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Ponderal Somatograms Assess Changes in Anthropometric Measurements Over an Academic Year in Division III Collegiate Football Players

Abstract
Ponderal somatograms evaluate body size and shape by converting muscular (shoulders, chest, biceps, forearm, thigh, calf) and nonmuscular (abdomen, hips, knee, ankle, wrist) girths into ponderal equivalent (PE) values. Anthropometric measurements, including stature, body mass, girths, and percent body fat by densitometry were collected in 54 Division III football players in preseason camp (fall) and at the beginning (winter) and end (spring) of the team strength and conditioning program. PE values were calculated for each girth as PE, kg = (girth, cm / k) squared x stature, dm, where k = k constant from Behnke’s reference man. PE values were compared to body mass to indicate overdevelopment (PE is greater than body mass) and underdevelopment (PE is less than body mass) at specific girth sites. From fall to winter, body mass (+1.6 kg), percent fat (+1.3%), fat mass (+1.6 kg), nonmuscular abdominal and hip girths (+2.1 cm, +1.5 cm), and PE values (+5.3 kg, +2.6 kg) increased significantly (p is less than 0.05). From winter to spring, percent fat (-1.5%), fat mass (-1.4 kg), nonmuscular abdominal girth (-1.0 cm), and PE value (-2.5 kg) decreased significantly (p is less than 0.05) from winter to spring. Fat-free mass (+1.5 kg), muscular biceps girth (+0.4 cm), and PE value (+2.6 kg) increased significantly (p is less than 0.05) from winter to spring. Ponderal somatograms muscular components were generally overdeveloped, with the greatest overdevelopment at the biceps in the fall (+14.7 kg), winter (+14.9 kg), and spring (+17.4 kg). Nonmuscular components generally were underdeveloped, except abdomen and hips that were overdeveloped. The abdomen remained the greatest nonmuscular overdevelopment in fall (+6.8 kg), winter (+10.5 kg), and spring (+7.9 kg). Ponderal somatograms provide a relatively simple, practical method to track specific changes in body size and shape over time.

Keywords
body composition, anthropometry, body profile

Disciplines
Other Medicine and Health Sciences | Sports Sciences

Authors
Kristin J. Stuempfle, Daniel G. Drury, David F. Petrie, and Frank I. Katch

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PONDERAL SOMATOGRAMS ASSESS CHANGES IN ANTHROPOMETRIC MEASUREMENTS OVER AN ACADEMIC YEAR IN DIVISION III COLLEGIATE FOOTBALL PLAYERS

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ABSTRACT. Stuempfle, K.J., D.G. Drury, D.F. Petrie, and F.I. Katch. Ponderal somatograms assess changes in anthropometric measurements over an academic year in Division III collegiate football players. J. Strength Cond. Res. 21(3):689–696. 2007.—Ponderal somatograms evaluate body size and shape by converting muscular (shoulders, chest, biceps, forearm, thigh, calf) and nonmuscular (abdomen, hips, knee, ankle, wrist) girths into ponderal equivalent (PE) values. Anthropometric measurements, including stature, body mass, girths, and percent body fat by densitometry were collected in 54 Division III football players in preseason camp (fall) and at the beginning (winter) and end (spring) of the team strength and conditioning program. PE values were calculated for each girth as PE, kg = (girth, cm + k×k) × stature, dm, where k = k constant from Behnke’s reference man. PE values were compared to body mass to indicate overdevelopment (PE > body mass) and underdevelopment (PE < body mass) at specific girth sites. From fall to winter, body mass (+1.6 kg), percent fat (+1.3%), fat mass (+1.6 kg), nonmuscular abdominal and hip girths (+2.1 cm, +1.5 cm), and PE values (+6.3 kg, +2.6 kg) increased significantly (p < 0.05). From winter to spring, percent fat (−1.5%), fat mass (−1.4 kg), nonmuscular abdominal girth (−1.0 cm), and PE value (−2.5 kg) decreased significantly (p < 0.05). Fat-free mass (+1.5 kg), muscular biceps girth (+0.4 cm), and PE value (+2.6 kg) increased significantly (p < 0.05) from winter to spring. Ponderal somatogram muscular components were generally overdeveloped, with the greatest overdevelopment at the biceps in fall (+14.7 kg), winter (+14.9 kg), and spring (+17.4 kg). Nonmuscular components generally were underdeveloped, except abdomen and hips that were overdeveloped. The abdomen remained the greatest nonmuscular overdevelopment in fall (+6.8 kg), winter (+10.5 kg), and spring (+7.9 kg). Ponderal somatograms provide a relatively simple, practical method to track specific changes in body size and shape over time.

