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The Accuracy of Consumer-Made Body Measurements for Women's Mail-Order Clothing

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An anthropometric study was performed on 103 women 19 to 50 years of age. Each subject measured 19 dimensions of her own body and then performed similar measurements on a random partner using a conventional tape measure with 1/16-inch (1.6-mm) precision. The experimenter measured all subjects using a laboratory-grade anthropometer and tape measure with 1.0-mm precision as a standard. Subjects' measurements of different body dimensions had significantly different average errors, ranging from −4.54 cm to +6.15 cm. Hip circumference, which is often utilized as a key dimension for garment sizing, was significantly undermeasured ($M = -4.54$ cm). Measurements having the least error included waist, bust, and neck circumferences and shoulder and waist heights. Subjects' measurements of their own bodies had greater absolute error ($M = 4.10$ cm, $SD = 6.06$ cm) than those of their partners ($M = 3.34$ cm, $SD = 4.86$ cm). Although subjects used a tape measure having 1.6-mm precision, 97% reported measurements using only 1/4-inch (6.4-mm) precision or less. Subjects overestimated their own stature by an average error of 0.68 cm ($SD = 4.02$ cm) and an absolute error of 2.26 cm ($SD = 3.39$ cm).

INTRODUCTION

Along with the rapid growth in catalog shopping for clothing (Smallwood and Wiener, 1987), there is a growing need for an anthropometric sizing system for women (Delk and Cassill, 1989; LaBat, 1987). Most clothing manufacturers and designers are reluctant to conform to a unified standard set of body measurements (Belkin, 1986). Even though women's ready-to-wear clothing may be labeled by the same size code, garments made by different manufacturers are often made to fit different figure types, body measurements, and proportions (Fellingham, 1991). Also, clothing manufacturers continuously revise their own size code standards. Consequently, the standard body measurements associated with specific size codes have varied, not only among different manufacturers but also within individual manufacturers over time. Furthermore, size labels attached to garments do not inform consumers of the body measurements associated with particular size codes.

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Because mail-order clothing cannot be tried on in advance of purchase, catalogs assist consumers by listing exact body measurements for key body dimensions that a particular garment is designed to fit. Most catalogs use similar key dimensions, including bust, waist, and hip circumferences, for all garment types. Different key dimensions, however, may be more appropriate for clothing and styles that cover different parts of the body. Little attention has been given to how accurately consumers measure key dimensions or to whether more-accurately measured dimensions could be substituted. Little is known about the magnitude of errors that untrained consumers make when they measure specific body dimensions using a conventional tape measure. Measurement error is particularly costly for mail-order houses because it results in returned merchandise and dissatisfied customers.

The objective of this investigation was to determine differences in the accuracy of body measurements made by consumers for various body dimensions. These data were needed for selecting specific body dimensions as key dimensions for an anthropometric sizing system describing women's garment size for use in retail mail-order women's clothing (Yoon, 1992). Key dimensions must satisfy two criteria for suitability as a mail-order retail sizing system. First, in order to select the correct garment size, consumers must be able to measure the key dimensions accurately. Second, a key dimension must also be a good predictor of other body dimensions that are related to a particular garment type in order to provide the framework from which size categories will be generated. This paper describes the procedures used for selecting key dimensions that satisfy the first qualification, accuracy of body measurement. The second criterion is treated in Yoon (1992). This study investigated the hypotheses that (1) consumers measure different body dimensions with the same accuracy and (2) consumers measure their own bodies and others' bodies with the same accuracy.

METHODS

Subjects

A group of 103 women in Madison, Wisconsin, took part in this study during September and October 1991. Subjects were recruited through advertisements and voluntary sign-up. They were paid a small fee for participating. Their ages ranged from 19 to 50 years (M = 24.7 years, SD = 7.5 years). Subjects were divided into two categories—experienced and nonexperienced—according to their reported experience in designing or constructing clothing. Of the 103 subjects, 36 reported that they had made a garment at least once.

The subjects in this study represented not only Wisconsin natives; many were university students who came from other states or foreign countries. They were, however, biased in age and educational level; most (80.5%) were under age 26, and many (76.7%) were college students.

Procedure

Subjects made all measurements using a conventional tape measure having an English system scale with 1/16-inch (1.6-mm) precision. These tape measures were used because they are commonly available in the home and retail stores. Measurements were made and recorded in units of inches because the English system is commonly used in the garment industry in the United States. Measurements were later converted into their metric equivalents for analysis. The experimenter measured all subject heights and breadths using a laboratory grade anthropometer (Siber Hegner, #101) with 1-mm precision. Circumferences and lengths were measured using a 1-mm-precision tape measure (Seritex, Inc.).

All measurements were made over a tightly fitted bodysuit or over underwear.

Instruments developed for this experiment included instructions for making specific measurements, data sheets, a set of illustrations of the female body form, and a set of demographic questions. The instruction sheet explained the measurement procedures and provided examples. So as not to influence performance for a particular measurement, examples in the instructions used body dimensions that were not included in the study (e.g., head circumference and ankle height). These instructions were no more detailed than the instructions typically provided in mail-order catalogs. Data sheets included specific instructions for measuring each dimension. In order to avoid confusion about measurement units, the word *inches* was written at the end of each line. The order in which body dimensions appeared on the data sheets was counterbalanced among subjects in order to eliminate order effects. Ten different sets of data sheets were distributed, each having different sequences of body dimensions.

