Biological systems, overview

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Biomarkers in panel surveys: outline of session

• Provide background to the frequently available biomarkers in panel surveys (see ICLS handbook common survey measurements 2\textsuperscript{nd} edition 2016)

• The aim to give overview key organs/systems, deeper understanding of practicalities of measurement and how to use them

• Divided into 2 parts: first with Neil Pendleton on selected organ systems and second part on the physical/physiological measures;

• Please ask questions at any time on anything
Endocrine system

- Definition is production of regulatory protein that travels distance from source tissue to place of action via blood
- They often act through a feedback regulation loop
- Often included as biomarkers in panel survey studies as collection feasible
Master regulator: Hypothalamus/Pituitary gland

Image by Jay Swan 2011
Regulating metabolism

- **Hypothalamus**
  - TRH = TSH-releasing hormone

- **Anterior Pituitary**
  - TSH = thyroid stimulating hormone

- **Thyroid**
  - produces thyroxine hormones
  - metabolism & development
    - bone growth
    - mental development
    - metabolic use of energy
    - blood pressure & heart rate
    - muscle tone
    - digestion
    - reproduction

AP Biology

Image by Jay Swan 2011
Endocrine System Control

Regulation of Blood Sugar

**Feedback**

- Insulin
  - Released by beta islet cells
  - Lowers blood sugar level
  - Body cells take up sugar from blood

- Glucagon
  - Released by alpha islet cells
  - Raises blood sugar level
  - Liver releases glucose

- Pancreas
- Liver

- High blood sugar level (90mg/100ml)
- Low blood sugar level

- Liver stores glycogen
- Reduces appetite

- Triggers hunger

Image by Jay Swan 2011
Kidney function

- Regulation of body fluid volume and osmolality
- Regulation of electrolyte balance
- Regulation of acid base balance
- Excretion of waste products (urea, creatinine, ammonia, drugs, toxins)
- Retention of substances vital to body glucose and amino acids
- Regulation blood pressure
- Production and secretion of hormones renin erythropoietin
- Activation vitamin D
Functional renal anatomy
Nephron

In selective reabsorption, sodium, amino acids and glucose are reabsorbed from the filtrate back into the blood.
Renal function tests

- Clearance tests: volume creatinine
- Calculation creatinine clearance
- Blood biochemistry
- Microalbuminuria and proteinuria
Estimated creatinine clearance

- Number of formula
- Cockcroft & Gault
- MDRD
- Note children use Schwartz or Counahan Barratt
- All use function of height plus serum creatinine

- **C&K equation**
  
  Creatinine clearance = \( \frac{(((140 - \text{age in years}) \times \text{wt in kg}) \times 1.23)}{(\text{serum creatinine in micromol/l})} \)

- **MDRD**
  
  MDRD equation: \( 186 \times \frac{\text{Creatinine}}{88.4} - 1.154 \times \text{Age} - 0.203 \times (0.742 \text{ if female}) \times (1.210 \text{ if black}) \).
Biochemistry blood and urine

- Available in all routine test profiles
- Electrolyte levels sodium and potassium (calcium) phosphate
- Metabolites creatinine and urea
- Protein levels
- Urine electrolytes sodium and potassium
- Microalbuminuria and proteinuria = renal damage diabetes and hypertension
Urinary chemistry

- Urine electrolytes sodium and potassium
- Microalbuminuria and proteinuria = renal damage diabetes and hypertension
- Clinical test is often the urine albumen/creatinine (ACR) ratio on single sample used to stage chronic kidney disease
Classification of Chronic Kidney Disease

Classification of chronic kidney disease using GFR and ACR categories

<table>
<thead>
<tr>
<th>GFR and ACR categories and risk of adverse outcomes</th>
<th>ACR categories (mg/mmol), description and range</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 Normal and high</td>
<td>A1 Normal to mildly increased</td>
</tr>
<tr>
<td>G2 60–89 Mild reduction related to normal range for a young adult</td>
<td></td>
</tr>
<tr>
<td>G3a 45–59 Mild-moderate reduction</td>
<td></td>
</tr>
<tr>
<td>G3b 30–44 Moderate-severe reduction</td>
<td></td>
</tr>
<tr>
<td>G4 15–29 Severe reduction</td>
<td></td>
</tr>
<tr>
<td>G5 Kidney failure</td>
<td></td>
</tr>
</tbody>
</table>

