Future trends in food intake assessment

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Conflict of interest regarding this presentation:

I have been invited and supported by ILSI Europe to give this presentation.

I have no conflict of interest to report with respect to the research presented in this presentation.
Objectives and problems in dietary assessment

Objective is to assess:
- What we eat
- How much we eat
- When we eat
- Under which circumstances

Problems:
- Unreliable
- Intrusive
- Impact behaviour

We need tools that can bypass sources of error while data collection should be more intuitive, fun, less expensive, and more objective and results should be directly available
Methods for assessment of individual intake

**Self-reports**
- 24 hour recalls
- Food records
- Dietary history
- Food frequency questionnaires

**Other methods**
- Observation
- Duplicate portions
- Biomarkers
How can we overcome the problems?

1. Web-based applications, and new technology
2. Standardisation of the techniques
3. Correction for measurement errors
4. Make use of various databases/information
5. New biomarkers
6. Integration of methods
1. Web-based applications and new technologies

Web based technologies

- Self-administered instruments for short- or long-term dietary assessment
- Digital photographs to estimate portion sizes
- Collection at time and place convenient for study participants, lower costs, no data-entry by researchers, ability to apply skipping patterns, restricting answers, and obligatory questions
- Requirement of computer literacy and skills, altered response behaviour, and possible increased reporting and memory bias
Webbased self-administered 24 hour recalls: example Compl-eat

www.compleat.nl
Quicklist for all meals: example evening meal  bread. After that: specification
Specify Step 1: what product did you eat from the food group bread?
Comparison with telephone 24 hR by dietician (n=514)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>% p-value</th>
<th>Lin’s CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal)</td>
<td>-171</td>
<td>430</td>
<td>-8.2</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Energy (kjoule)</td>
<td>-714</td>
<td>1795</td>
<td>-8.2</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>-7.5</td>
<td>13.6</td>
<td>-9.1</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>-9.2</td>
<td>12.5</td>
<td>-11.5</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>-13.5</td>
<td>30.5</td>
<td>-6.0</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Dietary Fiber (g)</td>
<td>-1.6</td>
<td>5.1</td>
<td>-6.8</td>
<td>&lt;.0001</td>
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<tr>
<td>Alcohol (g)</td>
<td>-0.05</td>
<td>10.9</td>
<td>-0.4</td>
<td>0.92</td>
</tr>
<tr>
<td>Bread (g)</td>
<td>0</td>
<td>46</td>
<td>-0.2</td>
<td>0.89</td>
</tr>
<tr>
<td>Cheese (g)</td>
<td>-6</td>
<td>25</td>
<td>-15.3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Dairy (g)</td>
<td>-28</td>
<td>136</td>
<td>-9.1</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Fats, oils (g)</td>
<td>-10</td>
<td>27</td>
<td>-26.0</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Fruit (g)</td>
<td>-12</td>
<td>118</td>
<td>-6.9</td>
<td>0.03</td>
</tr>
<tr>
<td>Vegetables (g)</td>
<td>-18</td>
<td>104</td>
<td>-11.1</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Meyboom et al. In preparation
Improvements

- Done already
  - Simple selection of frequently used foods
  - Description of foods and serving units
  - More reminders

- Future
  - Adding more standard recipes
  - Images of foods, serving units and portion sizes
  - App for use on tablet of smartphone
Brief instruments

Screeners

- Short questionnaires tailored for qualitative assessment of diet, e.g.
  - fruits and vegetable intake
  - dietary patterns (e.g. Mediterranean Diet)
  - adherence to guidelines

- Needed when very limited room for questions on diet
- Useful in situations that do not require assessment of the total diet, e.g. identify population subgroups at risk
- Estimates of intake are not as accurate as those from more detailed methods
Eetscore: Webbased tool including DHD-FFQ and targeted advice [www.eetscore.nl]
Example question on vegetables: on how many days do you eat cooked vegetables?

Vragenlijst

Op gemiddeld hoeveel dagen per week eet u gekookte of gewokte groente?

- ik eet geen gekookte of gewokte groente
- minder dan 1 dag per week
- 1–2 dagen per week
- 3–4 dagen per week
- 5–6 dagen per week
- elke dag
## The Dutch Healthy Diet Index (van Lee et al 2014)

