Fall 12-2010

The Effects of Body Composition Differences on Placement at Bodybuilding Competition Among Male Amateur Bodybuilders

Shinji Ogita
shinjiogita@gmail.com

THE EFFECTS OF BODY COMPOSITION DIFFERENCES ON PLACEMENT AT BODYBUILDING COMPETITION AMONG MALE AMATEUR BODYBUILDERS

By

Shinji Ogita

B.S., Southern Illinois University Carbondale, 2005

A Research Paper

Submitted in Partial Fulfillment of Requirements for the

Master of Science in Education Degree

Department of Kinesiology

in the Graduate School

Southern Illinois University Carbondale

November 2010

RESEARCH PAPER APPROVAL

THE EFFECTS OF BODY COMPOSITION DIFFERENCES ON PLACEMENT AT BODYBUILDING COMPETITION AMONG MALE AMATEUR BODYBUILDERS

By

Shinji Ogita

A Research Paper Submitted in Partial

Fulfillment of the Requirements

for the Degree of

Master's of Science in Education

in the field of Kinesiology

Approved by:

Dr. Joyce V. Fetro, Chair

Dr. M. Daniel Becque

Dr. Juliane Wallace

Graduate School
Southern Illinois University Carbondale
November 12, 2010

ACKNOWLEDGEMENTS

First of all, I would like to thank my academic advisor Dr. M. Daniel Becque for his support to complete this research paper. I also would like to thank Dr. Juliane Wallace and Dr. Joyce Fetro from the Kinesiology Department.

I would like to thank John Arnold, Becky Arnold, and Dave Yeates from the North American Natural Bodybuilding Federation and all participants for allowing me to collect data for this study.

I would like to thank Christopher Sofocleous and Shotaro Fukuda for helping my data collection.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Competitive bodybuilding is a sport that compares the visual presentation of muscularity, symmetry, presentation, and definition. The main goal of the sport is focused toward aesthetic muscular hypertrophy (Linder, 2007). The lifestyle of competitive bodybuilders can be separated into two parts, off-season and in-season. During the off-season, their weight training focus is muscular hypertrophy. Some competitors gain large amounts of fat mass at the same time. During their pre-competition preparation time, their goal is to reduce body fat while maintaining as much muscle mass as possible. Competitors make changes in both diet and exercise training. In general, dietary calorie intake decreases and many competitors add some type of cardiovascular exercise in their training program to increase energy expenditure and to increase fat loss (Sandoval, Heyward, & Lyons, 1989). Posing practice and tanning are also part of pre-competition preparation. The pre-competition duration is dependent on how much fat mass they must lose but a majority of competitors spend three to four months. Generally, the percent body fat of competitive bodybuilders on stage are 3 % to 6 % for men and 9 % to12 % for women at regional or national level competitions (Sandoval et al., 1989; Kleiner, Bazzarre, & Litchford, 1990; Van der Ploeg, Brooks, Withers, Dollman, Leaney, & Chatterton, 2001). At this body fat percent, separation and definition of each muscle becomes visible. In addition, their presentation posing skill, skin color, and muscle mass can influence their appearance on stage. Those who cannot perform the mandatory poses and individual posing routines well cannot display their physique to the judges. This will affect their placement in competition. The stage light is very bright and can make the skin look more white than usual. This whitening of the skin

reduces the highlights and shadows so that separations and definitions of the muscle is less apparent. Furthermore, competitors with a large muscle mass can have greater separation and definition at the same body fat percent. However, having a low body fat percent and low subcutaneous adipose tissue are likely the most important factors for bodybuilders.

One can measure body composition several ways but skinfolds and girth measurements may be the best way to assess a bodybuilder's condition and progress. The equipment necessary for these measurements can be portable and produce consistent results if tests are done by a well-trained individual. In the sport of bodybuilding, appearance is the most important factor to be considered by the judges when the competitors are on the stage. Some may have large amounts of visceral fat but it may not affect their appearance significantly. Therefore, the amount of subcutaneous and adipose tissue is the only concern for a bodybuilder. A competitor's ideal goal is to have the lowest possible skinfolds and create a "skin-tight" condition.

Another important way to assess body composition and shape of bodybuilders is to obtain girth measurements and calculate a ponderal somatogram. The original somatogram used each girth measurement (g) and its respective constant (k) value to calculate a deviation (d) score ($d = g/k$). Constant k was calculated as g/D which D was the sum of eleven girth measurements divided by 100. The deviation score was compared to a reference value for any shape comparison. It was helpful to examine changes in body shape from one point to the other (Behnke, Guttentag, & Brodsky, 1959). However, the original somatogram did not differentiate between muscular and nonmuscular components, did not allow the conversion of girths to mass, nor take body weight or

height into consideration. In 1987, Katch, Behnke, and Katch introduced a ponderal somatogram as an extension of the original somatogram. A ponderal somatogram separates the muscular components (shoulders, chest, biceps, forearm, thigh, and calf) and the nonmuscular (abdomen average, hips, knee, ankle, and wrist) components. Also, Katch et al. (1987) introduced the concept of a ponderal equivalent (PE) that enabled one to convert girth size into a volume and/or mass value in kilograms. It helps to identify locations of over or under development in comparison to other part of the body.

Several studies have examined the body composition of competitive bodybuilders (Sandoval et al., 1989; Kleiner et al., 1990; Da Silva, Trindade, and De Rose, 2003). Skinfold and girth measurements were taken in each of these studies and percent body fat of each competitor was calculated. Da Silva et al. (2003) analyzed data with somatotype. Gaines (2001) analyzed the relationship between placement and body composition differences within a bodybuilding competition. Anthropometric data collection and body fat percent analysis were also conducted but they did not examine body shape. Judging a bodybuilding competition is very subjective so there is always the potential for bias based upon the personal preferences of the judges. Although each bodybuilding organization provides some judging criteria, objective guidelines have never been available because it usually amounts to a comparison among competitors. Currently, a ranking system is the only method used to judge bodybuilding competitions. Therefore, it is difficult to say what factors are involved when making placement decisions. Skinfolds, girths, and the ponderal somatogram may help us understand the most important aspects of the body for high competition placement.

Statement of Purpose

The purpose of this study was to examine the relationship of body composition and body shape to placement at a bodybuilding competition among male amateur natural bodybuilders.

Hypotheses

1. Competitors who placed high in each class will have less percent body fat than those who placed low.
2. Competitors who placed high in each class will have greater positive ponderal somatogram muscular components than those who placed low.

Significance of Study

This study is important for competitive bodybuilders. Understanding data from percent body fat and the ponderal somatogram will help bodybuilders to set more specific goals towards competitions. By finding areas of overdevelopment or underdevelopment, it will help them find specific body parts they need to work on. Knowing target percent body fat will help create a more specific weight loss plan for dieting and will allow them to achieve their goals more precisely. To the best of our knowledge, no studies have examined the shape and body composition of competitive bodybuilders with the ponderal somatogram.

Assumptions

The following assumptions were identified for this study:

1. The participants did not have any health problems limiting their participation in the study.
2. Skin thickness and subcutaneous fat compressibility at all sites were constant.
3. Fat distribution pattern was relatively constant.
4. Proportion of internal and external fat was fixed.

Delimitations

The study was based on the following delimitations:

1. The participants were male competitors.
2. The participants were between 18 and 45 years old.

Limitations

The following limitations were identified for this study:

1. Pre contest meals and hydration status of the participants might affect skin condition and results from skinfold measurement.

Definitions

The following definitions were used for this study:

1. Natural bodybuilding: Sport of bodybuilding that prohibits use of anabolic steroids, growth hormone, and any other psychomotor stimulants. Many natural bodybuilding organizations follow the list of prohibited substances from the IOC.

2. Body composition: Components of body that are usually separated into fat and non-fat components. Non-fat components consist of muscle, bone, tendons, ligaments, and organs.
3. Muscularity: An impressive development of muscle of each body part that is greater than average as a bodybuilder. Development of muscle in relation to the size of skeletal structure.
4. Symmetry: Relation of each muscle in a group to other muscles. Measurement of evenness from upper to lower body and from front to back.
5. Presentation: Elements of display that shows the physique at best.
6. Definition: Clear delineation of each muscle groups.
7. Skinfold measurement: A method of measurement to obtain subcutaneous fat and skin thickness.
8. Girth measurement: A method of measurement to obtain specific trunk and limb circumferences.
9. Ponderal somatogram: A method that allows converting individual girths to ponderal equivalents or mass equivalents in kg.
10. Class: A part of a division based on a certain category. The North American Natural Bodybuilding Federation classifies each class by height. In the 4 height class system, competitors are categorized as; short (under 5'6"), medium (5'6" to under 5'9"), medium tall (5'9" to under 5'11"), and tall (5'11 to above). However, the classification may change depending on number of competitors to distribute competitors evenly.