KEY WORDS. body profile, body composition, anthropometry

INTRODUCTION

A great deal of time and effort is typically devoted to development and implementation of strength and conditioning programs for football players. These programs are designed to improve factors believed important for success on the football field, including strength, power, speed, agility, flexibility, and body composition (8, 9, 21). Testing can quantify individual and team physical progress in these components (8, 9).

Body composition assessment in football players typically includes hydrostatic weighing, skinfold and girth assessment, and bioelectrical impedance (11, 28). Hydrostatic weighing serves as the criterion method for determining body composition (26), but the procedure is time consuming and requires specialized laboratory equipment and expertise. In contrast, girth measurements are relatively simple to obtain, and can be useful for producing a ponderal somatogram or body profile. The ponderal somatogram was devised by Katch et al. (16) as an extension of the original Behnke somatogram (2). In the ponderal somatogram, girth measurements are differentiated into muscular (shoulders, chest, biceps, forearm, thigh, calf) and nonmuscular (abdomen, hips, knee, ankle, wrist) components. Individual girth measurements are converted into ponderal (or mass) equivalent values expressed in kg. This allows comparison of individual girths as ponderal equivalent (PE) values to body mass. PE values provide an appraisal of overdevelopment (PE > body mass) and underdevelopment (PE < body mass) for specific girth measurement regions. The ponderal somatogram also produces a visual appraisal of body size and shape when PE values are expressed as percent deviations from the reference man. In the reference man, all of the girth measurements plot as a vertical line. Deviation of a girth measurement from the vertical line indicates overdevelopment (positive deviation) or underdevelopment (negative deviation) at that location for a person (or group). A report by Sinning and Moore (27) provided evidence for the validity of the ponderal somatogram.

In the present study, ponderal somatograms evaluated changes in body size and shape in Division III football players over the course of an academic year. Anthropometric characteristics were assessed in the fall at the start of preseason camp (August), in winter at the start of the mandatory team strength and conditioning program (January), and in spring at the conclusion of the mandatory team strength and conditioning program (May). The muscular and nonmuscular PE values were compared to body mass at each of the 3 testing times. Additionally, the muscular and nonmuscular PE values were graphically represented as percent deviations from the reference man at each of the 3 testing times.

METHODS

Experimental Approach to the Problem

A repeated-measures experimental design tracked the anthropometric changes in Division III football players during an academic year. Anthropometric measurements including stature, body mass, girths, and percent body fat by densitometry were collected in the fall (August), win-
ter (January), and spring (May). Anthropometric measurements were used to construct postural somatograms that evaluate body size and shape by comparing musculoskeletal (shoulders, chest, hips, forearm, thigh, calf) and non-muscular (abdomen, hips, knee, wrist, ankle) girths into PE values. PE values were compared to body mass to indicate overdevelopment (PE > body mass) and underdevelopment (PE < body mass) at specific girth sites. PE values also were expressed as percent deviations from the reference man to provide a visual appraisal of body shape and size. In the reference man, all of the girth measurements plot as a vertical line. Deviation of a girth measurement from the vertical line indicates an overdevelopment (positive deviation) or underdevelopment (negative deviation) at that location for a person (or group).

