the hip bone (iliac crest) as recommended by the World Health Organization (Wang et al., 2003). This measurement site was chosen because it is the site that was originally used in the study that determined the cutoff points that have been adopted by major health organizations (*e.g.*, the World Health Organization, the National Institutes of Health, the National Heart Lung and Blood Institute *et al.*) (Lean et al., 1995; Han et al., 1995). Subjects were instructed to take the measurement at the end of a normal expiration, with the tape held snuggly against the skin, yet without pulling on the tape measure too tightly, as to avoid compressing the underlying tissues.

After completing the tutorial, subjects attempted to perform WC measurement on themselves in front of a mirror, in an isolated environment (*i.e.*, there was no one else in the laboratory during this period). Subjects used nontoxic marking pens (Colorific Temporary Tattoo Markers from Sanford Corp, Bellwood, IL) to mark anatomical reference points on their skin. All subjects’ performance of the measurement was videotaped so it could be evaluated (*i.e.*, by the principal investigator) for possible errors. The videotape recordings were checked for the following criteria: 1.) Whether or not subjects utilized the CBT, 2.) Correct location of anatomical landmarks, 3.) Whether or not subjects took the measurement on bare skin, 4.) Correct placement of the measuring tape, and 5.) Any other factor that might skew the measurement (*e.g.*, whether the subjects read the tape by looking in the mirror or looking down at the tape). Participating subjects also had their mass and stature measured (using a Seca 700 scale/stadiometer from Seca Corp, Hanover, MD). Subsequently, BMI was calculated and recorded for each subject.

Once the subjects completed their WC measurements and recorded the results, they had their measurements duplicated by an expert. The expert was an exercise physiologist with graduate-level academic and professional training (via books, classes, and laboratory instruction) and experience in WC measurement. At the time of this study, she had previously performed in excess of 3,700 WC measurements on individuals with a variety of different body types, in clinical practice. The experienced tester took multiple measurements on each subject in an effort to improve the accuracy of the validating measures. The same tester was used for all subjects in order to eliminate error that could exist among several different testers (Jackson, Pollock, & Gettman, 1978).

After all of the subjects completed the experiment, the results of their WC measurements were compared to those of the traditionally trained and experienced tester in order to validate the precision of the subjects as compared to the expert, and thereby determine the efficacy of the computer-based tutorial. The data were statistically analyzed using correlation coefficients (Pearson's product moment) and the alternative technique of bias and limits of agreement according to the recommendations of Williams & Bale (Williams & Bale, 1998).

Each subject's WC measurement, as well as the relevance of this measurement to her or his, was discussed with them in light of the WC cutoff points recommended by the World Health Organization (Han et al., 1995). The action levels corresponding to the cutoff points were also presented and discussed with each subject as follows (Han & Lean, 1998):

> Individuals with a waist circumference below action level 1 [<94.0 cm in men, <80.0 cm in women] do not need to lose weight but should be aware of potential health risks if their waist exceeds this level. In the range between action level 1 and action level 2 [94.0-102.0 cm in men, 80.0-88.0 cm in women], individuals should not further gain weight, but implement lifestyle modification such as increasing physical activity level and some self-weight management. Individuals above action level 2 [≥102.0 cm in men, ≥88.0 cm in women] should be urged to take action and to seek professional help to achieve sustained weight loss. (p. 87)

Subject Protection and Benefits of Participation

The experiment was approved by the University of Colorado's Institutional Review Board (IRB) Committee. Accordingly, the experiment followed the ethical standards for research with human subjects from the University of Colorado's IRB guidelines and policies.

The experiment posed no known risks to the subjects, and safety was considered continually as data were collected. The involved subjects benefited from acquiring their waist circumference value (taken by the experienced tester), BMI, and related information about their personal health. As needed or requested, subjects received recommendations for improving their body composition by the principal investigator and the expert that validated the subjects' WC measurements (both trained and experienced health and fitness professionals). Additionally, the subjects (registered UCCS students) received extra credit points for university courses, for participating in the experiment.

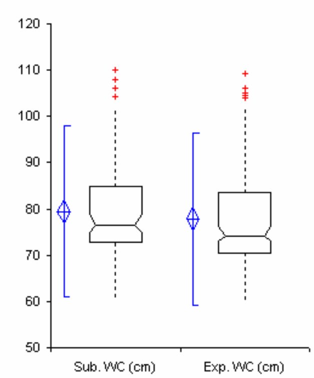
The data collected from each subject in the experiment were de-identified and closely guarded. Only the principal investigator and the validating expert had access to the data as it related to each subject's identity (*i.e.*, the subjects' identities were not revealed to anyone after the data were collected). It should be noted that the validating expert was blinded to the subject's measurements during the experimental process.

RESULTS

Figure R1.0 compares the overall representation of the of the WC measurements recorded by the subjects (Sub. WC) and the experienced tester (Exp. WC). The side-by-side box-whisker plots show the central locations and distributions of the observations. The blue diamond shows the mean and a 95% CI of the mean for each group. The notched blue lines show the 95 percentile range. The red pluses show near outliers (between 1.5 and 3.0 IQRs away). This figure shows the closeness of the mean WC measurement of the two groups (*i.e.*, a 1.57 cm difference between the Sub. WC and Exp. WC groups).

analysed with: Analyse-it • General 1.71

Variables | Sub. WC (cm), Exp. WC (cm)



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Sub. WC (cm)	83	79.459	11.2012	1.2295	77.013 to 81.905	76.400	11.850	75.000 to 78.800
Exp. WC (cm)	83	77.889	11.3181	1.2423	75.418 to 80.361	74.000	13.100	73.000 to 76.300

Figure R1.0 Comparative Descriptives for WC Measurements

The results of the statistical analyses performed are shown in their entirety in Appendix D. Data were analyzed using Microsoft Excel 2002 (Microsoft Corp, Redmond, WA) and Analyse-it General (Version 1.71) and Clinical Laboratory (Version 1.71) statistics modules (Analyse-it Software, Ltd., Leeds, England, UK).

The analysis sheets do not include data for two of the eighty-five subjects who were originally recruited for the experiment. These two subjects were excluded from the study since one of them forgot to record the WC self-measurement and the other revealed that she was pregnant (exclusionary criterion for the study) after the experiment began.

Table R1.0 summarizes the basic anthropometric measurements that were performed on the involved subjects. The %BF assessment was done *post hoc* (from the experienced tester's measurements) using validated formulae developed to predict %BF from WC, gender, and age (Lean et al., 1996). The data presented includes 83 subjects with a mean WC of 77.89 cm (from the experienced tester's measurements), a mean BMI of 23.74 kg/m^2, and a mean age of 24.

Statistic	Sub. WC (cm)	Exp. WC (cm)	%BF	BMI (kg/m2)	Mass (kg)	Weight (lb)	Stature (m)	Height (in)	Age
Sample (N):	83.00	83.00	83.00	83.00	83.00	83.00	83.00	83.00	83
Mean (X):	79.46	77.89	26.55	23.74	69.04	152.21	1.70	66.96	24
Median:	76.40	74.00	26.41	22.96	65.32	144.00	1.70	67.00	22
Mode:	75.00	74.00	26.41	#N/A	53.07	117.00	1.73	68.00	22
Minimum:	61.00	60.60	12.18	17.40	44.57	98.25	1.52	60.00	18
Maximum:	110.00	109.20	48.67	37.98	105.92	233.50	2.03	80.00	60

Table R1.0 Physical Characteristics of Subjects

The correlation coefficient (*r*=0.97, *p*<0.0001) in Figure R2.0 shows the linear relationship between the Sub. WC and the Exp. WC groups. This association supports the hypothesis that there is no significant skill difference ($p \leq 0.05$) in waist circumference measurements performed by computer trained testers compared to a traditionally trained and experienced tester.

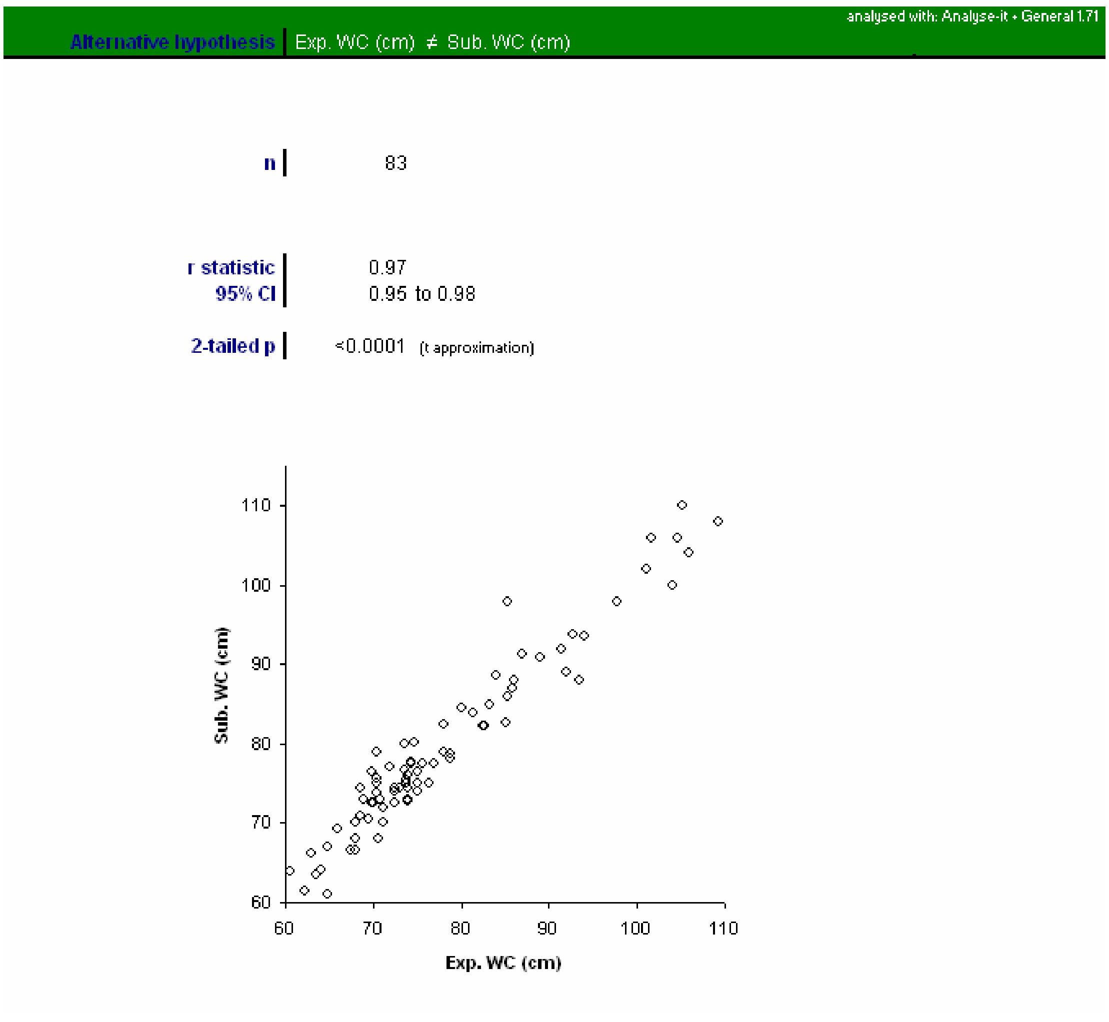


Figure R2.0 Pearson Correlation for WC Measurements

The bias plots in Figure R3.0 give visual representations of the level of agreement between the Sub. WC and the Exp. WC groups' measurements. The plots also show the precision of the measurements taken over the range of the subjects measured. For example, the plots show that the observations remain close to the zero line and the observations do not flare out or narrow across the sampling range. This indicates a rather constant variance of the subjects' measurements (*i.e.*, there does not appear to be a disproportional amount of error within any given range of the measurements).

The observations in the method comparison plot (top of Figure R3.0) closely follow the identity line, showing that the measurements of the two groups are comparable. The Bland-Altman plot (bottom of Figure R3.0) shows the difference between the two groups plotted against the mean of the two groups. The dashed black line shows the bias of the subjects' WC measurements (1.57 cm) compared to the experienced tester's measurements. The solid gray line indicates zero bias. The dashed red lines represent the 95% limits of agreement for the difference between the two groups' measurements. The fact that >95% of the differences lie within this range (±2 standard deviation units from the overall mean difference) indicates statistical agreement between the two groups of measurements (Bland & Altman, 1986). The frequency histogram shows the distribution of the differences.

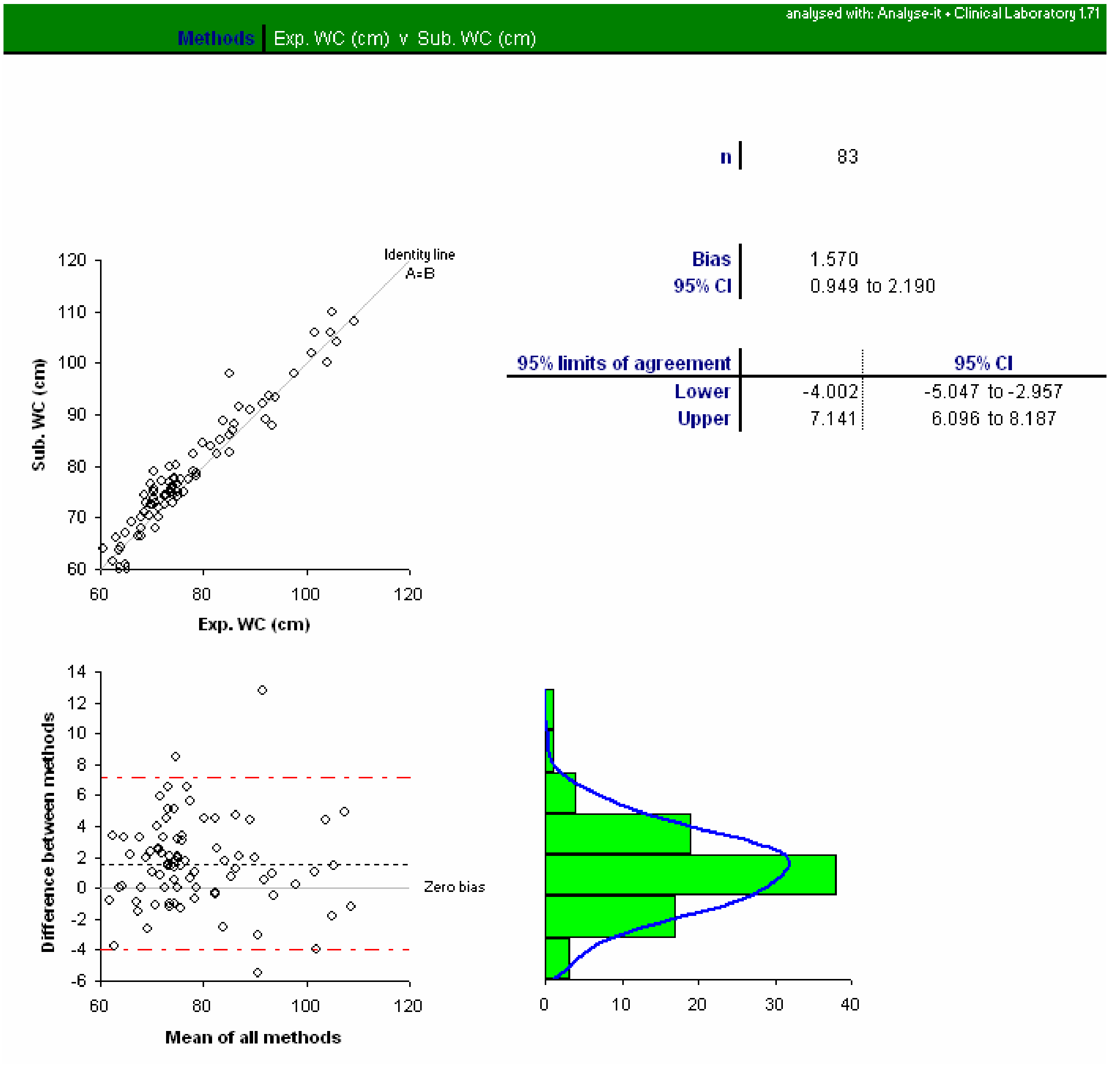


Figure R3.0 Bias Plots for WC Measurements

The results of this experiment show that the WCSM-CBT is efficacious in teaching WC self-measurement to untrained individuals. This means that the tutorial has potential for future use in the areas of health assessment, biomedical education, and scholarly research. Regarding health assessment, an example of such potential lies in the area of developing early detection and intervention strategies to battle the present overweight and obesity epidemic that exists in the U.S. and other developed countries (Bray, 2003; Zhu et al., 2002; Lean & Han, 2002; Han & Lean, 1998). If individuals can learn the value of the WC measurement, and how to properly self-measure it, they can use the results of regular monitoring to achieve and maintain optimal WC-related health goals. The Discussion section of this paper expands on these points, examines the limitations and strengths of this study, and suggests possibilities for future research.

