USING 3D BODY SCAN MEASUREMENT DATA AND BODY SHAPE

ASSESSMENT TO BUILD ANTHROPOMETRIC

PROFILES OF TWEEN GIRLS

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USING 3D BODY SCAN MEASUREMENT DATA AND BODY SHAPE ASSESSMENT TO BUILD ANTHROPOMETRIC PROFILES OF TWEEN GIRLS

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DISSERTATION ABSTRACT

USING 3D BODY SCAN MEASUREMENT DATA AND BODY SHAPE ASSESSMENT TO BUILD ANTHROPOMETRIC PROFILES OF TWEEN GIRLS

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Tween girls, especially plus sizes, have reported having difficulty finding appropriately sized clothing due to apparel sizing which is incongruous with their body size. As these adolescents progress through puberty, care needs to be taken in pattern development to reflect age-related changes in body shape and measurements. The purpose of this research was to construct anthropometric profiles of normal and plus size tween girls ages 9-14. The sample's mean heights, weights, and body measurements were compared to a seminal children's study from which current sizing standards were

derived. The sample heights and weights were also compared to those specified as the 50th percentile for age by the Centers for Disease Control and Prevention (CDC, 2008).

The sample's height and weight measurement means were higher than both the 1941 study and the CDC 50th percentiles and the body measurement means for the sample were predominately higher. The scans were categorized by year of age and divided by Body Mass Index (BMI) into normal and plus then visually analyzed to determine whole and component body shape incidence using the Body Shape Assessment Scale© (BSAS©) (Connell et al., 2006), and mean body measurements were compared.

Normal size tweens were most often an hourglass shape; plus size tweens more often exhibited the rectangle shape. Bust prominence increased linearly with age for both size groups, with plus size girls frequently showing more prominence at an earlier age. Buttocks prominence showed no age-related pattern. The "D" torso shape was the most common shape for the entire sample. As expected, tweens' grew taller and heavier at every age; their body measurements usually increased linearly with age. Calculated coefficients of determination for the normal and plus size resulted in linear growth slopes that were similar. Some larger changes between ages appeared to possibly be concurrent with expected pubertal changes. Plus size girls in this sample were enough larger than the normal size girls to need adult sizing in circumference but not length. Normal size girls appeared to more easily fit into existing options for tween sizing.

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I. INTRODUCTION

Tweens are the largest and most influential consumer market since the post World War II baby boomer generation, with a population of approximately 26 million and growing (Lesonsky, 2008). The term tweens refers specifically to children and adolescents as young as 7 and old as 15 years of age, but will be limited to girls between the ages of 9 and 14 for the scope of this study. Tweens have disposable income acquired from birthday gifts, allowances, odd-jobs and spend approximately $50 billion of their own money annually (De Mesa, 2005) on electronics, clothing, grooming products, and more. Tweens have been predicted to spend $209 billion annually by 2011 (Lesonsky, 2008).

Many marketers are trying to capture the attention of this "recession-proof" market, including companies in the apparel sector. It is common knowledge that tweens are a very appearance-focused market (Connell & Ulrich, 2005; Kaiser, 2004) for whom clothing is a commodity often used as a tool for self-expression and validation, as well as a means to fit in with peers (De Klerk & Tselepis, 2007). However, tween consumers have many pressing sizing issues that need to be understood by apparel companies seeking to make garments that appeal to and meet the needs of this niche market. Many tweens, especially those who wear plus-sizes and parents who buy their clothes, report an inability to find appropriately sized garments that are both well fitted and stylish (Brock, 2007; Lee, 2006). Ill-fitted clothing raises many socio-psychological issues for tweens such as feelings of clothing deprivation, body image distortion and even low self-esteem

(Gibbs, 2005; Kaiser, 2004). The pervasive conflict for apparel producers has been that bodies are different in shape as well as size, but this fact is not well-represented in apparel sizing charts. Apparel producers who reference body measurements for pattern development typically use the voluntary product standard sizing charts that are based on out-dated anthropometric measurements or their own proprietary sizing charts which are specifically tailored solely for their target market. By common consensus, most apparel companies realize that anthropometric body measurements need to be updated. Consequently, continuing to overlook the impact of varying body shapes within the pre- and early adolescent market population would be a mistake for apparel companies trying to maximize consumer satisfaction and profitability.

Sizes geared toward tweens are typically found in the children's and juniors' clothing departments of most retail stores. However, the selections are limited to brands that may not have sizes and styles that fit and appeal to tweens of all shapes and sizes. Older tweens have issues with shopping in the children's department and lean more towards junior selections. However, junior sizes are generally made for girls that are narrower at the hips and not for those who have curves. Also, many available junior selections may or may not be age-appropriate (Calabro, 2007).

Tweens who wear plus-sizes may find plus-size girls selections in stores such as JC Penny, Sears, Target, Wal-Mart, Old Navy, and Gap. However, these plus sizes are usually only a half-size up from the regular size and still do not take body shape into consideration, typically causing clothing fit to be erroneous. Because many older plus-size tweens have difficulty finding clothing that fits their larger figures, they are forced to shop in adult departments like Misses' or the Plus-Sizes. Unfortunately, these clothing

departments usually do not carry the age-appropriate and trendier styles that these tweens want to wear. Plus-size selections that are available are generally scarce without much style variety.

Tweens and their parents have had much to say concerning the difficulty of finding appropriately sized and styled garments (Brock, 2007; Lee, 2006). Many parents take issue with the hassle of time-consuming shopping because of the difficulty of finding age-appropriate clothes that fit, appeal to the tween, and are reasonably priced. Tweens have reported dissatisfaction with the availability of clothing choices in the market because of limited size options, limited styles, and price (Brock, 2007; Lee, 2006). Tweens and their parents have been able to share information concerning their experiences in focus groups discussing apparel sizing (Brock, 2007; Connell & Ulrich, 2005; Lee, 2006). Parents of tweens have also begun conversing through blog spots on the internet to try and find answers to the clothing and sizing issues that tweens face. Yoffe (2007) reported a comment by an internet blogger from Austin, Texas:

> I agree 'tween clothing is hard to find, but the question I have is this: With obesity being a big issue in our children, where do you find clothes that fit these obese children? My child is overweight and we have tried everything to get her to lose some weight and have not had any luck; then we go to buy school clothes this year and the only place we can find plus size is JC Penney's, and the styles are just not very good and the stores do not carry much. I am confused -if there are so many obese children, where are their parents shopping? (p.1)

Kim, a blogger on the Under the Clutter blogspot by Lynnae (2007) commented:

> I do have to look hard for appropriate clothing though. As far as skirts go, I still, at age 13, make her wear either shorts or leggings under a skirt. I used to always buy the skorts, the ones with built in shorts underneath. Can't find those in the juniors' department though. (p. 1)

Cabrera (2008) interviewed a tween's mother who stated:

> I want to find things that are fashionable and reflect her age. The little girl department is too young; the junior department is not good for her right now. The shorts and skirts are short, too short for school. What's fashionable and what's required doesn't always come together. (p. 1)

Brock (2007) reported the following three comments made by tweens in sizing focus group session:

> Tween 1: Um, I think it's real hard to find like stuff that you want for people that are, you know, I guess, kinda big because like most of the really popular stores that have like really, really good clothes like Gap and Rave and Delia's and that kind of stuff, it [is] for really small people. And like they don't have like bigger sizes and I think they should. (p. 71)
>
> Tween 2: Um, I know like a lot of shirts for me like they'll come down to my waist. . . like they're all the way down to my finger tips. And like I have to wrinkle them up and pull them up and then, when I put my hand back down they just fall. So that really bothers me. (p. 69)

> Tween 3: "I mostly like to shop with um sometimes my friends but not really cuz don't really want them to know my size in my pants . . .I'm kind of self-conscious about that. (p. 69)

As previously mentioned, tweens come in all shapes and sizes. During the adolescent growth period, pubertal changes inherently affect tweens' body size and body shape. Apparel companies targeting tweens must be cognizant of age related changes in body shapes and measurements in order to more efficiently meet their unique sizing needs in regard to garment construction and patternmaking (Calabro, 2007). Three-dimensional (3D) body scan technology enables academia and industry to tackle this goal. Determining the factors that influence body shape will give further insight into ways body shape research can be implemented in apparel design, patternmaking and garment construction for tween girls at different stages of body shape maturation.

Statement of the Problem

There is limited research relative to the female tween consumer as it relates to body shape analysis and updated anthropometric data, particularly using 3D body scanning as a data source. Industry sizing charts generally make the incorrect assumption that larger sized tweens get taller and heavier, respectively, for each graded size. Connell and Ulrich (2005) stated that "the same shape can have different sizes and one size can also have different shapes." Body shape research has studied proportional measures of the body as well as circumferential and side view details such as posture and buttocks definition for adult women. Studies have also done visual assessments of body shape and

body shape sorting. However, there are no studies that have focused on patterns of body shape incidence and body measurement changes for tweens at different ages and stages of maturation.

Purpose of the Study

The purpose of this research was to construct anthropometric profiles for a sample of normal and plus size tween girls ages 9-14. The research intended to do the following: 1) validate the need for updated anthropometrical data for tween girls in this age range; 2) visually analyze 3D body scans to determine body shape and body shape component incidence between the normal and plus size tweens in the sample; and 3) compare body measurements using 3D body scan data for normal and plus size tweens in the sample. The resulting information can be used by apparel manufacturers who produce garments for girls in this target age group to inform pattern making and garment construction.

Research Questions

Comparative Descriptive Analysis

To validate the need for updated anthropometric measurements for normal and plus size tweens, two objectives were explored for the first portion of the study. The objectives were the following:

1. Compare the sample subjects' mean heights and weights with (a) the mean heights and weights of the same aged sample subjects in the first children's body measurement study by O'Brien and Girshick (1939), and with (b) heights and weights designated as the median on the weight-for-age percentiles growth chart for girls aged 2 to 20 developed by the Center for Disease Control and Prevention (CDC, 2008).

2. Compare trunk girth measurement means (M) for bust, waist, and hip and length measurement means (M) for hip height, crotch height and waist height (along the side seam) to the same measures for corresponding age groups in the first children's body measurement study by O'Brien and Girshick (1939).

Central Research Analysis

Research questions 1-7 encompassed the central research analysis for this study. Research questions 1-4 were based on visual analysis to explore the incidence of whole body shapes and body shape components for normal and plus size tweens.

1. Does the incidence of specific whole body shapes change in relation to age for normal and plus size tweens?
2. Does the degree of bust prominence change in relation to age for normal and plus size tweens?
3. Does the degree of buttocks prominence change in relation to age for normal and plus size tweens?
4. Does the incidence of specific torso shapes change in relation to age for normal and plus size tweens?

Research questions 5-7 compared body measurements for normal and plus size tweens. The body measurements include three circumferences (bust circumference, waist circumference, and hip circumference), three lengths (waist height, hip height, and crotch height) and two principle girth differences (bust-waist difference and waist-hip difference).

5. Do specific body measurement circumference means including bust, waist, and hip change in relation to age for normal and plus size tweens?

5a. Do bust circumference measurements change in relation to age for normal and plus size tweens?

5b. Do waist circumference measurements change in relation to age for normal and plus size tweens?

5c. Do hip circumference measurements change in relation to age for normal and plus size tweens?

6. Do specific length measurement means including hip height, waist height, and crotch height change in relation to age for normal and plus size tweens?

    6a. Does waist height change in relation to age for normal and plus size tweens?

    6b. Does hip height change in relation to age for normal and plus size tweens?

    6c. Does crotch height change in relation to age for normal and plus size tweens?

7. Do two specific principle girth measurements (bust-to-waist difference and hip-to-waist difference) change in relation to age for normal and plus size tweens?

    7a. How do bust-to-waist differences change in relation to age for normal and plus size tweens?

    7b. How do waist-to-hip differences change in relation to age for normal and plus size tweens?

Definition of Terms

Body mass index [BMI]: BMI is calculated by dividing weight in pounds (lbs) by height in inches (in) squared and multiplying by a conversion factor of 703. Formula: weight (lb) / [height (in)]^2 x 703. For children and teens, BMI is age- and sex- specific and is usually referred to as BMI-for-age (CDC, 2008).

Body shape: The contour of the body which depends on the relative position of all points composing its outline or external surface (Simmons, 2002).

Measurement Extraction Profile (MEP): The set of parameters that can be set to determine which measurements will be extracted from the 3D visual image (Simmons, 2002).

Puberty: Sequence of events by which a child becomes a young adult, characterized by the beginning of gonadotropin secretion, gametogenesis, secretion of gonadal hormones, development of secondary sexual characteristics and reproductive functions; sexual dimorphism is accentuated. In girls, the first signs of normal puberty may be evident after age 8 with the process largely completed by age 16; in boys, normal puberty commonly begins at age 9 and is largely completed by age 18. Ethnic and geographic factors may influence the time at which various events typical of puberty occur (WebMd, 2008).

Reduced Body Data (RBD): "Data that has been filtered of any stray points, smoothed to remove low-level noise in the scan data, closed of any gaps in the scan data and compressed, on the order of 100:1, to achieve a very "light", yet fully defined data set" (Simmons, 2002). (p. 5)

Sizing: The process used to establish a size chart of key body measurements for a range of apparel sizes (Schofield & Labat, 2005).

Sizing System: A set of clothing sizes created by an apparel firm to fit the range of people in a population (Cornell University, 2001).

Three dimensional body scanning (3D body scanning): Data collection technology that uses white light to capture an image of the human body in three-dimensional space, with X, Y, and Z coordinates representing height, depth, and width ($[TC]^2$, 2005).

Tween: For the purposes of this study, "Tween" is defined as a pre- and early adolescent between the ages of 9 and 14 (Connell & Ulrich, 2005). At this age, a girl is experiencing, physical, socio-psychological, and cognitive changes (Tselepis & De Klerk, 2004).

II. REVIEW OF THE LITERATURE

The purpose of this research was to construct profiles of normal and plus size tween girls ages 9-14 in using three methods of exploration 1) comparative descriptive analysis to compare the heights and weight of the sample with the seminal O'Brien, Girshick and Hunt, (1941) children's body measurement study to validate the need for updated anthropometrical data for tween girls in this age range; 2) visual analysis using 3D body scans to determine body shape and body shape component incidence; 3) body measurement comparisons between normal and plus size tweens in the sample.

This study was driven by the need for more in-depth knowledge of body shape and body shape measurements for the pre-pubescent and pubescent population of females aged 9-14, referred to as "tweens". It was enabled by anthropometric data captured using a 3D body scanning system. The review of literature examines the following topics: tweens, apparel needs, obesity, anthropometric body shape profiling, and 3D body scanning.

Tween Culture

> Today's tweens are the confident, high-tech, optimistic, street-smart and marketing savvy members of the Echo Boom, and the largest group of children in American history...they are influenced by news media, virtual friends and the power that comes with technology. Today's tweens represent the first generation to practice adolescent independence on the Internet. Tweens do not need parents

> or teachers to help them gather information. This instant access to the world through the Web has bolstered a respect for knowledge (Simon, 2001). (p. 1)

The tween consumer group has quickly become one the fastest growing and most influential; even influencing small and large family purchases like the decision of what groceries to buy or what kind of family car to purchase (De Mesa, 2005; Paterson, 2003). Currently, marketing agencies are searching for plausible ways to reach the tween market and are also trying to determine tweens' expectations of the marketplace (Brock, 2007). Martin and Peters (2005) found that girls seem to develop brand and product awareness between the ages of 11 and 13. Most tweens are consistently aware of current trends and even have their own personal style. Sending "cool hunters" into the marketplace to investigate tween trends has been one of the more popular ways to infiltrate and try to influence tween culture (Media Awareness Network, 2008).

Many commercials and advertisements try to get tweens' attention by telling them how their products or clothing will make them "cool" or look their very best, or promise obscure "super-human abilities". However, getting "cool" products to the market in a timely manner has become like trying to hit the bulls-eye of a moving target because tween trends change rapidly. Marketers are cognizant of tween consumers' needs for group affiliation and product personalization; therefore, colossal efforts to capitalize on their impressionability and their desires to fit in with peers have become the premiere focus of marketing campaigns.

Tweens' Sizing Needs

Tween consumers can be uniquely different at varying pubertal stages. For this reason, the apparel industry is in need of updated anthropometric data and sizing charts that represent realistic body sizes and shapes for female tween consumers which take these differences into consideration. Some retailers are still convinced that using their own sizing charts as a marketing tool will guarantee a differential advantage (Simmons, Istook, & Devarajan, 2004). The fact remains, however, that in order to bring appropriately fitted garments to the market, apparel manufacturers must determine how to address a broader range of sizes and shapes. Understanding specific measurement differences and body shape changes at different stages of tween development can provide insight for improving sizing for tweens and should be investigated.

Current grade rules assure that if a pattern grade begins as one shape, it will remain that shape throughout the grading process. Grading patterns proportionally without considering body shape typically does not yield appropriately fitted garments for a range of body sizes and shapes. Actual tween measurements must be analyzed to understand where there may be discrepancies from the current measurements in the voluntary product standard sizing charts. Also, body shapes must be evaluated and taken into consideration to affect change and effectively begin to reform patternmaking and grading.

Providing various clothing size ranges based on currently graded measurements does not satisfy the tweens unique fit requirements. Since tween girls' body shapes and sizes are constantly changing, it is important to understand the dynamics of their physical development during and through puberty. Viewing body measurements and

demographics together with body shapes at different ages and stages of physical development can also provide an overview of market demographics as it relates to apparel sizing for tweens. According to Solomon and Rabolt (2004), manufacturers who want to deliver better products and create a differential advantage should consistently be aware of consumers' needs that are not being satisfied in existing markets. Carving out niches in the apparel market by reaching underserved and unsatisfied customers will help companies garner larger market shares and build customer loyalty within their brands.

Tweens' Physical Development

Tweens are on a continuum as they progress into adulthood. Puberty is the pivotal landmark that signifies the beginning of that transition. During the time of puberty, tweens go through physiological changes followed by a dramatic growth spurt one to two years after the onset of puberty (Dowshen, 2007). Females begin to develop breasts, grow pubic hair, and begin to experience changes in their body shape and contour (Whisnant & Zegans, 1975). The peak of puberty for females is reaching menarche, the first menstrual cycle (Dowshen, 2007). The age range for girls to have their first menstrual cycle is between 11 and 14 years of age (WebMd, 2008), the average being 13 years of age (Zacharias, Rand, & Wurtman, 1976). As reproductive organs become active, hormonal changes cause the hips and thighs widen. The waist may become smaller and more defined and the breasts typically begin to get larger. Adolescents in post-menarche matriculate on through the continuum into adulthood, getting taller, heavier and developing larger hands and feet.

Height and weight both typically increase as adolescents advance in age but may not increase at the same rate. In a longitudinal study of weight and height at adolescence,

Buckler and Wild (1987), found that boys increased rapidly in height and weight around the same age. Girls, on the other hand, put on weight later than the age they reached peak height. Height and weight are the two body dimensions most commonly used to monitor the growth of children and adolescents (CDC, 2008). Both height and weight are used to calculate the Body Mass Index (BMI). BMI is typically an indicator of body proportions; a mass adjusted for height and weight. BMI declines from infancy to about 5-6 years of age, and then increases linearly with age through childhood to the onset of puberty (CDC, 2008).

Height, weight, and the calculated BMI value are provided by the Center for Disease Control as tools for medical professionals to use in gauging children's health status and pre-disposition for illnesses such as hypertension, diabetes, and obesity (CDC, 2008). BMI is an adjusted mass based on height and weight proportions. Underweight normal, at risk for overweight and overweight BMI numbers can be categorized by percentile (CDC, 2008). BMI is calculated by dividing weight in pounds (lbs) by height in inches (in) squared and multiplying by a conversion factor of 703. For children and teens, BMI is age and sex specific and is usually referred to as BMI-for-age percentiles (CDC, 2008).

Tweens and Obesity

In addition to the need to understand apparel sizes for tweens in the normal size range, the rising rate of childhood obesity has sparked interest in plus size population profiles relative to body measurement differences as well as changing body shapes. According to the Center for Disease Control and Prevention (CDC, 2008) the most recently available published data (CDC, 2008) show a rapid increase in childhood

obesity. Figure 1 shows that the number of overweight children aged 6–11 years old had increased from 4.0% to 18.8% and the number of overweight children aged 12–19 years, increased from 6.1% to 17.4% since the 1971-1974 National Health and Nutrition Survey (NHANES) (CDC, 2008).

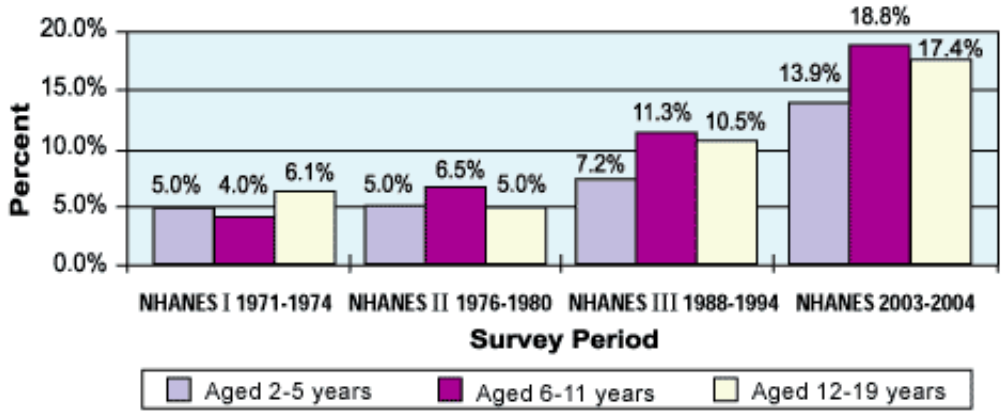


Figure 1. Prevalence of overweight among U.S. children and adolescents ages 2-19). National Health and Nutrition Examination Surveys *sex-and age-specific BMI $\geq$ 95th percentile based on the CDC growth charts (CDC, 2008).

These alarming statistics cause concern for the health of the individual as well as for the apparel industry as they try to meet the sizing needs of a changing market. Plus size tweens have a higher BMI, higher body fat percentage, and larger body measurements than their average sized peers and most likely need more ease at locations such as the bust, hips, or even the upper arm. Consequently, apparel companies providing plus sizes generally modify existing size scales by simply increasing the grade by mathematical increments to allow for increased or decreased measurements at key body points like the bust, waist and hips (Bailey, 2000).

In focus groups conducted by Connell and Ulrich (2005), plus size tweens and their mothers vented the many frustrations they had with the limited apparel selections due to size, age-appropriateness, and style. Plus size tweens reported feeling the

disappointment of clothing deprivation. Plus-size girls were also more dissatisfied with how their body looked and were concerned with how their clothing looked on them. Many of these plus size tweens reported that they wanted to be thinner and had tried dieting at some point. Even girls as young as 9 years old had thought about or had actively chosen to diet (Connell & Ulrich, 2005).

Tweens' Ideas about Clothing, Fit, and Appearance

As tweens progress through puberty they are experiencing physical, socio-psychological, and cognitive changes (Tselepis & De Klerk, 2004) and become very appearance focused (Connell & Ulrich, 2005; Kaiser, 2004). They are usually more socially active and very emotionally concerned about what peers think and say about their appearance (Brock, 2007; Kaiser, 2004; Tselepsis & De Klerk, , 2004). Many tweens are also weight conscious (Market Wire, 2003) and are becoming increasingly more aware of their bodies and how clothing fits their bodies (Tselepis & De Klerk, 2004). Tweens' preferences for specific socially desirable attire and peer approval often affect their self-esteem and body image (Tselepis & De Klerk, 2004). Kaiser (2004) stated that having or not having appropriately fitted and styled garments is a need which can help or hinder the development of healthy self-esteem.

Tselepis and De Klerk (2004) found that intrinsic design components such as (fabric, style/design, construction, size) typically affected how clothing actually fit the tween. In addition, extrinsic factors (brand name, price, store, opinions of others) were also very influential to the adolescents' perceptions of how clothing fit. De Klerk and Tselepis (2007) later found that the early adolescent female consumer was generally concerned with both the functional and emotional aspects of clothing fit. However, they

concluded that this consumer group was usually dissatisfied with the fit of clothing after the purchase because they lack the 'expertise, knowledge, and cognitive skills, to evaluate the fit of the clothing during the decision-making process.

Tweens typically want clothing to fit their bodies the same way the clothing is portrayed on models in the popular media and peers whom they admire. Body shape and size are an issue that tweens are forced to be concerned about because of the many visual images in the media. The media is inundated with bodies that are thin and toned with minimal to no curves (Ballentine & Ogle, 2005). Research has shown that images of models with body shapes and sizes that are unrealistic for the average tween have led to dieting at early ages, eating disorders, low self-esteem, and even distorted body image. Although African American tweens usually have curvier body shapes as they mature (Brock, 2007), studies show that their self-esteem is not as tied to images in the popular media and teen magazines. African American tweens have been reported to develop their sense of femininity and social acceptance through peer interaction and cultural standards (Kaiser Foundation, 2004).

Body Shape Analysis and the Apparel Industry

As consumer populations in America have become more ethnically diverse, body shape analysis has become an important topic for the apparel industry. Many apparel companies seek ways to collect and decipher anthropometric data coupled with knowledge of body shape trends to be used in manufacturing garments to fit the diversity of body shapes prevalent today. Better anthropometric data would ensure better pattern development and garment construction, higher rates of satisfaction among consumers, increased market share, and increased profits. Commercial attempts to explain body

shape and help consumers choose clothing that fits their body shapes have incorporated websites such as *My Virtual Model* (My Virtual Model, 2008), where consumers can build personal models using real measurements, try on clothes from participating retailers, and save clothing choices in a virtual closet until they are ready to make a purchase. Other websites, such as *Fit Logic* (Fit Logic, 2008) and *My Shape* (My Shape, 2008) offer customers information explaining their body shapes and making recommendations for clothing which is available for purchase. Lane Bryant, a women's clothing retailer, has launched a Right Fit Initiative that encourages their customers to purchase jeans that fit specific body shapes.

Variety in sizing gives consumers more fit options and may bolster sales for manufacturers and retailers who participate in body shape programs. However, most of the empirical knowledge needed to develop better fitting garments will need to come from updated anthropometric data which accurately represent the measurements and body shapes prevalent in today's population. From the early 1940's until recently, apparel sizes found in the marketplace have not reflected the actual body sizes and shapes of the American public. Voluntary sizing standards used over the years used for female apparel have been based on body measurements of mostly slim, hourglass-shaped, Caucasian women who were the primary subjects for early sizing studies (O'Brien & Shelton, 1941).

History of Sizing and Anthropometry

Early interest in body size was derived out of the necessity to define population growth and stature and to monitor individual and collective nutritional status. After the American Civil War of the 1860's, the measurements taken to make military uniforms

were used as sizing references for men's ready-made garments, but no such data were available for women or children. The ready-to-wear styles available for females at that time were cloaks and outerwear that did not fit closely to the body because that would have required more precise fitting techniques. This was one of several reasons that women's and children's ready-to-wear manufacturing developed more slowly and later than men's (Kidwell & Christman; 1974, LaBat, 1987). Clothing made by tailors in the 18th century was custom-fitted by hand using a tape measure to extract linear measurements. The tape measure rarely used numbers to denote measurements, but rather notched strips of paper which represented the measurements (Bye, LaBat & DeLong, 2006). Direct and proportional measuring methods became popular in the 19th century. Tailors used measuring devices that recorded critical body measurements while positioned next to the patron (Kidwell & Christman, 1974). Additional measurements were derived proportionally for other parts of the body from the extracted direct measures.

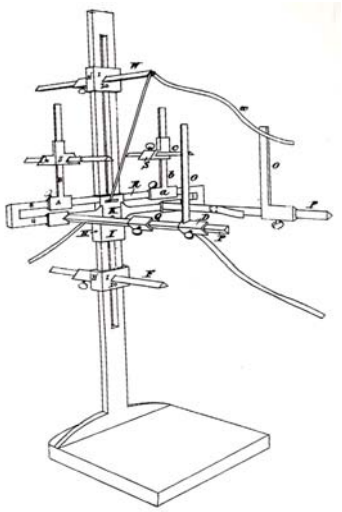


Figure 2. Original drawing for William W. Allen's direct measurement device. The patent was granted October 23, 1837. Patron stood while "arms were adjusted in to his sides and out to meet his waist, shoulders, and neck" (Kidwell & Christman, 1974).

Many of the early proportional systems were based on the principle that the human body was proportional; therefore, related body measurements were proportional and could be calculated mathematically (Kidwell, 1979). In the mid-19th century, drafting became the method used for creating standardized patterns (Kidwell & Christman, 1974). Although drafting could apply direct and proportional measures, measurements for a greater number of people were needed for making mass manufactured garments. The anthropometer (separating rod with scale markings and sliding right-angled blades) and calipers (tool with pivoted and curved arms that spread out) were 20th century tools developed by physical anthropologists to assess heights and widths of the human body. By comparing body measurements taken using these devices, heights and body proportions could be determined (Roebuck, 1995).

Using Body Measurements for Clarification Purposes

By the 1930's an overwhelming number of returns described by the Mail Order Association prompted the Department of Agriculture (USDA) to sponsor the first anthropometric survey of women in the United States. This survey was to provide measurement data which could be used to develop sizing standards for women's clothing (LaBat, 1987; Moore, Mullet, & Young, 2001; Simmons, 2002). This survey, conducted in 1940, consisted of 10,042 female volunteers who were predominately Caucasian and ranged in age from 18 to 30 years old. Actual measurements were taken at 60 locations on the body using hand held tape measures. Using the results of this study, O'Brien and Shelton (1941) statistically defined "key dimensions" in the data which were grouped into four different body types: juniors, misses, half-sizes, and women's. The USDA

published this anthropometric study in 1958 as the Voluntary Product Standard CS 215-58, Body Measurements for the Sizing of Women's Patterns and Apparel (U.S. Department of Commerce, 1958). It was the first anthropometric-based sizing system published in the U.S which provided a standard classification of body types (Moore et al., 2001).

At about the same time as O'Brien and Shelton's report on adult females (1941), O'Brien and Girshick (1939) proposed a children's sizing system based on measurements from children ages 4 through 17. The data collection was conducted from February 1937 to June 1939 using traditional measuring methods. Thirty-six measurements on the body were recorded. Although 147, 088 children were measured; the sample total was 133,807 and included 64,146 girls and 69,661 boys from 16 states across the U.S and the District of Columbia. In 1941, O'Brien, Girshick and Hunt released a comprehensive report of the measurement procedures and statistical analysis used in the study. Measurement collection was limited to weight assessment and trunk measurements to guard against fatigue of the children participants (O'Brien & Girshick, 1939; O'Brien, et al, 1941). The results showed that age was the least reliable predictor of body dimensions because some of the children who were the same age had different body measurements. The results also reported that a girth or weight and length combination was the best predictor of other girths and lengths (O'Brien & Girshick, 1939). Further statistical analysis revealed that the best predictor of all girths and lengths included one of two combinations: height and weight or height and hip circumference. A less reliable, but possible, combination was height and chest/bust girth.

The children's measurement study (O'Brien & Girshick, 1939; O'Brien, et al, 1941) was the seminal work that birthed the American Society of Testing and Materials (ASTM) standards for children, girls, and boys. Since then, sizing systems developed for children have typically been designated by age, height, and girth, and have not taken body shape into consideration (O'Brien and Girshick, 1939; O'Brien, et al, 1941; Winks, 1997). Currently, the ASTM has developed standard tables of body measurements for infants and children using the results from the original children's measurement study (O'Brien and Girshick, 1939; O'Brien, et al, 1941).

The most recent ASTM body measurement tables reflect growth patterns found in the 1980 growth charts recorded by the National Center for Health statistics and the 1977 Anthropometric Study of U.S. Infants and Children (Snyder, Schneider, Owings, Reynolds, Golomb, & Schork, 1977).

The current ASTM standard body measurement tables include the following: Standard Tables of Body Measurements for Children, sizes 2 to 6x/7(D 5826-00), Standard Tables of Body Measurements for Girls sizes 2 to 20 Regular, Slim, and Girls Plus (D 6192-98), Standard Tables of Body Measurements for Juniors, Sizes 0 to 19 (D 6829-02), and Standard Tables of Body Measurements for Boys, Sizes 8 to 14 Slim and 8 to 20 Regular (D 6458-99).

By 1971, Voluntary Product Standard, PS 42-70, Body Measurements for the Sizing of Women's Patterns and Apparel was published by the U.S. Department of Commerce National Bureau of Standards as a revision of the 1958 publication (Simmons, 2002; U.S. Department of Commerce, 1970). PS 42-70 expanded the body types to "improve the fit for a greater number of segments in the population" (Moore et al., 2001,

p. 4) and accommodate measurement differentials caused by increased heights and weights of the adult female population from 1940-1960. The new body types were junior petite, misses petite, and misses tall. The revisions still did not accommodate the varying body shapes present in the population represented by, e.g., ethnic groups and older women (Labat, 1987).

Other anthropometric studies found useful for collecting body measurements were the U.S. Army Women in 1977 and U.S. Air Force Women in 1978 (Churchill, Churchill, McConville & White, 1977; Tebbetts, McConville, & Alexander, 1979) which were used in developing size specifications for women in the Navy (McConville, Tebbetts, & Churchill,1979). According to Moore, et al. (2001), surveys such as those conducted for military sizing are not representative of the general population, but the information has "been useful to the civilian sector as an indicator of how some average measurements have changed (i.e increase in height and waist circumference)" (p. 4).

Linear and Non-Linear Anthropometric Measuring Methods

In the past, the practice of using two-dimensional (2D) linear body measurements for predicting other, related linear measurements was the primary way to analyze and interpret body dimensions when developing sizing specifications. Linear measurements reflect size; relationships between measurements can reflect shape. Linear methods are fundamental in developing systems for sizing; however, these methods are limited in that shape is reflected but not necessarily considered in development.

Bye, Labat and DeLong (2006) argued that in order "to provide well-fitting apparel, all lengths, widths, and depths of the body must be related (p.69)". They stated the following:

> Because the body is a complex form with many variations in shape, posture, and movement, the development of a superior body measurement system must continue as a priority, to provide a reliable, accurate description of the body using the best methods available. (p.76)

Sizing studies completed with primitive methods of measurement were both tedious and time consuming and subject to human error. The most recent studies have been enabled by the latest anthropometric sizing technology, three-dimensional (3D) body scanning which is not highly intrusive, fast and yields accurate results (Ashdown, 2000; Connell, et al., 2006; Simmons, 2002; Simmons et al., 2004; $[TC]^2$, 2005). Many studies have continued to analyze body measurement data sets to determine how to best develop body measurement tables (Yoon & Jasper,1996; Moore et al., 2001; Tamburrino 1992a; Tamburrino 1992b; Winks, 1997). Salusso-Deonier (1982) analyzed the measurements of 1,330 women to determine if they could fit the PS 42-70 standard. She (1982) determined that the sample could not fit the PS 42-70, but with a Principle Components Sizing system that she developed using linearity and laterality, 90 percent of the sub-sample tested could achieve good fit.

Gazzuolo (1985) proposed that visual analysis along with dimensional data were both important elements that should be combined to create a standard for a sizing system. She proposed that samples should be sorted by special groups to limit variance. She also

determined that any sizing system based on "averages" would be inadequate because of the variance within the sample. Robinette (1986) used regression estimates to determine and represent the largest weight and height values in the CAESAR sample. Goldsberry, Shim and Reich (1996) examined the differences in body measurements of 469 subjects 55 and older against the Voluntary Product Standard PS 42-70. The subjects were divided into 7 figure type classifications (Junior Petite, Junior, Misses Petite, Misses, Misses Tall, Women, and *Half-Size)*. Goldsberry et al. (1996) found that for older women abdominal-extension, waist, sitting-spread, armscye, bust-height (level), back-width, chest/bust-width, hip and hip-arc were significantly different from the PS-42-70 across a majority of the sizes within the 7 figure type categories. McCulloch, Paal, and Ashdown (1998) proposed anthropometric data could be used to create a sizing system by using optimization techniques, based on a mathematical model of garment fit.

3D Anthropometric Sizing Studies

A few studies have been conducted collecting 3D anthropometric scan data for large sample profiling. CAESAR was the first large scale anthropometric sizing study conducted using 3D scan technology from 1998 to 2001. The study collected the 3D surface measurements of civilians in the United States, Canada, and Europe (Italy and the Netherlands) to create a database to revise the then current anthropometric databases of males and females of various weight ages 18-65 (SAE International, 2008).

In 2001, the UK Department of Trade, along with the support of corporate sponsors, collected 3D body scan data from 11,000 people across the UK using body scanners developed by $[TC]^2$, a research and consulting firm which specializing in lean manufacturing and 3D technology for the soft goods industry. The Size UK study

intended to discover how the average sizes of the population had changed since the 1950's. Modeling the Size UK study, $[TC]^2$ developed Size USA, an anthropometric research survey used to gather body measurement and body shape data representative of the adult U. S. population. More than 10,000 adult men and women (aged 18 and older) were measured in locations around the country using 3D body scan technology ($[TC]^2$, 2005). The study was completed in September 2003. The 3D body scan measurement data collected for the SizeUSA study were not representative of consumers in the population under age 18. Though $[TC]^2$ has interest in scanning younger subjects, funding for data collection has not materialized($[TC]^2$, 2005).

Body Build and Shape Profiling

Apparel manufacturers have typically referenced body measurements for pattern development while overlooking the variation in body shapes found in the population. However, body builds and shape analysis has become an important factor in sizing research. In 1926, Berlei conducted an anthropometric study of female figures in Australia for the purpose of improving the fit of corsets (Hyslop, 1993). Berlei gathered and analyzed 23 measurements from over 6,000 women to categorize their basic figure types. This resulted in the Berlei Five Figure Type classification and the Berlei Figure Type Indicator. The five figure types included: big abdomen, heavy bust, big hips, sway back and average proportions (Hyslop, 1993).

Sheldon (1940) was the first to classify male bodies into build/shape categories or "somatotypes", but not for the purpose of sizing. Sheldon proposed that different somatotypes displayed different personality characteristics. Sheldon's three somatotypes were the endomorph, the mesomorph, and the ectomorph. The endomorph was

characterized as plump and round with a relaxed, easy-going, good, and tolerant personality. The mesomorph was characterized as broad and muscular with a bold, active, and assertive personality. The ectomorph was characterized as being lean and frail having a quiet, non-assertive and sensitive personality (Sheldon, 1940).

Douty, an Auburn University researcher who specialized in body shape, (1968a) was thinking about how to improve garment fit when she developed a graphic somatography technique to measure the human body, also referred to as silhouette photography. Douty (1968b) took standard measurements for comparison analysis and then photographed the silhouette of a person's body while they stood behind a translucent grid. This method was useful in classifying body characteristics which defined postural patterns and build variation. The resulting scales were the Douty Posture Scale for Women and Douty Body Build Scale for Women. Douty's Build Scale was characterized with an hourglass body shape (Simmons, 2002; Gazzuolo, 1985). The scales were useful in classifying and quantifying information about subjects for comparative analysis and pattern development. Douty's methodology became foundational for future research in the area of body typing and body shape analysis.

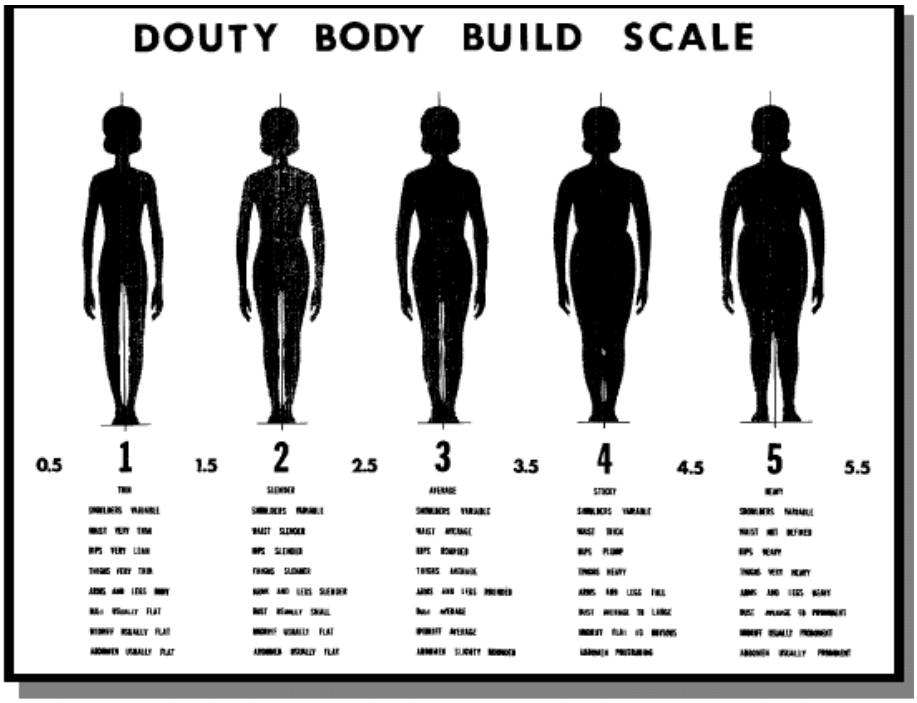


Figure 3. Body Build Scale (Douty, 1968a, p.28)

Douty (1968b) commented:

....to speak meaningfully of relative body characteristics there must be information on norms and variations with valid conceptions of size and contour of normal bodies. Detailed measurements of body units can provide for observation of these specific details and for statistical treatment of data but they provide little information on the nature and location of unit masses in relation to each other and to the whole. (p. 65)

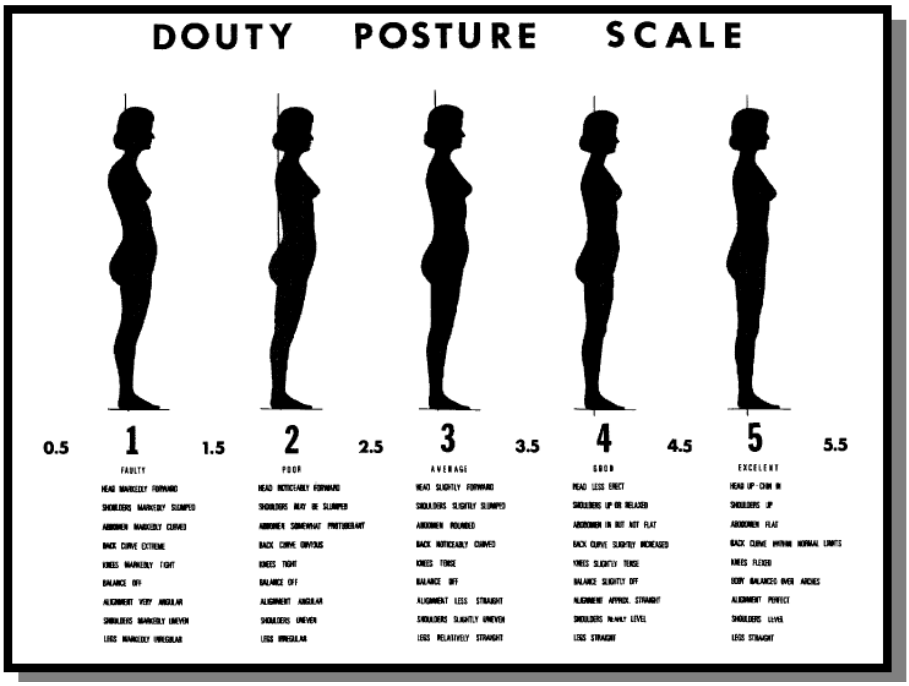


Figure 4. Posture Scale (Douty, 1968a, p. 29)

Gazzuolo (1985) developed a foundational theoretical framework for describing body form variation using a planar method which described how a person's body dimensions lying in a 3D plane relate to 2D fabric. Gazzuolo, DeLong, Lohr, Labat, and Bye (1992) tested pattern prediction based on the measurements of body lengths and angles taken from a person's photograph. Bye, et al. (2006) noted that although body-derived length measurements were slightly more accurate in predicting a few of the female torso pattern dimensions, photographic measurements were more accurate in predicting pattern angles.

Some refer to body build and shape classification as figure typing. The apparel pattern industry pioneered figure typing and used the terminology of naturally appearing letters, shapes, fruits and vegetables to label the variations (Armstrong, 2000). According

to Zangrillo (1990), body shapes of plus size women were divided into four major body silhouettes: Rectangular 8, Pear, Barrel, and the Box. Body shapes have commonly been named by other shapes, letters and numbers, or fruit and vegetables. Shape and build scales, or figure typing, have sometimes been developed from accumulative observations and sometimes through analysis of measurements and images. No matter the terminology used in body shape research, it has become increasingly evident that 2D sizing techniques are limited and do not sufficiently represent 3D shapes (Bougourd, 2006). New sizing technology along with the emerging classification of body shapes and sizes has become the new frontier in sizing science.

3-D Body Scanning

Three dimensional (3D) body scanning is currently being used to capture body measurement and body shape data. This state of the art technology makes it possible to quickly capture body measurements in 3D space, accurately taking measurements at multiple points on the body and deciphering body shapes. Three-dimensional body scanning is a tool that allows for rapid extrapolation of body measurements, and with enhanced algorithms and fast data processing, it is possible to collect and process data for large groups in the population (Costa & Cesar, 2000; Simmons, 2002; $[TC]^2$, 2005). According to $[TC]^2$ (2008), the point accuracy of the 3D body scanner is <1mm (0.0394 in.) and the circumferential accuracy is <3mm (0.1181 in.).

Three dimensional body scanning technology has helped to update the foundation of somatography in sizing research by capturing the 3D image of the human body surface which can be translated into non-linear measurements, including body shape silhouettes, surface area, circumferences, slice area, and volume measurements (Ashdown, Loker, &

Adelson, 2005; Simmons, 2002). Since evaluating 2D measurements for large populations for the purpose of apparel pattern development has been mostly limited to quantitative analysis, the introduction of three-dimensional (3D) body scanning presented a pivotal new method for anthropometric data collection and body shape analysis. Body shape analysis has become an increasingly important tool for informing apparel sizing research as apparel manufacturers seek to improve systems of making clothing that will fit different bodies in different target markets (Bougourd, 2006; Loker, 2006; Winks, 1997).

Measurements of multiple points for a range of ages and sizes of tweens can be studied using linear measurements and visually, using 3D body surface data and 3D point cloud data. Three dimensional body scanning technology has been used for measuring adult populations and studying sizing, but few studies have targeted the tween population. With 3D body scanning technology, it is possible to extract actual measurements to be examined across tweens in varying sizes to understand sizing.

Recently, researchers in apparel science have used 3D body scanning to implement body shape analysis, categorizing adult figures (Connell & Ulrich, 2005; Simmons, et al., 2004). The Female Figure Identification Technique© (FFIT) for apparel software was developed by researchers to sort and identify body shapes images using 3D body scan software (Simmons, et. al, 2002). The Body Shape Analysis Scale (BSAS©) developed by Connell, Ulrich, Brannon, Alexander and Presley (2006) was pivotal in providing a standard for visually quantifying adult women's 3D scans by whole body shape as well as component parts from both front and side views. They included

overweight and obese subjects. The BSAS© scale was developed from approximately 40 scans and validated using 700 scans classifying the scans into whole and component shape categories.

Whole body shape provided needed insight relative to the concave and convex surfaces of the human body, but understanding body component relationships from different views (frontal view and side view) adds depth to visual analysis. Minott (1978) categorized the upper and lower body components as well as characteristics of the waistline. August (1981) described characteristics of bust, buttocks, and abdomen prominence and whole body shapes for patternmaking. Armstrong (1995) classified upper body components (back & bust relationships, arm, and shoulder) and lower body components (hip and leg types). Other researchers have sought to find which body components were the best predictors of body build and whole body shape. Hutton, Bayley, Broadhead and Knox (2002), deemed the side silhouette as the most central gauge in determining body shape and posture. In a study using the BSAS© scale, Alexander (2003), found that hip shape was the best predictor of body build. Calabro (2008) compared pattern measurements of tweens to determine any differences between age, body shape and body size. She (2008) found that for pattern shapes, age and body size seemed to change pattern shapes the most.

