BODY COMPOSITION AND STUNTING AMONG ELDERLY MEN IN NAHUALA, GUATEMALA
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Tufts University
Applied Learning Experience Field Work
2. BACKGROUND

- Stunting
- Obesity
- Double Burden of Malnutrition
- Nahualá
- Health Indicators
- Sarcopenia
BACKGROUND - STUNTING

- Stunting is low height-for-age
  - According to the standard guide by the WHO stunting is a z-score < -2
- Used as an indicator for malnutrition
- 46.5% of children under 5 in Guatemala were stunted, the highest in Latin American
  - Prevalence can be high as 70% in some municipalities
  - Indigenous communities are disproportionately affected
- Stunting in childhood is a strong correlate for stunting in adulthood
- However, there is limited information on the affects of stunting in adulthood, particularly among men.
As with other developing countries, being overweight and obesity have been increasing rapidly, particularly among those living in urban areas.

This can be attributed to the adoption of diets high in refined carbohydrates, saturated fats and sugars as well as a shift towards a more sedentary lifestyle.

Increased dry seasons have reduced the amount of crop yield, making it more difficult to access healthy options for subsistence farmers.

In 2016 900,000 people were in need of food assistance.

As recently as 2009, an estimated 67% of Guatemalans ages 15 and above are overweight, of which 29% are obese.
Presence of Double Burden of Malnutrition (DBM) in Guatemala

DBM is the simultaneous existence of obesity and stunting within population

In 2008 mothers (15-49 years) and their children (0-60 months) in indigenous populations had a higher prevalence of DBM than non indigenous mothers, at the household level.

- 63.7% Stunted and 46.7% overweight in indigenous.
- 34.9% stunted and 51.3% overweight in nonindigenous.

Although overweight is increasing rather rapidly in both populations, stunting remains disproportionately higher in indigenous communities. Therefore making DBM prominent in indigenous communities.
BACKGROUND - NAHUALÁ

- Municipality of the Sololá department
- Elevation is 2,467 m
- Majority of residents are of Mayan decent and speak K’iche
- An estimated 78.2%(N=156) of women 35 and older were stunted
- 32.7% were overweight and 16.0% were obese
- What is happening with elderly men in Nahuala regarding nutrition?
BACKGROUND – HEALTH INDICATORS

- Body Mass Index (BMI)
- Waist Circumference (WC)
- Waist to Height Ratio (WtHR)
- Trunk to Leg Ratio (TtLR)
Sarcopenia is the degenerative loss of skeletal muscle mass, quality, and strength associated with aging.

What do the affect of sarcopenia look like in the elderly male population of Nahuala?
3. OBJECTIVES

- The overarching purpose of this project is to determine the relationship between adult stunting and body proportions & compositions among elderly men in Nahualá, Guatemala.
- The objectives are:
  - Determine the prevalence of stunting and its relationship with indicators- Body Mass Index (BMI), Waist Circumference (WC), Waist to Height Ratio (WtHR), and Trunk Leg Ratio (TLR).
  - Determine the relationship that adult stunting has on variables captured by bioelectric impedance analysis (BIA).
  - Understand the effects of sarcopenia using BIA variables
- Exploratory objective
  - Compare anthropometric measurements of Nahuala men and women
  - Compare arthrometric measurement of Nahuala men and Quetzaltenango men
4. METHODS

**Measurements**
- Anthropometric Measurements
- Bioelectric Impedance Analysis
- Demographic

**Recruitment**
- Eligibility
- Strategies

**Data Collection**
- Plan

**Data Analysis**
- Database & Calculation of anthropometric measurements (Excel)
- Data Manipulation and Statistical Analysis (STATA)
<table>
<thead>
<tr>
<th>Method</th>
<th>Measurements</th>
</tr>
</thead>
</table>
| **Anthropometry** | • Knee – Height  
   • Height  
   • Armspan  
   • Weight  
   • Waist Circumference  
   • Sagittal Photography |
| **Bioelectric Impedance Analysis** | • Total Lean Soft Tissue (LST)  
   • Total Fat Mass (FM)  
   • Segmental LST and FM |
| **Demographic Information** | • Age  
   • Civil state  
   • Education level  
   • Traditional Clothing  
   • Activity Level |
METHODS: RECRUITMENT

Eligibility

• Must be Male
• Age 60 or above (Born 1959 or earlier)
• Must be able to return for second phase of study

Strategies

• Health center patients
• Door – to – door
• Pass out flyers
• Radio station announcement
METHODS: DATA COLLECTION

First Visit (Individual Activity)
- Anthropometric Measurements

Second Visit (Collective Activity)
- BIA
  - Results from first visit returned

*This did not apply to new participants that arrived on the day of Jornada.
METHODS: DATA ANALYSIS

- Excel
  - Used to create database
  - Used to calculate indicators (i.e. BMI, Height from Knee Height)
  - Used to create bar graphs, pie graphs, and tables

- STATA
  - Used to code, clean, and analyze data
  - Created categorical variables
  - Descriptive and inferential stats
  - Used to create box plot and scatter plot
  - Test performed: Normality, T-test, Chi-Squared, Pearson correlation
5. FIELD WORK (IMPLEMENTATION OF METHODS)

Preparation

• Practicing measurements
• Step – by – step measurement intake plan
• Set up equipment in Nahuala

