SICOM & AOCO 2024

SOMS International Conference on Obesity & Metabolism
in conjunction with Asia-Oceania Conference on Obesity

Hosted by SOMS Society for Korean Obesity and Metabolism Studies

Co-Hosted by Asia Oceania Association for the Study of Obesity

Empowering Health, Inspiring Change: Practical Solutions for Obesity

Date October 24 (Thu)~26 (Sat), 2024

Venue aT Center, Seoul, Republic of Korea (3F Segyero Room & 4F Changjo Room)

Rising Star Symposium

Wearable device utilizing an electrical impedance tomography (EIT) system for quantification of hepatic steatosis, liver fibrosis and the role in ambulatory monitoring

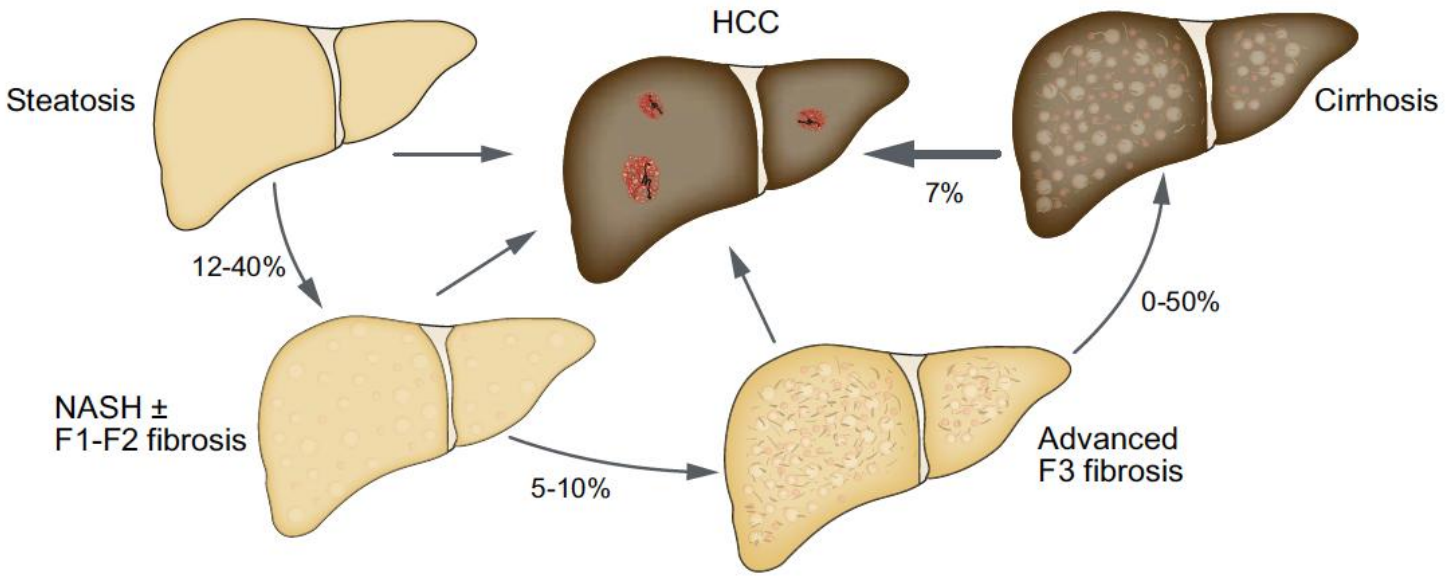
Dr. Lung-Yi Loey Mak

HKU Med

Department of Medicine, School of Clinical Medicine, LKS Faculty of Medicine, The University of Hong Kong, Hong Kong
State Key Laboratory of Liver Research, The University of Hong Kong, Hong Kong

Background

- Metabolic dysfunction-associated steatotic liver disease (MASLD) affects 60% of people with obesity
- MASLD can progress to steatohepatitis, cirrhosis and hepatocellular carcinoma (HCC)