Subjects

Anthropometric characteristics were assessed in 54 Division III football players from Gettysburg College, Gettysburg, PA, a National Collegiate Athletic Association (NCAA) Division III school with a 125-year history of competition in football at this level. Subjects were tested during the 2002-2003 academic year. The team was not ranked in NCAA Division III during the 2002 season. The school's Institutional Review Board approved the study. Subjects were informed of the purpose and nature of the study and provided informed consent.

Procedures

Subjects were tested in the fall (August) during preseason camp, in the winter (January) at the beginning of the mandatory team strength and conditioning program, and in the spring (May) at the end of the mandatory strength and conditioning program.

All subjects participated in the 13-week, 4 days weekly mandatory team strength and conditioning program from January through April. The program included upper extremity, lower extremity, and core weight training exercises, upper and lower body plyometrics, agility drills, and flexibility exercises (see Tables 1 and 2).

Measurements. Anthropometric measurements included stature, body mass, selected girths, vital capacity, and body mass in water. Data on an individual were recorded on the same day. Height was measured using a stadiometer to ± 0.1 cm, and body mass was measured on a balance beam scale to ± 0.05 kg. Girth measurements were taken by the same investigator throughout the study using a calibrated cloth tape to ± 0.1 cm. The 13 measurement sites included 6 muscular sites and 6 non-muscular sites. Bilateral paired measurements were made for the extremities, and an average of the paired scores served as the criterion score for those sites. The abdomen 1 and abdomen 2 measurements were averaged to produce an abdominal average criterion score. The anatomic landmarks for the muscular and nonmuscular girth sites were (12):

Anatomical landmarks for muscular component:

- Shoulders: laterally at the maximum projection of the deltoid muscles, and anteriorly at the prominence of the sternum at the junction of the second rib
- Chest: nipple line at midlateral volume of respiration
- Hips: femoral girth with ilium fixed to 90°
- Forearm: maximal girth with elbow extended and hand supinated
- Thigh: maximal girth
- Calf: maximal girth

Anatomical landmarks for nonmuscular component:

- Abdomen 1 (waist): laterally midway between the lowest rib and the iliac crest, and anteriorly midway between the midaxillary line and umbilicus
- Abdomen 2 (umbilicus): laterally at the level of the iliac crest, and anteriorly at the umbilicus
- Hips posteriorly at the maximal projection of the gluteal muscles, and anteriorly at the level of the symphysis pubis
- Knees: midpatellar level, with the knee slightly flexed
- Weight transferred to the opposite leg
- Wrist: maximal girth just distal to the styloid process of the radius and ulna with the hand supinated
- Ankle: maximal girth, superior to malleolus

Prior to hydrostatic weighing, 3 trials of seated vital capacity (ambient temperature and pressure, saturated with water vapor [ATPS]) were determined according to manufacturer's directions using a Microfuge metabolic cart. Residual lung volume was estimated from vital capacity (body temperature and pressure, saturated with water vapor [BTPS]) (residual lung volume = vital capacity × 0.20 according to Wilmore's data [33]) that showed close agreement between body composition measurements using measured vs. estimated residual lung volumes. Body mass in water was assessed by hydrostatic weighing in the seated position (n = 91). Body mass in water (kg) was multiplied by 1.024 to obtain body mass in air (kg). Body mass index (BMI) = body mass (kg) / height (m)².

Table 1. Strength and conditioning program.

<table>
<thead>
<tr>
<th>Week</th>
<th>Maximal load (kg)</th>
<th>Reps</th>
<th>Sets</th>
<th>Maximal load (kg)</th>
<th>Reps</th>
<th>Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>10</td>
<td>3</td>
<td>120</td>
<td>10</td>
<td>3</td>
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<td>2</td>
<td>120</td>
<td>10</td>
<td>3</td>
<td>140</td>
<td>10</td>
<td>3</td>
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<tr>
<td>3</td>
<td>140</td>
<td>10</td>
<td>3</td>
<td>160</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>

Ponderal Somatograms. The ponderal somatogram was used to describe the body profile (14). Ponderal (abdomen 1, abdomen 2, hips, knees, wrist, ankle) girth measurements were converted into ponderal (or mass) equivalent values expressed in kg. This allowed comparison of the muscular component (body mass, PE values) and of the non-muscular component (PE < body mass) for each of the muscular and nonmuscular girth measurement sites. For each girth measurement, the PE was calculated as follows (14):

\[ \text{PE} = \text{girth} - \text{cm} \times K \times \text{stature} \]

where K is a constant from the reference man (see Table 3).

