Cachexia, Artificial Intelligence and Smartphones

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Cancer Cachexia

- Potential of AI in improving cachexia assessments
- Current examples of AI and cachexia domains
  nutrition, imaging, genetics
- Limitations and opportunities

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AI

- Machines imitate human thought processes
- Ability to learn using digital binary logic of computers and then simulate the capacity for abstract, creative, deductive thought
- Rather than being taught everything step by step, machines can be programmed to think like humans, by observing, classifying and learning from mistakes

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AI and Artificial Neural networks

- ANN “a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs” *Robert Hecht-Nielsen*
- Use Reinforced learning and deep neural networks
- ANN enables discovery of more complex relationships in data than traditional statistical modes
- ANN are adaptive and can learn from data -this ability does not depend upon the prior knowledge of rules and only broadly resembles the original training data

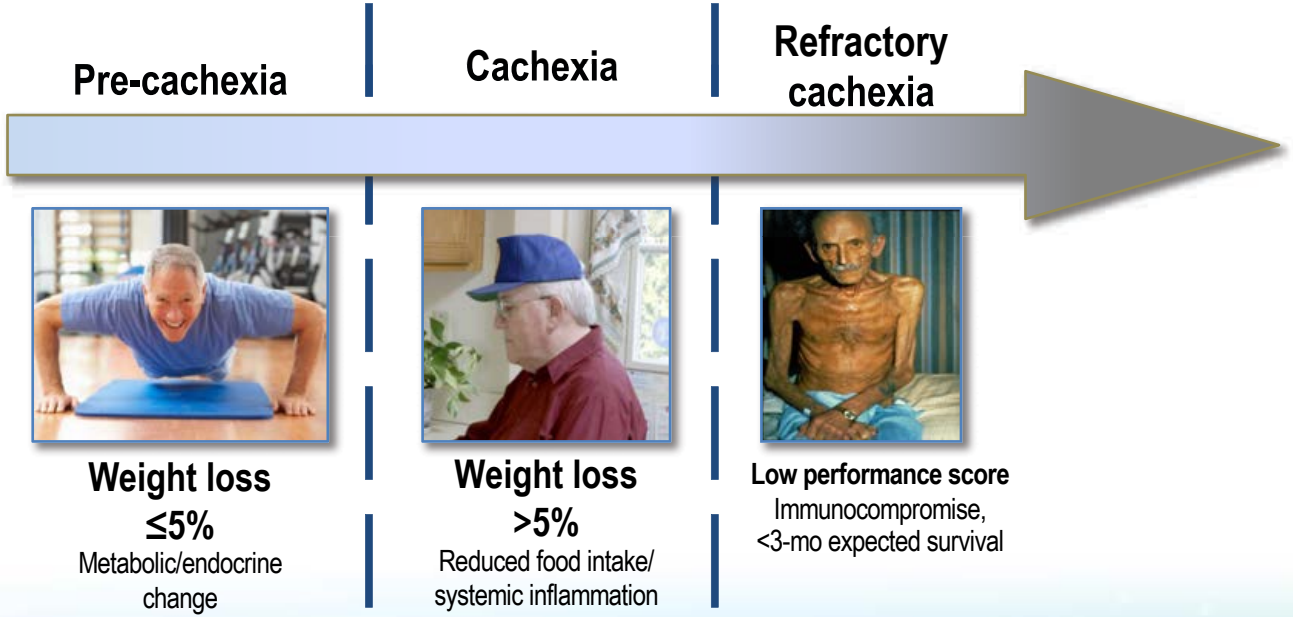
Definition of Cancer Cachexia

- Multi-factorial syndrome
  - Characterized by ongoing loss of skeletal muscle ± loss of fat mass
  - Cannot be reversed fully by conventional nutritional support
  - Leads to progressive functional impairment
  - *Complex, imprecise*

Weight loss >5% over 6 mo that cannot be attributed
to simple starvation
or
BMI <20 + weight loss >2%
or
Appendicular skeletal muscle mass index consistent with **sarcopenia + weight loss >2%**

BMI, body mass index.
Fearon K, et al. *Lancet Oncol*. 2011;12:489-495 .