A pilot study was performed involving 10 subjects who measured 32 body dimensions according to the procedures described. Based on the time needed to complete the pilot study and on the comments collected, measurements pertaining to the back, depth, and some circumferencial measurements of the lower limb were excluded, and 19 dimensions were selected for the full study (see Figure 1). Dimension code abbreviations are contained in Table 1.

Although questions were answered pertaining to experimental procedures, the experimenter did not explain how to accomplish the measurements. Each subject studied an illustration of the female body form showing each measurement, similar to that found in a mail-order catalog, and performed the experiment based on her understanding of the written instructions without obtaining additional explanation from the experimenter. Separate illustrations of female body forms were provided for describing each measurement. The illustrations included front, back, and side views of a woman's body. Figure 1 is a composite of all these dimensions.

Subjects first measured a dress mannequin (mannequin measurement) for 6 dimensions. They then measured their own bodies (self-measurement) for 19 dimensions. Afterward, randomly paired subjects measured each other for the same 19 dimensions (partner measurement). They then completed a demographic questionnaire, including an estimation of their own stature. After subjects completed these procedures, the experimenter measured each subject for the same body dimensions (standard measurement).

The dress mannequin was a typical body form used by dressmakers for constructing clothing. The mannequin measurement was included in order to determine the amount of error attributed directly to the use of the tape measure by having all subjects measure the same quantity, without the additional variability introduced from measuring different bodies. All subjects, including the experimenter, measured the same mannequin. Partner measurements were always made after self-measurements so that the partner measurement did not influence the self-measurement. Standard measurements were always made after subject measurements were completed, in order to keep the experimenter from influencing the way subjects performed the measurements. The experimenter measurements were performed according to the anthropometric procedures developed by Laubach, McConville, Churchill, and White (1977).

Experimental Design

The experimental design employed a full factorial linear model, including all interactions

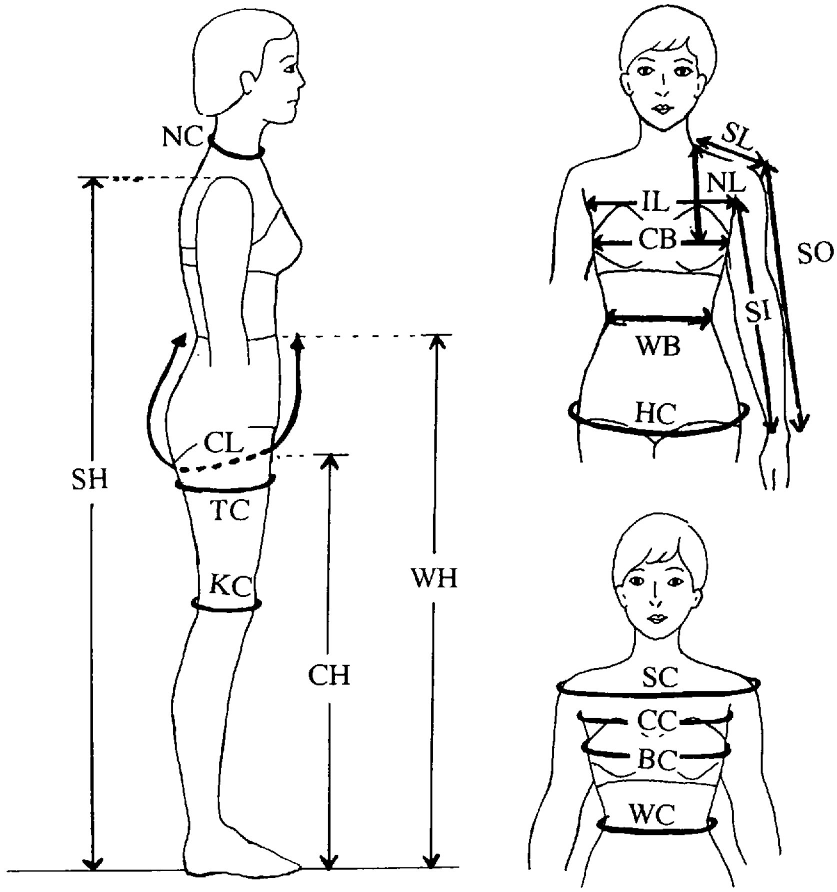

Figure 1. *Anthropometric dimensions and associated codes.*

of fixed effects with repeated measures, where the subject variable was a random-effect-blocking variable. Independent variables included dimension (19 dimensions), method (self-measurement and partner measurement), and experience (experienced and inexperienced in clothing construction). Analysis of variance (ANOVA) was used for testing statistically significant effects for each dependent variable. Post-hoc pairwise contrasts (Tukey's test) were used for testing significant treatment effects.

Measurement error was the difference between measurements made by subjects and the standard measurements made by the experimenter. Measurement error (*E*) was reported in units of centimeters and also as a percentage, labeled percentage error (*E%*). The absolute measurement error (|*E*|) and absolute percentage error (|*E%*|) were based on the magnitude of the difference between subject-made measurements and the standard measurement.