III. METHODOLOGY

This study analyzes the 3D body scan measurements of 151 tween girls aged 9-14. The intent of this study was to construct profiles for normal and plus size tweens in the sample by 1) comparing the sample's mean heights and weights with the seminal children's sizing study by O'Brien and Girshick (1939) and with the 50th percentile heights and weights specified by the Centers for Disease Control and Prevention to validate the need for updated anthropometrical data; 2) conducting a visual analysis using 3D body scans to determine body shape and body shape component incidence between the normal and plus size tweens in the sample; and 3) comparing body measurements means of normal and plus size tweens in the sample. The resulting information will be beneficial to inform garment sizing and pattern development. This chapter outlines the methods used in this research study. The following subjects are addressed: sample recruitment, data extraction and collection, 3D body scanning protocol, and data analysis.

Sample Recruitment

In order to conduct this study, tween body scans were selected from a database of 3D body scans collected during previous research initiatives in which the researcher participated. Actual data collection involved recruiting subjects at two different times and places. The first group of 41 tween girls was recruited by $[TC]^2$, in Cary, North Carolina,

October 2004, using a screening process to insure a mix of different ages and body sizes for that sample. Recruitment of the 41 tween girls was designed to fill each of four groups with 8-12 girls matching the age and size parameters for the group so that approximately one-half of the girls would be 9-11 and one-half 12-14 and approximately one-half of each of those groups would be below the 85th percentile of BMI and one-half at or above it. The second group of 110 tween girls was recruited in Auburn, AL, November 2005. In this second phase of the on-going study, the subjects were recruited through local newspaper articles and intercepted at a mall site in Auburn, AL and asked to participate in sizing study. The subjects were informed that their consensual participation involved having a 3D body scan using the NX12 $[TC]^2$ scanner, which was set up in the mall corridor, and responding to a questionnaire. The second sample took convenience volunteers on a first come, first serve basis; it was not truly randomized. Incentives were used in both settings and parental consent was required for each participant. Tween participants from both recruiting sessions were combined for a total of 151 participants (See Appendix A). Table 1 represents the breakdown of the tween girls sample arrayed according BMI categories.

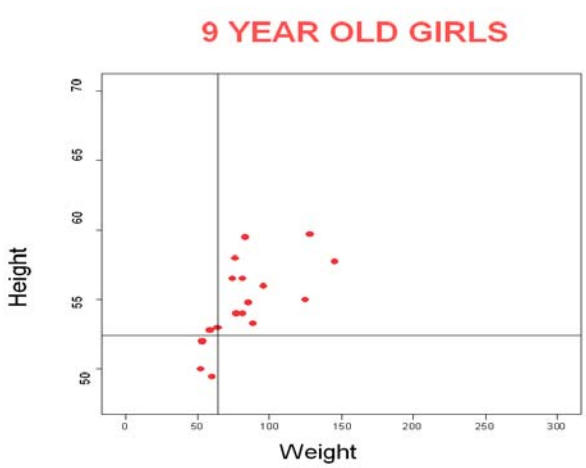
Table 1

Tween Girl Sample Arrayed by BMI as specified by Centers for Disease Control and Prevention

Age	Normal BMI 6^{th} to 84th Percentile	At Risk of Overweight 85^{th} to 94^{th} Percentile	Overweight 95^{th} Percentile and above	Number of subjects per age range	Percentage of sample (n=151)
9	11	3	4	17	11.26 %
10	10	9	3	22	14.57 %
11	17	4	5	27	17.88 %
12	17	5	6	28	18.54 %
13	20	4	3	27	17.88 %
14	16	7	7	30	19.87 %
Totals	91	32	28	151	100 %

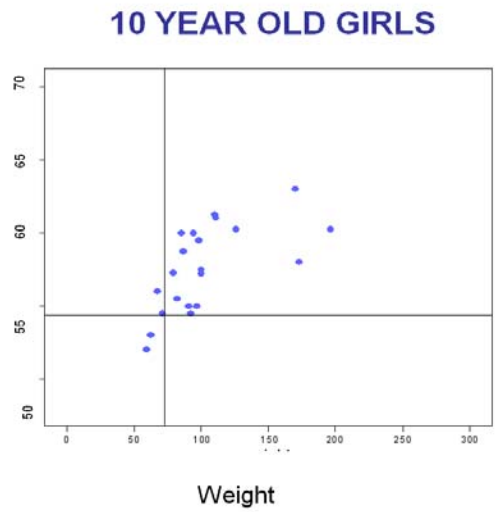
Note. Body Mass Index (BMI) categories for girls: Normal = 6^{th} to 84^{th} percentile, at risk of overweight = 85^{th} to 94^{th} percentile, Overweight = 95^{th} percentile and above

Table 1 takes the entire sample into account for the purpose of noting the BMI for all tweens in the sample. However, there were 6 scans with missing demographic information, e.g., age, race, onset of menarche, which were not used in the analysis of part of the study. The sample of 151 tween girls did not include any who fell into the CDC's underweight category (5^{th} percentile and below), although they were not specifically excluded. Figures 5 thru 10 give a visual representation of how the sample is dispersed relative to the CDC 50^{th} percentile indices for height and weight for ages 9-14.



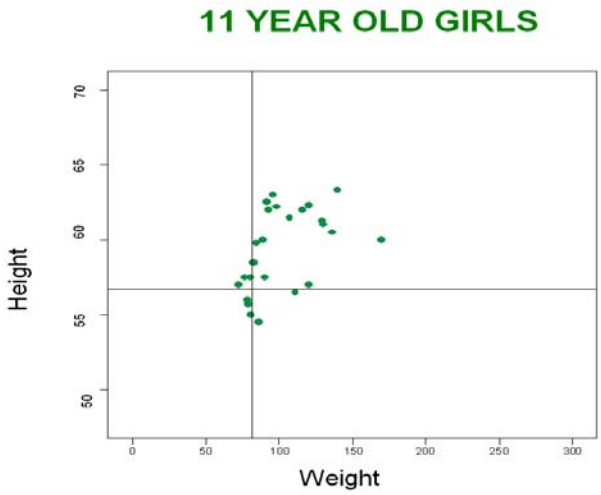
CDC
Weight 63.8 lbs Height 52.4 inches
Sample Data
Weight 78.8 lbs Height 54.4 inches

Figure 5. 9 year old sample relative to the CDC 50th percentile.



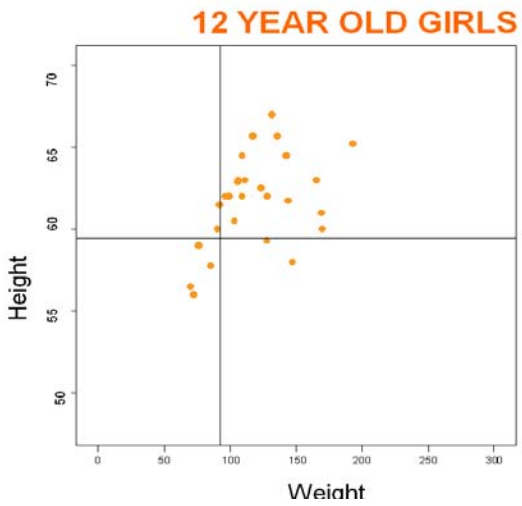
CDC
Weight 72.6 lbs Height 54.3 inches
Sample Data
Weight 93.8 lbs Height 57.5 inches

Figure 6. 10 year old sample relative to the CDC 50th percentile.



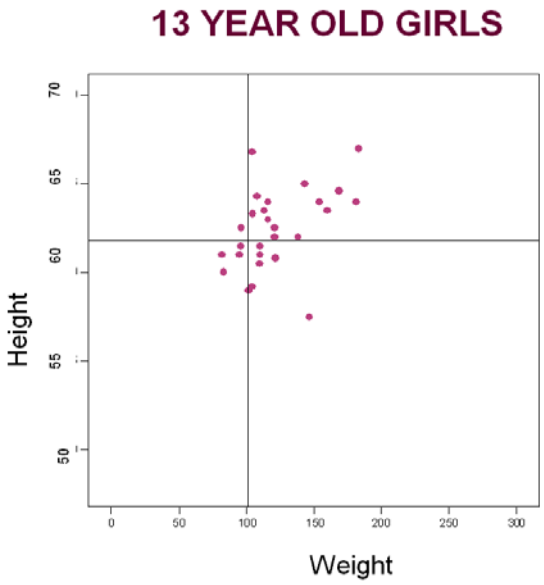
CDC
Weight 81.4 lbs Height 56.7 inches
Sample Data
Weight 91.8 lbs Height 62.3 inches

Figure 7. 11 year old sample relative to the CDC 50th percentile.



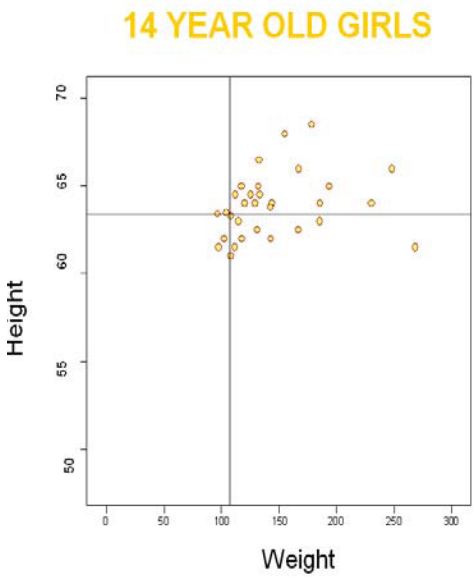
CDC
Weight 92.4 lbs Height 59.4 inches
Sample Data
Weight 114.0 lbs Height 62.0 inches

Figure 8. 12 year old sample relative to the CDC 50th percentile.



CDC
Weight 101.2 lbs Height 61.8 inches
Sample Data
Weight 114.5 lbs Height 62.3 inches

Figure 9. 13 year old sample relative to the CDC 50th percentile.



CDC
Weight 107.8 lbs Height 63.4 inches
Sample Data
Weight 132 lbs Height 64.0 inches

Figure 10. 14 year old sample relative to the CDC 50th percentile.

Data Collection and Extraction

Tween girls in the first sample completed research sessions at $[TC]^2$ headquarters in Cary. $[TC]^2$ personnel operated the body scanner and took height and weight measurements of the girls. For the second sample, the $[TC]^2$ body scanner owned by the Department of Consumer Affairs, Auburn University, was transported to a local shopping mall and erected in a convenient mall corridor close to two large department stores for the purpose of recruiting volunteer passersby who met the study criteria. After completing a parental consent form, the mother of each tween filled out a questionnaire

with questions about the tween, which provided demographic information for the study. Each participant's height and weight was manually recorded by the researchers. Each participant was given a unique and confidential identification number which could match the questionnaire with the same identification number of the corresponding body scan. After completing the preliminary forms, each participant was given instructions for the body scanning procedure. Measurements and body scanning were performed by trained individuals including $[TC]^2$ personnel, the Auburn University National Textile Center apparel research team, and graduate research assistants.

3D Body Scanning Protocol

Each subject selected an appropriately sized and snuggly fitted sports bra and sport short to wear during the scanning procedure. Participants were instructed to remove all loose objects such as jewelry and pull long hair up above the neck with head bands supplied by the researchers to ensure proper scanning. Tween girls entered the first part of the scanner, dressed in the private dressing room, and then entered the actual 3D body scanner. A researcher gave each subject instructions to stand very still with normal posture, hold the nearby handrails, and stand with feet shoulder width apart. The subject was then told to press the indicated button to start the scanner and remain still until the scan was completed and deemed good quality. In some cases, more than one scan was taken per individual, due to some type of error, e.g. body movement in the scanner, incomplete measurement data, or hair getting in the way. After the scan was completed, the participant was allowed to dress and was given a printout out of her 3D body scan and

measurements. The extracted measurements for each individual were automatically stored in the body scan database and coded with each individual subject's identification number.

Data Analysis

Data analysis for this study consisted of three parts: 1) comparative descriptive analysis to compare height and weight means of the sample with the seminal 1939 children's sizing study conducted by O'Brien and Girshick (1939) and the CDC 50th percentiles of weight and height by age; 2) visual analysis to count incidence of whole body shape and body shape components for normal and plus size tweens in each age group; and 3) comparing body measurements including, three circumferences, three lengths, and two principle girths.

Comparative Descriptive Analysis

The purpose of the comparative descriptive analysis was to give further credence to the need for updated sizing charts for tweens by illustrating how critical body measurements used for pattern making and garment construction have changed for girls ages 9-14 over the last six decades. The results of these descriptive comparisons are not for the purpose of generalizing to a larger population because the samples being compared had vastly different sample sizes. The comparative descriptive analysis included two objectives:

1. Compare the sample subjects' mean heights and weights with (a) the mean heights and weights of the same aged sample subjects in the first children's body measurement study by O'Brien and Girshick (1939), and (b) heights and weights designated as the median on the weight-for-age percentiles growth chart for girls aged 2 to 20 developed by the Centers for Disease Control and Prevention (CDC, 2008).

For the analysis of objective 1, descriptive analysis was used to find the mean (M), height (in) and weight (lbs) measurements for the current sample analyzing each age group, respectively. These means were compared to the height and weight means (M) of corresponding age groups reported in O'Brien and Girshick's (1939) children's body measurement study and the values representing the 50^{th} percentile for weight and height recorded in the CDC growth charts.

2. Compare trunk girth measurement means (M) for bust, waist, and hip and length measurement means (M) for hip height, crotch height and waist height (along the side seam) to the same measures for corresponding age groups in the first children's body measurement study (O'Brien & Girshick, 1939; O'Brien et al., 1941)

For the analysis of objective 2, extracted measurements from the current sample were analyzed using descriptive statistics to find the mean (M) measurements of the bust, waist, and hip, hip height, crotch height, waist height (along the side seam) for each age

group and then compared to the means (M) of the corresponding measurements and ages reported in the seminal O'Brien and Girshick's children's body measurement study.

Central Research Analysis

The central research analysis consisted of two integral parts: visual analysis and body measurement comparisons for normal and plus size tweens in the sample. The visual analysis portion of the study was designed to investigate the incidence of whole body shape (hourglass, rectangle, pear, and inverted triangle) and body shape components (bust prominence, buttocks prominence, and torso shape) for normal and plus size tweens in the sample. The body measurement comparisons analyzed three circumferences (bust, waist, and hip circumference), three lengths (waist height, hip height, and crotch height), and two principle girth differences (bust-to-waist difference and waist-to hip difference). Body scan information collected by the NX12 $[TC]^2$ body scanner can be output in different formats, such as extracted measurements, 3D point clouds, and body surface models. For the purpose of this study, the researcher used printed copies of 3D point cloud data which represented each subject's unidentifiable body form (for visual analysis) and used the extracted body measurements (for mean body measurement comparisons).

To conduct the preliminary visual analysis, original body scans for each subject were duplicated (photocopied). The printed scan displayed the 3D image along with the values of the body measurements which were extracted based on the chosen measurement extraction profile (*.mep) data file. The (*.mep) file format simply defines where each measurement on the body is taken (Simmons, 2002) and only outputs the measurements

that are specified by the (*mep) file. To define a (*.mep) file, the user can select a pre-defined set of measures from the NX12 Body Scan software or create a customized (*mep) file. The 3D point cloud data for this study was extracted using a pre-set (*.mep) file where the measurement locations were defined by the American Society of Testing and Materials (ASTM) standards for body measurements. ASTM standards are currently the most widely used body measurement standards in the apparel industry. The ASTM measurements used in this study are listed in Table 2.

Table 2

Defined (.mep) file parameters for specific body measurement locations*

Measurement	Parameter
Bust	The horizontal circumference taken across the bust points at the fullest part of the chest
Waist	Small of back (center back point) to point on front with set upper limit of +1 inch or above small of back and lower limit of -1 inch below small of back
Hip	Largest circumference between the crotch and waist
Waist Height	The vertical distance from the waistline of a standing subject to the floor
Crotch Height	The vertical distance from the crotch of a standing subject to the floor
Hips Height	The vertical distance from the hips of a standing subject to the floor

The printed body scans were divided by age to make a set for each of the six age groups between 9 and 14 years of age. Within each age category, scans were arrayed from smallest BMI to largest BMI. This visual analysis was accomplished based on the BSAS©, an adult female body shape profiling system developed by apparel researchers at

Auburn University (Connell et. al, 2006). The BSAS© included nine scales to analyze 3D body scans for adult females. These scales include: body build, body shape, hip shape, shoulder slope, front torso shape, buttocks shape, back curvature, posture, and bust prominence. The most common changes that occur during puberty affect whole body shape, bust, buttocks, and the torso. Therefore, under the recommendation of the experts who created the BSAS ©, the researcher assessed only four body shape categories using the BSAS © scales as the primary guide for visual evaluation. The body shape categories included whole body shape, bust prominence, buttocks prominence, and torso shape. The 3D body scans for each subject showed both the front and side view of the tween body. The front view was used to visually assess whole body shape. The side view of the 3D body scan was used to assess bust prominence, buttocks prominence, and torso shape (See Figure 11).

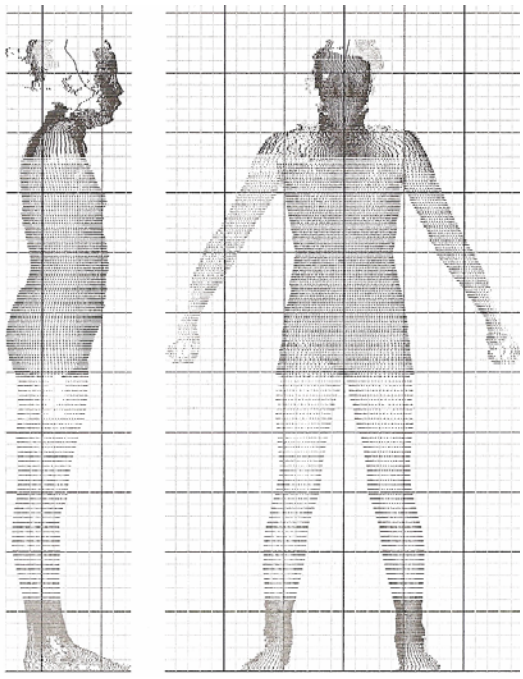


Figure 11. 3D Body Scan Side View and 3D Body Scan Front View

To determine if the tweens' body shapes and body shape components could be adequately categorized using the BSAS © scales, the researcher sought expert validation. The researcher used test/retest reliability for coding the tweens body scans to verify BSAS© usability. To do this, the researcher conducted an initial assessment of the 3D body scans to classify them using the BSAS© scales. Then BSAS© developers conducted a retrospective analysis to determine if the tween body scans were accurately categorized by the researcher according to the BSAS© scales. Final shape designations were counted for incidence. The BSAS© (Connell et al., 2006) categorized 3D body scans into the following whole body shape categories: Rectangular, Hourglass, Pear, and Inverted Triangle (See Figure 12). The BSAS © Bust prominence, Buttocks prominence, and torso shapes are shown in Figures 13, 14, and 15-17.

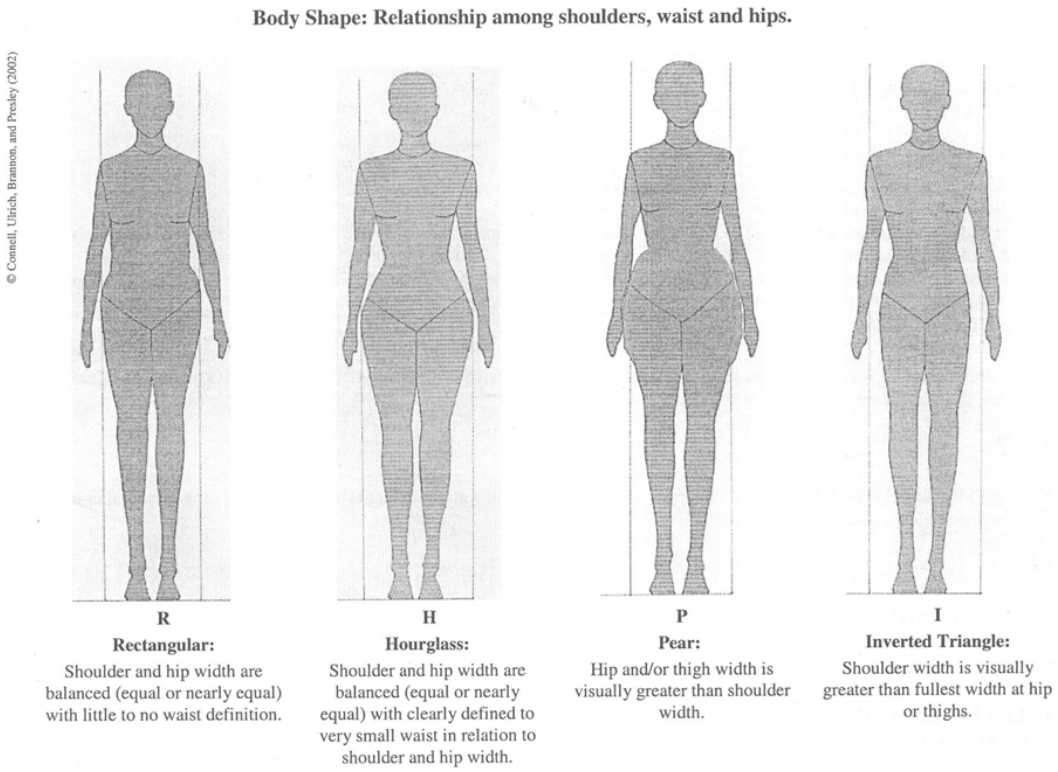


Figure 12. Body Shape Assessment Scale (BSAS ©) from Connell et al., 2006

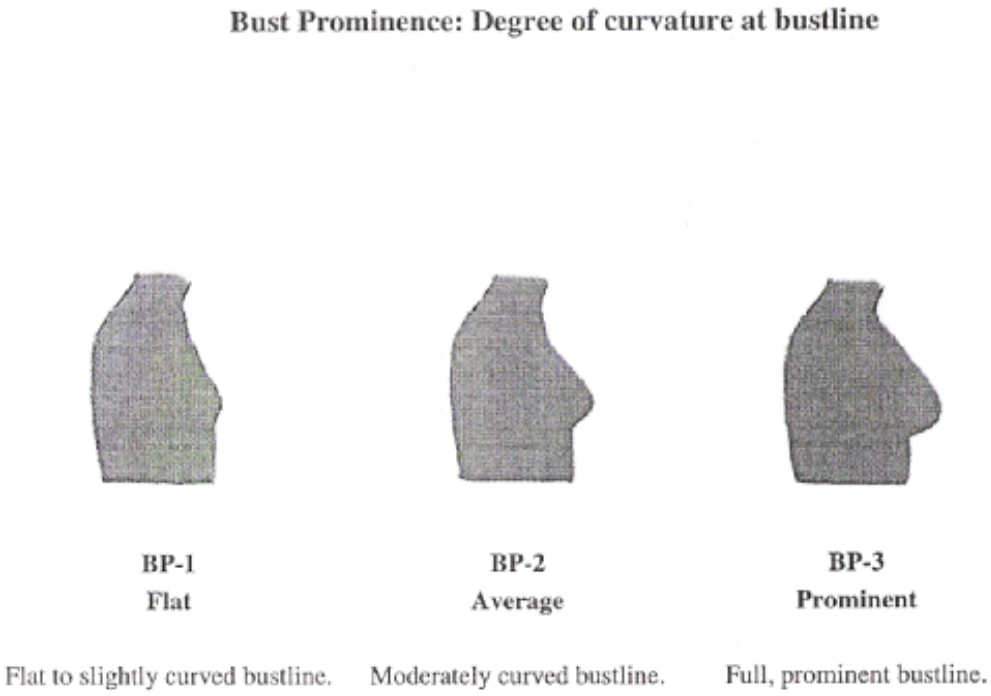


Figure 13. Bust Prominence scale from the Body Shape Assessment Scale (BSAS©) (Connell et al., 2006)

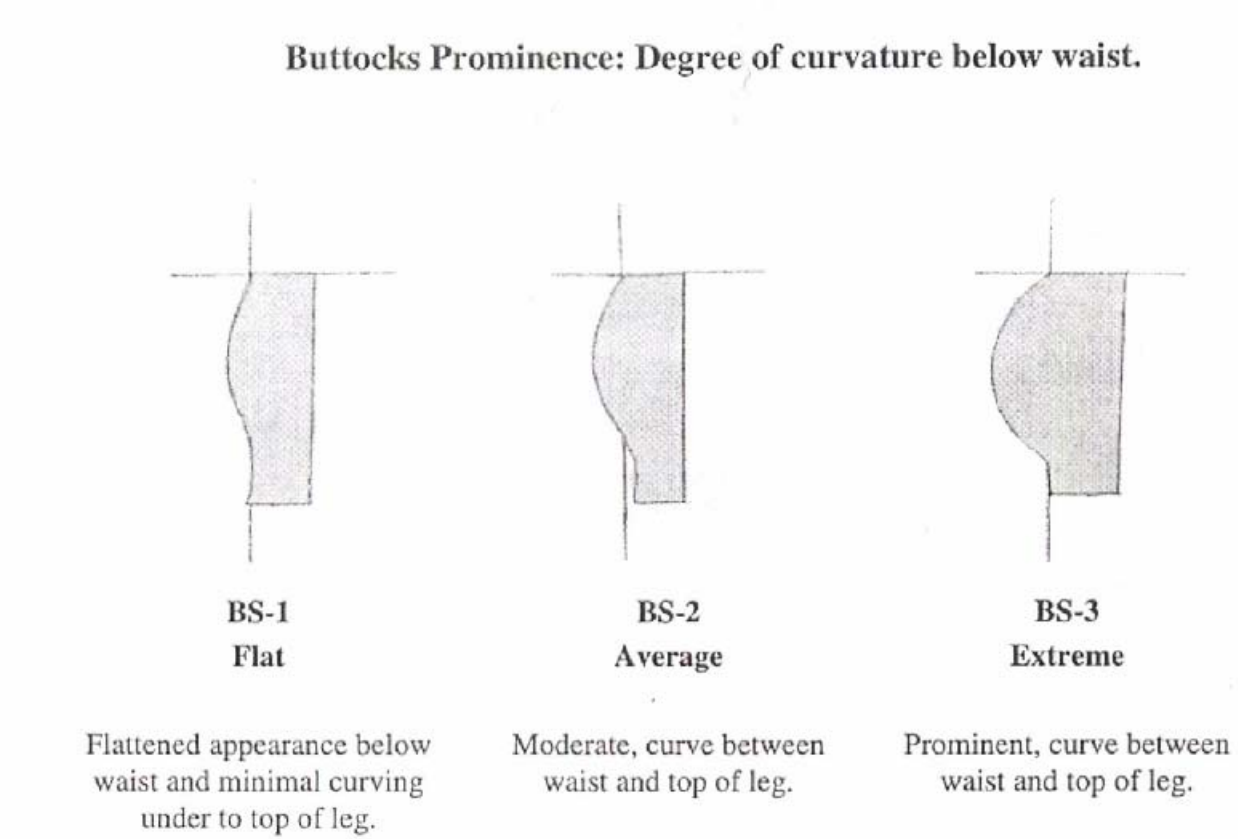


Figure 14. Buttocks Prominence Scale from the Body Shape Assessment Scale (BSAS©) (Connell et al., 2006)

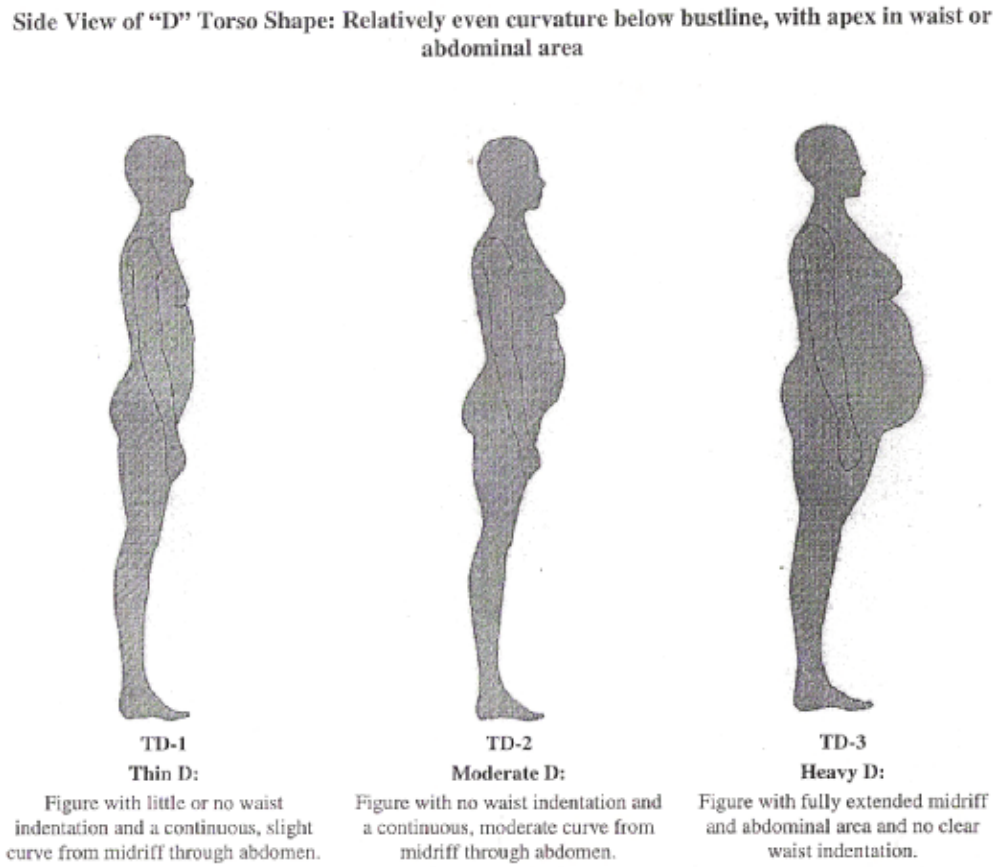


Figure 15. Side torso shapes "D" from the Body Shape Assessment Scale (BSAS ©) (Connell et al., 2006)

Figure 16. Side torso shapes "b" from the Body Shape Assessment Scale (BSAS ©) (Connell et al., 2006)

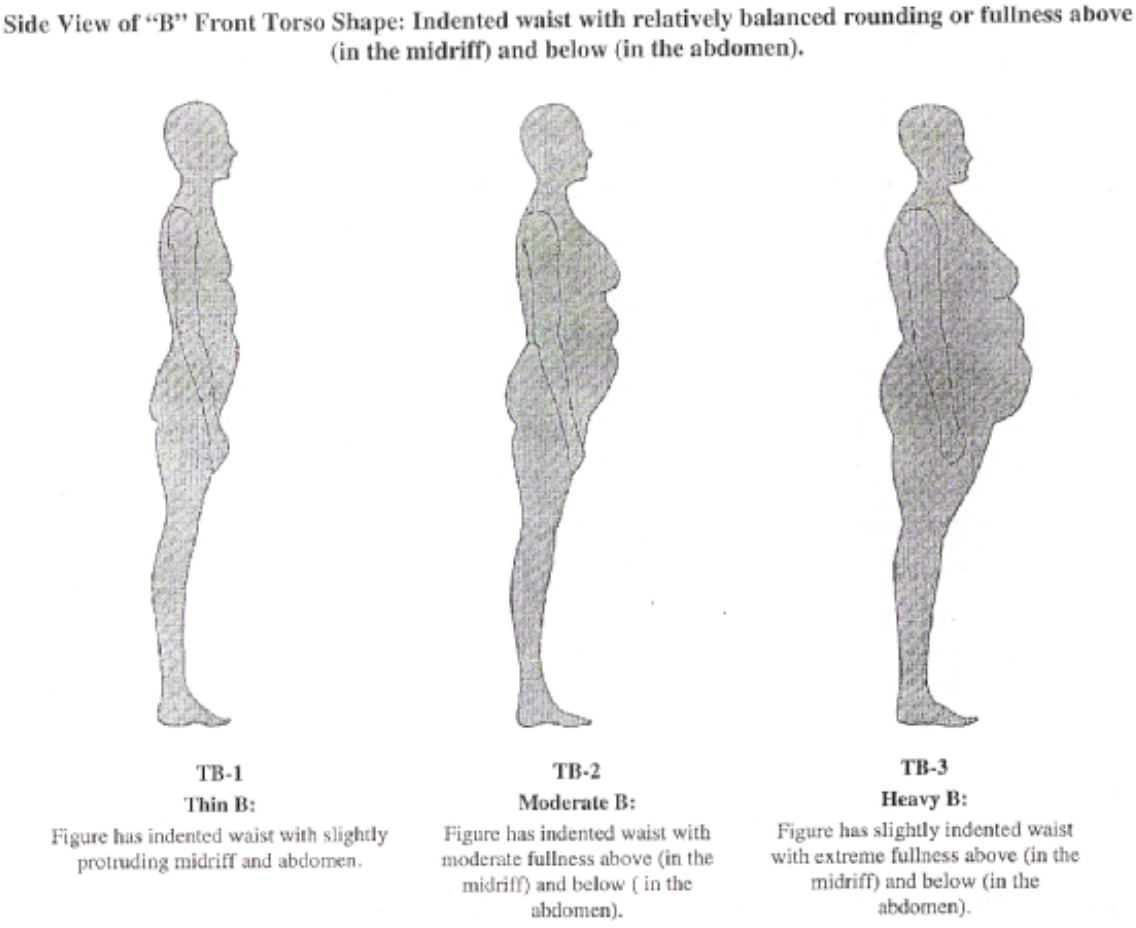


Figure 17. Side torso shapes "B" from the Body Shape Assessment Scale (BSAS ©) (Connell et al., 2006)

The body measurement portion of the study used extracted body measurements exported from the NX12 Body Scan data file into Microsoft EXCEL. The body measurements were screened for any obvious errors e.g. missing measurements, etc. During the body scanning sessions, if any problems were encountered with the first scan resulting in unusable measurement data, tweens were scanned a second time to obtain a better scan for research purposes. In Excel, each individual body measurement being studied was used to created histograms displaying the relationships between normal and plus size tweens for specific body measurements. Calculated coefficients of determination (R^2) were displayed on each chart as a reference for making inferences and drawing conclusions relative to each measurement's relationship for normal and plus size tweens. Trend lines were added for more accurate visual analysis of the correlation.

Research Questions 1-4 were based on visual analysis to explore the incidence of whole body shapes and body shape components for normal and plus size tweens. These questions were as follows:

1. Does the incidence of specific whole body shapes change in relation to age for normal and plus size tweens?
2. Does the degree of bust prominence change in relation to age for normal and plus size tweens?
3. Does the degree of buttocks prominence change in relation to age for normal and plus size tweens?
4. Does the incidence of specific torso shapes change in relation to age for normal and plus size tweens?

Research questions 5-7 compared body measurements for normal and plus size tweens. The body measurements included three circumferences (bust circumference, waist circumference, and hip circumference), three lengths (waist height, hip height, and crotch height) and two principle girth differences (bust-waist difference and waist-hip difference). These questions were as follows:

Research question 5: Do specific circumference measurements including bust, waist, and hips change in relation to age for normal and plus size tweens?

5a. Do bust measurements change in relation to age for normal and plus size tweens?

5b. Do waist measurements change in relation to age for normal and plus size tweens?

5c. Do hip circumference measurements change in relation to age for normal and plus size tweens?

Research question 6: Do specific length measurements including hip height, waist height, and crotch height change in relation to age for normal and plus size tweens?

6a. Does waist height change in relation to age for normal and plus size tweens?

6b. Does hip height change in relation to age for normal and plus size tweens?

6c. Does crotch height change in relation to age for normal and plus size tweens?

Research question 7: Do two specific principle girth measurements (bust-to-waist difference and hip-to-waist difference) change in relation to age for normal and plus size tweens?

7a. How do bust-to-waist differences change in relation to age for normal and plus size tweens?

7b. How do waist-to-hip differences change in relation to age for normal and plus size tweens?

To answer these research questions, the researcher gathered demographic data from each tween's questionnaire including: age, BMI, race, and whether or not the tween had begun menarche. Next body shape classifications including whole body shape, bust prominence, buttocks prominence, and torso shape were categorically coded for each tween. The extracted body measurements were checked for errors and exported to Microsoft Excel. Finally all three files including demographic information, body shape and body component incidence coding, and body measurements for each tween were merged together into one Microsoft Excel file for statistical analysis. Using the tweens' corresponding 3D body scan identification numbers, all of this data was exported to the Statistical Package for the Social Sciences (SPSS) for determining means and correlation.

IV. DATA PRESENTATION AND ANALYSIS

The purpose of this research was to construct profiles of normal and plus size tween girls ages 9-14 by validating the need for updated anthropometrical data for tween girls in this age range, visually analyzing 3D body scans to determine body shape and body shape component incidence, and comparing body measurements for normal and plus size tweens. Data presented in this chapter reports the patterns which emerged for the variables studied and the resulting profiles for tween girls in the sample.

Sample and Procedures

Tween data used in this study were retrieved from the 3D body scan database in the Department of Consumer Affairs, Auburn University. The participants of the original study that generated the database were recruited in two different sessions for a total of 151 participants. The first group was recruited by $[TC]^2$, in Cary, North Carolina, in October 2004, using a screening process to insure a mix of different ages and body sizes for that sample; the recruiting goal was to have a similar number of normal and plus size 9-11 and 12-14 year old girls. The second group was recruited in Auburn, AL, in November 2005, when 9-14 year old girls were scanned at a mall on a first come, first serve basis. The first group (N=41) and second group (N=110) of participants were combined for a total of 151 subjects.

Data analysis for this study consisted of three integral parts. The first part was a comparative descriptive analysis of the study sample with the seminal children's body

measurement study conducted by O'Brien and Girshick (1939), not to generalize to a larger population, but to investigate possible differences in tweens' height, weight, and selected body measurements from then to now. O'Brien et al. (1941) recorded the measurement techniques and statistical analysis used in the study. The second part encompassed the central research analysis which included visual analysis as well as body measurement comparisons for normal and plus size tweens in the sample. The visual analysis was designed to investigate recurring themes within a sample to determine which body shape factors showed patterns of occurrence relative to whole body shape and which body shape components (bust prominence, buttocks prominence, and torso shape) for the purpose of profiling normal and plus size tweens ages 9-14. The body measurement comparisons for normal and plus size tweens included the comparison of three circumference means (bust, waist, and hip), three length means (waist height, hip height, and crotch height) and two principle girth differences (bust-to-waist difference and waist-to-hip difference).

Preceding the analysis, it was to be determined if the sample of tweens should be divided by age, race, BMI, and timing of menarche, or some specific combination of these factors in order to analyze the data. Experts in body shape analysis (two primary developers, Connell and Ulrich, of the BSAS©) recommended subdividing and profiling tween subjects by BMI and age. In addition to the recommendation, correlation analysis was conducted to determine if race and menarche significantly affected body shape and/or any of the body shape components. It was determined that neither race (r= -01.25) nor menarche (r= -0.130) were significant factors of determination for this sample of tweens, therefore the sample was not divided by race and menarche, only age and BMI.

However, menarche was included in the discussion and the profile descriptions for all age groups to add depth to the analysis.

To begin the analysis, the researcher used BMI scores, to divide the sample of tweens into two BMI groups for each age group for analysis. The two BMI groups were a) tweens with normal BMI scores (6th to 84th percentile for BMI) and b) tweens with BMI scores that were deemed "at risk of overweight" (85th to 94th percentile for BMI) and those deemed "overweight" (95th percentile or higher) by the Centers for Disease Control and Prevention (CDC, 2008). For this study, tweens deemed "at risk of overweight" and those deemed "overweight" were combined into one category called plus size because the sample sizes would be too small if divided by "at risk of overweight" and "overweight". There were not any underweight tween girls in the database.

Procedures for Visual Analysis

For the visual analysis, the researcher and body shape experts used test/retest reliability for coding the tweens' body scans to verify BSAS© usability. The BSAS© was initially developed to only categorize adult female body figures. An overall consensus for the test/retest reliability results was that although the tween bodies were different heights and different body weights than adult female figures, the bodies still had multiple features similar to adult figures and the BSAS© should be used as a tool to analyze tween body scans. Each tween scan was then analyzed and categorized by the researcher according to whole body shape and body shape components (bust prominence, buttocks prominence, and torso shape.

After preliminary categorization by the researcher, the experts reviewed the researcher's designations and confirmed or corrected the body shape and body shape component categorizations for each tween scan. There was some difficulty determining whole body shape for some of the 9 year old tweens. This was because girls' rib cages sometimes protruded out past the waist line. This protrusion caused more of an angle just below the rib cage that could not necessary be labeled as waist indentation.

When developing the BSAS©, guidelines included using the right side of the body on the printed 3D scan to determine body shape when the left and right sides appeared different in the face front position. In the tweens case, the experts recommended making a judgment call by comparing both sides of the body to determine body shape in instances where it appeared that the tween was shifting weight to one side or standing in a twisted manner.

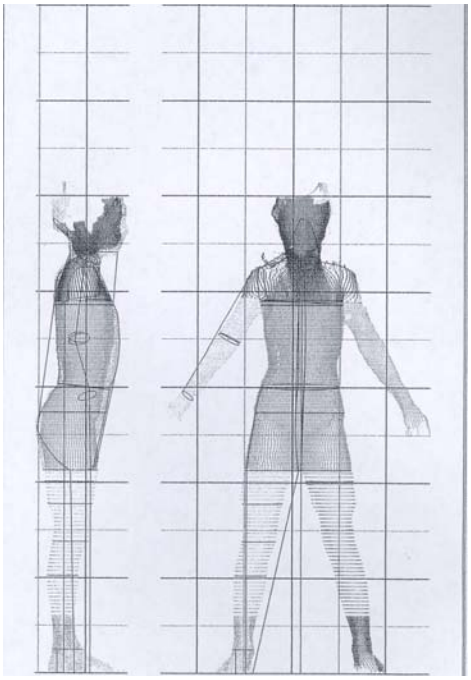


Figure 18. Nine year old tween with protruding rib cage standing with torso twisted while in the body scanner.

Experts involved in data collection recalled that the girls sometimes seemed tense and anxious while having their body scans completed and may not always have stood naturally (See Figure 18).

Description of the Sample

Tweens recruited for this sample totaled 151 subjects. However, six questionnaires were not completed or had missing demographic information, reducing the sample size to 145. For the visual analysis, scans of each subject were printed. Ten of the scans in the sample were omitted from the visual analysis portion of the study because those ten body scans could not be printed from the database (N=141). However, the measurement data for these scans were available for the other parts of the study.

Age Distribution

Table 3

Age Distribution within the Sample

Age	N	Percentage
9	15	10.34%
10	20	13.80%
11	27	18.62%
12	25	17.24%
13	28	19.31%
14	30	20.69%
Totals	145	100.00%

The age distribution of the sample (N=145) by percentages is presented in Table 3. The 14 year old age group had the largest percentage of subjects, 20.69% (n=30) and the 9 year old age group had the smallest percentage 10.34% (n=15).

Height Distribution

Table 4 lists the mean heights (in) for normal and plus size tweens for each age group within the sample. As expected the mean heights for both the normal and plus size groups increased with age. In general, heights for plus size tweens were greater than heights for the normal size tweens, but the difference narrowed for the older age groups. The biggest difference between age groups was 2.92 inches (10 and 11 year old normal size girls) and 2.66 inches (11 and 12 year old plus size girls).

Table 4

Height Means Within the Sample

Age	Mean Height (inches) Normal Size Tweens	Standard Deviation (SD)	Mean Height (inches) Plus Size Tweens	Standard Deviation (SD)
9 (n=15)	53.81	3.46	56.79	2.52
10 (n=20)	56.34	2.73	58.92	2.87
11 (n=27)	59.26	2.70	59.80	2.85
12 (n=25)	61.35	2.79	62.46	2.63
13 (n=28)	62.53	2.18	62.29	2.33
14 (n=30)	63.02	1.09	64.11	1.96

Weight Distribution

Table 5 lists the mean weights for both the normal and plus size tweens in each group. Overall, weight means increased with age. Means increased from year to year for the normal size tweens except for ages 10-11 and for the plus size tweens except for ages 10-11 and 12-13. The largest increase was just over 21 pounds for normal size tweens between ages 11 and 12. For the normal size tweens, the weight changes between age groups were as follows 9-10 (10.3 lbs), 10-11 (-2.1 lbs), 11-12 (21.3 lbs), 12-13 (1 lb), and 13-14 (15.9lbs). For the plus size tweens, the weight differences between age groups were as follows: 9-10 (16.6 lbs) 10-11 (-2 lbs), 11-12 (18.5 lbs), 12-13 (-10.5 lbs), and 13-14 (21.8 lbs).

Table 5

Weight Means Within the Sample

Age	Mean Weight in lbs Normal Size Tweens	Standard Deviation (SD)	Mean Weight in lbs Plus Size Tweens	Standard Deviation (SD)
9 (n=15)	65.6	11.62	110.2	25.94
10 (n=20)	75.9	11.26	126.8	38.43
11 (n=27)	73.8	29.68	124.8	22.37
12 (n=25)	95.1	14.33	143.3	24.47
13 (n=28)	96.1	9.58	132.8	25.99
14 (n=30)	112.0	6.03	153.82	43.80

Race Distribution

In this sample, Table 6 shows the largest percentage of subjects, 65.52% (n=95) were Caucasian, followed in percentage rank by African Americans, 26.89% (n=39). The smallest percentage of subjects in the sample were Asian (n=2) and Hispanic (n=2), 1.38% respectively, with only a slightly higher percentage of Native American subjects (4.83%, n=7).

Table 6

Race Distribution within the Sample

Race	N	Percentage
African American	39	26.89%
Asian	2	1.38%
Caucasian	95	65.52%
Hispanic	2	1.38%
Native American	7	4.83%
	145	100.00%

BMI Distribution

Table 7 shows that 63% of the entire sample fell within the 6^{th}- 84^{th} percentile, which is the normal range of BMI; 22% of the entire sample was "at risk of overweight", and 19% were at or above the 95^{th} percentile. For this study the latter two groups, "at risk of overweight" and "overweight," were combined into one category labeled "plus size". Within the plus size category in each age group, the number of tween girls who fell into the "at risk of overweight" and the "overweight" categories were close except for the 10 year olds.

Table 8 shows the BMI score ranges for the normal and plus size categories and the midpoint in the normal range as defined by the CDC, along with the mean BMI scores by age for the sample. The mean BMI scores for the plus size tweens in the sample were much higher than those of the normal size tweens. The means for the normal size tweens within the sample were close to the midpoint BMI specified by the CDC. The 11 year olds had the largest difference between the mean BMI and the CDC midpoint (1.8). The 9 and 10 year old plus size tweens exceeded the specified BMI range for the overweight category by 2.2 and 2.5. The 11 and 12 year olds were minimally larger, and the 13 and14 year olds' BMI scores were within the upper portion of the range.

Table 7

BMI Mean Distribution by Age within the Entire Sample

Age	Normal 6th-84th Percentile	At Risk of Overweight 85th-94th Percentile	Overweight 95th Percentile and Above	At Risk of Overweight & Overweight Combined "Plus-Size"	*Total Number of Tweens in each Age Group*
9	11 N=73%	*2*	*2*	4 N=27%	15
10	10 N=50%	*0*	*10*	10 N=50%	20
11	18 N=67%	*2*	*7*	9 N=33%	27
12	14 N=56%	*3*	*8*	11 N=44%	25
13	20 N=71.4%	*2*	*6*	8 N=28.6%	28
14	17 N=57%	*5*	*8*	13 N=43%	30
	90	*14*	*41*	*55*	145

Table 8

BMI Comparisons Separated by Normal and Plus Size Tweens

Age	CDC* BMI by Age for the 6th-84tth Percentile)	BMI Means Normal Size Tweens 6th-84th Percentile	Standard Deviation (SD)	CDC* BMI by Age for the 85th Percentile and Above	BMI Means Plus Size Tweens 85th Percentile & Above	Standard Deviation (SD)
9 (n=15)	13.7-19.1 16.4**	15.8	1.28	19.2-over 21.9	24.1	5.24
10 (n= 20)	14.1-20.0 17.05**	16.9	1.39	20.1-over 23.1	25.6	6.76
11 (n= 27)	14.0-20.8 17.4**	15.6	5.84	20.9-over 24.2	24.3	3.52
12 (n= 25)	14.9-21.6 18.25**	18.1	1.29	21.7-over 25.3	25.9	4.73
13 (n= 28)	15.3-22.6 18.95**	18.8	1.08	22.7-over 26.3	23.5	3.80
14 (n= 30)	15.9-23.2 19.55**	19.6	0.77	23.3-over 27.2	26.35	7.68

* Centers for Disease Control and Prevention ** Midpoint BMI in the CDC BMI range

Menarche Distribution

Table 9 shows the number of subjects in each age category who had reached menarche (the first menstruation cycle) and those who had not. For the most part, the percentages of girls at each age who had or had not reached menarche were not very different for the normal and plus size groups. The clear exception was the 11 year olds. As expected more 9 and 10 year olds had not reached menarche than those who had. However, at years 13 and 14, there were still approximately one half to one third of the girls who had not begun menstruating. Perhaps because of the sensitivity of the subject of menarche, mother of one of the 11 year old respondents did not answer whether or not her daughter had reached menarche.