11. Teen class: A category for competitors who are between 13 and 19 years old at the time of competition.
12. Novice class: A category for competitors who have not won first place in a novice class in any organization or who have not placed in the top three in any open class before.
13. Open class: A category that all competitors are allowed to compete. Open class does not have any age restrictions and those who do not meet the criteria for novice class can compete in the open class.
14. Masters class: A category of competitors who are 35 years or older. Submasters are age 35 to 44, master's 40-49, 50-59, and grandmasters over 60.
15. Prejudging: A part of a bodybuilding competition that consists of group comparisons with mandatory posing in each class. Competitors in each class are compared under the instruction of judges.
16. Mandatory poses: Standardized poses that competitors are required to execute for comparison between the competitors..
17. Individual posing routine: A group of poses that display the physique of the competitor best in 60 seconds. These poses and their order are chosen by the competitor.
18. Evening show: The evening part of a bodybuilding competition. Competitors perform their individual posing routine and the announcement of placement in the competition.

REVIEW OF LITERATURE

Anthropometry

An anthropometric profile consists of stature, body mass, nine skinfolds, thirteen girths, and sixteen lengths and breadths (Norton & Olds, 1996). Obtaining the full profile can be employed to estimate various things, such as body density, percent body fat, body mass index, waist to hip ratio, indices of body surface area, and somatotype. It is also possible to estimate fat mass, fat free mass, and the proportionality of the body (Norton & Olds, 1996).

In the sport of bodybuilding, obtaining anthropometric data can be an important assessment to identify what judges seek because of the nature of the sport. Bodybuilding does not measure performance like other sports. Contestants are evaluated and ranked on stage by the judges. There are no data that give indication of what the judges are looking for as they rank the competitors. Data must be both valid and reliable. Validity is the extent to which a measurement actually measures a characteristic and reliability is the extent to which the measurements produce consistent results with repeated testing under the same conditions (Norton & Olds, 1996). In order to increase reliability, repeated measurements are necessary for skinfold and girth measurements.

Densitometry

Densitometry is analyzed based on the assumption of a two compartment model that consists of fat mass and fat free mass. Fat mass is measured based on the assumption that its density is 0.9007 kg/L at 36 Cº (Fridanza, Keys, & Anderson, 1953). Fat free mass is measured based on the assumption that its density is 1.1000 kg/L at 36 Cº

(Brozek, Grande, Anderson, & Keys, 1963). Another assumption is the water content of the fat free body. Several studies have lead to the use of 73.2 % as the water content of the fat free body for adults. (Norton & Olds, 1996; Forbes & Lewis, 1956; Michell, Hamilton, Steggerda, & Bean, 1945; Shohl, 1939; Widdowson, McCance, & Spray, 1951). Various methods are used to estimate body density, such as underwater weighing, skinfold measurements, and air-displacement. Then, body density can be used in equations from Siri (1961) or Brozek et al. (1963) to calculate body fat percentage.

Hydrodensitometry or underwater weighing (UWW) is considered the gold standard to assess body density. It is based on Archimedes' Principle that measures body volume by the displacement of water. "When a body is immersed in water it is buoyed up by a force which is equivalent to the weight of the volume of water displaced" (Norton & Olds, 1996, p. 175). Mass per unit volume (kg/L) is defined as the density of an object. Factors to be considered are body density (kg/L), mass of body in the air (g), mass of body (g) when immersed in water, water density (kg/L), and residual lung volume (ml). Body density can be calculated as body mass in air / ((body mass in air – body mass in water) / water density) – residual lung volume. Measurement error in UWW is usually small and it can be about 0.9 % body fat depending on other characteristics (Durnin & Taylor, 1960). The main characteristic that affects measurement error is poor estimation of residual lung volume and body mass in water (Withers, 1983). In order to increase accuracy, a subject needs to give a maximum effort. The subject is required to exhale the air as much as possible to obtain accurate results. Although this method has been known as the gold standard, availability of equipment and the difficulty of the procedures make it hard to apply.

Skinfold measurement is another method used to estimate body density that measures the thickness of subcutaneous fat and skin. It is generally accepted as a valid method to estimate body fat percent in adults (Fuller, Jebb, Laskey, Coward, & Elia, 1992; Jebb, Murgatroyd, Coward, Goldberg, & Prentice, 1993; Reilly, Murray, Wilson, & Durnin, 1994). A skinfold caliper is inexpensive and can be used anywhere. This method takes about 10 to 15 minutes if it is done by an experienced tester. Measurements should always be taken from the right side of the body. Calipers are placed 1cm lateral to the thumb and index finger and depth of calipers is about mid-fingernail (Norton & Olds, 1996). Multiple sites and repeated measurements are recommended to increase accuracy and to minimize bias. Two or three times of repeated measurements are usually taken per site and an average is used in for calculations. Due to compression of the skin from the jaw of the caliper, measurements need to be taken two seconds after compression (Kramer & Ulmer, 1981). Individuals whose skin is very firm and does not deform very well may have difficulty obtaining valid results (Lukaski, 1987). To estimate body density, many equations are available for both men and women. For the adult Caucasian population, Durnin and Womersley (1974) developed an equation from 481 men and women aged between 16 and 72 years old. The equation estimated body density from the sum of 4 skinfolds (triceps, biceps, subscapular, and iliac crest), age, and gender. Jackson and Pollock (1978) developed a generalized equation for men from the sum of 7 skinfolds (chest, axial, triceps, subscapular, abdomen, thigh, and suprailiac), age, wrist, and forearm circumferences. The latter equation is the most common equation used to estimate body density. Differences among skinfold equation can vary from 3 % to 9 % body fat (Jackson & Polluck, 1977; Lohman, 1981) and averaging results likely provides

a better estimate of body fatness. Improper skinfold site selection, lack of experience, and subject fatness can dramatically influence the results (Pollock, Schmidt, & Jackson, 1980). In experienced testers, a precision of within 5% can be obtained (Cameron, 1978).

Bioelectrical Impedance Analysis (BIA)

BIA is another method to assess body fat percentage. It is the most common method used to assess body composition (Buchholz, Bartok, & Schoeller, 2004). BIA devices measure bioelectrical resistive impedance to estimate body composition (Lukaski, Johnson, Bolonchuk, & Lykken, 1985). Devices can be either hand-held or standing type. Electric current is sent from one side (hand or foot) of the body and goes through to the other side of the body. Advantages of this method are that it is noninvasive, short testing time, no active collaboration of participants, portable, and inexpensive (Schols, Wouters, Soeters, & Westerterp, 1991). Reliability and validity of this technique has been assessed and well-accepted (Maughman, 1993; Jackson, Pollock, Groves, & Mahar, 1988; Schols et al., 1991). However, the main problem of BIA is hydration status and its effect on results. Small fluid changes occurring with exercise or diet can create errors in the estimation of body fat percent (Saunders, Blevins, & Broeder, 1998). Therefore, any sports that create fluid change during training should not be measured with BIA. Hydration status should be kept the same every time a measurement is made. BIA is likely not suitable for bodybuilders because many of them stop drinking water before competition and are dehydrated. Dehydration reduces body water and subcutaneous water making competitors “look dry” on stage. Also, BIA is not a valid method for individuals who have experienced body mass changes in short periods of time. None of the equations

are applicable for this type of change (Vazques & Janosky, 1991). When using BIA, participants need to be healthy individuals with stable hydration and electrolytes.

Ponderal Somatogram

The original idea of the somatogram was introduced by Behnke et al. in 1959. Behnke et al. used 11 girth measurements and compared with the reference value to examine how far each girth size was different from the reference based on percent deviation units. It was useful and could be used to track growth to compare a person's physique changes from one point to the other. However, the original somatogram did not include the idea of muscular and nonmuscular components and it was unable to convert girth size into a volume or mass equivalent (Katch et al., 1987).

Katch et al. introduced the ponderal sotmatogram in 1987. The ponderal somatogram defined muscular components that included the shoulder, chest, biceps, forearm, thigh, and calf, and nonmuscular components that included the abdominal, hips, knee, wrist, and ankle. Katch et al. (1987) also created Ponderal equivalent (PE) values that allowed conversion of girths into mass. Calculating the deviation d value helped to identify over and under development at each site. Positive values indicated overdevelopment and negative values indicated underdevelopment compared to the opposite PE component (Stuempfle, Drury, Petrie, & Katch, 2009). For example if a person weighs 80 kg and has a PE of 120 kg for his biceps, it means his biceps size is the projected size of the biceps for average person who weighs 120 kg. A ponderal somatogram gives an objective assessment of an individual's physique and can be useful for many sports. For example, different positions in football require different physiques

and athletic abilities. Linemen tend to be tall and heavy and running backs tend to be shorter and lighter than linemen (Stuempfle et al., 2009). Using ponderal somatogram helps to examine and classifies athletes into different positions that can help place athletes in the best position based on their body type. Validity of the ponderal somatogram was established by Sinning and Moore in 1989.