Increasing risk

1 Consider using eGFRcystatinC for people with CKD G3aA1 (see recommendations 1.1.14 and 1.1.16)

Abbreviations: ACR, albumin:creatinine ratio; CKD, chronic kidney disease; GFR, glomerular filtration rate


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Liver anatomy

- Represents 2% of total body weight
- Weighs about 1300-1500om
- Located right upper quadrant of abdomen behind right ribs
- Surface 2/5
- Lobes 2/2
The Liver and Hepatic Function

- Formation and secretion of bile
- Nutrient and Vitamin metabolism
  - Glucose and other sugars
  - Amino acids
  - Lipids
  - Fatty Acids
  - Cholesterol
  - Lipoproteins
  - Fat soluble vitamins
  - Water soluble vitamins
- Inactivation of various substances
  - Toxins
  - Steroids
  - Other hormones
- Synthesis of plasma proteins
  - Acute phase proteins
  - Albumin
  - Clotting factors
  - Steroid and other hormone binding proteins
- Immunity
  - Kupffer Cells
# Liver function tests

## Implications

<table>
<thead>
<tr>
<th>Biochemical Test</th>
<th>Clinical Implication of abnormality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alanine amino transferase</td>
<td>Hepatocellular damage</td>
</tr>
<tr>
<td>Aspartate Amino Transferase</td>
<td>Hepatocellular damage</td>
</tr>
<tr>
<td>Bilirubin</td>
<td>Cholestasis, impaired conjugation or bile tract obstruction</td>
</tr>
<tr>
<td>Alkaline Phosphatase</td>
<td>Cholestasis, infiltrative disease (malignancy) or bile tract obstruction</td>
</tr>
<tr>
<td>Prothrombin time</td>
<td>Synthetic Function</td>
</tr>
<tr>
<td>Albumen</td>
<td>Synthetic Function</td>
</tr>
<tr>
<td>Gamma-glutamyl Transferase</td>
<td>Cholestasis or bile tract obstruction</td>
</tr>
<tr>
<td>5 nucleotidase</td>
<td>Cholestasis or bile tract obstruction</td>
</tr>
</tbody>
</table>
Liver function tests
clinical interpretation

- Alanine aminotransferase and aspartate amino transferase are all associated with hepatitis, alcohol related and non alcoholic fatty liver disease (NAFLD). Alanine aminotransferase more specific for the liver (aspartate amino transferase linked to muscle cell damage also)
- Alkaline phosphatase linked to obstruction bile flow
- Gamma-glutamyl transferase associated with obstruction bile flow,NALFD but also with alcohol intake
- Bilirubin causes jaundice and linked to obstruction bile flow (also damage to red blood cells in some cases)
- Albumen lower levels associated with liver damage of any cause
- NOTE almost all instances the blood tests would be correlated with more information and imaging tests like ultrasound
Anthropometry
Anthropometry

• A branch of anthropology that involves the quantitative measurement of the human body

• Portable, inexpensive (equipment) and non-invasive assessment of size, proportion and composition of the human body

• Historical perspective including da Vinci and Galton
Adult anthropometric parameters

**Basic measures**
- Height (length)
- Weight (mass)
- Waist and hip circumference
- Mid upper arm circumference
- Skin fold thickness
- Triceps, Biceps, Subscapular and Supra-iliac

**Derived measures**
- BMI
- Waist hip ratio
Body Mass Index ranges and comorbidity risk

**QUANTIFYING OBESITY WITH BODY MASS INDEX (WEIGHT/HEIGHT²)**

<table>
<thead>
<tr>
<th>BMI (kg/m²)</th>
<th>CLASSIFICATION*</th>
<th>RISK OF OBESITY COMORBIDITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.5 - 24.9</td>
<td>Normal range</td>
<td>Negligible</td>
</tr>
<tr>
<td>25.0 - 29.9</td>
<td>Overweight</td>
<td>Mildly increased</td>
</tr>
<tr>
<td>&gt;30</td>
<td>Obese</td>
<td></td>
</tr>
<tr>
<td>30.0 - 34.9</td>
<td>Class I</td>
<td>Moderate</td>
</tr>
<tr>
<td>35.0 - 39.9</td>
<td>Class II</td>
<td>Severe</td>
</tr>
<tr>
<td>&gt;40.0</td>
<td>Class III</td>
<td>Very severe</td>
</tr>
</tbody>
</table>

\[
\text{Body Mass Index} = \frac{\text{Weight (in kg)}}{\text{Height}^2 \text{ (in m)}}
\]