Table 9

Menarche Distribution Within the Sample

Age	Had reached Menarche Normal BMI	Had not reached Menarche Normal BMI	Total	Had reached Menarche Plus Size BMI	Had not reached Menarche Plus Size BMI	Total
9 (n=15)	36.3% (N=4)	63.6% (N=7)	100%	0% (N=0)	100% (N=4)	100%
10 (n=20)	30% (N=3)	70% (N=7)	100%	40% (N=4)	60% (N=6)	100%
11 (n=26)	25% (N=4)	75% (N=12)	100%	50% (N=5)	50% (N=5)	100%
12 (n=25)	71.4% (N=10)	28.6% (N=4)	100%	45.4% (N=5)	54.5% (N=6)	100%
13 (n=28)	55% (N=11)	45% (N=9)	100%	37.5% (N=3)	62.5% (N=5)	100%
14 (n=30)	92.9% (N=13)	7.1% (N=1)	100%	43.8% (N=7)	56.2% (N=9)	100%
Total (N=144)	N=45	N=40		N=24	N=35	

Findings

Comparative Descriptive Analysis

The purpose of this portion of the study was to provide a descriptive analysis to give further credence to the need for updated sizing charts for tweens by illustrating how critical body measurements used for pattern making and garment construction may have changed for girls ages 9-14 over the past decades. The first research objective was as follows:

1. Compare the sample subjects' mean heights and weights with (a) the mean heights and weights of the same aged sample subjects in the first children's body measurement study by O'Brien et al. (1941), and with (b) heights and weights designated as the median on the weight-for-age percentiles growth chart for girls aged 2 to 20 developed by the Centers for Disease Control and Prevention (CDC, 2008).

Table 10 compares the heights and weights of the sample from the O'Brien et al.(1941) study, and the heights and weights noted as the 50^{th} percentile for each age as specified by the Centers for Disease Control and prevention (CDC, 2008).

Table 10

Height and Weight Comparisons

Age	O'Brien , Girshick & Hunt (1941) (mean)	CDC** (median)	Sample (mean)
9 Years			
Height (inches)	52.2 (2.2)*	52.4 (2)*	54.4
Weight (lbs)	63.1 (15.7)*	63.8 (15)*	78.8
10 Years			
Height (inches)	54.41 (3.09)*	54.3 (3.2)*	57.5
Weight (lbs)	70.2 (23.6)*	72.6 (21.2)*	93.8
11 Years			
Height (inches)	56.74 (3.16)*	56.7 (3.2)*	59.9
Weight (lbs)	78.77 (13.03)*	81.4 (10.4)*	91.8
12 Years			
Height (inches)	59.11 (2.89)*	59.4 (2.6)*	62
Weight (lbs)	89.08 (24.92)*	92.4 (21.6)*	114
13 Years			
Height (inches)	61.02 (1.23)*	61.8 (0.45)*	62.25
Weight (lbs)	98.88 (15.62)*	101.2 (13.3)*	114.5
14 Years			
Height (inches)	62.17 (1.83)*	63.4 (0.6)*	64
Weight (lbs)	106.17 (25.83)*	107.8 (24.2)*	132

** Net Difference calculated by subtracting from the sample height and weight, respectively*

*** Centers for Disease Control and Prevention (CDC, 2008)*

9 year olds height and weight comparisons

The mean height (M=54.4 in) and weight (M=78.8 lbs) for sample subjects in the 9 year old age group was greater than the CDC 50th percentile height (M= 52.4 in) and weight (M=63.8 lbs). It was also greater than mean height (M= 52.2 in) and weight (M= 63.06 lbs) for 9 year olds in the O'Brien et al. (1941) children's study. The CDC and O'Brien et al. numbers for 9 year olds were similar.

10 year old height and weight comparisons

The mean height (M=57.5 in) and weight (M=93.8 lbs) for the 10 year old age group in the sample was greater than the CDC 50th percentile height (54.3 in) and weight (M=72.6 lbs) for 10 year olds. It was also greater than mean height (M= 54.4 in) and mean weight (70.2) for 10 year olds in the O'Brien et al. (1941) children's study. The CDC 50th percentile height (54.3 in) and weight (M=72.6 lbs) for 10 year olds was in close proximity to the mean height (M= 54.4 in) and weight (M= 70.2 lbs) for 10 year olds in the O'Brien et al. (1941) children's study.

11 year old height and weight comparisons

The mean height (M=59.9 in) for the 11 year old subjects was greater than the CDC 50th percentile height (56.7 in) for 11 year olds and the mean height (56.7 in) for 11 year olds in the O'Brien et al. (1941) study. However, both the CDC 50th percentile (56.7 in) and the O'Brien et al. (1941) study had equal heights (M= 56.7 in). The sample's mean weight for 11 year olds (M=91.8 lbs) was higher than both the CDC 50th percentile (81.4 lbs) and O'Brien et al.(M=78.7 lbs).

12 year old height and weight comparisons

For the 12 year old age groups, height was quite similar between the CDC 50th percentile (59.4 in) and the O'Brien et al. study (M=59.1 in), but the mean height (M=62 in) for 12 year olds in the sample was greater than both. There was a big difference between the 12 year olds' mean weight (M=114 lbs), the CDC 50th percentile (92.4 lbs) and O'Brien and Girshick's mean weight for 12 year olds (M= 89.1 lbs).

13 year old height and weight comparisons

The mean or median heights for all three groups of 13 year olds, sample (M=62.2 in), CDC 50th percentile (61.8 in) and O'Brien et al. (M= 61) were fairly similar. However, the mean weight (M= 114.5 lbs) for the 13 year olds in the sample was still much higher than for 13 year olds in the CDC 50th percentile (101.2 lbs) and the O'Brien et al. study (M=98.8 lbs)

14 year old height and weight comparisons

The mean height for the 14 year olds was somewhat different for the sample (M=64 in), the CDC 50th percentile (63.4 in) and O'Brien et al. (M=62.17 in). There was only a slight difference between the weight for the CDC 50th percentile (M=107.8 lbs) and the O'Brien et al. study (M= 106.1 lbs.), but the sample (M= 132 lbs) was much greater.

The second objective in the comparative descriptive analysis was as follows:

2. Compare trunk girth measurement means (M) for bust, waist, and hip and length measurement means (M) for hip height, crotch height and waist height (along the side seam) to the same measures for corresponding age groups in the first children's body measurement study by O'Brien et al. (1941). Table 11 presents

these critical body measurements that are generally used in pattern development for the sample and the O'Brien et al. (1941) study.

Table 11

Body Measurement Comparisons

	Bust	Waist	Hips	Hips Ht	Crotch Ht	Waist Ht
9 year olds						
Sample	29.6	26.1	32.11	25.94	25.01	33.29
O'Brien et al.	25.7	22.7	26.64	25.31	23.94	32.89
Net Difference	3.9	3.4	5.47	0.63	1.07	1.00
10 year olds						
Sample	28.22	28.13	34.4	28.27	26.38	35.44
O'Brien et al.	27.08	23.23	27.61	27.82	25.06	34.3
Net Difference	1.14	4.9	6.79	0.45	1.32	1.14
11 years old						
Sample	30.23	27.99	34.62	28.69	27.23	36.67
O'Brien et al.	27.82	23.44	29.74	29.28	26.25	36.27
Net Difference	2.41	4.59	4.88	-0.59	0.98	0.4
12 years old						
Sample	34.95	29.65	36.95	30.42	28.76	38.67
O'Brien et al.	29	24.15	31.48	30.53	27.38	37.85
Net Difference	5.95	5.5	5.47	-0.11	1.38	0.82
13 years old						
Sample	33.64	29.81	37.16	29.72	28.73	38.15
O'Brien et al.	30.28	24.7	33.19	31.43	28.16	39.02
Net Difference	3.36	5.11	3.97	-1.71	0.57	-0.87

Table 11 Cont.	Bust	Waist	Hips	Hips Ht	Crotch Ht	Waist Ht
14 years old						
Sample	36.17	30.74	35.32	30.33	28.35	38.46
O'Brien et al.	27.19	25.87	34.48	31.87	28.54	39.7
Net Difference	8.98	4.87	0.84	-1.54	-0.19	-1.24

9 year old tween comparison of mean body measurement

The bust mean (29.6) for the 9 year olds in this sample was 3.9 inches greater than the measurement for bust in the O'Brien et al. study (M=25.73 . The waist (M= 26.1 in.) and hip (M= 32.11 in.) means for the sample were approximately 3 to 5 inches greater, respectively, than waist (M=22.7 in.) and hip (M= 26.64 in.) means for the O'Brien et al. study. Hip height means for the sample (M=25.94 in.) and the comparison study (M= 25.31 in.) were fairly close in range, having only a 0.63 inch difference. Crotch height for the sample (M=25.01 in.) was greater than O'Brien et al. (M=23.91 in.) but only by a small margin. Waist height means for the sample (M= 33.29 in.) and the O'Brien et al. study (M= 32.89 in.) were less than half an inch different.

10 year old tween comparison of mean body measurements

The bust mean for the 10 year olds in the sample (M= 28.22 in.) was slightly more than 1 inch greater than the O'Brien et al. study (M= 27.08 in.). The waist (M= 28.13 in.) and hip (M=34.4 in.) means for the sample had bigger differences. The sample's waist mean was almost 5 inches more than that of the O'Brien et al. study (M=23.23 in.), and the hip mean was almost 7 inches more than the O'Brien et al. study hip mean (M=27.61 in.). Hip height was 0.45 inch greater for the sample (M= 28.27 in.) than for the comparison study (M= 27.82 in.). Crotch height for the sample (M= 26.38

in.) was 1.32 inches greater than the comparison study (M=25.06 in). The waist height mean for the sample (M= 35.44 in) was 1.14 inches more than the O'Brien et al. study (M= 34.3 in).

11 year old tween comparison of mean body measurements

The bust (M=30.23 in.), waist (M=27.99 in.), and hip (M=34.62 in.) means for the 11 year olds in the sample were 3-5 inches higher than those for the O'Brien et. al. study, which were: bust(M=27.82 in.), waist(M=23.44 in.), and hip (M=29.74 in.). The hip height (M=29.28 in.), for the O'Brien et al. study was more than half an inch higher than the sample (M= 28.69 in.). The crotch height (M=27.23 in.) and waist height (M=36.67) also were greater in the sample. The crotch height and waist height means for the comparison study were M= 26.25 inches and M= 36.27 inches, respectively.

12 year old tween comparison of mean body measurements

Like the previous age groups, the twelve year old sample was nearly consistent with larger measurements than the comparison study. In this instance, the bust (M= 34.95 in.), waist (M=29.65 in.), and hip (M=35.95 in.) means were greater than the bust (M=29.0 in.), waist (M=25.15 in.), and hip (M=31.48 in.) means of the comparison study. The hip height mean (M=30.53 in.) for the comparison study was greater that the sample (M=30.42 in.) by less than a quarter inch. The sample's crotch height (M=28.76 in.) and waist height (M=38.67 in.) means were almost an inch and a half greater than the same measurements of the O'Brien et al. study, (M=27.38 in.) and (M=37.85 in.), respectively.

13 year old tween comparison of mean body measurements

The bust (M=33.64 in.), waist (M=29.81 in.), and hip (M=37.16 in.) means followed the same pattern as most of the other age groups, having greater values than those of the comparison study for which the means were bust (M=30.28 in), waist(M=24.7 in.), and hip (M=33.19 in.). However, the hip height mean (M=31.43 in.) for the comparison study was greater that the sample (M=30.53 in.). The sample's crotch height (M=28.73 in.) mean was 0.57 inches greater than the crotch height mean for 13 year olds in the O'Brien et al. study, but the waist height mean (M=38.15 in.) was 0.87 inches less than the study.

14 year old tween comparison of mean body measurements

The 14 year old group had a slightly different pattern. The bust (M=36.17 in.), waist (M=30.74 in.), and hip (M=35.32 in.) means were still greater than the bust (M=27.19 in.), waist (M=25.87 in.), and hip means (34.48 in.) of the comparison study. However, the hip height (M=31.87 in.), crotch height (M=28.54 in), and waist height (M=39.7 in) means of the O'Brien et al. study were all greater than the hip height (M=30.33 in.), crotch height (M=28.35 in.) and waist height (M=38.46 in.) means of the 14 year old group in the sample.

Central Research Analysis

Research questions 1-4 were answered using visual analysis. To address the questions, tween body shapes and body shape components were coded and recorded in tables that showed the incidence of each of the different body shapes and body shape components for normal and plus size tweens in each age group. Body shape was coded as 1=Hourglass, 2= Rectangle, 3= Pear, and 4= Inverted Triangle. Bust prominence was

coded as 1=Flat, 2=Flat with Budding, 3=Average, and 4=Prominent. During the visual analysis session, the researcher and experts deemed it necessary to add an additional category of "Flat with budding" to accommodate the tweens in the sample who did not fit into one of the categories designated by the BSAS© bust prominence scale. This addition was prompted by frequent occurrences of subjects in the sample who had started to show signs of breast development. Therefore the BSAS© designations for Bust Prominence were modified to "Flat with budding". Buttocks Prominence was coded as 1=Flat, 2=Average, and 3=Extreme. Torso shape was coded as 1=Thin D, 2=Moderate D, 3=Heavy; D, 4=Thin b, 5= Moderate b, 6= Heavy b; and 7=Thin B, 8=Moderate B, 9=Heavy B. The incidences of each body shape and each body shape component were counted and recorded for the Normal BMI group (BMI= 6^{th}-84^{th} percentile according to CDC) and those in the Plus Size BMI group (BMI= 85^{th} percentile and above according to CDC) in each age group. The counted numbers were transformed into percentages to facilitate analysis of possible patterns and development of profiles.

Research question 1: Does the incidence of specific whole body shapes change in relation to age for normal and plus size tweens?

Table 12 shows that most of the normal size 9 year olds had an hourglass body shape. The 10 year olds were nearly evenly divided between the rectangle and hourglass body shapes. Fifty to sixty-five percent of the 11-14 year olds were hourglass. For the 11-13 year olds, rectangle was the second most common shape (25-36%). However, pear was observed as the second most common shape for the 14 year olds. Although some of the cell sizes were small, there was still a noticeable pattern of body shape incidence for the normal size tweens.

Table 12

Whole Body Shape for Tweens with Normal BMI

		Whole Body Shape Tweens with Normal BMI (6th-84th Percentile)				Total
		Hourglass	Rectangle	Pear	Inverted Triangle	
AGE	9	72%	10%	18%	0%	100%
		N=8	N=1	N=2	N=0	N=11
	10	40%	50%	0%	10%	100%
		N=4	N=5	N=0	N=1	N=10
	11	59%	35%	6%	0%	100%
		N=10	N=6	N=1	N=0	N=17
	12	50%	36%	14%	0%	100%
		N=7	N=5	N=2	N=0	N=14
	13	65%	25%	10%	0%	100%
		N=13	N=5	N=2	N=0	N=20
	14	50%	14.3%	35.7%	0%	100%
		N=7	N=2	N=5	N=0	N=14
Total		49	24	12	1	86

Table 13 shows that overall the plus size tweens showed a smaller incidence of the hourglass shape and a greater incidence of the pear shape. For the 9 year olds, however, there was an even split between hourglass and rectangle. Rectangle was the most common shape for the 10 and 11 year olds. Most 12 year olds were either rectangle or pear shape. More 13 year olds were a rectangle than appear. Among 14 year olds, there was a relatively close split between hourglass, rectangle, and pear.

Table 13

Whole Body Shape for Tweens with Plus Size BMI

		Whole Body Shape Tweens with Plus Size BMI (85th Percentile and Above)				Total
		Hourglass	Rectangle	Pear	Inverted Triangle	
Age	9	50% N=2	50% N=2	0% N=0	0% N=0	4
	10	10% N=1	70% N=7	20% N=2	0% N=0	10
	11	10% N=1	70% N=7	20% N=2	0% N=0	10
	12	10% N=1	45% N=5	45% N=5	0% N=0	11
	13	0% N=0	63% N=5	37% N=3	0% N=0	8
	14	37.5 N=6	25% N=4	37.5% N=6	0% N=0	16
Total		11	30	18	0	59

Research question 2: Does the degree of bust prominence change in relation to age for normal and plus size tweens?

Table 14

Bust Prominence for Tweens with Normal BMI

		BUST PROMINENCE Tweens with Normal BMI (6th-84th Percentile)				Total
		Flat	Flat with Budding	Average	Prominent	
AGE	9	82%	18%	0%	0%	
		N=9	N=2	N=0	N=0	11
	10	80%	20%	0%	0%	
		N=8	N=2	N=0	N=0	10
	11	65%	29%	6%	0%	
		N=11	N=5	N=1	N=0	17
	12	21%	50%	29%	0%	
		N=3	N=7	N=4	N=0	14
	13	5%	75%	15%	5%	
		N=1	N=15	N=3	N=1	20
	14	0%	36%	50%	14%	
		N=0	N=5	N=7	N=2	14
Total		32	36	15	3	86

Table 14 shows that a large percentage of the normal size 9 and 10 year old tweens were in the flat category for bust prominence, but that decreased steadily with age to zero incidence at age 14. The incidence of flat with budding, i.e. minimal bust prominence or the beginning of bust development, rose from age 9 to age 13 and then dropped; 75% of the 13 year olds in the sample were in this budding category, followed by 50% of the 12 year olds. One-half of the normal size 14 year olds were in the average bust category, followed by 36% in the Flat with budding category. One 13 year old and

two 14 year olds displayed prominent busts. Bust prominence seemed to increase with age for the normal size tweens.

Table 15

Bust Prominence for Tweens with Plus Size BMI

		BUST PROMINENCE				Total
		Tweens with Plus Size BMI (85th Percentile and above)				
		Flat	Flat with Budding	Average	Prominent	
AGE	9	100%	0%	0%	0%	
		N=4	N=0	N=0	N=0	4
	10	20%	40%	40%	0%	
		N=2	N=4	N=4	N=0	10
	11	10%	60%	30%	0%	
		N=1	N=6	N=3	N=0	10
	12	0%	45%	45%	10%	
		N=0	N=5	N=5	N=1	11
	13	0%	25%	63%	12%	
		N=0	N=2	N=5	N=1	8
	14	0%	43.7%	37.5%	18.8%	
		N=0	N=7	N=6	N=3	16
Total		7	24	23	5	59

The incidence of bust prominence for plus size tweens displayed in Table 15 suggests that the plus size tweens were more prominent at younger ages than the normal size tweens. All of the 9 year old plus size tweens were in the flat bust category. Among plus size 10 year olds, 40% were flat with budding, and another 40% had average bust prominence. Sixty percent of the 11 year olds were flat with budding, and the second largest percentage (30%) was the average category. For the plus sized tweens at 12, 13, and 14 there are no subjects in the flat category at all. The 12, 13, and 14 year old plus size tweens were mostly split between flat with budding and average; a few had prominent busts.

Research question 3: Does the degree of buttocks prominence change in relation to age for normal and plus size tweens?

Table 16

Buttocks Prominence for Tweens with Normal BMI

		BUTTOCKS PROMINENCE Tweens with Normal BMI (6th-84th Percentile)			Total
		Flat	Average	Extreme	
AGE	9	9%	82%	9%	
		N=1	N=9	N=1	11
	10	50%	50%	0%	
		N=5	N=5	N=0	10
	11	53%	41%	6%	
		N=9	N=7	N=1	17
	12	14.3%	64.3%	21.4%	
		N=2	N=9	N=3	14
	13	35%	45%	20%	
		N=7	N=9	N=4	20
	14	57.1%	35.8%	7.1%	
		N=8	N=5	N=1	14
Total		32	44	10	86

According to Table 16, most of the normal size tweens were in the flat and average buttocks categories. Buttocks prominence did not seem to follow an age progression. Sometimes more tweens were flat and sometimes more average; extreme prominence was shown by 10 girls, most of whom were 12 or 13. No pattern of buttocks prominence was apparent for the normal size group.

Table 17

Buttocks Prominence for Tweens with Plus Size BMI

		BUTTOCKS PROMINENCE Tweens with Plus Size BMI (85th Percentile and above)			Total
		Flat	Average	Extreme	
AGE	9	50%	50%	0%	
		N=2	N=2	N=0	4
	10	20%	70%	10%	
		N=2	N=7	N=1	10
	11	20%	80%	0%	
		N=2	N=8	N=0	10
	12	18.2%	54.5%	27.3%	
		N=2	N=6	N=3	11
	13	50%	50%	0%	
		N=4	N=4	N=0	8
	14	50%	50%	0%	
		N=8	N=8	N=0	16
Total		20	35	4	59

Table 17 shows buttocks prominence for plus size tweens, who also did not evidence an age-related pattern. Like the normal size tweens, more of the plus size tweens had average buttocks prominence across all age groups, and the second largest percentage of plus size tweens across all of the age groups had flat buttocks prominence. The splits in incidence were either even between flat and average or more average than flat. A few plus size tweens had extreme buttocks prominence.

Research Question 4: Does the incidence of specific torso shapes change in relation to age for normal and plus size tweens?

Table 18

Torso Shape for Tweens with Normal BMI

		TORSOSHAPE Tweens with Normal Size BMI (6^{th}- 84^{th} Percentile)									Total
		Thin "D"	Moderate "D"	Heavy "D"	Thin "b"	Moderate "b"	Heavy "b"	Thin "B"	Moderate "B"	Heavy "B"	
AGE	9	100%	0%	0%	0%	0%	0%	0%	0%	0%	11
		N=11	N=0	N=0	N=0	N=0	N=0	N=0	N=0	N=0	
	10	50%	30%	0%	20%	0%	0%	0%	0%	0%	10
		N=5	N=3	N=0	N=2	N=0	N=0	N=0	N=0	N=0	
	11	47%	12%	0%	29%	6%	0%	6%	0%	0%	17
		N=8	N=2	N=0	N=5	N=1	N=0	N=1	N=0	N=0	
	12	79%	7%	0%	7%	0%	0%	7%	0%	0%	14
		N=11	N=1	N=0	N=1	N=0	N=0	N=1	N=0	N=0	
	13	55%	25%	5%	5%	0%	0%	10%	0%	0%	20
		N=11	N=5	N=1	N=1	N=0	N=0	N=2	N=0	N=0	
	14	14.3%	35.8%	0%	21.4%	7.1%	0%	14.3	7.1%	0%	14
		N=2	N=5	N=0	N=3	N=1	N=0	N=2	N=1	N=0	
Total		48	16	1	12	2	0	6	1	0	86

Torso Shape for Tweens with Normal BMI

Overall, Table 18 shows a high incidence of the “D” shape for normal size tweens, a lesser incidence of the b shape, and a minimal incidence of the “B” shape. All of the 9 year olds were in the Thin “D” torso shape category. Most of the 10 year olds were Thin “D” and Moderate “D”, except two who were Thin “b”. Nearly half of the 11 year olds were in the Thin “D” category followed by the next highest percentage in the Thin “b” category. The normal size 12 year olds were mostly Thin “D”. The normal size 13 and 14 year olds showed more variation, although about half of the 13 year olds were Thin “D”. Half of the 14 year olds were Thin “D”, “b”, or “B”, and about one-third was Moderate “D”. None of the normal size girls fit into a heavy torso shape category.

Table 19

Torso Shape for Tweens with Plus Size BMI

		TORSO SHAPE Tweens with Plus Size BMI (85th Percentile and above)									Total
		Thin "D"	Moderate "D"	Heavy "D"	Thin "b"	Moderate "b"	Heavy "b"	Thin "B"	Moderate "B"	Heavy "B"	
AGE	9	100%	0%	0%	0%	0%	0%	0%	0%	0%	
		N=4	N=0	N=0	N=0	N=0	N=0	N=0	N=0	N=0	4
	10	20%	50%	30%	0%	0%	0%	0%	0%	0%	
		N=2	N=5	N=3	N=0	N=0	N=0	N=0	N=0	N=0	10
	11	10%	60%	10%	10%	0%	0%	0%	0%	10%	
		N=1	N=6	N=1	N=1	N=0	N=0	N=0	N=0	N=1	10
	12	0%	72.8%	18.2%	0%	0%	0%	0%	9%	0%	
		N=0	N=8	N=2	N=0	N=0	N=0	N=0	N=1	N=0	11
	13	0%	50%	0%	12.5%	25%	0%	12.5%	0%	0%	
		N=0	N=4	N=0	N=1	N=2	N=0	N=1	N=0	N=0	8
	14	31%	25%	13%	19%	0%	0%	6%	0%	6%	
		N=5	N=4	N=2	N=3	N=0	N=0	N=1	N=0	N=1	16
Total		12	27	8	5	2	0	2	1	2	59

Table 19 shows the incidence of torso shape among plus size tweens. Overall, relatively more of them displayed a moderate rather than thin shape, and a few were heavy. All plus size 9 year old tweens were collectively categorized as Thin "D". Designation of thin does not mean that the figure was thin overall, but rather describes how much the torso protrudes from the front of the body looking at a side view. One-half to nearly three-quarters of the 10-13 year old plus size tweens were in the Moderate "D" category. Ten year olds only displayed the "D" shape, with 30% being Heavy "D" and 20% Thin "D". Except for three girls, all 11 and 12 year olds were D shape. In addition to the more common incidence of the "D" shape, a few 13 and 14 year olds showed a "b" or "B" shape.

Body Measurement Comparisons

This section answers research questions 5-7 and shows graphs displaying trend lines representing goodness of fit and the coefficient of determination (R^2). These were used to show the relationships of variables for normal and plus size tweens which included: three circumferences (bust circumference, waist circumference, hip circumference), three lengths (waist height, hip height, and crotch height) and two principle girth differences (bust-waist difference and waist-hip difference).

Research question 5: Do specific circumference measurements including bust, waist, and hips change in relation to age for normal and plus size tweens?

Table 20 lists the body measurements that are compared to address research question 5. This table lists body measurement means for normal and plus size tweens including bust circumference, waist circumference, and hip circumference.

Table 20

Body Measurement Comparisons for Bust, Waist, and Hip Circumference

Age	Bust (inches)		Waist (inches)		Hip (inches)	
	N*	P*	N	P	N	P
9	26.7	35.2	23.8	32.7	30.5	37.9
10	28.3	38.2	24.3	33.3	30.4	40.4
11	30.2	38.0	25.7	33.0	32.1	40.2
12	32.0	41.1	26.3	35.9	34.0	43.4
13	32.4	39.9	26.8	34.8	35.5	41.2
14	33.2	42.4	28.0	36.5	36.2	44.7

*N= Tweens within the Normal BMI range (6^{th}-84^{th} percentile according to the Centers for Disease Control and Prevention)

*P= Tweens within the Plus Size BMI (as noted by the researcher, combining tweens in the 85^{th} percentile and above according to the Centers for Disease Control and Prevention)

Research question 5a: Do bust measurements change in relation to age for normal and plus size tweens?

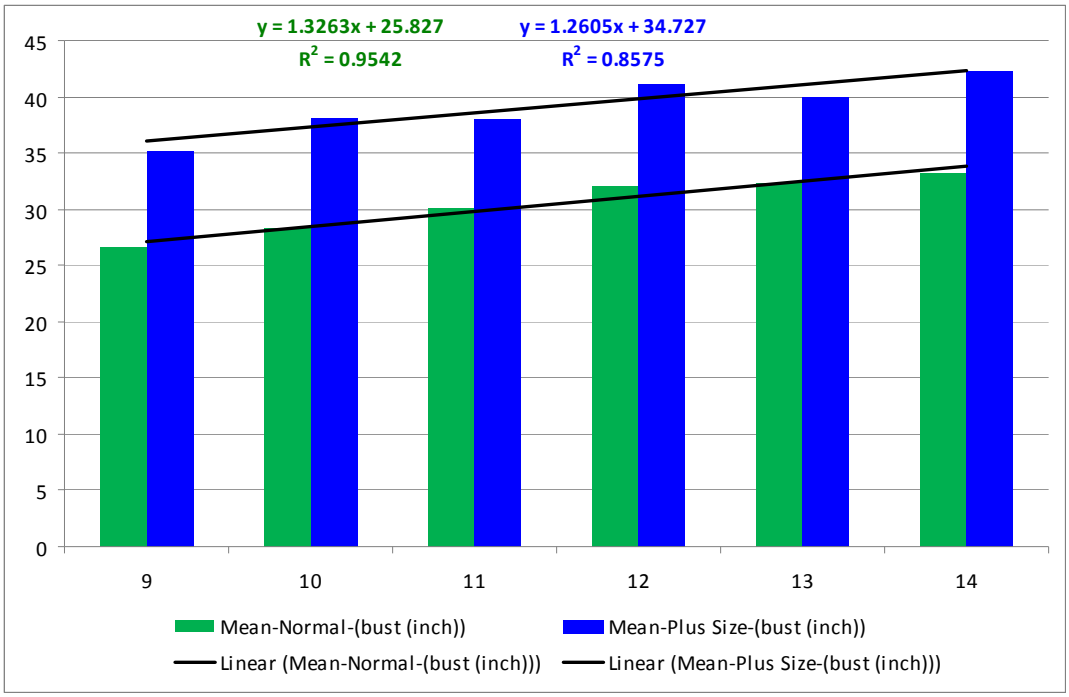


Figure 19. Bust circumference measurements for normal and plus size tweens

The Figure 19 histogram includes the slopes representing the correlation statistics for bust circumference statistics. As age increased, bust circumference increased across age groups for normal and plus size tweens. Although plus size tweens had higher bust circumference means, measurements for both normal size and plus size tweens increased linearly over all the age groups, visually apparent in the seemingly parallel trend lines. Normal size tweens' bust circumference means increased in an almost perfect linear progression (R^2=0.9542). Plus size tweens' bust circumference means were slightly irregular, and seemed to take small leaps at every other age 10, 12, and 14, similar to other measurement patterns previously reported such as height and weight, but the sequence of progression was still linear (R^2=0.8575).

Research question 5b: Do waist measurements change in relation to age for normal and plus size tweens?

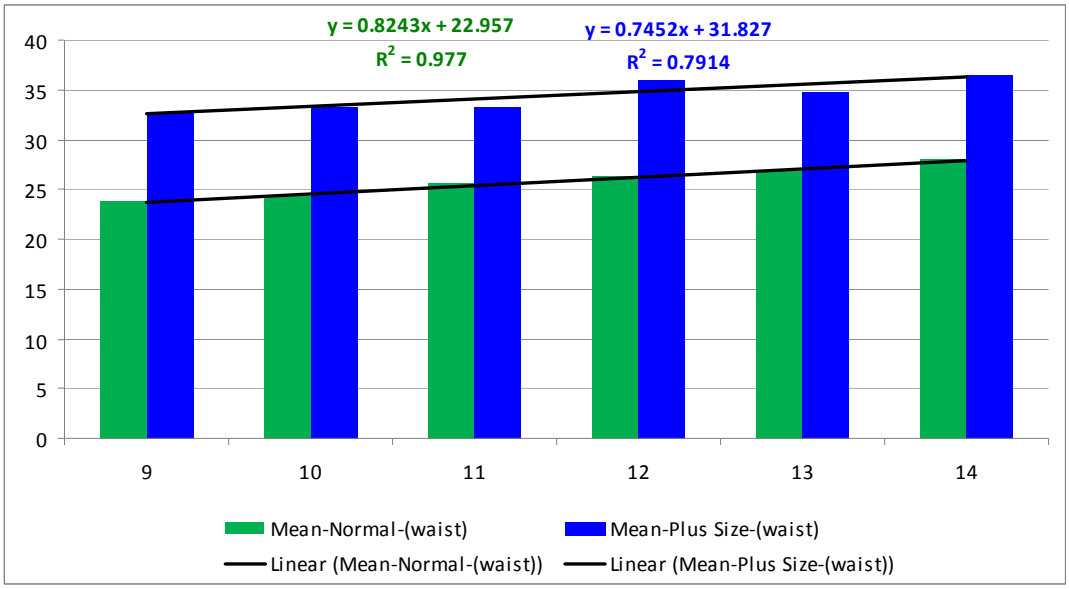


Figure 20. Waist circumference measurements for normal and plus size tweens

The Figure 20 histogram includes the slopes representing the correlation statistics for waist circumference statistics. As age increased, waist circumference measurements increased for both normal and plus size tweens. However, waist measurements were higher for plus size tweens at each age. Waist circumference measurements progressed linearly over all the age groups for the normal size tweens. The plus size waist measurement correlation (R^2= 0.7914) was smaller than that of the normal size tweens (R^2= 0.977). This appears to be because waist measurements for plus size tweens in this sample fluctuated between ages and did not increase incrementally. Rather, waist circumference measurements for plus size tweens seemed to take small leaps at every other age, 10, 12, and 14. The 13 year old plus size group had a smaller waist

circumference mean than the 12 year olds, possibly the time when they start to see more waist definition. The 14 year old plus size group had higher waist measurement which is concurrent with the increase in weight.

Research question 5c: Do hip circumference measurements change in relation to age for normal and plus size tweens?

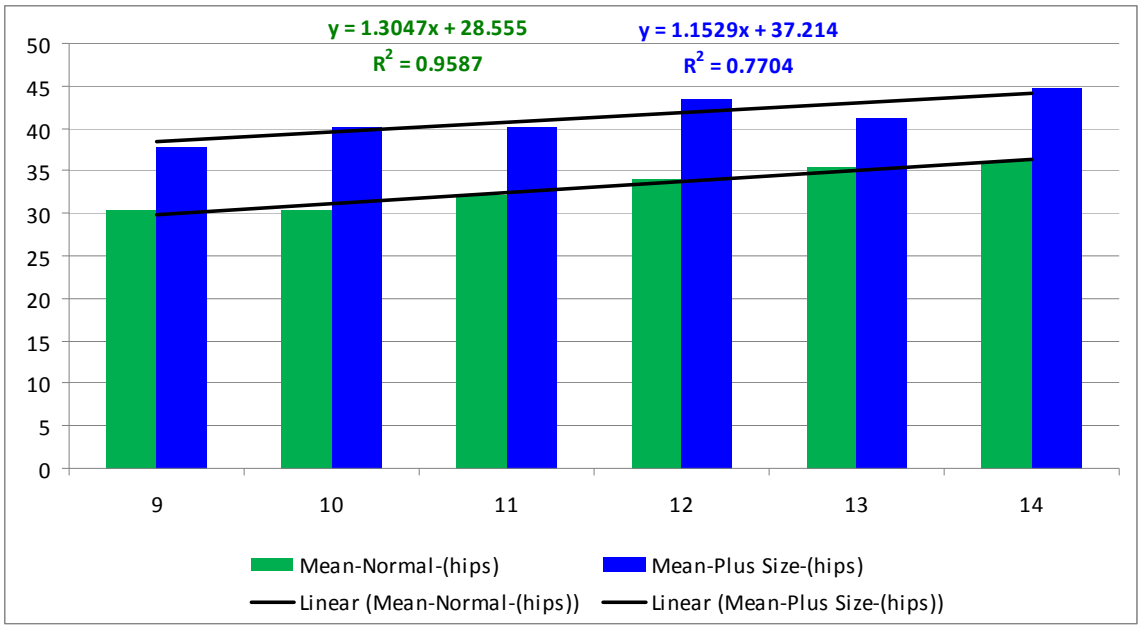


Figure 21. Hips circumference measurements for normal and plus size tweens

The Figure 21 histogram includes the slopes representing the correlation statistics for hip circumference statistics. Hip circumference measurements progressed linearly over all of the age groups for normal size tweens (R^2= 0.958). For plus size tweens, the pattern of progression was linear (R^2= 0.770) but less even. The hip measurements for plus size tweens followed the same pattern as the waist and bust measurements for plus size tweens in this sample, increasing at ages 10, 12, and 14. Hip circumference means increased by almost 3 inches between ages 11 and 12 for plus size tweens and almost 2 inches for normal size tweens.

Research question 6: Do specific length measurements including hip height, waist height, and crotch height change in relation to age for normal and plus size tweens?

Results are reported using bar graphs that include trend lines and correlation coefficients representing goodness of fit. Table 21 lists the body measurements that are compared in the succeeding research questions. This table lists body measurement length means for normal and plus size tweens including waist height, hip height, and crotch height.

Table 21

Body measurement comparisons for waist height, hip height, and crotch height

Age	Waist Ht (inches)		Hip Ht (inches)		Crotch Ht (inches)	
	N*	P*	N*	P*	N*	P*
9	33.2	34.8	24.5	29.8	24.7	25.7
10	33.8	38.0	25.8	32.3	25.2	28.5
11	35.9	38.1	28.1	30.8	27.0	27.8
12	39.1	39.7	30.3	31.9	29.3	29.0
13	37.7	39.2	28.6	31.6	28.3	30.5
14	38.7	40.5	29.9	32.7	28.9	29.3

*N= Tweens within the Normal BMI range
(6^{th}-84^{th} percentile according to the Centers for Disease Control and Prevention)
*P= Tweens within the Plus Size BMI
(as noted by the researcher, combining tweens in the 85^{th} percentile and above according to the Centers for Disease Control and Prevention)

Research Question 6a: Does waist height change in relation to age for normal and plus size tweens?

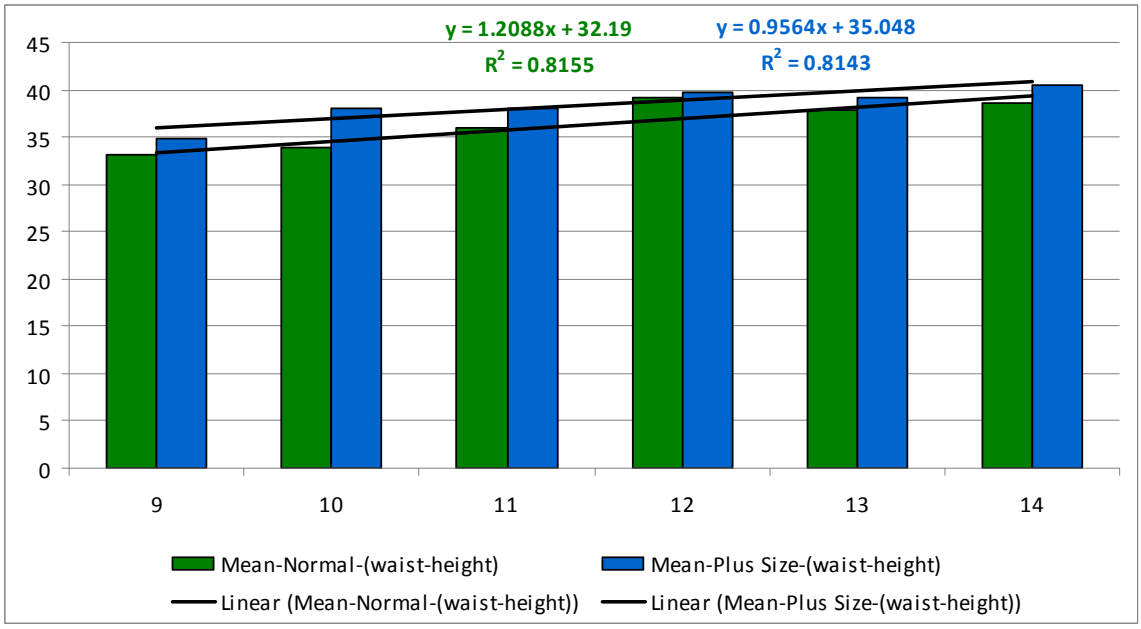


Figure 22. Waist height measurements for normal and plus size tweens

In Figure 22 the histogram includes the slopes representing the correlation statistics for waist height. Waist height was taken along the side of the leg (where the side seam of a garment is placed) for this measurement. As age increased, waist height mean measurements increased linearly for normal ((R^2=0.8155), and plus size (R^2= 0.8143). The plus size tweens had higher waist height measurements than their normal size peers in all age groups. The normal size tweens had a 3 inch increase in waist height between ages 11 and 12. The plus size tweens showed a 3 inch increase earlier, between ages 9 and 10.

Research question 6b: Does hip height change in relation to age for normal and plus size tweens?

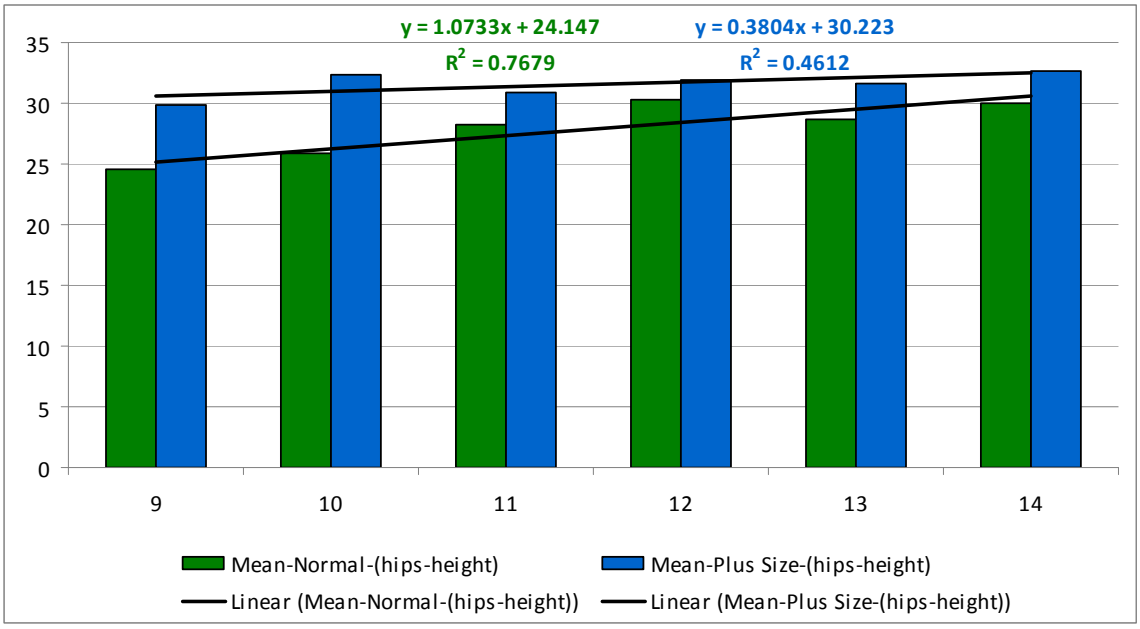


Figure 23. Hip height measurements for normal and plus size tweens

Figure 23 shows that hip height for the normal size tweens in the sample increased linearly from ages 9 to 12. This measurement was less for the 13 year old normal size tweens and increased slightly for those age 14. Hip height means for plus size tweens were linear, (R^2= 0.4612), but less of the variance was explained. As with previous measurements, the plus size tweens did not increase exactly linearly with age, but rather they had an increase in hip height mean from age 9 to 10, from age 11 to 12, and again from age 13 to 14. The difference between the hip height for normal and plus size tweens appeared to lessen with age.

Research question 6c: Does crotch height change in relation to age for normal and plus size tweens?

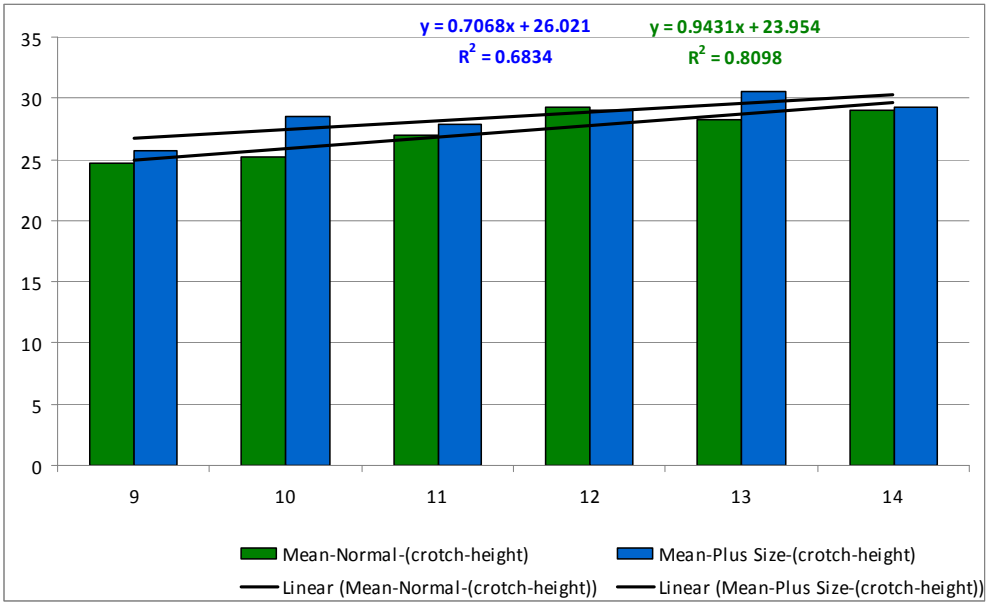


Figure 24. Crotch height measurements for normal and plus size tweens

Figure 24, shows that crotch height for normal size tweens increased linearly (R^2= 0.8098) between ages 9-12, but decreased slightly for ages 13 and 14. For normal size tweens, crotch height increased 1 inch between ages 9 and 10, 2 inches between ages 10 and 11, and 2 inches between ages 11 and 12. Plus size tweens' increase in crotch height (R^2= 0.6834) was slightly less linear than that of the normal size tweens. The largest increase in crotch height means for plus size tweens was 3 inches between ages 9 and 10.

Research question 7: Do two specific principle girth measurements (bust-to-waist difference and hip-to-waist difference) change in relation to age for normal and plus size tweens?

Results are reported using bar graphs that include trend lines and correlation coefficients representing goodness of fit. Table 22 lists the two principle girth differences, bust-waist difference and waist-hip difference. To calculate bust-to- waist difference, waist circumference was subtracted from the bust measurement for each individual. Waist-to-hip difference was calculated by subtracting the waist circumference from the hip measurement.

Table 22

Measurement Comparisons for Principle Girth Differences

Age	Bust - Waist Difference (inches)		Waist - Hip Difference (inches)	
	N*	P*	N*	P*
9	2.83	2.51	6.59	5.15
10	4.06	4.84	6.15	6.28
11	4.44	4.72	6.40	6.83
12	5.65	5.16	7.68	7.45
13	5.59	5.18	8.64	6.44
14	5.18	5.80	8.20	8.13

*N= Tweens within the Normal BMI range (6^{th}-84^{th} percentile according to the Centers for Disease Control and Prevention)
*P= Tweens within the Plus Size BMI (as noted by the researcher, combining tweens in the 85^{th} percentile and above according to the Centers for Disease Control and Prevention)

Research question 7a: Does bust-to-waist differences change in relation to age for normal and plus size tweens?