Stuempfle, Drury, Petrie, and Katch used ponderal somatogram to assess body size and shape of division III collegiate football players over an academic year in 2007. Fifty four football players were assessed in preseason camp, at the beginning, and at the end of the strength conditioning program. K constants were used from the reference values (Behnke et al., 1959). Each girth was used to calculate PEs to identify overdevelopment and underdevelopment sites and changes over an academic year. In their study, biceps showed the greatest overdevelopment in muscular components. Abdomen and hips were overdeveloped in nonmuscular components. They concluded that the ponderal somatogram was a practical method to track changes in body shape and size and was easy and simple.

In addition, the same authors conducted a study of 82 football players by position (Stuempfle et al., 2009). Four groups of players, such as offensive linemen, defensive linemen, offensive backs, and defensive backs, were assessed using ponderal somatograms. PEs and the ratio of the PE muscular to the PE nonmuscular components were calculated. Offensive linemen were heavier than others and had the greatest biceps and abdomen development. This simple method is easy to understand and can provide a relatively clear idea of body shape and size. By understanding the specific requirement

for each position, athletes and coaches can set specific goals for training programs and monitor effectiveness.

METHODS

Introduction

This chapter provides information regarding the procedures used in this study. This chapter consists of the following section: (a) Selection of Participants, (b) Equipment, (c) Data Collection Procedures, and (d) Data Analysis Procedures.

Selection of Participants

Participants were recruited from a state and a regional level natural bodybuilding competition in the Midwest. The recruitment procedure and data collection procedures were approved by the SIUC Human Subjects Committee. All competitors claimed to be drug-free for the past 7 years and passed polygraph tests prior to the competition. Promoters from two of the North American Natural Bodybuilding Federation competitions were contacted prior to the competitions and they gave the researcher permission to come to the competitions to recruit participants. At a morning meeting prior to the prejudging, the purpose and procedures of the study were explained verbally to the competitors. Upon getting an understanding, competitors were then asked to participate in the study. Those who were willing to participate in the study contacted the researcher after the meeting to set up an appointment for data collection. Prior to their participation, the purpose and the procedures for the study were reiterated orally to the participants. Those who were comfortable with having skinfold and girth measurements taken agreed to participate in the study. After the agreement, each participant signed an informed consent form and was asked to complete a medical history form. Any participant, who had any medical condition that was not under doctor's provision, had

any disease or musculoskeletal/orthopedic problems were excluded from the study. Participants were also allowed to terminate the study at anytime if they wished to do so. Participation in the study was voluntary and the researcher did not know competition results at the time when the data was collected. As a result, the researcher had no control over which groups were represented in the study and the number of competitors who participated in the study from each class varied. There was no information regarding their level of hydration and its effect on their skin elasticity.

Equipment

A Lange skinfold caliper was used to measure skinfolds to the nearest 0.1 mm on the right side of the body. A standard stadiometer was used to measure height to the nearest millimeter. A portable electronic weight scale was used to measure body weight to the nearest 0.1 kg. A standard tape measure was used for girth measurements.

Data Collection Procedures

Testing for each participant took approximately 15 minutes. They were asked to relax and stand still while the researcher took skinfold and girth measurements. They were then instructed to move their arms or legs to obtain an accurate measurement during testing. They did not engage in any physical activity during the study. Four types of anthropometric measurements were taken in the following order; (1) height, (2) weight, (3) skinfolds and (4) girths.

Height was obtained using the stretch stature method. Participants stood with their feet and heels together. Their buttocks, the upper back, and backside of the head touched

the stadiometer. The height was then measured by looking at the top of their head (Norton & Olds, 1996). After obtaining a height, participants were weighed while wearing only their competition suits.

For skinfold and girth measurements, the right side of the body was used to obtain consistent results. The left side of the body was used if the right side was problematic for obtaining accurate measurements. Skinfolds were taken two seconds after the caliper was applied (Kramer & Ulmer, 1981). The caliper was held at 90 degrees to skinfold sites. Ten skinfold sites were used and measurements were taken in the following order:

1. Triceps: A vertical fold on the most posterior surface of the upper arm at the mid-acromiale radiale line.
2. Subscapular: A diagonal fold (about 45 degrees angle) at 2 cm below the inferior angle of the scapula.
3. Midaxillary: A vertical fold on the midaxillary line at the level of the xiphoid process of the sternum. Participant lifts their right arm at about 90 degree angles.
4. Illiac Crest: A horizontal fold immediately superior to the iliocristale on the ilio-axilla line.
5. Chest: A diagonal fold (about 45 degree angle) at the midpoint between acromiale and the nipple.
6. Biceps: A vertical fold on the most anterior aspect of the right arm at the midpoint of acromiale-radiale line.
7. Abdominal: A vertical fold 5 cm away from the right side of the midpoint of the naval.

8. Supraspinale: A diagonal (about 45 degree angle) fold on 5 to 7 cm above the iliospinale.
9. Front thigh: Participant's knee was either bent or straight. A vertical fold on the mid-point of the axis between the patella and the inguinal fold.
10. Medial calf: Calf needed to be relaxed. A vertical fold on the medial aspect at a maximum circumference of the calf.

Thirteen girth sites were used and the measurements were taken in the following order:

1. Neck: Immediately superior to the thyroid cartilage.
2. Arm-relaxed: Arm needed to be relaxed. The girth was measured at the level of the mid-acromiale-radiale.
3. Arm-flexed: The maximum circumference of the right upper arm. The upper arm needed to be raised horizontally with the forearm at about 45 degrees angle to the upper-arm.
4. Forearm: The maximum girth of the forearm and the palm up.
5. Wrist: From distal to the styloid processes of the right wrist.
6. Chest: At the level of the mesosternale, the midpoint of the sternum.
7. Waist: At the level of the narrowest point between the rib and the iliac crest.
8. Hips: At the level of the greatest posterior protuberance of the buttocks. Participant stood with feet together.
9. Thigh: At 1 cm below the level of the gluteal fold perpendicular to the long axis of the thigh.

10. Mid-thigh: At the midway between the trochanterion and tibiale laterale perpendicular to the long axis of the thigh.
11. Knee: At the midpoint of the patella.
12. Calf: The maximum circumference of the right calf. A girth measurement was taken from the lateral aspect of the leg.
13. Ankle: At the narrowest point superior to the sphyrion tibiale.

Measurements at each site were taken twice for both skinfold and girth measurements. All of the skinfold and girth measurements were made one time and then repeated from the beginning.

Data Analysis Procedures

Means of each site from skinfold measurements were calculated and were used as data. These data were used to calculate body density with the Jackson and Pollock (1978) equation:

Body density = $1.11200000 – 0.00043499 (X1) + 0.00000055 (X1)^2 - 0.00028826 (X3)$

X1 = sum of chest, midaxillary, triceps, subscapular, abdominal, supraspinale and front thigh skinfolds

X3 = age

Body density from the Jackson and Pollock (1978) equation was employed to calculate percent body fat for each participant using the Siri (1961) equation. Means of each girth measurement site were calculated and were used for the ponderal somatogram. Ponderal somatogram allowed the researcher to convert girth measurements into PEs

expressed in kilograms. Muscular components consisted of the chest, flexed-biceps, forearm, mid-thigh, and calf. Nonmuscular components consisted of the abdomen, hips, knee, wrist, and ankle. Reference girth measurements and k constants for the ponderal somatogram were taken from Katch et al. (1987). Formulas used in the ponderal somatogram were the following (Katch et al., 1987):

- The k constant = g/F. g = individual girth in cm. F = the square root of the reference male body weight in kg divided by stature in dm.
- Ponderal equivalent (PE, kg) = $(g/k)^2$ x stature.
- Muscular component % deviation = (PE muscular value – average PE nonmuscular components) / average PE nonmuscular components x 100.
- Nonmuscular component % deviation = (PE nonmuscular value – average PE muscular components) / average PE muscular components x 100.

Conversion to PEs from each girth measurement provided a projected mass of a body part in kilograms compared to the opposite component. For example, the body mass of an individual was 70 kg but the PE for this individual's biceps was 100 kg. The biceps size would then be equivalent to the size of an individual who weighs 100 kg or its region is overdeveloped by 30 kg. The deviation was the percentage of how much one site in the muscular or nonmuscular component was over or under developed compared to the opposite component. A positive value indicated over development and a negative value indicated under development of a body part in relation to the opposite component (Stuempfle et al., 2009).