RESULTS

A summary of the ANOVA results is provided in Table 2. The results showed that (1) subjects measured different body dimensions with different measurement errors, (2) partner measurement, on the average, had

TABLE 1

Body Dimensions Included in Study and Legend of Abbreviations

Classification	*Body Dimension*	*Code*	*Abbreviation*
Height measurements	Shoulder height	3 C	SH
	Waist height	6 C	WH
	Crotch height	7 C	CH
Breadth measurements	Chest breadth	20 C	CB
	Waist breadth	21 C	WB
Circumference measurements	Neck circumference	24 C	NC
	Shoulder circumference	25 C	SC
	Chest circumference at scye	26 C	CC
	Bust circumference	27 C	BC
	Waist circumference	29 C	WC
	Hip circumference	30 C	HC
	Upper thigh circumference	37 C	TC
	Knee circumference	38 C	KC
Length measurements	Neck-to-bust point length	49 C	NL
	Interscye, front	43 C	IL
	Shoulder length	41 C	SL
	Crotch length	53 C	CL
	Sleeve inseam length	51 C	SI
	Sleeve outseam length	52 C	SO

Note. Codes are as defined in Churchill et al. (1977).

smaller errors than did self-measurement, and (3) significant interactions between dimension and measurement method indicate that some dimensions were measured with significantly smaller errors by a partner than were other dimensions. Details of these findings will be presented in the following sections.

Measurement Error for Different Dimensions

Mean measurement errors and standard deviations for each body dimension are plotted in Figure 2. Significant ($p < 0.05$) multiple contrasts using Tukey's test are indicated at the bottom of each plot. Four dimensions (HC, CL, SC, and NL) were undermeasured

TABLE 2

Summary of Analysis of Variance for Measurement Error of 19 Dimensions (N = 103)

			E		$\|E\|$		$\%E$		$\|\%E\|$	
Source	$d.f._1$	$d.f._2$	F	p	F	p	F	p	F	p
Between-subjects:										
Experience (*Ex*)	1	101	0.17	0.681	1.74	0.190	3.75	0.056	3.56	0.062
Within subjects:										
Measurer (*M*)	1	101	7.29	0.008*	6.10	0.015*	14.37	0.000*	7.44	0.008*
$Ex \times M$	1	101	1.66	0.201	1.07	0.303	0.61	0.437	0.020	0.888
Dimension (*D*)	18	1818	24.90	0.000*	9.50	0.000*	28.52	0.000*	21.97	0.000*
$Ex \times D$	18	1818	1.05	0.394	.094	0.999	1.77	0.024*	1.88	0.016*
$M \times D$	18	1818	6.26	0.000*	4.54	0.000*	6.67	0.000*	4.83	0.000*
$Ex \times M \times D$	18	1818	0.82	0.679	0.63	0.875	0.62	0.885	0.40	0.988

Notes: $d.f._1$ = numerator degrees of freedom; $d.f._2$ = denominator degree of freedom; *$p < 0.05$

more than were the other body dimensions. Three dimensions (CB, IL, and WB) were overmeasured more than were the other dimensions. Two dimensions (IL and WB) were overmeasured by an average error of 6 cm or more. The dimensions having $|E| > 5$ cm included SC, HC, CL, IL, and WB. In terms of percentages, four dimensions (CB, SL, IL, and WB) were overmeasured more than were the other overmeasured dimensions, ranging from 11.9% to 26.0%. Waist breadth (WB) had the greatest $|E\%|$.

Dimensions having the greatest measurement variation among subjects ($SD > 8.00$ cm) included shoulder circumference (SC), waist breadth (WB), sleeve outseam (SO), upper thigh circumference (TC), and chest breadth (CB). Dimensions having the smallest variation among subjects ($SD < 4.31$ cm) were knee circumference (KC), neck circumference (NC), waist height (WH), neck to bust point length (NL), and bust circumference (BC). Dimensions having the greatest mean relative error ($E\% > 17\%$) and variation among subjects ($SD > 16.3\%$) were WB, SL, IL, and CB (see Figure 2).

Measurement Errors for Self-Measurement and Partner Measurement

Overall, partner-measurement error was significantly smaller than self-measurement error for all error variables (see Table 2). Average $|E|$ was 4.10 cm ($SD = 6.06$ cm) for self-measurement and 3.34 cm ($SD = 4.86$ cm) for partner measurement. Mean E for self-measurement and partner measurement are plotted against 19 body dimensions in Figure 3.

The interaction between dimension and measurer was also significant for all error variables (see Table 2 and Figure 3). Eight dimensions (HC, CL, BC, NC, SH, CB, IL, and WB) had smaller $|E|$ for partner measurement than for self-measurement (0.55 cm $\leq |E| \leq$ 6.37 cm). Three dimensions (TC, KC, and WH) had smaller $|E|$ for self-measurement than for partner measurement; however, the magnitude of this difference was small (0.44 cm $\leq$ $|E| \leq$ 0.72 cm).

Average errors for self-measurement, partner measurement, and mannequin measurement are plotted in Figure 4. Tukey's pairwise contrasts showed that waist breadth (WB), front interscye length (IL), and chest breadth (CB) were measured with significantly greater error (5.22 cm $< |E| <$ 6.60 cm); waist circumference (WC) and bust circumference (BC) were measured with the smallest error ($|E| = 1.90$ cm); $p < 0.05$. Waist breadth (WB) was more accurately measured by partner measurement ($|E| = 3.25$ cm) and mannequin measurement ($|E| = 4.12$ cm) than by self-measurement ($|E| = 9.62$ cm). Waist circumference (WC) and bust circumference (BC) were more accurately measured on a mannequin (2.24 cm $< |E| <$ 2.57 cm) than on human subjects (0.77 cm $< |E| <$ 0.90 cm).