Procedures

• Intro/Consent
• Measurements
• Returning Results
FIELD WORK: PREPARATION

- Learn and practice measurements
  - Practiced anthropometry and BIA first week
- Step-by-step measurement intake plan
  1. Knee Height
  2. Weight
  3. Height
  4. Waist circumference
  5. Armspan
  6. Photography
  7. BIA (Second Visit)
- Set equipment up in Nahuala public health clinic
FIELD WORK: PROCEDURES

Introduction/Consent

- Maria Tambriz explains protocol to participants in K’iche
- If participants agreed to participate and met the eligibility criteria they would either sign or finger-print the consent form
- A copy of consent forms was given to participants
- Second visit appointment was made
- Demographics collected
- Participants were then explained the order of the measurements and were asked to take off shoes to begin anthropometric measurements
I. Knee Height
- Measured on the right leg with the leg and foot at 90 degrees.
- Measured to the nearest tenth of a centimeter
- Measured using a MediForm anthropometric caliper
2. Weight

- Participants were asked to remove jackets and hats.
- They stood up straight facing forward
- Measured to the nearest tenth of a kilogram
- Measured using a Rothal® electronic glass scale
- Scale was calibrated
3. Height

- Participant asked to stand face-forward, feet placed together and heels touching the stadiometer base
- Measured to the nearest tenth of a centimeter
- Measured using SECA® Stadiometer
4. Waist Circumference

- Measured at the “clinical waist,” halfway between the iliac crest and lowest rib
- Participants instructed to lift jacket or thick shirts
- Measured to the nearest tenth of a centimeter
- Measured using a SECA® flexible meter tape
FIELD WORK: PROCEDURES

5. Armspan

- Participants asked to extend arms
- Measured by both Maria and Rubeen
- Measured to the nearest tenth of a centimeter
- Specialized measuring stick was used
6. Sagittal Photography & Gift Photo

- I tagged the iliac crest of the participants left lateral side, using red tape
- Participants stood on wooden box and was asked to stand straight with left arm placed on right shoulder
- Participants subject number was place behind them
- A camera was place 3-4 feet away and a photo was taken of their left lateral side.
- Participants then asked to face forward for a gift photo
- Camera used was a Nikon® Coolpix
FIELD WORK: PROCEDURES

7. BIA (Second Visit)

- Participants asked to remove shoes and socks, and lay face-up on a cot.
- Hands and feet are cleaned with alcohol for electrodes.
- BIA is connected for reading.
- Measured using RJL Systems Quantum V Segmental BIA.
Return of Results (Second Visit)

- Participants were given their results and an explanation of their BMI and Waist Circumference.
- If underweight participants were given an extra bag of Incaparina® and instructed to seek consultation with health center nutritionist
- If overweight and obese participants were instructed to seek consultation with health center nutritionist
- Participants also received their gift photo
6. RESULTS

- Retention
- Demographics
- Anthropometry
  - BMI
  - Waist Circumference
  - Sagittal Photography
- BIA
  - Soft Tissue Composition
  - LST Composition
  - FM Composition
  - Sarcopenia
- Stunting
  - Stunting and BMI
  - Stunting and waist circumference
  - Stunting and trunk leg ratio
  - Stunting and sarcopenia
- Exploratory Analysis
  - Nahuala Elderly Men vs. Quetzaltenango Men
  - Nahuala Elderly Men vs. Women
RESULTS - RETENTION

- **Phase I: Anthropometric Measurements**
  - 50 Participants Completed

- **Phase I and Phase II: BIA**
  - 47 Participants Completed

94% Retention
**RESULTS: DEMOGRAPHICS**

**Highlights:**
- Mean age is 72.54
- 82% Are still married.
- 50% have received no formal education.
- 36% Have completed Primary School.
- 72% of Participants perform at heavy (pesado) activity levels daily.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency/Mean (±SD), N=50</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>72.54 (8.14)</td>
<td></td>
</tr>
<tr>
<td><strong>Civil State</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soltero</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>Unido</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Casado</td>
<td>41</td>
<td>82%</td>
</tr>
<tr>
<td>Divorciado</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Viudo</td>
<td>6</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>25</td>
<td>50%</td>
</tr>
<tr>
<td>Primary Incomplete</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Primary Complete</td>
<td>18</td>
<td>36%</td>
</tr>
<tr>
<td>Basico Incompleto</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Basico Completo</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Diversificado Incompleto</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Diversificado Completo</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Traditional Clothes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>40</td>
<td>80%</td>
</tr>
<tr>
<td>SI</td>
<td>10</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Daily Physical Activity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muy Ligero</td>
<td>8</td>
<td>16%</td>
</tr>
<tr>
<td>Ligero</td>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td>Moderado</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Pesado</td>
<td>36</td>
<td>72%</td>
</tr>
<tr>
<td>Excepcional</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>
# RESULTS: TABULAR SUMMARY OF MEASUREMENTS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean(± SD)</th>
<th>Median (Range)</th>
<th>Normality (P-Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>150.49 (±5.31)</td>
<td>149.85 (134.7 - 162.2)</td>
<td>Yes (P=.40)</td>
</tr>
<tr>
<td>Armspan (cm)</td>
<td>155.01 (±6.30)</td>
<td>155.25 (139 - 167)</td>
<td>Yes (P=.67)</td>
</tr>
<tr>
<td>Knee Height (cm)</td>
<td>46.77 (±2.10)</td>
<td>46.55 (42.3 - 51)</td>
<td>Yes (P=.76)</td>
</tr>
<tr>
<td>Height from Knee (cm)*</td>
<td>154.71 (±2.10)</td>
<td>154.32 (146.5 - 162.8)</td>
<td>Yes (P=.77)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>52.54 (±10.18)</td>
<td>50.95 (32.7 - 88.2)</td>
<td>Yes (P=.05)</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>84.72(±10.14)</td>
<td>83.55 (67.8 - 117.6)</td>
<td>Yes (P=.06)</td>
</tr>
</tbody>
</table>