After the percentage of deviation from each competitor was calculated, the data were compared within each class. Competitors who placed higher in each class were compared to the other competitors in the class.

RESULTS

Data were collected from a total of twenty male amateur bodybuilders from state and regional level competitions in the Midwest. Data were collected from the following classes; submasters, masters, grandmasters, open short, open medium, open tall, novice short, novice medium, novice medium tall, novice tall, and teen division. Due to a need for voluntary willingness to participate in the research, only several competitors from each class participated in the study. In the NANBF competitions, only the top five competitors from each class were placed from 1st to 5th. Those who finished 6th or below were placed as "9". For the novice overall, only the first place was ranked and placement for the other competitors was not decided.

Submasters class

Table 1 shows skinfold data for the submasters class. There were ten competitors and five of them participated in the study. First place had the lowest sum of skinfolds and body fat percent. Other competitors had similar results while the third place competitor had the highest body fat percentage among the top five competitors.

Table 2 shows girth measurements for the submasters class. First place had the smallest forearm and wrist sizes while achieving the largest calf size. The rest of his body parts were of average size.

Table 1

Skinfold Data for the Submasters Class (mm)

Placement	1	3	4	9	9
Triceps	3.00	5.00	2.25	5.00	3.50
Subscapular	6.00	8.00	10.00	7.75	9.50
Midaxillary	3.50	4.00	5.50	3.50	5.00
Illiac Crest	6.00	7.50	8.00	9.00	10.00
Chest	3.00	3.00	2.00	3.00	3.00
Biceps	2.25	3.00	2.00	3.25	2.25
Abdominal	4.75	7.50	8.00	7.50	6.00
Supraspinale	3.00	3.50	3.50	4.00	3.75
Front Thigh	4.75	7.00	8.00	6.75	5.75
Medial Calf	4.00	4.00	3.00	5.50	5.00
Sum of skinfolds	40.25	52.5	52.25	55.25	53.75
Body fat (%)	4.30	5.97	5.81	5.77	5.60

Table 2

Girth Measurements for the Submasters Class (cm)

Placement	1	3	4	9	9
Chest	101.90	110.90	98.50	107.20	99.00
Biceps	36.55	37.35	41.75	37.40	33.75
Forearm	28.00	30.00	31.50	31.65	30.75
Thigh	53.80	57.00	54.85	55.50	50.05
Calf	40.20	36.90	35.05	35.55	36.65
Abdominal	82.55	87.15	76.45	78.10	74.05
Hips	90.50	92.15	88.00	95.50	88.65
Knee	35.55	35.15	36.05	36.40	36.40
Wrist	16.55	17.10	16.75	17.45	18.50
Ankle	22.10	21.55	20.85	21.10	23.95

Table 3 shows PEs for the submasters class. There was no specific pattern or tendency from the first place to the rest of competitors. It is interesting that the first place competitor had the largest calf but smallest forearm.

Table 4 shows percentage deviation of PEs for the submasters class. All of the nonmuscular components from the non-placed competitors showed negative values with the exception of their wrist and ankle sizes. First place did not have the largest or smallest body parts in comparison with his average nonmuscular PE except his calf and forearm. Fourth place had very large biceps and forearm size and the smallest abdominal, hip, wrist, and ankle sizes.

Table 3

Ponderal Equivalent Values for the Submasters Class (kg)

Placement	1	3	4	9	9
Chest	82.01	98.07	75.11	98.38	76.53
Biceps	88.48	93.29	113.16	95.32	74.59
Forearm	72.11	83.58	89.46	94.80	85.98
Thigh	64.15	72.70	65.36	70.24	54.89
Calf	83.93	71.39	62.54	67.53	68.96
Abdominal	76.50	86.08	64.31	70.45	60.85
Hips	62.49	65.41	57.91	73.10	59.28
Knee	62.80	61.98	63.29	67.73	65.08
Wrist	61.65	65.66	61.16	69.67	75.24
Ankle	64.21	61.66	56.02	60.22	74.55

Table 4

Ponderal Equivalent Percentage Deviation for the Submasters Class (%)

Placement	1	3	4	9	9
Chest	25.1	43.9	24.1	36.9	14.2
Biceps	35.0	36.9	86.9	39.7	11.3
Forearm	10.0	22.6	47.8	38.9	28.3
Thigh	-2.1	6.7	8.0	2.9	-18.1
Calf	28.1	4.7	3.3	-1.0	2.9
Abdominal	-2.1	2.7	-20.7	-16.4	-15.7
Hips	-20.0	-21.9	-28.6	-13.2	-17.9
Knee	-19.6	-26.0	-22.0	-19.6	-9.8
Wrist	-21.1	-21.7	-24.6	-17.3	4.2
Ankle	-17.8	-26.4	-30.9	-28.5	3.3

Masters Class

Table 5 shows skinfold data for the masters class. There were six competitors and two of them participated in the study. First place had a higher sum of skinfolds and body fat percentage than the fourth place competitor.

Table 6 shows girth measurements for the masters class. First place had larger girth measurements than the fourth place for all of his muscular components except the calf. His nonmuscular components were smaller than the fourth place.

Table 5

Skinfold Data for the Masters Class (mm)

Placement	1	4
Triceps	5	4
Subscapular	7.75	6.25
Midaxillary	4.50	3.25
Illiac Crest	7.25	4.00
Chest	2.75	2.00
Biceps	2.25	2.00
Abdominal	6.25	4.00
Supraspinale	5.25	3.00
Front Thigh	9.50	4.75
Medial Calf	5.50	4.00
Sum of skinfolds	56.00	37.25
Body fat (%)	7.44	5.74

Table 6

Girth Measurements for the Masters Class (cm)

Placement	1	4
Chest	109.80	100.50
Biceps	37.35	34.75
Forearm	30.90	29.40
Thigh	57.40	56.95
Calf	36.00	38.90
Abdominal	70.75	78.35
Hips	89.30	91.25
Knee	35.05	37.65
Wrist	17.60	17.60
Ankle	23.00	24.30

Table 7 shows PEs for the masters class. The chest, biceps, forearm, and thigh PEs were larger for the first place competitor than the fourth place competitor. Thigh size was similar in both competitors. In the nonmuscular components, the first place competitor had smaller PEs than the fourth place competitor except in his ankle PEs.

Table 8 shows percentage deviation of PEs for the masters class. All of the muscular components showed positive values and all of the nonmuscular components showed negative values for both competitors. The first place competitor had a larger chest, biceps, forearm, and thigh sizes while maintaining a very small abdominal size.

Table 7

Ponderal Equivalent Values for the Masters Class (kg)

Placement	1	4
Chest	100.09	82.27
Biceps	97.12	82.48
Forearm	92.31	81.99
Thigh	76.76	74.13
Calf	70.74	81.04
Abdominal	59.06	71.07
Hips	63.95	65.52
Knee	64.16	72.63
Wrist	72.41	71.04
Ankle	73.10	80.06

Table 8

Ponderal Equivalent Percentage Deviation for the Masters Class (%)

Placement	1	4
Chest	50.4	14.2
Biceps	46	14.5
Forearm	38.7	13.8
Thigh	15.4	2.9
Calf	6.3	12.5
Abdominal	-32.4	-11.6
Hips	-26.8	-18.5
Knee	-26.6	-9.6
Wrist	-17.2	-11.6
Ankle	-16.4	-0.4

Novice Short Class

Table 9 shows skinfold data for the novice short class. There were nine competitors and five of them participated in the study. First place had the lowest sum of skinfolds and second lowest body fat percentage among the competitors. Areas where large muscle mass is typically located, such as subscapular, abdominal, and front thigh had lower skinfold thicknesses from the first to the last place competitor.

Table 10 shows girth measurements for the novice short class. There was no tendency or pattern for girth measurements from the first place to the rest of competitors. The first place competitor had the largest calf measurement while his wrist was smallest

in the class. None of his other sites were either largest or smallest in class. The fourth place competitor had the highest girth measurements for his chest, biceps, abdominal, and hip, while maintaining the highest body fat percentage of the available competitors.