For example, if PE = -94 kg for abdomen, this means the person (or group) has an abdominal girth of a person (or group) weight 80 kg, the person (or group) is overdeveloped in this region by 14 kg.

Ponderal somatograms produced a visual appraisal of body size and shape by expressing PE values as percent deviations from the reference man. In the reference man, all of the girth measurements plot as a vertical line. The percent deviation from the reference man for each girth measurement was calculated as described below (16):
ter (January), and spring (May). Anthropometric measurements were used to construct pedometer somagrams that evaluate body size and shape by comparing muscular (shoulders, chest, hips, forearm, thigh, calf) and non-muscular (abdomen, hips, knees, waist, ankle) girths to PE values. PE values were compared to body mass to indicate overdevelopment (PE > body mass) and underdevelopment (PE < body mass) at specific girth sites. PE values also were expressed as percent deviations from the reference man to provide a visual appraisal of body shape and size. In the reference man, all of the girth measurements plot as a vertical line. Deviation of a girth measurement from the vertical line indicates an overdevelopment (positive deviation) or underdevelopment (negative deviation) at that location for a person (or group).

**Subjects**

Anthropometric characteristics were assessed in 54 Division III football players from Gettysburg College, Gettysburg, PA, a National Collegiate Athletic Association (NCAA) Division III school with a 12-year history of competition in football at this level. Subjects were tested during the 2002-2003 academic year. The team was not ranked in NCAA Division III during the 2002 season. The school's Institutional Review Board approved the study. Subjects were fully informed of the purpose and nature of the study and provided informed consent.

**Procedures**

Subjects were tested in the fall (August) during pre-season camp, in the winter (January) at the beginning of the mandatory team strength and conditioning program, and in the spring (May) at the end of the mandatory strength and conditioning program.

All subjects participated in the 12-week, 4 days weekly mandatory team strength and conditioning program from January through April. The program included upper extremity, lower extremity, and core weight training exercises, upper and lower body plyometrics, agility drills, and flexibility exercises (see Tables 1 and 2).

**Measurements** Anthropometric measurements included stature, body mass, selected girths, vital capacity, and body mass in water. Data on an individual were collected in the same manner. Height was measured using a stadiometer to 0.1 cm, and body mass was measured on a balance beam scale to ± 0.25 lb. Girth measurements were taken by the same investigator throughout the study. Girth measurements were converted to girth tape to ± 0.1 cm. The 13 measurement sites included 6 muscular sites and 6 nonmuscular sites. Bilateral paired measurements were made for the extremities, and an average of the paired scores was offered as the criterion score for those sites. The abdomen 1 and abdomen 2 measurements were averaged to produce an abdominal average criterion score. The abdominal landmarks for the muscular and nonmuscular girth sites were (12):

**Anatomical landmarks for nonmuscular component:**

- **Abdomen 1 (waist):** laterally midway between the lowest rib and the iliac crest, and anteriorly midway between the inguinal crease and umbilicus.
- **Abdomen 2 (umbilicus):** laterally at the level of the iliac crest, and anteriorly at the umbilicus.
- **Hips:** posteriorly at the maximal protrusion of the gluteal muscles, and anteriorly at the level of the symphysis pubis.
- **Knee:** midpatellar level, with the knee slightly flexed and weight transferred to the opposite leg.
- **Wrist:** maximal girth just distal to the styloid process of the radius and ulna with the hand supinated.
- **Ankle:** maximal girth, superior to malleoli.