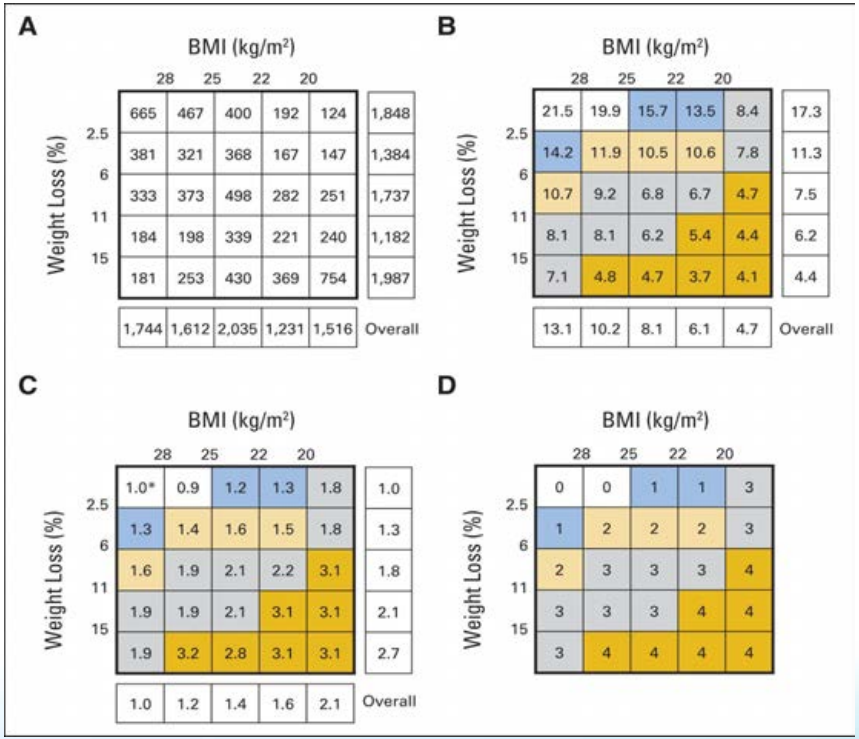
Stages of Cancer Cachexia



- *Identify anabolic opportunity; determine clinical trial inclusion*
- *Avoid using medication or additional resources on non-cachexia patients*
- *Need more patient data to distinguish between stages*

Fearon K, et al. *Lancet Oncol*. 2011;12:489-495.