*Calculated using Bermudez et al. linear regression equations of Hispanic men 60 and above in northeastern U.S.
RESULTS: DISTRIBUTION OF EACH HEIGHT MEASUREMENT

- **149.85 cm**
- **155.25 cm**
- **154.32 cm**
RESULTS: DISTRIBUTION OF KNEE HEIGHT

46.55 cm
RESULTS: DISTRIBUTION OF WEIGHT

50.95 kg
RESULTS: DISTRIBUTION OF WAIST CIRCUMFERENCE

83.55 cm
The median height of 150 cm compares to 177 cm for adult men in the United States.

The median weight of 51 kg compares to 90 kg for adult men over 60 y in the United States.

As would be expected, the arm span is greater than the current standing height. If we assume the arm span represents maximal adult height for these men, they have an cumulative aging height loss of ~5 cm.

All of the measures are normally distributed. Absence of any bimodality suggests that the men are harmonically affected by the factors influencing body size.
### RESULTS: SUMMARY OF INDICATORS CALCULATED

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean(± SD)</th>
<th>Median (Range)</th>
<th>Normality (P-Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI from Height (kg/m2)</td>
<td>23.08 (±3.65)</td>
<td>22.4 (17.3 - 36.9)</td>
<td>No (P &lt; .05)</td>
</tr>
<tr>
<td>BMI form Armspan (kg/m2)</td>
<td>21.77 (±3.50)</td>
<td>20.9 (16.4 - 34.2)</td>
<td>No (P &lt; .05)</td>
</tr>
<tr>
<td>BMI from Knee Height (kg/m2)</td>
<td>21.85 (±3.58)</td>
<td>21.4 (15.2 - 33.8)</td>
<td>Yes (P = .07)</td>
</tr>
<tr>
<td>Armspan to Height Ratio</td>
<td>1.03 (±.02)</td>
<td>1.03 (.9 - 1.1)</td>
<td>Yes (P = .32)</td>
</tr>
<tr>
<td>Waist to Height Ratio</td>
<td>.56 (±.06)</td>
<td>.55 (.4 -.8)</td>
<td>Yes (P = .27)</td>
</tr>
</tbody>
</table>
FOLLOWING: GRAPHIC DISTRIBUTIONS
INDICATORS CALCULATED
RESULTS: DISTRIBUTION OF BMIs USING DIFFERENT HEIGHTS

- Height BMI: 22.4 kg/cm^2
- Armspan BMI: 20.9 kg/cm^2
- Knee Height BMI: 21.4 kg/cm^2
RESULTS: DISTRIBUTION OF ARMSPAN-TO-HEIGHT RATIO
RESULTS: DISTRIBUTION OF WAIST-TO-HEIGHT RATIO
Consistent with the higher length value in the denominator of the BMI formula, the index with armspan is 1.0 – 1.5 BMI units lower than the others.

The armspan-derived value probably represents a more valid population BMI median than that created from the currently measured stature.

The armspan-to-height ratio of 1.03, with a 3% deviation from unity (= no height loss), is consistent with the 5 cm cumulative height loss as calculated from the armspan – height difference.

A waist-to-height ratio of greater than 1-to-2 (>0.50) is considered to represent greater cardiovascular-event risk. Taken on its face, the displacement to the right represents high population risk.
FOLLOWING: CORRELATES OF BODY MASS INDEX
RESULTS: BMIs (N=50)
### RESULTS: BMI-CORRELATIONS

<table>
<thead>
<tr>
<th>Variables</th>
<th>r</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height to Armspan</td>
<td>0.8825</td>
<td>P&lt; .0000</td>
</tr>
<tr>
<td>Height to Knee-Height</td>
<td>0.7799</td>
<td>P&lt; .0000</td>
</tr>
<tr>
<td>Armspan to Knee-Height</td>
<td>0.8909</td>
<td>P&lt; .0000</td>
</tr>
<tr>
<td>BMI to Armspan BMI</td>
<td>0.9694</td>
<td>P&lt; .0000</td>
</tr>
<tr>
<td>BMI to Knee-Height BMI</td>
<td>0.9634</td>
<td>P&lt; .0000</td>
</tr>
<tr>
<td>Armspan BMI to Knee-Height BMI</td>
<td>0.9560</td>
<td>P&lt; .0000</td>
</tr>
</tbody>
</table>

*Pearson Correlation Used*
RESULTS: CORRELATION OF HEIGHT ESTIMATES
RESULTS: BMI - CORRELATION OF BMIs (KG/M^2)

*Correlations are stronger due to transformation of data
As expected, the association of the measured standing height and the armspan is strong.

The two derivative (estimated) height values are equally strongly associated.