Table 9

Skinfold Data for the Novice Short Class (mm)

Placement	1	3	4	9	9
Triceps	3.00	4.50	5.00	3.50	2.25
Subscapular	6.00	7.75	8.00	9.50	10.00
Midaxillary	3.50	4.25	4.00	5.00	5.50
Illiac Crest	6.00	5.50	7.50	10.00	8.00
Chest	3.00	2.50	3.00	3.00	2.00
Biceps	2.25	2.75	3.00	2.25	2.00
Abdominal	4.75	5.00	7.50	6.00	8.00
Supraspinale	3.00	3.50	3.50	3.75	3.50
Front Thigh	4.75	5.00	7.00	5.75	8.00
Medial Calf	4.00	4.50	4.00	5.00	3.00
Sum of skinfolds	40.25	45.25	52.50	53.75	52.25
Body fat (%)	4.30	2.90	5.97	5.07	5.81

Table 10

Girth Measurements for the Novice Short Class (cm)

Placement	1	3	4	9	9
Chest	101.90	97.00	110.90	99.00	98.50
Biceps	36.55	36.30	37.35	33.75	41.75
Forearm	28.00	27.55	30.00	30.75	31.50
Thigh	53.80	57.30	57.00	50.05	54.85
Calf	40.20	37.00	36.90	36.65	35.05
Abdominal	82.55	72.90	87.15	74.05	76.45
Hips	90.50	87.85	92.15	88.65	88.00
Knee	35.55	35.30	35.15	36.40	36.05
Wrist	16.55	16.80	17.10	18.50	16.75
Ankle	22.10	22.30	21.55	23.95	20.85

Table 11 shows PEs for the novice short class. There was no tendency in both the muscular and the nonmuscular components. The first place competitor did not have the highest PEs in any of his body parts except the calf.

Table 11

Ponderal Equivalent Values for the Novice Short Class (kg)

Placement	1	3	4	9	9
Chest	82.01	72.93	98.07	76.53	75.11
Biceps	88.48	85.65	93.29	74.59	113.16
Forearm	72.11	68.51	83.58	85.98	89.46
Thigh	64.15	71.42	72.70	54.89	65.36
Calf	83.93	69.77	71.39	68.96	62.54
Abdominal	76.50	58.55	86.08	60.85	64.31
Hips	62.49	57.79	65.41	59.28	57.91
Knee	62.80	60.76	61.98	65.08	63.29
Wrist	61.65	61.60	65.66	75.24	61.16
Ankle	64.21	64.16	61.66	74.55	56.02

Table 12 shows percentage deviation of PEs for the novice short class. Nearly all of the muscular components except the thigh in the first and non-placed competitors showed positive values. Correspondingly all of the nonmuscular components except the abdominal from the fourth place competitor and the wrist and ankle from the non-placed competitors showed negative values. The first place competitor had the smallest forearm and largest calf size in muscular components while the rest of his sites were neither largest nor smallest.

Table 12

Ponderal Equivalent Percentage Deviation for the Novice Short Class (%)

Placement	1	3	4	9	9
Chest	25.1	20.4	43.9	14.2	24.1
Biceps	35	41.4	36.9	11.3	86.9
Forearm	10	13.1	22.6	28.3	47.8
Thigh	-2.1	17.9	6.7	-18.1	8
Calf	28.1	15.2	4.7	2.9	3.3
Abdominal	-2.1	-20.5	2.7	-15.7	-20.7
Hips	-20	-21.5	-21.9	-17.9	-28.6
Knee	-19.6	-17.5	-26	-9.8	-22
Wrist	-21.1	-16.4	-21.7	4.2	-24.6
Ankle	-17.8	-12.9	-26.7	3.3	-30.9

Novice Medium Class

Table 13 shows skinfold data for the novice medium class. There were seven competitors and two of them participated in the study. First place had a lower sum of skinfolds and body fat percentage than the second place competitor. First place competitor was also the overall winner of the novice division.

Table 14 shows girth measurements for the novice medium class. In muscular components, the first place finisher had slightly larger biceps while the second place competitor had larger forearm, thigh, and calf sizes than the first place competitor. In

nonmuscular components, the first place competitor had smaller abdominal, hips, and knee sizes but had larger wrist and ankle sizes than the second place competitor.

Table 13

Skinfold Data for the Novice Medium Class (mm)

Placement	1	2
Triceps	2.75	5.00
Subscapular	7.50	10.00
Midaxillary	3.00	5.25
Illiac Crest	4.50	11.00
Chest	2.00	2.75
Biceps	2.25	3.00
Abdominal	5.00	8.50
Supraspinale	3.00	4.25
Front Thigh	4.75	8.50
Medial Calf	3.00	5.00
Sum of skinfolds	37.75	63.25
Body fat (%)	2.98	5.42

Table 14

Girth Measurements for the Novice Medium Class (cm)

Placement	1	2
Chest	104.20	108.90
Biceps	40.00	39.65
Forearm	30.70	31.35
Thigh	55.45	57.85
Calf	38.05	38.50
Abdominal	74.10	78.20
Hips	91.95	94.25
Knee	36.20	36.65
Wrist	17.55	16.80
Ankle	22.55	21.70

Table 15 shows PEs for the novice medium class. First place had larger biceps, wrist, and ankle while maintaining smaller forearm, thigh, calf, abdominal, hips, and knee measurement than his opponent.

Table 15

Ponderal Equivalent Values for the Novice Medium Class (kg)

Placement	1	2
Chest	89.26	95.81
Biceps	110.31	106.51
Forearm	90.24	92.47
Thigh	70.93	75.87
Calf	78.26	78.74
Abdominal	64.16	70.22
Hips	67.15	69.32
Knee	67.77	68.27
Wrist	71.30	64.20
Ankle	69.59	63.32

Table 16 shows percentage deviation of PE for the novice medium class. Muscular components showed positive values and nonmuscular components showed negative values. First place competitor had bigger biceps, knee, wrist, and ankle size in comparison with the second place competitor.

Table 16

Ponderal Equivalent Percentage Deviation for the Novice Medium Class (%)

Placement	1	2
Chest	31.3	42.8
Biceps	62.6	58.8
Forearm	32.7	37.9
Thigh	4.3	13.1
Calf	15.1	17.4
Abdominal	-26.9	-21.9
Hips	-23.5	-22.9
Knee	-22.8	-24
Wrist	-18.8	-28.6
Ankle	-20.7	-29.5

Novice Medium Tall Class

Table 17 shows skinfold data for the novice medium tall class. There were seven competitors and two of them participated in the study. First place competitor had a higher sum of skinfolds and body fat percentage than the non-placed competitor.

Table 17

Skinfold Data for the Novice Medium Tall Class (mm)

Placement	1	9
Triceps	5.00	7.25
Subscapular	7.75	10.00
Midaxillary	4.50	4.00
Illiac Crest	7.25	6.00
Chest	2.75	3.00
Biceps	2.25	3.00
Abdominal	6.25	5.00
Supraspinale	5.25	3.00
Front Thigh	9.50	5.50
Medial Calf	5.50	3.50
Sum of skinfolds	56.00	50.25
Body fat (%)	7.44	4.36

Table 18 shows girth measurements for the novice medium tall class. In muscular components, the first place competitor had larger girth measurements from all sites. In nonmuscular components, the first place finisher had smaller abdominal, hips, and knee size than the non-placed competitor.

Table 19 shows PEs for the novice medium tall class. PEs showed the same pattern as the girth measurements. The first place competitor had larger muscular components than the non-placed competitor. In nonmuscular components, the first place

competitor had smaller abdominal, hips, and knee size while he had larger wrist and ankle size measurements than the non-placed competitor.

Table 18

Girth Measurements for the Novice Medium Tall Class (cm)

Placement	1	9
Chest	109.80	102.40
Biceps	37.35	36.50
Forearm	30.90	29.40
Thigh	57.40	55.10
Calf	36.00	35.30
Abdominal	70.75	79.00
Hips	89.30	90.90
Knee	35.05	36.10
Wrist	17.60	15.95
Ankle	23.00	21.65

Table 19

Ponderal Equivalent Values for the Novice Medium Tall Class (kg)

Placement	1	9
Chest	100.09	85.36
Biceps	97.12	90.95
Forearm	92.31	81.94
Thigh	76.76	69.35
Calf	70.74	66.70
Abdominal	59.06	72.21
Hips	63.95	64.98
Knee	64.16	66.74
Wrist	72.41	58.31
Ankle	73.10	63.51

Table 20 shows percentage deviation of PEs for the novice medium tall class. Percentage deviation showed the same pattern. All the muscular components showed positive values and all the nonmuscular components showed negative values. The first place competitor had larger chest, biceps, and forearm measurements while maintaining a smaller abdominal size.

Table 20

Ponderal Equivalent Percentage Deviation for the Novice Medium Tall Class (%)

Placement	1	9
Chest	50.4	31
Biceps	46	39.6
Forearm	38.7	25.8
Thigh	15.4	6.5
Calf	6.3	2.4
Abdominal	-32.4	-8.4
Hips	-26.8	-17.6
Knee	-26.6	-15.4
Wrist	-17.2	-26.1
Ankle	-16.4	-19.5

Novice Tall Class

Table 21 shows skinfold data for the novice tall class. There were five competitors and two of them participated in the study. The first place competitor had a lower sum of skinfolds and body fat percentage than the fourth place competitor. All skinfolds were smaller in the first place competitor than the fourth place competitor.