DISCUSSION

Findings and Implications

This experiment shows the efficacy of the WCSM-CBT in teaching WC self-measurement to untrained individuals. The results of this study have quantified the average bias that is presented during WC self-measurement for subjects trained by means of the WCSM-CBT. The 1.57 cm bias can be subtracted from the results obtained by subjects who self-measure WC, in order to get accurate results. While the exact cause of the bias is unknown, the principal investigator of the study has suggested that the bias (*i.e.*, an overestimation) may be due, in part, to some individuals viewing the final reading on the tape measure by forwardly flexing the spine to look at the tape instead of using the mirror. Such forward flexing could cause compression of the abdominal contents and temporarily increase the WC. Perhaps the bias could be reduced or eliminated by having individuals take the final WC measurement by looking in the mirror instead of bending forward. Although this could be problematic in that some individuals might misread the results on the tape measure when viewing them in a mirror. The 1.57 cm bias could also stem from individuals compressing their abdominal contents (*i.e.*, "sucking it in") during the experienced tester's measurements.

The results of the videotape analysis revealed that all of the subjects used the CBT, correctly located the anatomical landmarks, took the measurement on bare skin, and placed the tape correctly. However, it was difficult to determine if other factors could have potentially contributed to measurement inaccuracies. For example, it was difficult to determine whether or not subjects were taking the measurement at the end of a normal expiration. It was also difficult to tell if subjects were getting their final measurement readings from the mirror or from looking down at the measuring tape since most subjects looked at both the mirror and the tape. Perhaps, in future research, multiple camera locations would help an investigator to recognize any factors that might skew the measurement.

Unmonitored self-measurements can be difficult because individuals performing the measurement on themselves may not have proper training and many not perform the measurement correctly. However, this study showed that, with the help of the tested computer-based tutorial, subjects were quite accurate in performing their measurements. The results of the study revealed that the subjects had an average bias of only 1.57 cm (a statistically insignificant bias) when performing the measurement. Additionally, this bias was in the direction of overestimation, which presents a safety margin for individuals performing the measurement on themselves (after being trained by the tutorial).

Comparison of Findings with Those of Other Studies

Other studies have attempted to compare WC measurements between expert and novice groups with varied results. The results of these studies are difficult to directly compare because different aspects of each study (*e.g.*, methodology and design differences) have the potential to skew the results and/or the presentation of a study's results (*e.g.*, statistical analyses). The present study attempted to build on previous studies by eliminating methodology and design flaws, and by using optimal statistical treatments for experimental data. Please see Table D1.0 (below) for a comparison of the present study to other expert *vs.* novice WC measurement studies. The table presents the mean subject bias that resulted from this study and others, alongside factors that could have influenced the bias.

Study & year	**Mean subject bias (cm)**	**Used highly controlled method(s) of instruction and measure-ment conditions**	**Used the same visit for expert and novice measure-ments**	**Gave a description of the validation "expert's" experience**	**Used the same expert for validation measure-ments**	**Used the same measurement site that was used to determine the most common cutoff points**	**Used a conventional tape measure (*i.e.*, no specialized equipment) to measure WC**
Present Study (Elliott, 2007)	1.57	Yes	Yes	Yes	Yes	Yes	Yes
Bigaard *et al.*, 2005	-2.41	No, however, "simple written instructions" were given to the subjects	No, many measurements taken between 3 and 15 months apart	No	No, three "technicians" were used	No, the level of the "natural waist" was used	Yes (subjects) Uncertain ("technicians")
Han & Lean, 1998	-0.45	Uncertain, unclear as to what personal "guidance" may have been given and what environment the measurements were done in	Yes	No	Uncertain, unclear as to whether or not only one "investigator" was used	Yes	No, used "Waist Watcher" tape measure
Rimm *et al.*, 1990	0.36	No, measurements taken over clothing, at the participants convenience	No, measure-ments taken up to nine months apart	Yes, but only that correlations were done on a sample of the "technicians" duplicate measures	No	No, the "level of the navel" was used	Yes
Hall & Young, 1989	-0.47	No, measurements were taken over clothing, at "various meeting sites"	Yes	Yes, but only stated that "the technician was extensively trained in anthropometry"	Yes	No, the subjects used both "the smallest circumference" and "at the navel"	Yes

Table D1.0 Mean Bias & Differences in Expert *vs.* Novice WC Studies

Each “No” listed in Table D1.0 represents an example of an instance where the measurement results in a given study might have been made less accurate by the absence of the corresponding factor in the table. While it is difficult to quantify how much each of these factors could affect the results of a study, there is good reason to believe that each factor in the table could generate some degree of error. A brief explanation of how each factor listed in Table D1.0 might influence error is given in the following bulleted points:

- Using a highly controlled method of instruction and measurement conditions might reduce error that could come from using method(s) of instruction and measurement conditions that have little or no control (Kerr et al., 1994; Shaw, 1986; Oppliger et al., 1992). For example, if a subject learns how to take her or his WC measurement by spending an hour with a well trained and experienced instructor, the subject is likely to perform the measurement more accurately than a subject who learns to take the measurement on her or his own after being given a piece of paper reading, “Please measure the circumference of your waist.” Since little detailed information is provided in the latter situation, performing the measurement accurately is less likely.

  In a similar way that the method of instruction could influence the accuracy of a subject’s measurement performance, the conditions in which a subject takes the measurements might also influence a subject’s measurement accuracy. For example, if a subject was instructed to measure her or his waist circumference at her or his own convenience, over clothing, and then her or his validation measurement was taken while wearing different clothing on a different day, or on the same day while wearing less clothing (as might happen if the subject removed an overshirt before having her or his validation measurement taken in another room), the results could be different. While the difference might turn out to be insignificant in such instances, the subject and expert would not be measuring the same circumference. Of note, through anecdotal trials the author of the present study has found that the transverse thickness of a light cotton t-shirt can easily measure 10 centimeters.

• Using the same visit for expert and novice measurements might reduce error that could be generated from differences in each of two separate visits. For example, if a subject gains weight in-between her or his first and second visits, her or his WC is likely to be greater when it is measured during the second visit. As mentioned above, if measurements are taken over clothing, differences in the clothing worn at each of two visits might cause different measurement results.

• Using a well experienced validation expert to take validation measurements could reduce error that might arise from using someone with little experience (American College of Sports Medicine, 2006; Heyward & Wagner, 2004). Each study should use the most experienced individual available to validate all of the subjects' measurements. Additionally, authors should give a description of the validation expert's experience. This is important so that readers of a study can take this factor into consideration when comparing its results to those of other studies.

• Using the same expert, if properly trained and well experienced, to take validation measurements for all of the subjects in a study, eliminates error that could arise between multiple validation experts (Jackson et al., 1978). For example, if a study uses a multiple expert design and one expert has more experience than another, the one with more experience is likely to perform the most valid and reliable measurements.

• Using the same anatomical measuring sites to take WC measurements limits error that could be introduced into a study from having subjects and validating experts take measurements at different sites (Wang et al., 2003). Part of the reason for this is that the body is a curvilinear, asymmetrical, compressible, dynamic structure rather than a rigid, symmetrical, cylinder Researchers should consider using the same measurement site that was used to determine the most commonly used health-related cutoff points for WC (Lean et al., 1995; Han et al., 1995).

• Using a conventional tape measure rather than a specialized measuring device helps to eliminate any error that might arise from differences in using such a device. Even if a specialized measuring device tends to give more accurate results, it should be recognized that such results will be less applicable to the general population since it is likely that individuals in this population will measure WC with a conventional tape measure. Additionally, it should be recognized that studies that use specialized equipment to measure WC are more difficult to directly compare to studies that use a conventional tape measure (Bigaard et al., 2005). If a specialized device is used by a validating expert in an expert *vs.* novice WC measurement study, the same device should also be used by all of the subjects in the study, unless the device is tested for bias.

Short notes have also been added to some of the “Yes” and “No” entries in Table D1.0 where they might provide additional clarity for a given situation. Upon first looking at the table, one might be tempted to simply compare the mean subject biases of the studies. However, the influence of each of the corresponding factors listed in the table must be considered when comparing the findings of these studies. The more “No” entries there are for a given study, the less accurate the value determined for the subject bias is likely to be. Even if one factor turns out to be insignificant in a given study, the sum total of all the factors might lead to a significant difference.

Additionally, it should be noted when comparing the studies in Table D1.0 that positive values for the mean subject bias indicate a general overestimation of the subjects’ WC measurements. From a clinical perspective, overestimation of the WC is also an overestimation of morbidity and mortality, and is more conservative and thus safer than underestimation since underestimation may lead individuals to misclassify themselves as being healthier than they actually are. The fact that the present study resulted in the highest bias (*i.e.*, 1.57 cm) of the studies compared in Table D1.0 makes the tutorial trained subjects’ measurements the safest. This should be considered with the fact that the subjects’ measurements are still accurate in comparison to the expert’s.

This is evidenced by the Bland-Altman bias plots in the Results section which showed agreement (>95% of the differences lie within ±2 standard deviation units from the overall mean difference) between the subjects' and experienced tester's measurements, and Pearson correlation (r=0.97) which showed no significant (p<0.0001) difference between the two groups of measurements.

Of specific interest in this investigation was the method of instruction used to teach individuals to perform WC self-measurement. As mentioned in the Literature Review, several studies have shown that different methods of teaching anthropometric measurements can differently affect the resultant accuracy of individuals taking the measurements (Shaw, 1986; Kerr et al., 1994; Oppliger et al., 1992; Whitehead & Parker, 1993). These expert *vs.* novice studies compared methods such as videotape instructions, training clinics, written instructions, and classroom instructions. In the present study, the method of instruction was highly controlled through the use of the CBT (the first expert *vs.* novice WC measurement study to do so), and the contents of the CBT are clearly shown in "Appendix E: WCSM-CBT Lesson Screen Captures and Audio Scripts." However, the other studies represented in Table D1.0 gave very little attention to the methods of teaching WC self-measurement. They offer little or no description of how their novice subjects learned to perform WC self- measurement. For example, one study simply mentions that, "Subjects were asked to measure their waist at the smallest circumference or just at the navel …" (Hall & Young, 1989). Besides the fact that subjects were told to take the measurement at two different anatomical measurement sites, nothing else is said about how the subjects learned to take the measurement and whether or not they received any additional assistance in performing the measurement. Obviously, interactive personal communication on how to perform the measurement could influence a subject's measurement skills. In the present study, subjects were not given any help in learning to take the measurement beyond what was provided by the CBT.

In another study, participants took their WC measurements over clothing, at their convenience (Rimm et al., 1990). Since the expert and novice measurements were taken up to nine months apart in that study, in different clothing, in different locales, there was very little control of the conditions in which WC measurements were taken. The Hall & Young (1989) study also says that the WC measurements were taken over clothing at "various meeting sites." In order to minimize error that could be introduced into the results of such studies, the conditions in which the measurements are taken should be controlled as much as possible. The Methodology section gives a description of the conditions in which all of the measurements were taken in the present study. To summarize, all of the measurements were performed under the following conditions:

- All measurements were taken in a the same laboratory room;
- All subjects used the WCSM-CBT to learn WC self-measurement in the same laboratory room;
- All subjects used the same CBT, on the same computer, at the same desk;
- All subjects used the same type of measuring tape;
- All subjects took the measurement on the surface of their skin rather than over clothing;

• All subjects attempted to perform the measurement on themselves in front of a mirror;

• All subjects learned and performed the measurement without anyone else being present in the room;

• All subjects' performance of the measurement was videotaped so it could be evaluated for possible errors;

• All subjects had their mass and stature measured on the same scale/stadiometer;

• Immediately after each subject recorded her/his WC measurement, the experienced tester took validation measurements on them;

• The validating expert was blinded to the subjects' measurements during the entire experimental process.

Another way the present study attempted to achieve accurate results was to use the same visit to take novice and expert measurements. Other studies took many of the expert and novice measurements taken between 3 and 15 months apart (Bigaard et al., 2005; Rimm et al., 1990). While such an experimental design might make it easier to get a larger sample size, it also has the potential to produce highly inaccurate results since the subjects' WCs could have changed significantly during this period of time due to weight gain or loss.

In addition to using the same visit to take novice and expert measurements, the present study used the same expert to take all of the validation measurements. The idea of having more than one expert was considered in the development of this study.

However, after careful consideration it was decided to use only one expert in order to eliminate error that could arise between several different testers. This idea is reflected in the thoughts of Jackson, Pollock, & Gettman, eminent researchers in the field of anthropometry (Jackson et al., 1978):

> Most investigations using anthropometric measures to estimate body composition use the same investigator to take all measures. The use of the same tester eliminates error that could exist among testers, and thus provides the most reliable measure of skinfold fat and body circumferences. (p. 546-547)

Two of the previous expert *vs.* novice WC measurement studies used multiple validation experts (Bigaard et al., 2005; Rimm et al., 1990). This design factor could have introduced additional error into the results of these studies.