Prior to hydrostatic weighing, 3 trials of seated vital capacity (ambient temperature and pressure, saturated with water vapor (ATPS)) were determined according to manufacturer's directions using a Medgraphics metabolic cart. Residual lung volume was estimated from vital capacity (body temperature and pressures saturated with water vapor (BTPS)) (residual lung volume = vital capacity ∗ 0.20) according to Wilmore's data (31) that showed close agreement between body composition measurements using measured vs. estimated residual lung volume. Body mass in water was assessed by hydrostatic weighing in the seated position (n = 91 = 94.3 ± 22.8 kg an aluminum tank. Subjects performed 10 successive underwater weighing trials, with approximately a 1-minute rest interval among trials following procedures described previously (15). Ten repeated weighings using an average of the last 5 trials) produced a true underwater weight score (14). For white players, percent fat was calculated with the Siri equation (25), where % fat = (4.95 ∗ density) + 468 for light skin, and (24.9 ∗ density) - 818 for dark skin. Percent fat was calculated with the Siri equation (25).

**Pedometer Somograms** The pedometer somogram was used to describe the body profile (14). Muscular (abdominal, arm, thigh, calf), and nonmuscular (abdomen 1, abdomen 2, hips, knees, waist, ankle) girth measurements were converted to pedometer (or mass) equivalent values expressed in kg. This allowed comparisons of body mass and PE values provided an indication of overdevelopment (PE > body mass) or underdevelopment (PE < body mass) for each of the muscular and nonmuscular girth measurements. Percent deviation from the reference man for each girth measurement was calculated as follows (14):

\[
PE = \left( \frac{girth_{	ext{subject}} - girth_{	ext{reference}}}{girth_{	ext{reference}}} \right) \times 100
\]

where PE is the percent deviation from the reference man (see Table 3).

For example, if PE = 94 kg for abdomen, this means the person (or group) has an abdominal girth of 94 kg (or group weight 94 kg). If the person (or group) weight 80 kg, the person (or group) is overdeveloped in this region by 14 kg.

**Pedometer somagrams** produced a visual appraisal of body size and shape by expressing PE values as percent deviations from the reference man. In the reference man, all of the girth measurements plot as a vertical line. The percent deviation from the reference man for each girth measurement was calculated as described below (16):
TABLE 3. Physiostatistics program, agility drills, and flexibility exercises.

<table>
<thead>
<tr>
<th>Dynamic work program</th>
<th>Agility drills</th>
<th>Flexibility exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball push-ups</td>
<td>1 step push-ups over bags</td>
<td>Calisthenics stretch</td>
</tr>
<tr>
<td>Dead lifts</td>
<td>2 step push-ups over bags</td>
<td>Hip flexor stretch</td>
</tr>
<tr>
<td>Box jumps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push-up (nOGQ)</td>
<td>Shoulder stretch</td>
<td></td>
</tr>
<tr>
<td>Jump high</td>
<td>Back pedal and sprint</td>
<td></td>
</tr>
<tr>
<td>Squat jumps</td>
<td>Jump rope risotto</td>
<td></td>
</tr>
<tr>
<td>Sprint</td>
<td>Square drills</td>
<td></td>
</tr>
<tr>
<td>Squat jump</td>
<td>Quick stretch</td>
<td></td>
</tr>
</tbody>
</table>

Muscular component girths:

- **% Deviation**
  - (PE girth - average PE nonmuscular components) / average PE nonmuscular components * 100

Nonmuscular component girths:

- **% Deviation**
  - (PF girth - average PE muscular components) / average PE muscular components * 100

Statistical Analyses:

One-way analysis of variance with repeated measures examined changes in anthropometric characteristics throughout the year. When statistically significant main effect results were obtained, Tukey-Kramer’s post hoc test assessed where the differences occurred. Statistical significance was established at p < 0.05.