Table 21

Skinfold Data for the Novice Tall Class (mm)

Placement	1	4
Triceps	3.25	5.00
Subscapular	5.75	7.75
Midaxillary	3.75	3.50
Illiac Crest	5.25	9.00
Chest	3.00	3.00
Biceps	2.50	3.25
Abdominal	4.75	7.50
Supraspinale	2.75	4.00
Front Thigh	4.00	6.75
Medial Calf	3.50	5.50
Sum of skinfolds	38.5	55.25
Body fat (%)	3.22	5.77

Table 22 shows girth measurements for the novice tall class. The first place competitor had smaller size on most sites except his calf, knee, and ankle sizes. The fourth place competitor was generally larger than the first place competitor.

Table 22

Girth Measurements for the Novice Tall Class (cm)

Placement	1	4
Chest	99.80	107.20
Biceps	36.05	37.40
Forearm	29.60	31.65
Thigh	53.25	55.50
Calf	36.15	35.55
Abdominal	72.20	78.10
Hips	88.35	95.50
Knee	37.40	36.40
Wrist	16.20	17.45
Ankle	22.10	21.10

Table 23 shows PEs for the novice tall class. In muscular components, the first placed competitor had smaller measurements than the fourth place competitor except his calf. In nonmuscular components, the first place competitor had a smaller abdominal, hips, and wrist size than the fourth place competitor.

Table 23

Ponderal Equivalent Values for the Novice Tall Class (kg)

Placement	1	4
Chest	86.56	98.38
Biceps	94.72	95.32
Forearm	88.68	94.80
Thigh	69.16	70.24
Calf	74.68	67.53
Abdominal	64.39	70.45
Hips	65.53	73.10
Knee	76.48	67.73
Wrist	64.22	69.67
Ankle	70.66	60.22

Table 24 shows percentage deviation of PEs for the novice tall class. All sites in muscular components except calf size in the fourth place showed positive values. All sites in nonmuscular components showed negative values.

Table 24

Ponderal Equivalent Percentage Deviation for the Novice Tall Class (%)

Placement	1	4
Chest	26.8	36.9
Biceps	38.8	39.7
Forearm	29.9	38.9
Thigh	1.3	2.9
Calf	9.4	-1
Abdominal	-22.2	-16.4
Hips	-20.8	-13.2
Knee	-7.6	-19.6
Wrist	-22.4	-17.3
Ankle	-14.6	-28.5

Novice Overall

Table 25 shows skinfold data for the novice overall. The first place competitor had the lowest sum of skinfolds and lowest body fat percent among the four competitors. The first place competitor had also the lowest triceps, midaxillary, illiac crest, chest, biceps, and medial calf skinfold thicknesses.

Table 26 shows girth measurements for the novice overall. The first place competitor had the largest biceps and hip size. His forearm, thigh, calf, abdominal, knee, wrist, and ankle size were neither largest nor smallest among the competitors.

Table 25

Skinfold Data for the Novice Overall (mm)

Class winner	Med	Short	Med tall	Tall
Placement	1			
Triceps	2.75	3.00	5.00	3.25
Subscapular	7.50	6.00	7.75	5.75
Midaxillary	3.00	3.50	4.50	3.75
Illiac Crest	4.50	6.00	7.25	5.25
Chest	2.00	3.00	2.75	3.00
Biceps	2.25	2.25	2.25	2.50
Abdominal	5.00	4.76	6.25	4.75
Supraspinale	3.00	3.00	5.25	2.75
Front Thigh	4.75	4.75	9.50	4.00
Medial Calf	3.00	4.00	5.50	3.50
Sum of skinfolds	37.75	40.26	56.00	38.50
Body fat (%)	2.98	4.30	7.44	3.22

Table 26

Girth Measurements for the Novice Overall (cm)

Class winner	Med	Short	Med tall	Tall
Placement	1			
Chest	104.20	101.90	109.80	99.80
Biceps	40.00	36.55	37.35	36.05
Forearm	30.70	28.00	30.90	29.60
Thigh	55.45	53.80	57.40	53.25
Calf	38.05	40.20	36.00	36.15
Abdominal	74.10	82.55	70.75	72.20
Hips	91.95	90.50	89.30	88.35
Knee	36.20	35.55	35.05	37.40
Wrist	17.55	16.55	17.60	16.20
Ankle	22.55	22.10	23.00	22.10

Table 27 shows the PEs for the novice overall. The first place competitor had the largest biceps and hip PEs. The medium tall class competitor had the largest PE for the chest, forearm, and thigh while also having the lowest PE on the abdominal although he had the highest skinfold number in the abdominal region. The short class competitor had the largest calf size.

Table 27

Ponderal Equivalents Values for the Novice Overall (kg)

Class winner	Med	Short	Med tall	Tall
Placement	1			
Chest	89.26	82.01	100.09	86.56
Biceps	110.31	88.48	97.12	94.72
Forearm	90.24	72.11	92.31	88.68
Thigh	70.93	64.15	76.76	69.16
Calf	78.26	83.93	70.74	74.68
Abdominal	64.16	76.50	59.06	64.39
Hips	67.15	62.49	63.95	65.53
Knee	67.77	62.80	64.16	76.48
Wrist	71.30	61.65	72.41	64.22
Ankle	69.59	64.21	73.10	70.66

Table 28 shows the percentage deviation of the PE for the novice overall. Thigh size for the short class competitor showed a negative value but other sites from all of the competitors within the muscular components showed positive values. All sites from all competitors in the nonmuscular components showed negative values. The first place competitor had the largest biceps size. The rest of his body parts were neither largest nor smallest. The medium tall class competitor had the largest chest, forearm, thigh, and wrist size while having the smallest calf, abdominal, hips, and knee size. The short class competitor had the largest calf, abdominal, and hip size but had the smallest chest, biceps,

forearm, and thigh size. The tall class competitor had the largest knee and ankle size but had the smallest wrist size.

Table 28

Ponderal Equivalent Percentage Deviation for the Novice Overall (%)

Class winner	Short	Med	Med tall	Tall
Placement	1			
Chest	31.3	25.1	50.4	26.8
Biceps	62.6	35	46	38.8
Forearm	32.7	10	38.7	29.9
Thigh	4.3	-2.1	15.4	1.3
Calf	15.1	28.1	6.3	9.4
Abdominal	-26.9	-2.1	-32.4	-22.2
Hips	-23.5	-20	-26.8	-20.8
Knee	-22.8	-19.6	-26.6	-7.6
Wrist	-18.8	-21.1	-17.2	-22.4
Ankle	-20.7	-17.8	-16.4	-14.6

Teen Division

Table 29 shows skinfold data for the teen division. There were four competitors and three of them participated in the study. From the first place finisher to the third place finisher, there was a pattern of the sum of skinfold and body fat percentage. They increased as the place the competitor was lower.

Table 29

Skinfold Data for the Teen Division (mm)

Placement	1	2	3
Triceps	4.25	4.25	4.50
Subscapular	9.00	9.00	8.50
Midaxillary	4.00	5.25	6.25
Illiac Crest	9.00	10.00	13.00
Chest	3.00	2.75	3.50
Biceps	3.25	3.00	3.25
Abdominal	5.00	7.50	9.50
Supraspinale	4.00	5.00	4.00
Front Thigh	5.25	7.75	13.00
Medial Calf	5.25	6.00	4.00
Sum of skinfolds	52.00	60.50	69.50
Body fat (%)	3.11	4.37	5.50

Table 30 shows the girth measurements for the teen division. The first place competitor had the largest thigh, calf, and ankle sizes while having the smallest knee size. The second place finisher had the smallest sizes of all of them except for his knee, wrist, and ankle size. The third place finisher had the largest chest, biceps, calf, abdominal, and hip sizes but had the smallest wrist and ankle size.

Table 30

Girth Measurements for the Teen Division (cm)

Placement	1	2	3
Chest	107.40	97.05	110.00
Biceps	40.80	37.00	41.35
Forearm	30.90	29.05	32.15
Thigh	62.65	55.65	59.70
Calf	40.40	37.85	38.00
Abdominal	81.45	76.20	84.05
Hips	93.30	91.80	97.75
Knee	36.15	36.80	36.75
Wrist	17.50	17.60	17.10
Ankle	23.05	22.75	21.70

Table 31 shows the PEs for the teen division. The first place competitor had the largest thigh, calf, and ankle sizes and the smallest knee size. The second place finisher had the smallest size in all sites except knee and ankle size. The third place finisher had the largest chest, biceps, forearm, abdominal, hips, knee, and wrist size while having the smallest ankle size.