While there is no universally accepted definition of an expert waist circumference measurer, Vivian H. Heyward and Dale R. Wagner, authors of *Applied Body Composition Assessment* (which is directed at body composition practitioners), say that practice is needed to "perfect the identification of the measurement sites and your measurement techniques." (Heyward & Wagner, 2004). Furthermore, Heyward and Wagner state that "Experts recommend practicing on at least 50 people and taking a minimum of three measurements for each site in rotational order." As mentioned in the Methodology section of this paper, the expert in the present study had performed in excess of 3,700 WC measurements on individuals with a variety of different body types, in clinical practice, prior to participating in the study. Additionally, the expert was an exercise physiologist with graduate-level academic training and professional training, from a variety of resources including, classes, books and laboratory instruction).

Generally, very little or no information was given about the experts' training and experience in the reviewed expert *vs.* novice WC measurement research literature. One of the only two studies to mention anything about their expert's experience simply stated that, "the technician was extensively trained in anthropometry" (Hall & Young, 1989). The other study mentioned that correlations were calculated between duplicate circumference measurements made at the same visit on 48 participants in the study, before accepting the technicians' measurements as a gold standard. However, the study did not mention anything about the technicians' training or how much experience they had prior to the study (Rimm et al., 1990).

Readers should note that in the context of this study, the term "expert" was simply used to keep in accord with the common terminology of expert *vs.* novice research designs. The term "expert" was not chosen to imply that our validating WC measurer had attained a particular level of expertise that warrants the use of the term "expert." While the expert in this study had a high level of training and experience, it is certainly conceivable that someone with less training and experience could serve as an "expert" in such a study. Similar studies with expert *vs.* novice research designs have used other terms to describe their expert. Such terms include: "investigator" (Han & Lean, 1998), "technician" (Hall & Young, 1989; Bigaard et al., 2005; Rimm et al., 1990), "experienced tester" (Shaw, 1986; Oppliger et al., 1992; Kerr et al., 1994), and "technologist" (Gardner et al., 2001).

In addition to being well-trained and experienced, the expert in the present study took all WC measurements at the same measurement site used to determine the most common cutoff points for WC values. The CBT instructed the untrained subjects to use this site too. Previous WC measurement studies have used several different measurement sites which makes it difficult to directly compare the results of this study with their results (Wang et al., 2003). See Table D1.0 to see measurement sites that were used in other expert *vs.* novice WC measurement studies. As mentioned in the Methodology section of this paper, the measurement site used in the present study was chosen because it is the site that was originally used in the study that determined the cutoff points that have been adopted by major health organizations (*e.g.*, the World Health Organization, the National Institutes of Health, the National Heart Lung and Blood Institute *et al.*) (Lean et al., 1995; Han et al., 1995). If future WC comparison studies would use the same site, the results of such studies would be easier to compare.

Another factor that could make a difference in the results of novice and expert measurements is the use of specialized equipment for taking WC measurements. While most of the previous studies used a conventional tape measure to measure the WC, one study used a special measuring tape call the "Waist Watcher" (Han & Lean, 1998). According to the authors of the study:

> This tape-measure was made to help subjects measure their waist circumference easily. The tape is made into a complete loop and fitted firmly around the waist by a spring mechanism, controlled by a push-button. This allows subjects to have their hands free for adjusting the tape. The measurement could be

> conveniently read by removing the tape from the waist, which was particularly helpful to overweight subjects who found it hard to read bending down. (p. 82)

While the "Waist Watcher" tape is an interesting device and the study was fairly well-designed, the fact that the researchers in the study used a specialized device introduces question about how accurately the results of using this device compare with those of studies where a conventional tape measure was used to take WC measurements. Both the expert and novice subjects in the present study used a conventional tape measure. In addition to making the results more comparable to other expert *vs.* novice WC studies, the bias resulting from studies using a conventional tape measure is more applicable to the laity, which is likely to self-measure WC using a conventional tape measure.

A final point should be made before moving away from this discussion of factors that distinguish the present study from previous expert *vs.* novice WC measurement studies, regarding the statistical treatments that are used on the data collected in such studies. Even if all data are collected with consideration to the aforementioned factors that make it difficult to directly compare the results of similar studies, differences in the presentation of the data can make it difficult to compare the results of one study to another. According to statisticians who specialize in method comparison and expert *vs.* novice research design, bias plots are a much better way of comparing the results of two methods because they give a better indication of agreement between methods or groups than correlations, which simply show the relationship between methods or groups (Bland & Altman, 1986; Williams & Bale, 1998). While correlations work well for hypothesis testing, bias plots do a much better job of giving a visual representation of the data and the agreement between methods or groups being studied. Bias plots also show the precision of the measurements taken over the range of the subjects measured in a study.

The WC measurement results in this study were statistically analyzed using correlation coefficients (Pearson's product moment) and bias plots showing both the bias and limits of agreement. Please see Figure R3.0 and the corresponding text in the Results section of this paper for a detailed description of what various aspects of the bias plots represent in this study. Unfortunately, not all of the previous expert *vs.* novice WC measurement studies used bias plots to present their results (Hall & Young, 1989; Rimm et al., 1990). This makes it more difficult to fully analyze and compare their results with other studies, and to observe the level of agreement between the expert and novice groups' measurements. While additional ways of presenting the results of expert *vs.* novice anthropometric measurement studies might be useful to one degree or another (*e.g.*, various types of correlations and t-tests), bias plots (not just bias calculations) should be used in the presentation of the results of such studies (Bland & Altman, 1986; Williams & Bale, 1998).

Limitations, Strengths, and Future Work

Limitations of this study include the fact that the subjects were of a homogeneous sample (in general, the subjects were young college-aged and non-obese). Performing a similar experiment on an older or obese (*i.e.*, having a greater WC and/or BMI) population might yield different results. Future studies could focus on either of these groups. However, it should be pointed out that the isolated older and obese subjects in this study performed the measurement as well as the younger and non-obese subjects. To make the study more generalizable, the study could have also benefited from a larger, varied population with a better balance males and females.

Another criticism of the study might be that subjects were only asked to record a single measure of their WC. However, the main purpose this study was to test the efficacy of a functional and practical learning tool. An important aspect of the tool is ease of use. Along those lines, the subjects in the study were simply told to use the tutorial to derive their WC. While having the subjects take multiple measurements would have provided more information, this might also have complicated the process for them. Additionally, the tutorial does not tell the subjects to take multiple measurements (again, for ease of completing the measurement). Here again, it should be noted that the results of the study showed agreement between the two groups (according to Bland-Altman analysis) and that there is no significant skill difference ($p \leq 0.05$) in WC measurements performed by the tutorial trained testers compared to the traditionally trained and experienced tester. Thus, multiple measures seem to be unnecessary when the tested tutorial is used. This is especially true if the 1.57 cm bias is subtracted from individual measurement results.

This study is an important contribution to the body composition literature because it is the first study known to directly investigate a method of teaching WC measurement technique. The results of this study will serve as a foundation for further research in the area of body composition self-measurement and self health assessment in general. Furthermore, this study has validated the efficacy of a tool that has potential to teach the masses to properly self-measure WC, and ultimately to help individuals monitor WC-related health status.

Future scholarly research might involve studies that couple the basic tenets of this study with other variables. For example, studies could compare other methods of instruction (*e.g.*, written, video, or audio [*e.g.*, telephone] only instructions; or such instructions in varying combinations) with the WCSM-CBT that was investigated in this study. Longitudinal studies of performance could compare subject groups using *vs.* not using the CBT over time, to test how accuracy improves or decreases over time. Other studies might work to further elucidate sources of error that might be involved with self-measuring WC. In future expert *vs.* novice WC measurement studies, it would be helpful if authors would do a better job of describing their validation experts' level of training and experience for comparison purposes. For example, if all such studies would give some description of how their experts were trained and how much experience they had prior to a given study (*e.g.*, the number of times they had taken the measurement in practice), readers of the study would be able to take this into consideration when comparing the results of the study with those of others.

In the area of biomedical education, the basic components of the WCSM-CBT might be used to develop future tutorials that could be used in teaching WC measurement to additional populations such as those in clinical, military, insurance, and health organizations. The tutorial could also be used as a model for developing tutorials that teach similar anthropometric measurement techniques, such as those used in skinfold measurements. Future tutorials could be tested for efficacy in a way similar to the way the WCSM-CBT was tested in this study.

The tutorial might also be used in the field of Internet research (or other forms of distance research). For example, if individuals could accurately perform WC self-measurement, researchers may be able to accept self-report of WC measurement for their research. This would allow such researchers to draw from larger, more diverse populations, and have larger sample sizes in their studies. The research of Tate *et al.* provides a good example of where such self-measurement might be used (Tate, Wing, & Winett, 2001; Tate, Jackvony, & Wing, 2003). Dr. Deborah F. Tate's work surrounds the area of health behavior and health education. More specifically, Dr. Tate conducts research focused on the use of computer technology and the Internet in weight management.

In addition to the aforementioned possibilities, the WCSM-CBT could be helpful in the processes of continuing education (*e.g.*, CEUs, CECs and CMEs) through the Internet and other computer technologies. Here, the tutorial (or a variation of it) could serve as a standardized way of teaching individuals to measure WC. In biomedical research, the use of such a tutorial as a standard for learning WC measurement could provide readers of published research studies with greater assurance of the validity of WC measurements.

Conclusions

This study has demonstrated that the WCSM-CBT is a valid tool for use in teaching WC self-measurement. Since WC is strongly linked to morbidity and mortality, individuals should be aware of their WC, as they should be aware of other well-established indicators of health (*e.g.*, blood pressure, cholesterol, diet, activity level and family history). The WCSM-CBT holds great potential for teaching the masses how to properly perform WC self-measurement.

APPENDICES

Appendix A: Informed Consent Form

(Document on Following Page)

INFORMED CONSENT FORM

Title of Study: The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement (Approved by the UCCS Institutional Review Board – IRB #: 03-082 / Expiration Date: 10-22-04)

Invitation to the Study: You are being invited to participate in a research study conducted by William L. Elliott, an exercise physiologist and course instructor for the University of Colorado at Colorado Springs Biology Department.

Purpose of the Study: The purpose of this study is to determine how effective a computer-based tutorial is in teaching untrained individuals to properly measure the circumference of their waist (called the *waist circumference* or *WC*).

Procedures/Expectations: You and the other participants involved in this study will be asked to use a multimedia tutorial, (*i.e.*, a tutorial containing video, audio, and text), to learn how to properly measure the circumference of your waist. After completing the tutorial, you will be asked to perform the measurement on yourself in front of a mirror, without any additional instruction (no one will be in the room to give you instructions beyond what the tutorial has given you). As you perform this measurement on yourself, you will be videotaped so that the principle investigator of this study can analyze this process at a later time.

Once you have finished performing the measurement on yourself, someone with academic and professional training and experienced in WC measurement, will perform the same measurement on you. Afterwards, your results will be compared with the experienced tester's results.

Your height and weight measurements will also be taken by an investigator for research purposes but you will not be asked to perform these measurements.

Location: Data (WC, height, and weight) will be collected in Berning Laboratory in the Science Building at UCCS.

Duration: Your involvement in the study should take no more than 30 minutes from the time you begin the tutorial.

Risks: The procedures involved in this study are not known to pose any risks to human subjects.

Benefits: You will benefit from acquiring your waist circumference value (taken by someone with academic and professional training and experienced in WC measurement), as this measurement is closely associated with your health status. Additionally, you may receive extra credit points (as approved individual course instructor) for participating in this study.

Participation: Please understand that your participation in this study is completely voluntary and you have the right to withdraw your consent to participate at any time during the study for any reason, without penalty (You will still receive any extra credit points that have been promised to you if you choose to withdraw your participation.).

Privacy and Confidentiality: The data collected from you in this study will only be seen by the principle investigator and the co-investigator of the study (*i.e.*, the expert that takes your WC measurement). All of the collected data will be maintained by the principle investigator of the study and will remain private and confidential (*i.e.*, your name will not be identified to anyone else after the data is collected). Also note that after the videotape of your WC measurement performance is viewed and compared to a criterion checklist, it will be destroyed (the tape will be shredded in a paper shredder).

Inquiries: If you have any questions about this study, you may contact William L. Elliott (the principle investigator of the study) at (719) 262-0931 or visit him at his UCCS office in the Science Building (room #136). If you have any questions regarding your rights as a research participant, you may contact the UCCS Chairperson of the Institutional Review Board at (719) 262-4150

I have read and understand the information provided above and consent to participate in the research study.

Signature of Participant ____ **Date** ____________________

Signature of Investigator ____ **Date** ____________________

Appendix B: Data Collection Sheet

(Document on Following Page)

Subject #: _________

DATA COLLECTION SHEET

[*Note: This section is to be filled out by the subject.*]

*** Waist Circumference Self-Measurement (Please record your measurement below):**

_________(centimeters to nearest tenth) ***or*** **_________(inches to nearest sixteenth)**

First Name: ___________________________ Last Name: ____________________________

Date: _________ Age: ______ Gender (M or F): ___ Telephone: __________________

Street Address: ____

City: ______________________________ State: ____________________ Zip: _________

E-mail Address: _____________________

[*Note: This section is to be filled out by one of the investigators.*]

* Waist Circumference Measurement: _________(cm)

BMI: _________(kg/cm^2)

Mass: _________(kg) *or* Weight: _________(lb)

Stature: _________ (cm) *or* _________ (in)

Additional Information:

____

____

____

____

____

Appendix C: Subject Result Sheets

(Document on Following Page)

Subject #: _________

RESULTS SHEET

Date: _________

Waist Circumference Measurement: _________(cm)

BMI: _________(kg/cm^2)

Mass: _________(kg) *or* Weight: _________(lb)

Stature: _________ (cm) *or* _________ (in)

Subject #: _________

RESULTS SHEET

Date: _________

Waist Circumference Measurement: _________(cm)

BMI: _________(kg/cm^2)

Mass: _________(kg) *or* Weight: _________(lb)

Stature: _________ (cm) *or* _________ (in)

Subject #: _________

RESULTS SHEET

Date: _________

Waist Circumference Measurement: _________(cm)

BMI: _________(kg/cm^2)

Mass: _________(kg) *or* Weight: _________(lb)

Stature: _________ (cm) *or* _________ (in)

Subject #: _________

RESULTS SHEET

Date: _________

Waist Circumference Measurement: _________(cm)

BMI: _________(kg/cm^2)

Mass: _________(kg) *or* Weight: _________(lb)

Stature: _________ (cm) *or* _________ (in)

Appendix D: Data Analysis Spreadsheets

List of Data Analysis Spreadsheets

Please note that each entry within the List of Data Analysis Spreadsheets may be used as a hyperlink to its corresponding sheet when it is viewed on a computer. In order to use this feature, mouse click anywhere on an entry title in the List of Data Analysis Spreadsheets and then hit the Enter key on the computer keyboard to access the corresponding sheet.