As expected, moving from a measured value to an adjusted value in the formula of BMI, the three estimates for height produce even stronger associations.
FOLLOWING: CORRELATES OF ABDOMINAL CIRCUMFERENCE (WAIST)
RESULTS: WAIST CIRCUMFERENCE (N=50)

Waist Circumference Risk Levels

- Level 0 (Low Risk) - <94cm
- Level 1 (High Risk) - ≥94 and <102cm
- Level 2 (Very High Risk) - ≥102cm
### RESULTS: WAIST - WAIST CIRCUMFERENCE X BMI

<table>
<thead>
<tr>
<th>Waist Circumference Categories</th>
<th>Underweight/Normal</th>
<th>Overweight</th>
<th>Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0 (Low Risk)</td>
<td>37</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Level 1 (High Risk)</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Level 2 (Very High Risk)</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Percent Concordant = 88%, P-Value < .0000
RESULTS: WAIST – WAIST-TO-HEIGHT RATIO

<table>
<thead>
<tr>
<th>Waist to Height Ratio</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; .50</td>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td>≥ .50</td>
<td>45</td>
<td>90%</td>
</tr>
</tbody>
</table>

*Cut-off value purported to be a metabolic/CV risk factor. Questionable in short-stature populations.
Abdominal circumference has been shown in references of men from Glasgow, Scotland to correlate in a categorical manner with the classes of normal/subnormal weight, overweight and obesity,

The vast majority of elderly men are in the low-risk classification by waist circumference.

There is a high inter-class concordance (0.88) of the three categories from BMI classifications and the corresponding WC action levels.

Whereas the absolute measure (WC) indicates low risk, the relative measure of waist circumference to stature (WHR) indicates high risk in 90%. These men, however, are of such short stature that one would need a WC of 75 cm or less to meet ratio criteria at 150 cm of stature.
SAGITTAL PHOTOGRAPHIC IMAGES FOR TRUNK AND LEG ESTIMATES FOR RATIOS
RESULTS: SAGITTAL PHOTOGRAPHY
### RESULTS: SAGITTAL PHOTOGRAPHY

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nahualá (N=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (± SD)</td>
</tr>
<tr>
<td>Trunk/Leg Ratio</td>
<td>.59 (± .04)</td>
</tr>
<tr>
<td>Trunk/Height Ratio</td>
<td>.37 (±.02)</td>
</tr>
</tbody>
</table>
RESULTS: SAGITTAL PHOTOGRAPHY – DISTRIBUTIONS

[Graphs showing distributions for Trunk:Height Ratio and Trunk:Leg Ratio with values 0.37 and 0.60 respectively]
Recent observations converge in the demonstration that failure of elongation of the lower extremities is the mechanism of the impaired linear growth. To what extent does this persist into adulthood?

The relative length of the torso (waist-to-crown) and the lower extremities (waist to soles of feet) can be assessed from a sagittal photo, and the ratios have been widely explored in young children, with shorter, disadvantaged children having relatively shorter legs.

The ratio values in the 50 elderly men can only be interpreted in reference to taller populations with more favorably early-life experiences (see below).
The total soft tissue is the combined weight of both lean and fat tissue as registered by bioelectrical impedance analysis.

The lean soft tissue (LST) represents skeletal muscle in the extremities, and organs (lungs, heart, viscera, kidneys) in the torso.

The fat mass (FM) represents adipose tissue in whatever location (subcutaneous, visceral, interstitial).
# RESULTS: BIA - SUMMARY OF TOTAL SOFT TISSUE VARIABLES (COMBINED LEAN AND FAT TISSUE)

<table>
<thead>
<tr>
<th>Variable (kg)</th>
<th>Mean(± SD)</th>
<th>Median (Range)</th>
<th>Normality (P-Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Tissue Right Arm</td>
<td>2.69(± .69)</td>
<td>2.6 (1.5-4.8)</td>
<td>Yes (P= 0.28)</td>
</tr>
<tr>
<td>Soft Tissue Left Arm</td>
<td>2.62 (±.74)</td>
<td>2.5(1.4-5.1)</td>
<td>Yes (P=0.12)</td>
</tr>
<tr>
<td>Soft Tissue Right Leg</td>
<td>7.71(±1.64)</td>
<td>7.6(4.3-13.2)</td>
<td>Yes (P=0.21)</td>
</tr>
<tr>
<td>Soft Tissue Left Leg</td>
<td>7.61(±1.67)</td>
<td>7.5(4.2-13.1)</td>
<td>Yes (P=0.26)</td>
</tr>
<tr>
<td>Soft Tissue Torso</td>
<td>29.58(±5.20)</td>
<td>29.3(19.6-47.6)</td>
<td>Yes (P=0.07)</td>
</tr>
<tr>
<td>Soft Tissue Total</td>
<td>50.23(±9.91)</td>
<td>49.5(31.1-83.8)</td>
<td>Yes (P=0.12)</td>
</tr>
</tbody>
</table>
RESULTS: BIA – DISTRIBUTIONS FOR TOTAL SOFT TISSUE (COMBINED LEAN AND FAT TISSUE) IN ARMS & LEGS (KG)

- 2.6 kg
- 2.5 kg
- 7.6 kg
- 7.5 kg
RESULTS: BIA – DISTRIBUTIONS FOR TOTAL SOFT TISSUE (COMBINED LEAN AND FAT TISSUE) IN TORSO & WHOLE BODY (KG)

- Torso: 29.3 kg
- Whole Body: 49.51 kg
RESULTS: BIA – TOTAL SOFT TISSUE (COMBINED LEAN AND FAT TISSUE) SYMMETRY/ASYMMETRY

Right to Left Arm Ratio:

- Mean: 1.035 (± 0.066)
- Median: 1.043 (0.846 -1.176)