Table 31

Ponderal Equivalent for Teen Division (kg)

Placement	1	2	3
Chest	93.35	75.15	105.79
Biceps	112.98	91.60	125.37
Forearm	89.99	78.42	105.25
Thigh	89.14	69.32	87.45
Calf	86.85	75.16	83.01
Abdominal	76.31	65.85	87.79
Hips	68.05	64.96	80.70
Knee	66.53	67.98	74.29
Wrist	69.79	69.59	71.99
Ankle	71.57	68.74	68.53

Table 32 shows the percentage of deviation within the PEs for the teen division. The same pattern as Table 31 was seen for the muscular components. The first place competitor had the largest thigh and calf sizes and the third place finisher had the largest chest, biceps, and forearm sizes. In nonmuscular components, the first place finisher had the smallest abdominal, hips, and knee sizes. The second place competitor had the largest hips, knee, wrist, and ankle sizes. The third place finisher had the largest abdominal while having the smallest wrist and ankle sizes.

Table 32

Ponderal Equivalent Percentage Deviation for the Teen Division (%)

Placement	1	2	3
Chest	32.5	11.5	38
Biceps	60.4	35.9	63.5
Forearm	27.7	16.3	37.3
Thigh	26.5	2.8	14.1
Calf	23.3	11.5	8.3
Abdominal	-19.2	-15.5	-13.4
Hips	-28	-16.7	-20.4
Knee	-29.6	-12.8	-26.7
Wrist	-26.1	-10.7	-29
Ankle	-24.2	-11.8	-32.4

DISCUSSION

In the present study, leanness appears to be considered the main factor affecting placement of competitors. Muscularity and proportion were also important factors but having a low sum of skinfolds and leanness seemed to be the first priority in the consideration of competitor placement.

In the submasters class, having a low sum of skinfolds and low body fat percentage was the main factor. Muscularity did not seem very important and a well balanced physique seemed not to be an important factor. The first place contestant had large chest and biceps PEs but his other body parts were neither largest nor smallest. The first place finisher did not have much of a difference between his chest and abdominal size as compared to other competitors which means he had less of a v-taper shape. It would appear that his very low body fat, giving him a ripped look, was the most important factor for the judges.

In the masters class, leanness was not the main factor for placement because the fourth place competitor was leaner than the first place competitor. However, the first place competitor had larger girth measurements than the fourth place competitor. Further, the first place competitor had a smaller waist than the fourth place competitor creating a v-taper look. The first place competitor had a larger chest to abdominal ratio than the fourth place competitor. Therefore, muscularity and proportion played important roles. A competitor with greater muscularity and good proportion with a v-taper and low but not extremely low body fat beat the competitor who was only lean.

In the novice short class, leanness was also an important factor for placement. The winner had the lowest sum of skinfold measurement. None of his body parts were the

biggest or the smallest but he had a balanced development of physique from top to bottom. For example, the fourth place competitor had the biggest PE for most of his body parts but at the same time he had a large abdominal size too. Thus, he did not have a good v-taper and a balanced physique like the first place competitor. Therefore, balance and symmetry with leanness were the most important factors.

In the novice medium class, leanness was again the main factor for placement. First place and second place had similar girth measurements but they had big differences in their sum of skinfolds and body fat percent. The first place competitor had the lowest sum of skinfolds, 37.75 mm. Bodybuilding does not have specific objective guidelines for each body part, so it was difficult to define what size is the best. However, the percentage deviation of the first place competitor's biceps PE was almost twice as big as his chest and forearm PEs. It could be that judges are looking for large biceps to demonstrate good symmetry.

In the novice medium tall class, leanness was not a major factor for placement. The first place competitor was not the leanest competitor. Girth measurements indicated there was not much of a difference between first place and non-placed competitor except abdominal and hip. However, PEs indicated that all the muscular components of the first place competitor were bigger than the non-placed competitor. At the same time, the abdominal PE was smaller for the first place competitor than the non-placed competitor. The first place competitor had a greater v-taper look and greater size with proportionality lead to his placement even though some of the other competitors were leaner.

In the novice tall class, leanness was the main factor for placement. The first place competitor had smaller girth measurements and PEs than the other competitors. The

fourth place competitor had a greater chest to abdominal ratio than the first place competitor. His greater but not much bigger size and better proportionality was not enough to beat the leanness of the first place competitor.

In the novice overall, only first place was decided by the judges. Therefore, the judges' comparisons from second to fourth place were unknown. The first place competitor had a well balanced physique with the largest biceps and hip PEs and he was the leanest competitor in the class. It would seem that leanness was the first priority and some muscle mass on the biceps and chest was the winning combination.

In the teen division, leanness was clearly the main factor for placement. The effect of leanness was seen from first place to third place. The first place and third place competitors had similar girth measurements and PEs and second place was clearly smaller than other two competitors. However, he was leaner than the third place competitor and was placed second. The first place competitor was the leanest competitor and also was more muscular than the second place competitor. The first place competitor had leanness and muscularity whereas the second place competitor had only leanness and the third place competitor had only muscularity.

Besides leanness, it was clear that having a big chest, big biceps, and a small abdominal size were key factors for placement. In this competition, it appeared that the biceps PE must be greater than the chest PE. A similar pattern with large biceps size in comparison with chest size was found in football players by Stuempfle et al. (2009). Thigh size was not as important in this level of competition. None of class winners had a bigger thigh PE percentage deviation than their chest or biceps PE deviation. The novice short class winner actually had a negative percentage deviation that indicated

underdevelopment of the thigh area compared to his nonmuscular components and yet he won his class. The NANBF guidelines (2007) indicate legs should have balanced development on the front and inner thighs and hamstrings. It is unclear how this was determined but the thigh girth of the competitors was surprisingly small.

In the sport of competitive bodybuilding, a low amount of subcutaneous fat is essential. Percent body fat is not important in and of itself. Therefore, skinfolds are likely an excellent tool to help athletes prepare for competitions. It seemed that a body fat around three to four percent was necessary for the competitors to have low subcutaneous fat and have the leanness to win. Kleiner et al. (1990) and Van der Ploeg et al. (2001) found that competitive bodybuilders had body fat percents between three and six percent. Besides skinfolds, the ponderal somatogram can also help athletes and coaches develop specific training programs to improve muscularity and proportionality. The ponderal somatogram is an excellent tool to compare changes over time (Katch et al., 1987).

In addition, there were other factors to consider. At least some muscle mass was necessary and competitors needed to be somewhat equally developed. Competitors tended to have large chest and biceps sizes but not so big thigh size. That seemed to be considered by the judges to be good proportion. It was impossible to measure the amount of back muscle but it was also very important because it helped to create a v-taper shape and increases the chest measurement. Also, competitors must have the skill to present their body at its best. Weak body parts needed to be minimized and well-developed body parts must be shown off. If they did not present their physique well, competitors would likely not place well. It was not in criteria for judging but being able to pose properly is a necessity. It was impossible to define who posed well, but generally those who win a

class also have posed well. Finally, skin color is important to winning. The brightness of stage lights washes out light skin tones so skin color must be as dark as possible. The bright light reduces the ability to see muscle definition of light skin. Good competitors know how to adjust their skin color by using artificial tanning products and brighten the skin by using oil that will reflect light and cause highlights. This combination of skin color and highlights can enhance muscle definition and improve the stage presence of the competitor. Performing the poses correctly and knowing the right skin color must be learned by the competitors prior to the contest. In this study, it was assumed that the competitors had similar skills in presenting their figure and that this was not a factor in their placement.

CONCLUSION

In this study, body composition and body shape differences in natural amateur bodybuilders were measured and compared to determine their relationship to placement in bodybuilding competitions. These results suggest that leanness is the most important factor in placement. The leanest competitor was almost always the class winner. Muscularity was also important for placement. A highly muscular and lean competitor was always chosen the winner. If muscularity was similar between competitors, then the leanest competitor always won. It was clear that a competitor needed to be considerably larger in order to beat a leaner competitor. Also, proportion was important. A large chest and biceps with a small waist was the desired shape. Thigh size was not important in the judges' decisions. Other factors, such as posing skill and skin color were impossible to control within the scope of this study.

In conclusion, leanness was the most important factor in the placing of competitors in natural amateur bodybuilding contests.

There were some limitations in this study. First, it was impossible to obtain data from all competitors which minimized the ability to compare all competitors. In some classes, there were more participants than other classes. Being able to measure all competitors would have given more definitive results. Secondly, these competitions were based on height categories. Some classes may have considerable differences between the competitors in body mass. Obtaining data from competitions that use weight classes may make comparisons easier because competitors within a class will nearly weigh the same so size differences from fat or muscle will be more noticeable.

.