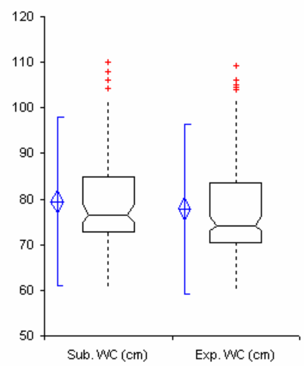
D1.0: Raw Data and Basic Statistics for all Subjects

The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement										
Raw Data and Basic Statistics for all Subjects										
Subject #	Sub. WC (cm)	Exp. WC (cm)	%BF	BMI (kg/m2)	Mass (kg)	Weight (lb)	Stature (m)	Height (in)	Gender	Age
1	102.00	101.00	41.57	35.71	103.42	228.00	1.70	67.00	F	30
2	87.00	85.80	19.68	23.94	81.19	179.00	1.84	72.50	M	28
3	79.00	70.50	26.41	22.96	68.49	151.00	1.73	68.00	F	22
4	82.50	78.00	29.93	24.07	73.94	163.00	1.75	69.00	F	23
5	73.80	70.50	26.19	21.40	53.07	117.00	1.57	62.00	F	21
6	88.10	86.00	19.18	24.48	80.74	178.00	1.82	71.50	M	22
7	64.00	60.60	21.84	17.79	53.07	117.00	1.73	68.00	F	21
8	80.20	74.60	28.21	24.25	76.66	169.00	1.78	70.00	F	22
9	72.80	74.00	27.51	22.80	62.14	137.00	1.65	65.00	F	20
10	69.30	66.00	24.44	20.99	60.78	134.00	1.70	67.00	F	22
11	74.50	74.00	27.29	23.02	66.68	147.00	1.70	67.00	F	19
12	72.50	72.50	27.51	21.55	60.78	134.00	1.68	66.13	F	23
13	76.00	74.00	12.18	21.78	66.91	147.50	1.75	69.00	M	20
14	88.70	84.00	18.15	24.39	77.11	170.00	1.78	70.00	M	23
15	80.00	73.50	27.73	21.69	63.05	139.00	1.71	67.13	F	22
16	79.00	78.00	14.85	23.31	85.73	189.00	1.92	75.50	M	24
17	77.50	74.40	27.90	22.39	65.32	144.00	1.71	67.25	F	21
18	76.10	74.00	27.29	20.86	58.63	129.25	1.68	66.00	F	19
19	77.50	75.70	29.14	22.11	64.98	143.25	1.71	67.50	F	24
20	78.10	78.80	15.10	22.94	79.95	176.25	1.87	73.50	M	22
21	67.00	64.80	23.69	19.33	44.91	99.00	1.52	60.00	F	21
22	84.50	80.00	30.36	24.23	65.55	144.50	1.64	64.75	F	21
23	106.00	104.60	31.75	30.82	100.25	221.00	1.80	71.00	M	42
24	76.70	73.50	27.73	22.25	63.96	141.00	1.70	66.75	F	22
25	66.50	68.00	25.31	18.76	50.35	111.00	1.64	64.50	F	22
26	75.60	70.50	26.41	23.10	62.48	137.75	1.64	64.75	F	22
27	72.00	71.20	26.28	24.61	72.35	159.50	1.71	67.50	F	20
28	74.50	72.40	27.02	22.97	65.55	144.50	1.69	66.50	F	21
29	75.00	73.70	27.60	23.58	63.28	139.50	1.64	64.50	F	21
30	91.40	87.00	19.95	22.96	78.93	174.00	1.85	73.00	M	24
31	77.60	77.00	14.18	22.81	68.04	150.00	1.73	68.00	M	23
32	70.10	71.20	26.28	20.62	58.17	128.25	1.68	66.13	F	20
33	73.00	70.70	26.06	23.39	61.80	136.25	1.63	64.00	F	20
34	66.50	67.40	24.83	21.17	54.21	119.50	1.60	63.00	F	21
35	108.00	109.20	34.26	31.89	105.92	233.50	1.82	71.75	M	41
36	110.00	105.10	48.67	37.98	101.15	223.00	1.63	64.25	F	54
37	91.00	89.00	34.53	27.41	79.38	175.00	1.70	67.00	F	22
38	85.00	83.20	17.70	25.70	76.66	169.00	1.73	68.00	M	23
39	64.20	64.10	23.60	17.40	44.57	98.25	1.60	63.00	F	22
40	74.50	68.60	25.14	19.75	58.06	128.00	1.71	67.50	F	20
41	72.50	70.00	25.97	21.05	52.62	116.00	1.58	62.25	F	21
42	68.00	68.00	24.65	23.33	62.14	137.00	1.63	64.25	F	19
44	89.00	92.00	36.29	25.60	68.72	151.50	1.64	64.50	F	24
45	75.00	70.50	26.41	21.39	60.10	132.50	1.68	66.00	F	22
46	74.00	72.40	26.58	25.28	66.79	147.25	1.63	64.00	F	19
47	92.00	91.50	22.40	29.16	96.84	213.50	1.82	71.75	M	23
48	73.00	74.00	27.06	22.14	58.51	129.00	1.63	64.00	F	18
49	73.00	69.00	24.87	21.62	62.14	137.00	1.70	66.75	F	18
50	74.50	73.00	27.73	20.75	62.82	138.50	1.74	68.50	F	23
51	79.00	78.00	28.82	22.02	62.82	138.50	1.69	66.50	F	18
52	75.50	73.70	26.93	20.07	59.88	132.00	1.73	68.00	F	18
53	93.50	94.00	23.82	29.92	97.98	216.00	1.81	71.25	M	23
54	71.00	68.60	25.58	18.78	52.39	115.50	1.67	65.75	F	22
55	75.00	75.00	12.95	22.67	71.67	158.00	1.78	70.00	M	22
56	70.00	68.00	24.65	20.23	52.62	116.00	1.61	63.50	F	19
57	88.00	93.50	36.51	31.25	93.21	205.50	1.73	68.00	F	22
58	75.00	76.30	28.74	20.09	64.86	143.00	1.80	70.75	F	21
59	106.00	101.60	46.69	31.24	95.26	210.00	1.75	68.75	F	52
60	61.00	64.80	23.69	21.21	49.67	109.50	1.53	60.25	F	21
61	78.80	78.80	30.28	23.11	68.95	152.00	1.73	68.00	F	23
62	74.00	72.50	26.85	25.79	70.31	155.00	1.65	65.00	F	20
63	61.50	62.30	25.02	17.41	46.72	103.00	1.64	64.50	F	32
64	76.40	75.00	12.64	22.25	67.36	148.50	1.74	68.50	M	19
66	104.14	106.00	34.36	32.32	95.71	211.00	1.72	67.75	M	60
67	82.20	82.50	17.10	23.40	96.62	213.00	2.03	80.00	M	21
68	77.70	74.30	29.63	22.62	64.52	142.25	1.69	66.50	F	29
69	82.60	85.10	32.60	26.24	70.99	156.50	1.64	64.75	F	21
70	66.25	63.00	22.46	18.24	48.20	106.25	1.63	64.00	F	19
71	100.00	104.00	41.34	32.32	82.10	181.00	1.59	62.75	F	23
72	68.00	70.60	28.67	18.84	46.72	103.00	1.57	62.00	F	32
73	76.50	69.90	26.15	20.09	58.17	128.25	1.70	67.00	F	22
74	72.50	69.90	25.93	22.50	58.06	128.00	1.61	63.25	F	21
75	74.00	75.00	27.72	22.12	61.69	136.00	1.67	65.75	F	19
76	83.90	81.30	16.52	23.81	76.89	169.50	1.80	70.75	M	22
77	63.60	63.60	22.72	19.17	53.07	117.00	1.66	65.50	F	19
78	70.50	69.50	25.53	19.08	56.93	125.50	1.73	68.00	F	20
79	77.00	71.90	26.81	23.24	62.37	137.50	1.64	64.50	F	21
80	93.70	92.80	22.94	27.76	87.77	193.50	1.78	70.00	M	21
81	98.00	85.20	35.96	29.58	88.91	196.00	1.73	68.25	F	36
82	98.00	97.80	40.16	36.22	91.29	201.25	1.59	62.50	F	30
83	82.20	82.60	17.26	24.09	75.07	165.50	1.77	69.50	M	22
84	85.90	85.20	33.31	26.30	72.80	160.50	1.66	65.50	F	24
85	75.00	75.00	27.72	23.15	60.22	132.75	1.61	63.50	F	19
Sample (N):	83.00	83.00	83.00	83.00	83.00	83.00	83.00	83.00	NA	83
Mean (X):	79.46	77.89	26.55	23.74	69.04	152.21	1.70	66.96	NA	24
Median:	76.40	74.00	26.41	22.96	65.32	144.00	1.70	67.00	NA	22
Mode:	75.00	74.00	26.41	#N/A	53.07	117.00	1.73	68.00	NA	22
Minimum:	61.00	60.60	12.18	17.40	44.57	98.25	1.52	60.00	NA	18
Maximum:	110.00	109.20	48.67	37.98	105.92	233.50	2.03	80.00	NA	60

D2.0: Comparative Descriptives for all Subjects

analysed with: Analyse-it + General 1.71

Test	**Comparative Descriptives for all Subjects**
	The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement
Variables	Sub. WC (cm), Exp. WC (cm)
Performed by	William L. Elliott



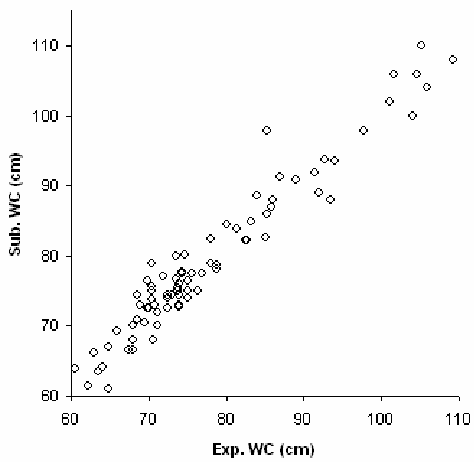
	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Sub. WC (cm)	83	79.459	11.2012	1.2295	77.013 to 81.905	76.400	11.850	75.000 to 78.800
Exp. WC (cm)	83	77.889	11.3181	1.2423	75.418 to 80.361	74.000	13.100	73.000 to 76.300

D3.0: Pearson Correlation for all Subjects

analysed with: Analyse-it + General 1.71

Test	**Pearson Correlation for all Subjects**
	The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement
Alternative hypothesis	Exp. WC (cm) ≠ Sub. WC (cm)
Performed by	William L. Elliott

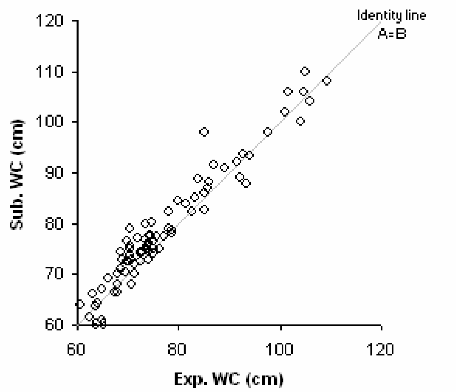
n	83
r statistic	0.97
95% CI	0.95 to 0.98
2-tailed p	<0.0001 (t approximation)



D4.0: Bias Plots for all Subjects

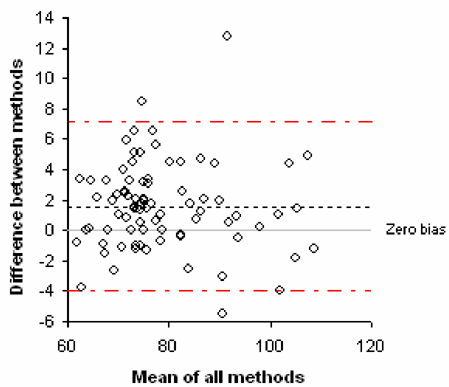
analysed with: Analyse-it + Clinical Laboratory 1.71

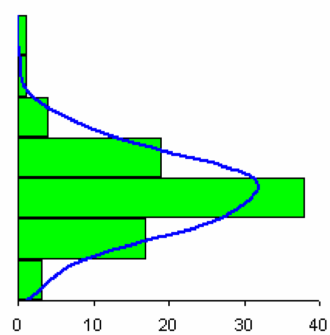
Test	**Bias Plots for all Subjects** The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement Exp. WC (cm) v Sub. WC (cm)
Performed by	William L. Elliott

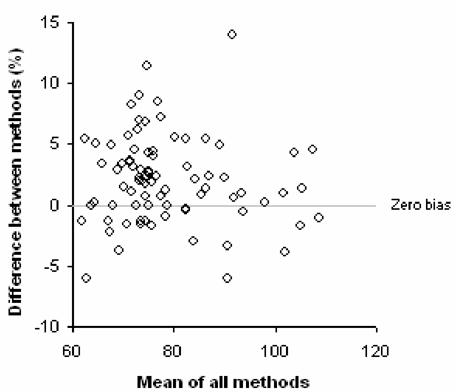


n	83	
Bias	1.570	
95% CI	0.949 to 2.190	

95% limits of agreement		**95% CI**
Lower	-4.002	-5.047 to -2.957
Upper	7.141	6.096 to 8.187







D5.0: Raw Data and Basic Statistics for Female Subjects

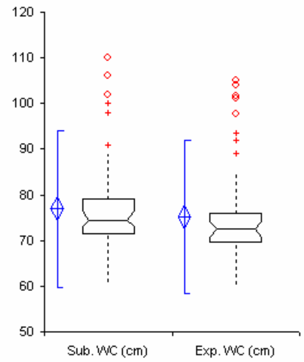
The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement
Raw Data and Basic Statistics for Female Subjects