WHO and International Obesity Task Force
Waist-to-Hip Circumference Ratio (WHR)

- Indicator of distribution of subcutaneous adipose tissue
- CHD risk linked to abdominal fat
- Gender and racial variation
- Women WHR 0.85-1.7 (high risk) <0.85 (low risk)
- Men 0.95-1.9 (high risk) <0.95 (low risk)
- Asians increased metabolic risk lower WHR
Child anthropology

• These used to examine values with addition of age related growth patterns (Growth Velocity Charts)

• Some measures are more challenging in babies/infants with different equipment

• Unlike adults some are age dependent
Body composition

- Muscle: 45%
- Essential fat: 3%
- Nonessential (storage) fat: 12%
- Bone: 15%
- Other: 25%

- Dual X-Ray absorptiometry (DXA)
- Bioelectric impedance analysis (BIA)
- Infra-red spectroscopy
- Ultrasound
- Imaging techniques (DEXA)

Image by Fahmida Hashem 2015
Bio impedance

- Low frequency current is unable to pass the cell membrane and it flows outside the cell.
- High frequency current is able to penetrate the cell membrane and can also flow within the cell.
X-ray absorption and DEXA

- Principle of x-ray attenuation
- Bone higher attenuation than soft tissue

Image by Majid Abi SaaB 2015
DEXA

- Use 3 compartment model
- Define bone area
- Use 2 energies to calculate bone mass
- Calculate fat using area outside bone with 2 energies
- Use local uniform composition over bone region to calculate whole soft tissue region
- This permits estimation lean mass
- Examine bone, lean and fat masses for sub regions

Image by Majid Abi SaaB 2015
Cardiovascular and Respiratory measures
Cardiovascular measures
Cardiovascular measures

- Common addition to human panel surveys
- Arterial blood pressure
- Electrocardiogram
- Heart rate variability
- Arterial (carotid) intimal thickness
Arterial blood pressure

- Understand the concept of mean blood pressure, systolic, diastolic, and pulse pressure and mean blood pressure.
- Understand normal variations in arterial blood pressure.
- Understand the relationship between cardiac output blood pressure and total peripheral resistance.
- Understand factors determining blood pressure.
- Regulation of arterial blood pressure

Image by Harsitha Sinivasan 2018
Background

- High Blood Pressure:
- Major risk factor for stroke, myocardial infarction, heart failure, chronic kidney disease, cognitive decline and premature death.
- Untreated hypertension can cause vascular and renal damage leading to a treatment-resistant state.
- Each 2 mmHg rise in systolic blood pressure associated with increased risk of mortality:
  - 7% from heart disease
  - 10% from stroke.
Epidemiology

- Hypertension is common in the UK population.
- Prevalence influenced by age and lifestyle factors.
- 25% of the adult population in the UK have hypertension.
- 50% of those over 60 years have hypertension.
- With an ageing population, the prevalence of hypertension and requirement for treatment will continue to increase.
Electrocardiogram
Electrocardiogram

- Measure of the electrical activity coordinating cardiac cycle across the 4 chambers
- 1924 - the noble prize for physiology or medicine is given to William Einthoven for his work on ECG
- Cardiac systole ventricular contraction=depolarization
- Cardiac diastole ventricular relaxation=repolarization (atrial systole)
Electrocardiogram

- **P wave**: contraction of atria depolarisation
- **QRS complex**: ventricular depolarisation
- **T wave**: ventricular repolarisation
- **ECG trace**: collection of complexes over time so rhythm and rate can be observed

Image by Ragwhender Singh 2008
Electrocardiogram

- Determined by primary pathologies of the heart such as cardiovascular disease
- Also affected by external factors such as exercise, emotional stress, pain, temperature, respiratory, hormonal factors, medicines and substance use
- Consider operator affects also such as lead positioning, body position

Image by Ragwhender Singh 2008
Heart Rate Variability
Heart Rate Variability (HRV)

• HRV is index of autonomic function
• Decrease in HRV increases risk of arrhythmia and sudden cardiac death
• Associated with: depression; diabetes mellitus; heart failure; hypertension

Courtesy Dr M Ababnah
Heart Rate Variability (HRV)

• HRV criterion is normal R-R interval
• Factors influencing data accuracy
• Quality of ECG wave forms
• Quality of data subjects vary
• Quantity data (day ~0.85M beats)
• Influenced by age, gender, disease status and medicines cf. ECG
Heart Rate Variability (HRV)