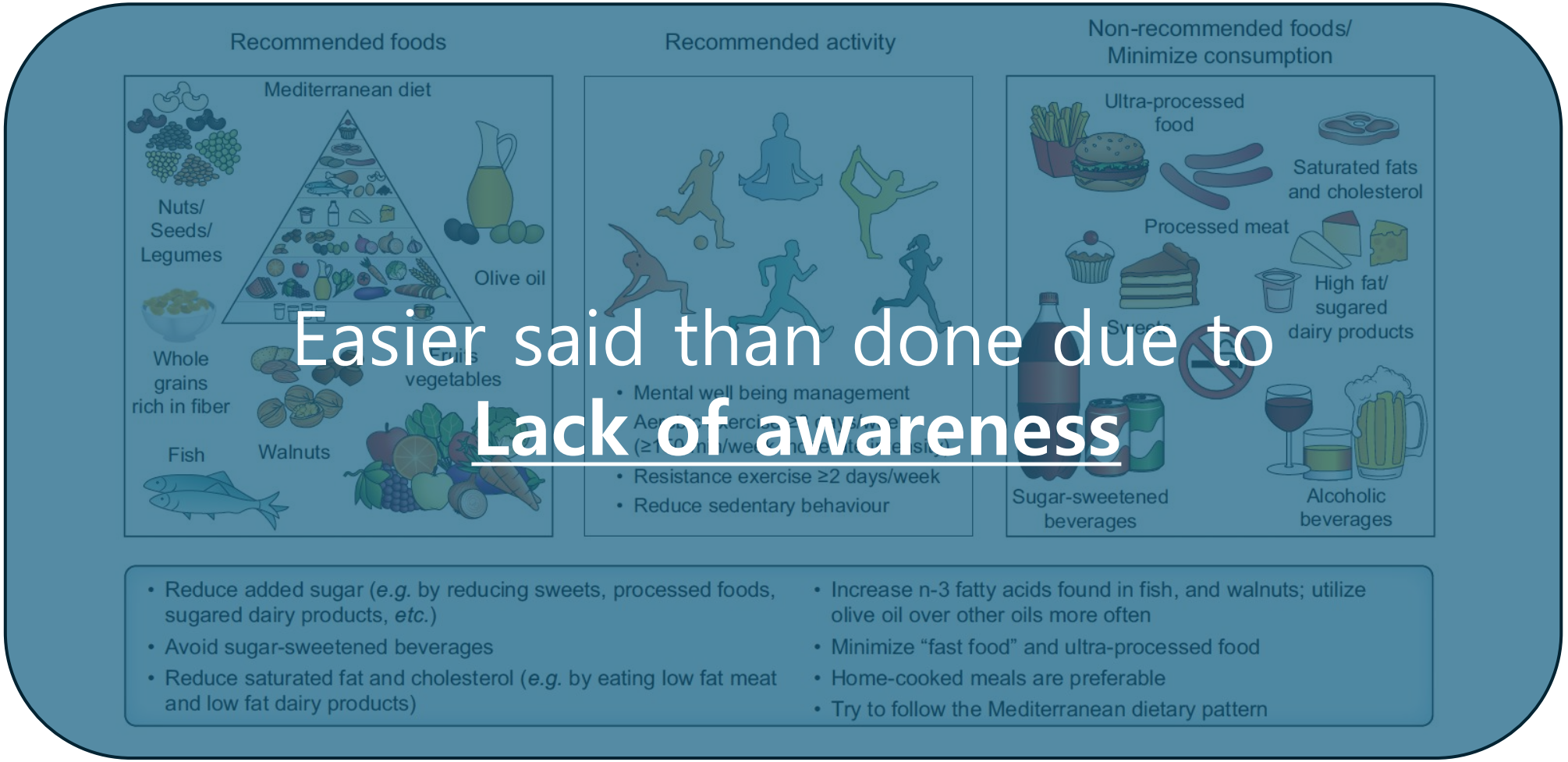
Fassio E et al. Hepatology 2004
Day CP. Gastroenterology 2005
Singh S et al. Clin Gastroenterol Hepatol 2015

Background

- The only effective treatment for patients with MASLD living outside USA is achieving weight loss through lifestyle modifications, which is largely dependent on patient motivation
- Weight loss of ≥7-10% is associated with significant improvement in steatosis, necrosis and inflammation without worsening of liver fibrosis
- Difficult to achieve target weight loss due to lack of motivation – need long-term behavioral changes to lifestyle
  - >80% patients fail to achieve target weight loss
  - <10% patients can maintain a healthy body weight

Musso G et al. Hepatology 2010
Vilar-Gomez E et al. Gastroenterology 2015

Background



Easier said than done due to

Lack of awareness

Francque SM et al. JHEP Rep. 2021

Background

- **Patient empowerment** in *chronic medical illness*
  - an essential process for patient participation and gain a sense of control over their condition

- **Ambulatory monitoring** can achieve **patient empowerment** and **improve clinical outcomes** in chronic medical conditions
  - diabetes mellitus: ↑ glycemic control
  - hypertension: ↑ blood pressure control
  - ↑ adherence to medical therapy

Nutbeam D. Health Promot 1986
Franciosi M et al. Diabetes Care 2001
Vrijens B et al. Control Clin Trials 1997
Friedman RH et al. Am J Hypertens 1996
Rudd P et al. Am J Hypertens 2004
Haynes RB et al. Lancet 1976

- A novel **portable** **non-invasive** device is recently developed and able to **rapidly** quantify the degree of hepatic steatosis and liver fibrosis in an unsupervised manner

We hypothesize that performing **ambulatory monitoring of liver fat** will improve hepatic steatosis through patient empowerment and boosting health awareness.