Self-Estimation of Stature

Subjects estimated their own height with an error ranging from -30.0 cm to $+14.8$ cm. The average $|E|$ was 2.26 cm ($SD = 3.39$ cm). Average E was 0.68 cm ($SD = 4.02$ cm). More than 64% of the subjects overestimated their stature. Almost half (48.5%) of the subjects overestimated their stature by more than 1 cm, whereas more than a third (35.9%) underestimated their stature by more than 1 cm.

Precision of Subject Measurements

Subjects performed all measurements using a conventional tape measure having an English system scale with 1/16-inch (1.6-mm) precision. No subjects, however, actually reported their measurements with 1.6-mm precision. Only 3 subjects (3%) made their measurements using 1/8-inch (3.2-mm) precision; 46 subjects (44.6%) used 1/4-inch (6.4-mm) precision; 48 subjects (46.6%) used 1/2-inch

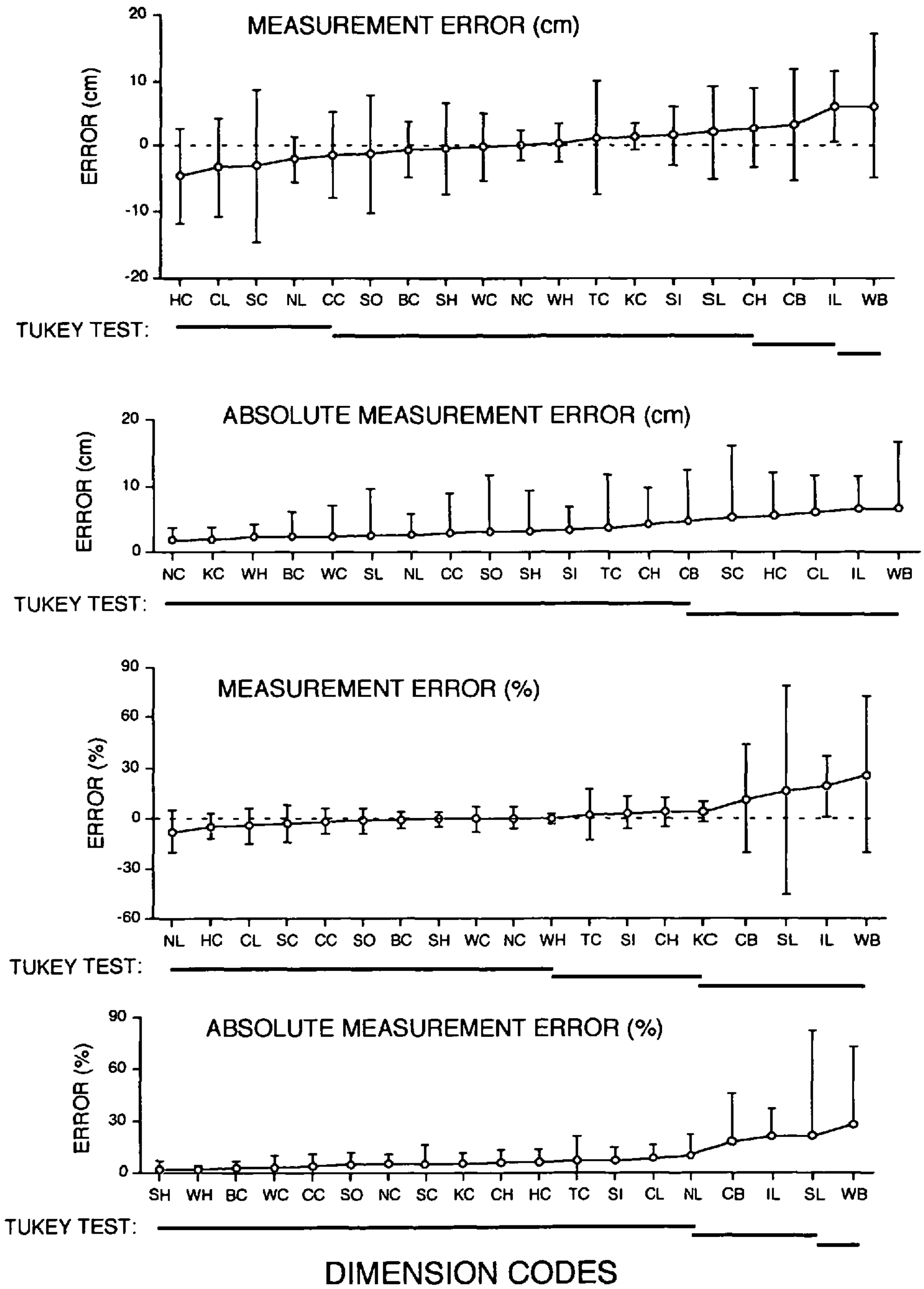

Figure 2. *Mean error for 19 body measurements (*N = *103). Dimensions are ordered along the* x-*axis in ascending order of error.*