Survival =a function of BMI and % weight loss in *8160 patients*

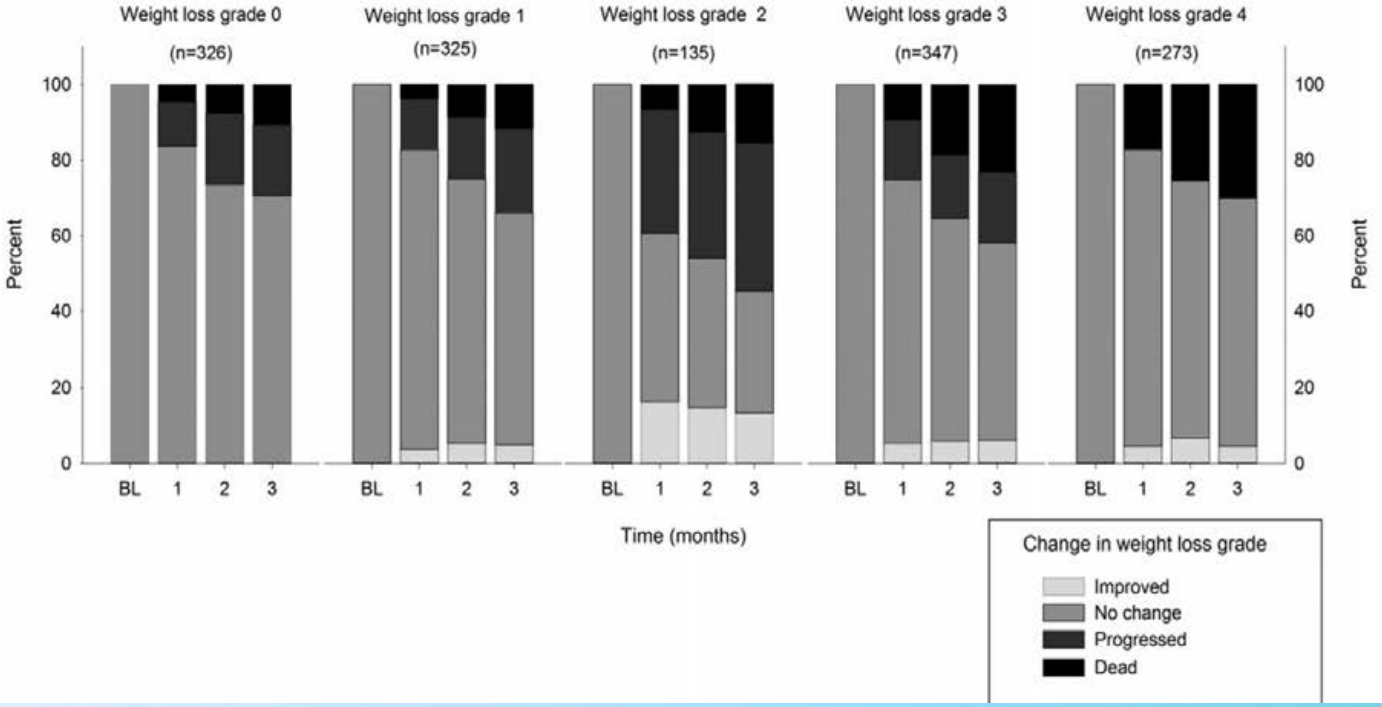


Median survival by grade
0=20.9 months
1=14.6
2=10.8
3=7.6
4=4.3

Panels A to C represent a 5 × 5 matrix analysis of the five categories of BMI and five categories of %WL for a total of 25 possible combinations. The (A) sample size, (B) median overall survival (months), and (C) unadjusted estimated hazard ratios (HRs; HR, 1.0) are presented for each cell. (*) Reference categories are BMI ≥ 28.0 kg/m2 and weight stable ± 2.4%. Different colors represent significant differences (P < .05) in median overall survival and HRs within and between cells of the matrix. Panel D represents the BMI-adjusted WL grading system (grades 0 to 4)

Lisa Martin *JCO* **2015**

Figure 4 Bar charts for each baseline weight loss grade (0–4) showing the likelihood of improvement to preceding or progress to subsequent grades death at 1, 2, and 3 months of follow-up.



Additional cachexia domains

- Body composition[1]
- Patient reported outcomes

  Appetite[2]

  Nutrition Impact symptoms [3,4]

  Fatigue and function[5]
- Dietary intake[6]
- Physical Function[7]
- Chronic inflammation[8]
- Other- chemo & endocrine dysfunction[9]
- Genomics

1.Prado .Proc nutr Soc 2016 Quinten Lancet Oncology 2011. 2. Farhangfar 2010 Oral Onc. 3.Zhou JPSM 2017 4.Del Fabbro JPM 2010 6. Nasrah Clin Nutr. 2016 9.Burney JCEM2012

Genomics and Cachexia

- Predict risk, prognosis, Rx response for cachexia based on genomic data
- Muscle reserve may be a factor in developing cachexia
- Allele variations are associated with muscle mass & strength
- myostatin (GDF8, K133R), CNTF and receptor, vitamin D receptor (VDR Bsml), androgen receptor gene (CAG repeats), cyclin-dependent kinase inhibitor 1A
- SNPs of ACE and TNF associated with cachexia

Morley JCSM 2017,Johns JCSM2017

Genomics, AI and Cachexia

- New insight into genetics of lean body mass and sarcopenia
- Lean body mass is a highly heritable trait
- A meta-analysis of genome-wide association studies for whole body lean body mass in >38000 individuals
- five novel genetic loci were significantly associated
- for whole body lean mass and for appendicular lean mass

- Future :Genomics England project=100000 genomes sequenced
- 1 sequenced genome=200 GB
- Cost $1500 will decrease to $100