- **Electrical Impedance Tomography (EIT)**
  - Electrical impedance = a measure of the total opposition that a circuit presents to electric current
  - Electrical conductivity of biological tissues varies according to tissue type (inductor vs capacitor) and frequency of the applied electrical field
  - **The impedance data → image reconstruction 'tomography'**

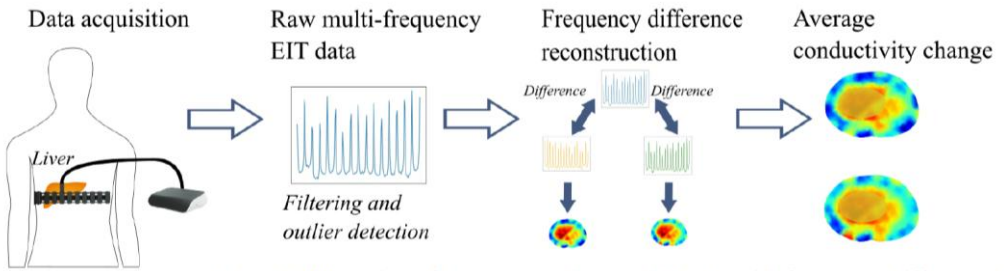
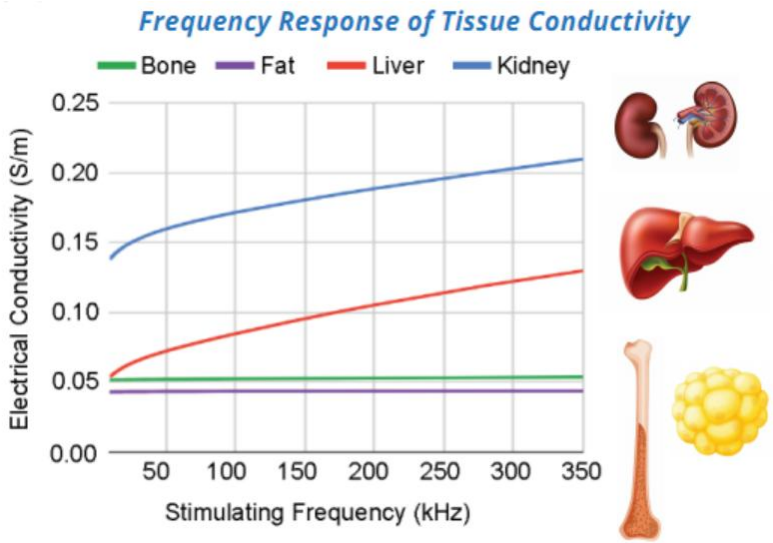
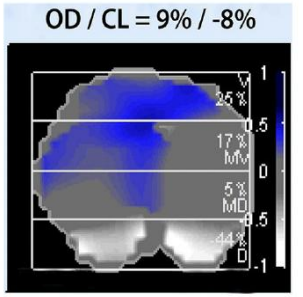


Figure 1 Illustration of the steps used to predict CAP with frequency-difference EIT



Solid organs such as liver and kidney are sensitive to the frequency, while bone and fat are less sensitive to frequency changes

- EIT has been used in other clinical settings:
  - Assist mechanically ventilated patients in AICU to prevent lung damage caused by invasive mechanical ventilation (Heines et al., 2018)
    - Dräger's EIT lung imaging device (PulmoVista® 500) (Walsh & Smallwood, 2016)
    - Enlight® (Timpel, Brasil) (Bachmann et al., 2018)



Alveolar overdistension and alveolar collapse (OD/CL)

Heines SJH et al. J Clin Monit Comput 2019

Aims

- To evaluate the **accuracy** of the EIT technology to quantify hepatic steatosis and fibrosis (part 1)
  - *Benchmark against VCTE (fat and fibrosis)*
- To explore the role of **ambulatory monitoring** of hepatic steatosis using the EIT system (part 2)

Method

Inclusion criteria

Fatty liver patients

- Age: 20 – 75
- Diagnosed with fatty liver at S1, S2 and S3 stages, will be included. These patients will undergo an interview (with a structured questionnaire, see Appendix), FibroScan® and EIT examination.
- Gender: Male/ Female.

Control subjects

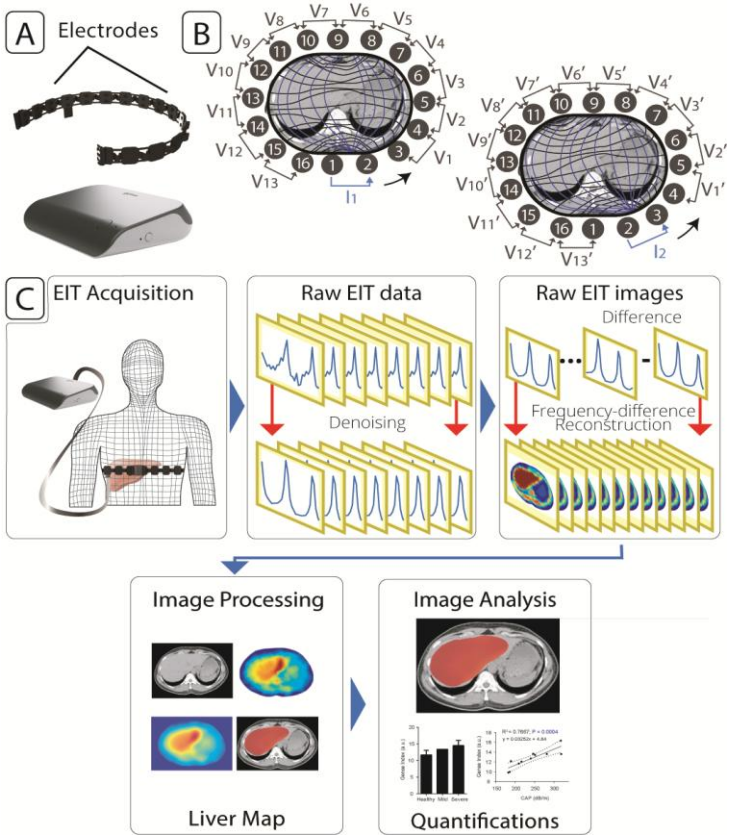
- Age: 20-75
- Healthy adults who do not have any known liver diseases.
- Gender: Male/ Female.