SDNN
- Standard deviation (SD) of all normal-to-normal RR intervals (NN)

CV%
- $100 \times \frac{SDNN}{RR_{mean}}$

SDANN
- SD of averages of normal RR intervals in all 2 min segments

SDNNIDX
- Mean of SD of normal RR intervals in all 2 min segments

rMSSD
- SD of differences between adjacent normal RR intervals

SBNN=para+sympathetic+hormonal system
SDANN/SDNNIDX=para+sympathetic
rMSSD=parasympathetic

Courtesy of Dr E Karey
Methods of cleaning data HRV

<table>
<thead>
<tr>
<th></th>
<th>SDNN</th>
<th>SDANN</th>
<th>SDNNIDX</th>
<th>rMSSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Data</td>
<td>66.44</td>
<td>14.07</td>
<td>24.63</td>
<td>87.93</td>
</tr>
<tr>
<td>Hand Cleaned</td>
<td>16.36</td>
<td>14.01</td>
<td>9.06</td>
<td>6.39</td>
</tr>
<tr>
<td>2 SD</td>
<td>17.62</td>
<td>13.92</td>
<td>11.21</td>
<td>11.53</td>
</tr>
<tr>
<td>20% cut off</td>
<td>15.80</td>
<td>13.91</td>
<td>8.94</td>
<td>5.89</td>
</tr>
</tbody>
</table>

Courtesy of Dr E Karey
Arterial Carotid Artery Intima Medial Thickness
Arterial Carotid Artery Intimal Medial Thickness

• Arteries throughout the body can be examined by ultrasound
• Allows visualisation and measurement of the lumen and the wall structure
• Carotid artery often used to represent systemic and cerebral circulation
• Identify arterial disease especially atheroma deposition
• Varies by gender, age, ethnicity, BMI, lipid levels hypertension
• Prognostic significance carotid IMT >1.0
Pulse Wave Velocity
Pulse Wave Velocity

Cuffs over the carotid and femoral arteries

Speed of the pulse wave down the full aorta

PWV = Distance/Time
Distance = Carotid - femoral distance
Time = Lag between carotid & femoral waveforms
Arterial stiffness

Pulse Wave Velocity (PWV) is a measure of arterial (aortic) stiffness

- Stiffness is the inverse of compliance ($\Delta$Diameter/$\Delta$ Pressure)
- Higher PWV = stiffer arteries

Large arteries buffer pressure changes from ventricular contraction
- Windkessel effect
Pulse Wave Velocity

I. Correlates of Pulse Pressure
   a. Stroke volume
   b. Effective aortic diameter
   c. Aortic compliance
   d. Pulse wave velocity
   e. Reflection distance

II. Peripheral Amplification of Pulse Wave

III. Summated Forward & Reflected Waves in the setting of a stiff aorta

Reflection sites

Forward Wave
Reflected wave

Systolic Pressure

Reflection
Augmented Pressure

Inflection point

Diastolic Pressure
Pulmonary function
Pulmonary function

• Essential to life, development and health

• Controls gas exchange and acid:base balance
Pulmonary function test

- Human physiology focuses on lung volumes and capacities
- Variation in healthy humans by age, gender, height and fitness
- Also affected by posture, pregnancy and chest wall muscle strength
- In disease predictable changes for classes of condition example COPD
Measurements available

- Pulmonary Function tests are dynamic lung volumes
- Peak expiratory flow rate (PEFR)
- Spirometry
- Exercise capacity such as walk tests (but consider multi factorial)
Peak expiratory flow rate

- Simple hand held device
- Measures airway calibre
- Measures the maximum expiratory flow rate ml/min
- Requires individual to engage with test maximal exertion
Spirometry

- Measures the volume of air an individual can inhale and exhale as a function of time
- Vital capacity
- Forced Vital capacity
- Forced expiratory volume 1 second
- PEFR
- Best of 3 measures in standard conditions
Spirometry

[Diagram showing spirometry curves]

Image from Ravindra Jha 2019
Spirometry

- Most used values are FEV1 and FVC
- Both assessed against predicted values
- FVC 80-120% normal; 70-79% mild reduction; 50-69% moderate reduction; <50% severe reduction
- FEV1 >75% normal; 60-75% mild obstruction; 50-59% moderate obstruction; <49% severe obstruction
- Also FEV1/FVC is .8 or higher normal if .79 or lower abnormal
### Spirometry