Kiel Nat Commun. 2017

nature REVIEWS CLINICAL ONCOLOGY

Extensive muscle wasting can be obscured by large fat mass

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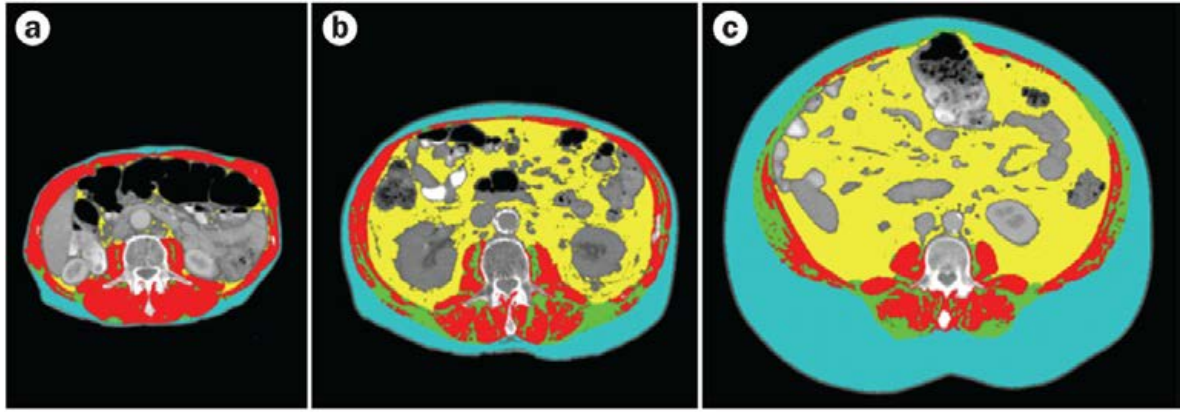
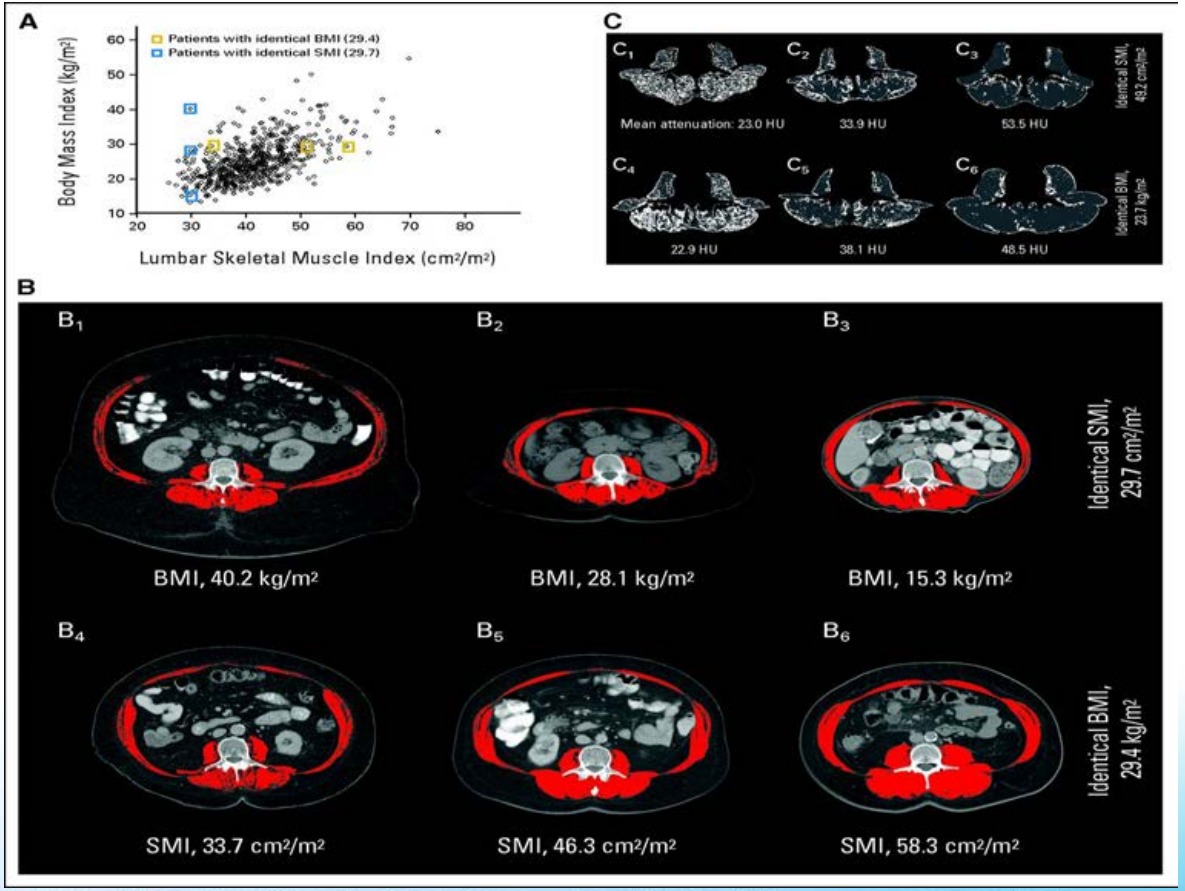