Exclusion criteria

- Subjects with previous liver diseases (in the control group) or any liver diseases other than fatty liver (in fatty liver patients)
- Subjects who had any kind of liver surgery or liver transplantation
- Heavy alcohol intake
- Ascites
- Subjects with damaged skin on the abdomen
- Subjects with spinal diseases/discomfort
- Subjects who had any recent abdominal surgery
- Pregnant women
- Subjects with implanted electronic devices
- Metallic implants

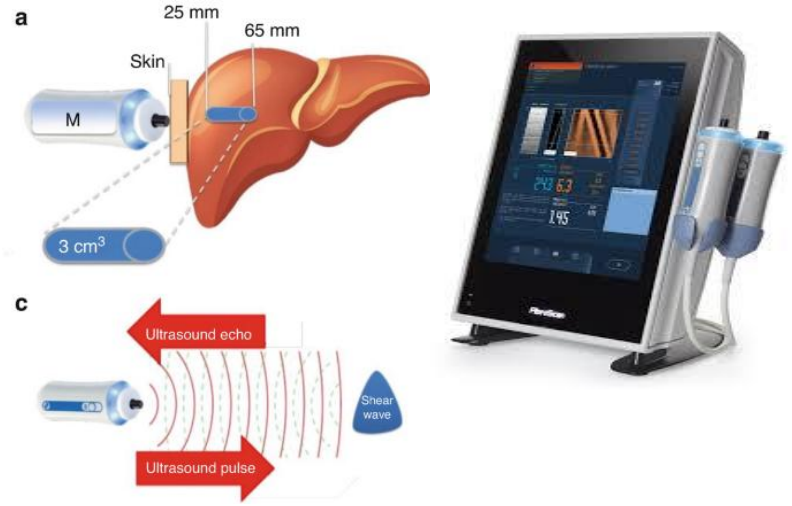
Method

EIT scan



Transient Elastography

Vibration-Controlled Transient Elastography (VCTE)



Liver fat (CAP)

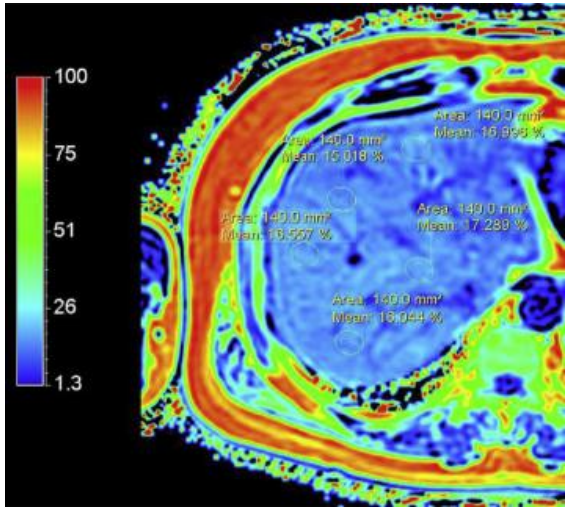
<248: No steatosis
>248: Steatosis
≥280: Severe steatosis

Liver fibrosis (LS)

<6: no significant fibrosis
>6-9: advanced fibrosis
≥12: cirrhosis

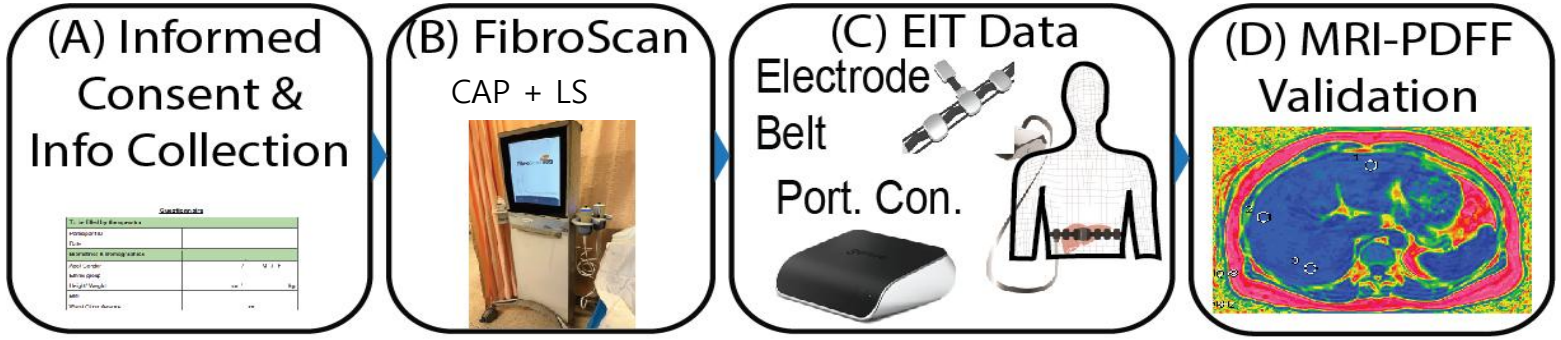
Karlas T et al. J Hepatol 2017

MRI-PDFF



Method

- 44 healthy controls and 190 patients with known MASLD were recruited for vibration controlled transient elastography (VCTE)
  - Measure hepatic steatosis by controlled attenuation parameter (CAP)
  - Measure liver fibrosis by liver stiffness (LS)
- EIT examination was performed with a 16-electrode belt worn on the waist connected to a portable non-ionizing non-invasive system designed for use without needing trained operators
- A subgroup (n=90) also underwent MRI-PDFF scan