Subject #	Sub. WC (cm)	Exp. WC (cm)	%BF	BMI (kg/m2)	Mass (kg)	Weight (lb)	Stature (m)	Height (in)	Gender	Age
1	102.00	101.00	41.57	35.71	103.42	228.00	1.70	67.00	F	30
3	79.00	70.50	26.41	22.96	68.49	151.00	1.73	68.00	F	22
4	82.50	78.00	29.93	24.07	73.94	163.00	1.75	69.00	F	23
5	73.80	70.50	26.19	21.40	53.07	117.00	1.57	62.00	F	21
7	64.00	60.60	21.84	17.79	53.07	117.00	1.73	68.00	F	21
8	80.20	74.60	28.21	24.25	76.66	169.00	1.78	70.00	F	22
9	72.80	74.00	27.51	22.80	62.14	137.00	1.65	65.00	F	20
10	69.30	66.00	24.44	20.99	60.78	134.00	1.70	67.00	F	22
11	74.50	74.00	27.29	23.02	66.68	147.00	1.70	67.00	F	19
12	72.50	72.50	27.51	21.55	60.78	134.00	1.68	66.13	F	23
15	80.00	73.50	27.73	21.69	63.05	139.00	1.71	67.13	F	22
17	77.50	74.40	27.90	22.39	65.32	144.00	1.71	67.25	F	21
18	76.10	74.00	27.29	21.18	59.54	131.25	1.68	66.00	F	19
19	77.50	75.70	29.14	22.11	64.98	143.25	1.71	67.50	F	24
21	67.00	64.80	23.69	19.33	44.91	99.00	1.52	60.00	F	21
22	84.50	80.00	30.36	24.23	65.55	144.50	1.64	64.75	F	21
24	76.70	73.50	27.73	22.25	63.96	141.00	1.70	66.75	F	22
25	66.50	68.00	25.31	18.76	50.35	111.00	1.64	64.50	F	22
26	75.60	70.50	26.41	23.10	62.48	137.75	1.64	64.75	F	22
27	72.00	71.20	26.28	24.61	72.35	159.50	1.71	67.50	F	20
28	74.50	72.40	27.02	22.97	65.55	144.50	1.69	66.50	F	21
29	75.00	73.70	27.60	23.58	63.28	139.50	1.64	64.50	F	21
32	70.10	71.20	26.28	20.62	58.17	128.25	1.68	66.13	F	20
33	73.00	70.70	26.06	23.39	61.80	136.25	1.63	64.00	F	20
34	66.50	67.40	24.83	21.17	54.21	119.50	1.60	63.00	F	21
36	110.00	105.10	48.67	37.98	101.15	223.00	1.63	64.25	F	54
37	91.00	89.00	34.53	27.41	79.38	175.00	1.70	67.00	F	22
39	64.20	64.10	23.60	17.40	44.57	98.25	1.60	63.00	F	22
40	74.50	68.60	25.14	19.75	58.06	128.00	1.71	67.50	F	20
41	72.50	70.00	25.97	21.05	52.62	116.00	1.58	62.25	F	21
42	68.00	68.00	24.65	23.33	62.14	137.00	1.63	64.25	F	19
44	89.00	92.00	36.29	25.60	68.72	151.50	1.64	64.50	F	24
45	75.00	70.50	26.41	21.39	60.10	132.50	1.68	66.00	F	22
46	74.00	72.40	26.58	25.28	66.79	147.25	1.63	64.00	F	19
48	73.00	74.00	27.06	22.14	58.51	129.00	1.63	64.00	F	18
49	73.00	69.00	24.87	21.62	62.14	137.00	1.70	66.75	F	18
50	74.50	73.00	27.73	20.75	62.82	138.50	1.74	68.50	F	23
51	79.00	78.00	28.82	22.02	62.82	138.50	1.69	66.50	F	18
52	75.50	73.70	26.93	20.07	59.88	132.00	1.73	68.00	F	18
54	71.00	68.60	25.58	18.78	52.39	115.50	1.67	65.75	F	22
56	70.00	68.00	24.65	20.23	52.62	116.00	1.61	63.50	F	19
57	88.00	93.50	36.51	31.25	93.21	205.50	1.73	68.00	F	22
58	75.00	76.30	28.74	20.09	64.86	143.00	1.80	70.75	F	21
59	106.00	101.60	46.69	31.24	95.26	210.00	1.75	68.75	F	52
60	61.00	64.80	23.69	21.21	49.67	109.50	1.53	60.25	F	21
61	78.80	78.80	30.28	23.11	68.95	152.00	1.73	68.00	F	23
62	74.00	72.50	26.85	25.79	70.31	155.00	1.65	65.00	F	20
63	61.50	62.30	25.02	17.41	46.72	103.00	1.64	64.50	F	32
68	77.70	74.30	29.63	22.62	64.52	142.25	1.69	66.50	F	29
69	82.60	85.10	32.60	26.24	70.99	156.50	1.64	64.75	F	21
70	66.25	63.00	22.46	18.24	48.20	106.25	1.63	64.00	F	19
71	100.00	104.00	41.34	32.32	82.10	181.00	1.59	62.75	F	23
72	68.00	70.60	28.67	18.84	46.72	103.00	1.57	62.00	F	32
73	76.50	69.90	26.15	20.09	58.17	128.25	1.70	67.00	F	22
74	72.50	69.90	25.93	22.50	58.06	128.00	1.61	63.25	F	21
75	74.00	75.00	27.72	22.12	61.69	136.00	1.67	65.75	F	19
77	63.60	63.60	22.72	19.17	53.07	117.00	1.66	65.50	F	19
78	70.50	69.50	25.53	19.08	56.93	125.50	1.73	68.00	F	20
79	77.00	71.90	26.81	23.24	62.37	137.50	1.64	64.50	F	21
81	98.00	85.20	35.96	29.58	88.91	196.00	1.73	68.25	F	36
82	98.00	97.80	40.16	36.22	91.29	201.25	1.59	62.50	F	30
84	85.90	85.20	33.31	26.30	72.80	160.50	1.66	65.50	F	24
85	75.00	75.00	27.72	23.15	60.22	132.75	1.61	63.50	F	19
Sample (N):	63.00	63.00	63.00	63.00	63.00	63.00	63.00	63.00	NA	63
Mean (X):	76.94	75.18	28.67	23.18	64.51	142.22	1.67	65.62	NA	23
Median:	74.50	72.50	27.06	22.25	62.37	137.50	1.67	65.75	NA	21
Mode:	74.50	70.50	26.41	#N/A	53.07	117.00	1.73	68.00	NA	21
Minimum:	61.00	60.60	21.84	17.40	44.57	98.25	1.52	60.00	NA	18
Maximum:	110.00	105.10	48.67	37.98	103.42	228.00	1.80	70.75	NA	54

D6.0: Comparative Descriptives for Female Subjects

analysed with: Analyse-it + General 1.71

Test	**Comparative Descriptives for Female Subjects**
	The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement
Variables	Sub. WC (cm), Exp. WC (cm)
Performed by	William L. Elliott



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Sub. WC (cm)	63	76.939	10.4196	1.3127	74.315 to 79.563	74.500	7.500	73.000 to 76.500
Exp. WC (cm)	63	75.183	10.2595	1.2926	72.599 to 77.766	72.500	6.300	70.600 to 74.000

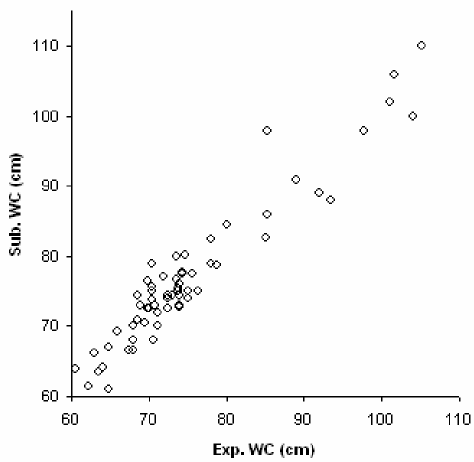
D7.0: Pearson Correlation for Female Subjects

analysed with: Analyse-it + General 1.71

Test	**Pearson Correlation for Female Subjects**
	The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement
Alternative hypothesis	Exp. WC (cm) ≠ Sub. WC (cm)
Performed by	William L. Elliott

n	63

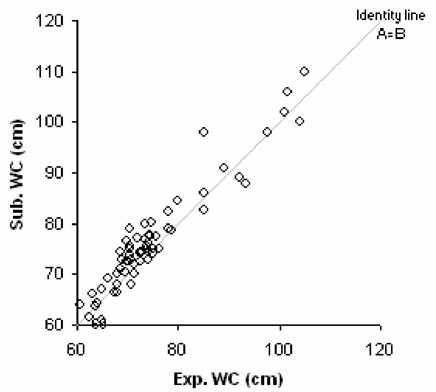
r statistic	0.95
95% CI	0.93 to 0.97
2-tailed p	<0.0001 (t approximation)



D8.0: Bias Plots for Female Subjects

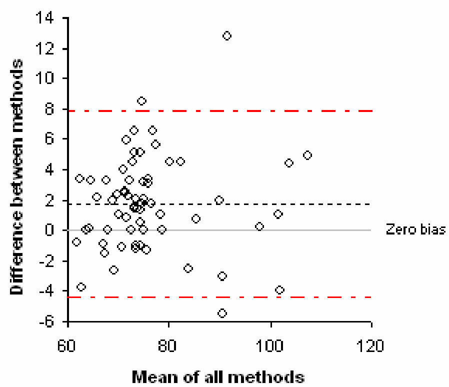
analysed with: Analyse-it + Clinical Laboratory 1.71

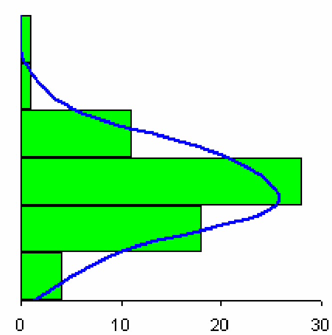
Test	**Bias Plots for Female Subjects**
	The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement
	Exp. WC (cm) v Sub. WC (cm)
Performed by	William L. Elliott

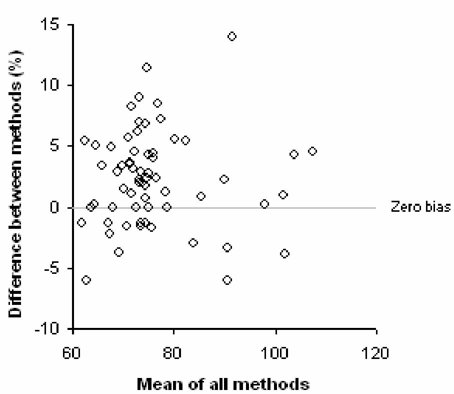


n	63	
Bias	1.756	
95% CI	0.973 to 2.539	

95% limits of agreement		95% CI
Lower	-4.337	-5.649 to -3.025
Upper	7.850	6.538 to 9.162





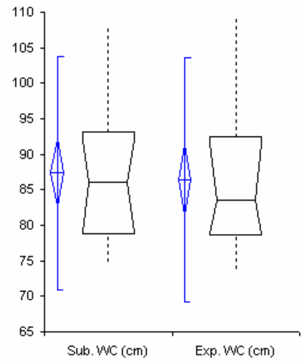


D9.0: Raw Data and Basic Statistics for Male Subjects

The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement										
Raw Data and Basic Statistics for Male Subjects										
Subject #	Sub. WC (cm)	Exp. WC (cm)	%BF	BMI (kg/m2)	Mass (kg)	Weight (lb)	Stature (m)	Height (in)	Gender	Age
2	87.00	85.80	19.68	23.94	81.19	179.00	1.84	72.50	M	28
6	88.10	86.00	19.18	24.48	80.74	178.00	1.82	71.50	M	22
13	76.00	74.00	12.18	21.78	66.91	147.50	1.75	69.00	M	20
14	88.70	84.00	18.15	24.39	77.11	170.00	1.78	70.00	M	23
16	79.00	78.00	14.85	23.31	85.73	189.00	1.92	75.50	M	24
20	78.10	78.80	15.10	22.94	79.95	176.25	1.87	73.50	M	22
23	106.00	104.60	31.75	30.82	100.25	221.00	1.80	71.00	M	42
30	91.40	87.00	19.95	22.96	78.93	174.00	1.85	73.00	M	24
31	77.60	77.00	14.18	22.81	68.04	150.00	1.73	68.00	M	23
35	108.00	109.20	34.26	31.89	105.92	233.50	1.82	71.75	M	41
38	85.00	83.20	17.70	25.70	76.66	169.00	1.73	68.00	M	23
47	92.00	91.50	22.40	29.16	96.84	213.50	1.82	71.75	M	23
53	93.50	94.00	23.82	29.50	96.62	213.00	1.81	71.25	M	23
55	75.00	75.00	12.95	22.67	71.67	158.00	1.78	70.00	M	22
64	76.40	75.00	12.64	22.25	67.36	148.50	1.74	68.50	M	19
66	104.14	106.00	34.36	32.32	95.71	211.00	1.72	67.75	M	60
67	82.20	82.50	17.10	23.40	96.62	213.00	2.03	80.00	M	21
76	83.90	81.30	16.52	23.81	76.89	169.50	1.80	70.75	M	22
80	93.70	92.80	22.94	27.76	87.77	193.50	1.78	70.00	M	21
83	82.20	82.60	17.26	24.09	75.07	165.50	1.77	69.50	M	22
Sample (N):	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	NA	20
Mean (X):	87.40	86.42	19.85	25.50	83.30	183.64	1.81	71.16	NA	26
Median:	86.00	83.60	17.92	24.02	80.34	177.13	1.80	70.88	NA	23
Mode:	82.20	75.00	#N/A	#N/A	96.62	213.00	1.78	70.00	NA	22
Minimum:	75.00	74.00	12.18	21.78	66.91	147.50	1.72	67.75	NA	19
Maximum:	108.00	109.20	34.36	32.32	105.92	233.50	2.03	80.00	NA	60

D10.0: Comparative Descriptives for Male Subjects

	analysed with: Analyse-it + General 1.71
Test	**Comparative Descriptives for Male Subjects**
	The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement
Variables	Sub. WC (cm), Exp. WC (cm)
Performed by	William L. Elliott

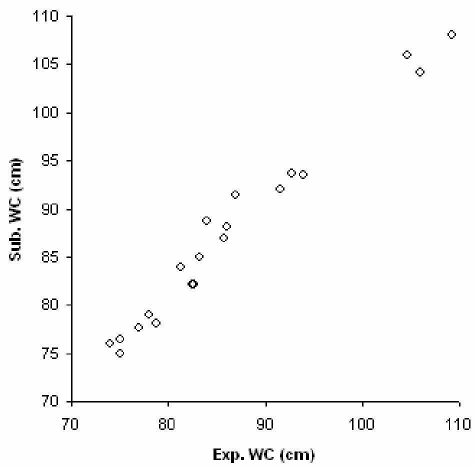


	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Sub. WC (cm)	20	87.397	9.9917	2.2342	82.721 to 92.073	86.000	14.350	79.000 to 92.000
Exp. WC (cm)	20	86.415	10.4198	2.3299	81.538 to 91.292	83.600	13.875	78.800 to 91.500

D11.0: Pearson Correlation for Male Subjects

	analysed with: Analyse-it + General 1.71
Test	**Pearson Correlation for Male Subjects**
	The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement
Alternative hypothesis	Exp. WC (cm) ≠ Sub. WC (cm)
Performed by	William L. Elliott

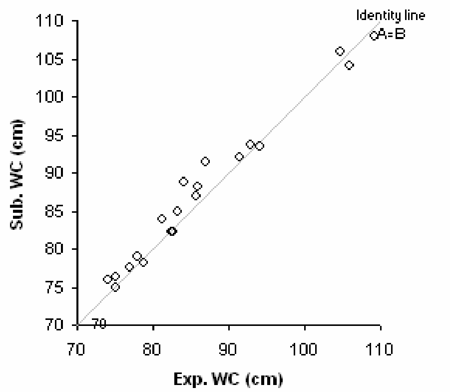
n	20
r statistic	0.99
95% CI	0.97 to 1.00
2-tailed p	<0.0001 (t approximation)