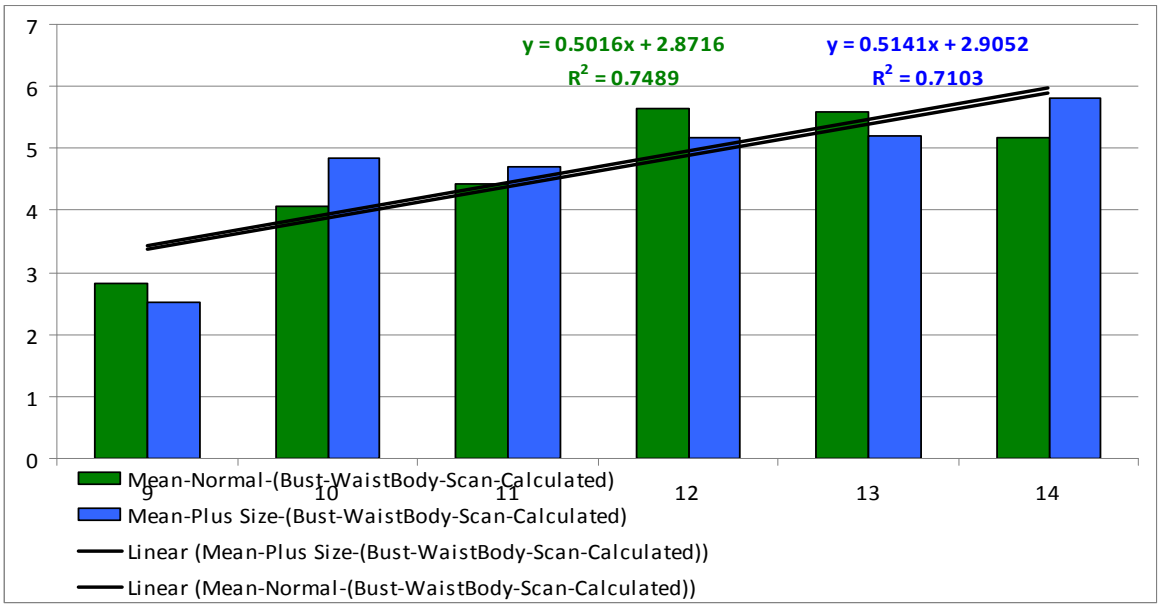


Figure 25. Bust-to-waist difference measurements for normal and plus size tweens

Figure 25 shows that for normal size tweens, as age increased, bust-to-waist differences increased linearly (R^2= 0.7489) until age 12 and then slightly dropped at ages 13 and 14. At age 9, there was just less than a 3 inch difference between the bust and waist; at ages 10 and 11, the difference was between 4 and 4.5 inches, and thereafter it was between 5 and 6 inches. The pattern was more irregular for plus size girls, but still increased linearly (R^2= 0.7103). From 9 to 10 year olds, the difference nearly doubled from 2.5 inches; it was approximately the same for 10 and 11 year olds, but increased for 12-14 year olds up to nearly 6 inches. Plus size bust-to-waist differences were smaller than normal size tweens for ages 9, 12, and 13. The plus size differences were greater for ages 10, 11, and 14.

Research question 7b: How do waist-to-hip differences change in relation to age for normal and plus size tweens?

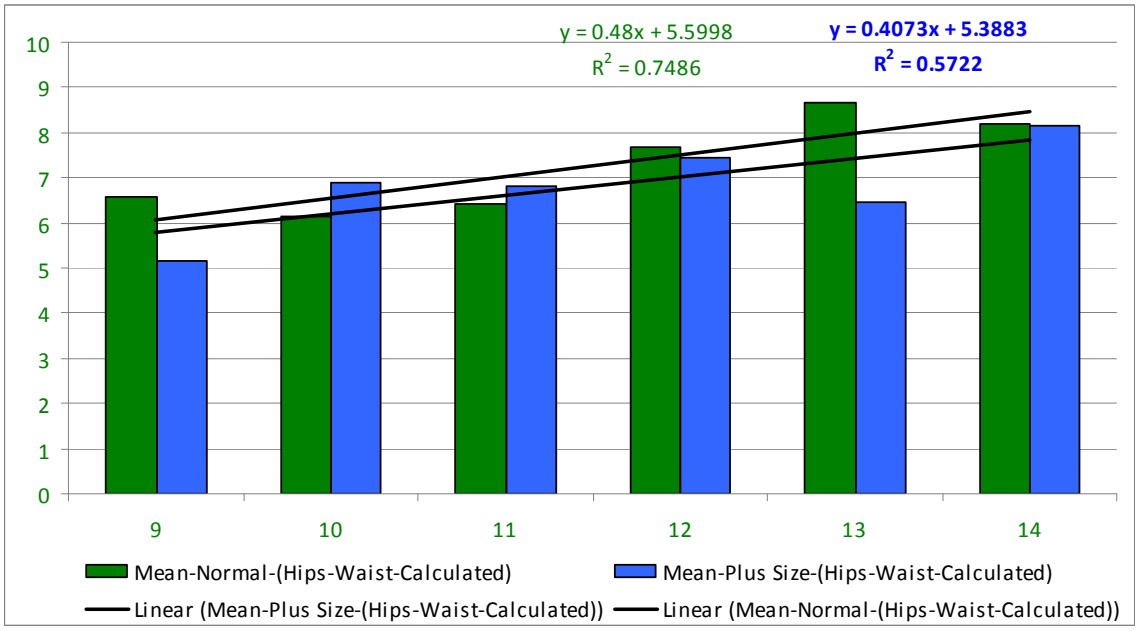


Figure 26. Waist-to-Hip Difference Measurements for Normal and Plus Size Tweens

Figure 26 graphically displays the waist-to-hip differences shown in Table 24. Hip-to-waist difference increased linearly for normal size tweens (R^2= 0.7486). For normal size tweens, the overall trend was linear with waist-to-hip difference increasing with age. This increase was more apparent from ages 10 to 13. For plus size tweens, the increase in waist-to-hip difference showed a linear relationship ((R^2=0.5722), but this increase was less stable and fluctuated with age. The 9, 10, and 11 year old normal and plus size tweens had differences between 6 and 7 inches; the 12 year old normal and plus size tweens had differences between 7 and 8 inches, and the 13 and 14 year old normal and plus size tweens had differences between 8 and 9 inches. The plus size tweens' differences rose from just over 5 inches at age 9 to 7.45 inches at age 12, then dropped and increased to over 8 inches at age 14.

V. SUMMARY, DISCUSSIONS, CONCLUSIONS, IMPLICATIONS, AND RECOMENDATIONS

Summary of Purpose and Method

The purpose of this research was to build anthropometric profiles of normal and plus size tween girls using three primary data probing methods. First, a comparative descriptive analysis was used to relate the sample to historic and existing anthropometrics and demonstrate the need for an updated evaluation of this age group. This was accomplished by comparing height and weight mean differences between the tween girls in the sample and measurements for tween girls in the seminal children's body measurement study reported in O'Brien et al. (1941). The sample's mean heights and weights were also compared to the 50^{th} percentile of height and weight by age according to the Centers for Disease Control and Prevention (CDC).

Body measurement means of the sample including bust, waist, hip, waist height, hip height, crotch height were compared to the children's measurement study by O'Brien et al. (1941) to explore possible patterns of body measurement change. Secondly, visual analysis was conducted to explore incidence of whole body shapes (Hourglass, Rectangle, Pear and Inverted Triangle) and specific body shape components (bust prominence, buttocks prominence, and torso shape) among both normal and plus size tweens in the sample. The intent was to seek emerging patterns or themes that could help

to inform profiles for each age and size group. The BSAS© (Connell et al., 2006), a shape analysis tool developed from and for adult females, was used as the starting point. Lastly, body measurements were compared for normal and plus size tweens at all ages in the sample group for three circumferences (bust, waist, and hip), three lengths (waist height, hip height, and crotch height) and two principle girths (bust-to-waist difference and waist-to-hip difference). These measurements were visually expressed using histograms that included the calculated coefficient of determination (R^2). Trend lines were added to these figures for easier assessment of the goodness of fit.

Although O'Brien and Girshick (1939) found that age was not an accurate predictor of body size and measurements, physical transition with age cannot be ignored. Understanding how measurements changed in relationship to age was an important variant in building profiles for tweens growing through puberty. This study used age as a gauge to benchmark any recognizable changes in physical dimensions, incidence of body shape and body shape component patterns, and varying body measurements at different ages for normal and plus size tweens in the sample.

This research was enabled by the use of 3D body scanning as a resource for data collection. The sample involved recruiting subjects at two different times and places. The first group, 41 tween girls, was recruited by $[TC]^2$, in Cary, North Carolina, in October 2004. This group was designed to fill each of four groups with 8-12 girls, matching the age and size parameters for the group with one-half of the girls' ages being 9-11 and one-half 12-14. It was also designed for one-half of each of those groups to be below the 85^{th} percentile of BMI and one-half at or above it. The second group, 110 tween girls, was recruited in Auburn, Alabama, in November 2005. These subjects

formed a convenience sample and were recruited to participate through local newspaper articles and a mall intercept in Auburn, Alabama. Their consensual participation involved having a 3D body scan using the NX12 $[TC]^2$ scanner and responding to a confidential questionnaire. Incentives were used in both settings and parental consent was required for each participant.

For comparative descriptive analysis, visual analysis, and body measurement comparisons, all subjects were divided into two groups defined as normal size and plus size. These categories were specified according to Body Mass Index (BMI) scores according to CDC guidelines (CDC, 2008). Tweens with normal size BMI were those with BMI scores within the 6th-84^{th} percentile range of BMI for age. Tweens with BMI scores that were deemed "at risk of overweight" (85^{th} to 94^{th} percentile for BMI) and those deemed "overweight" (95^{th} percentile or higher) were combined into one category called plus size for the purpose of this study.

The race distribution in the sample was predominately Caucasian (65.52 %, N=95), followed by African American (26.89%, N= 39). There were 7 Native American subjects (4.83%), 2 Hispanic subjects (1.38 %) and 2 Asian subjects (1.38%) represented in the sample as well. The following section discusses the descriptive comparisons, patterns of incidence, and body measurement relationships and disparities for normal and plus size tweens in all age groups within the sample.

Discussion and Conclusions: Comparative Descriptive Analysis

For the initial portion of the study, the sample was not divided by size (BMI category) for comparison. The O'Brien and Girshick study (1939) was divided only by age, therefore, the current sample was as well, to ensure homogenous comparisons between mean measurements.

Height and Weight Comparisons between the Sample, CDC, and O'Brien et al. (1941)

Distinct differences were found when comparing the sample's mean heights and weights for each age group with the CDC 50th percentile and the first children's body measurement study (O'Brien and Girshick, 1939; O'Brien et al., 1941). The sample's mean heights were greater for all ages compared to both the CDC 50th percentile and the O'Brien et al., study (1941). The CDC 50th percentile heights were predominately larger than the children's body measurement study. The sample's weight means were heavier for every age group compared to the CDC 50th percentile and the study by O'Brien et al. (1941). The CDC 50th percentile weights were also larger than the children's measurement study within every age group.

These findings suggested that tweens have indeed become taller and heavier over the last six decades. The CDC 50th percentile heights and weights for each age group were nearly all greater than the 1941 O'Brien et al. study (See Table 11). The tweens in this sample were still larger and heavier than the CDC 50th percentile measures (See Figures 5-10). This is consistent with the reports of increased obesity in the United States from the National Health and Nutrition Survey (NHANES) (CDC, 2008). The average difference in mean height between the sample and the CDC 50th percentile was 2 inches.

The average difference in mean height between the sample and O'Brien et al. (1941) was 2.4 inches.

Body Measurements between the Sample and O'Brien et al. (1941)

Body measurement means in the sample, including the three circumference means (bust, waist and hip), the three length means (waist height, hip height, and crotch height), and the two principle girths (bust-to-waist difference and waist-to-hip difference) were larger than those in O'Brien et al. (1941) across all ages, with a few exceptions. These exceptions were the 11, 12, 13 and 14 year olds' hip height means, and the 14 year olds' crotch height and waist height means. Hip height was longer for tweens in the 1941 study for all ages except 9 and 10 year olds (See Table 12). All three length means for the 14 year olds in the sample were smaller than those in the 1941 O'Brien et al. study. The differences between the average means of the sample and O'Brien et al. (1941) were as follows: bust circumference 2.99 inches, waist circumference 4.72 inches, hip circumference 4.57 inches, hip height -0.48 inches, crotch height 0.86 inches, waist height 0.21 inches. Circumference differences were clearly greater than length or height differences.

Discussion and Conclusions: Visual Analysis

Whole Body Shape

Hourglass, Rectangle, and Pear were the three body shapes most prevalent in the sample of normal size tweens. More of the normal size 9 year old tweens were Hourglass (72%) rather than Rectangle (10%) or Pear. More of the normal size 10 year olds (50%) and 11 year olds had Rectangle (59%) body shapes. More of the normal size 12 year olds (50%), 13 year olds (65%), and 14 year olds (50%) had Hourglass body shapes.

Plus size tweens were predominately categorized in the Rectangle and Pear shape categories. Although the cells were small, the plus size 9 years olds were split 50/50 between Hourglass and Rectangle. More of the plus size 10 and 11 year olds had Rectangle body shapes. The 12 year old plus size tweens were mostly Rectangle and Pear shaped (45%). More of the plus size 13 year olds were Rectangle (63%). The plus size 14 year olds were mostly Hourglass (37.5%) and Pear (37.5%) shaped. Thus, the plus size tweens tended to be relatively fuller through the hips or have less clearly defined waists having mostly Rectangle body shapes.

Bust Prominence

The degree of bust prominence increased with age for normal size tweens. Most of the 9 year olds were flat busted (82%). Only 18% were flat with budding busts (i.e. early bust development). Similarly, 80% of the normal size 10 year olds were flat busted, and 20% were flat with budding. Fewer, 65%, of the 11 year olds were flat busted, and 29% were flat with budding. There was a distinct shift in degree of bust prominence starting with age 12 for normal size tweens. Only 21% were flat busted; 50% were flat with budding, and 29% of the 12 year old normal size tweens had an average size bust. For 13 and 14 year old normal size tweens, there was a decrease in the flat bust category with age. Seventy-five percent of the 13 year old normal size tweens were flat with budding; 15% were average. One-half of the 14 year old normal size tweens had an average size bust; 36% were flat with budding, and 4% had a prominent bust.

Plus size tweens degree of bust prominence increased at earlier ages. All of the 9 year old plus size tweens in the sample were flat busted. Only 20% of the 10 year old plus size tweens were flat busted; more were either flat with budding (40%) or average

(40%). Only 10% of the plus size 11 year olds were flat busted. Sixty percent of the 11 year old plus size tweens were flat with budding; 30% had an average size bust. There were no flat busted 12, 13, or 14 year old plus size tweens. Plus size tweens in those age groups were either flat with budding or had average or prominent size busts.

Buttocks Prominence

Buttocks prominence for both normal and plus size tweens did not follow a pattern of changing with age. Most of the normal size 9 year olds had average size buttocks (82%). The 10 and 11 year old normal size tweens were split nearly evenly between flat and average size buttocks. Whereas the 12 and 13 year old normal size tweens had more average size buttocks, the 14 year olds had mostly flat buttocks. Among plus size tweens, 9 year olds were split 50/50 between flat and average size buttocks. More 10 year old (70%), 11 year old (80%), and 12 year old (54.5%) plus size tweens had average size buttocks. The 13 and 14 year old plus size tween age groups were both evenly split between and flat and average size buttocks.

Torso Shape

Most of the normal size tweens had a thin “D” torso shape across all age groups. The second most populated category for normal size tweens was the moderate “D” torso shape. Thin “b” and thin “B” were the third and fourth most populated torso shape categories for normal size tweens. All of the 9 year old normal size tweens were thin “D;” 50% of the 10 year old normal size tweens were thin “D,” and 30% were moderate “D;” just 20% were thin “b.” The largest percentage of 11, 12, and 13 year old normal size tweens was in the thin “D” category. Most of the 14 year old normal size tweens were in the Moderate “D” category.

All of the plus size 9 year old tweens were in the moderate "D" category and most of the 10 year old plus size tweens were moderate "D" (50%); smaller percentages (30% and 20%, respectively) were heavy "D" and thin "D". The 11, 12, and 13 year old plus size tweens had the largest percentage of subjects in the moderate "D" category. Smaller percentages of the 13 year old plus size tweens were in the moderate "b" (25%), Thin "b" (12.5%), and Thin "B" (12.5%) categories. The 14 year old plus size tweens were found in every category except moderate "b" and moderate "B."

Torso shape did not demonstrate an age-related progression, but the pattern of incidence tended towards the thin "D" for normal size tweens and moderate to heavy "D" for plus size tweens. There were some few exceptions for thin or moderate "b" and thin or moderate "B". These findings, relative to plus size tweens, were comparable to Fu (2004), who found that torso shape "D" was the common torso shape in her study of obese and overweight adult women.

Discussion and Conclusions:

Comparing Normal and Plus Size Tweens' Measurements

Bust Circumference

The body measurement comparisons yielded telling results for tweens in the sample. Bust circumference means increased linearly with age across each age group. The largest increases between age groups were between the 10 and 11 year olds (1.85 inches) and the 11 and 12 year olds (1.8 inches). For the entire sample of normal size tweens, the average increase between successive ages for bust circumference means was 1.3 inches. For plus size tweens, the largest bust circumference increases were between the 9 and 10 year olds (2.93 inches), 11 and 12 year olds (3.1 inches), and 13 and 14 year

olds (2.5 inches). For the entire sample of plus size tweens, the average increase between successive ages for bust circumference means was 1.97 inches, approximately one-half inch greater than the average for normal size tweens.

Waist Circumference

Waist circumference means increased linearly with age for normal size tweens in the sample. The biggest increases in waist circumference means were between ages 10 and 11 (1.4 inches) and ages 13 and 14 (1.2 inches). The average increase between ages in waist circumference means for normal size tweens in the sample was 0.84 inches. Waist circumference means for plus size tweens in the sample did not increase at ages 11 and 13, but did increase at ages 10, 12, and 14. The largest increases in means were between ages 11 and 12 (2.9 inches) and 13 and 14 (1.7 inches). The average increase in waist circumference means for the entire sample of plus size tweens was 1.32 inches, which was not quite one-half inch greater than the normal size tweens.

Hip Circumference

Although the hip circumference mean for normal size 9 year olds was 0.1 inch more than 10 year old normal size, hip circumference means increased linearly across age groups. The largest increases between hip circumference means were between ages 10 and 11 (1.7 inches) and 11 and 12 (1.9 inches). The average increase in hip circumference mean for the entire sample of normal size tweens was 1.18 inches. Hip circumference means for plus size tweens in the sample increased at ages 10, 12, and 14. The largest increases were between ages 9 and 10 (2.5 inches), 11 and 12 (3.2 inches), and 13 and 14 (3.5 inches) The average increase in hip circumference means for plus size tweens was 2.32 inches, approximately one inch greater than the average for normal size tweens.

Waist Height

Waist height means for normal and plus size tweens increased linearly overall with age. However, among normal size tweens, the means for ages 13 and 14 were lower than for age 12, and among plus size tweens, the 13 year old mean was lower than the 12 mean. The largest increase in waist height means for normal size tweens was between ages 11 and 12 (3.2 inches). The largest increase in waist height means for plus size tweens was between ages 9 and 10 (3.2 inches). The average increase in waist height means for normal size tweens was 1.66 inches and 1.32 inches for plus size tweens, approximately one-quarter inch apart.

Hip Height

Although hip height means for normal size tweens increased linearly overall across all ages, the differences between means showed both increases and decreases. The largest increases in hip height means for normal size tweens were between 10 and 11 (2.3 inches) and 11 and 12 (2.2 inches). The average hip height mean increase for the normal size tweens was 1.76 inches. Hip height means for plus size tweens were not as consistently linear as those for normal size tweens. The largest increase in hip height means for plus size tweens was between ages 9 and 10 (2.4 inches). The average increase in hip height means for plus size tweens was 1.30 inches.

Crotch Height

Crotch height means increased linearly overall with age for normal and plus size tweens in the sample, but the pattern was less linear for plus size tweens. The largest increase in crotch height for normal size tweens was between ages 11 and 12 (2.3 inches) and between ages 9 and 10 for plus size tweens (2.8) inches. The average increase in

crotch height means for the normal size tweens in the sample was 1.24 inches and 1.48 inches for plus size tweens.

Bust-to-Waist Difference

Mean bust-to-waist differences (bust circumference minus waist circumference) increased linearly with age for normal and plus size tweens. The increases in the differences across ages suggest the progression of breast development relative to the waist as tweens get older. Previous discussion showed that the average mean increases for bust size were more than for waist size. The greatest increases in bust-to-waist difference for normal size tweens happened between ages 9 and 10 (1.23 inches) and ages 11 and 12 (1.21 inches). The average increase in bust-to-waist difference among normal size tweens in the sample was 0.66 inches and was 0.71 inches for all plus size tweens.

For plus size tweens, the largest increase was between ages 9 and 10 (2.33 inches), which was one inch greater than for normal size 9 year old tweens. Shape analysis findings showed that at age 9, all plus size tweens were flat busted, but 40% of the 10 year old plus size tweens in the sample were flat with budding and 40% had average bust prominence. This pattern suggests early breast development for plus size tweens.

Waist-to-Hip Difference

Mean waist-to-hip differences (hip circumference minus waist circumference) increased with age for both normal and plus size tweens, but not in a perfectly linear progression. Increases in the difference suggest greater waist definition relative to hip size. In the sample of normal size tweens, the mean waist-to-hip difference was 0.44 inches greater at age 9 than 10 and at age 13 than 14. The 13 year olds were also just 0.06

inches smaller than the 12 year olds. The normal size 9 year old group had relatively more Hourglass shape figures, and the 10 year old group had relatively more rectangular figures. The 14 year old group had a predominance of Hourglass and Pear shape figures and relatively few rectangular figures. Whole body shape is analyzed from a frontal position and does not take buttocks prominence into account. The normal size 10 year olds had relatively flat buttocks and the 9 year olds relatively average buttocks. The same was true for the normal size 14 compared to the 13 year olds. Approximately two-thirds of the 13 year olds had average or extreme buttocks prominence, whereas 93% of the 14 year olds had flat or average buttocks prominence.

Mean waist-to-hip differences did increase for the normal size tweens between ages 10 and 11 (0.38 inches), 11 and 12 (1.28 inches). The small difference between 10 and 11 year old normal size tweens may reflect their incidence of buttocks prominence, which was more balanced than some other ages. The largest waist-to-hip difference for normal size tweens was between the 11 and 12 year olds, and this may have derived from the relatively greater incidence of average and prominent buttocks among the older group.

The waist-to-hip difference increased linearly for plus size tweens although it decreased slightly for the plus size 13 year olds. As with the normal size tweens, increases in the difference suggest greater waist definition relative to hip size. In the sample of plus size tweens the greatest increase in waist-to-hip difference (1.69 inches) was between the 13 and 14 year olds in the sample. The smallest increase in waist-to-hip difference (0.55 inches) was between the 10 and 11 year old plus tweens. The plus size 9 year olds had an equal share of Hourglass (50%) and Rectangle (50%) body shapes. The

10, 11, and 13 year old plus size groups had relatively more Rectangle shape figures. The 14 year old plus size group had a predominance of Hourglass and Pear shape figures and relatively few rectangular figures. The 12 year old plus size group had a predominance of Rectangle and Pear shape figures and relatively few Hourglass figures. The plus size 9, 13, and 14 year olds had a predominance of flat (50%) and average (50%) buttocks. However, 10, 11, and 12 had more incidents of average buttocks prominence. Mean waist-to-hip differences for plus size tweens increased the most between ages 9 and 10 (1.13 inches), 12 and 13 (1.01 inches) and 13 and 14 years old (1.69 inches). The small waist-to-hip differences were found for the 10 and 11 year old plus size tweens. These smaller differences may reflect the predominance of average size buttocks for these two age groups.

Profiles by Age and Size

The following profiles were constructed for normal and plus size tweens based on age. These following tables are compilations of findings for each age group from the preceding chapter. Discussion follows.

Table 23

9 Year Old Normal and Plus Size Tweens' Profile

Characteristics	9 Year Old Normal Size Tweens (n = 11)	9 Year Old Plus Size Tweens (n = 4)
Height Mean	53.81 inches	56.79 inches
Weight Mean	65.6 lbs	110.2 lbs
BMI Mean	15.8	24.1
Menarche: Yes	36.3%	0%
Menarche: No	63.6%	100%
Body Shape: Hourglass	72%	50%
Rectangle	10%	50%
Pear	18%	0%
Bust: Flat	82%	100%
Flat with Budding	18%	0%
Buttocks: Flat	9%	50%
Average	82%	50%
Extreme	9%	0%
Torso Shape: Thin "D"	100%	0%
Moderate "D"	0%	100%
Bust Circumference Mean	26.7 inches	35.2 inches
Waist Circumference Mean	23.8 inches	32.7 inches
Hip Circumference Mean	30.5 inches	37.9 inches
Waist Height Mean	33.2 inches	34.8 inches
Hip Height Mean	24.5 inches	29.8 inches
Crotch Height Mean	24.7 inches	25.7 inches
Bust-to-Waist Difference	2.83 inches	2.51 inches
Waist-to-Hip Difference	6.59 inches	5.51 inches

9 Year Old Normal Size Tweens

Nine year old normal size tweens in the sample were only slightly above the height (1.41 inches) and weight (1.8 lbs) of the CDC 50th percentiles for height (52.4 inches-CDC) and weight (63.8 lbs). Their mean BMI (15.8) was actually slightly less than the CDC's midpoint in the Body Mass Index (BMI) range for 9 years olds (16.4) between the 6th-84th percentiles. This finding suggests that the normal size 9 year olds in this sample were within the normal range of body size. Most of these tweens had not begun menarche and had Hourglass body shapes, and, therefore, changes in body shape, such as bust development relative to the waist, would not be of major consequence when designing garments and making patterns.

All of the normal size 9 year old tweens in this sample fell within thin "D" body shape category, meaning that their front torso, as viewed from the side, was curved slightly outward and not indented at the waist. The consistency of this finding may suggest that other normal size 9 year olds would have similar torso shapes, if not the same. The body circumference, length, and principle girth difference measurement means found for the group may serve as reference for determining how similar sizing chart measurements compare. It should be noted, however, that this was one of the smallest sample size groups, with only 11 tweens.

9 Year Old Plus Size Tweens

Nine year old plus size tweens in the sample were 4.39 inches above the CDC 50th percentile for height (52.4 inches-CDC) and 46.4 lbs more than the CDC 50th percentile for weight (63.8 lbs-CDC) for 9 year olds. Their mean BMI (24.1) was 2.2 points above

the maximum BMI listed by the CDC in the range of "at risk of overweight" and "overweight" (85th percentile and above, 19.2- over 21.9). These four plus size 9 year olds were outside the normal range of body size and were also at high risk for health related problems (CDC, 2008). If these four tweens are representative of the increased numbers of larger children, the findings suggest that current clothing offerings are not likely to meet their needs because current measurements are based on old anthropometrics. The problem of finding clothes to fit was identified in the focus groups associated with this research (Brock, 2007; Lee, 2006)

None of the 9 year old plus size tweens had experienced menarche, and breast development had not begun. Their buttocks were either flat or average. Two had Hourglass body shape, and two were rectangular. Whole body shape proportions suggest appropriate shapes for patterns. Hourglass shapes would be similar widths at the shoulders and hips but smaller at the waist relative to body measurements used for garment construction. Rectangle shapes would have similar proportions at the shoulder waist and hips. The sample size was too small and split too evenly on some shape components to fully inform patternmakers in terms of shape. However, it would be informative to evaluate the principle girth differences because they were somewhat different than those for the normal size 9 year olds.

It should be noted, however, that all four of the plus size 9 year old tweens had moderate "D" torso shapes, whereas the normal size group were all thin "Ds." The possibility of extra front curvature should be considered when determining length measures for torso garments for tweens wearing larger sizes (e.g. shirts that cover the entire stomach and need added length to extend to the appropriate place at the waist).

Table 24

10 Year Old Normal and Plus Size Tweens' Profile

Characteristics	10 Year Old Normal Size Tweens (n = 10)	10 Year Old Plus Size Tweens (n = 10)
Height Mean	56.34 inches	58.92 inches
Weight Mean	75.9 lbs	126.8 lbs
BMI Mean	16.9	25.6
Menarche: Yes	30%	40%
No	70%	60%
Body Shape: Hourglass	40%	10%
Rectangle	50%	70%
Pear	0%	20%
Inverted	1%	0%
Triangle		
Bust: Flat	80%	20%
Flat with Budding	20%	40%
Average	0%	40%
Buttocks: Flat	50%	20%
Average	50%	70%
Extreme	0%	10%
Torso Shape: Thin "D"	50%	20%
Moderate	30%	50%
"D"		
Heavy "D"	0%	30%
Thin "b"	20%	0%
Bust Circumference Mean	28.35 inches	38.15 inches
Waist Circumference Mean	24.3 inches	33.3 inches
Hip Circumference Mean	30.4 inches	40.4 inches
Waist Height Mean	33.8 inches	38.0 inches
Hip Height Mean	25.8 inches	32.3 inches
Crotch Height Mean	25.2 inches	28.5 inches
Bust-to-Waist Difference	4.06 inches	4.84 inches
Waist-to-Hip Difference	6.15 inches	6.28 inches

10 Year Old Normal Size Tweens

Ten year old normal size tweens in the sample had taller height (2.04 inches) and greater weight (3.3 lbs) means than the CDC 50th percentile for height (54.3 inches-CDC)

and weight (72.6 lbs-CDC). However, this group's mean BMI (16.9) was 0.15 points less than the CDC's midpoint of the BMI range for normal size 10 years olds (17.05) between the 6th-84th percentiles. This finding shows that 10 year old normal size tweens were still within the normal range of body size. Only three of the 10 normal size tweens had begun menarche. Eight had flat busts, but the net difference in bust measurement compared to the 9 year old normal size tweens was 1.65 inches. The net difference for the bust-to-waist means between 9 and 10 year old normal size tweens was 1.23 inches.

Approximately one-half had flat buttocks. The net difference in the waist circumference mean for this group compared to the 9 year old normal size tweens was only 0.5; the hip circumference difference was negligible. More of the 10 than 9 year olds were Rectangle in shape. This could have been incidental to the sample rather than related to physical transitions with age. Five of the 10 tweens were thin "D," similar to the 9 year olds who were all that; three were moderate "D," and two were thin "b, showing minimal rounding below the waist.

The 10 year old normal size tweens in this sample had a mean height that was 2.53 inches more than the normal size 9 year olds, suggesting the need for longer garment lengths. The lower body length measurements were not much greater than the 9 year olds. The net differences in waist and crotch heights compared to the 9 year old normal size group were only about one-half inch. The net difference in hip height mean was 1.3 inches; this measurement is relative to the placement of the fullest part of the hip.

10 Year Old Plus Size Tweens

Ten year old plus size tweens in the sample were taller as well as heavier than their normal size counterparts. They were 4.62 inches above the CDC 50th percentile for

height (54.3 inches-CDC) and 54.2 lbs more than the CDC 50th percentile for weight (72.6 lbs-CDC) for 10 year olds. Mean BMI for this group (25.6) was 2.5 points above the maximum BMI listed by the CDC in the range of "at risk of overweight" and "overweight" (85th percentile and above, 20.1- over 23.1). These 10 tweens were well over the normal body size for their age.

Four of the 10 plus size 10 year olds had begun menarche. Only two had flat busts; the other eight were split evenly between the flat with budding and the average bust categories. All fit the "D" torso profile; five were moderate in front fullness, and three were heavy. The bust circumference mean was 2.95 inches more for plus size 10 year olds than plus size 9 year olds and hip circumference was 2.5 inches more. Waist circumference was nearly the same. Since more of these plus size tweens had busts that were flat with budding or average, and torsos that were moderate or heavy "Ds," longer front lengths appear to be needed when making patterns covering the upper body.

Seven of the plus size 10 year olds had Rectangle body shapes; two had Pear shapes. Most had average buttocks prominence. Their principle girth differences were greater than the plus size 9 year olds, and much larger than the normal size 10 year olds. They were 2.13 inches taller than the plus size 9 year olds; the lower body length differences were relatively similar, perhaps suggesting relatively more lower body growth. The hip height mean for 10 year old plus size tweens was 2.5 inches longer than that of the 9 year old plus size tweens. The waist height was 3.2 inches longer and crotch height was 2.8 inches longer. Hip height must be considered in order to correctly place the fullest part of the hip in lower body garments. The waist height influences overall pant length, and crotch height is related to inseam length.

Table 25

11 Year Old Normal and Plus Size Tweens' Profile

Characteristics	11 Year Old Normal Size Tweens (n = 17)	11 Year Old Plus Size Tweens (n = 10)
Height Mean	59.26 inches	59.8 inches
Weight Mean	73.8 lbs	124.8 lbs
BMI Mean	15.6	24.3
Menarche: Yes	25%	50%
Menarche: No	75%	50%
Body Shape: Hourglass	59%	10%
Rectangle	35%	70%
Pear	6%	20%
Bust: Flat	65%	10%
Flat with Budding	29%	60%
Average	6%	30%
Buttocks: Flat	53%	20%
Average	41%	80%
Extreme	6%	0%
Torso Shape: Thin "D"	47%	10%
Moderate "D"	12%	60%
Heavy "D"	0%	10%
Thin "b"	29%	10%
Moderate "b"	6%	0%
Thin "B"	6%	0%
Torso Shape: Heavy "B"	0%	10%
Bust Circumference Mean	30.2 inches	38.0 inches
Waist Circumference Mean	25.7 inches	33.0 inches
Hip Circumference Mean	32.1 inches	40.2 inches
Waist Height Mean	35.9 inches	38.1 inches
Hip Height Mean	28.1 inches	30.8 inches
Crotch Height Mean	27 inches	27.8 inches
Bust-to-Waist Difference	4.44 inches	4.72 inches
Waist-to-Hip Difference	6.40 inches	6.83 inches

11 Year Old Normal Size Tweens

Eleven year old normal size tweens in the sample had higher height (2.56 inches) and weight (7.6 lbs) means than the CDC 50th percentile for height (56.7 inches-CDC) and weight (81.4 lbs-CDC). This group's mean BMI (15.6) was 1.84 points less than the

CDC's midpoint of the BMI range (17.4) for normal size 11 year olds in the 6th-84th percentiles. They were still well within the normal range of body size. Only 25% of the normal size 11 year old tweens had begun menarche. Approximately two-thirds were still in the flat bust category. Their bust, waist, and hip circumference means were 1.85, 1.4, and 1.7 inches more than those of the normal size 10 year olds. Like the 10 year olds, most had either Hourglass or Rectangle shapes, but the 11 year olds had relatively more of the former. Although the 11 year old group was similar to the 10 year old one in the incidence (47%) of thin "D," overall the group showed more variation in front torso shape, with 29% being thin "b," 12% moderate "D," and 6% moderate "b." Also like the 10 year olds, they predominantly had flat or average buttocks prominence.

Although the 11 year olds' mean height was 2.92 inches more than normal size 10 year olds, they weighed slightly less. Nonetheless, the 11 year old normal size tweens still had 1-2 inch larger principle girth body measurements than the 10 year old normal size tweens in the sample. The 11 year olds' lower body lengths were each approximately 2 inches longer than the normal size 10 year olds.

11 Year Old Plus Size Tweens

The height mean for 11 year old plus size tweens in the sample was 3.1 inches above the CDC 50th percentile for height (56.7 inches-CDC) and 43.4 lbs more than the CDC 50th percentile for weight (81.4 lbs-CDC) for 11 year olds. Mean BMI for this group (24.3) was only 0.1 point above the maximum BMI listed by the CDC in the range of "at risk of overweight" and "overweight" (85th percentile and above, 20.1- over 23.1). The plus size 11 year olds in this sample were 0.88 inches taller than the plus size 10 year olds, but weighed slightly less. One-half of the plus size 11 year old tweens had begun

menarche compared to 25% of their normal size counterparts. Six of the 10 girls were in the flat with budding bust prominence category, three were average, and only one was flat. This was not too different than the plus size 10 year olds, but was different than the normal size 11 year olds. With most being Rectangle, the plus size 11 year olds were identical in body shape to the plus size 10 year olds. Except that there were no heavy "Ds" among the plus size 11 year olds, they were also similar in torso shape to the plus size 10 years olds.

The circumference means of the plus size 11 year olds were slightly smaller than the 10 year old plus sizes (bust 0.15 inches, waist 0.3 inches, and hip 0.2 inches). With the plus size 11 year olds being not quite an inch taller than the plus size 10 year olds, the lower body lengths were not too different. The hip and crotch height means were actually shorter.

Table 26

12 Year Old Normal and Plus Size Tweens' Profile

Characteristics	12 Year Old Normal Size Tweens (n = 14)	12 Year Old Plus Size Tweens (n = 11)
Height Mean	61.35 inches	62.46 inches
Weight Mean	95.1 lbs	143.3 lbs
BMI Mean	18.1	25.9
Menarche: Yes	71.4%	45.4%
Menarche: No	28.6%	54.5%
Body Shape: Hourglass	50%	10%
Rectangle	36%	45%
Pear	14%	45%
Bust: Flat	21%	0%
Flat with Budding	50%	45%
Average	29%	45%
Prominent	0%	10%
Buttocks: Flat	14.3%	18.2%
Average	64.3%	54.5%
Extreme	21.4%	27.3%
Torso Shape: Thin "D"	79%	0%
Moderate "D"	7%	72.8%
Heavy "D"	0%	18.2%
Thin "b"	7%	0%
Thin "B"	7%	0%
Moderate "B"	0%	9%
Bust Circumference Mean	32.0 inches	41.1 inches
Waist Circumference Mean	26.3 inches	35.9 inches
Hip Circumference Mean	34.0 inches	43.4 inches
Waist Height Mean	39.1 inches	39.7 inches
Hip Height Mean	30.3 inches	31.9 inches
Crotch Height Mean	29.3 inches	29.0 inches
Bust-to-Waist Difference	5.65 inches	5.16 inches
Waist-to-Hip Difference	7.68 inches	7.45 inches

12 Year Old Normal Size Tweens

Twelve year old normal size tweens in the sample were only slightly above the height (1.95 inches) and weight (3.06 lbs) of the CDC 50th percentile. Their mean BMI (18.1) was actually slightly less than the midpoint of the BMI range for 12 years olds

(18.25) between the 6th-84th percentiles. This finding shows that normal size 12 year olds were within the normal range of body size. They were approximately 2 inches taller and 20 pounds heavier than the normal size 11 year olds. Whereas 25% of those 11 year olds had experienced menarche, 71.4% of the normal size 12 year old tweens had begun menarche, documenting the years 11 to 12 as being pivotal. Evidence of this transitional period was also shown in bust prominence. Whereas 65% of the 11 normal 11 year olds were flat, just 21% of their 12 year old counterparts were. One half of the latter were in the flat with budding category, and 29% were average (compared to 6% of the 11 year olds).

Bust and hip circumference means for the 12 year olds were both almost two inches more than for the normal size 11 year olds. Waist circumference, however, was just 0.6 inch larger, suggesting a more adult-like figure, and this was also evident in comparing the two ages' bust-to-waist and waist-to-hip differences. The relative proportions of Hourglass and Rectangle body shapes, though, were not too different, but it is the result of a visual frontal assessment, not a comparison of circumference measurements. Assessing the proportional rates of changes in bust, waist, and hip measurement changes between ages (an approximate surrogate for menarche) is important to adjusting patterns to fit tweens as they matriculate through puberty. The incidence of the Rectangle (less waist definition) and Pear (fuller hips) shapes should also be considered in pattern development.

Most (79%) of the normal size 12 year old tweens were thin "D." The difference between 9 year old thin "D's" (100%) and this group was that the younger girls predominantly had flat busts, and these 12 year olds had some bust development. Torso

shape is defined as beginning below the bust line. In the 12 year old normal group, there were fewer girls with flat buttocks than in the 11 and 10 year old groups; 64.3% had average, and 21.4% had extreme prominence. Approximately 2 inches taller than the normal size 11 year olds, the 12 year old tweens showed increases in waist height (3.2 inches), hip height (2.2 inches) and crotch height (2.3 inches).

12 Year Old Plus Size Tweens

The height mean for 12 year old plus size tweens was 2.7 inches above the CDC 50th percentile for height (59.4 inches-CDC) and 50.9 lbs more than the CDC 50th percentile for weight (92.4 lbs-CDC) for 12 year olds. Mean BMI for this group (25.9) was just 0.6 of a point above the maximum BMI listed by the CDC in the range of "at risk of overweight" and "overweight" (85th percentile and above, 21.7- over 25.3). Perhaps surprisingly, fewer of the 12 year old plus size tweens' mothers (45.4%) reported that their daughters had begun menarche than was the case for the normal size girls. The two previous ages showed the reverse. Nonetheless, none of these plus size girls had flat busts; a similar percentage to the 11 year olds was flat with budding, and more were average or prominent.

Like the 11 year old plus size group, the 12 year olds were predominantly Rectangle or Pear in body shape, but they were different in being split evenly between those two shapes. The differences in body measurement means between the two age groups were bust circumference (3.1 inches), waist circumference (2.9 inches) and hip circumference (3.2 inches). All of the 12 year old plus size tweens were either moderate or heavy 'D," as were most of the plus size 11 year olds. Both age groups had similarly

small proportions of flat buttocks; the difference was in the greater incidence of extreme buttocks in the 12 year olds.

The mean height of the plus size 12 year olds was 2.66 inches taller than the plus sized 11 year olds. Lower body length measurements were also longer, than but not as different as that. Differences were waist height (1.6 inches), hip height (1.1 inches), and crotch height (1.2 inches). Thus, lengths were not varying as much as longer as circumference measurements were larger when comparing the 11 and 12 year old plus size tweens.

Table 27

13 Year Old Normal and Plus Size Tweens' Profile

Characteristics	13 Year Old Normal Size Tweens (n = 20)	13 Year Old Plus Size Tweens (n = 8)
Height Mean	62.53 inches	62.29 inches
Weight Mean	96.1 lbs	132.8 lbs
BMI Mean	18.8	23.5
Menarche: Yes	55%	37.5%
Menarche: No	45%	62.5%
Body Shape: Hourglass	65%	0%
Rectangle	25%	63%
Pear	10%	37%
Bust: Flat	5%	0%
Flat with Budding	75%	25%
Average	15%	63%
Prominent	5%	12%
Buttocks: Flat	35%	50%
Average	45%	50%
Extreme	20%	0%
Torso Shape: Thin "D"	55%	0%
Moderate "D"	25%	50%
Heavy "D"	5%	0%
Thin "b"	5%	12.5%
Moderate "b"	0%	25%
Thin "B"	10%	12.5%
Bust Circumference Mean	32.4 inches	39.9 inches
Waist Circumference Mean	26.8 inches	34.8 inches
Hip Circumference Mean	35.5 inches	41.2 inches
Waist Height Mean	37.7 inches	39.24 inches
Hip Height Mean	28.6 inches	31.6 inches
Crotch Height Mean	28.3 inches	30.5 inches
Bust-to-Waist Difference	5.59 inches	5.18 inches
Waist-to-Hip Difference	8.64 inches	6.44 inches

13 Year Old Normal Size Tweens

Thirteen year old normal size tweens in the sample had a slightly greater height (.73 inches) and weight (5.1 lbs) means than the CDC 50th percentile for height (61.8 inches-CDC) and weight (101.2 lbs-CDC). The group's mean BMI (18.8) was only 0.15

points less than the CDC's midpoint of the BMI range (18.95) for normal size 13 years olds in the 6th - 84th percentiles. The normal size 13 year olds were within the normal range of body size. Fifty-five percent of the 13 year old normal size tweens had begun menarche. Only one of 20 girls was judged to have a flat bust; 75% were flat with budding, and one girl had a prominent bust, the first incidence in a normal size group.

Compared to the 11 and 12 year olds, a similar proportion (65%) of normal size 13 year olds had an Hourglass shape and the second most common shape was Rectangle (25%). There were only small differences between bust (0.4 inches) and waist (0.5 inches) circumference means for the two groups. However, the difference between hip circumference means was 1.5 inches. Also like the 12 year olds, most of the 13 year old normal size tweens had thin or moderate "D" torsos, and a mix of primarily average buttocks (45%) with some flat (35%) and extreme (20%) buttocks prominence.

Although the normal size 13 year olds were 1.18 inches taller than the 12 year olds, the older girls' lower body length measurements were shorter by 1.4 inches (waist height), 1.7 inches (hip height) and 1 inch (crotch height). This could be the result of uneven growth during puberty or simply a chance circumstance of the sample.

13 Year Old Plus Size Tweens

The height mean for 13 year old plus size tweens in the sample was 0.49 inches above the CDC 50th percentile for height (61.8 inches-CDC) and 31.6 lbs more than the CDC 50th percentile for weight (101.2 lbs-CDC) for 13 year olds. Mean BMI for this group (23.5) was 2.8 points less than the maximum BMI listed by the CDC in the range of "at risk of overweight" and "overweight" (85th percentile and above, 22.7- over 26.3). Mothers reported that just 37.5% of their 13 year old plus size daughters had begun

menarche; this finding was similar to the 12 year plus size girls and again surprising. Despite this, 63% of these tweens had average and 12% had prominent busts; 25% were in the flat with budding category.

There were no Hourglass body shape tweens among the plus size 13 year olds; 63% had Rectangle and 37% had Pear body shapes. Most of the 12 year old plus size girls had also been split between the latter two shapes. The mean weight for the plus size 13 year olds was 10.5 pounds lighter than the plus size 12 year olds, and the older girls' circumference measurements were smaller, too (bust: -1.2 inches, waist: -1.1 inch, and hip: -2.2 inches). However, the two groups' bust-to-waist differences were similar; the older girls' waist-to-hip difference was 1 inch larger than the 12 year olds. The plus size 13 year old tweens were evenly divided between the flat and average buttocks categories. One-half were in the moderate "D" and one-quarter in the moderate "b" torso shape category.

The plus size 13 year old tweens were barely shorter than the 12 year old group. The older girls' waist and bust heights were less than one-half inch shorter, as well, but their mean crotch height measured 1.5 inches longer. This could have resulted from the body scanner mis-assigning the crotch level because of full thighs. Waist-to-hip difference was 1.01 inch; crotch height had 1.5 inch net difference from 12 year old plus size tweens.

Table 28.

14 Year Old Normal and Plus Size Tweens' Profile

Characteristics	14 Year Old Normal Size Tweens (n = 14)	14 Year Old Plus Size Tweens (n = 16)
Height Mean	63.02 inches	64.11 inches
Weight Mean	112 lbs	153.8 lbs
BMI Mean	19.6	26.35
Menarche: Yes	92.9%	43.8%
Menarche: No	7.1%	56.2%
Body Shape: Hourglass	50%	37.5%
Rectangle	14.3%	25%
Pear	35.7%	37.5%
Bust: Flat with Budding	36%	43.7%
Average	50%	37.5%
Prominent	14%	18.8%
Buttocks: Flat	57.1%	50%
Average	35.8%	50%
Extreme	7.1%	0%
Torso Shape: Thin "D"	14.3%	31%
Moderate "D"	35.8%	25%
Heavy "D"	0%	13%
Moderate "b"	7.1%	0%
Thin "B"	14.3%	6%
Moderate "B"	7.1%	0%
Heavy "B"	0%	6%
Bust Circumference Mean	33.2 inches	42.4 inches
Waist Circumference Mean	28 inches	36.5 inches
Hip Circumference Mean	36.2 inches	44.7 inches
Waist Height Mean	38.7 inches	40.5 inches
Hip Height Mean	29.9 inches	32.7 inches
Crotch Height Mean	28.9 inches	29.3 inches
Bust-to-Waist Difference	5.18 inches	5.8 inches
Waist-to-Hip Difference	8.2 inches	8.13 inches

14 Year Old Normal Size Tweens

Fourteen year old normal size tweens in the sample were only slightly below the height (-0.38 inches) and above the weight (4.2 lbs) of the CDC 50th percentile. Their mean BMI (19.6) was slightly more (0.05) than the CDC's midpoint of the BMI range for

14 years olds (19.55) between the 6th-84th percentiles. This finding shows that normal size 14 year olds were within the normal range of body size. A large majority of normal size 14 year old normal size tweens had begun menarche (92.9%). This was the first age at which there was no incidence of flat busts among the normal sizes; 36% were characterized as flat with budding; 50% as average; and 14% as prominent.

One-half of these same tweens had Hourglass body shapes. Unlike the normal size groups for ages 10-13, the incidence (35.7%) of Pear shape exceeded the Rectangle shape (14.3%), indicating relatively wider hips and/or thighs. Bust, waist and hip circumference means were larger than the 13 year old normal size group by 0.8, 1.2, and 0.7 inches (respectively); their bust-to-waist and waist-to-hip differences were within one-half inch of each other. The normal size 14 year olds' mean weight was 15.9 pounds heavier than the normal size 13 year olds.

Whereas most of the normal size 13 year olds were thin "D," "B," or "b," 35.8% of the 14 year olds were moderate "D" torso shape. This oldest group had more variation in torso shape than the younger ages, perhaps suggesting the progress towards adulthood. In the buttocks prominence category, more of the 14 year olds were flat (57.1%) than average (35.8%) or extreme (7.1%). The normal size 14 year olds were just one-half inch taller than their 13 year old counterparts. Their length differences were slightly greater or for waist height (1 inch) and hip height (1.3 inches), and comparable for crotch height (0.6 inch).