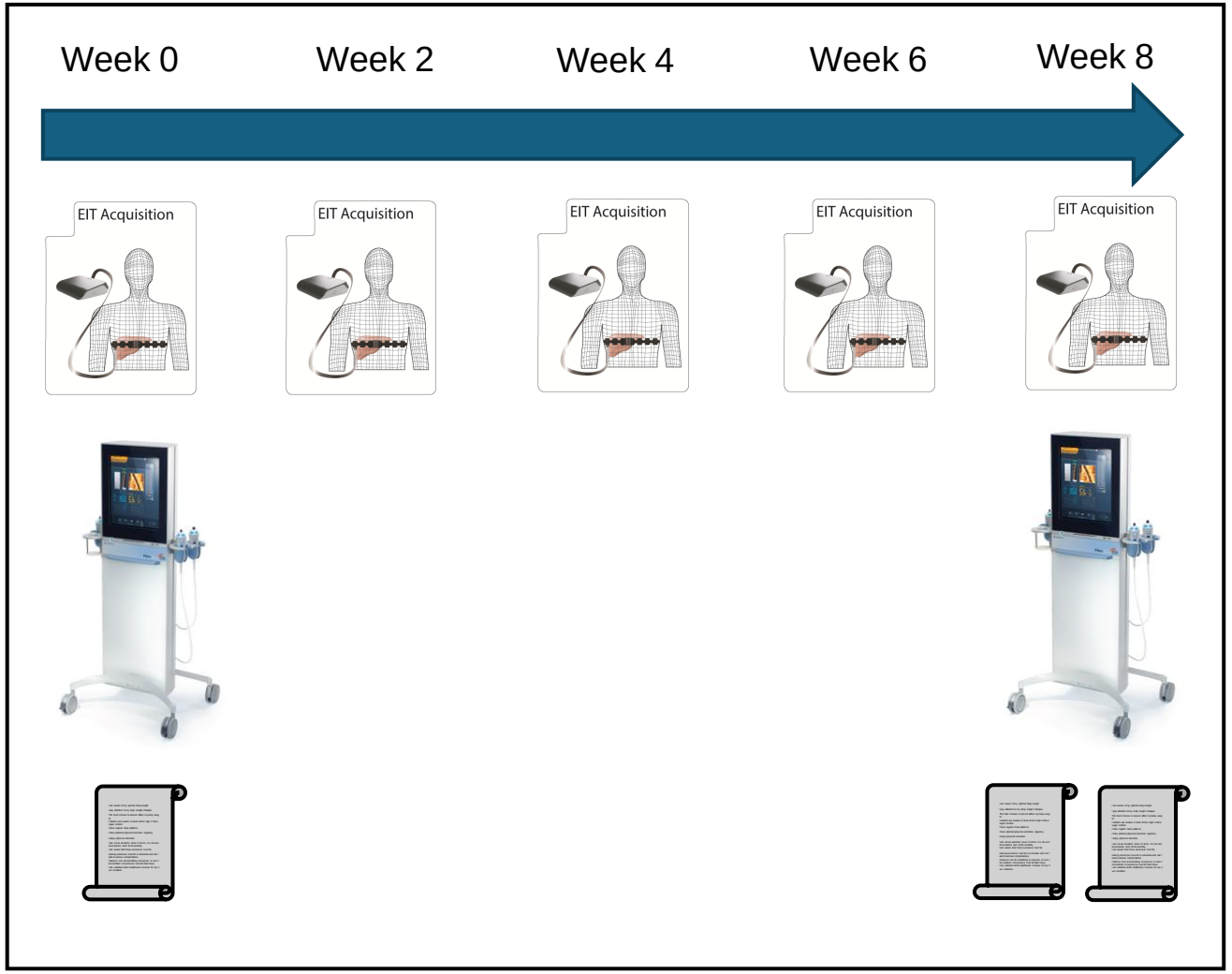
Method

- 8 subjects (2 with known MASLD – defined by USG or CAP ≥248 dB/m; and 6 healthy controls) were recruited
- Self-administered EIT scan every 2-3 weeks
- Independent of trained operators
- No additional instructions/ advice given

- VCTE was performed at week 0 and week 8 for CAP values
  - ***significant CAP reduction was defined as ≥40 dB/m decline***

Wong VWS et al. J Hepatol 2017

- ***Subjects' health perception*** and ***user experience*** were assessed by a questionnaire-based survey