Fearon, K. *et al*. (2012) Understanding the mechanisms and treatment options in cancer cachexia
Nat. Rev. Clin. Oncol.

Variation between skeletal muscle index (SMI) and body mass index (BMI) females (n = 645)



Patients with cancer cachexia by the conventional criterion (involuntary weight loss) and by two additional criteria (muscle depletion and low muscle attenuation) share a poor prognosis, regardless of overall body weight

Martin L et al. JCO 2013;31:1539-1547

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AI identifies aging signals in CT scans

- Application of pattern recognition and machine learning as a tool for analyzing medical images
- CT scans of abdominal L4 sections (Baltimore Long Study Aging) n=1092
- Method: supervised machine learning and generic image descriptors
- Goal: insight into tissue changes (texture and morphology) with aging

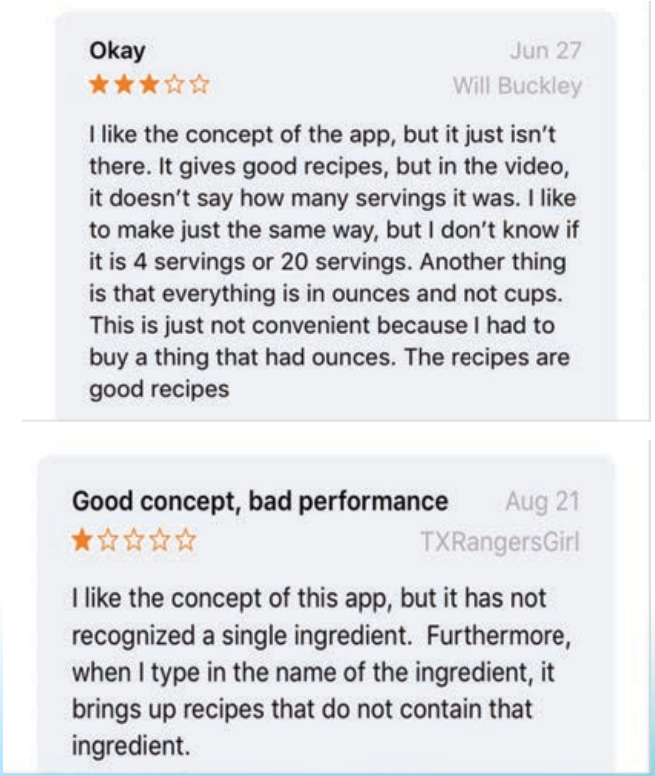
- Robust aging signal found
- Males > Females
- Aging signal predominantly In Adipose tissue