REFERENCES

Behnke, A., Guttentag, O., & Brodsky, C. (1959). Quantification of body weight and configuration from anthropometric measurements. *Human Biology*, *31*, 213-234.

Brozek, J., Grande, F., Anderson, J. T., & Keys, A. (1963). Densitometric analysis of body composition: Revision of some quantitative assumptions. *Annals of the New York Academy of Science*, *110*, 113-140.

Buchholz, A. C., Bartok, C., & Schoeller, D. A. (2004). The validity of bioelectrical impedance models in clinical populations. *Nutrition in Clinical Practice*, *19*(5), 433-446.

Cameron, N. (1978). The methods of anxological anthropometry. In F. Falkner, & J. M. Tanner (Eds.), *Human growth. 2 Postnatal growth* (pp. 35-90). New York, NY: Plenum Press.

Da Silva, P. R. P., Trindade, R. D. S., & De Rose, E. H. (2003). Body composition, somatotype and proorcionality of elite bodybuilders in Brazil. *Revista Brasileira de Medicina do Esporte*, *9*(6), 408-412.

Durnin, J. V. G. A., & Taylor, A. (1960). Reproducibility of measurements of density of the human body as determined by underwater weighing. *Journal of Applied Physiology*, *15*, 142-144.

Durnin, J. V. G. A., & Womersley, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness measurement on 481 men and women aged 16 to 72 years. *British Journal of Nutrition*, *32*, 77-97.

Forbes, G. B., & Lewis, A. M. (1956). Total sodium, potassium and chloride in adult man. *Journal of Clinical Investigation*, *35*, 596-600.

Fridanza, F., Keys, A., & Anderson, J. T. (1953). Density of body fat in man and other mammals. *Journal of Applied Physiology*, *6*, 252-256.

Fuller, J. J., Jebb, S. A., Laskey, M. A., Coward, W. A., & Elia, M. A. (1992). A four component model for the assessment of body composition of elderly subjects: a comparison of methods. *Clinical Science*, *82*, 687-693.

Gaines, R. P. (2001). Comparison of anthropometric measures of competitive bodybuilders to judges' scores and a comparison of judges' scores (Doctoral dissertation, Virginia Polytechnic Institute and State University, 2001). Blacksburg: Virginia Polytechnic Institute and State University.

Jackson, A. S., & Pollock, M. L. (1977). Prediction accuracy of body density, lean body weight, and total body volume equations. *Medicine and Science in Sports and Exercise*, *4*, 197-201.

Jackson, A. S., & Pollock, M. L. (1978). Generalized equations for predicting body density of men. *British Journal of Nutrition*, *40*, 497-504.

Jackson, A. S., Pollock, M. L., Graves, J. E., & Mahar, M. T. (1988). Reliability and validity of bioelectrical impedance in determining body composition. *Journal of Applied Physiology*, *64*, 529-534.

Jebb, S. A., Murgatroyd, P. R., Coward, W. A., Goldberg, G. R., & Prentice, A. M. (1993). In vivo measurement of changes in body composition. *American Journal of Clinical Nutrition*, *58*, 455-462.

Katch, F. I., Behnke, A. R., & Katch, V. L. (1987). The ponderal somatogram: evaluation of body size and shape from anthropometric girths and stature. *Human Biology*, *59*(3), 439-458.

Katch, F. I., & McArdle, W. D. (1973). Prediction of body density from simple

anthropometric measurements in college-age men and women. *Human Biology*, *45*, 445-454.

Kleiner, S. M., Bazzarre, T. L., & Litchford, M. D. (1990). Metabolic profiles, diet, and health practices of championship male and female bodybuilders. *Journal of American Dietetic Association*, *90*(7), 962-967.

Kramer, H. J., & Ulmer, H. V. (1981). Two seconds standardization of the Harpenden caliper. *European Journal of Applied Physiology*, *46*, 103-104.

Linder, F. (2007). Life as art, and seeing the promise of big bodies. *American Ethnologist*, *34*(3), 451-472.

Lohman, T. G. (1981). Skinfolds and body density and their relation to body fatness: a review. *Human Biology*, *53*, 181-225.

Lukaski, H. C. (1987). Methods for the assessment of human body composition: traditional and new. *American Journal of Clinical Nutrition*, *46*, 537-556.

Lukaski, H. C., Johnson, P. E., Bolonchuk, W. W., & Lykken, G. I. (1985). Assessment of fat-free mass using bioelectrical impedance measurements of the human body. *American Journal of Clinical Nutrition*, *41*, 810-817.

Maughan, R. J. (1993). An evaluation of a bioelectrical impedance analyzer for the estimation of body fat content. *British Journal of Sports Medicine*, *27*(1), 63-66.

Mitchell, H. H., Hamilton, T. S., Steggerda, F. R., & Bean, H. W. (1945). The chemical composition of the adult human body and its bearing on the biochemistry of growth. *Journal of Biological Chemistry*, *158*, 625-637.

North American Natural Bodybuilding Federation. (2007). *Bodybuilding information*. Retrieved July 6, 2009 from www.nanabf.org.

Norton, K., & Olds, T. (Eds.). (1996). *Anthropometrica*. Sydney: University of New South Sales Press Ltd.

Pollock, M. L., Schmidt, D. H., & Jackson, A. S. (1980). Measurement of cardiorespiratory fitness and body composition. *Comprehensive Therapy*, *6*, 12-27.

Reilly, J. J., Murray, L. A., Wilson, J., & Durnin, J. V. G. A. (1994). Measuring the body composition of elderly subjects: a comparison of methods. *British Journal of Nutrition*, *72*, 33-44.

Sandoval, W. M., Heyward, V. H., & Lyons, T. M. (1989). Comparison of body composition, exercise and nutritional profiles of female and male body builders at competition. *Journal of Medicine and Physical Fitness*, *29*(1), 1989.

Saunders, M. J., Blevins, J. E., & Broeder, C. E. (1998). Effects of hydration changes on bioelectrical impedance in endurance trained individuals. *Medicine and Science in Sports and Exercise, 30 (6),* 885-892.

Schols, A. M., Wouters, E. F., Soeters, P. B., Westerterp, K. R. (1991). Body composition by bioelectrical-impedance analysis compared with deuterium dilusion and skinfold anthropometry in patients with chronic obstructive pulmonary disease. *The American Journal of Clinical Nutrition*, *53*(2), 421-424

Shohl, A. T. (1939). *Mineral metabolism*. New York, NY: Reinhold Publishing Corporation.

Sinning, W. E., & Moore, C. (1989). A validation of the ponderal somatogram for evaluating muscularity. *Medicine & Science in Sports & Exercise*, *21*(2), 101.

Siri, W. E. (1961). Body volume measurement by gas dilution. In J. Brozek, & A.

Henschel, (Eds.), *Techniques for measuring body composition* (pp. 108-117). Washington, DC: National Academy of Sciences, National Research Council.

Stuempfle, K. J., Drury, D. G., Petrie, D. F., & Katch, F. I. (2007). Ponderal somatograms assess changes in anthropometric measurements over an academic year in division III collegiate football players. *Journal of Strength and Conditioning Research*, *21*(3), 689-696.

Stuempfle, K. J., Drury, D. G., Petrie, D. F., & Katch, F. I. (2009). Ponderal somatogram analysis of girth measurements by position in division III college football players. *Journal of Strength and Conditioning Research*, *23*(3), 788-799.

Van der Ploeg, G. E., Brooks, A. G., Withers, R. T., Dollman, J., Leaney, F., & Chatterton, B. E. (2001). Body composition changes in female bodybuilders during preparation for competition. *European Journal of Clinical Nutrition*, *55*, 268-277.

Vazques, J. A., & Janosky, J. E. (1991). Validity of bioelectrical-impedance analysis in measuring changes in lean body mass during weight reduction. *American Journal of Clinical Nutrition*, *54*, 970-975.

Widdowson, E. M., McCance, R. A., & Spray, C. M. (1951). The chemical composition of the human body. *Clinical Science*, *10*, 113-125.

Withers, R. T. (1983). The measurement of relative body fat: assumptions, limitations and measurement error. *Transactions of the Menzies Foundation*, *5*, 83-89.

VITA

Graduate School
Southern Illinois University Carbondale

Shinji Ogita

Home address : 2301 S. Illinois Ave. Lot # 147 Carbondale, IL 62903

Permanent address : 3-79 Imai Nagaoka, Niigata, Japan 940-1166

shinjiogita@gmail.com

Southern Illinois University Carbondale
Bachelor of Science, Dietetics, May 2005

Research Paper Title:
The Effects of Body Composition Differences on Placement at Bodybuilding Competition Among Male Amateur Bodybuilders

Major Professor: M. Daniel Becque, Ph. D.