Right to Left Leg Ratio:

- Mean: 1.014 (± 0.016)
- Median: 1.012 (0.981-1.058)
RESULTS: BIA – TOTAL SOFT SOFT TISSUE (COMBINED LEAN AND FAT TISSUE) SYMMETRY/ASYMMETRY, ARMS AND LEGS RATIO DISTRIBUTION (KG)

![Graph showing soft tissue arm and leg ratio distribution with values 1.043 kg and 1.012 kg respectively.](image)
## RESULTS BIA – SUMMARY OF LST & FM VARIABLES (KG)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean(± SD)</th>
<th>Median (Range)</th>
<th>Normality (P-Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Arm LST</td>
<td>2.00 (± .48)</td>
<td>2.0 (1 - 2.9)</td>
<td>Yes (P = .82)</td>
</tr>
<tr>
<td>Right Arm FM</td>
<td>.69 (± .31)</td>
<td>.60 (.3 - 1.9)</td>
<td>No (P &lt; .05)</td>
</tr>
<tr>
<td>Left Arm LST</td>
<td>1.98 (± .52)</td>
<td>2.0 (1 - 3.2)</td>
<td>Yes (P=.65)</td>
</tr>
<tr>
<td>Left Arm FM</td>
<td>.63 (± .31)</td>
<td>.60 (.2 - 1.9)</td>
<td>No (P &lt; .05)</td>
</tr>
<tr>
<td>Right Leg LST</td>
<td>5.60 (± 1.07)</td>
<td>5.7 (3.2 - 8.2)</td>
<td>Yes (P .98)</td>
</tr>
<tr>
<td>Right Leg FM</td>
<td>2.10 (± .78)</td>
<td>2.0 (1.1 - 5)</td>
<td>No (P &lt; .05)</td>
</tr>
<tr>
<td>Left Leg LST</td>
<td>5.45 (± 1.11)</td>
<td>5.5 (3.1 - 8.2)</td>
<td>Yes (P .90)</td>
</tr>
<tr>
<td>Left Leg FM</td>
<td>2.15 (± .73)</td>
<td>2.0 (1.1 - 4.9)</td>
<td>No (P &lt; .05)</td>
</tr>
<tr>
<td>Torso LST</td>
<td>20.63 (± 2.97)</td>
<td>21.0 (13.9 - 25.9)</td>
<td>Yes (P= .48)</td>
</tr>
<tr>
<td>Torso FM</td>
<td>8.95 (± 3.53)</td>
<td>8.3 (3.9 - 22.4)</td>
<td>No (P &lt; .05)</td>
</tr>
<tr>
<td>LST Total</td>
<td>35.68 (± 6.02)</td>
<td>35.9 (22.6 - 47.7)</td>
<td>Yes (P .90)</td>
</tr>
</tbody>
</table>
| FM Total       | 14.55 (± 5.64) | 13.6 (6.8 - 36.1)| No (P < .05)
RESULTS: BIA – DISTRIBUTIONS FOR LST & FM ARM VARIABLES (KG)
RESULTS: BIA – DISTRIBUTIONS FOR LST & FM LEG VARIABLES (KG)

- Right Leg LST
- Left Leg LST
- Right Leg FM
- Left Leg FM
RESULTS: BIA – DISTRIBUTIONS FOR LST & FM TORSO VARIABLES (KG)

- Torso LST: 21.0 kg
- Torso FM: 8.3 kg
RESULTS: BIA – DISTRIBUTIONS FOR LST & FM TOTAL VARIABLES (KG)
RESULTS: BIA – PROPORTIONS OF LST

Total LST: 35.68 kg
Body Weight: 52.83 kg
LST in body:
68.07%

LST Relative to Total Body Weight

LST BY SEGMENT Relative to Total LST

Left Side
5.49%
15.20%

Right Side
5.56%
15.67%
58.08%
RESULTS: BIA – PROPORTIONS OF FM TISSUE

Total FM: 35.68 kg
Body Weight: 52.83 kg
FM in body:

26.99%

FM Relative to Total Body Weight

FM BY SEGMENTS Relative to Total FM

Left Side:
- 4.24%

Right Side:
- 4.65%

Total FM: 35.68 kg
Body Weight: 52.83 kg
FM in body:

26.99%
RESULTS: BIA – SEGMENTAL LST TO FM RATIOS WITHIN LIMBS

Left Arm Ratio:
Mean: 3.64 (±1.61)
Median: 3.33 (1.36-9.5)

Right Arm Ratio:
Mean: 3.34 (±1.39)
Median: 3 (1.33-7)

Left Leg Ratio:
Mean: 2.69 (±.73)
Median: 2.54 (1.67-5.09)

Right Leg Ratio:
Mean: 2.91 (±.95)
Median: 2.6 (1.59-5.27)

Torso Ratio:
Mean: 2.61 (±.98)
Median: 2.45 (1.12-5.36)
RESULTS: BIA – SEGMENTAL LST TO FM RATIOS WITHIN LIMBS

- **Right Arm Ratio**
  - 3.0
  - 3.3

- **Left Arm Ratio**
  - 2.5

- **Right Leg Ratio**
  - 2.6

- **Left Leg Ratio**
  - 2.5
RESULTS: BIA – DISTRIBUTION OF LST-FM RATIOS IN TORSO & TOTAL

![Box plots showing the distribution of LST-FM ratios in torso and total.]