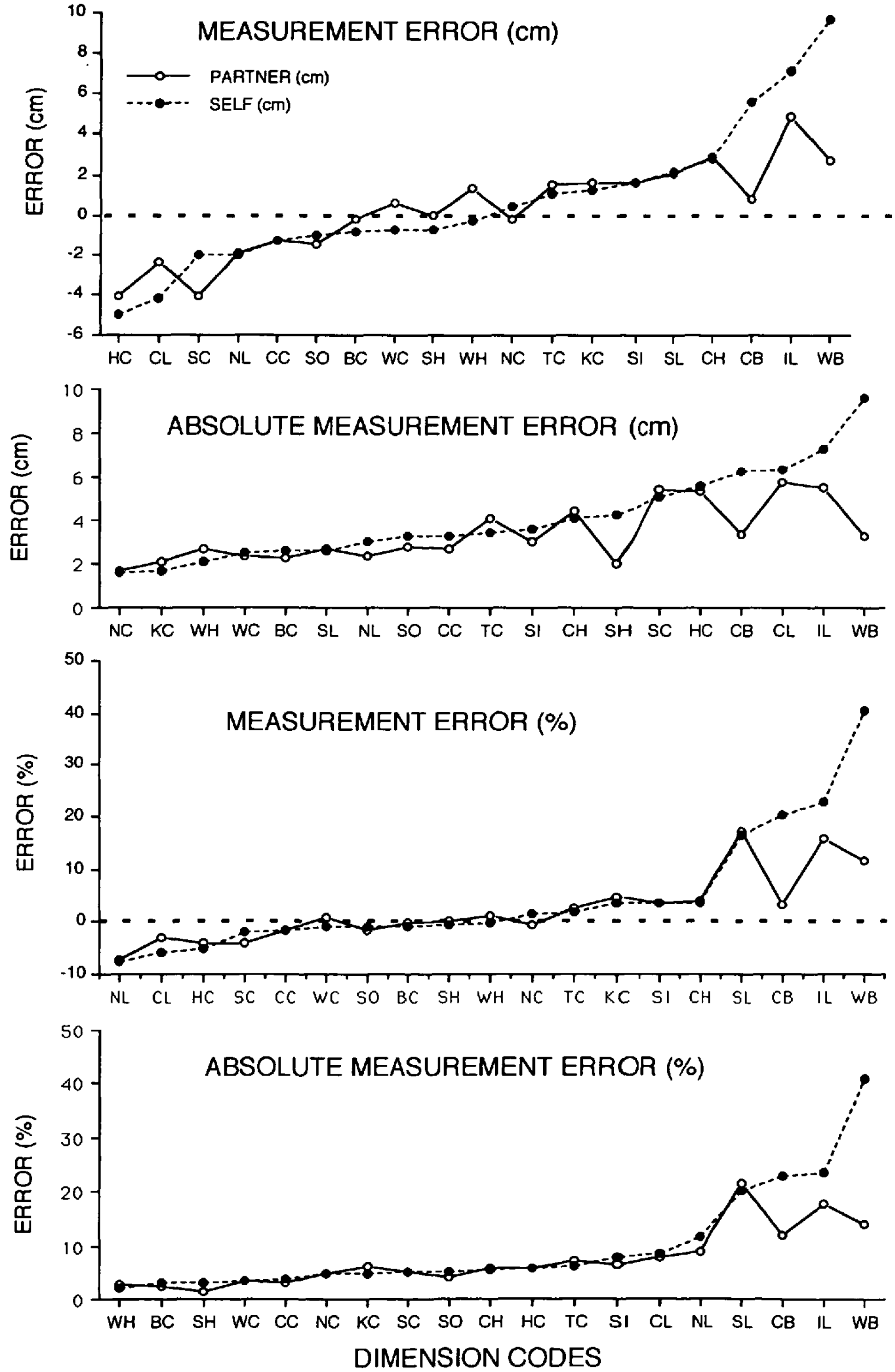

Figure 3. *Mean error for interaction between dimension and measurer (*N = *103). Dimensions are ordered along the* x-*axis in ascending order of error for the self-measurement condition.*