14 Year Old Plus Size Tweens

Fourteen year old plus size tweens in the sample were 0.71 inches above the CDC 50th percentile for height (63.4 inches-CDC) and 46 pounds more than the CDC 50th

percentile for weight (107.8 lbs-CDC) for 14 year olds. Their mean BMI (26.4) was 0.8 points below the maximum BMI listed by the CDC in the range of "at risk of overweight" and "overweight" (85th percentile and above, 23.3- over 27.2). This finding shows that the plus size 14 year olds were outside the normal range of body size. Similar to the 12 and 13 year old plus size tweens, more plus size 14 year olds were reported to have not begun menarche than to have begun. The finding was distinctly different than the finding for the normal size 14 year olds. There was relatively more plus size 14 than 13 year olds who fit into the flat with budding bust category, but also a few more in the prominent category.

Unlike the plus size 13 year olds, 37.5% of the 14 year old group had Hourglass body shape, and relatively fewer had the Rectangle shape. A similar proportion was Pear shape. The 14 year old plus size tweens were 21 pounds heavier than the 13 year old group, and their mean bust, waist, and hip circumferences were larger by 2.5, 1.7, and 3.5 inches, respectively. These differences were reflected in the increases in bust-to-waist (0.62 inch) and waist-to-hip (1.69 inches) relationships.

Although most exhibited the "D" shape, like their normal size peers, the 14 year old plus size tweens displayed more variation in torso shape than younger ages. That 31% were thin "D" and 25% moderate "D" is a reflection of how much outward contouring their bodies showed, not how deep they were from front to back, and that there was not clear waist indentation. The plus size 14 and 13 year olds had the same incidence of buttocks prominence, one-half flat and one-half average.

The plus size 14 year olds were 1.8 2 inches taller than the 13 year olds. Their waist and hip height means were longer by 1.26 and 1.1 inches (respectively). Although

their crotch height was less by 1.2 inches, this could have resulted from inaccurate placement of the crotch line due to full thighs.

General Findings

Whether considering height or weight, tween girls in this sample had predominately larger measurements than those in the CDC sample and O'Brien et al. (1941). Body circumferences and lower body height measurements for the sample were also generally larger than those reported in O'Brien et al. (1941) for comparable age groups.

Normally, apparel is produced by developing slopers (first patterns) to fit a central or target set of body measurements then scaling (or grading) those measurements up or down to make smaller and larger sizes. When comparing normal and plus size girls in this study, it appears that measurements for plus size girls are larger by several inches than those for normal size girls of a comparable age. Clothing made for normal size girls would be much too small for these tweens. Plus size girls had circumferential measurements that would allow them to fit adult into adult clothing e.g. 9 year old plus size girls in the sample fit the bust and hip measurements for a Misses size 12. Their waists were larger than the ASTM© Size 12 standard. They could, perhaps, wear adult clothing with elastic waistbands. However, there are two problems with this approach; one is that the vertical height measurements for the plus size girls were shorter by several inches (e.g. -5.6 inches for 9 year olds) than those for adult Misses' sizes. Adult clothing does not fit the height measurements for these shorter, plus size girls. Secondly, adult clothing is not age appropriate for this tween market because styling may be too mature. For example, when adult sizing is made to conform to a tween body, a lowered neckline

which fits an adult may be immodest on a nine year old because of the shorter vertical body measurements. Tween daughters and their mothers identified modesty as a primary issue in clothing selection (Brock, 2007).

Clothing appearance and fit is of significant importance to tween girls (Brock, 2007). Based on this study, finding clothing sized for the body measurements of today's young girls can be problematic. The current study is the first study to look at body shape for this target market. These young girls were mostly identified as Hourglass or rectangular and body shape should be taken into consideration when designing and grading patterns to fit this group.

Specific Findings

Between ages 9 to 11 years old normal size tweens grew taller faster than they developed bust and larger hip circumference. Younger plus size tweens, however, began to show signs of breast development at earlier ages than normal size tweens. Plus size tweens were taller and heavier than normal girls at every age. Twelve to fourteen year old normal sizes had high incidences of menarche, therefore changes in body shape such as increasing bust and hip should be circumference should be noted when making patterns and constructing garments for this group. These normal size tweens had more Hourglass than Rectangle shaped bodies. At 12-14 years of age, tweens gained weight and developed bust and hips faster than they grew taller. The 12-14 year old plus size tweens were heavier and taller. They were heavier busted than the normal size tweens, but generally had had more Rectangle shaped bodies. Findings suggested that bust and hip and length measurements should be primary concerns for patternmaking as tweens age.

The body measurement means found in the tables for each age group may serve as references for determining how sizing chart measurements compare for tweens with similar profiles.

Limitations

There are limitations that may have impacted the study. Though assistants were trained in data collection and analysis procedures, human error is a possibility in a study of this magnitude which includes manipulation of numerical variables at several different levels. The accuracy of the data collected using the 3D body scanner is about 1 mm in the horizontal plane and 2 mm in the vertical plane (Simmons, 2002). However, limitations can result due to human manipulation of calibration for the system or even problems with the subject being scanned e.g. hair not pulled up from the back of the neck, not standing still during scan. Because of the sensitivity of the 3D body scanner, subjects had to follow specific guidelines to ensure a good quality scan was produced. In some instances, scans had to be taken more than once which was limiting in terms of time. In order to extract body measurement Also, while in the body scanner some of the younger tweens in this study seemed to have difficulty grasping the handholds in the scanner in order to stand perfectly straight. This caused some body scans to appear crooked and more difficult to decipher when conducting visual analysis.

In order to extract body measurements, the 3D scan software operates using a measurement extraction profile (*.mep file), which indicates where the body landmarks are located that are used in data extraction, e.g., bust, waist, hips, etc. At times the scanner software may find it difficult to locate certain landmarks like the crotch when a person's thighs are too close together. Correct measurement extraction can be a limitation

when using the 3D body scanner, even though the accuracy of the actual measurement extracted is very precise.

It is common knowledge that race can be the reason for a difference in body shape characteristics for a population. However, because of the small sample size the subjects were not divided by race. It is a possibility that the inclusion of all races represented in the sample could have skewed the results. The study was limited by the small sample size. Cell sizes for individual age groups perhaps could not be used to generalize the results to a large population. However, patterns were found among different ages and BMI groups. A larger sample would insure a better cross section of body shapes.

Another limitation of the study was that the sample was collected at two different times using two different methods, random sampling and convenience sampling. The first group of subjects was specifically recruited to represent the cross-section of subjects need for the study according to age and BMI. The second group of subjects was recruited as a convenience sample.

Implications

This research has very practical application for the apparel industry as well as academia. This research study validated, by comparing measurements to the seminal children's body measurement study (O'Brien and Girshick, 1939; O'Brien et al., 1941), the distinct need for updated anthropometric data for tween girls in the United States. The results present profiles of tween girls based on age and BMI that show patterns of incidence of body shapes and body shape components and give specific measurement means that can be used as references for sizing charts. Although current sizing charts for tweens are not age related, it seems that it would be beneficial to consider age related

changes in body measurements and body shape for more accurate pattern development and garment construction.

Recommendations

There are a limited amount of studies on body measurements and body shapes in the tween population. It is recommended that more studies be conducted to gain more in-depth knowledge concerning this growing population. For apparel companies that want to bring better sizing options to the market it would be wise to continue this research with larger samples of tweens with the aid of 3D body scan technology as a resource for data collection. Other recommendations include:

- Study underweight girls in the tween population.
- Study body shape for tweens from specific ethnic backgrounds.
- Add other upper body measurement variables such as arm length, upper arm circumference, center front trunk length.
- Add other lower body measurement variables such as thigh circumferences, abdomen, and high hip.
- Study fit problems for plus size and underweight tweens.
- Compare existing sizing charts to updated anthropometric data for tweens.
- Develop a longitudinal study to assess tween body shape changes over time.

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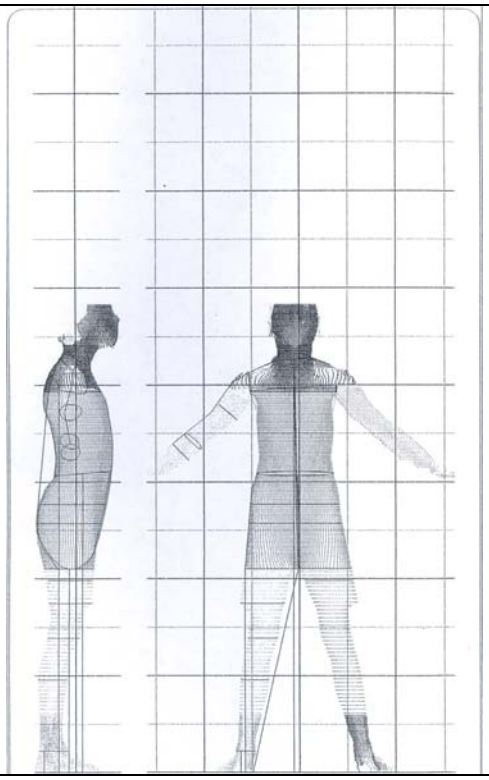
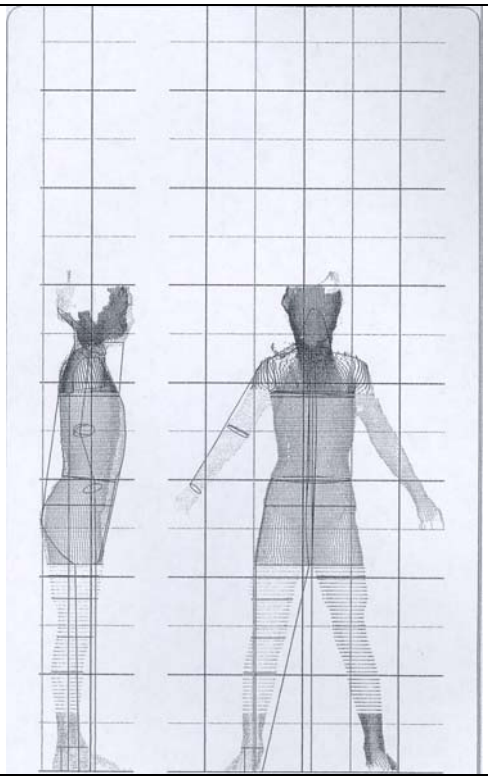
APPENDICES