- Torso Ratio: Median = 2.4
- Total Ratio: Median = 2.5
RESULTS: BIA – LST RATIOS (SYMMETRY/ASYMMETRY)

Right to Left Arm Ratio:
Mean: 1.016 (± 0.074)
Median: 1.04 (.8 – 1.166)

Right to Left Leg Ratio:
Mean: 1.031 (± 0.042)
Median: 1.026 (.95 - 1.169)
RESULTS: BIA – LST RATIO (SYMMETRY/ASYMMETRY) DISTRIBUTIONS
RESULTS: BIA – LST DIFFERENCES IN KG (SYMMETRY/ASYMMETRY)
The two sides of the body are extraordinarily symmetrical in terms of their overall contents of lean and fat tissues as shown in the tabular data. Left- vs right-side median weights are virtually identical.

In terms of lean soft tissue, 58% is located in the torso, and the remainder in the extremities.

About 21% of the lean soft tissue of the body is found in the combination of the upper and lower extremities on each side.

About 31% of the body’s LST is in the lower legs, whereas 11% is contained in the two arms.
In terms of fat mass (adipose tissue), 64.5% is located in the torso, and the remainder in the arms and legs.

About 21% of the lean soft tissue of the body is found in the combination of the upper and lower extremities on each side.

About 30.5% of the body’s LST is in the lower legs, whereas 9% is contained in the two arms.

As a consequence, there is relatively less lean tissue (organs) in relation to fat mass in the torso than in the same relationship found in the extremities. More there is slightly over three times as much LST (muscle) in the arms, whereas there is slightly less than a 3-to-1 ratio of the respective tissues in the legs.
AS A PERSON AGES, THE SKELETAL MUSCLE DETERIORATES WITH LOSS OF FIBER BUNDLES AND INFILTRATION OF THE MUSCLES WITH FAT, A PROCESS KNOW AS “SARCOPENIA” WITH THE LST VARIABLE REPRESENTING MUSCLE IN THE LIMBS AND WITH A LOOK AT FAT RATIO AND “DENSITY” (LST per CM) WITH PROXIES FOR LENGTH, WE PERFORM PRELIMINARY DATA EXPLORATION FOR INDICATORS OF MUSCLE CONSERVATION OR LOSS.
RESULTS: BIA – LST/LEG LENGTH (KG/CM)

Kg of LST/ Length of leg:
Mean: .057 (± .01)
Median: .058 (0.035 - .084)

Kg of LST/ Length of leg:
Mean: .059 (± .01)
Median: .060 (0.036 - .083)
RESULTS: BIA – LST/LEG LENGTH DISTRIBUTION

- Right Leg LST/Length (kg/cm): 0.06 kg/cm
- Left Leg LST/Length (kg/cm): 0.058 kg/cm
RESULTS: BIA – LEG LENGTH & KNEE LENGTH
RESULTS: BIA – LST/KNEE HEIGHT (SARCOPENIA)

Kg of LST/ Length of leg:

Left Side

Mean: .116 (± .02)
Median: .115 (.073 - .172)

Right Side

Mean: .119 (± .01)
Median: .119 (.075 - .163)
RESULTS: BIA – LST/KNEE LENGTH DISTRIBUTION (SARCOPENIA)

![Box plot showing BIA results for LST/Knee length distribution with right leg at 0.119 kg/cm and left leg at 0.115 kg/cm.](image)
RESULTS: BIA – RIGHT & LEFT LST/LEG VS. LST/KNEE
The conceptual basis for “muscle density” is analogous to that of taking imaginary “tomographic slices” of cm thickness in relation to the skeletal muscle content, excluding the fat and the bone core. The average would assume a perfect cylinder form. Cancelling out the tapering of the leg toward the joints at the knee and the ankle.

Our empirical expression uses the total LST weight of the lower extremity in Kg and the estimation of leg-length from the sagittal photo proportions and the standing height. This allowed the density expression of kg/cm.

We also explored whether, if one only had a knee-height caliper, the knee-height is a suitable proxy for the leg-length (proxy) from the photo. Associations were strong.

We find promise in this use of the leg’s total LST as a prime variable, and with suitable measurement of arm length, the upper extremity could be subject to a homologous procedure.
FOLLOWING: EVALUATION OF THE CORRELATES OF ADULT STUNTING ON MEASUREMENTS AND INDICATORS

- This setting of Nahuala was chosen to allow a study of the biology of adult short stature.
- In applying the widely-used <150 cm criterion, for adult stunting, participants were almost equally split into stunted and non-stunted.
- Anthropometric values of interest to stature were compared across the two sub-groups.
## Results: Stunting

### Visit 1

<table>
<thead>
<tr>
<th></th>
<th>Nahualá (N=50)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>Not Stunted</td>
<td>24</td>
<td>48%</td>
<td></td>
</tr>
<tr>
<td>Stunted</td>
<td>26</td>
<td>52%</td>
<td></td>
</tr>
</tbody>
</table>

### Visit 1&2

<table>
<thead>
<tr>
<th></th>
<th>Nahualá (N=47)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>Not Stunted</td>
<td>22</td>
<td>47%</td>
<td></td>
</tr>
<tr>
<td>Stunted</td>
<td>25</td>
<td>53%</td>
<td></td>
</tr>
</tbody>
</table>
## RESULT: STUNTING & BMI