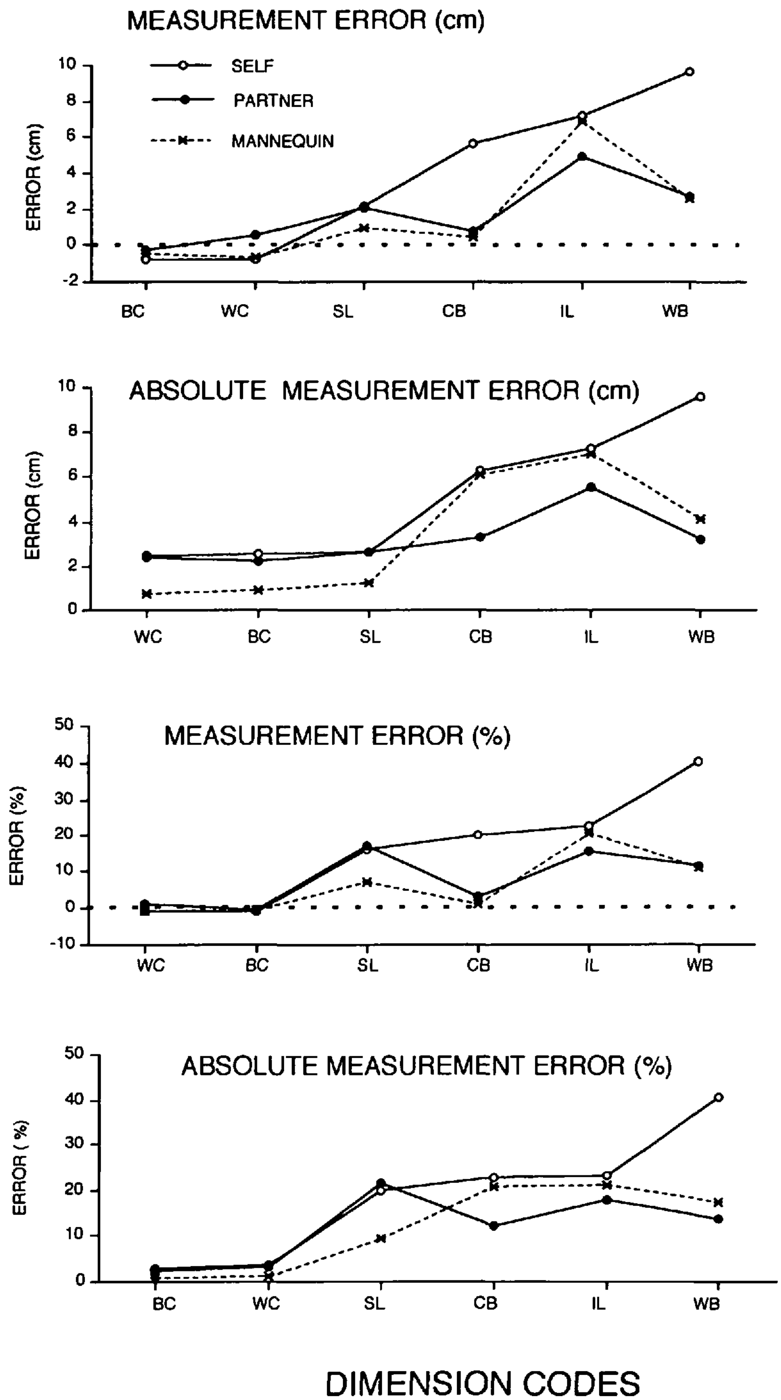

Figure 4. *Mean error for self-measurement, partner measurement, and mannequin measurements. Dimensions are ordered along the x-axis in ascending order of error for the self-measurement condition.*

(12.7-mm) precision; and 6 subjects (5.8%) made their measurements using no more than 1-inch (25.4-mm) precision.

DISCUSSION

This study measured the precision and accuracy of body measurements made by consumers for various body dimensions in order to determine appropriate key dimensions for mail-order garment size descriptions. The accuracy of body measurements varied widely for different body dimensions. The results indicated that two key dimensions—bust circumference (BC) and waist circumference (WC)—frequently used for mail-order garment sizing, were measured with relatively small error. Waist height (WH) and shoulder height (SH) were measured by consumers with similar accuracy. The results also showed that hip circumference (HC) was significantly undermeasured by consumers, even though that dimension is often used as a key dimension in mail-order catalogs.

Waist circumference (WC) and bust circumference (BC) were measured with smallest absolute error (see Figure 2). Neck circumference (NC), a measurement often used for men's dress shirts, was measured with a small average error and standard deviation. Therefore, it was concluded that these three dimensions satisfy the first qualification for key size dimensions: accuracy of body measurement. The results imply that waist circumference and bust circumference may be good key dimensions for garments covering those body parts. Neck circumference may be a suitable key dimension for a garment designed to fit around the neck (e.g., a man's dress shirt).

Hip circumference (HC), which is often utilized in the garment industry, was undermeasured ($E = -4.54$ cm). Further studies are needed to identify the actual reason for the large measurement errors observed for hip circumference. Waist breadth (WB) and interscye length (IL) were overmeasured with the greatest errors ($E_{WB} = +6.15$ cm and $E_{IL} = +6.01$ cm; see Figure 2). These results indicate that a conventional tape measure is not appropriate for breadth measurements. An alternative measuring tool, such as a caliper, is needed if these dimensions are used for sizing. Further investigation into alternative measurement methods and instruments for consumers is therefore needed.

Shoulder height (SH) and waist height (WH) were measured with the smallest $|E|$. $|E|$ of waist height (WH) also had the smallest standard deviation of all the dimensions measured. These results imply that waist height may be a good key dimension for garments covering the lower body and that shoulder height may be useful for garments covering the neck base or shoulder to the lower body.

Yoon (1992) classified garments into groups of related body dimensions. Key dimension candidates were then selected based on correlation among body dimensions using residual variance analysis for data from the 1977 U.S. Army anthropometry data base (Churchill, Churchill, McConville, and White, 1977). The selection of these key dimensions was confirmed using factor analysis. Bust circumference (BC) or scye chest circumference (CC) was selected as a potential key dimension for all upper body garments. Sleeve inseam (SI) or sleeve outseam (SO) was selected for long-sleeve garments, and shoulder height (SH) was selected as the vertical key dimension for short-sleeve or no-sleeve upper body garments. Hip circumference (HC), waist circumference (WC), hip breadth, waist breadth (WB), or back curvature at the waist was selected as the horizontal key dimension for pants. Hip circumference (HC) or waist circumference (WC) was selected as the key dimension for skirts. Crotch height (CH) or crotch length (CL) was selected as the vertical key dimension for pants, and waist height (WH), buttock height, or knee-cap height was selected for skirts. To be suitable in an anthropometric size designation, it is necessary that a selected key dimension be a good predictor of other body dimensions and that consumers be able to measure key dimensions accurately.