RESULTS:

Table 4 presents the changes in body composition for the fall, winter, and spring tests, while Table 5 displays the percentage change in girth measurements and percentage change in girth measurements. From fall to winter, a significant increase occurred in body mass (1.2%), percent fat (1.3%), and fat mass (2.0%). These body composition changes were matched by significant increases in the nonmuscular abdominal (2.3 cm) and hips (1.1 cm) girths. The abdominal and hips percentage equivalents also increased significantly during this time interval (+6.5% and +2.6%, respectively).

From winter to spring, percent fat (+1.8%) and fat mass (+1.4%) decreased significantly. This was accompanied by a significant decrease in the nonmuscular abdominal girth (-1.0 cm) and PE value (-3.5%). Fat-free mass increased significantly from winter to spring (+1.5 kg), matched by a significant increase in the muscular girths (hip +0.4 cm) and biceps tendon equivalent (+0.9 kg).

The percent nonmuscular component girths were generally overdeveloped (PE > body mass) in the football players in this study. The greater overdevelopment occurred in the biceps. In the fall, the biceps percent equivalent (207.9 kg) was 14.7 kg greater than body mass (90.9 kg). The discrepancy was similar in the winter (+14.9 kg), but increased in the spring to 17.4 kg. The nonmuscular component remained generally underdeveloped (PE < body mass), with the notable exceptions of the abdomen and hips at all 3 testing times. Of the nonmuscular components, the greatest overdevelopment occurred in the abdomen. In the fall, the abdomen percent equivalent (90.9 kg) was 6.8 kg greater than body mass (90.9 kg). This discrepancy increased to 10.6 kg in the winter and decreased to 7.9 kg in the spring.

DISCUSSION:

The construction of a ponderal somatogram or body profile is a practical application of the relative representation of the body's mass girth measurements. The ponderal somatogram (18) differs from the original Bekke somatogram (18) by separating the girth measurements into muscular and nonmuscular components, and by converting girth measurements into muscular and nonmuscular equivalents to allow comparison to body mass to indicate overdeveloped or underdeveloped at each girth location.

The ponderal somatogram (or Bekke somatogram) quantifies the relative proportions of the body's girth dimensions, and charts changes in these physical dimensions as a function of time from such factors as training, dietary intervention, or influences of aging (18, 18). For example, changes in Dr. Bekke's body profile over a span of 26 years have been published (17), and the ponderal somatogram can document changes during or after withdrawal from starvation, bed rest, disability, injury, or weightlessness (17). The ponderal or Bekke somatogram also can compare individuals or groups with the reference man, or reference woman, and permit quantification of differences in physique between individuals or groups (16, 16). For example, Bekke somatograms have compared women with amenorrhea (6, 6), and adolescent and prepubertal body forms to the reference woman (7, 7), with Hispanic women (52, 52), and somatographic differences between obese and nonobese adolescents (19).

In the present study, ponderal somatograms tracked changes that occurred in the body profile of Division I football players over the course of an academic year. Numerous studies have been published describing body composition and measurements of the position and performance test data for American football players at the professional (20, 20), Division I (20, 20), Division II (5, 5), Division III (5, 5), and Division IV (5, 5) levels. Yet few studies have reported body composition data for football players at different time points throughout the year. Gettas et al. reported that body composition, cardiopulmonary fitness, leg power, and agility of American professional football players improved following a 14-week preseason training program. Thompson (20) reported that fat mass decreased and fat-free mass increased during the season in Division I football players, and Huffman and Kung (22) revealed that strength improved in Division III football players during the season when players adhered to a 2-day per week in-season resistance training program. Miller et al. (21) reported that performance in the power clean, bench press, and squat increased over time in Division I football players participating in the team's strength and conditioning program. The present study documents longitudinal changes in the body composition of Division I football players, but perhaps most importantly, provides an example of the usefulness of ponderal somatograms to track changes in physical dimensions over a 3-month interval.