<table>
<thead>
<tr>
<th>BMI Category</th>
<th>Stunting</th>
<th>Not Stunted</th>
<th>Stunted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td></td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Normal</td>
<td>15</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>8</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

P-Value = .127, Fisher’s Exact Test
# RESULTS: STUNTING & WAIST CIRCUMFERENCE

<table>
<thead>
<tr>
<th>Waist Circumference</th>
<th>Stunting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Stunted</td>
</tr>
<tr>
<td>Low Risk</td>
<td>16</td>
</tr>
<tr>
<td>High Risk</td>
<td>5</td>
</tr>
<tr>
<td>Very High Risk</td>
<td>3</td>
</tr>
</tbody>
</table>

Nahualá (N=50)

*P-Value = .022*, Fisher’s Exact Test
# RESULTS: STUNTING & TRUNK-LEG RATIO

<table>
<thead>
<tr>
<th>Stunting</th>
<th>Mean Not Stunted (±SD)</th>
<th>Mean Stunted (±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nahuala (N=50)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trunk:Leg Ratio</td>
<td>.59 (± .04)</td>
<td>.60 (± .05)</td>
</tr>
</tbody>
</table>

P-Value = .59
## RESULTS: STUNTING & LST/LEG LENGTH

<table>
<thead>
<tr>
<th></th>
<th>Stunting Mean Not Stunted (±SD)</th>
<th>Mean Stunted (±SD)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LST/Right Leg Length (kg/cm)</td>
<td>0.065 (± 0.007)</td>
<td>0.053 (± 0.008)</td>
<td>&lt; .0000</td>
</tr>
<tr>
<td>LST/Left Leg Length (kg/cm)</td>
<td>0.064 (± 0.008)</td>
<td>0.051 (± 0.008)</td>
<td>&lt; .0000</td>
</tr>
</tbody>
</table>
It has been hypothesized that a shorter stature within the maintenance of a certain common body weight would drive a higher BMI (for lower denominator value in the formula). Contrary to that postulate, here, the overweight rate was two-fold higher in non-stunted elderly men.

Not unexpectedly, increased height associated with greater WC, which drove the classification by risk level into the abnormal range in one-third of the non-stunted men.

The trunk-to-leg ratio was only marginally higher in men with meeting the adult stunting criterion than in those who did not.
Previous field work by exchange students with CeSSIAM staff on this webpage, using the same measurement procedures, was available in the data spread-sheets in the files.

We used the data from 50 men of the same age-criterion in more affluent and ethnically-diverse city of Quetzaltenango, from the presentation of Brian Engle and Jenny McManus, and those from 75 women form the same setting (Nahualá) in the same age-range and ethnicity, from the presentation of Marlou-flour Kirkhuis.
### RESULTS: EXPLORATORY COMPARISONS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nahualá (N=50)</th>
<th>Xela (N=50)</th>
<th>CI, p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean(± SD)</td>
<td>Mean(± SD)</td>
<td>(-8.21,-3.48), p&lt;.0000</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>150.49 (±5.31)</td>
<td>156.33(±6.55)</td>
<td>(-7.76,-1.98), p = .0012</td>
</tr>
<tr>
<td>Armspan (cm)</td>
<td>155.01 (±6.30)</td>
<td>159.88 (±8.14)</td>
<td>(-2.8,-1.05), p&lt;.0000</td>
</tr>
<tr>
<td>Knee Height (cm)</td>
<td>46.77 (±2.10)</td>
<td>48.70 (±2.30)</td>
<td>(-4.01,-1.30), p = .0002</td>
</tr>
<tr>
<td>Height from Knee (cm)</td>
<td>154.71 (±2.10)</td>
<td>157.37 (±4.33)</td>
<td>(-9.97,-1.68), p=.0064</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>52.54 (±10.18)</td>
<td>58.37 (±10.72)</td>
<td>(-2.13,.72), p=.3277</td>
</tr>
<tr>
<td>BMI from Height (kg/m²)</td>
<td>23.08 (±3.65)</td>
<td>23.79 (±3.51)</td>
<td>(-2.39,.38), p = .1537</td>
</tr>
<tr>
<td>BMI form Armspan (kg/m²)</td>
<td>21.77(±3.50)</td>
<td>22.78 (±3.5)</td>
<td>(-3.06,-.18), p=.0273</td>
</tr>
<tr>
<td>BMI from Knee Height (kg/m²)</td>
<td>21.85(±3.58)</td>
<td>23.48(±3.66)</td>
<td>(-9.26,-1.49), p=.0071</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>84.72(±10.14)</td>
<td>90.1(±9.4)</td>
<td></td>
</tr>
</tbody>
</table>