The combined results of the current study and results by Yoon (1992) indicate that bust circumference (BC) and waist circumference (WC) are suitable key dimensions because they were accurately measured by consumers and they predict other body dimensions related to garments covering the upper body. For the same reason, waist height (WH) is recommended as a key dimension for garments covering the lower body.

Subjects measured their partners' bodies more accurately than they measured themselves for the waist breadth (WB; average difference = 6.37 cm) and chest breadth (CB; average difference = 2.96 cm) dimensions (see Figure 3). Therefore, if these dimensions are used as key dimensions, it is recommended that they be measured by someone else.

When subjects estimated rather than measured their own body sizes, they overestimated stature by 0.68 ± 4.02 cm. Stature was used because it is a body dimension commonly estimated in daily life, such as when applying for a driver's license or for other personal identification. These observations are supported by the results of a previous study (Buckle, 1985). The results indicate that consumer-estimated body sizes are not very reliable and therefore should be measured.

Methods often used for published anthropometric surveys include either direct measurement (Gallwey and Fittzgibbon, 1991; Garrett, 1971; Molenbroek, 1987) or indirect photographic methods (Frobin, Hierholzer, and Drerup, 1982; Lovesey, 1974; Mollard, Sauvignon, and Pineau, 1982; Sheldon, 1970). Measurement errors are typically made because of the complicated effects of subject variation, experimenter experience and training, instrument resolution, and accuracy. For instance, measurement of some body dimensions changes with body posture (e.g., waist circumference), breathing cycle (e.g., chest circumference), or muscle tension (e.g., biceps circumference; Roebuck, Kroemer, and Thomson, 1975). Other errors occur because of difficulties in finding body landmarks. Subject-made measurements were accomplished using a conventional tape measure. Error introduced by this type of instrument should be considered in establishing size tolerances in an anthropometric size system.

A portion of measurement error in this study was introduced by the difference in precision used by the subjects and the experimenter. However, this error was consistent among all measurements. Measurement error less than 0.64 cm (1/4 inch) may have been caused by reading precision selection rather than by measurement accuracy (see Figure 4). Another source of measurement error concerns the actual reading of the measurement instruments. Although subjects performed measurements using a conventional tape measure having an English system scale with 1/16-inch (1.6-mm) precision, no subjects chose to report measurements with that degree of precision. Only 3% of the subjects used 1/8-inch (3.2-mm) precision, whereas 97% of the subjects used 1/4-inch (6.4 mm) or more.

CONCLUSIONS

This study investigated differences in the measurement of specific body dimensions made by consumers. The results of these experiments lead to the following conclusions.

1. Measurement error varied, depending on body dimension. The dimensions measured with less than 2.5 cm absolute error included shoulder and waist heights and neck, knee, waist, and bust circumferences. Hip and shoulder circumferences were undermeasured by −4.54 cm and −3.06 cm, respectively. Waist breadth, chest breadth, and front interscye length were

overmeasured by 6.15 cm, 3.19 cm, and 6.01 cm, respectively.

2. Self-measurement was generally less accurate for waist and chest breadths and for shoulder height (ranging from 2.27 cm to 6.32 cm absolute error). Hip circumference, crotch length, chest breadth, front interscye length, and waist breadth were more accurately measured by partners (ranging from 6.37 cm to 2.15 cm absolute error). These results indicated that partner measurement was more accurate than self-measurement for breadth measurements or for measurements related to the waist. These measurements should be measured by someone else if they are used for key dimensions.
3. Estimation of body sizes is not reliable. Stature, one of the most commonly referenced body dimensions in daily life, was overestimated by 64.1% of the subjects. More than 50% of the subjects overestimated their height by 1.1 to 14.8 cm.
4. These studies indicated that waist height, waist circumference, bust circumference, and shoulder height are appropriate as key dimensions because they are accurately measured. Hip circumference may also be used as a key dimension if it is measured by someone other than the consumer.

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DOUGLAS J. GILLAN *and* ROBERT LEWIS (*A Componential Model of Human Interaction with Graphs: 1. Linear Regression Modeling*)

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(*Effects of Speech Intelligibility Level on Concurrent Visual Task Performance*)

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JOANNE M. WOOD *and* ROD TROUTBECK (*Effect of Visual Impairment on Driving*)

JOANNE M. WOOD received a B.Sc. (Hons) degree in optometry from the University of Aston in Birmingham in 1982 and for two years worked as an optometrist in private practice. She received a Ph.D. in vision science from the University of Aston in Birmingham in 1987 and worked for a year as a research fellow in the Visual Science Unit at Oxford. Since 1989, she has been a tenured faculty member of the Centre for Eye Research at the Queensland University of Technology in Brisbane, Australia. Her research interests are concerned with the importance of vision and visual impairment in driving performance, particularly with respect to the elderly, and with the functional role of peripheral vision.