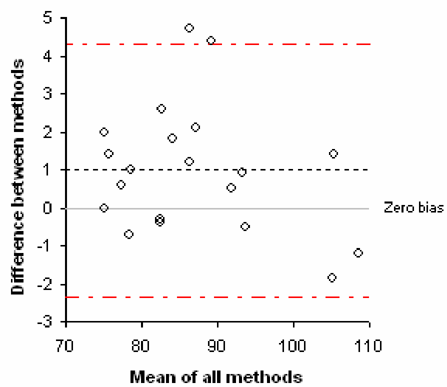
D12.0: Bias Plots for Male Subjects

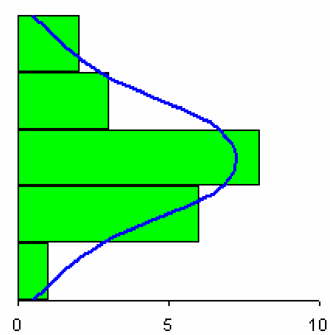
analysed with: Analyse-it + Clinical Laboratory 1.71

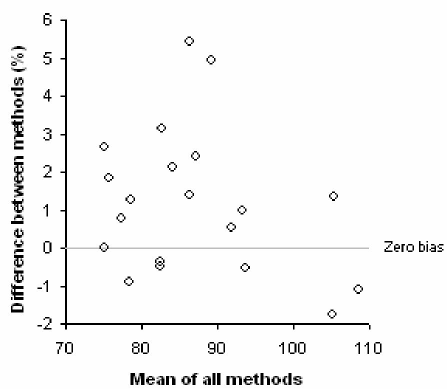
Test	**Bias Plots for Male Subjects**
	The Efficacy of a Computer-Based Tutorial in Teaching Waist Circumference Self-Measurement
	Exp. WC (cm) v Sub. WC (cm)
Performed by	William L. Elliott



n	20	
Bias	0.982	
95% CI	0.191 to 1.773	
95% limits of agreement		**95% CI**
Lower	-2.330	-3.595 to -1.064
Upper	4.294	3.028 to 5.559





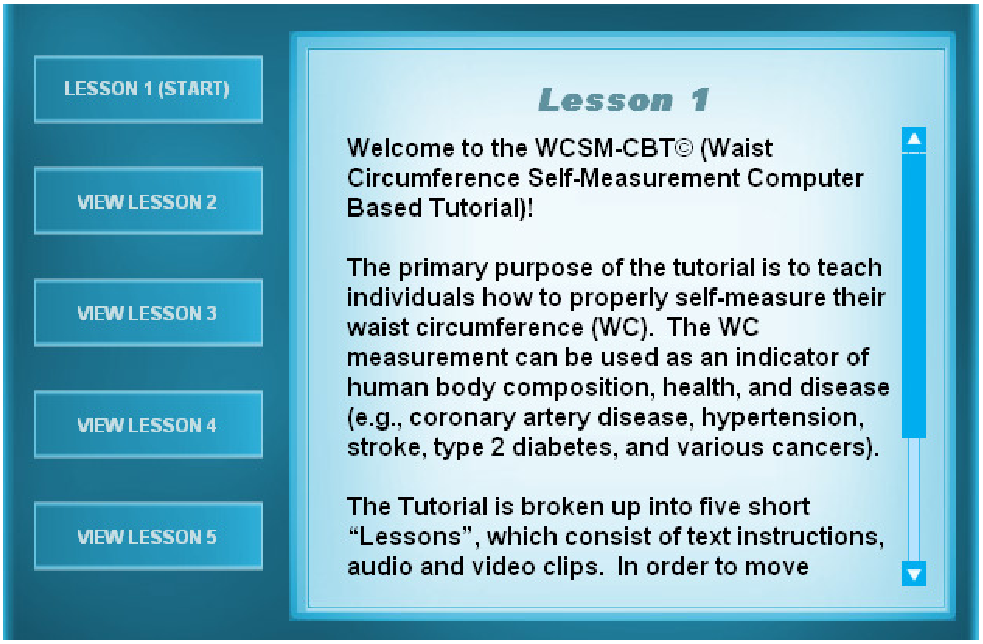


Appendix E: WCSM-CBT Lesson Screen Captures and Audio Scripts

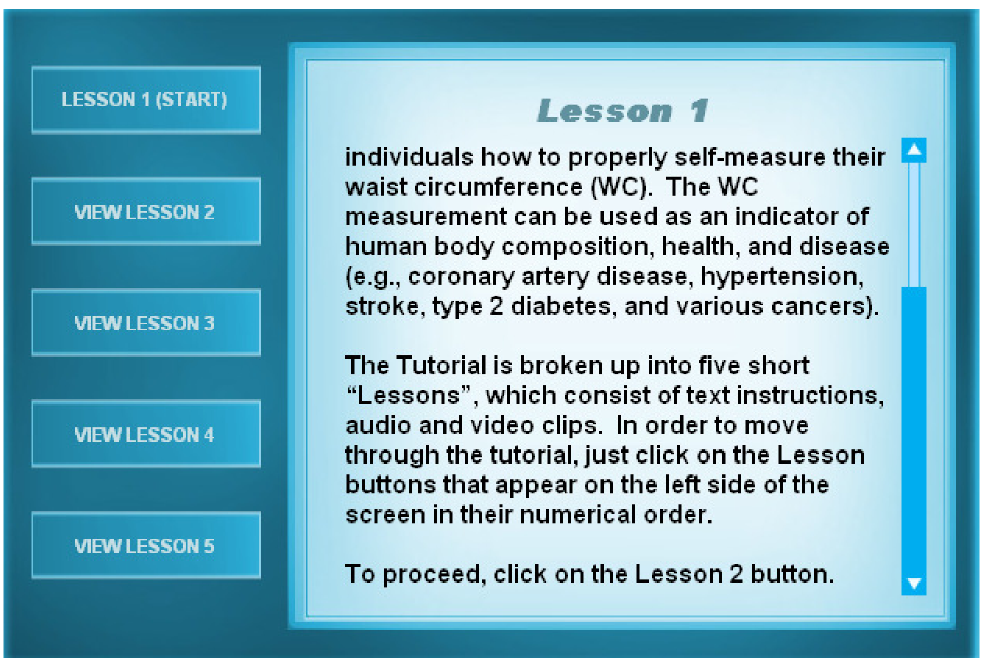
List of WCSM-CBT Lesson Screen Captures and Audio Scripts

Please note that each entry within the List of WCSM-CBT Screen Captures and Audio Scripts may be used as a hyperlink to its corresponding page when it is viewed on a computer. In order to use this feature, mouse click anywhere on an entry title in the List of WCSM-CBT Screen Captures and Audio Scripts and then hit the Enter key on the computer keyboard to access the corresponding page.

E1.0: WCSM-CBT Lesson 1 Screen Captures

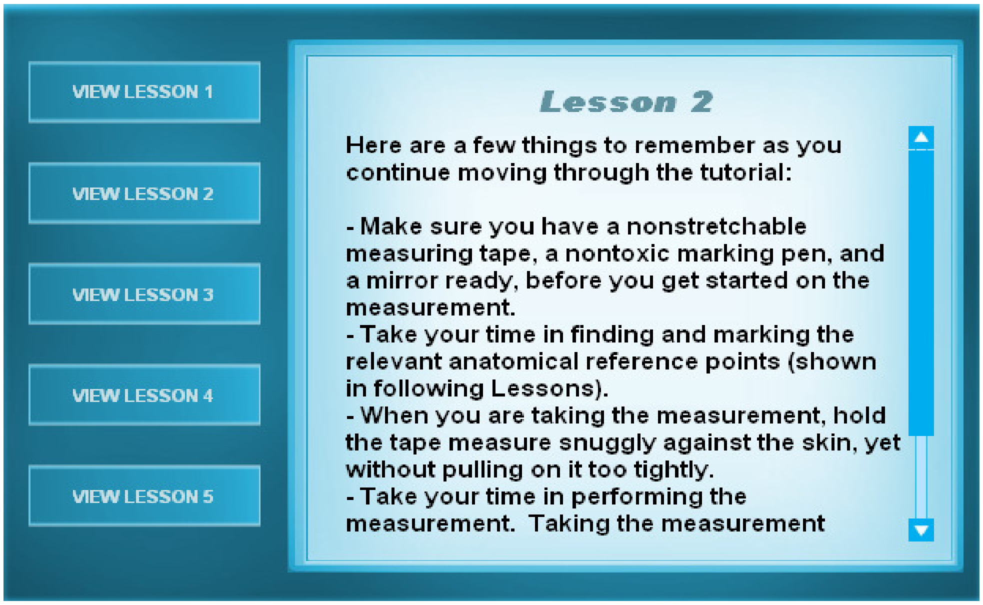


E1.0a: Beginning of Lesson 1

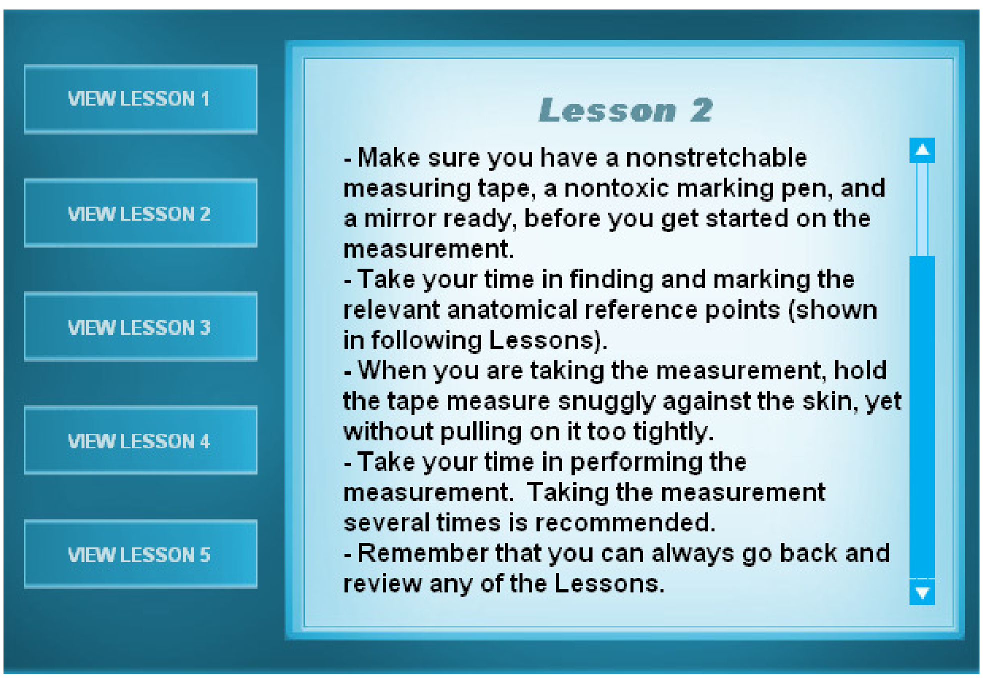


E1.0b: End of Lesson 1

E2.0: WCSM-CBT Lesson 2 Screen Captures



E2.0a: Beginning of Lesson 2



E2.0b: End of Lesson 2

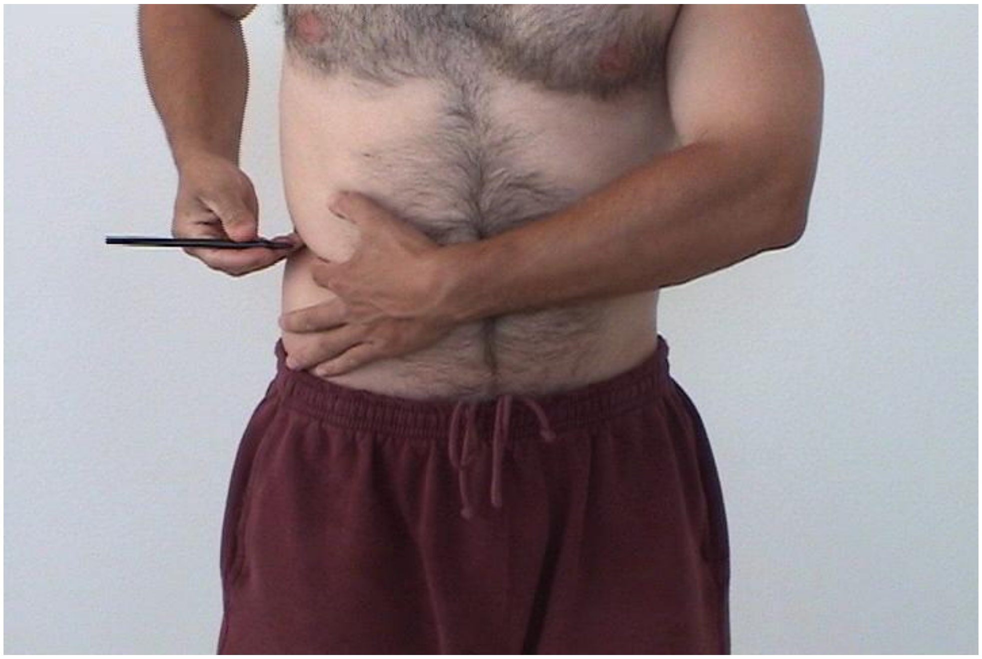
E3.0: WCSM-CBT Lesson 3 Video Captures and Audio Scripts

E3.0a: Video frame from Lesson 3 at the 5 second point. Corresponding audio script: "In the first part of this video clip, you will learn how to mark the appropriate anatomical reference sites on your body with a marking pen."

E3.0b: Video frame from Lesson 3 at the 11 second point. Corresponding audio script: "Make sure you have a nonstretchable measuring tape, a nontoxic marking pen, and a mirror ready, before you get started."

E3.0c: Video frame from Lesson 3 at the 22 second point. Corresponding audio script: “While standing with your weight evenly distributed over both feet, use your hands to find the highest point of your hip bone. When you find this anatomical location, use your pen to draw a horizontal line that represents it.”

E3.0d: Video frame from Lesson 3 at the 29 second point. Corresponding audio script: “Make sure that the line you draw is perpendicular to your torso.”



E3.0e: Video frame from Lesson 3 at the 45 second point. Corresponding audio script: "Next, use your hands to find the lowest point of your ribs. When you find this anatomical location, use your pen to draw a horizontal line that represents it."