APPENDIX A

TWEEN 3D BODY SCANS CATEGORIZED BY AGE

ARRANGED BY ASCENDING BMI

9 Years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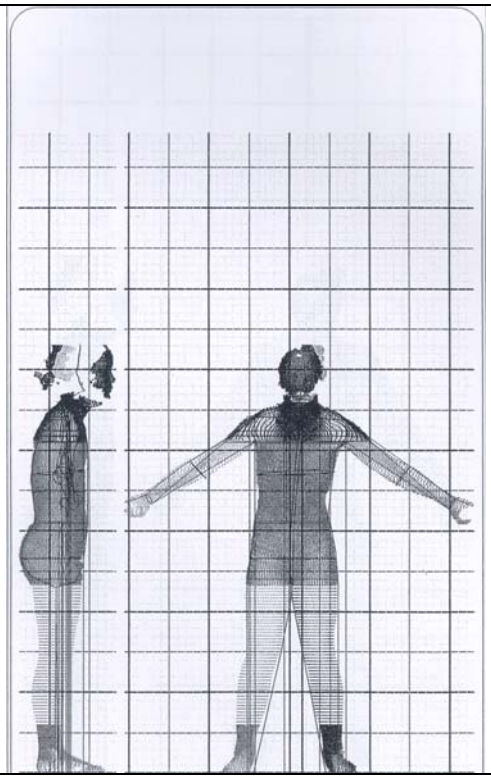	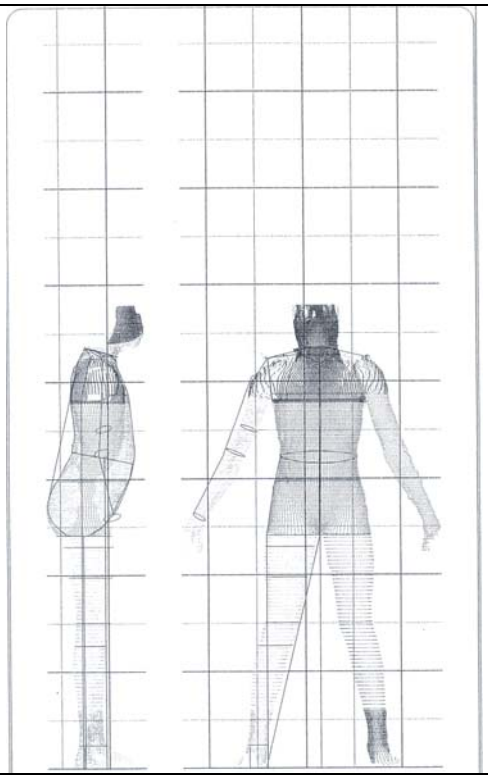
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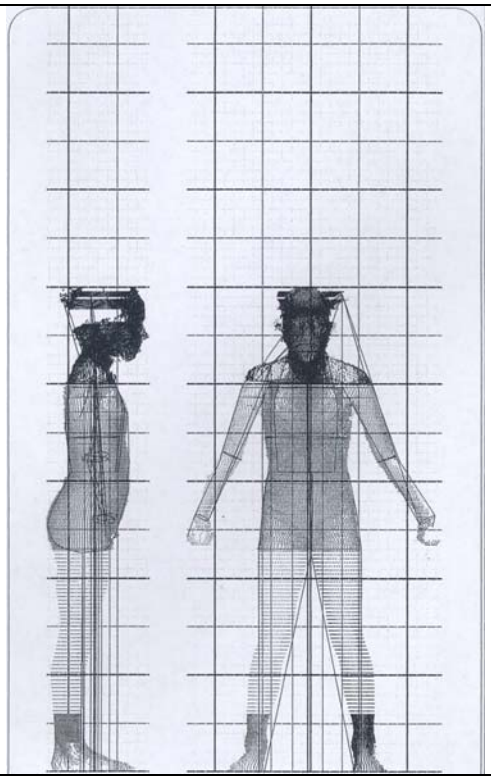	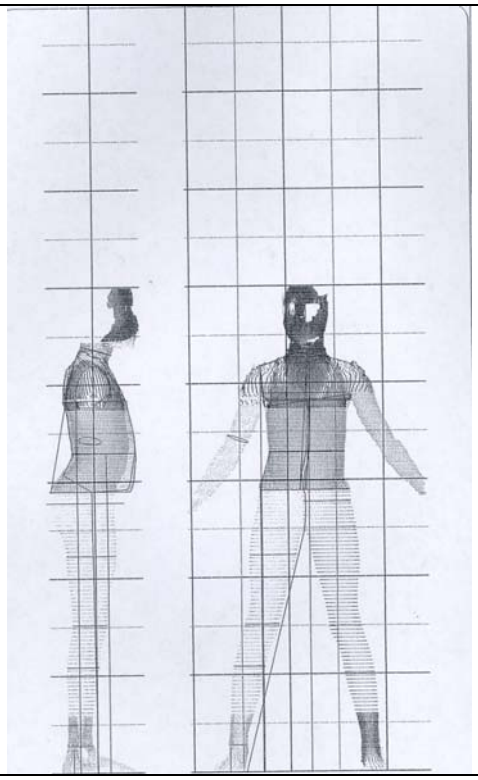
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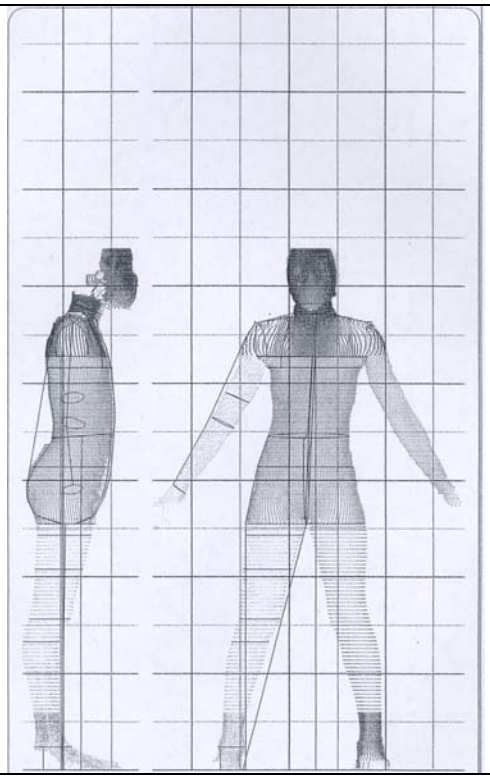	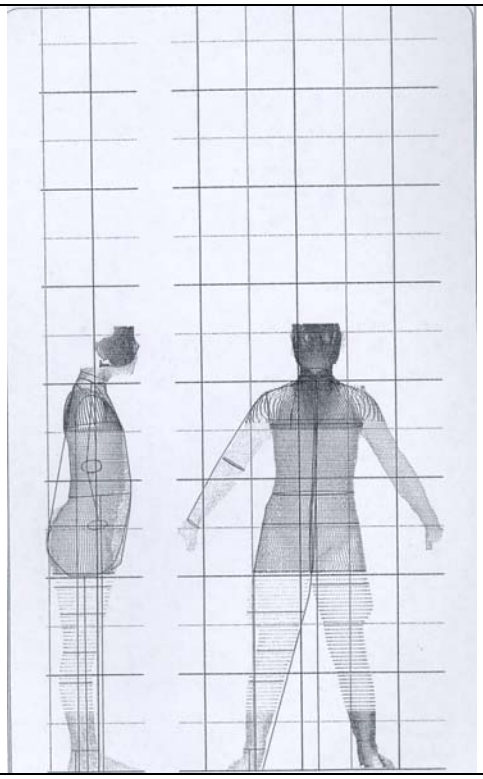
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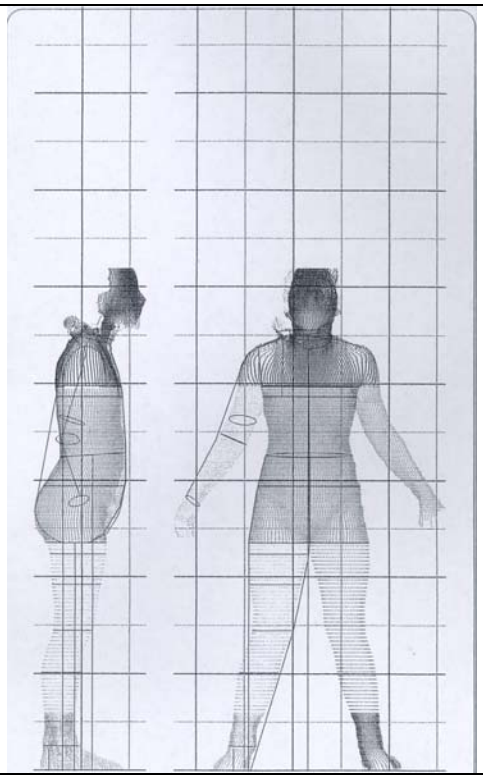	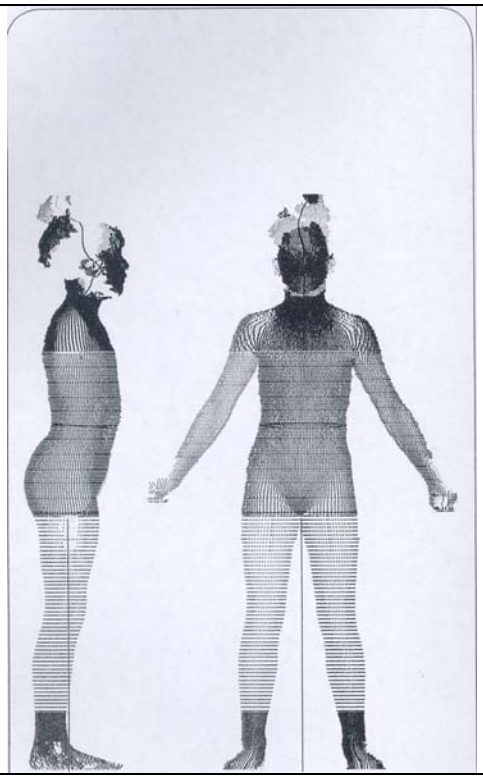
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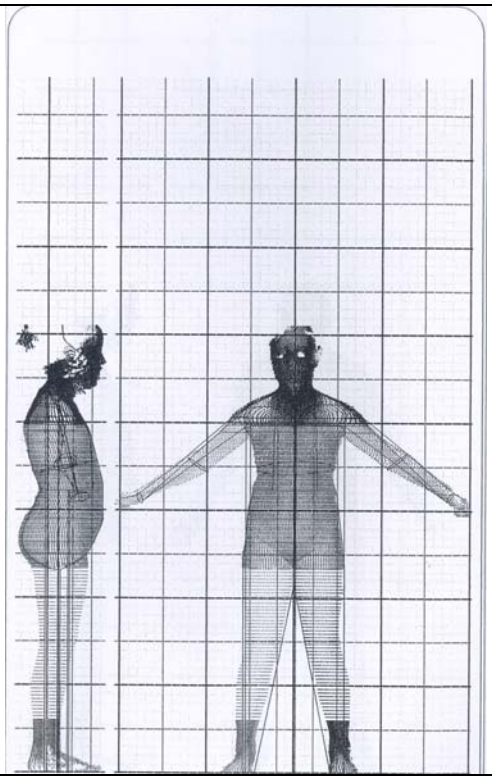	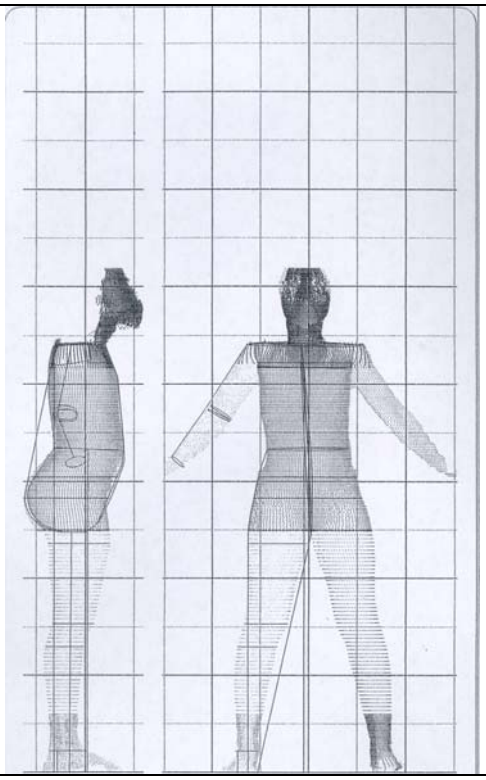
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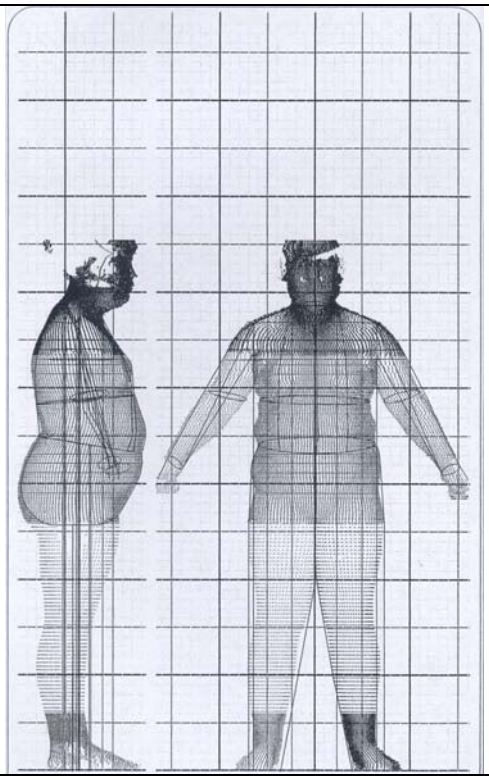	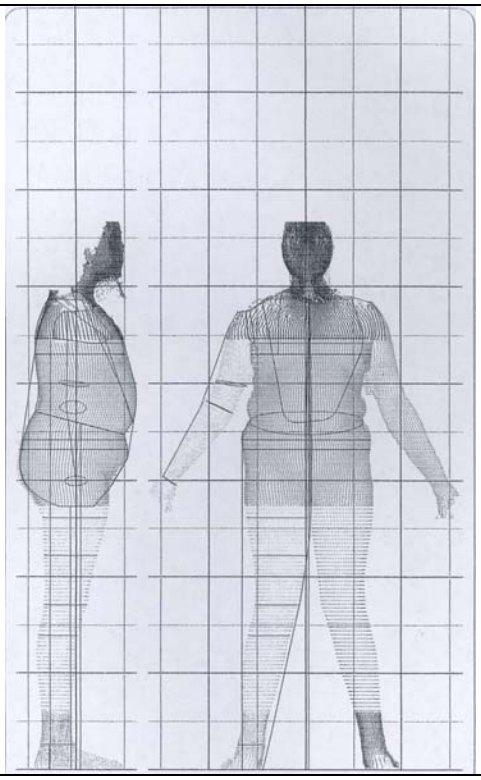
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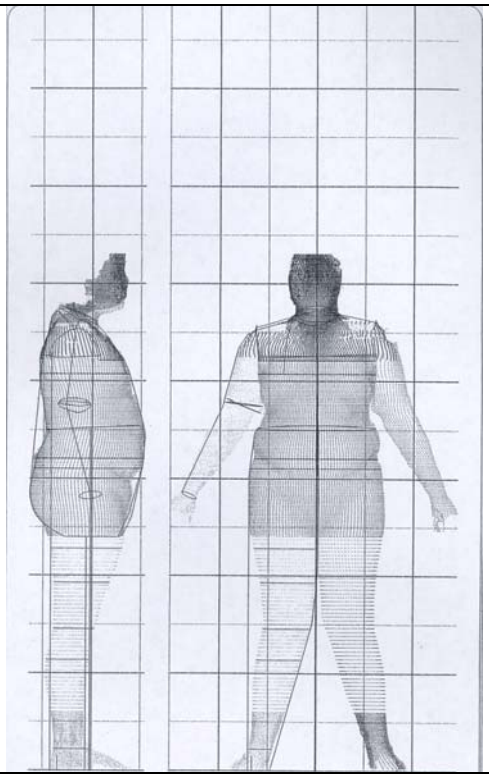	
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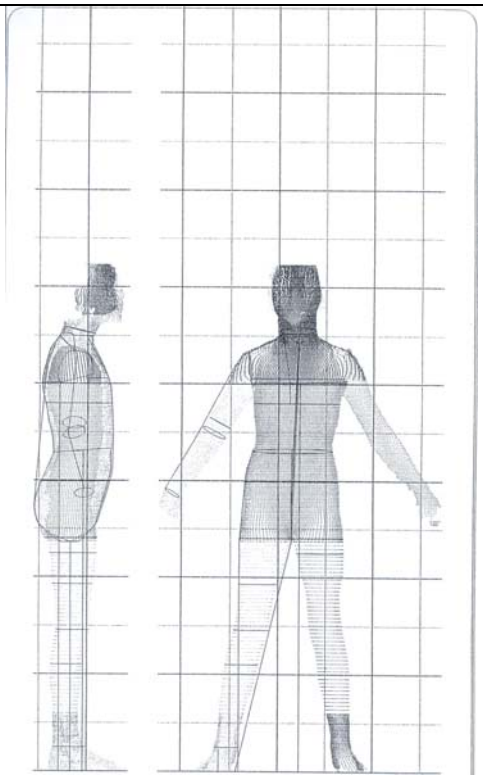
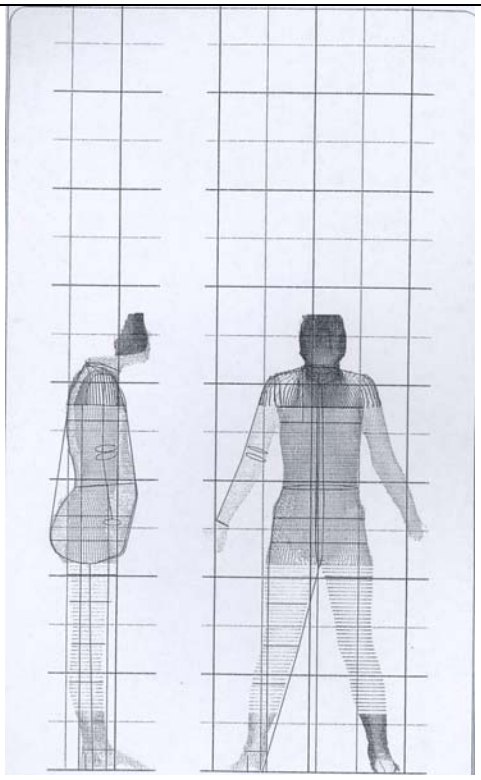
10 Years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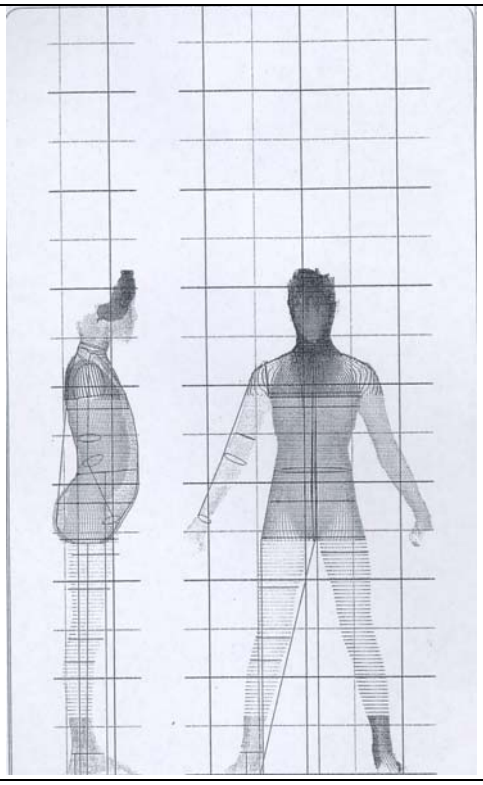	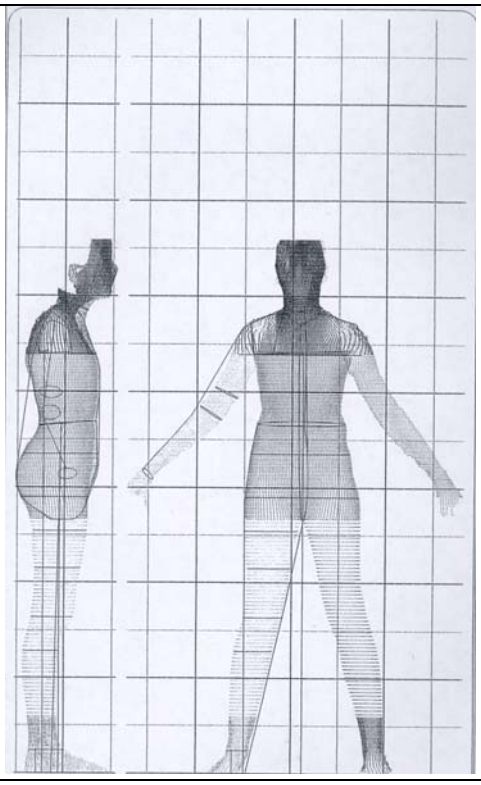
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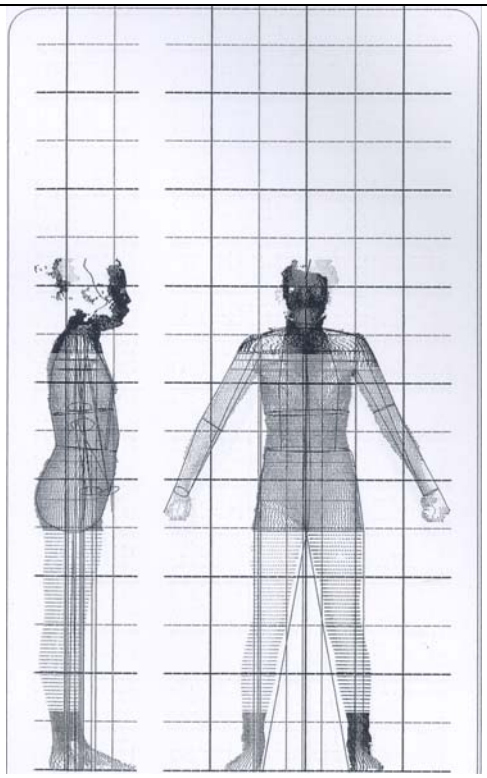	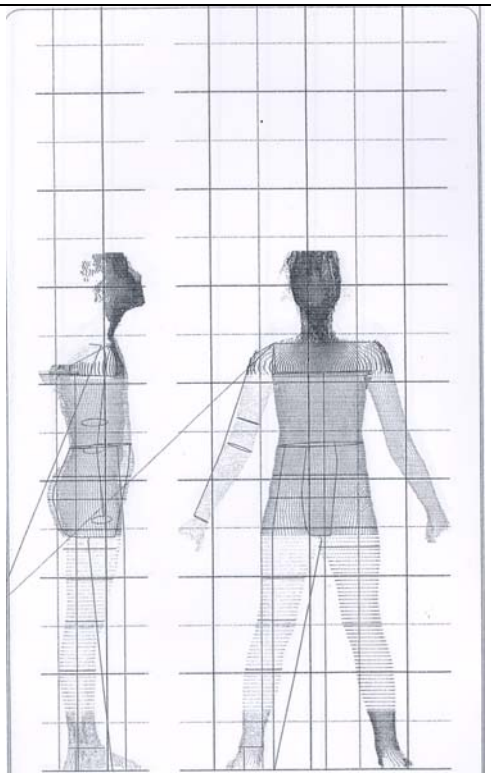
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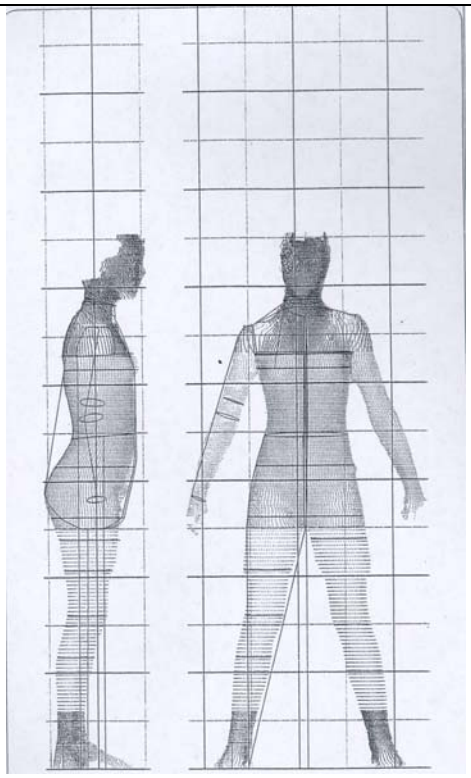	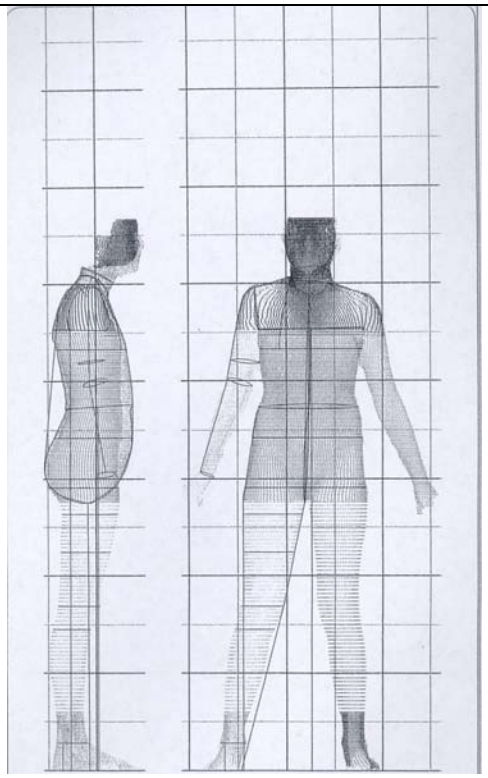
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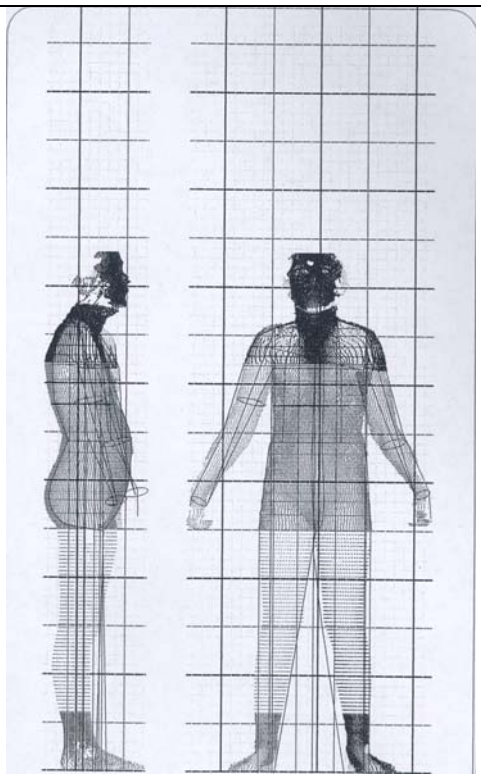	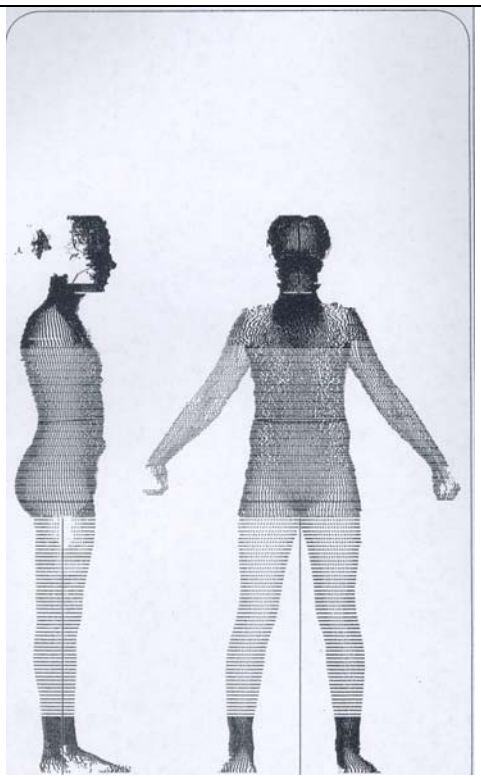
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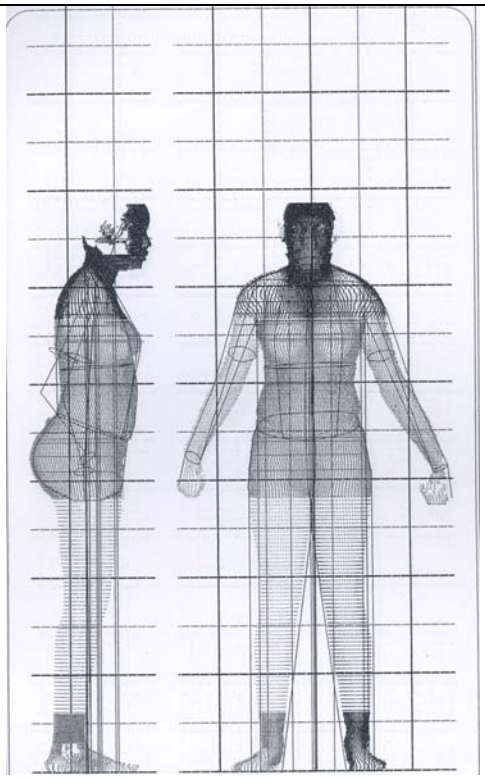	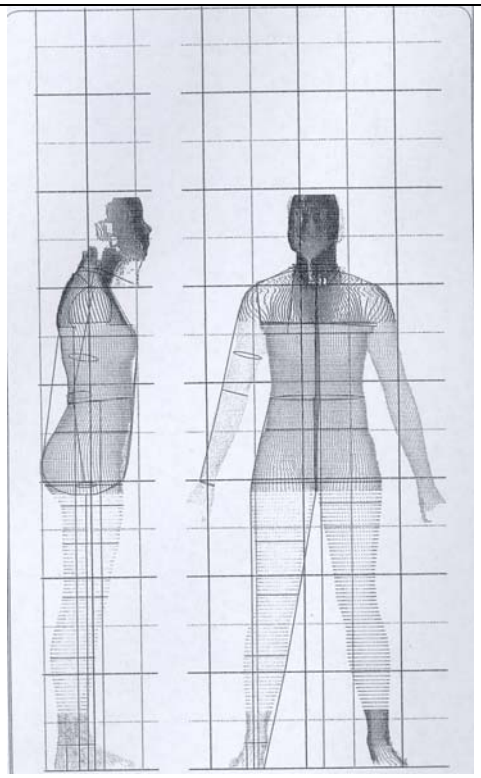
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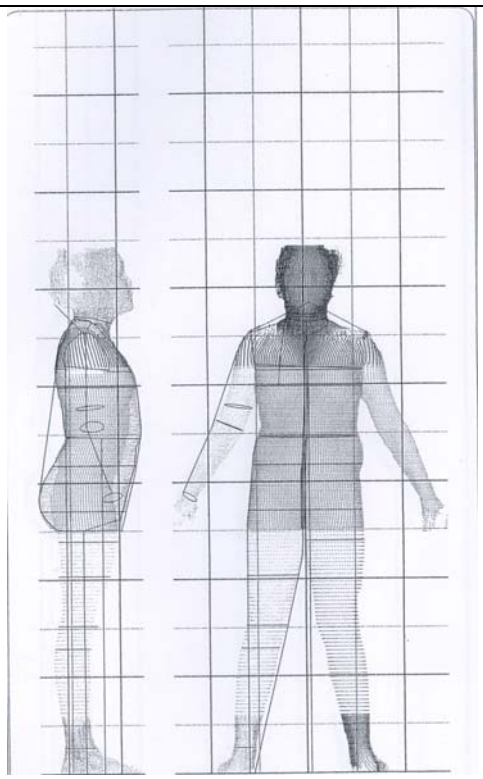	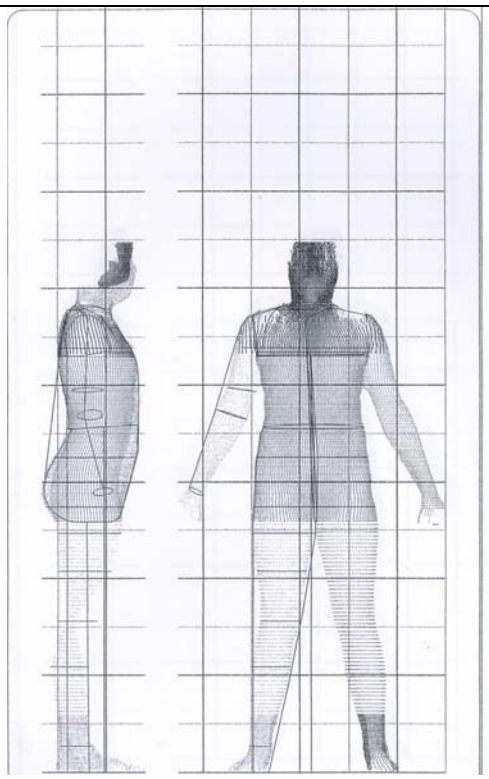
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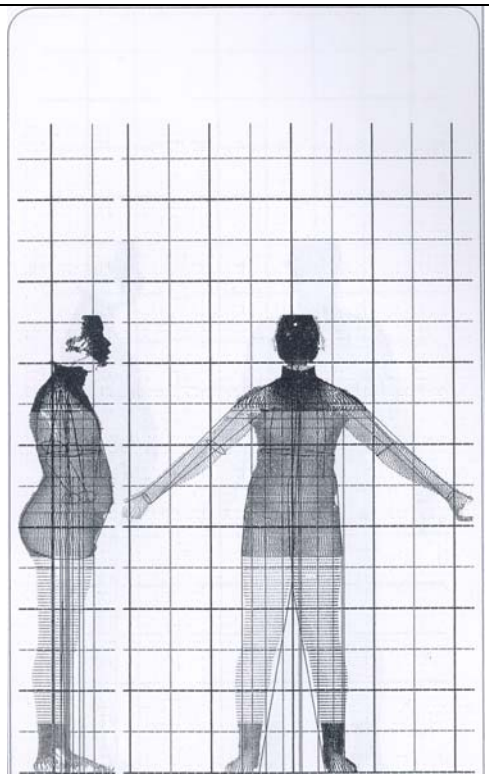	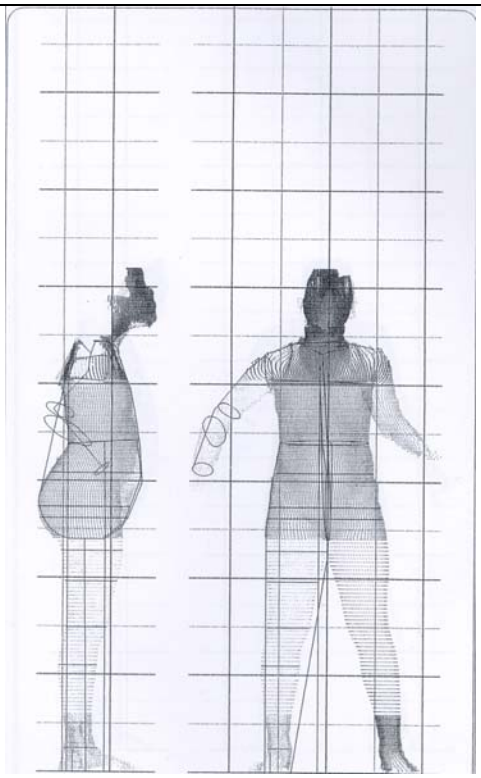
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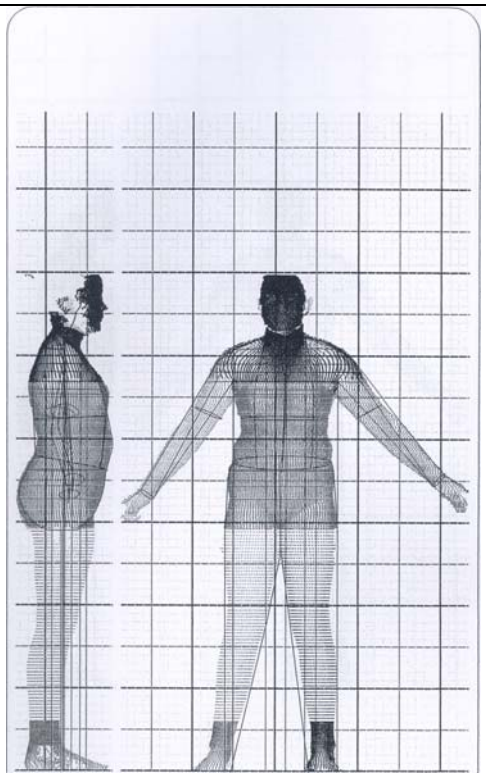	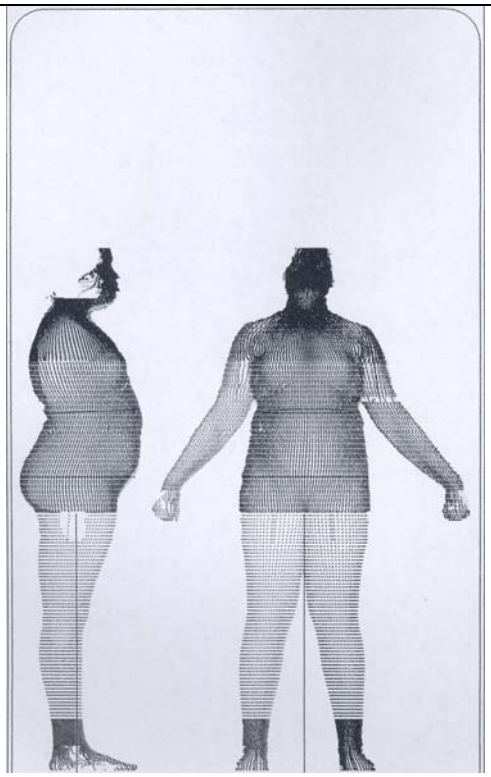
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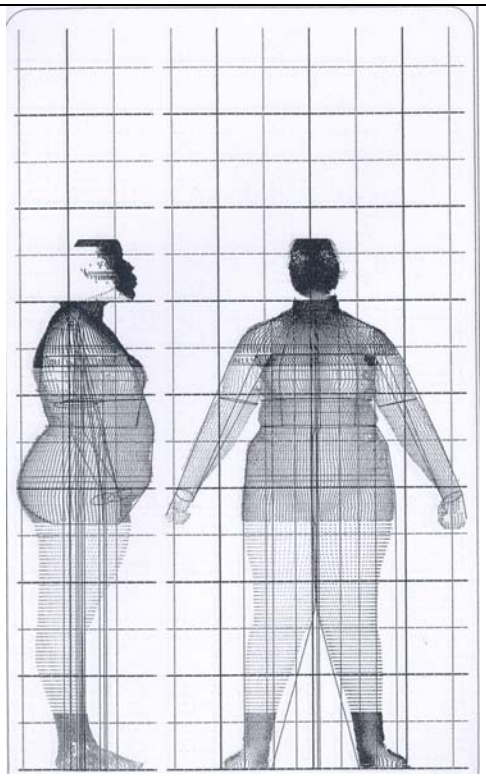	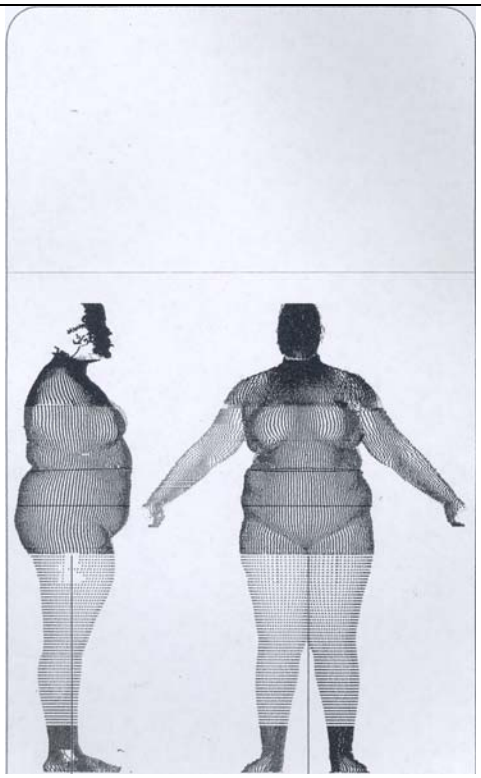
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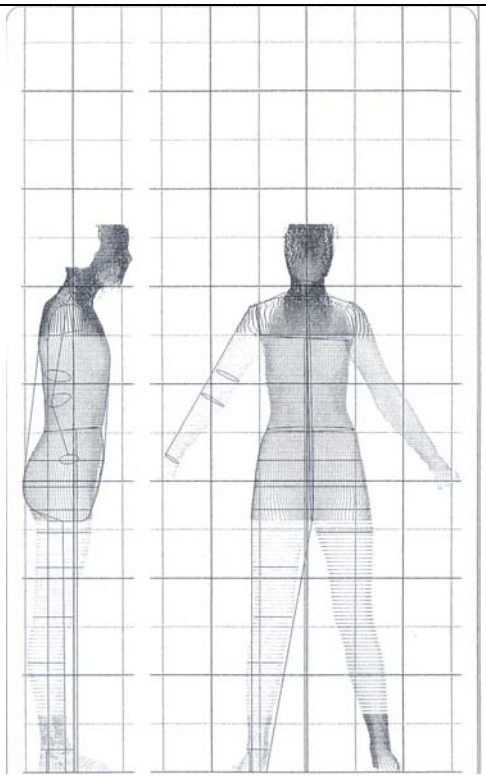	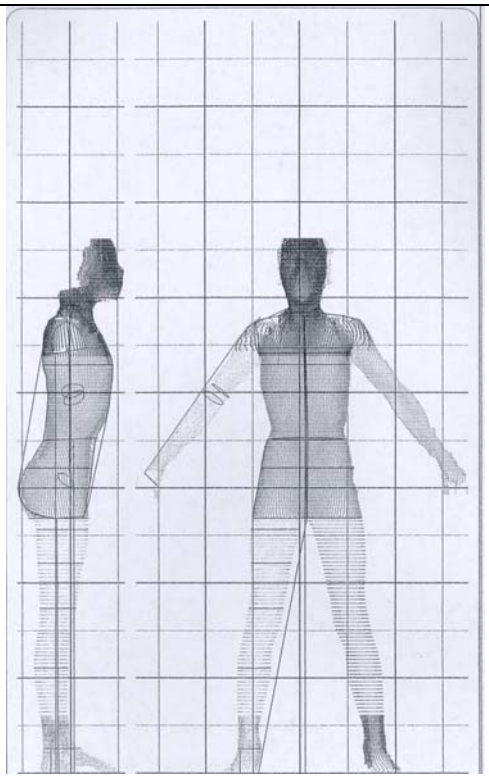
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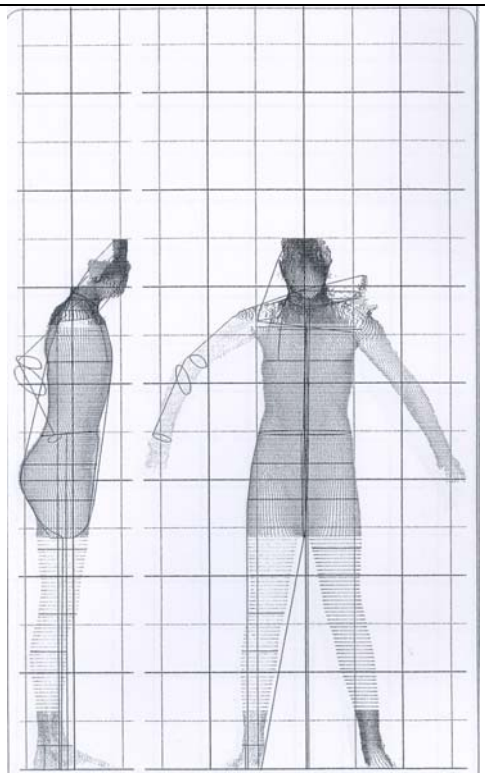	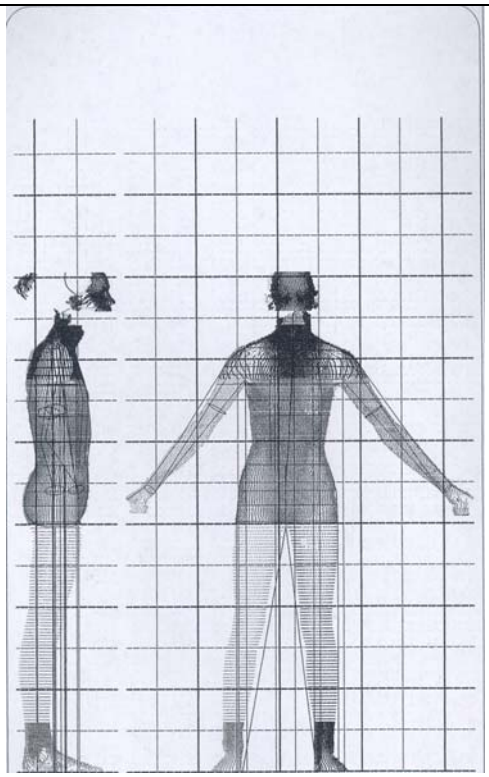
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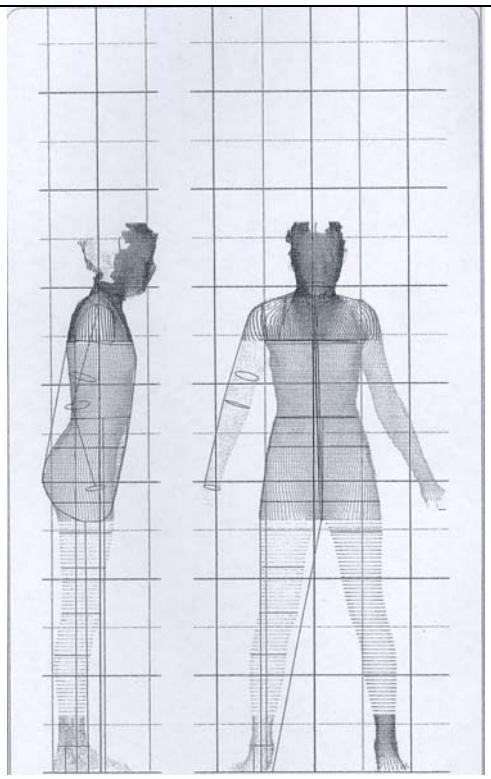	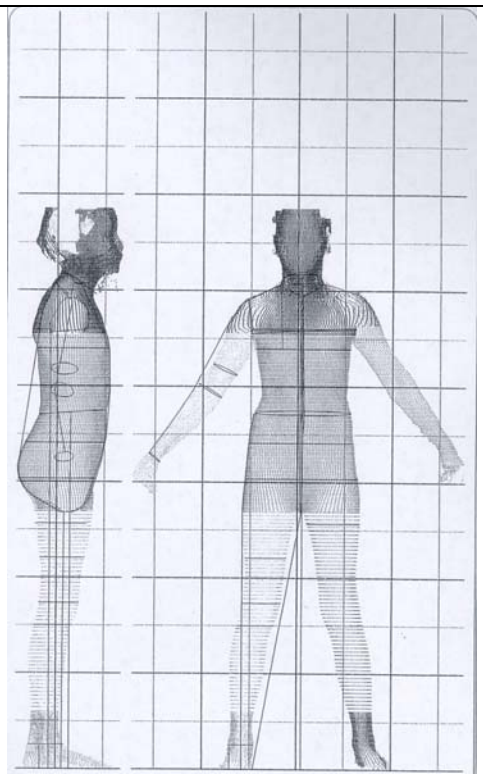
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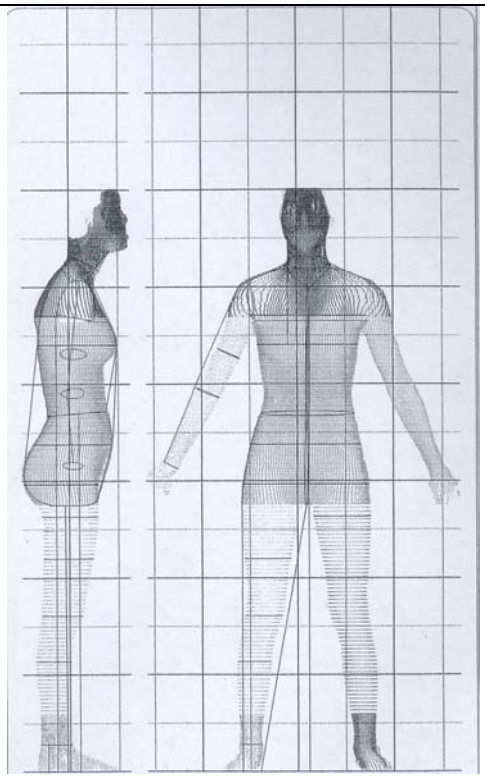	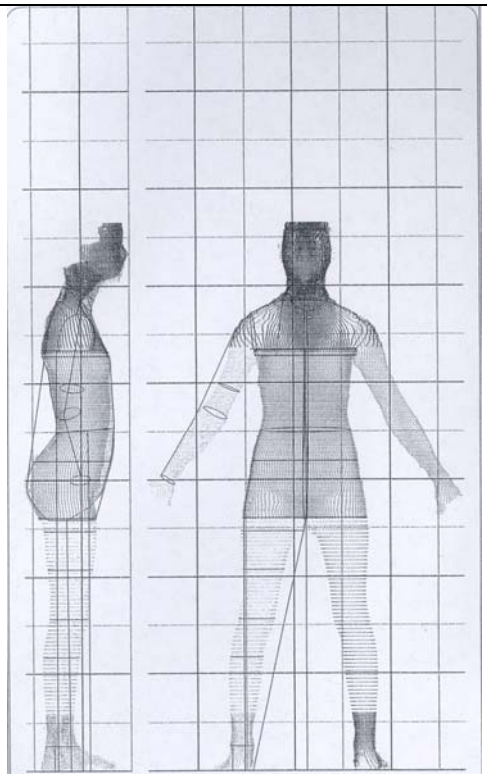
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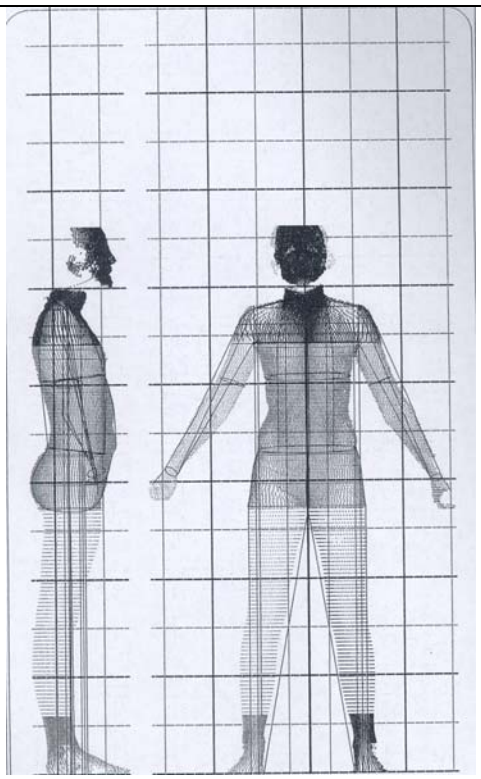	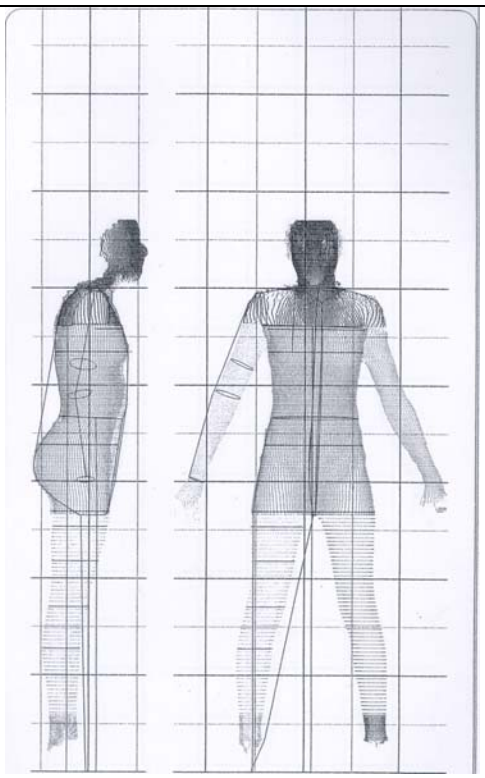
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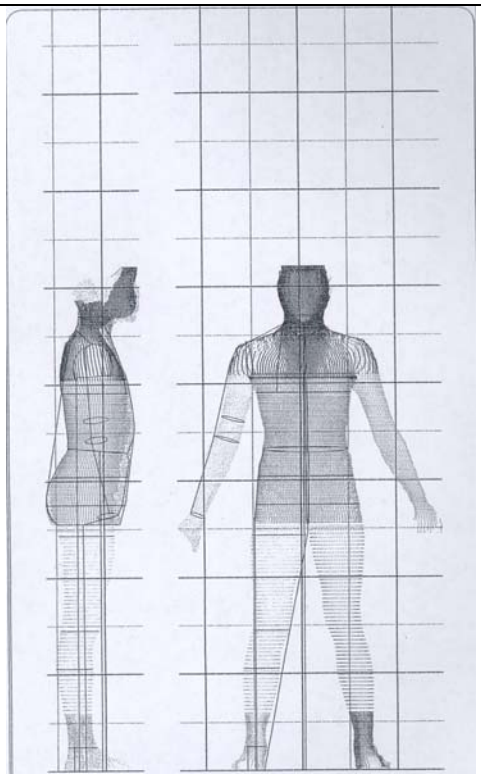	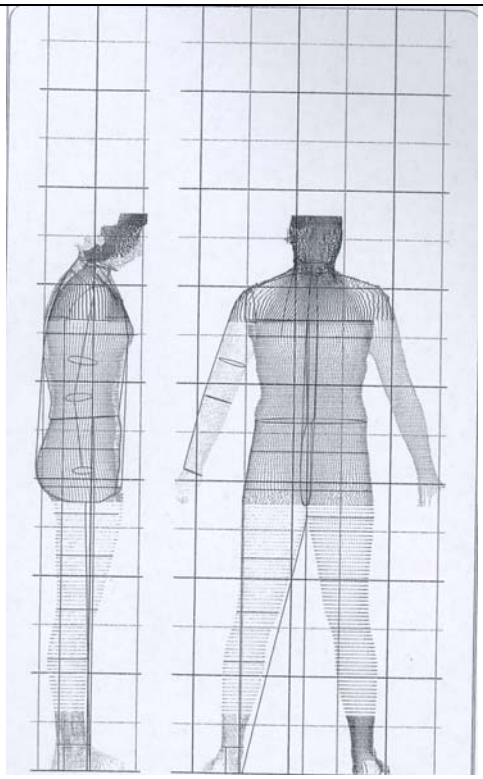
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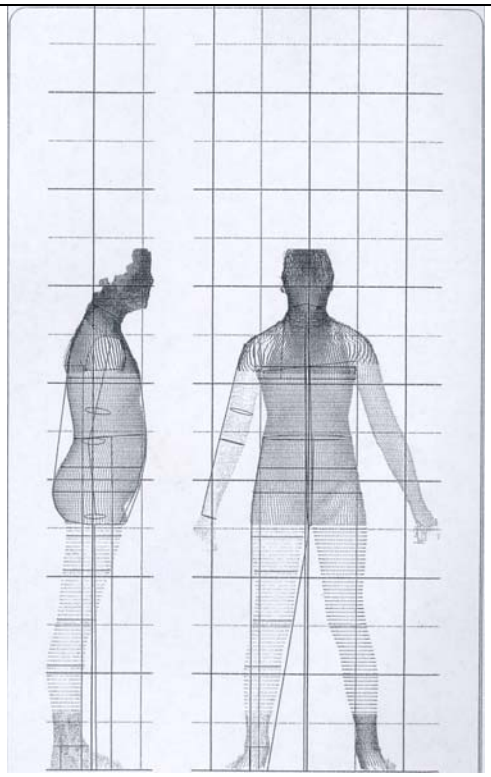	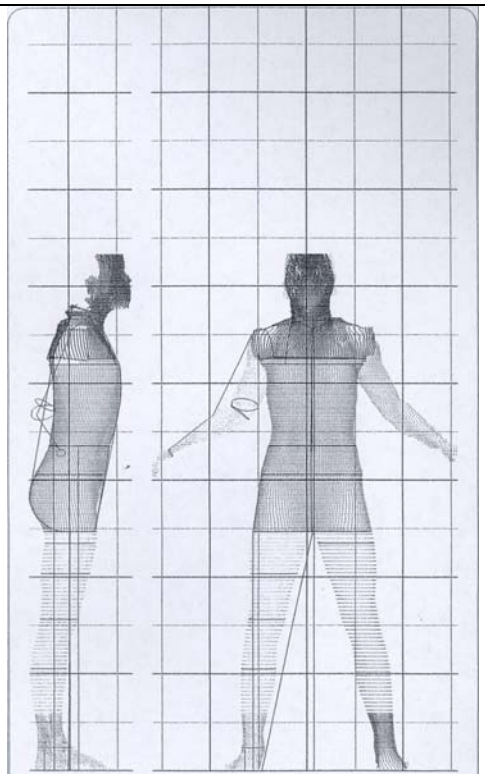
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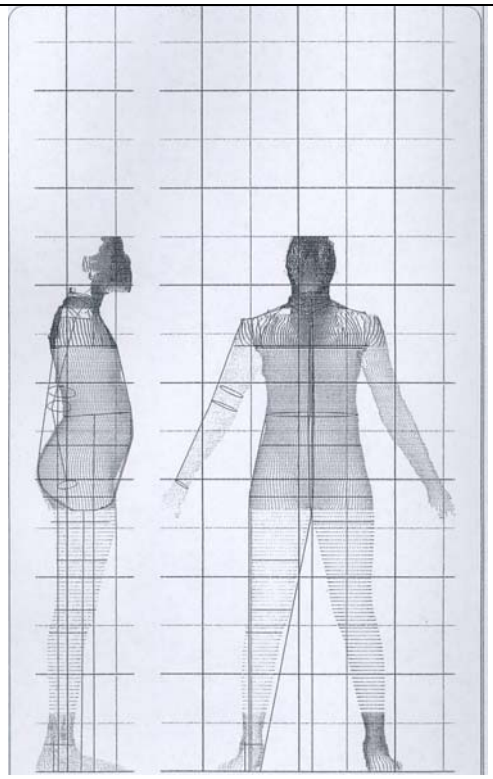	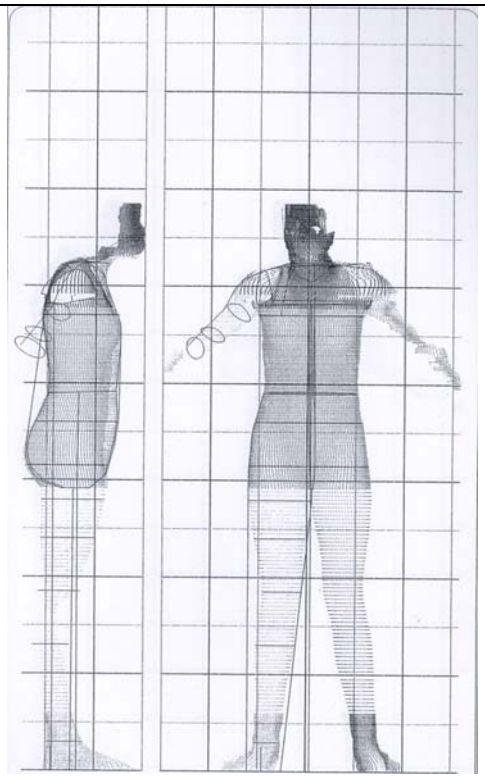
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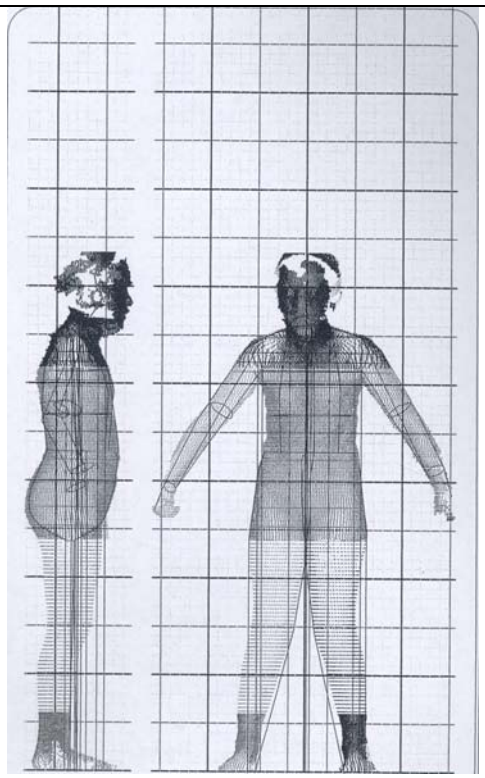	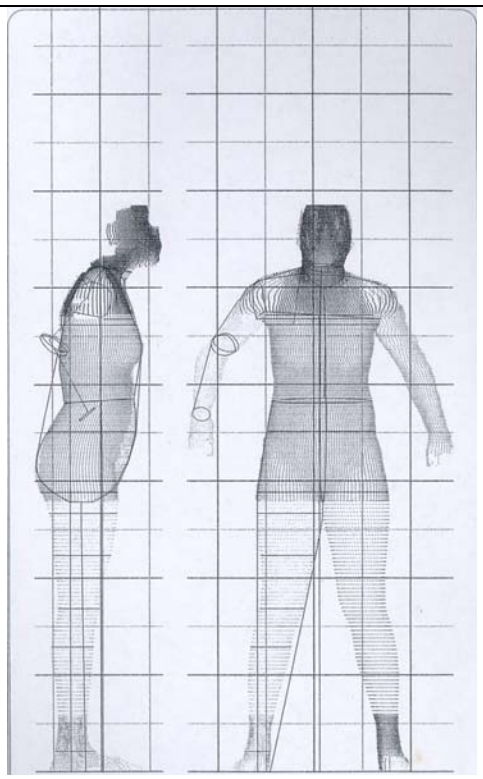
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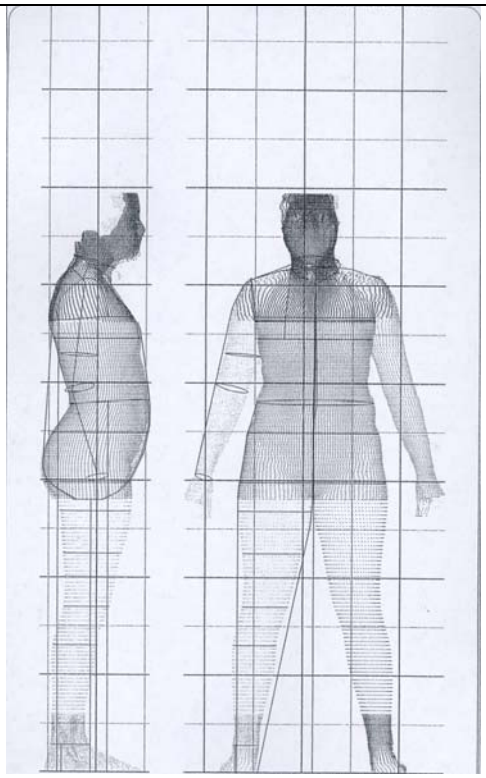	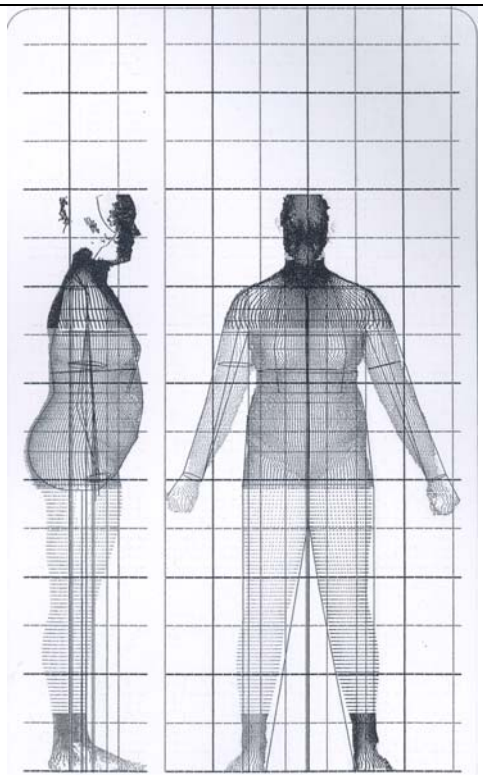
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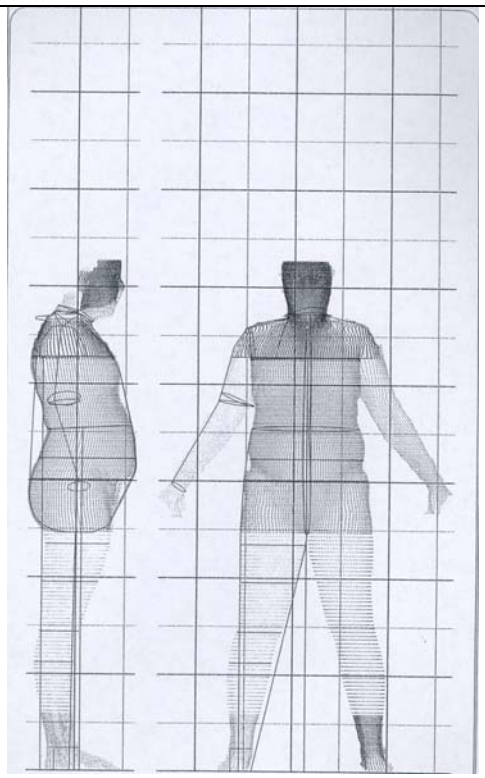	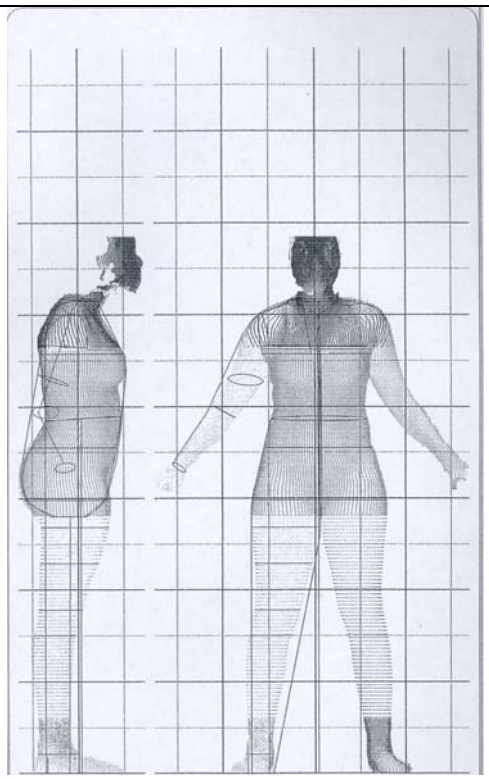
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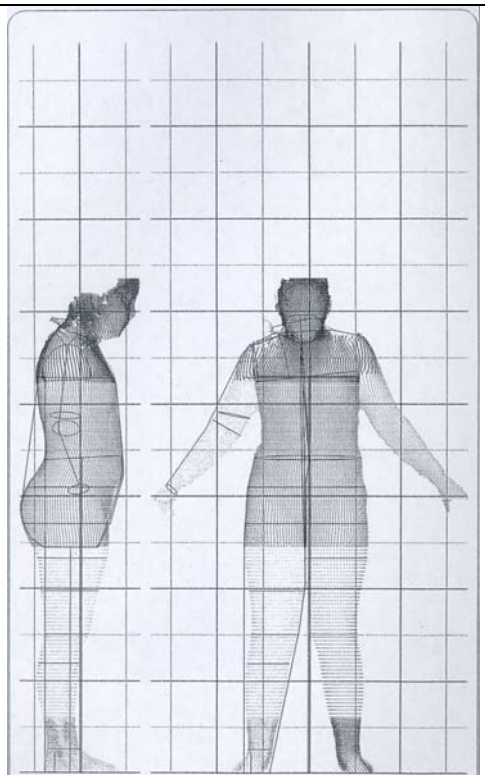	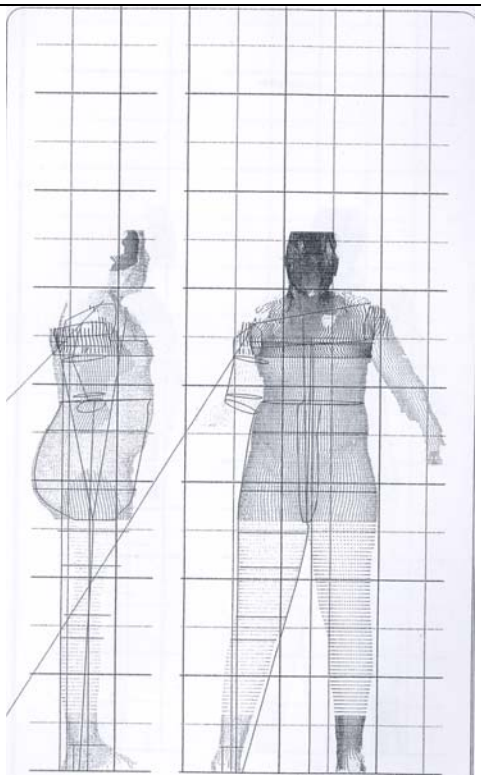
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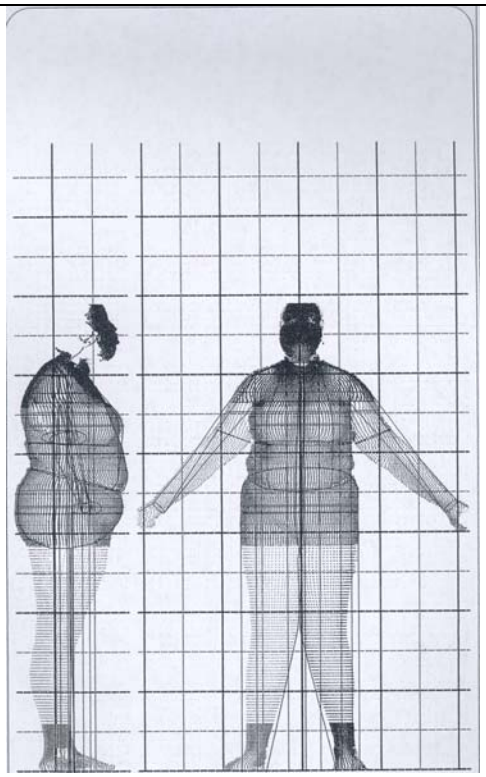	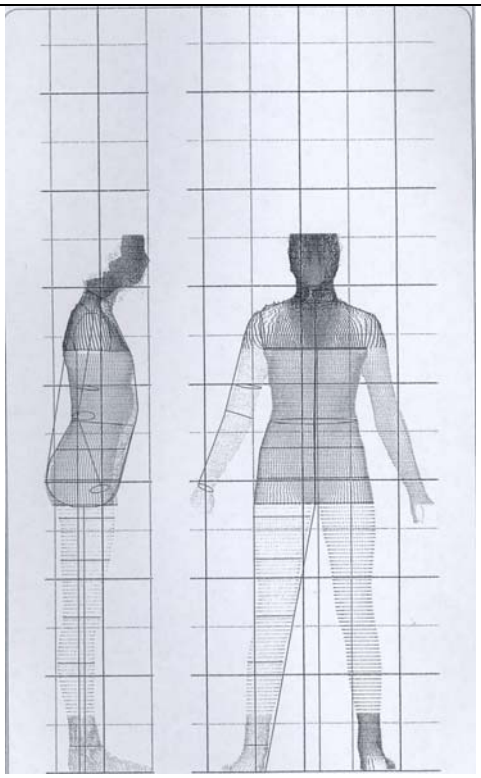
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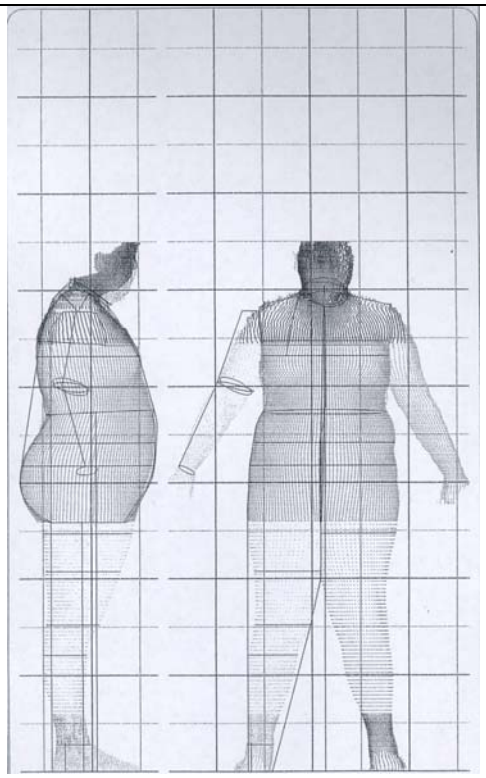	
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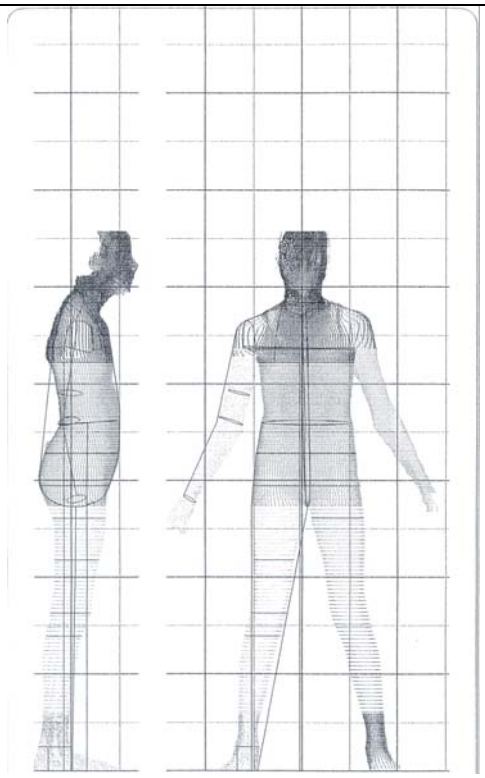	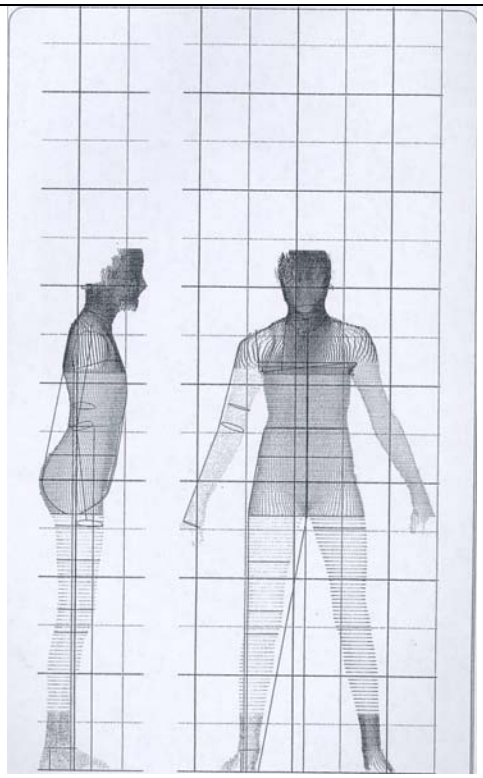
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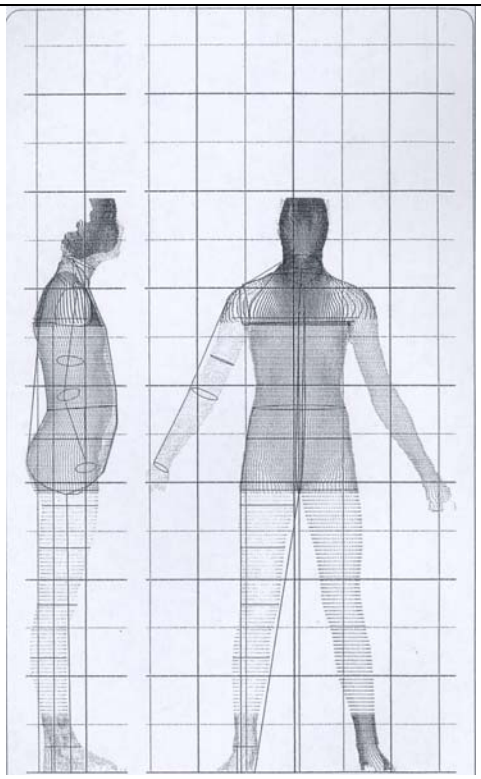	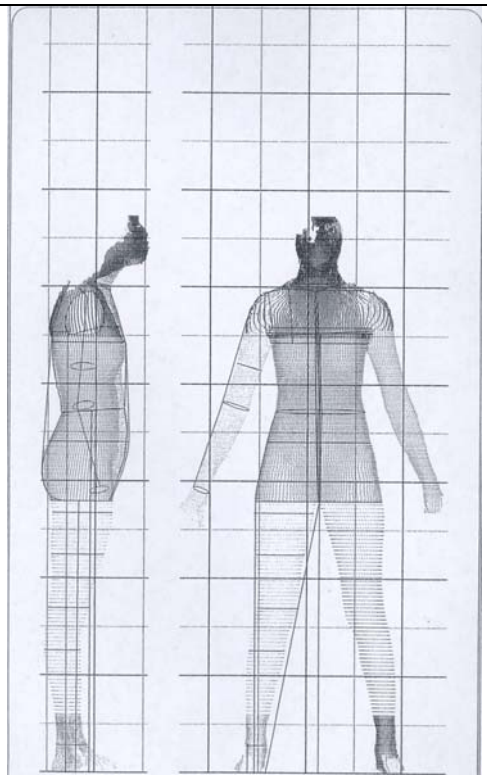
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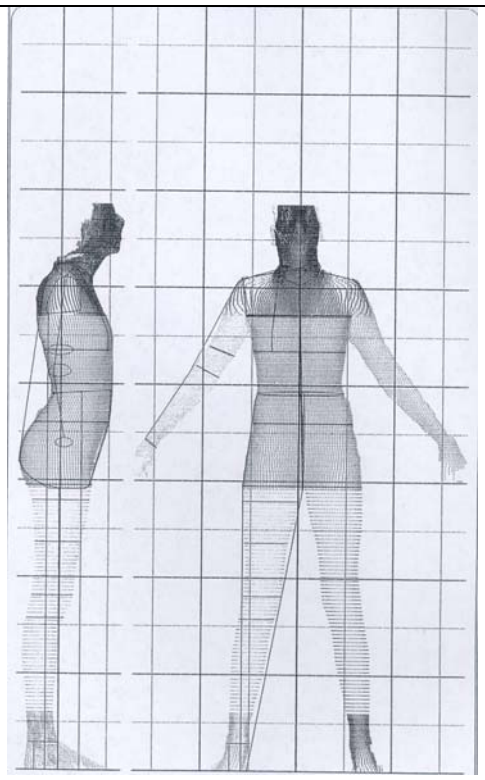	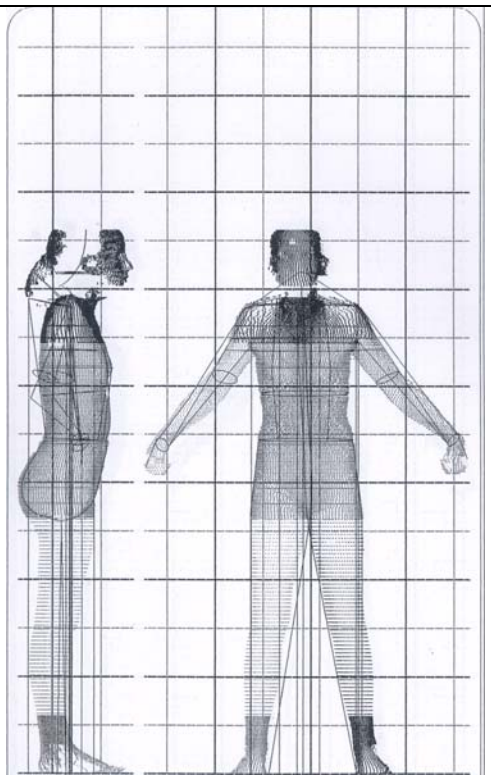
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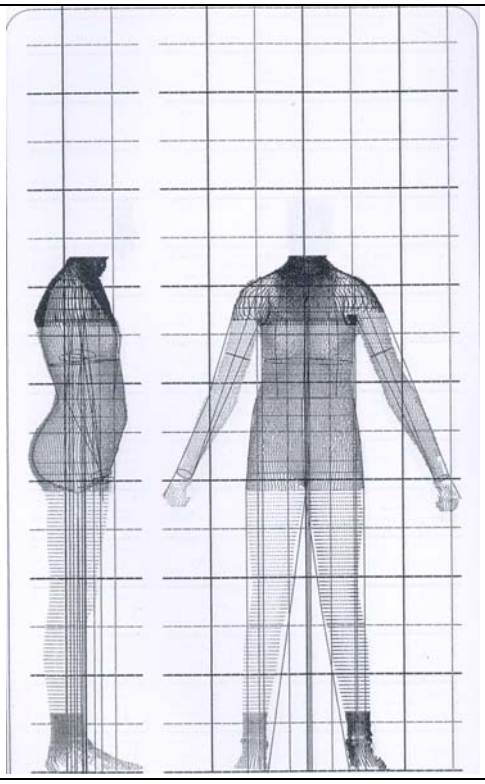
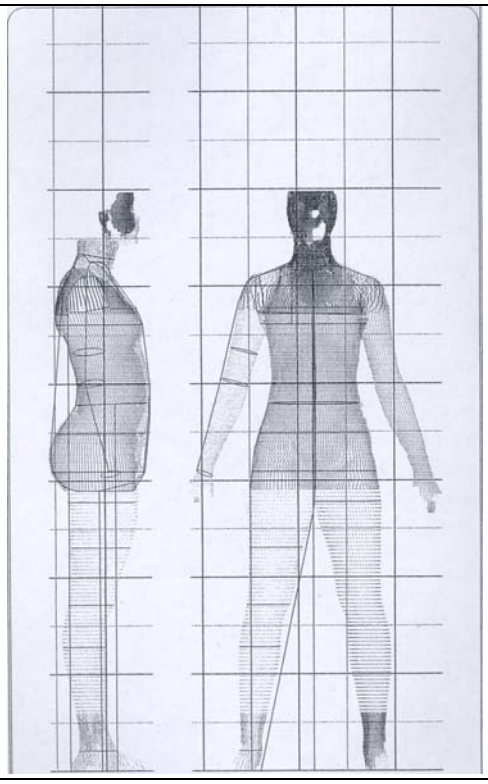
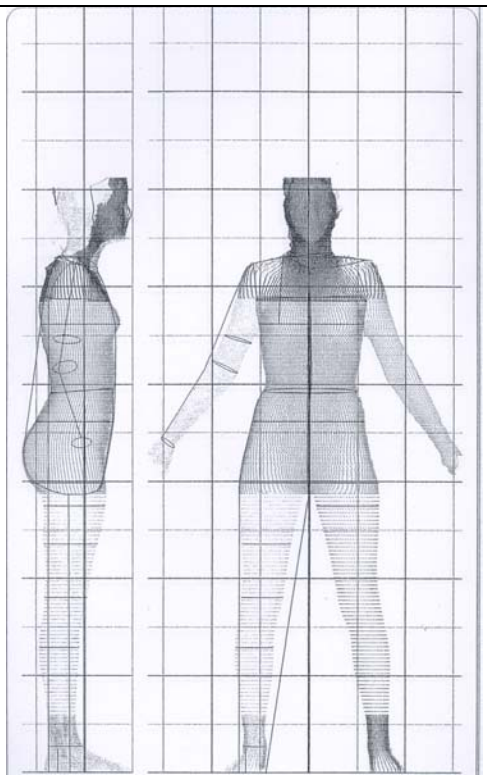
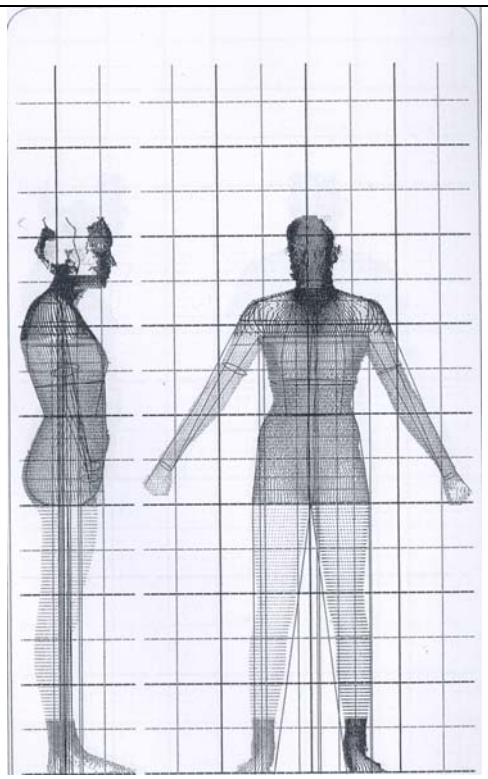
	