ROD TROUTBECK received a B.E. (Civil) and an M.Eng.Sc. from the University of Melbourne. He then worked for a road authority for 2 years before joining the Australian Road Research Board where he worked for 15 years. He obtained his Ph.D in transportation from the University of Queensland in 1989. Since 1989 he has been a tenured faculty member of the Physical Infrastructure Centre at the Queensland University of Technology. His research interests include the performance of drivers on urban roads, in particular their ability to negotiate intersections.

WILLIAM R. UTTAL, TODD BARUCH, *and* LINDA ALLEN (*Psychophysical Foundations of a Model of Amplified Night Vision in Target Detection Tasks*)

WILLIAM R. UTTAL is professor of industrial and management systems engineering and of computer science and engineering. He is principal investigator at the Perception Laboratory at Arizona State University. He received his Ph.D. from Ohio State University in 1957 and has done research at International Business Machines Corporation, the University of Michigan, and the Naval Ocean Systems Laboratory in Hawaii. He is the author of 14 books on various topics in sensory psychology, neurophysiology, and computer science, as well as numerous articles and chapters.

TODD BARUCH received his B.S. in psychology in 1992. He also conducted experimental research in visual perception at Armstrong Laboratory, Williams Air Force Base, Arizona, from 1987 until 1992, when he joined the Perception Laboratory at Arizona State University.

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PAMELA S. TSANG *and* MICHAEL A. VIDULICH (*The Roles of Immediacy and Redundancy in Relative Subjective Workload Assessment*)

PAMELA S. TSANG is an associate professor at Wright State University. Previously she was a National Research Council postdoctoral research associate at NASA-Ames Research Center and a research associate at the Institute of Aviation, University of Illinois. She received her A.B. from Mount Holyoke College and her M.A. and Ph.D. degrees in engineering psychology from the University of Illinois at Urbana-Champaign. Her research interests are in time-sharing performance, mental workload, aviation psychology, and aging.

MICHAEL A. VIDULICH received his M.A. in experimental psychology from Ohio State University in 1979 and his Ph.D. in engineering psychology from the University of Illinois in 1983. From 1983 to 1987 he was a member of the Human Workload and Performance Group at NASA-Ames Research Center. Currently he works at the Performance Assessment and Interface Technology Branch of the Human Engineering Division of the U.S. Air Force's Armstrong Laboratory. His main interests are in the role of attention in human performance and developing workload and situation awareness metrics.

RICHARD W. BACKS, ARTHUR M. RYAN, *and* GLENN F. WILSON (*Psychophysiological Measures of Workload during Continuous Manual Performance*)

RICHARD W. BACKS received a B.A. in psychology from the University of Missouri-St. Louis and an M.A. and Ph.D. in experimental psychology from the University of Southern California. From 1984 to 1989 he was a senior human factors engineer at McDonnell Douglas Corporation in St. Louis. He is currently an assistant professor of psychology at Wright State University. His research interests are in the cognitive psychophysiology of attention and performance, particularly central and autonomic nervous system interaction in stressful environments.

ARTHUR M. RYAN completed his undergraduate work at Wright State University, where he received a B.S. degree in psychology with a human factors concentration. He is currently a student in the human factors graduate program in the Department of Psychology at Wright State. His primary research interest concerns psychophysiological measures of central and autonomic nervous system functioning during performance in dynamic environments.

GLENN F. WILSON received his Ph.D. in psychology from the University of Arizona. He is a research psychologist at the Performance Assessment Branch of the Armstrong Laboratory at Wright-Patterson Air Force Base, Ohio. His research interests include cognitive workload, in-flight workload evaluation, and evaluation methodology.

J. PAUL FRANTZ (*Effect of Location and Procedural Explicitness on User Processing of and Compliance with Product Warnings*) received a B.S.E. in human factors engineering from Wright State University and a Ph.D. in industrial and operations engineering from the University of Michigan in 1992. He is currently a senior research engineer with Miller Engineering, Inc., in Ann Arbor, Michigan. His research interests and areas of specialization include human factors applied to consumer and industrial products, product safety, and occupational/home accident prevention with a particular emphasis on safety-related communications such as warnings, instructions, and other product-accompanying information.

MICHAEL S. WOGALTER, STEPHEN W. JARRARD, *and* S. NOEL SIMPSON (*Influence of Warning Label Signal Words on Perceived Hazard Level*)

MICHAEL S. WOGALTER received a B.A. from the University of Virginia, an M.A. from the University of South Florida, and a Ph.D. from Rice University. Before joining the psychology faculty at North Carolina State University, he held appointments at the University of Richmond and Rensselaer Polytechnic Institute. His research interests include safety, warnings and instructions, hazard and risk perception, human-computer interaction, and human cognition.

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JONGSUK C. YOON *and* ROBERT G. RADWIN (*The Accuracy of Consumer-Made Body Measurements for Women's Mail-Order Clothing*)

JONGSUK C. YOON has B.S. and M.S. degrees in clothing and textile science from Yonsei University in Seoul, South Korea, where she is now an assistant professor of clothing and textiles. She received a Ph.D. in psychology from the University of Wisconsin-Madison in 1992. Her research interests include international sizing systems for women's ready-to-wear garments.

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