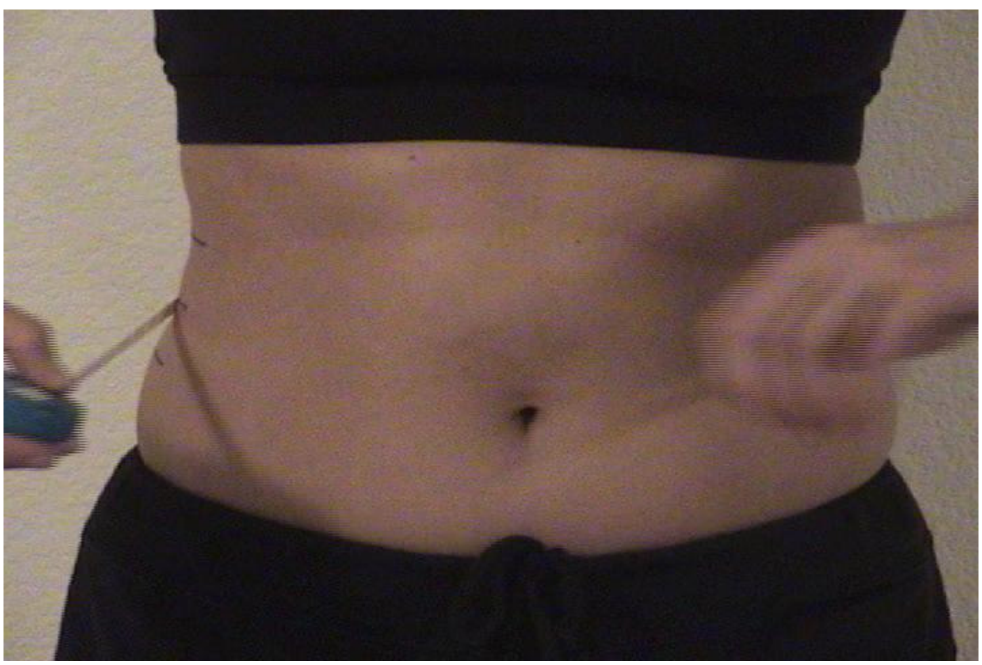
E3.0f: Video frame from Lesson 3 at the 54 second point. Corresponding audio script: "After you have drawn the two parallel lines, draw a third line midway between them. This middle line is the one that the measuring tape will cross over when you do your waist circumference measurement."

E3.0g: Video frame from Lesson 3 at the 73 second point. Corresponding audio script: "After you have drawn the three lines on each side of your body, you can begin the measurement. Wrap the measuring tape around your waist and check each side to make sure that the tape crosses over the middle line and is perpendicular to the torso."

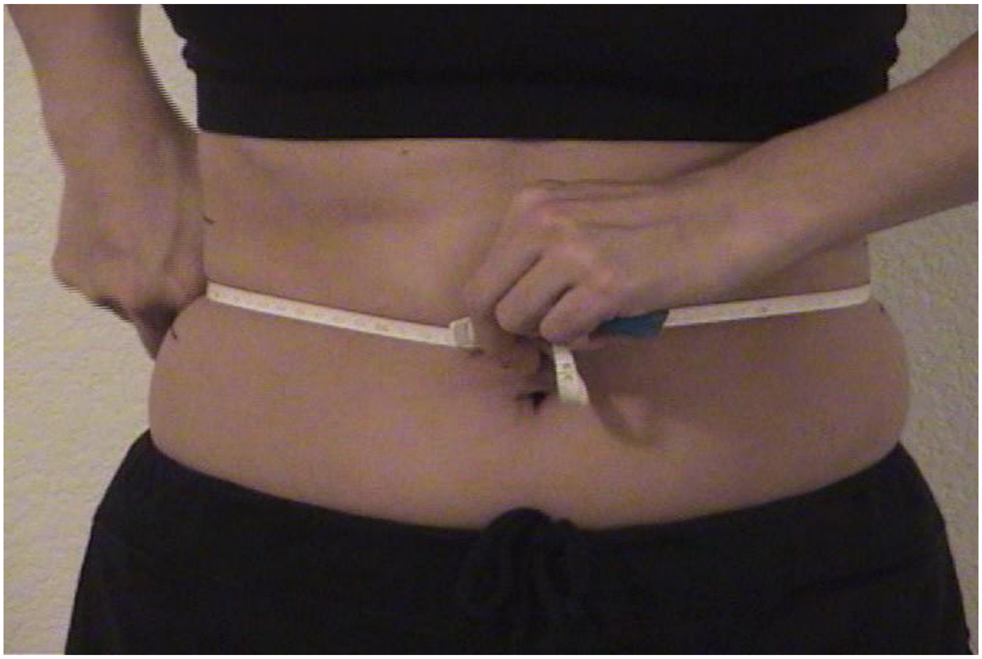
E3.0h: Video frame from Lesson 3 at the 91 second point. Corresponding audio script: "Lastly, note and record the measurement indicated by the measuring tape, at the end of a normal expiration, to the nearest tenth of a centimeter, or the nearest 16th of an inch."

E4.0: WCSM-CBT Lesson 4 Video Captures and Audio Script

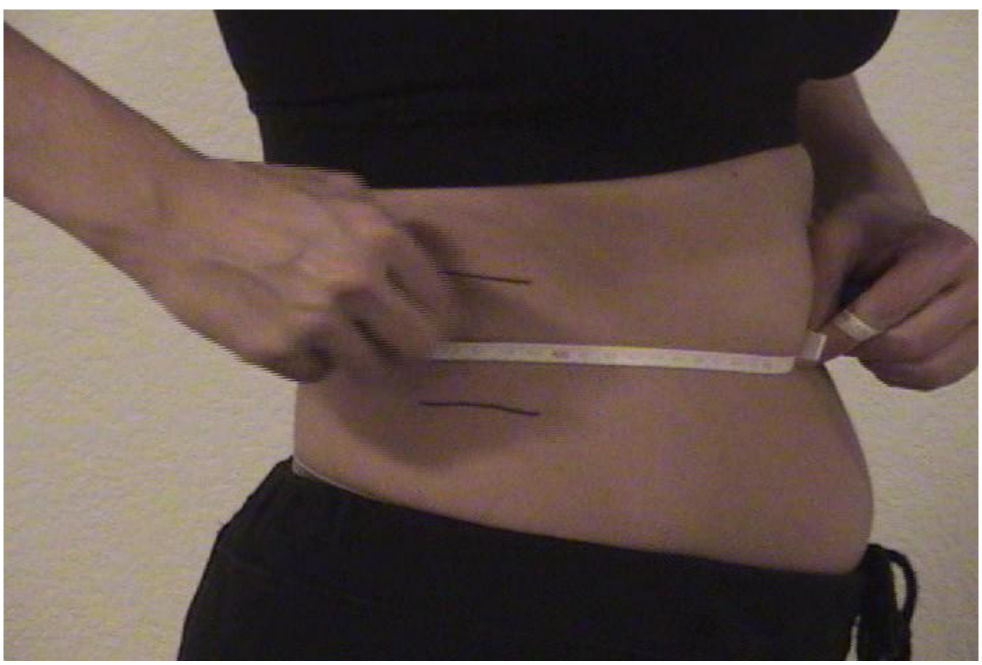
E4.0a: Video frame from Lesson 4 at the 3 second point. Corresponding audio script: "In this video clip, you will see the waist circumference self-measurement performed from beginning to end."



E4.0b: Video frame from Lesson 4 at the 8 second point.

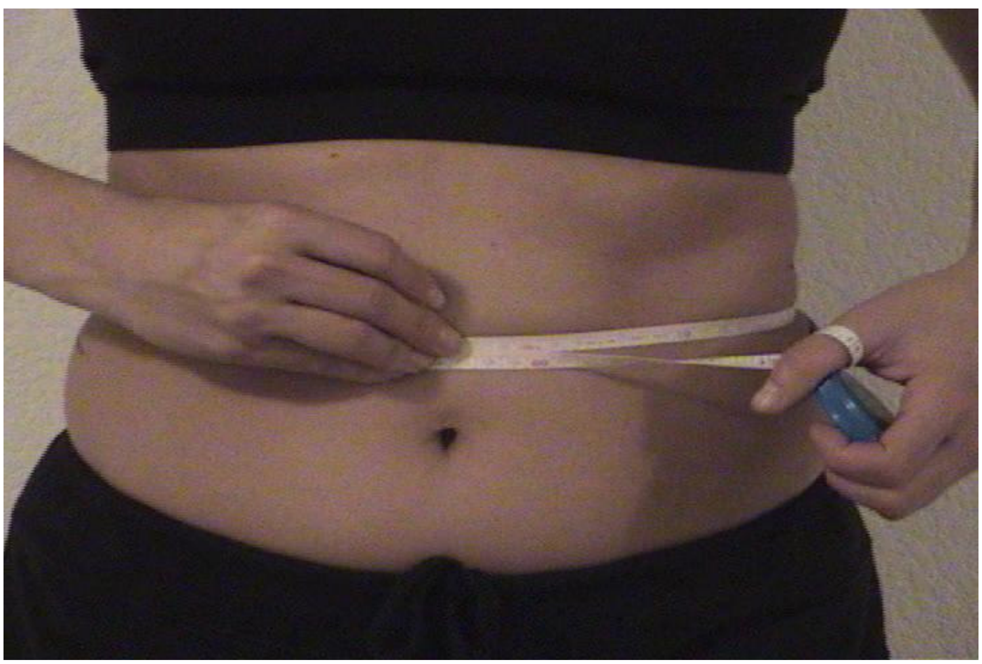


E4.0c: Video frame from Lesson 4 at the 22 second point.



E4.0d: Video frame from Lesson 4 at the 32 second point.

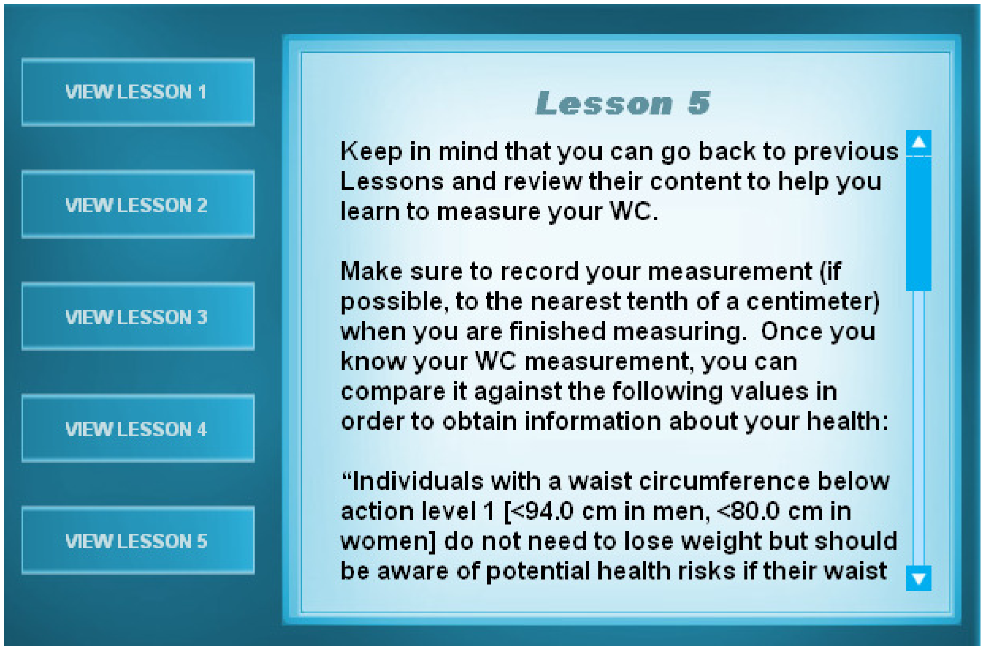
E4.0e: Video frame from Lesson 4 at the 40 second point.



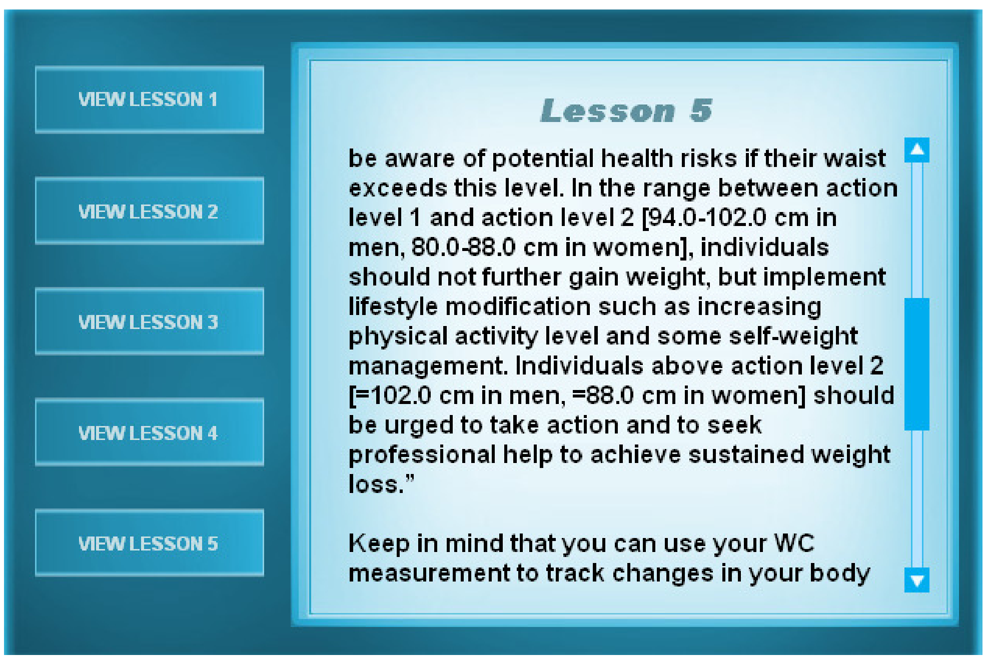
E4.0f: Video frame from Lesson 4 at the 48 second point.

E4.0g: Video frame from Lesson 4 at the 57 second point.