1005-1 BMI-18.1	5063-1 BMI-18.4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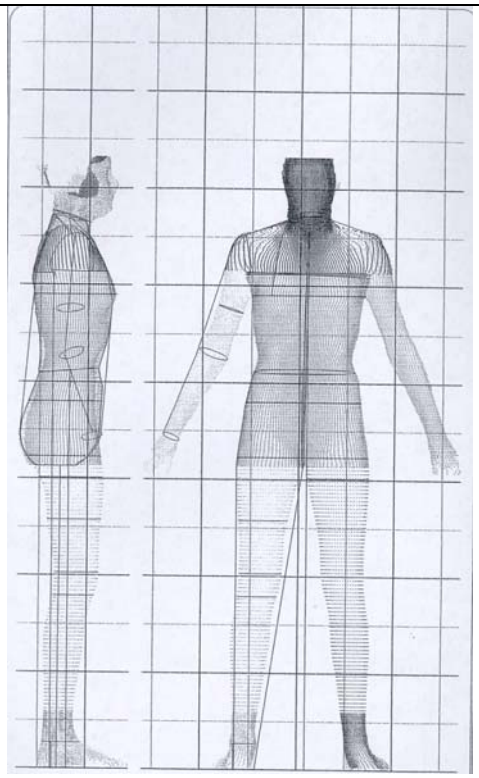	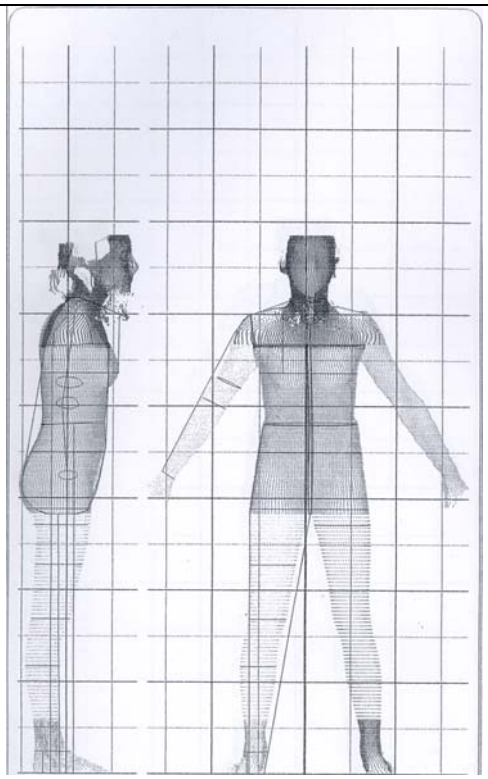
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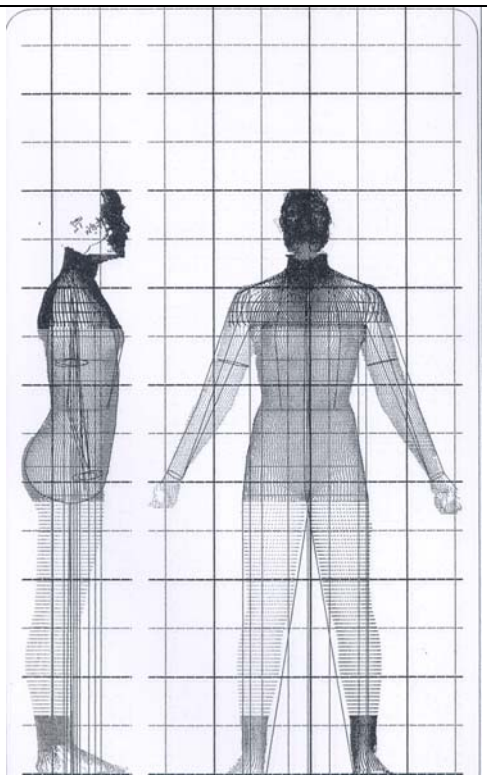
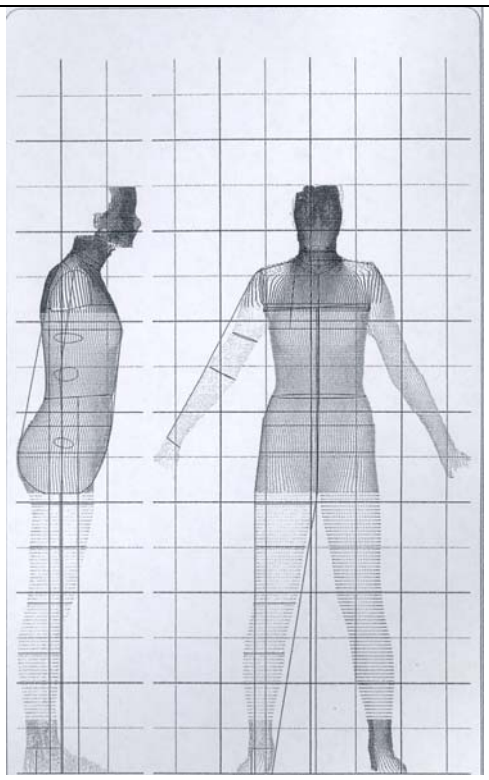
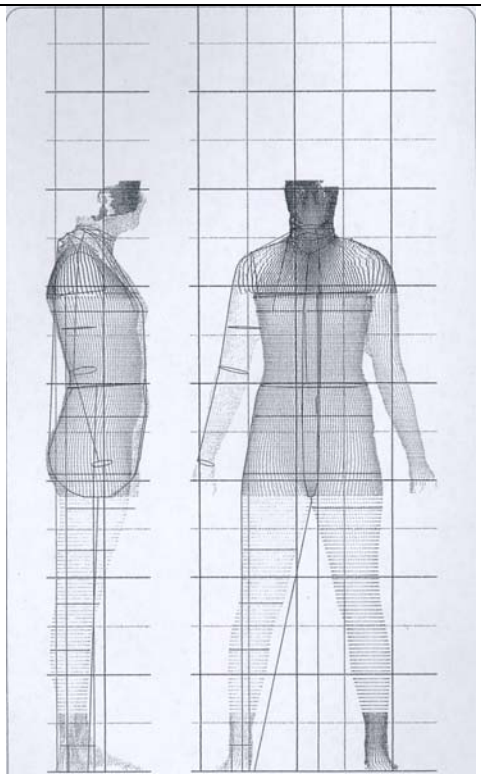
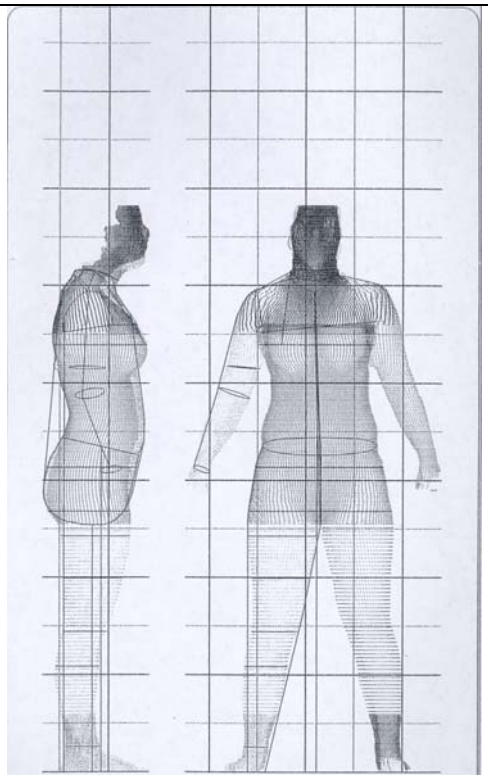
	
1004-1 BMI-19.9	5079-1 BMI-20.4
	
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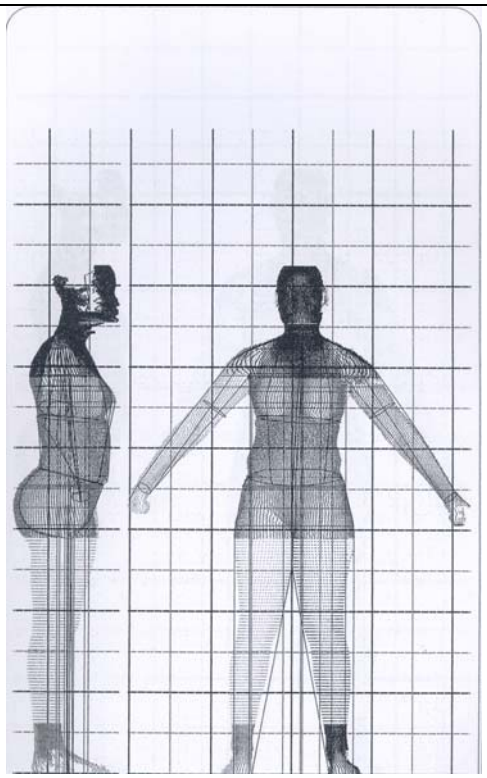
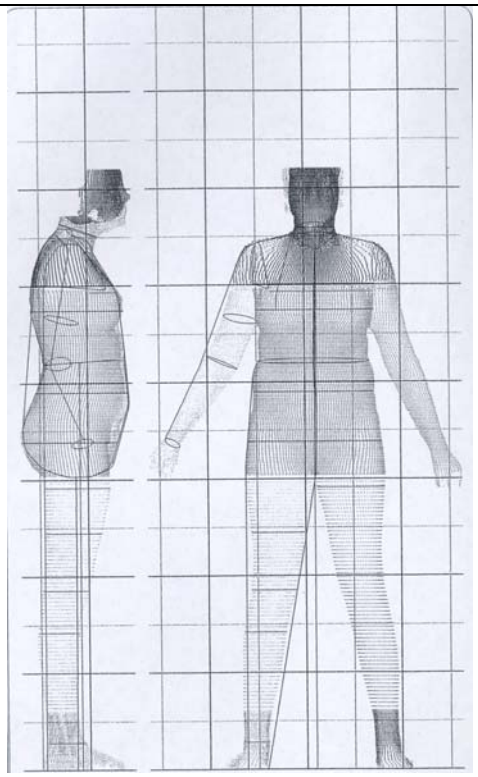
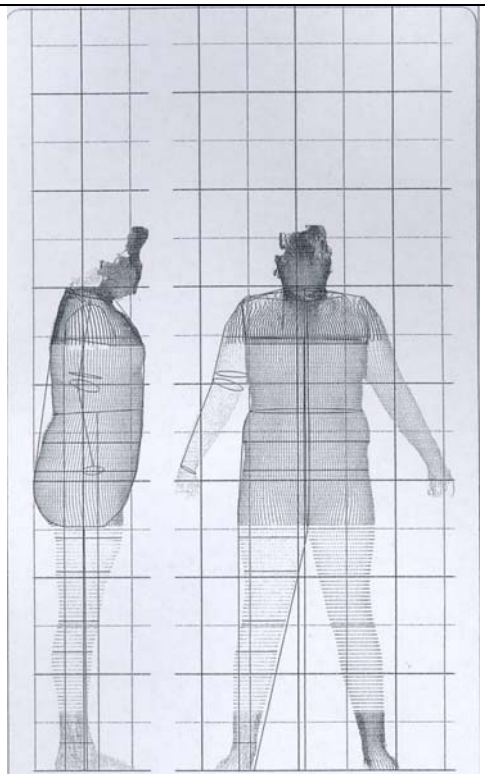
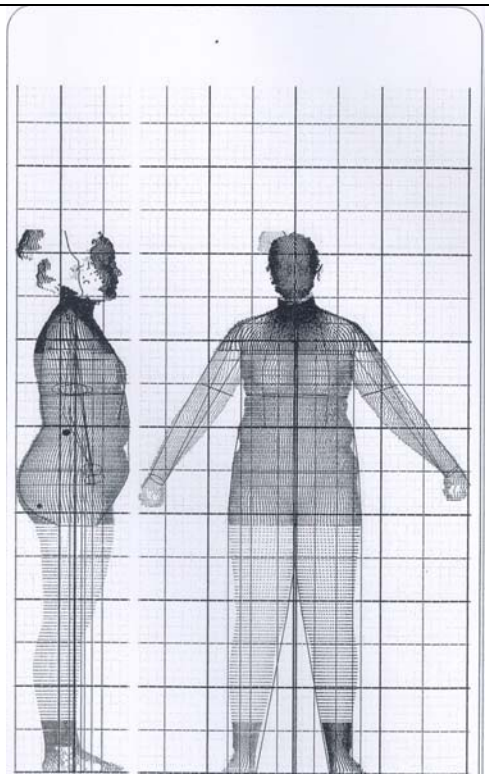
	
2002-1 BMI-23.5	5024-2 BMI-24.1
	
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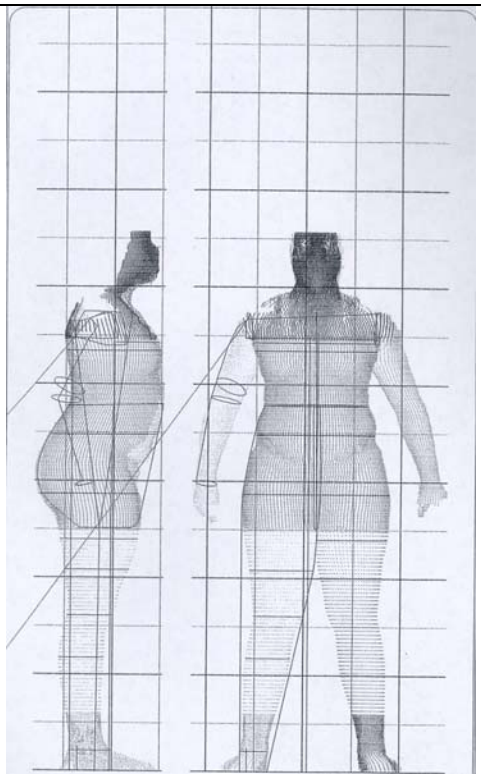
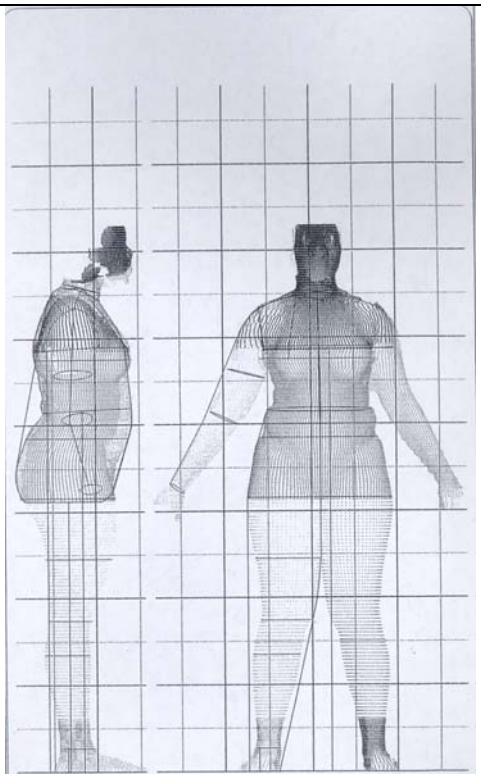
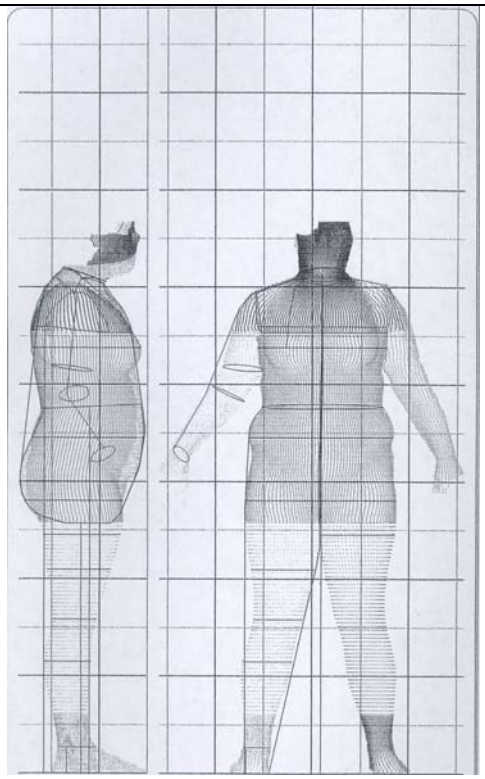
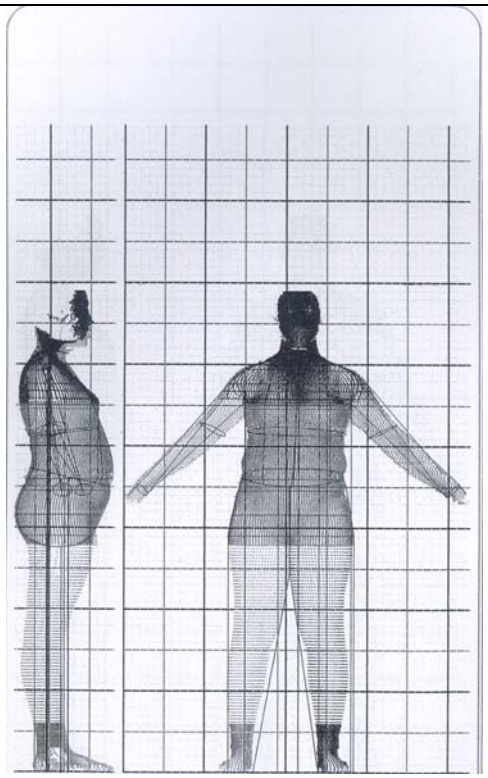
	
5038-1 BMI-30.8	5088-1 BMI-31.8
	
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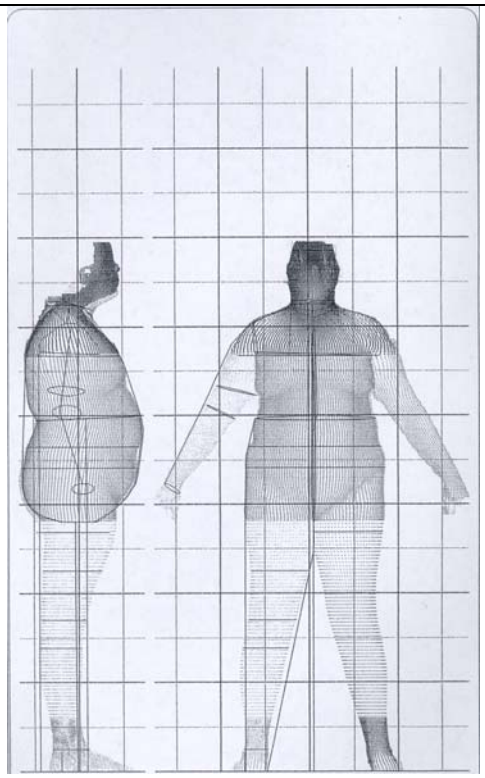	
5025-1 BMI-33.2	

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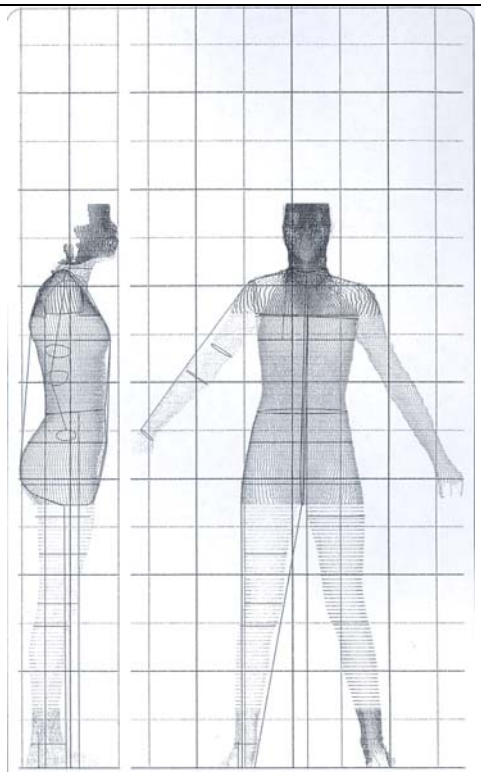
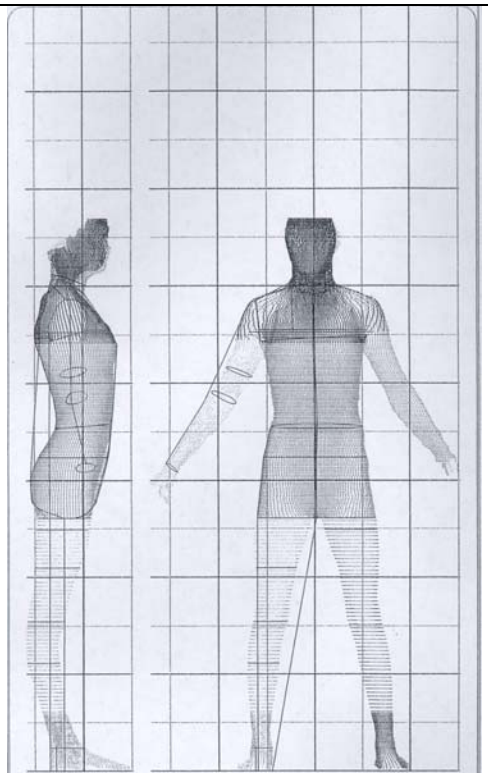
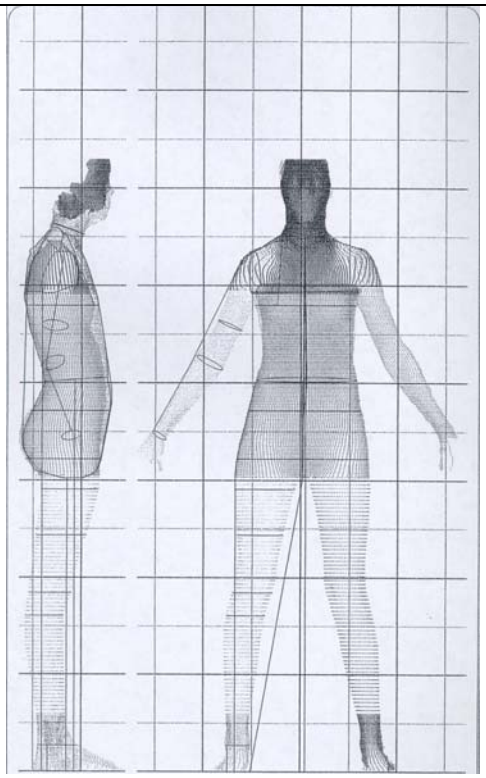


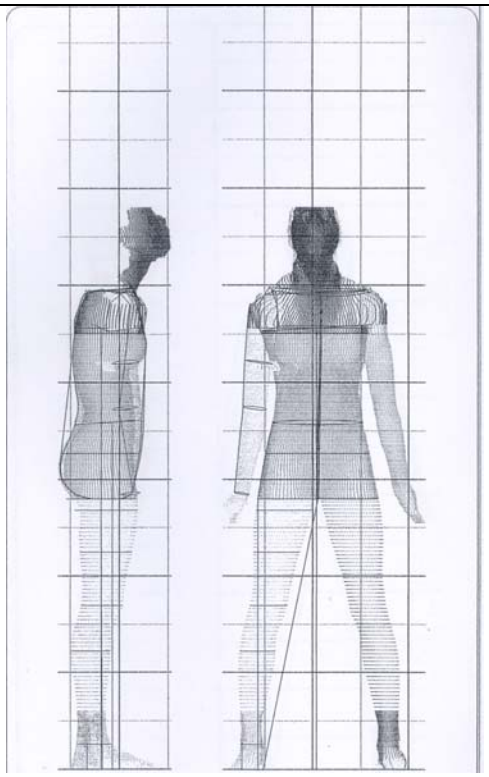
5070-1 BMI-15.5



5002-1 BMI-16.2



5031-1 BMI-16.4



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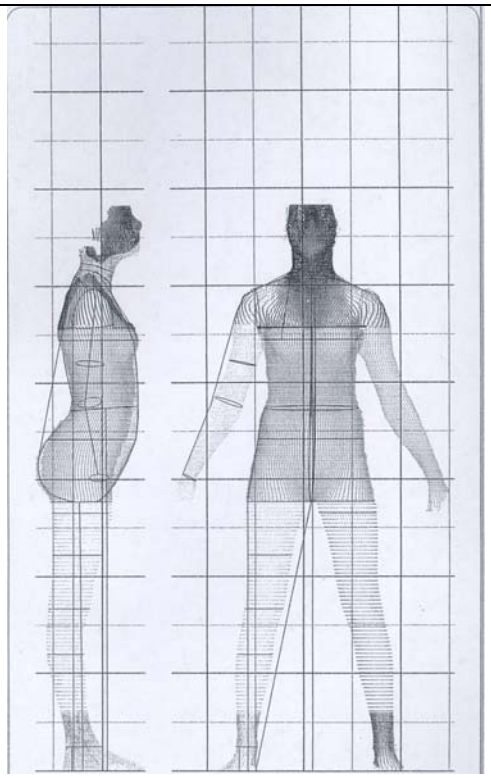
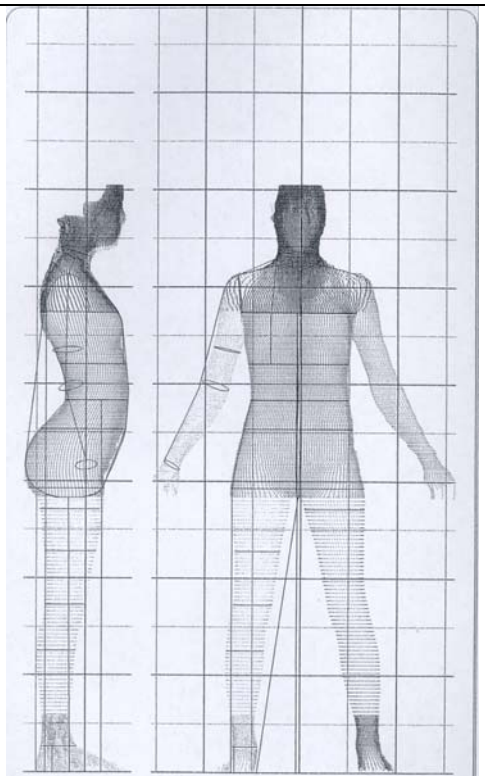
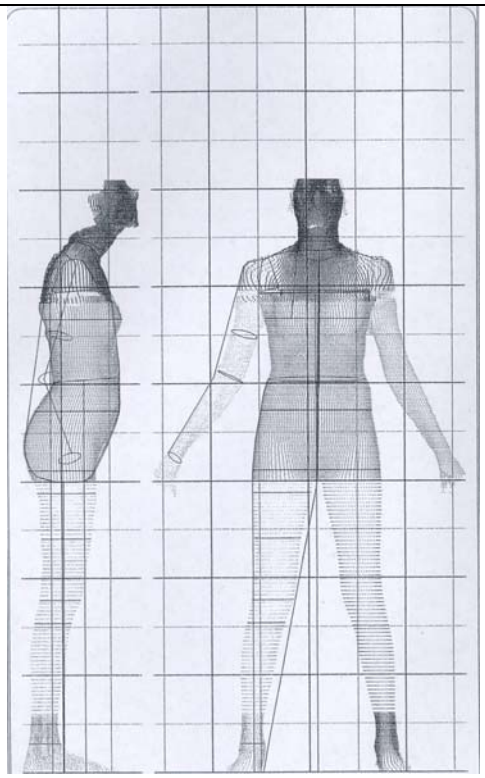
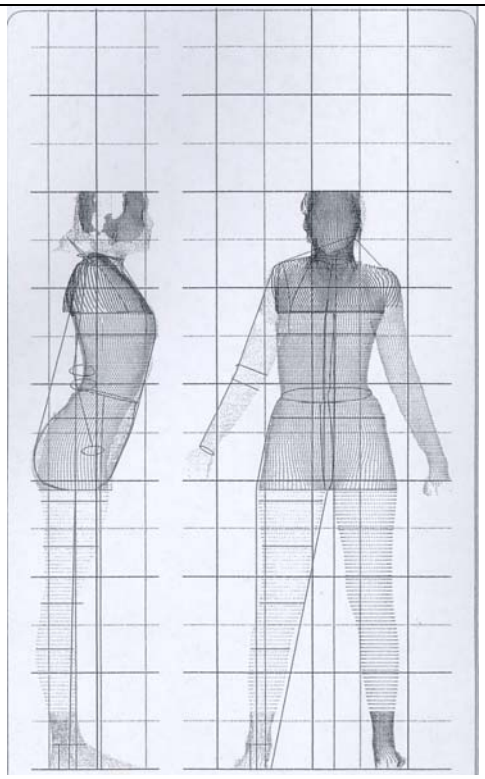
	
5034-1 BMI-17.8	5015-1 BMI-18.4
	
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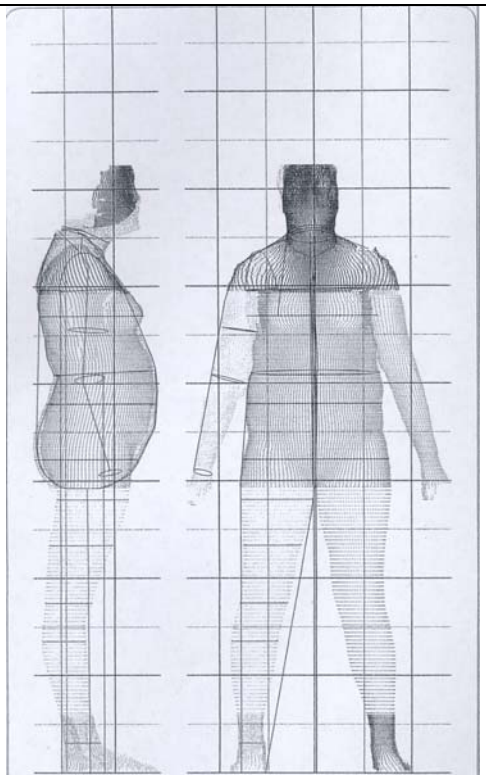	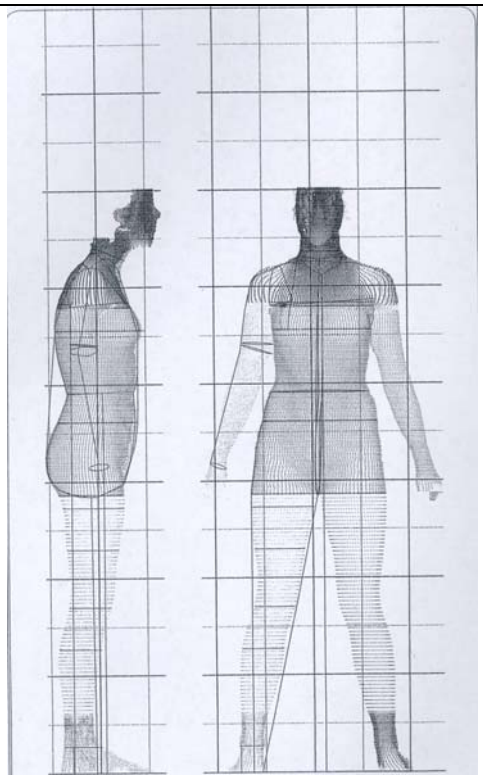
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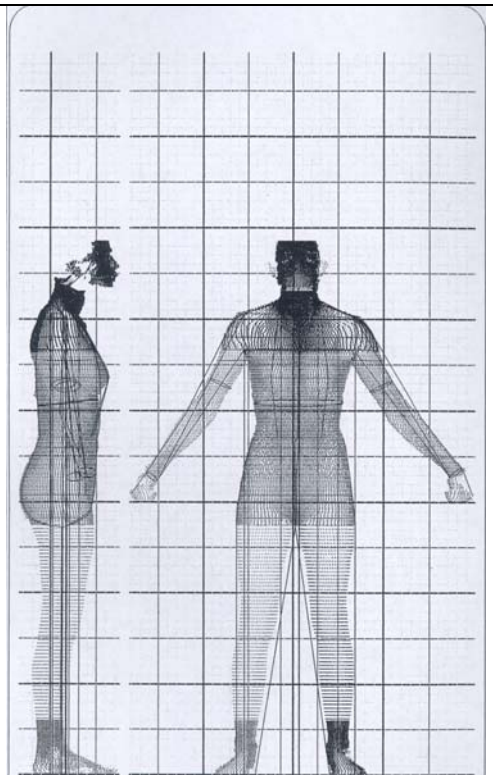	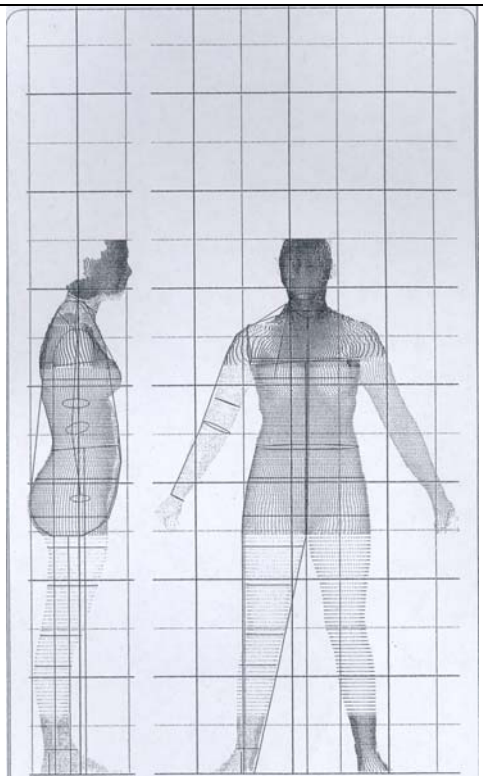
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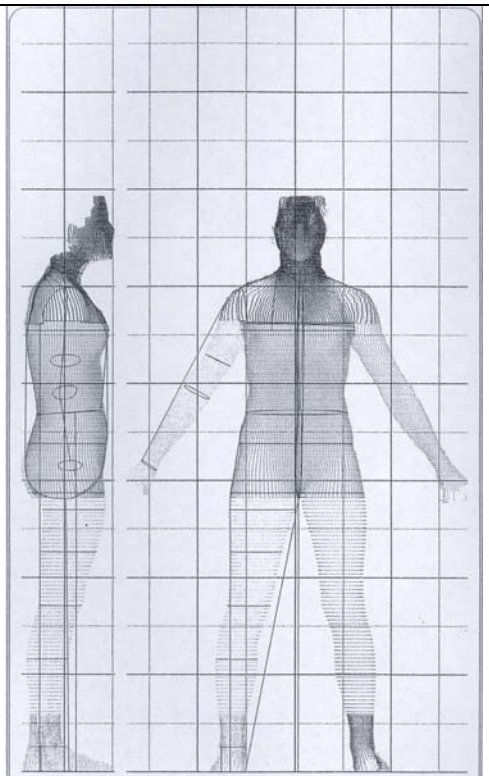	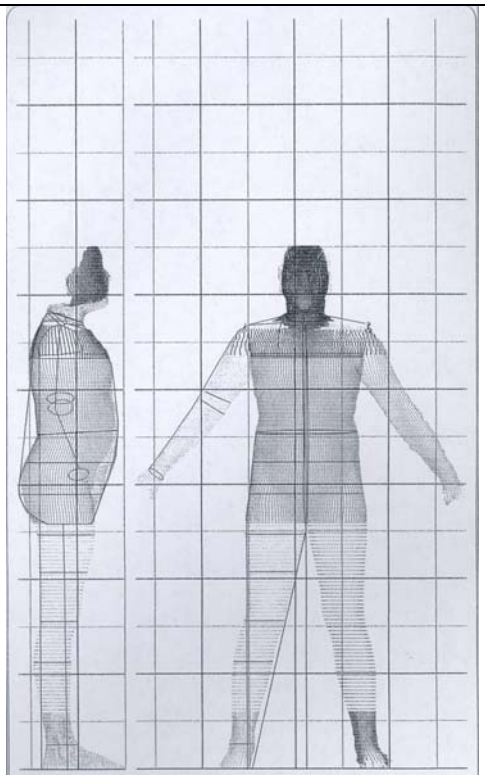
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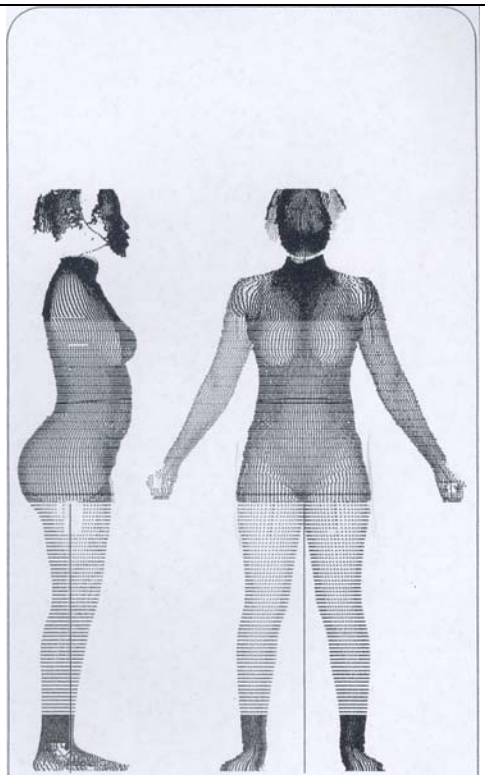	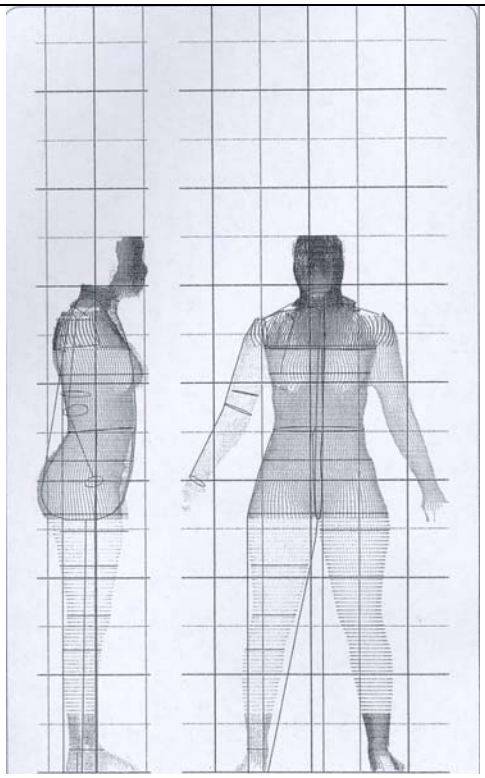
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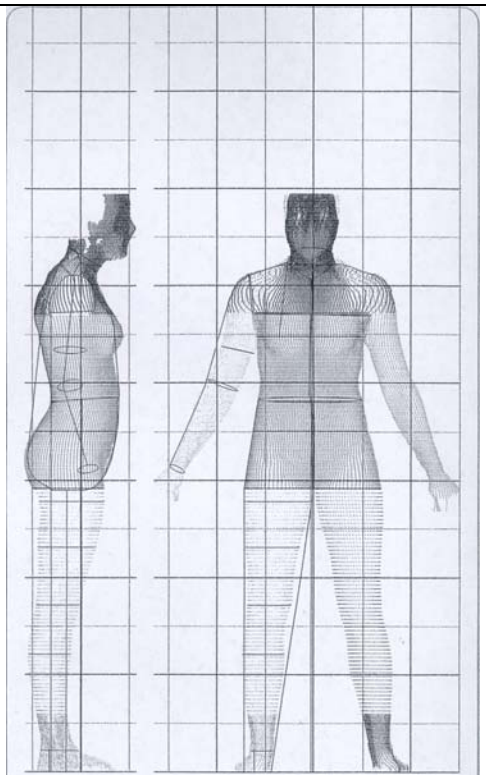	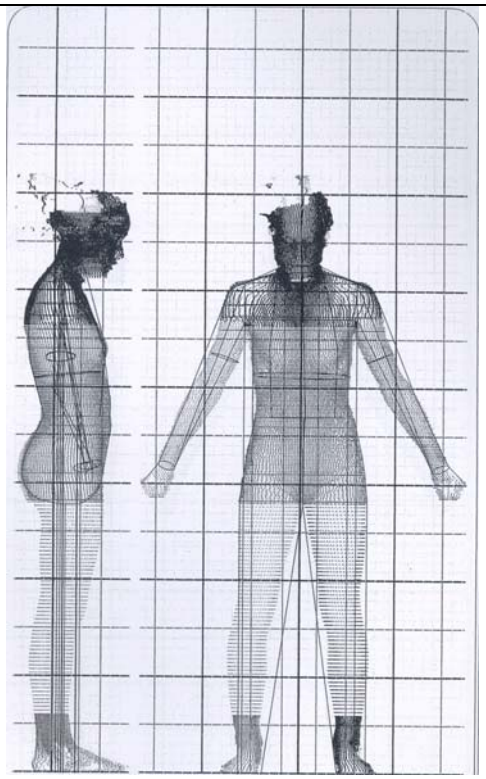
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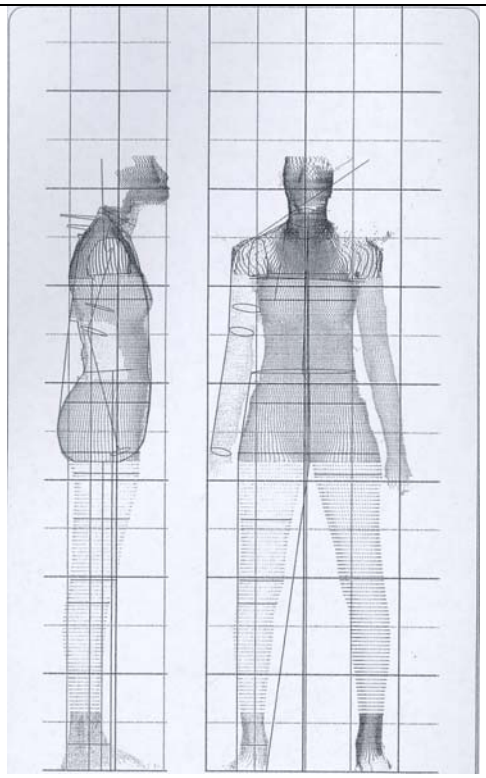	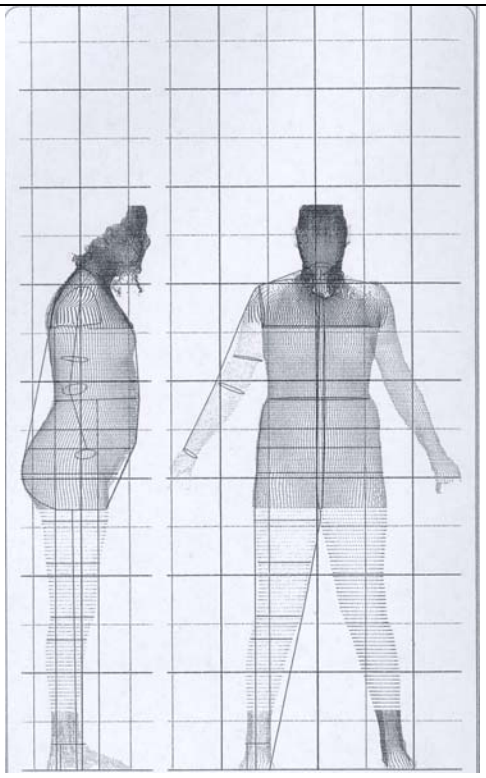
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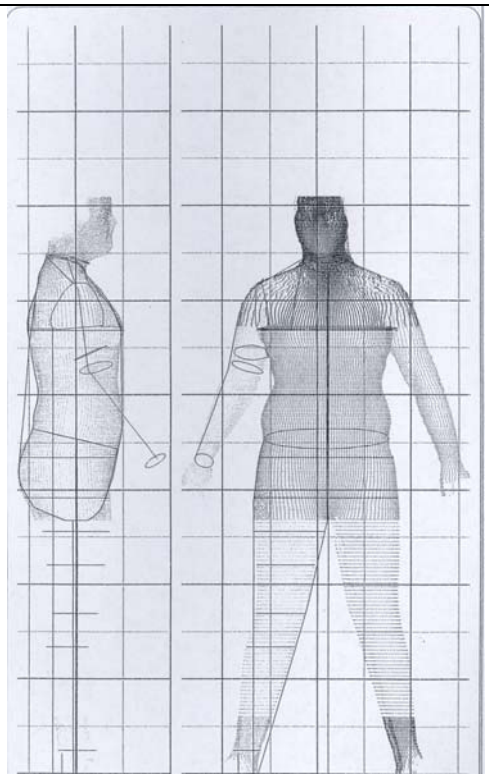	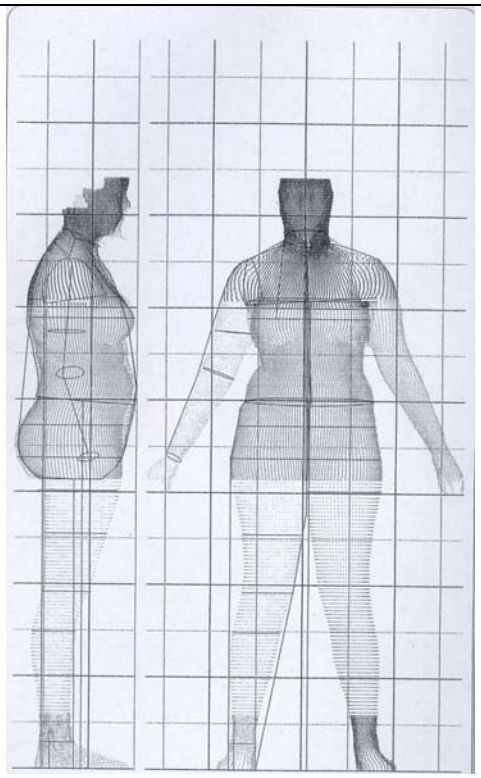
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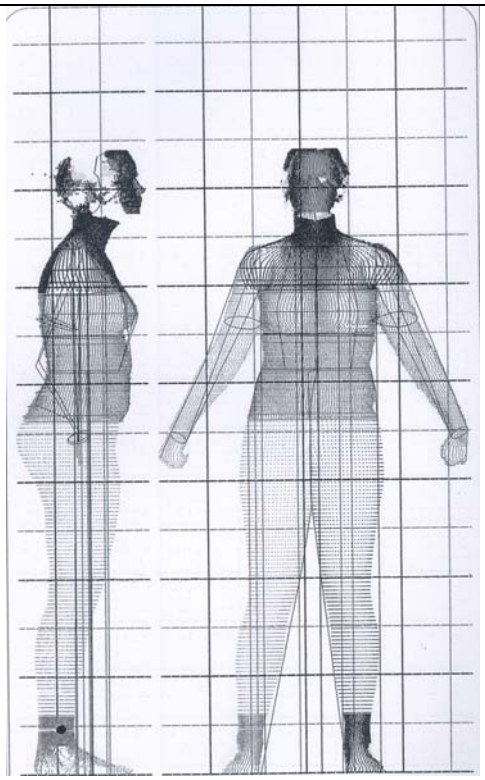	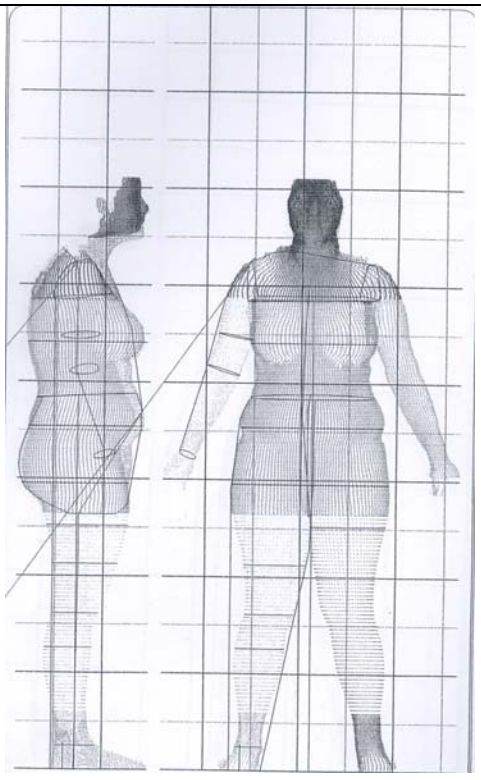
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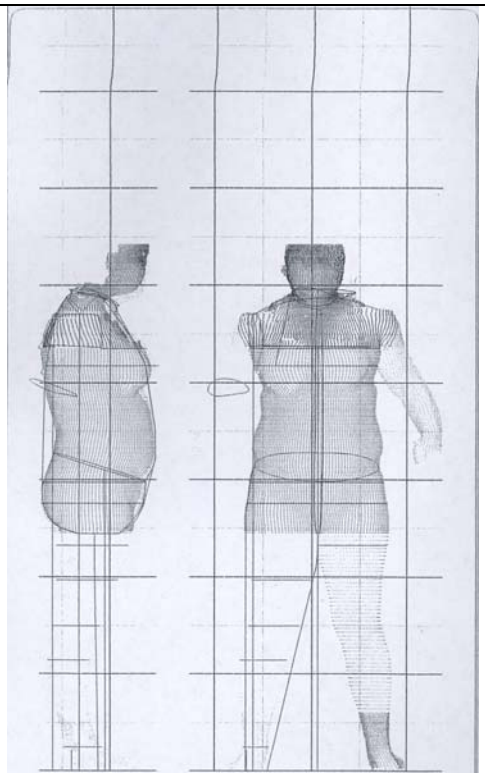	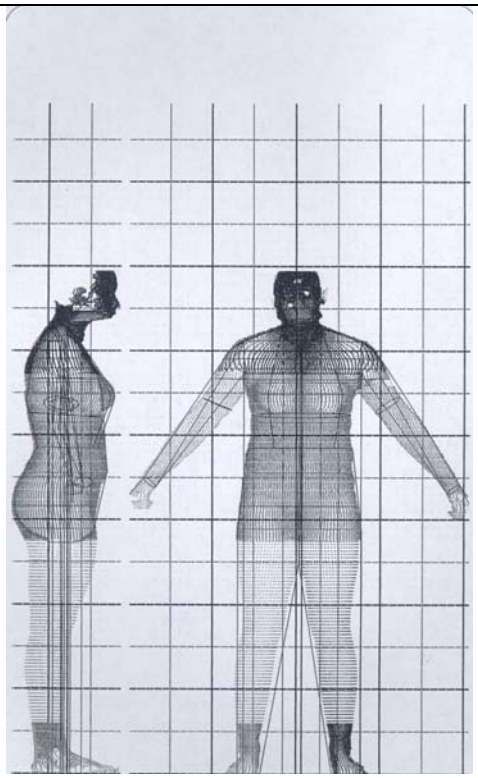
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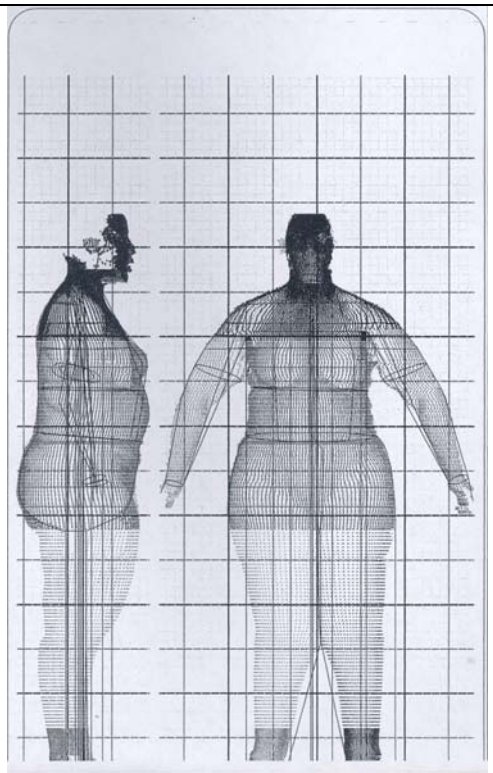	
2005-1 BMI-33.5	