<table>
<thead>
<tr>
<th>Component</th>
<th>Minimum score (=0)</th>
<th>Maximum score (=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical activity (week)</td>
<td>0</td>
<td>&gt;5 activities</td>
</tr>
<tr>
<td>2. Vegetables (day)</td>
<td>0g</td>
<td>&gt;200 g</td>
</tr>
<tr>
<td>3. Fruit+fruit juices (day)</td>
<td>0g</td>
<td>&gt;200g</td>
</tr>
<tr>
<td>4. Fiber (day)</td>
<td>0g /4.2 MJ</td>
<td>&gt;14g/4.2MJ</td>
</tr>
<tr>
<td>5. Fish (day)</td>
<td>0 mg EPA+DHA</td>
<td>&gt;450 mg EPA+DHA</td>
</tr>
<tr>
<td>6. Saturated FA (day)</td>
<td>&gt;16.6 en%</td>
<td>&lt;10 en%</td>
</tr>
<tr>
<td>7. Trans FA (day)</td>
<td>&gt;1.6 en%</td>
<td>&lt;1 en%</td>
</tr>
<tr>
<td>8. Acidic foods (day)</td>
<td>&gt; 7 occasions</td>
<td>≤ 7 occasions</td>
</tr>
<tr>
<td>9. Sodium (day)</td>
<td>≥ 2.45 g</td>
<td>&lt; 1.68 g</td>
</tr>
<tr>
<td>10. Alcohol (day)</td>
<td>Female ≥ 40g</td>
<td>Female ≤ 10 g</td>
</tr>
<tr>
<td></td>
<td>Male ≥ 60 g</td>
<td>Male &lt; 20 g</td>
</tr>
</tbody>
</table>
Example of scoring: low scores for vegetables fruit and fish

Uw totaalscore is 62 van 90.

Uitleg scores:
Score 10: Voldoet wel aan de Richtlijnen Goede Voeding
Score 0: Voldoet niet aan de Richtlijnen Goede Voeding
The person selects the advice about the component he/she is willing to improve

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**U eet geen of erg weinig groente, dat kan beter!**

Het eten van groente is goed voor uw gezondheid. Groente bevat weinig calorieën en veel voedingsstoffen en verkleint het risico op hart- en vaatziekten en een aantal vormen van kanker. Eet 150–200 gram of 3–4 opscheplepels groente per dag.

U kunt op verschillende manieren proberen (meer) groente te gaan eten. Indien u bepaalde groenten niet lust maakt deze groente dan eens op een andere manier klaar: gekookt, gestoomd, gestoofd, gewekt, gegratineerd of met een groentesaus. Voeg niet te vaak kaas of een sausje toe, deze leveren weer extra vet en calorieën.

Andere variatietips:

- Maak eens een gezonde soep met veel verse groenten of diepvriesgroenten.
- Verwerk groente in een gerecht zoals salade of stamppot.
- Doe extra groenten, zoals prei, paprika, wortel en champignon door de pastasaus, het pannenkoekenbeslag of roerei.
- Voeg kruiden en specerijen toe om de groente meer smaak te geven. Denk aan nootmuskaat, basilicum, kerrie of paprika.
Comparison of DHD-FFQ with full length FFQ and urinary data (n=1235)

<table>
<thead>
<tr>
<th>Reference method</th>
<th>DHD-FFQ</th>
<th>Association</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>DHD</td>
<td>54.0</td>
<td>10.1</td>
<td>57.6</td>
</tr>
<tr>
<td>Vegetables</td>
<td>7.0</td>
<td>2.7</td>
<td>6.7</td>
</tr>
<tr>
<td>Fruit</td>
<td>7.2</td>
<td>3.4</td>
<td>8.0</td>
</tr>
<tr>
<td>Fibre</td>
<td>8.2</td>
<td>1.4</td>
<td>7.8</td>
</tr>
<tr>
<td>Fish</td>
<td>4.1</td>
<td>2.9</td>
<td>5.5</td>
</tr>
<tr>
<td>SFA</td>
<td>6.1</td>
<td>3.4</td>
<td>5.5</td>
</tr>
<tr>
<td>TFA</td>
<td>9.9</td>
<td>1.0</td>
<td>9.2</td>
</tr>
<tr>
<td>Sodium</td>
<td>2.4</td>
<td>3.7</td>
<td>6.3</td>
</tr>
<tr>
<td>Alcohol</td>
<td>9.2</td>
<td>1.9</td>
<td>8.6</td>
</tr>
</tbody>
</table>
Smart phone based technology

- Devices get smaller, more convenient, with longer sampling
- ‘Real-time’ recording at eating events with automatic log of time and location of consumption
- Smartphone can integrate multiple sensors, digital photography, voice recording, etc.
- Improvements in compliance and reactivity
- Improvement in data interpretation: pattern recognition, multilevel modelling
Wearable electronic device, containing sensors and data processing and storage elements, i.e. miniature camera and microphone

Subject wearing the device

Electronic circuit board within the device

The eButton takes a picture of the food, removes the background, and then matches the food with a 3D shape

www.lcn.pitt.edu/ebutton
2. Standardisation of methods: examples

Websites for information on the use of dietary assessment tools

- The National Cancer Institute’s Dietary Assessment Primer: A Resource for Diet Research

Development of methods in a standardised and transparent way

- NDARD: referencedatabase based on validation of different FFQs, web and interviewer based 24 hR using biomarkers
Transparant and standard development of food frequency questionnaires by FFQ creator

Scientific basis of the Dutch FFQ-TOOLTM, a computer system to generate, apply and process food frequency questionnaires
How to select food items automatically?