As documented in Tables 4 and 5, significant increases occurred in body mass, percent fat, and fat mass from the fall to winter testing. These body composition changes were accompanied by significant increases in the nonmuscular abdominal and hip girths and ponderal equivalent values. We acknowledge that these changes may have occurred gradually from the August to January testing. It is certainly more probable that these body composition changes primarily occurred between the end of the football season in mid-November and the start of January's mandatory team strength and conditioning program. During this time, players were not required to participate in a formal strength and conditioning program. Table 5 also revealed that percent fat and fat mass decreased significantly, accompanied by a significant decrease in the nonmuscular abdominal girth and PE value. During this interval, fat-free mass increased significantly, matched by a significant increase in the muscular girths and ponderal equivalent value. The results suggest that the mandatory team strength and conditioning program positively impacted fat-free mass development. These findings agree with Gettas et al., who reported that body composition in professional football players improved significantly following a 14-week preseason strength and conditioning program (15).

One particularly useful feature of the ponderal somatogram approach is the conversion of muscular and nonmuscular girth measurements into ponderal equivalent values to allow comparisons of individual girth measurements to body mass. This provides an indication of whether an individual muscular or nonmuscular component is either overdeveloped (PE > body mass) or underdeveloped (PE < body mass) in comparison to the muscular ponderal equivalent values in Table 5 to body mass values in Table 4 indicates that, in general, the muscular components of the ponderal somatogram were underdeveloped PE < body mass) in comparison to the muscular ponderal equivalent values in Table 5 to body mass values in Table 4 indicates that, in general, the muscular components of the ponderal somatogram were underdeveloped PE < body mass) in comparison to the muscular ponderal equivalent values in Table 5 to body mass values in Table 4 indicates that, in general, the muscular components of the ponderal somatogram were underdeveloped PE < body mass) in comparison to the muscular ponderal equivalent values in Table 5 to body mass values in Table 4 indicates that, in general, the muscular components of the ponderal somatogram were underdeveloped PE < body mass) in comparison to the muscular ponderal equivalent values in Table 5 to body mass values in Table 4 indicates that, in general, the muscular components of the ponderal somatogram were underdeveloped PE < body mass) in comparison to the muscular ponderal equivalent values in Table 5 to body mass values in Table 4 indicates that, in general, the muscular components of the ponderal somatogram were underdeveloped PE < body mass) in comparison to the muscular ponderal equivalent values in Table 5 to body mass values in Table 4 indicates that, in general, the muscular components of the ponderal somatogram were underdeveloped PE < body mass).
Pendulum Somatometry of Football Players

### Table 3. Physical fitness measures, agility drills, and flexibility exercises.

<table>
<thead>
<tr>
<th>Physical fitness measures</th>
<th>Agility drills</th>
<th>Flexibility exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball push-ups</td>
<td>15 sec</td>
<td>Hip flexing stretch</td>
</tr>
<tr>
<td>Push-ups</td>
<td>20 sec</td>
<td>Hip flexing stretch</td>
</tr>
<tr>
<td>Jump-height</td>
<td>30 sec</td>
<td>Hip flexing stretch</td>
</tr>
<tr>
<td>Pull-up (on bar)</td>
<td>15 sec</td>
<td>Arm pull</td>
</tr>
<tr>
<td>Bench press</td>
<td>30 sec</td>
<td>Squat drill</td>
</tr>
<tr>
<td>Sprint drill</td>
<td>10 sec</td>
<td>Quick cardio</td>
</tr>
</tbody>
</table>

### Table 4. Fitness levels: body mass, body fat, and percent body fat for the fall, winter, and spring: values expressed as mean ± SD.