*Knee Height Equations used were different

*Insignificant finding perhaps caused by issues of normality
### RESULTS: EXPLORATORY COMPARISONS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nahualá Men (N=50) Mean(± SD)</th>
<th>Nahualá Women (N=75) Mean(± SD)</th>
<th>CI, p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>150.49 (±5.31)</td>
<td>138.7 (±5.5)</td>
<td>(9.82,13.74), p&lt;.0000</td>
</tr>
<tr>
<td>Armspan (cm)</td>
<td>155.01 (±6.30)</td>
<td>142.5 (±6.0)</td>
<td>(10.29,14.72), p &lt; .0000</td>
</tr>
<tr>
<td>Knee Height (cm)</td>
<td>46.77 (±2.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height from Knee (cm)</td>
<td>154.71 (±2.10)</td>
<td>139.6 (±4.6)</td>
<td>(13.73,16.49), p &lt; .0000</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>52.54 (±10.18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI from Height (kg/m²)</td>
<td>23.08 (±3.65)</td>
<td>23.8 (±3.6)</td>
<td>(-2.02,.59), p=.2818</td>
</tr>
<tr>
<td>BMI form Armspan (kg/m²)</td>
<td>21.77(±3.50)</td>
<td>22.2 (±3.49)</td>
<td>(-1.69,.83), p = .5055</td>
</tr>
<tr>
<td>BMI from Knee Height (kg/m²)</td>
<td>21.85(±3.58)</td>
<td>23.5(±3.5)</td>
<td>(-2.92,-.36), p=.0121</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>84.72(±10.14)</td>
<td>78.8(±9.1)</td>
<td>(2.48,9.37), p=.0009</td>
</tr>
</tbody>
</table>

*Knee Height Equations used were different

*Insignificant finding perhaps caused by issues of normality
CONCLUSIONS – HEALTH INDICATORS

BMI
- The three height measurements and BMIs from those measurements were strongly correlated
  - some variation between the BMI categories depending on the height measurements
- Using standing height BMI, 70% (N=50) reported a normal BMI.

Waist Circumference
- 82% had a low risk waist circumference

WC and BMI
- 88% concordance with each other

Waist to height ratio
- 90% had a WtHR ≥ .50 indicating high risk
- Given the overall shorter population this occurrence is expected. Smaller height produces a greater ratio
- WtHR is not an accurate representation of BMI

Trunk to leg ratio
- The average TtLR was .59
- On average the trunk was larger than the legs for participants
CONCLUSIONS - BIA

Soft Tissue
- Soft Tissue makes up 95.06% of total body weight
- Right arms and legs has slightly higher soft tissue than left arms and legs. 3.5% more soft tissue in arms and 1.4% in legs.

LST and FM
- LST makes up 68.07% of total body weight
- FM makes up 6.99% of total body weight
- On average the LST to FM ratio is greater in left arms (3.64) than right right arms (3.34)
- On average the LST to FM ratio is greater in right legs (2.91) than left legs (2.69)

LST Asymmetry/Symmetry
- However, right arms had 1.6% more LST than left arms
- Right legs had 3.1% more LST than left legs

Measurement of Sarcopenia
- Right legs had .059kg of LST per cm of leg length
- Left legs had .057kg of LST per cm of leg length
CONCLUSIONS - STUNTING

**Stunting**
- 52% of phase I (N=50) participants were stunted and 53% of phase II (N=47) participants were stunted

**Stunting and BMI**
- Given the p-value = .127, we conclude BMI is not calculated with stunting.

**Stunting and Waist Circumference**
- Given the p-value = .022, we conclude waist circumference is associated with stunting.

**Stunting and TtLR**
- The mean TtLR for those stunted (.60) was not significantly different from those who were not stunted(.59) (p=value = .59).

**Stunting and Sarcopenia**
- The mean LST/Leg Length in the right leg for those those stunted (.053kg/cm) was significantly different than for those not stunted (.065 kg/cm) (p<.0000)
- The mean LST/Leg Length in the left leg for those those stunted (.051kg/cm) was significantly different than for those not stunted (.064 kg/cm) (p<.0000)
CONCLUSIONS - EXPLORATORY

Nahuala Men vs. Quetzaltenango Men

- Height, arm span, knee height, height from knee, weight, waist circumference and BMI with height from knee were significantly different between the Nahuala and Quetzaltenango men. (P-value < .05)

Nahuala Men vs. Nahuala Women

- Height, arm span, height from knee, waist circumference and BMI with height from knee were significantly different between the Nahuala men and women. (P-value < .05)
CONCLUSION - LESSONS LEARNED

- Recruitment
  - Actions to actively find participants should be taken earlier
  - Door-to-door recruitment was most effective

- Data collection
  - Multiple visits should be avoided with older populations as many barriers hinder retention

- Field work
  - Find more spacious location to collect data as sharing clinic room made it difficult to effectively process participants.
CONCLUSIONS – NEXT STEPS

- Determine arm length of participants to calculate LST (kg)/ centimeter of arm length
- Given the background of body size and body proportion studies in this community, a high priority for application of the QUANTUMV system, would be in a sample of women from Nahuala.
- Given the theory that sarcopenia is advancing with age, the enrolling of a younger, e.g. 35-59 y sample, and applying the same measurements protocol.
8. ACKNOWLEDGMENTS

- Dr. Noel Solomons
- CeSSIAM Xela: Rosario Garcia, Marta Escobar, Alejandra Maldonado, Deborah Fuentes
- Brian Engle for sharing data for comparison with men in Quetzaltenango
- Marlou-Floor for sharing data for comparison with women in Nahuala
- Prof. Klaus Schuemann, President of the Hildegard Grunow Foundation for investment of operational funds
- Mr. Rudi J Leidtke, Founder of the RJL Systems Co, for the donation of the QUANTUM V BIA instrument for segmental analysis
- Prof. Odilia Bermudez, Department of Community and Public Health
- Prof. Ginny Chomitz, Department of Community and Public Health
- Municipality of Nahuala
- Maria Rosalia Tambriz, Translator
- Healthcare Center of Nahualá: Doctor Rodas, Nurse Flora, Nurse Magda
- Lastly, thank you to all the participants who gave their time to make this project a reality.
GRACIAS! – MALTYOX!
CITATIONS