- Selecting foods that are important for
  - Level of intake
  - Ranking
    - Stepwise regression: uses variance and covariance (Willett 2012)
    - MOM2*: uses variance

- Using food consumption database with open data (e.g. the Dutch National Food Consumption survey)

*[Mark, 1996; Am J Epidemiol]*
Standardisation e.g. on FFQ development the Dutch FFQTOOL

**DATASET**
- Selection of
  - Reference population
  - Nutrients of interest
  - Items

**QUESTIONNAIRE**
- Selection of
  - Dataset
  - Reference period
- Introduction text
- Introduction questions
- Questions about food intake
- Participants
- Results

Molag et al. 2010
3. Reduction of measurement errors: improvement of methods

<table>
<thead>
<tr>
<th>Error</th>
<th>Potential reduction of errors by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>Photo’s (recognition by software), barcodes, purchases (retail) + personalised food list</td>
</tr>
<tr>
<td>Occasionally consumed foods</td>
<td>Combine 24h recall and FFQ (web-based); ambulatory monitoring</td>
</tr>
<tr>
<td>Portion size estimation</td>
<td>Smartphone with 3D-options</td>
</tr>
<tr>
<td>Food tables</td>
<td>Harmonisation of food composition databases</td>
</tr>
<tr>
<td>Total amount of food and energy</td>
<td>Link to external data; accelerometry, body size measures</td>
</tr>
</tbody>
</table>
Correction by statistical methods. Example—Use of Duplicate portion collection as reference method of FFQ

- No food composition table data
- Not based on memory
- No portion size estimation
## Results and conclusion about DP vs 24 hR

**Protein**
- DP: Proportional scaling bias = 0.58±0.06, Correlated error with FFQ = 0.28±0.06, Attenuation factor = 0.74±0.07
- 24hR: Proportional scaling bias = 0.53±0.08, Correlated error with FFQ = 0.28±0.05, Attenuation factor = 0.45±0.06

**Potassium**
- DP: Proportional scaling bias = 0.72±0.10, Correlated error with FFQ = 0.17±0.07, Attenuation factor = 0.54±0.06
- 24hR: Proportional scaling bias = 0.68±0.09, Correlated error with FFQ = 0.27±0.06, Attenuation factor = 0.47±0.05

**Sodium**
- DP: Proportional scaling bias = 0.52±0.11, Correlated error with FFQ = 0.19±0.07, Attenuation factor = 0.43±0.08
- 24hR: Proportional scaling bias = 0.32±0.13, Correlated error with FFQ = 0.29±0.05, Attenuation factor = 0.19±0.06

DP is a better reference method than the 24hR for FFQ validation for nutrients that currently have no recovery biomarker.
4. Make use of different databases and self-learning systems

- Purchase information of the consumer
- Make use of own reported data
- Information from the manufacturers
- Other data as predictors of intake
5. Development of new biomarkers

- Biomarkers for specific target groups e.g. Clinical setting
- Biomarkers for specific foods
Metabolomics techniques to discover biomarkers of food intake
6. Combination of methods: SPLENDID

http://splendid-program.eu/splendid-technology/

Types of sensors

- **Mandometer**
  - Plate weight at fixed sampling rate

- **Chewing sensor(s)**
  - Air microphone (adapted in an ear bud)
    - Audio recording
  - Bone conduction microphone
    - Audio recording
  - Photoplethysmography
    - Light measurement time series

- **Physical activity sensor**
  - Triaxial accelerometer

- **Also, user provided input**
HDIM-Physiodom-project: a home monitoring system (EU-project)

- Dietary quality: Eetscore
- Appetite: SNAQ
- Nutritional status: MNA-SF
- Weight
6. Integration of methods
Summary future steps

- Challenge is to address different target groups (e.g. Children, adolescents, elderly, patients, immigrants, low SES)
- Databases: types of foods, brands, amounts in packages and portions, recipes, nutrient database
- Technology: web-based technologies, mobile phone applications, sensors, home monitoring, smart weighing scales, photo’s, videotaping, scanning
- Psychology: Use of technology, feasibility, change of eating behaviour
- Modeling: Use of databases, internet information, snapshots of intake, optimising diet
- Biochemistry: biomarkers of intake
- Integration: integrate all information?
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