<table>
<thead>
<tr>
<th>Disease states</th>
<th>FVC</th>
<th>FEV1</th>
<th>FEV1/FVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstruction</td>
<td>Normal</td>
<td>Reduced</td>
<td>Reduced</td>
</tr>
<tr>
<td>Stiff lungs</td>
<td>Reduced</td>
<td>Reduced</td>
<td>Normal</td>
</tr>
<tr>
<td>Weak chest muscles</td>
<td>Reduced</td>
<td>Reduced</td>
<td>Normal</td>
</tr>
</tbody>
</table>
Human Performance Measures
Timed Up and Go test (TUG)
Timed Up and Go test (TUG)

• Widely used mobility test
• Transfers, gait, neuromuscular mobility
• Stand from a chair (standard height), walk 3m; turn around and walk back (can use aids but this reduces sensitivity balance element)
• Completed multiple times (best 2-4) with one treated as trial (unused)
Timed Up and Go test (TUG)

- Content validity agreed by expert consensus
- Concurrent validity: Berg Balance Scale = 0.81 Bartel Index = 0.79
- Reliability (ICC)
  - Interrater = 0.98
  - Intrarater = 0.96
- O’Sullivan and Schmitz 2007

- Good correlation with Berg Balance Scale $r=0.81$ (Cattaneo et al, 2006)
- Clinical cut offs between 11-13.5 seconds (Schoene et al, 2013)
- Cut off >13 seconds and % fallers prediction (Kisner et al 2012); sensitivity and specificity 87%
Walk speed
Walk speed

- Used widely as measure of muscle strength, physical performance and frailty
- Simple minimal equipment
- Methods vary measurement; different distances (3-30ms); additional actions (whether turn); number trials (2-4)
Walk speed

- Bohannon Age and Ageing 1997
- Reliability by reproducibility maximal and comfortable walk speed \( r > 0.9 \)
- Concurrent validity variety muscle strengths comfortable pace \( (r=0.19-0.25) \) maximum pace \( (r=0.29-0.56) \)

<table>
<thead>
<tr>
<th>Sex/decade</th>
<th>Comfortable gait speed (cm/s)</th>
<th>Maximum gait speed (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Height-normalized</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>s</td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20s</td>
<td>139.3</td>
<td>15.3</td>
</tr>
<tr>
<td>30s</td>
<td>145.8</td>
<td>9.4</td>
</tr>
<tr>
<td>40s</td>
<td>146.2</td>
<td>16.4</td>
</tr>
<tr>
<td>50s</td>
<td>139.3</td>
<td>22.9</td>
</tr>
<tr>
<td>60s</td>
<td>135.9</td>
<td>20.5</td>
</tr>
<tr>
<td>70s</td>
<td>153.0</td>
<td>19.6</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20s</td>
<td>140.7</td>
<td>17.5</td>
</tr>
<tr>
<td>30s</td>
<td>141.5</td>
<td>12.7</td>
</tr>
<tr>
<td>40s</td>
<td>139.1</td>
<td>15.8</td>
</tr>
<tr>
<td>50s</td>
<td>139.5</td>
<td>15.1</td>
</tr>
<tr>
<td>60s</td>
<td>129.6</td>
<td>21.3</td>
</tr>
<tr>
<td>70s</td>
<td>127.2</td>
<td>21.1</td>
</tr>
</tbody>
</table>

\(^a\) actual speed (cm/s)/height (cm).
Walk speed

- Walk speed associated with variety of adverse outcomes
- Lifespan
- Cardiovascular disease outcomes
- Risk dementia
- Walking speed groups defined based on risk of adverse outcomes (Verghese et al 2011)
Chair stands test

• Used as test of leg strength, balance and stamina
• Protocols can be timed maximum number (30 seconds) or time taken to complete number of stands (5 or 10)
• Armless chair and hand positioning
• Associated with falls, disease and community lifespan

Image Hellmers et al Sensors 2019, 19, 1370; doi:10.3390/s19061370
Chair stands test

• Time to 5 stands
  Bohannon et al 2007
• Reliability test re test
  ICC=0.95
• Concurrent validity Lord
  et al 2002 against knee
  flexion/extension
  isometric force  r=0.43
• Normative data 5
  repetition from Bohannon
  et al 2015

