MCNER Webinar Series

A Review of Digital Innovations for Precision Nutrition

Thursday, February 22, 2024

Moderator:
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- Slides are posted at villanova.edu/cope
- From right menu→ Webinars
- Go to 2/22/24 webinar presented by Ricardo Gutierrez-Osuna, PhD.
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- This Continuing Professional Education (CPE) activity is pending approval by the Commission on Dietetic Registration for 1 CPEU.

- Contact hours are not available for nurses for this webinar.
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- To receive CE credit, you must attend the entire program.
- Evaluation completion is encouraged by all disciplines
- Level 2
- Suggested CDR Performance Indicators: 5.2.5, 5.2.7, 6.2.3, 8.2.3
A Review of Digital Innovations for Precision Nutrition

Ricardo Gutierrez-Osuna, PhD.
Professor of Computer Science and Engineering
Texas A&M University
Disclosures

There are no relevant financial relationships with ineligible companies for the planners of this activity.

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A review of digital innovations for precision nutrition

Ricardo Gutierrez-Osuna
Motivation

Diet and exercise are essential components of interventions to diabetes and obesity

– Sensing approaches exist to measure exercise automatically
Motivation

Diet and exercise are essential components of interventions to diabetes and obesity

– Sensing approaches exist to measure exercise automatically
– Yet, no automated methods exist to measure diet
– Currently, diet monitoring requires manual entry or recall, which are tedious and error-prone
– Can sensing technology and AI help?

Ricardo Gutierrez-Osuna | CSE@TAMU
Overview

In this talk, I overview current technology in 3 areas

– Advances in mobile applications for diet logging
– Wearable sensors to detect dietary behaviors
– Personalized nutrition programs

I also present ongoing work at TAMU in this area
I. Mobile applications for diet logging

Advantages over paper-based diaries

– Ubiquity of smartphones avoids the need to carry physical food diary

– Access to large food databases
  • MyFitnessPal has 11M food items (unverified)
  • Nutritionix has 800k grocery items and 170k restaurant items (verified)

– Ability to scan barcodes of packaged foods

– Can be integrated with external devices
  • Smart scales
  • Fitness trackers
  • Continuous glucose monitors, ketone monitors
Recent advances in mobile apps

– Photographic food diaries
  • Avoid data hoarding
  • Photos encourage in-the-moment awareness
  • Photos improve memory recall and understanding

– Food recognition from photographs using AI
  • Apps: Lose it!, CalorieMama, Snaq, Undermyfork
  • APIs: bite.ai, FoodAI
Examples

undermyfork

snaq
https://doi.org/10.1145/3391624
II. Wearable sensors for diet

Physical sensors

– Gesture recognition with inertial sensors
  • 3D accelerometers
  • Gyroscopes

https://mug.ee.auth.gr/intake-cycle-detection/
II. Wearable sensors for diet

Physical sensors

– Gesture recognition with gyro and accelerometers
– Muscle movement and sound with electromyography and microphones

II. Wearable sensors for diet

Physical sensors

– Gesture recognition with gyro and accelerometers
– Muscle movement and sound with electromyography and microphones
– Smart utensils

https://www.hapilabs.com/
Chemical sensors

– Breathalyzers (ketone meters, metabolic fuel)
– Experimental sensors (sweat, tooth-mounted)
– Continuous glucose/ketone monitors

https://www.ketonix.com/
https://www.lumen.me/

[Tseng et al, 2018]
[Sempionatto et al. 2020]

https://www.freestyle.abbott/
https://www.dexcom.com/
https://www.ascensiadiabetes.com/
III. Personalized nutrition

Based on gut microbiome
- DayTwo
- Viome

Based on CGMs
- NutriSense
- Levels
- Cignos

https://www.daytwo.com/
https://www.viome.com/
https://www.nutrisense.io/

DayTwo [Zeevi et al. 2015]
DayTwo [Zeevi et al. 2015]


https://www.daytwo.com/
The Zeevi et al. (2015) study
Ongoing work at Texas A&M University

The goal of Zeevi et al. (2015) study was to develop a **forward** metabolic model

– Given food macronutrients (and phenotype* variables), predict the postprandial glucose response (PPGR)

My work with colleagues at TAMU aims to develop **inverse** metabolic models

– Given the PPGR to a meal (and phenotype), predict the meal’s macronutrient composition

* HbA1c, BMI, gut microbiome...
Inverse problems deal with calculating the causal factors that led to a series of observations:

- Localizing brain activity from surface measurements (EEG)
- Localizing a sound from dispersed microphones
- Reconstructing speech acoustics from facial movements
- Solving crime from evidence...
How to build inverse metabolic models

In the long term, by developing sensors for other nutritional biomarkers
- Amino acids (for protein)
- Triglycerides (for fat)
- Glucose + Insulin (for carbs)