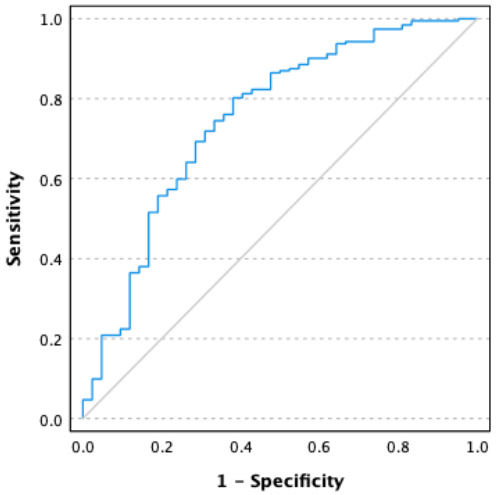


Results (part 1)

N=234

EIT index to predict:

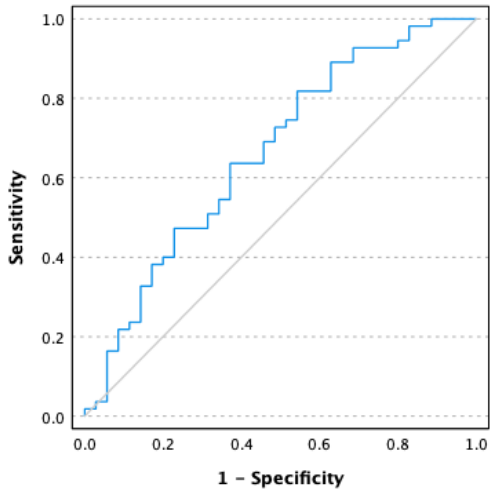
Liver fat: VCTE-CAP



AUROC: 0.749

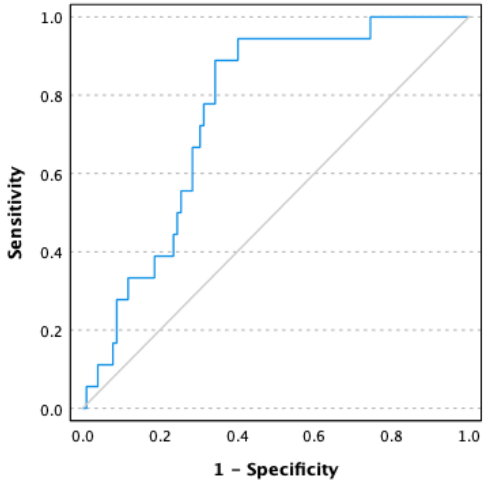
(n=90)