Orlov Acad Radiol. 2017

Goals	• Identify those at increased risk • Identify patients early • Monitor relevant outcomes • Incorporate a multidisciplinary approach
Assessment Tool	• Symptom severity assessment including appetite (e.g. ESAS) • Checklist of nutritional impact factors and weight loss (e.g. abbreviated PG-SGA) • Physical performance (e.g. SPPB, handgrip) dynamometer
Multidisciplinary* Management	• Physician = Pharmacological symptom management, education • Dietitian = Nutritional counseling, protein and calorie goal • Physical Therapist = resistance and aerobic exercise, fall prevention • Psychologist = reframing eating, conscious control, body image • Nurse = education, reinforcement of management plan, phone contact
Monitor Key Outcomes	• Weight change, BMI • Appetite • Fatigue, Nutritional impact symptoms and overall symptom burden • Physical performance • Body composition

Nutrition-Related Mobile Apps

- 58% U.S own smartphones
- Cost of Apps
- Dietician/expert consult available?
- Free trials
- Syncs with other apps and devices
- Reduce recording burden



Okay Jun 27

★★★☆☆ Will Buckley

I like the concept of the app, but it just isn't there. It gives good recipes, but in the video, it doesn't say how many servings it was. I like to make just the same way, but I don't know if it is 4 servings or 20 servings. Another thing is that everything is in ounces and not cups. This is just not convenient because I had to buy a thing that had ounces. The recipes are good recipes

Good concept, bad performance Aug 21

★☆☆☆☆ TXRangersGirl

I like the concept of this app, but it has not recognized a single ingredient. Furthermore, when I type in the name of the ingredient, it brings up recipes that do not contain that ingredient.

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Image recognition services estimate nutritional values dietary assessment and management

Google Cloud Vision

AWS Rekognition

Microsoft Computer Vision

Instagaze

Zeta Metrics
Instagaze

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Smartphone Applications for Promoting Healthy Diet and Nutrition: A Literature Review

- 193 articles identified in the searches
- 9 RCT's
- Comparisons to web-based app, tracking with paper, smartphone plus counseling, health education
- Use of smartphone apps associated with better dietary compliance for lower calorie, low fat, and high fiber foods, physical activity levels (p=0.01-0.02) more weight loss (p=0.042-<0.0001)

Coughlin SS Jacobs J Food Nutr. 2015

Popular Nutrition-Related Mobile Apps

- Objective: analyze main features of the most popular nutrition apps
- Compare strategies and technologies for dietary assessment and user feedback
- 13 apps qualified based on search terms and popularity
- high number of installs indicates interest for diet monitoring and recommendation
- All apps collecting dietary intake used same nutrition assessment method (food diary record) and technologies for data input (text search and barcode scanner)
- Image recognition, natural language processing, artificial intelligence, ***not*** identified.
- None of the apps had a decision engine capable of providing personalized diet advice

Franco JMIR Mhealth Uhealth. 2016

Mobile Apps and food recognition

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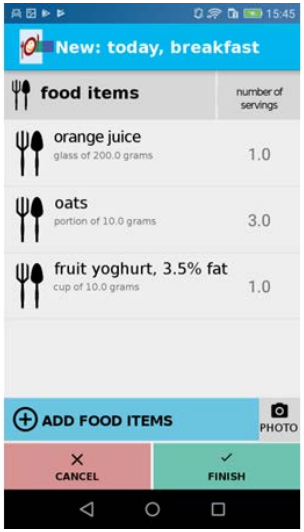
A Novel Mobile Phone App (OncoFood) to Record and Optimize the Dietary Behavior of Oncologic Patients *Pilot Study*

- feasibility and applicability of a novel mobile app to assess and evaluate dietary behaviors
- 1400 nutritional records analyzed
- App=simple, set goals,recording the daily intake, a comparison of nutrient targets and current status
- All patients received nutritional analysis and nutritional counseling
- 12 also used the app vs control
- Weight and body composition evaluated after 4 weeks