<table>
<thead>
<tr>
<th>Age (n)</th>
<th>Mean ± SD (95% CI)</th>
<th>Min-Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>14–19 (25)</td>
<td>6.5 ± 1.2 (6.0–7.0)</td>
<td>4.7–9.7</td>
</tr>
<tr>
<td>20–29 (36)</td>
<td>6.0 ± 1.4 (5.6–6.5)</td>
<td>3.9–11.2</td>
</tr>
<tr>
<td>30–39 (22)</td>
<td>6.1 ± 1.4 (5.5–6.8)</td>
<td>4.1–10.4</td>
</tr>
<tr>
<td>40–49 (15)</td>
<td>7.6 ± 1.8 (6.6–8.6)</td>
<td>5.6–13.2</td>
</tr>
<tr>
<td>50–59 (20)</td>
<td>7.7 ± 2.6 (6.5–8.9)</td>
<td>4.2–12.1</td>
</tr>
<tr>
<td>60–69 (25)</td>
<td>7.8 ± 2.4 (6.8–8.7)</td>
<td>4.7–15.1</td>
</tr>
<tr>
<td>70–79 (24)</td>
<td>9.3 ± 2.1 (8.4–10.1)</td>
<td>5.5–13.3</td>
</tr>
<tr>
<td>80–85 (14)</td>
<td>10.8 ± 2.6 (9.3–12.3)</td>
<td>5.8–17.6</td>
</tr>
<tr>
<td>14–85 (181)</td>
<td>7.5 ± 2.4 (7.1–7.8)</td>
<td>3.9–17.6</td>
</tr>
<tr>
<td>50–85 (83)</td>
<td>8.7 ± 2.6 (8.1–9.3)</td>
<td>4.2–17.6</td>
</tr>
</tbody>
</table>
Physical activity
Physical activity

• Definition: any bodily activity by skeletal muscles resulting in an increased energy expenditure
• Sedentary defined as any waking behaviour characterised by MET <1.5 sitting or reclining
• Inactivity defined at performing insufficient amounts of Moderate to Vigorous PA (compared to guidelines)
Physical activity a complex behaviour

- Type
- Domain or location
- Frequency
- Duration
- Intensity or physiological effort
- Volume product of frequency, duration and intensity
Measuring Physical Activity Levels of Sophistication

• Trade off between accuracy and feasibility
• Criterion methods in black
• Monitor based in blue
• Report based in red
• Note first two are objective and red subjective
Physical Activity Questionnaires

• Systematic review 96 studies
• Reliability objective validity: accelerometers; Heart Rate; Pedometer; double label water
• Reliability by ICC 0.62-0.76
• Validity by r 0.3-0.41
• Old and new tools not difference

Helmerhorst et al IJBNPA 2012
Physical Activity Objective Measures

- Methods use wearables
- Many devices many positions
- Heart rate (limitations elevation stress or environment)
- Accelerometer (cannot differentiate walking on flat or uphill or intensity of movement)
- Solution may be combination HR and Accelerometer
Physical Activity Objective Measures

Daily Activity Energy Expenditure and Mortality Among Older Adults

Log-Rank $P = .05$
$P$ for Trend $= .01$

Activity Energy Expenditure, kcal/d
- $>770$
- 521-770
- $<521$

Time, y

(Manini et al, JAMA 2006)
Grip strength
Grip strength measurement

- Maximal hand grip strength (HGS) is a method for assessing muscle strength and function.
- Number of determinants including volition thus standardisation of methodology critical.
- Image Instrument Takei Japan.
Grip strength measurement influences

- Hand dominance
- Gender
- Age
- Hand size
- Time of day/day of week
- Temperature
- Occupation
- Hand deformities/diseases
- Examiner/motivation
Figure 1. Cross-cohort centile curves for grip strength.

http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0113637
Acknowledgements

- Endocrine system hormones: presentation by Jay Swan 2011
- Kidney function tests: presentation by Tapeshwar Yadav 2016
- Body composition 720: presentation Fahmida Hashem 2015
- Anthropometry and Physical Characteristics in Man: presentation by Babakayode A Olagbaye 2017
- Anthropometry presentation by Amerendra Singh 2013
- Body Composition Concept and Utility: presentation Majid Abi SaaB 2015
- Arterial blood pressure: presentation Mohamed Ababmeh and Lubna Abu Alrub 2015
- Blood pressure and its regulation: by Haristha Srinivasan 2018
- Blood pressure targets 2017 still struggling for the right answer: presentation Magdy El-Masry 2017
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