Liver fat: MRI-PDFF



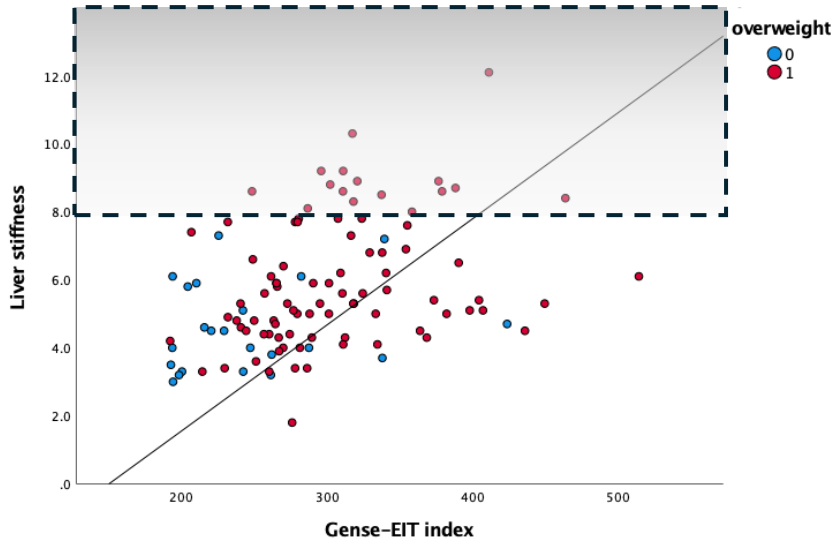
AUROC: 0.662

Liver fibrosis: VCTE-LS



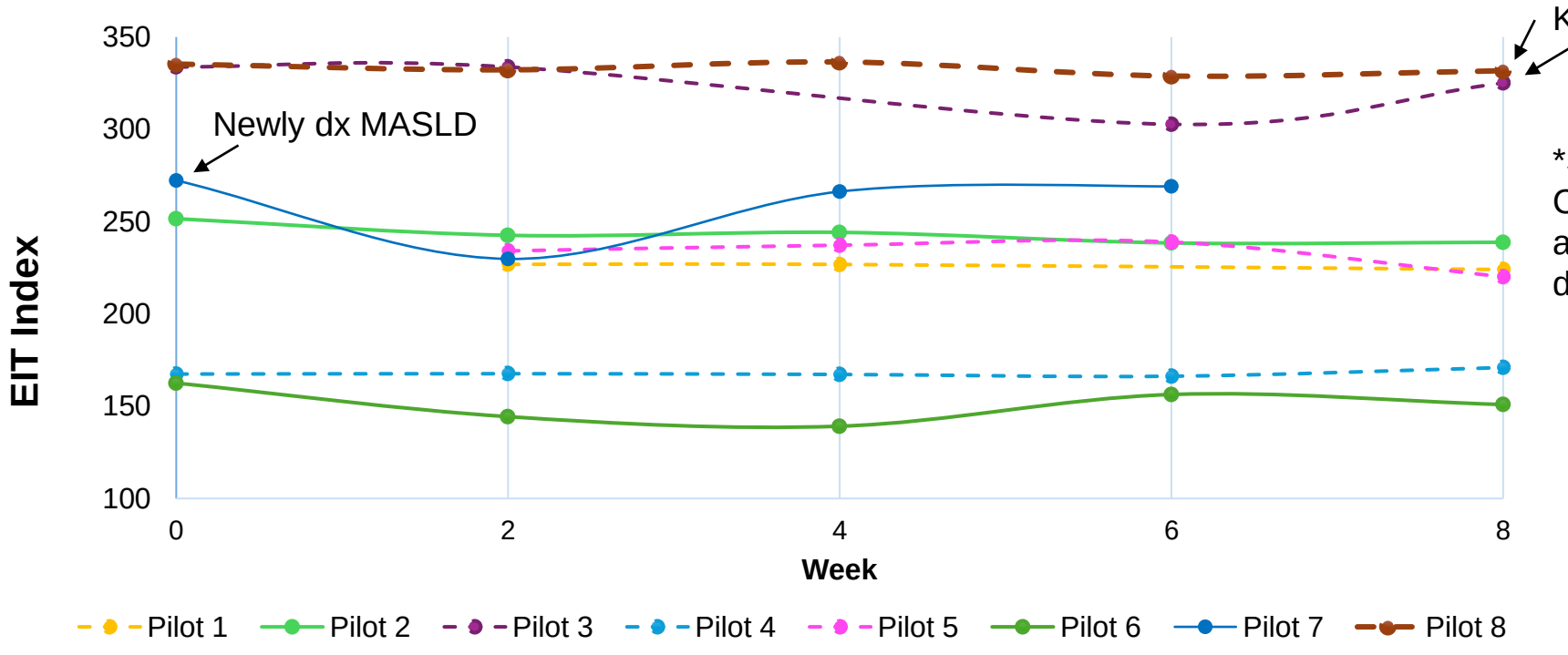
AUROC: 0.758

EIT index weakly correlated with LS
(r=0.368, p<0.001)



Results (part 2)

- All 8 subjects conducted ambulatory monitoring at a frequency of ≥3 times over the 8-week observation period, confirming feasibility of this approach
- 5/8 (62.5%) subjects, including the 2 subjects with known MASLD, achieved significant CAP reduction



*Subjects with significant CAP reduction at week 8 are represented by dashed lines in the graph