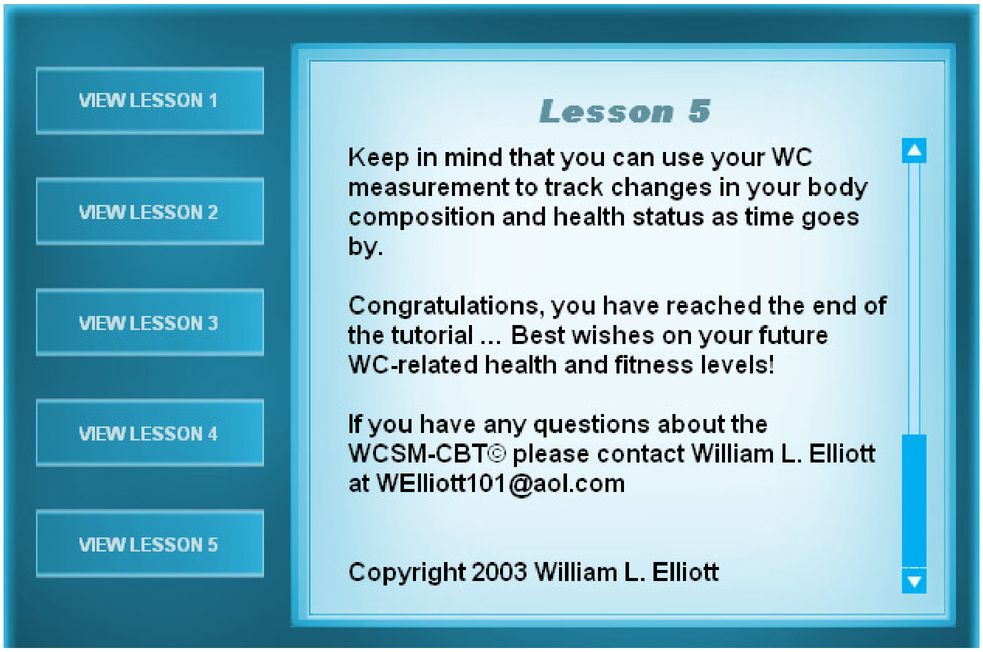
E5.0: WCSM-CBT Lesson 5 Screen Captures



E5.0a: Beginning of Lesson 5



E5.0b: Midpoint of Lesson 5



E5.0c: End of Lesson 5

BIBLIOGRAPHY

American College of Sports Medicine. (2001). ACSM's resource manual for guidelines for exercise testing and prescription (4th ed.). Philadelphia, Pennsylvania: Lippincott, Williams & Wilkins.

American College of Sports Medicine. (2005). ACSM's health-related physical fitness assessment manual (1st ed.). Baltimore, Maryland: Lippincott Williams & Wilkins.

American College of Sports Medicine. (2006). ACSM's resource manual for guidelines for exercise testing and prescription (5th ed.). Baltimore, Maryland: Lippincott Williams & Wilkins.

Ashwell, M., Lejeune, S., & McPherson, K. (1996). Ratio of waist circumference to height may be better indicator of need for weight management. BMJ, 312(7027), 377.

Berner, E. S. (Editor). (1999). Clinical decision support systems: Theory and practice (1st ed.). New York, New York: Springer-Verlag.

Bigaard, J., Spanggaard, I., Thomsen, B. L., Overvad, K., & Tjonneland, A. (2005). Self-reported and technician-measured waist circumferences differ in middle-aged men and women. The Journal of Nutrition, 135(9), 2263-2270.

Bland, J. M., & Altman, D. G. (1986). Statistical methods for assessing agreement between two methods of clinical measurement. The Lancet, I(1), 307-310.

Bouchard, C., Blair, S. N., & Haskell, W. L. (Editors). (2007). Physical activity and health (1st ed.). Champaign, Illinois: Human Kinetics.

Bray, B. A. (2003). An atlas of obesity and weight control (1st ed.). New York, New York: The Parthenon Publishing Group.

Coiera, E. (1997). Guide to medical informatics, the Internet and telemedicine (1st ed.). London: Arnold; A member of the Hodder Headline Group.

Cornish, B. (2006). Bioimpedance analysis: Scientific background. Lymphatic Research and Biology, 4(1), 47-50.

Disease Management Association of America. (DMAA initiative produces first definition of obesity with co-morbidities [Web Page]. URL http://www.dmaa.org/news_releases/2006/pressrelease_051606.asp [2006, June 14].

Eckerson, J. M., Stout, J. R., Evetovich, T. K., Housh, T. J., Johnson, G. O., & Worrell, N. (1998). Validity of self-assessment techniques for estimating percent fat in men and women. Journal of Strength and Conditioning Research, 12(4), 243-247.

Ezzati, M., Martin, H., Skjold, S., Vander Hoorn, S., & Murray, C. J. L. (2006). Trends in national and state-level obesity in the USA after connection for self-report bias: Analysis of health surveys. Journal of the Royal Society of Medicine, 99(5), 250-257.

Gallagher, D., Heymsfield, S. B., Heo, M., Jebb, S. A., Murgatroyd, P. R., & Sakamoto, Y. (2000). Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Am J Clin Nutr, 72(3), 694-701.

Gardner, J. C., von Ingersleben, G., Heyano, S. L., & Chesnut, C. H. 3rd. (2001). An interactive tutorial-based training technique for vertebral morphometry. Osteoporosis International, 12(1), 63-70.

Gartner, A., Maire, B., Kameli, Y., Traissac, P., & Delpeuch, F. (2001). Body composition unaltered for African women classified as 'normal but vulnerable' by body mass index and mid-upper-arm-circumference criteria. Eur J Clin Nutr, 55(5), 393-9.

Groff, J. L., & Sareen, S. S. (2000). Advanced nutrition and human metabolism (3rd ed.). Belmont, California: Wadsworth/Thompson Learning.

Hall, T. R., & Young, T. B. (1989). A validation study of body fat distribution as determined by self- measurement of waist and hip circumference. International Journal of Obesity, 13(6), 801-7.

Han, T. S., & Lean, M. E. (1998). Self-reported waist circumference compared with the 'Waist Watcher' tape-measure to identify individuals at increased health risk through intra-abdominal fat accumulation. British Journal of Nutrition, 80(1), 81-8.

Han, T. S., van Leer, E. M., Seidell, J. C., & Lean, M. E. (1995). Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. BMJ, 311(7017), 1401-5.

Heymsfield, S. B., Lohman, T. G., Wang, Z., & Going, S. B. (2005). Human body composition (2nd ed.). Champaign, Illinois: Human Kinetics.

Heymsfield, S. B., Nunez, C., Testolin, C., & Gallagher, D. (2000). Anthropometry and methods of body composition measurement for research and field application in the elderly. Eur J Clin Nutr, 54 Suppl 3, S26-32.

Heyward, V., & Wagner, D. (2004). Applied body composition assessment (2nd ed.). Champaign, Illinois: Human Kinetics.

Heyward, V. H. (1998). Practical body composition assessment for children, adults, and older adults. International Journal of Sport Nutrition, 8(3), 285-307.

Heyward, V. H., & Stolarczyk, L. M. (1996). Applied body composition assessment (1st ed.). Champaign, Illinois: Human Kinetics.

Hoffman, J. (2006). Norms for fitness, performance, and health (1st ed.). Champaign, Illiniois: Human Kinetics.

Howley, E. T., & Franks, B. D. (2003). Health fitness instructor's handbook (4th ed.). Champaign, Illinois: Human Kinetics.

Jackson, A. S., Pollock, M. L., & Gettman, L. R. (1978). Intertester reliability of selected skinfold and circumference measurements and percent fat estimates. Research Quarterly, 49(4), 546-51.

Janssen, I., Heymsfield, S. B., Allison, D. B., Kotler, D. P., & Ross, R. (2002). Body mass index and waist circumference independently contribute to the prediction of nonabdominal, abdominal subcutaneous, and visceral fat. Am J Clin Nutr, 75(4), 683-8.

Janssen, I., Katzmarzyk, P. T., & Ross, R. (2002). Body mass index, waist circumference, and health risk: evidence in support of current National Institutes of Health guidelines. Arch Intern Med, 162(18), 2074-9.

Kerr, L., Wilkerson, S., Bandy, W. D., & Ishee, J. (1994). Reliability and validity of skinfold measurements of trained versus untrained testers. Isokinetics and Exercise Science, 4(4), 137-140.

Kim, S., Schaad, D. C., Scott, C. S., Robins, L. S., & Astion, M. L. (2001). A longitudinal evaluation of an educational software program: a case study of Urinalysis-Tutor. Academic Medicine, 76(11), 1136-43.

Kohlstadt, I. (Editor). (2006). Scientific evidence for musculoskeletal, bariatric, and sports nutrition (1st ed.). Boca Raton, Florida: CRC Press, Taylor & Fancis Group.

Lean, M. E., Han, T. S., & Deurenberg, P. (1996). Predicting body composition by densitometry from simple anthropometric measurements. Am J Clin Nutr, 63(1), 4-14.

Lean, M. E., Han, T. S., & Morrison, C. E. (1995). Waist circumference as a measure for indicating need for weight management. BMJ, 311(6998), 158-61.

Lean, M. E. J. (2003). Clinical handbook of weight management (2nd ed.). Independence, Kentucky: Taylor & Francis.

Lean, M. J., & Han, T. S. (2002). Waist worries. American Journal of Clinical Nutrition, 76(4), 699-700.

Mangione, S., & Dennis, S. (1992). CompuLung: a multimedia CBL on pulmonary auscultation. Proceedings of the Annual Symposium on Computers in Applied Medical Care, 820-1.

Marieb, E. N. (2004). Human anatomy and physiology (6th ed.). Redwood City, California: Benjamin/Cummings.

Maud, P. J., & Foster, C. (Editors). (2006). Physiolgical assessment of human fitness (2nd ed.). Champaign, Illinois: Human Kinetics .

McArdle, W. D., Katch, F. I., & Katch, V. L. (2005). Sports & exercise nutrition (2nd ed.). Baltimore, Maryland: Lippincott Williams & Wilkins.

McArdle, W. D., Katch, F. I., & Katch, V. L. (2007). Exercise physiology: Energy, nutrition, & human performance (6th ed.). Baltimore, Maryland: Lippincott Williams & Wilkins.

McArdle, W. D., Katch, F. L., & Katch, V. L. (2001). Exercise physiology: Energy, nutrition and human performance (5th ed.). Baltimore, Maryland: Lippincott Williams & Wilkins.

McTiernan, A. (Editor). (2006). Cancer prevention and management through exercise and weight control (1st ed.). Boca Raton, Florida: CRC Press, Taylor & Fancis Group.

Mooney, G. A., & Bligh, J. G. (1997). Computer-based learning materials for medical education: a model production. Medical Education, 31(3), 197-201.

Morrow, J. R. J. r., Fridye, T., & Monaghen, S. D. (1986). Generalizability of the AAHPERD health related skinfold test. Research Quarterly for Exercise and Sport, 57(3), 187-195.

Norris, A. C. (2002). Essentials of telemedicine and telecare (1st ed.). West Sussex, England: John Wiley & Sons, Ltd.

Oppliger, R. A., Clark, R. R., & Kuta, J. M. (1992). Efficacy of skinfold training clinics: a comparison between clinic trained and experienced testers. Research Quarterly for Exercise and Sport, 63(4), 438-43.

Phillips, C., Henderson, P. J., Mandel, L., Kim, S., Schaad, D., Cooper, M., Bien, C., Orkand, A., Wener, M. H., Fine, J. S., & Astion, M. L. (1998). Teaching the microscopic examination of urine sediment to second year medical students using the Urinalysis-Tutor computer program. Clinical Chemistry, 44(8 Pt 1), 1692-700.

Pieter, W., Palabrica, J. M., & Bercades, L. T. (1998). Fat and skinfold patterning in national elite female Filipino judo athletes. Biology of Sport, 15(2), 87-98.

Pietrobelli, A., Heymsfield, S. B., Wang, Z. M., & Gallagher, D. (2001). Multi-component body composition models: recent advances and future directions. Eur J Clin Nutr, 55(2), 69-75.

Pounder, D., Carson, D., Davison, M., & Orihara, Y. (1998). Evaluation of indices of obesity in men: descriptive study. BMJ, 316(7142), 1428-9.

Powers, S. K., & Howley, E. T. (2007). Exercise physiology: Theory and application to fitness and performance (6th ed.). New York, New York: McGraw-Hill.

Rimm, E. B., Stampfer, M. J., Colditz, G. A., Chute, C. G., Litin, L. B., & Willett, W. C. (1990). Validity of self-reported waist and hip circumferences in men and women. Epidemiology, 1(6), 466-73.

Roche, A. F., Heymsfield, S. B., & Lohman, T. G. (Editors). (1996). Human body composition (1st ed.). Champaign, Illinois: Human Kinetics.

Schardt, D. (2006). Men's health: Checking under the hood. Nutrition Action, 33(6), 1-7.

Sedlack, R. E., & Kolars, J. C. (2002). Colonoscopy curriculum development and performance-based assessment criteria on a computer-based endoscopy simulator. Academic Medicine, 77(7), 750-1.

Shah, J., & Darzi, A. (2002). Virtual reality flexible cystoscopy: a validation study. BJU International, 90(9), 828-32.

Sharkey, B. J. (2002). Fitness and health (5th ed.). Champaign, Illinois: Human Kinetics.

Shaw, V. W. (1986). The accuracy of two training methods on skinfold assessment. Research Quarterly for Exercise and Sport, 57(1), 85-90.

Shortliffe, E. H., & Perreault, L. E. (Editors). (2001). Medical informatics: Computer applications in health care and biomedicine (2nd ed.). New York, New York: Springer-Verlag.

Slack, W. V. (2001). Cybermedicine: How computing empowers doctors and patients for better health care (2nd ed.). San Francisco, California: Jossey-Bass, A Wiley Company.

Spallholz, J. E., Boylan, L. M., & Driskell, J. A. (1999). Nutrition: Chemistry and biology (2nd ed.). Boca Raton, Florida: CRC Press.

Tate, D. F., Jackvony, E. H., & Wing, R. R. (2003). Effects of Internet behavioral counseling on weight loss in adults at risk for type 2 diabetes: a randomized trial. JAMA, 289(14), 1833-6.

Tate, D. F., Wing, R. R., & Winett, R. A. (2001). Using Internet technology to deliver a behavioral weight loss program. JAMA, 285(9), 1172-7.

Wang, J., Thornton, J. C., Bari, S., Williamson, B., Gallagher, D., Heymsfield, S. B., Horlick, M., Kotler, D., Laferrere, B., Mayer, L., Pi-Sunyer, F. X., & Pierson, R. N. Jr. (2003). Comparisons of waist circumferences measured at 4 sites. Am J Clin Nutr, 77(2), 379-84.

Whitehead, J. R., & Parker, M. A. (1993). Teaching concepts of body fatness while skinfold testing: An experimental test of different methods. Physical Educator, 50(4), 187-193.

Williams, C. A., & Bale, P. (1998). Bias and limits of agreement between hydrodensitometry, bioelectrical impedance and skinfold calipers measures of percentage body fat. European Journal of Applied Physiology and Occupational Physiology, 77(3), 271-7.

Wilmore, J. H., & Costill, D. L. (1999). Physiology of sport and exercise (2nd ed.). Champaign, Illinois: Human Kinetics.

Wilmore, J. H., & Costill, D. L. (2004). Physiology of sport and exercise (3rd ed.). Champaign, Illinois: Human Kinetics.

Wit, B., Piechaczek, H., D. Blachnio, D., & Busko, K. (1998). Comparative assessment of selected body components from bioelectrical impedance or skinfold measurements. Biology of Sport, 15(4), 205-210.

Zhu, S., Wang, Z., Heshka, S., Heo, M., Faith, M. S., & Heymsfield, S. B. (2002). Waist circumference and obesity-associated risk factors among whites in the third National Health and Nutrition Examination Survey: clinical action thresholds. American Journal of Clinical Nutrition, 76(4), 743-9.