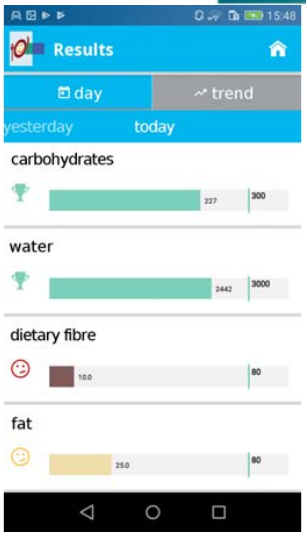
Orlemann JMIR Cancer 2018

Oncofood app screenshots

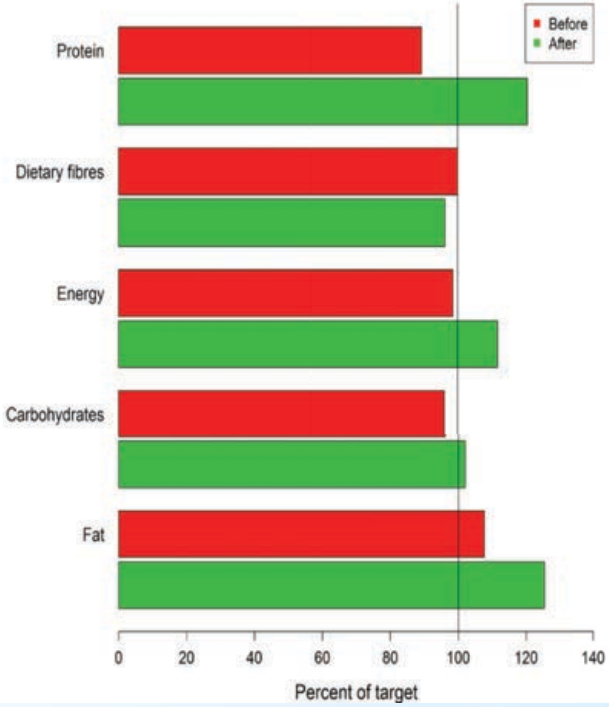
Nutritional goals and weight

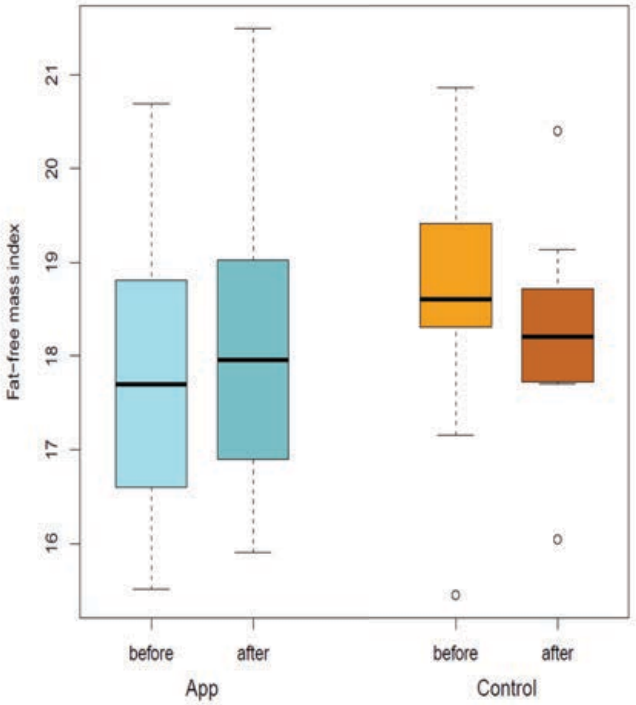


Daily food record
Keyboard or voice



Nutritional goals met





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Opportunities

- Easy, accurate dietary records with image recognition
- Show patterns of protein and daily calorie consumption, along with energy expenditure
- Motivational Feedback to modify behavior
- Combined with data from shopping, grocery delivery services, app users are guided to order groceries using recipes that better replace macronutrients and taste better

Internet of Medical Things

- Tracking physical activity
- Overcoming inaccuracy
- Interconnected devices
- Medical and non-medical

Summary AI and cachexia

- Enhance assessment of body composition, muscle quality, calorie needs, metabolic rate, physical activity, muscle risk
- Enhance screening and prediction for cachexia and identify clinically relevant pre-cachexia/cachexia conditions
- Enhance assessment + management of dietary patterns and behavior
- Individualize management for a multi-domain, heterogeneous syndrome
- Underserved gain increased access to assessment & Mx
- Identify effective pharm Rx (old, repurposed, new)

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