<table>
<thead>
<tr>
<th>Season</th>
<th>Body Mass (kg)</th>
<th>Body Fat (%)</th>
<th>Percent Body Fat (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>100.6 ± 4.5</td>
<td>15.2 ± 2.1</td>
<td>15.2 ± 2.1</td>
</tr>
<tr>
<td>Winter</td>
<td>102.3 ± 4.8</td>
<td>15.5 ± 2.3</td>
<td>15.5 ± 2.3</td>
</tr>
<tr>
<td>Spring</td>
<td>98.9 ± 4.2</td>
<td>14.8 ± 2.0</td>
<td>14.8 ± 2.0</td>
</tr>
</tbody>
</table>

This suggests an increase of mass and fat during the cold season, possibly due to changes in dietary intake or increased activity levels.
Figure 1. Ponderal somatogram for fall testing. (Note: The center line denotes the reference man.)

Figure 2. Ponderal somatogram for winter testing. (Note: The center line denotes the reference man.)

PRACTICAL APPLICATIONS

The ponderal somatogram offers a simple, practical anthropometric method to track specific changes in body size and shape over a defined time period. Girth measurements are a reliable alternative to other anthropometric techniques (e.g., skinfolds) to evaluate changes in the body profile. The ponderal somatogram is unique because it partitions the body into muscular and nonmuscular components. Ponderal equivalent values provide an indication of overdevelopment (ponderal equivalent > body mass) and underdevelopment (ponderal equivalent < body mass) at specific girth measurement locations.

The ponderal somatogram produces a visual appraisal of body size and shape when ponderal equivalent values are expressed as percent deviations from the reference standard.

The technique for measuring body composition in American football players (and other individuals) has been established. The practical application of this information is less well developed. Indeed, it is too common for a plethora of body composition measurements to be taken, only to be lost as meaningless data in the file cabinets of strength and conditioning coaches, athletic trainers, and other athletic and allied-health care professionals. With minimal effort, it is possible to translate girth measurements into ponderal somatograms. Plotting ponderal equivalent values as percent deviations from the reference man provides a simple and powerful visual representation of an individual's or a group's body composition status. Tracking changes in individual and group ponderal somatograms over time can provide motivation for players to adhere to strength and conditioning programs and help coaches assess the effectiveness of these programs. Ponderal somatograms (especially the nonmuscular abdomen, abdomen, and hip components) also can graphically monitor the "silhouette" status of individuals, of which course has important health implications.

REFERENCES


TABLE 1. Girth measurements and percent deviation values for the fall, winter, and spring testing, values expressed as percent of body mass. Values in parentheses represent the percent range of each girth measurement.

<table>
<thead>
<tr>
<th>Muscular Component</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
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<tr>
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</tr>
<tr>
<td>Wrist</td>
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</table>

PRACTICAL APPLICATIONS

The ponderal somatogram offers a simple, practical anthropometric method to track specific changes in body size and shape over a defined time period. Girth measurements are a reliable alternative to other anthropometric techniques (e.g., skinfolds) to evaluate changes in the body profile. The ponderal somatogram is unique because it partitions the body into muscular and nonmuscular components. Ponderal equivalent values provide an indication of overdevelopment (ponderal equivalent = body mass) and underdevelopment (ponderal equivalent > body mass) at specific girth measurement locations. The ponderal somatogram produces a visual appraisal of body size and shape when ponderal equivalent values are expressed as percent deviations from the reference standard.

The technique for measuring body composition in American football players (and other individuals) is well-established, yet the practical application of this information is less well developed. Indeed, it is too common for a player's body composition measurements to be taken, only to be lost as meaningless data in the file cabinet of a strength and conditioning coach, trainer, or athletic assistant. With minimal effort, it is possible to translate girth measurements into ponderal somatograms. Plotting ponderal equivalent values as percent deviations from the reference man provide a simple and powerful visual representation of an individual's or a group's body composition status. Tracking changes in individual and group ponderal somatograms over time can provide motivation for players to adhere to strength and conditioning programs, and help coaches assess the effectiveness of these programs. Ponderal somatograms (especially the nonmuscular abdomen, abdomen, and hip component) also can graphically monitor the "obesity status" of individuals, of course has important health implications.

REFERENCES


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