In the short term, by exploiting information in the PPGR
Laboratory study (proof of concept)

Fifteen subjects consumed nine liquid meals with different amounts of macronutrients

– Participants consumed meals in a fasted state
– Participants rested for 8 hours in a clinic
– Study days were 2-3 days apart
– Participants wore a Freestyle Libre CGM

<table>
<thead>
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<th>Meal</th>
<th>CHO (g)</th>
<th>Protein (g)</th>
<th>Fat (ml)</th>
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<td>C1P1F1</td>
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<td>15</td>
<td>13</td>
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<tr>
<td>C1P2F2</td>
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<tr>
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<tr>
<td>C3P3F3</td>
<td>180</td>
<td>60</td>
<td>52</td>
</tr>
</tbody>
</table>
Experimental data (2)

At regular intervals, we drew blood samples to measure four types of biomarkers

- Glucose (CGM, LC, finger stick)
- Amino acids (24 AAs + combos)
- Triglycerides
- Insulin
Visual inspection of CGM responses

(a) Blood glucose (mg/dL) over time (15 min)

- C3P2F2
- C2P2F2
- C1P2F2

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Data preparation

For each post-prandial glucose response (PPGR), we

- Subtract the baseline at mealtime
- Compute area-under-the-curve (AUC) at various times
- Perform z-score normalization to remove individual diffs
Prediction model

For prediction, we use an AI technique based on decision trees

https://www.datacamp.com/tutorial/decision-tree-classification-python
Prediction model

For prediction, we use an AI technique based on decision trees

- The particular technique is known as XGBoost
- XGBoost builds an ensemble of trees in an iterative fashion

Data set: \((X, y)\)

Add up predictions
Prediction results from CGM

We report prediction accuracy in terms of the Normalized Root Mean Square Error (NRMSE)

- NRMSE is the percent error relative to ground truth
- Assume a participant consumed a meal containing 50 grams of carbs, and the model predicted 40 grams

\[ NRMSE = \frac{50 - 40}{50} = 20\% \]
Prediction results from CGM

Prediction errors based on CGMs alone are too large to be of practical use.

In a second step, we investigated additional biomarkers that might help reduce errors:
- Individual biomarkers (e.g., Leucine)
- Combinations of biomarkers (e.g., Leucine + Glucose)

Potential biomarkers (measured in the study):
- Amino acids (24 individual AAs + combinations)
- Triglycerides
- Insulin
Single-marker predictions (Carbs)
Single-marker predictions (Protein)

NRMSE

LYS, TRP, LEU, TYR, EAA, ILE, PHE, BCAA, SUMA, MET, VAL, PRO, ASN, NEAA, ARG, ASP, ORN, LC-TG, LC-glucose, LC-insulin, THR, GLY, GLU, ALA, cgm-glucose, SER, TAU, hPRO, CIT, GLN, HIS, tauMEH
Single-marker predictions (Fat)
Model for multi-marker predictions
Multi-marker predictions (Carbs)

Notation: GITA

NRMSE

Amino Acids
Triglycerides
Insulin
Glucose

No Insulin

No Glucose

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Multi-marker predictions (Protein)
Multi-marker predictions (Fat)

No Triglycerides
Ongoing work

Ambulatory study

Breakfast start
Breakfast end
Lunch start
Lunch end
Dinner start
Dinner end


Graph showing glucose levels with time.
Ongoing work

Accounting for macronutrient correlations
Ongoing work

Implantable sensors for glucose and amino acids
Caveats...

Technology can reduce burden

– But is burden always bad?
  • There appears to be a tradeoff between reducing user burden and enabling users to form the critical habit of monitoring their diet [Turner-McGrievy et al., 2021]

– Law of attrition
  • eHealth trials tend to experience higher dropout rates than drug trials [Eysenbach, 2005]
  • Adherence to diet monitoring is likely to decrease with time, no matter how low-burden the tool is
Thank you
References


To Receive Your CE Certificate

• A link to an evaluation will be sent within a day or two.

• Although completing an evaluation is not required, we truly appreciate your feedback. 

  If you do not see the evaluation, look in your spam folder.

• CE certificates for RDs/RDNs/DTRs will be emailed to you once the activity receives approval from CDR.
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Upcoming MCNER Free Webinar

Food Allergy Prevention and Management

Wednesday, March 20th
12-1 PM ET

1 contact hour (CH) RN/NP
1 CPEU RD/RDN/DTR

Registration:
villanova.edu/cope

Raquel Durban, MS, RDN, LD/N
Registered Dietitian
Carolina Asthma and Allergy Center
Q&A

Moderator: Lisa Diewald, MS, RDN, LDN
mcner@villanova.edu

If you are an RD or RDN and have any questions or concerns about this continuing education activity, you may contact CDR directly at QualityCPE@eatright.org.