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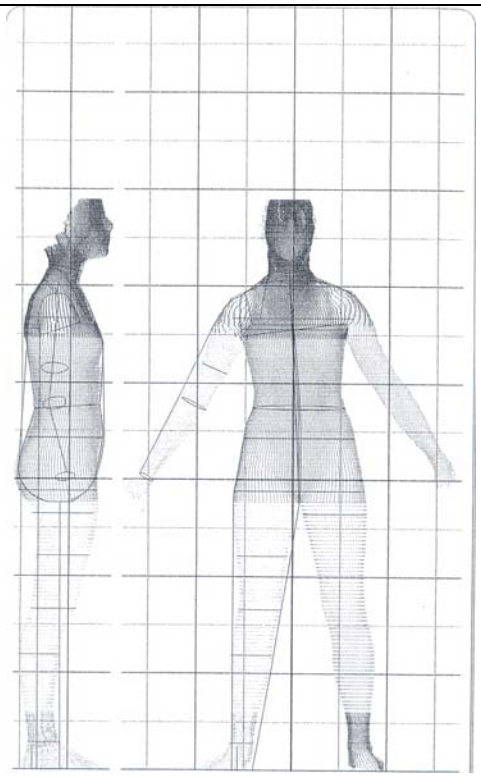
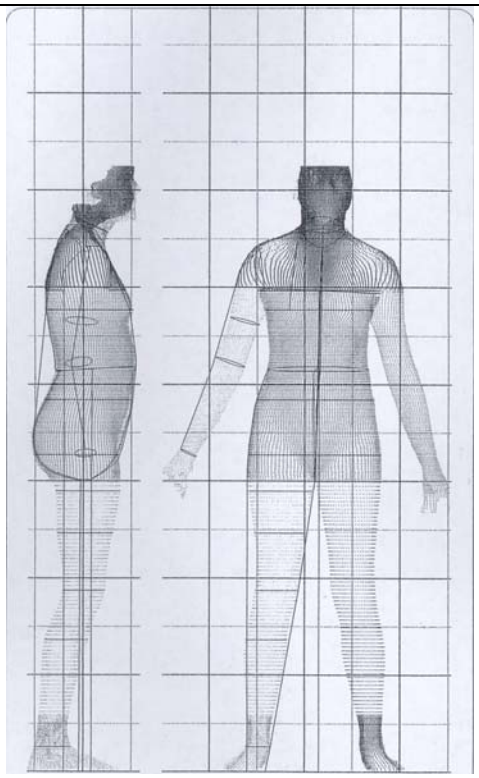
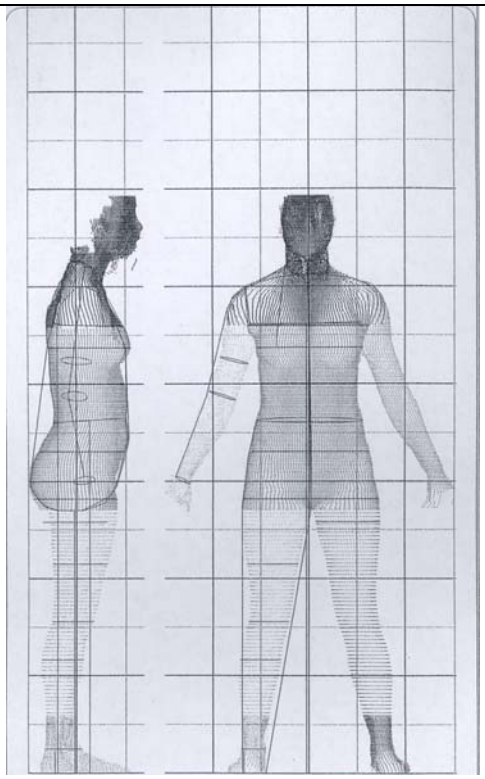
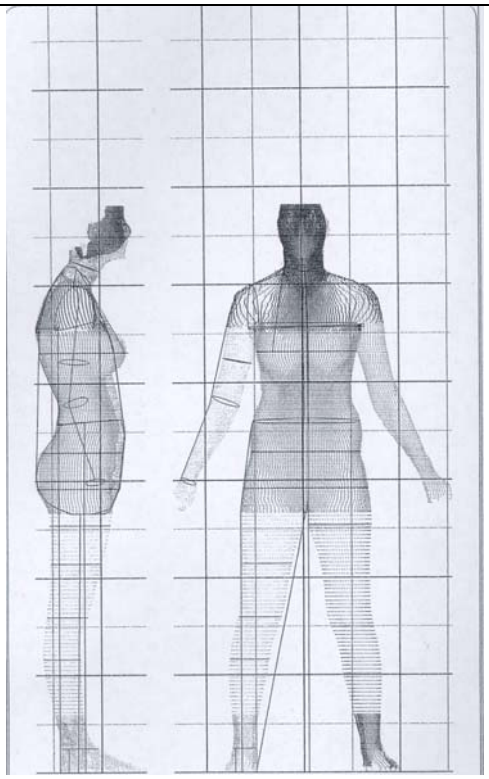
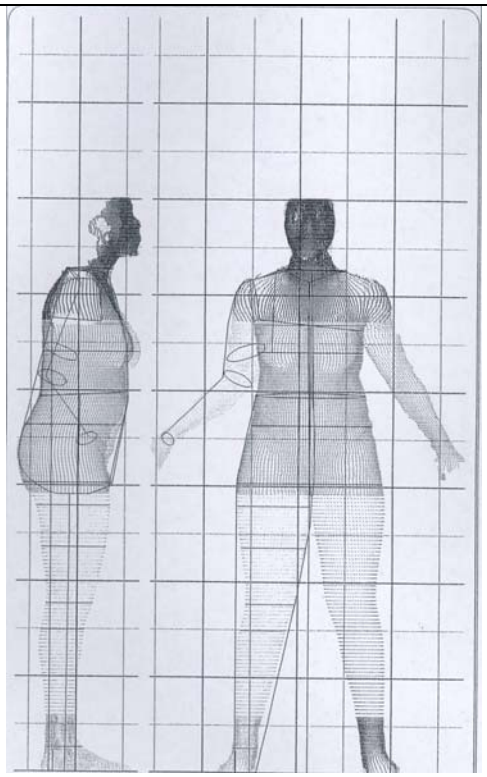
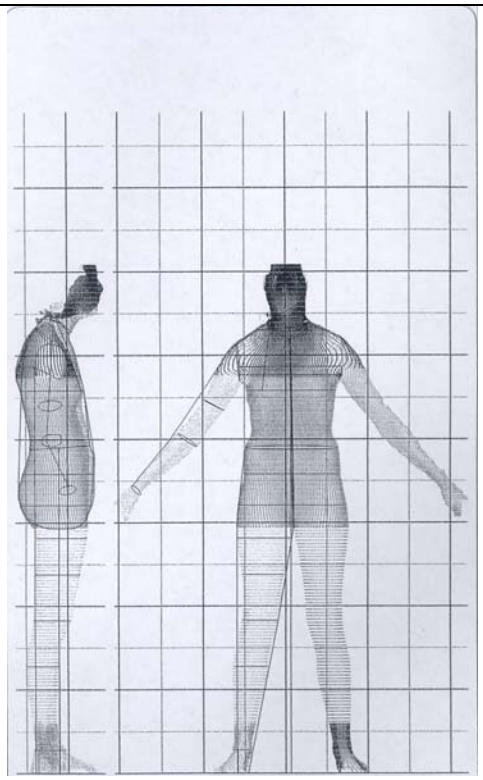
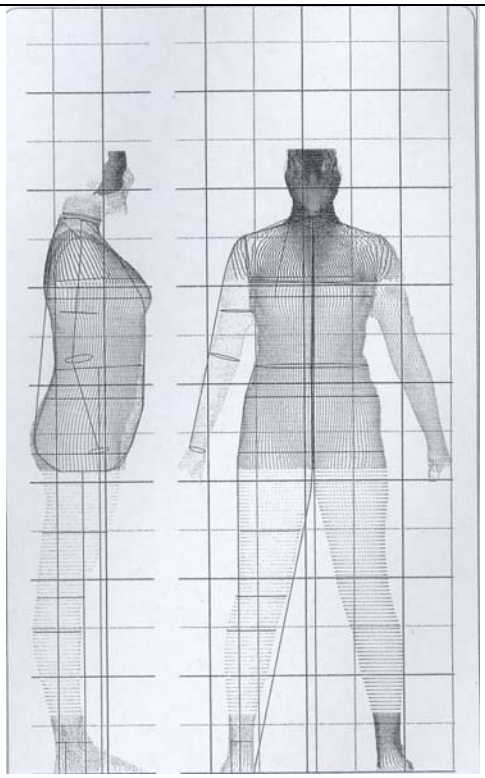
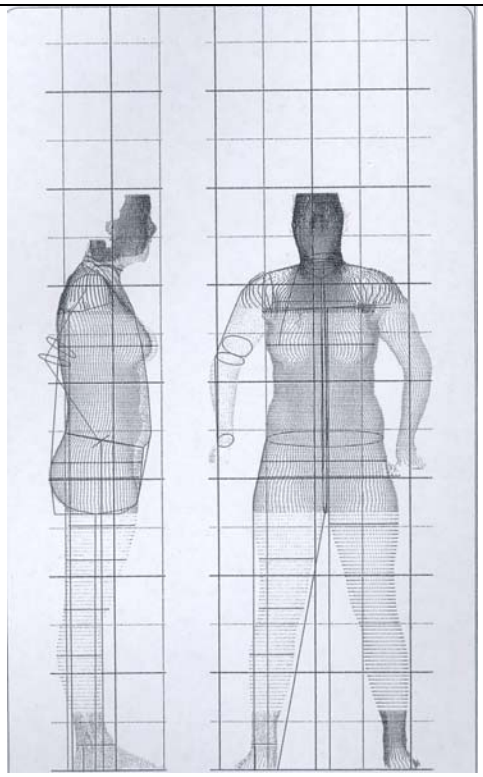
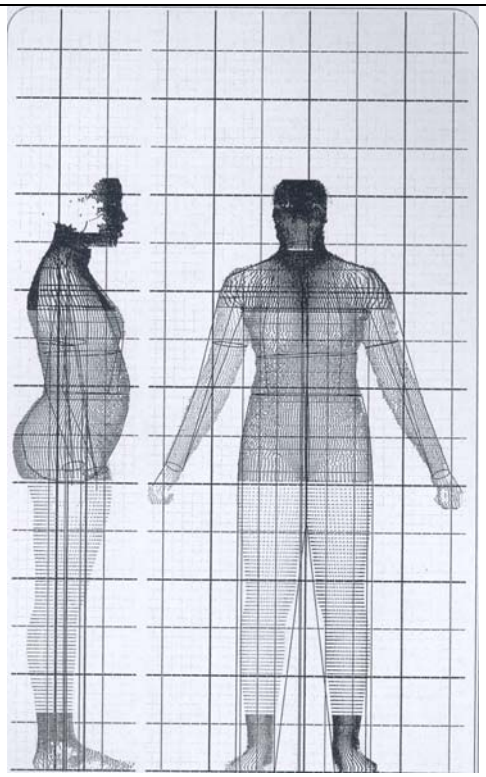
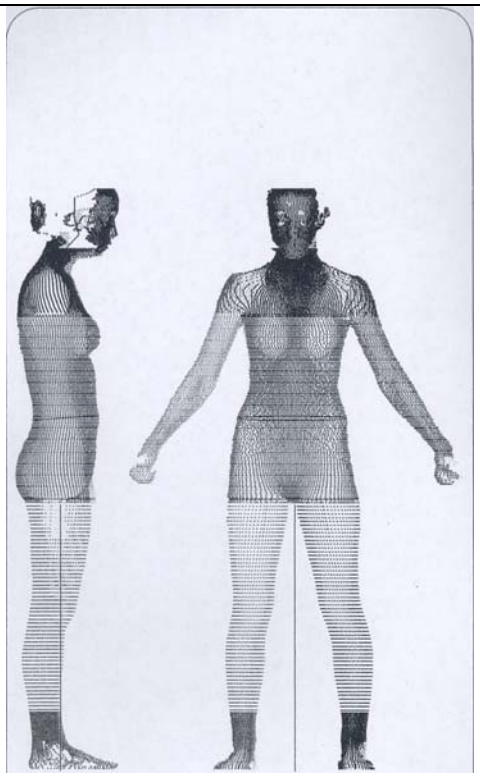
	
5032-1 BMI-16.9	5026-1 BMI-18.1
	
5085-1 BMI-18.7	5086-1 BMI-18.9

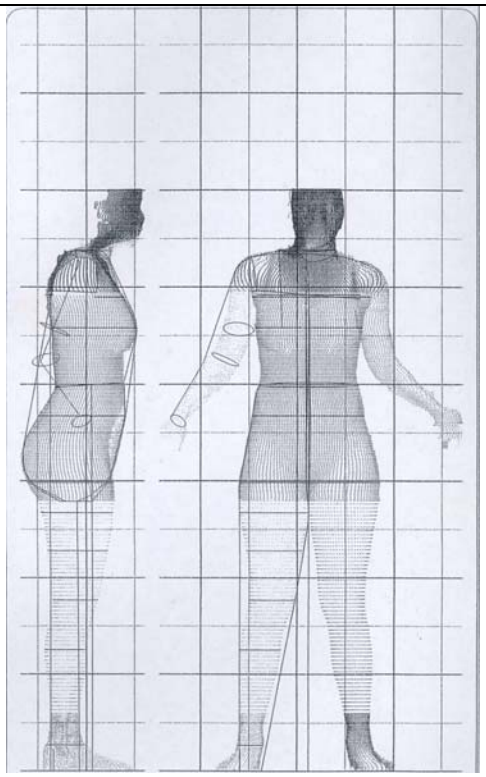
	
5052-1 BMI-19.0	5064-1 BMI-20.3
	
5030-1 BMI-20.4	5041-1 BMI-20.6



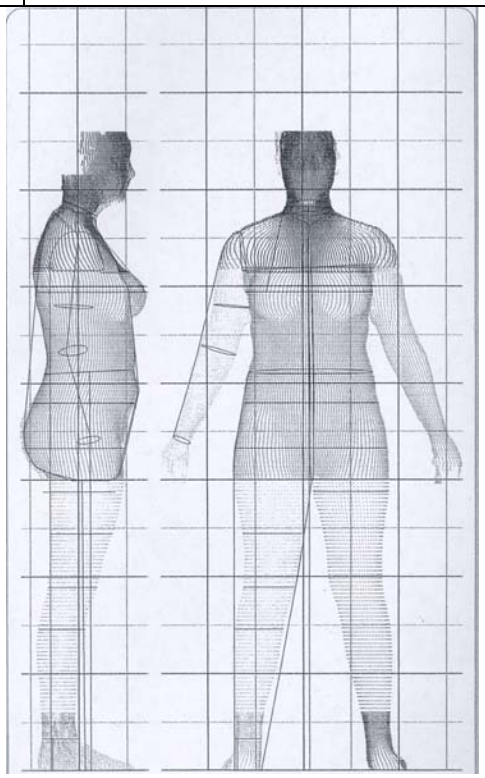
2001-1 BMI-20.6



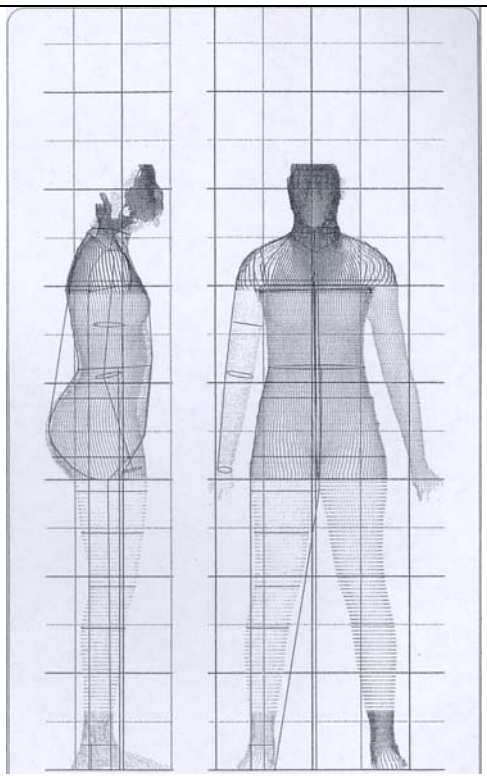
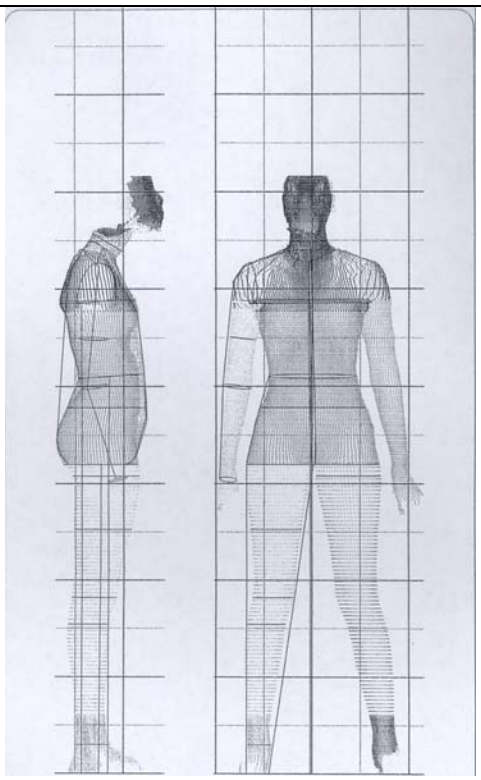
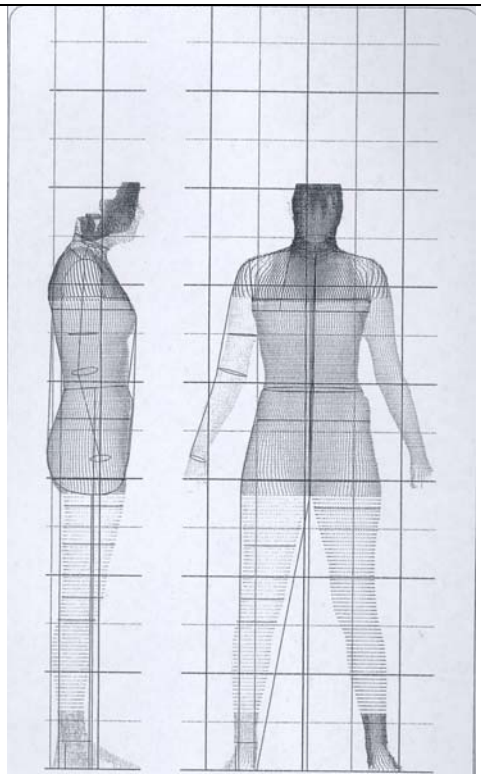
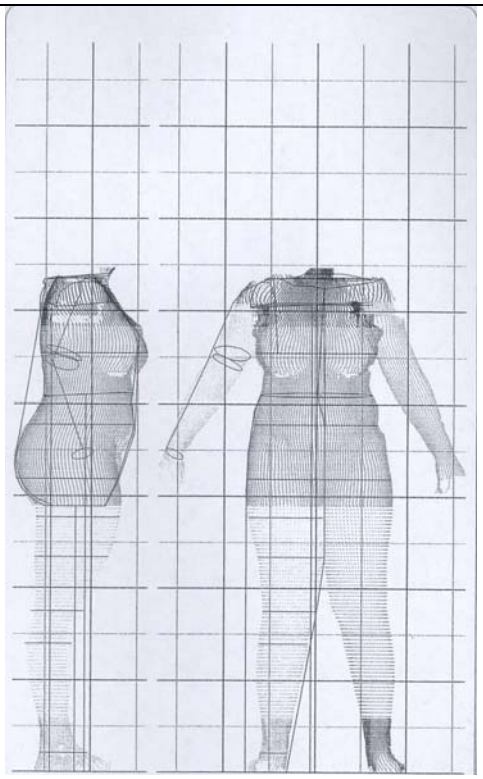
1008-1 BMI-20.7

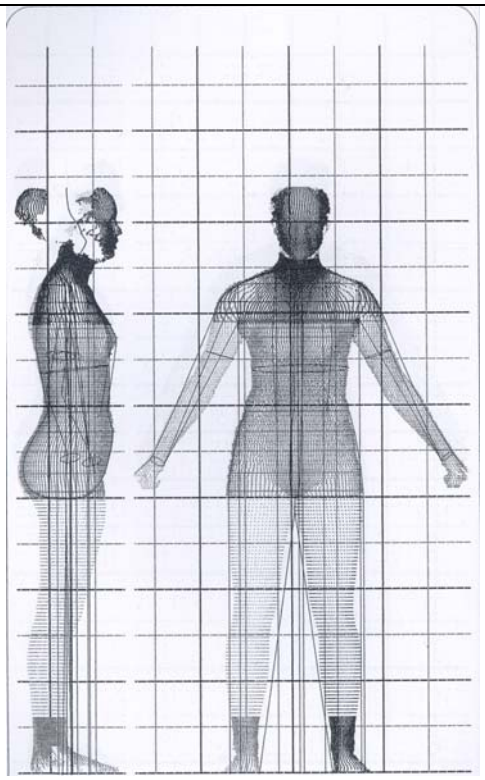
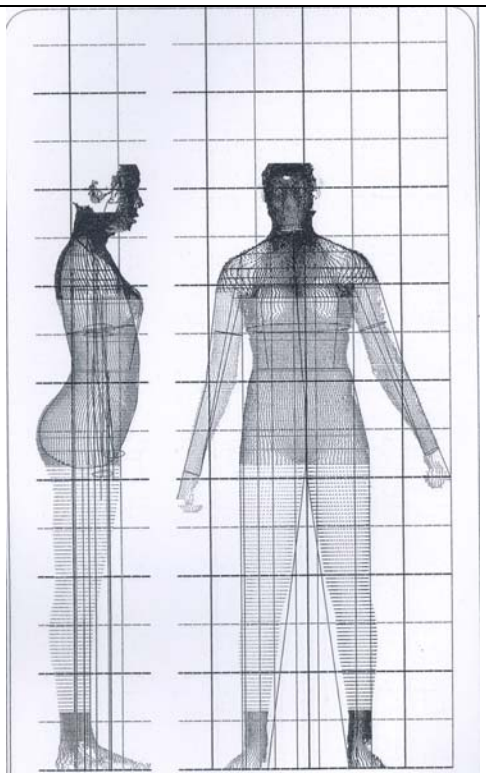


5006-1 BMI-20.7



5024-1 BMI-21.1

	
5081-3 BMI-21.5	5091-2 BMI-21.7
	
5068-1 BMI-22.0	5081-2 BMI-22.5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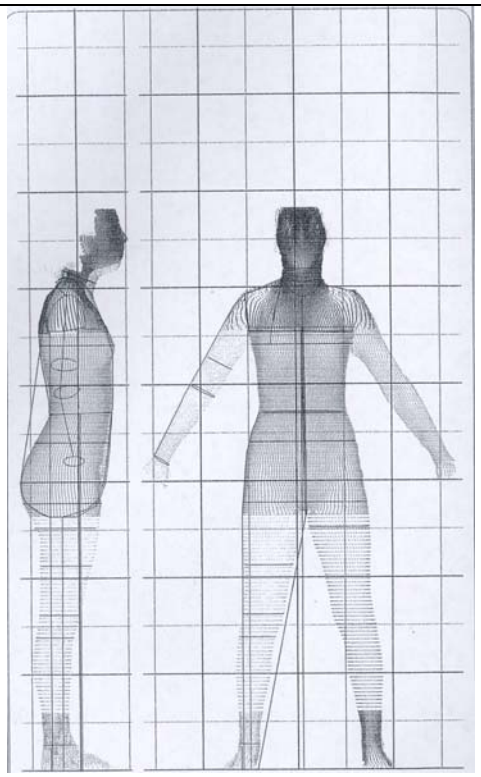	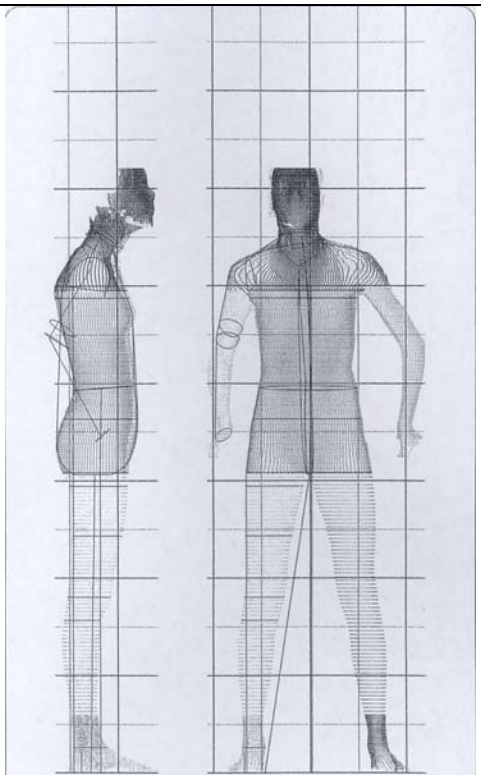
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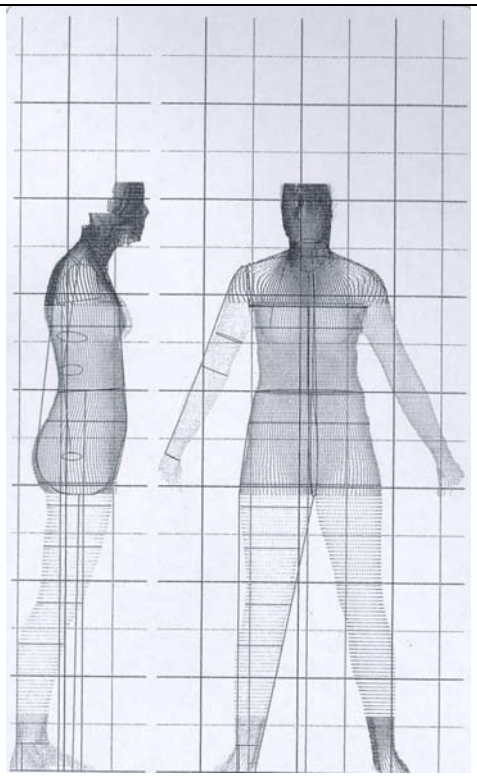	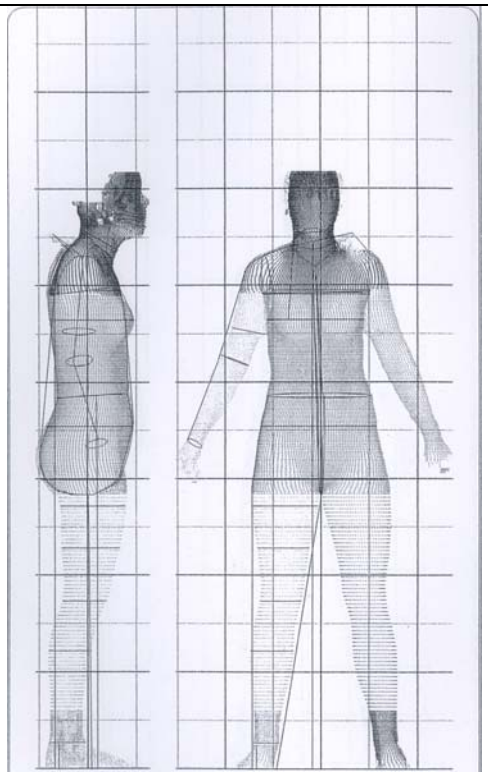
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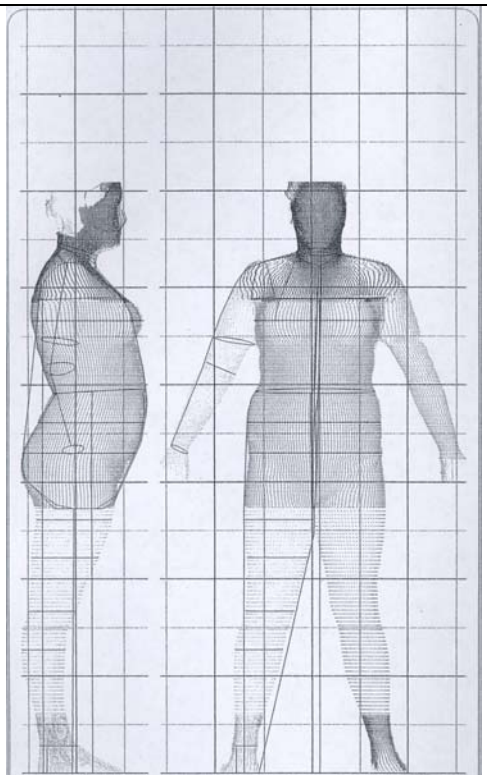	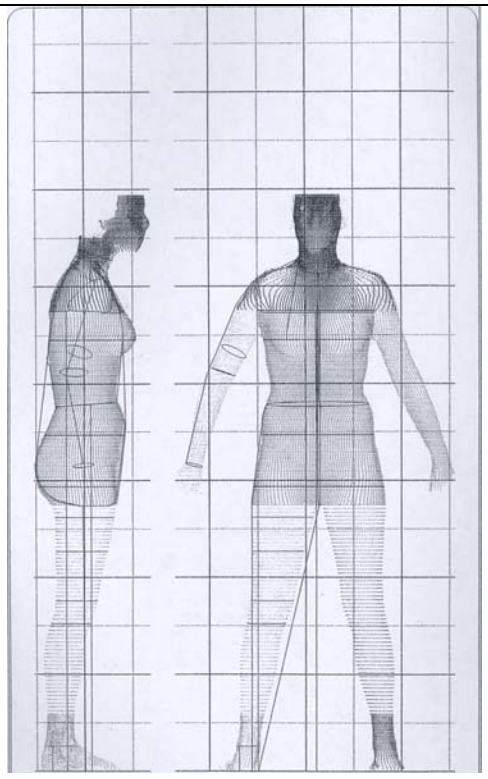
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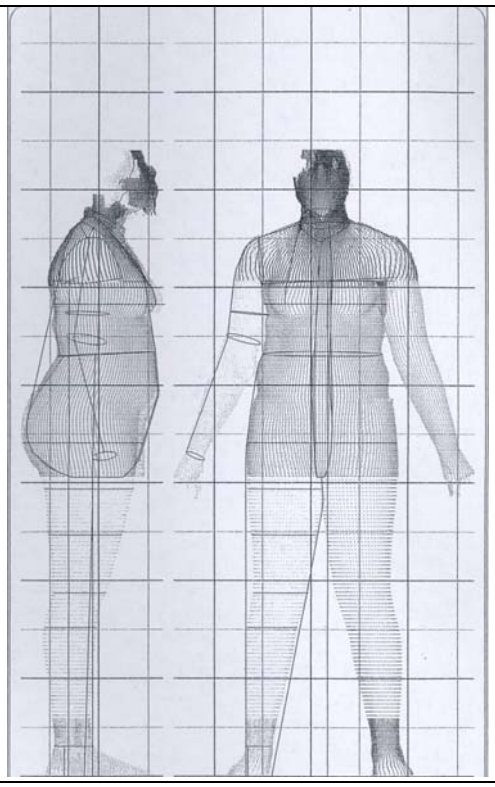	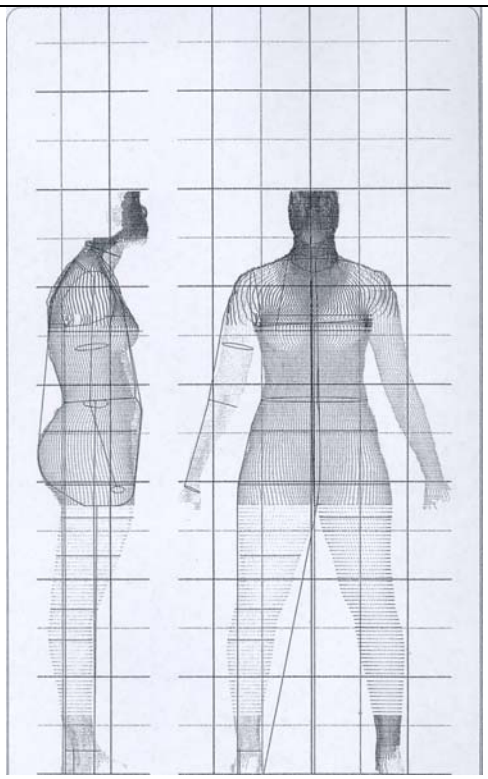
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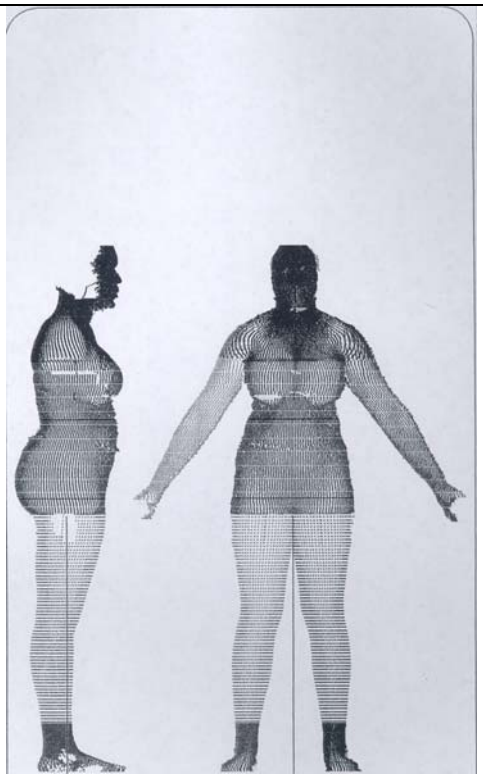	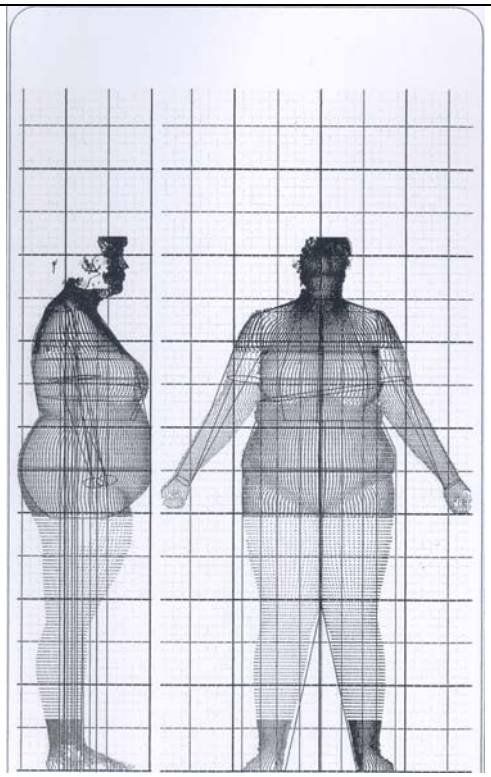
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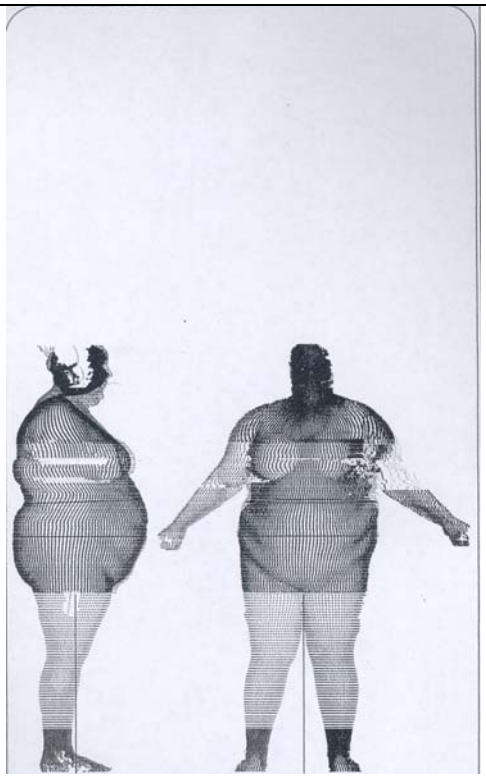	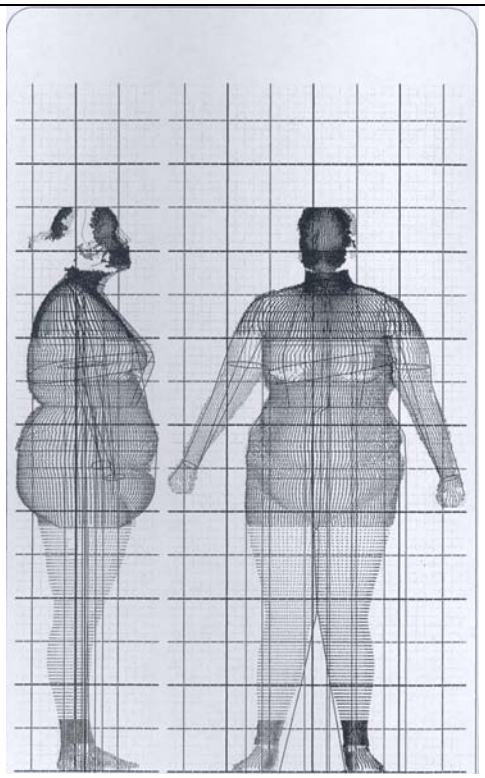
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APPENDIX B

QUESTIONNAIRE PART 4: PORTION OF QUESTIONNAIRE USED IN STUDY TO COLLECT DEMOGRAPHIC INFORMATION FOR TWEEN SUBJECTS

PART 4: DEMOGRAPHICS

Your age _____

Your daughter's age _____ Your daughter's birth month _____ Your daughter's grade in

school _____

Has your daughter had her first period (menstruation)? YES / NO

IF YES, please check her age at onset. _____ 9 _____ 9 2

_____ 10 _____ 10 2

_____ 11 _____ 11 2

_____ 12 _____ 12 2

_____ 13 _____ 13 2

_____ 14 _____ 14 2

Your marital status Single _____ Married _____ Divorced _____ Widowed _____

Your daughter=s siblings None _____ Number of sisters _____ Number of brothers _____

Your daughter=s ethnicity Your ethnicity Your daughter=s father=s ethnicity

_____ African-American _____ African-American _____ African-American

_____ Asian _____ Asian _____ Asian

_____ Caucasian _____ Caucasian _____ Caucasian

_____ Hispanic _____ Hispanic _____ Hispanic

_____ Native American _____ Native American _____ Native American

APPENDIX C

MEASUREMENT TABLES FROM THE O'BRIEN ET AL., 1941

Measurement	Age 9			Age 10			Age 11			Age 12			Age 13			Age 14		
	Mean	S. D.	Number of cases	Mean	S. D.	Number of cases	Mean	S. D.	Number of cases	Mean	S. D.	Number of cases	Mean	S. D.	Number of cases	Mean	S. D.	Number of cases
Waist height	83.81	4.81	6,174	87.97	4.99	6,253	92.12	5.34	6,132	96.13	5.25	5,865	99.12	4.74	5,133	100.83	4.50	3,633
Hip height	67.53	4.10	6,174	70.97	4.22	6,253	74.38	4.48	6,132	77.57	4.42	5,865	79.84	4.15	5,133	80.95	4.08	3,633
Weight	63.06	11.06	6,174	70.19	12.91	6,253	78.77	15.01	6,132	89.08	17.01	5,865	98.88	17.18	5,133	106.17	15.98	3,633
Stature	132.66	6.29	6,174	138.19	6.65	6,253	144.11	7.34	6,132	150.14	7.47	5,865	154.98	6.75	5,133	157.90	6.14	3,633
Cervicale height	111.53	5.89	6,174	116.73	6.26	6,253	122.27	6.85	6,132	127.85	6.95	5,865	132.34	6.21	5,133	135.08	5.69	3,633
Tibiale height	36.77	2.41	6,174	38.60	2.46	6,253	40.44	2.66	6,132	42.11	2.57	5,865	43.30	2.44	5,133	43.82	2.36	3,633
Crotch height	60.38	3.84	6,172	63.57	3.97	6,217	66.69	4.20	6,091	69.57	4.17	5,832	71.53	3.92	5,100	72.50	3.91	3,614
Bitrochanteric diameter	24.17	1.86	6,174	25.32	2.03	6,253	26.67	2.29	6,132	28.36	2.49	5,865	29.99	2.44	5,133	31.17	2.19	3,633
Shoulder slope	25.16	4.13	6,157	25.09	4.11	6,232	25.12	4.01	6,112	24.90	4.10	5,849	24.97	4.08	5,125	25.05	4.10	3,630
Anterior chest width	24.19	1.86	6,172	25.12	1.97	6,250	26.15	2.05	6,128	27.29	2.14	5,861	28.27	2.12	5,128	29.07	1.99	3,626
Anterior waist length	26.23	1.67	6,166	27.03	1.80	6,252	28.03	1.97	6,129	29.10	2.07	5,861	30.20	2.06	5,128	30.93	1.99	3,632
Posterior chest width	27.69	2.03	6,170	28.61	2.18	6,250	29.66	2.38	6,125	30.90	2.55	5,853	31.93	2.51	5,128	32.59	2.49	3,627
Posterior waist length	28.83	1.82	6,172	29.97	1.99	6,250	31.40	2.24	6,123	33.01	2.44	5,858	34.57	2.35	5,125	35.63	2.20	3,627
Chest girth at armscye	65.29	4.49	6,174	67.76	5.06	6,253	70.68	5.42	6,132	74.00	5.83	5,865	76.92	5.63	5,133	79.06	5.19	3,633
Seye depth	14.17	1.46	6,170	14.69	1.48	6,252	15.32	1.61	6,131	15.95	1.74	5,858	16.63	1.76	5,130	17.08	1.77	3,630
Posterior hip arc	34.02	3.36	6,164	35.53	3.65	6,239	37.26	4.06	6,117	39.59	4.35	5,855	41.89	4.41	5,117	43.62	4.08	3,623
Maximum chest girth	65.93	4.96	2,151	67.90	5.03	5,587	70.82	5.70	5,949	74.63	6.42	5,817	78.13	6.21	5,121	80.79	5.77	3,624
Anterior chest arc	34.50	3.09	6,168	35.88	3.26	6,241	37.43	3.42	6,126	39.09	3.66	5,853	40.60	3.75	5,123	41.89	3.45	3,629
Waist girth	56.17	4.53	6,174	57.77	4.95	6,253	59.54	5.13	6,132	61.36	5.23	5,865	62.75	5.01	5,133	63.70	4.85	3,633
Hip girth	68.77	5.54	6,174	71.88	6.06	6,253	75.53	6.67	6,132	79.96	7.20	5,865	84.31	7.12	5,133	87.60	6.30	3,633
Neck-base girth	30.77	1.70	6,174	31.57	1.80	6,253	32.53	1.92	6,132	33.67	1.97	5,865	34.67	1.94	5,133	35.31	1.76	3,633
Shoulder length	9.11	.90	6,169	9.46	.94	6,247	9.88	.99	6,120	10.28	1.06	5,862	10.62	1.04	5,131	10.88	1.02	3,630
Armscye girth	30.00	2.26	6,174	31.28	2.42	6,253	32.63	2.55	6,132	34.11	2.67	5,865	35.47	2.65	5,133	36.49	2.49	3,633
Upper-arm girth	19.10	2.03	6,174	19.87	2.21	6,253	20.65	2.45	6,132	21.49	2.42	5,865	22.40	2.44	5,133	23.18	2.37	3,633
Elbow girth	20.90	1.63	6,165	21.73	1.71	6,247	22.67	1.82	6,124	23.60	1.82	5,855	24.37	1.75	5,123	24.94	1.68	3,630
Upper posterior arm length	26.83	1.71	6,173	28.14	1.78	6,248	29.54	1.95	6,127	30.94	1.95	5,860	32.05	1.90	5,126	32.73	1.77	3,626
Total posterior arm length	47.21	2.80	6,174	49.53	2.95	6,253	52.00	3.20	6,132	54.43	3.22	5,865	56.33	2.98	5,133	57.44	2.84	3,633
Trunk line	15.06	1.58	6,172	15.62	1.68	6,252	16.35	1.75	6,132	17.22	1.80	5,863	17.94	1.79	5,130	18.47	1.83	3,633
Waist to hips	16.70	1.62	6,173	17.46	1.73	6,250	18.27	1.89	6,131	19.24	1.98	5,862	20.20	2.00	5,131	20.92	1.97	3,630
Thigh girth	39.84	4.18	6,174	41.66	4.52	6,253	43.65	4.77	6,132	45.94	5.07	5,865	27.82	5.20	5,133	50.23	4.84	3,633
Maximum calf girth	26.36	2.11	6,174	27.40	2.28	6,253	28.55	2.39	6,132	29.81	2.54	5,865	31.01	2.54	5,133	31.90	2.41	3,633
Knee girth	27.87	2.09	6,174	29.03	2.25	6,253	30.26	2.36	6,132	31.56	2.42	5,865	32.59	2.38	5,133	33.29	2.26	3,633
Total crotch length	55.43	4.22	6,174	57.76	4.42	6,253	60.19	4.76	6,132	62.93	5.02	5,865	65.44	4.92	5,133	67.27	4.46	3,633
Anterior crotch length	27.40	2.45	6,166	28.52	2.51	6,249	29.68	2.64	6,128	31.04	2.87	5,856	32.13	2.76	5,124	32.88	2.62	3,628
Extreme bend	57.54	3.76	6,166	60.24	3.93	6,249	62.98	4.26	6,124	65.92	4.50	5,858	68.56	4.33	5,122	70.41	3.98	3,630
Vertical trunk girth	113.67	6.22	6,174	118.17	6.85	6,253	23.29	7.72	6,132	129.07	8.13	5,865	134.26	7.71	5,133	138.08	6.91	3,633