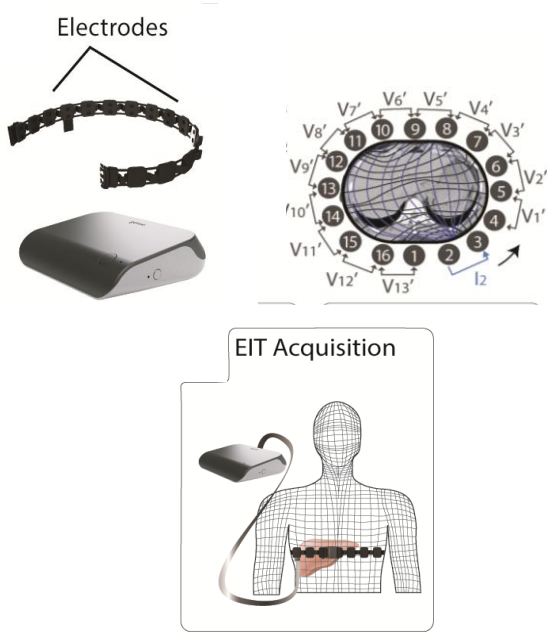
Known MASLD

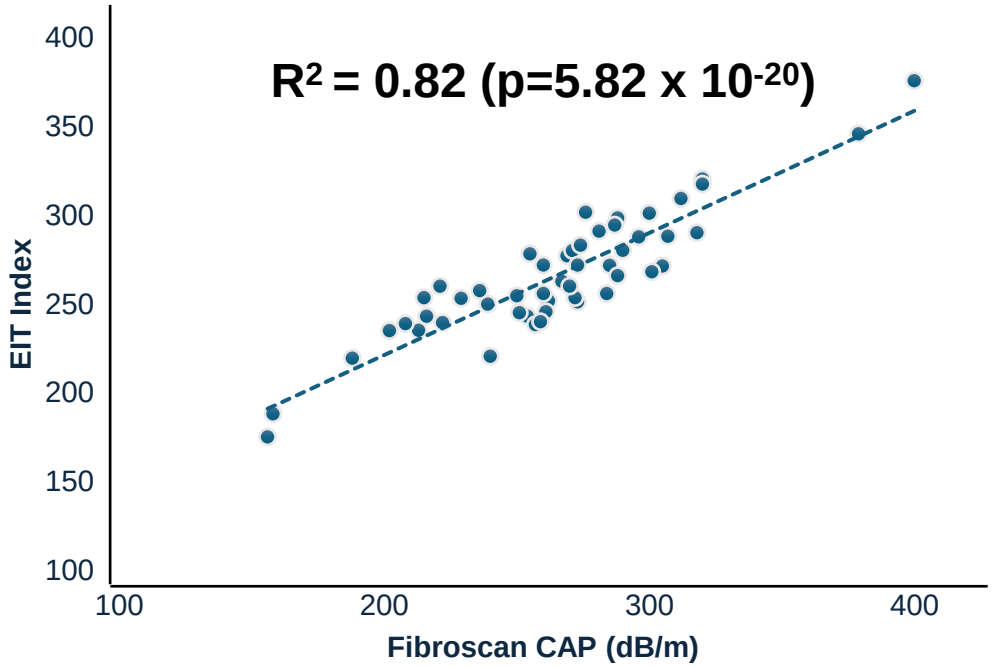
	Pilot 1*	Pilot 2	Pilot 3*#	Pilot 4*	Pilot 5*	Pilot 6	Pilot 7	Pilot 8*#
Week 0 CAP	229	198	373	244	216	156	277	347
Week 8 CAP	175	192	320	158	172	277	299	293

Results (part 2)

- R^2 between EIT and CAP values was 0.82 ($p<0.0001$)
- EIT and CAP values at baseline and week 8 yielded 8 pairs of values, with 14/16 (87.5%) concordance in categorizing liver fat quantity.

EIT index (predicted CAP) was highly correlated with actual CAP





Results (part 2)

- Health perception score (median) improved from 2.04 to 2.28.

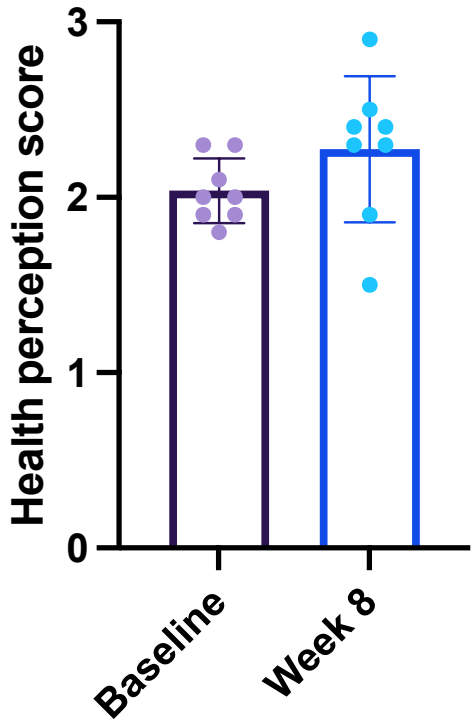
Survey for recruited subjects in the Ambulatory Liver Fat Monitoring Trial
[Modified from the Diabetes Self-Management Questionnaire (DSMQ))

Study ID of subject: _____ Age:_____ Gender:_____

Date of recruitment: _____

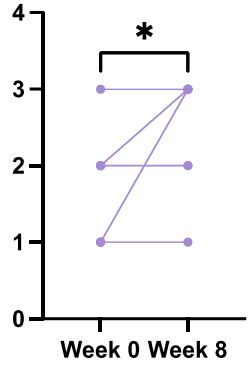
Part A (week 0 & week 8)

	Strongly agree [3]	Moderately agree [2]	Slightly agree [1]	Disagree [0]
1. I am aware of my optimal body weight.	☐	☐	☐	☐
2. I pay attention to my body weight changes.	☐	☐	☐	☐
3. The food I choose to eat will affect my body weight.	☐	☐	☐	☐
4. I seldom eat sweets or food/ drinks high in fat or sugar content.	☐	☐	☐	☐
5. I have regular meal patterns.	☐	☐	☐	☐
6. I have planned physical activities regularly.	☐	☐	☐	☐
7. I enjoy physical activities.	☐	☐	☐	☐
8. I am not an alcoholic. Even if I drink, it is for social occasions and I drink sensibly.	☐	☐	☐	☐
9. I am aware that I have excessive liver fat.	☐	☐	☐	☐
10. Having excessive liver fat is a disease and can lead to serious complications.	☐	☐	☐	☐
11. I believe I can do something to improve or cure the condition of excessive liver fat that I have.	☐	☐	☐	☐
12. I am satisfied at the healthcare I receive for my liver condition.	☐	☐	☐	☐

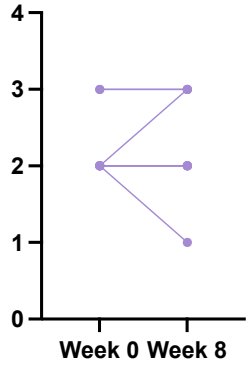


Results (part 2)

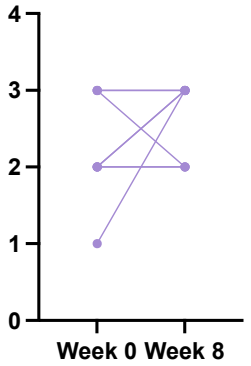
Q1 Optimal BW awareness



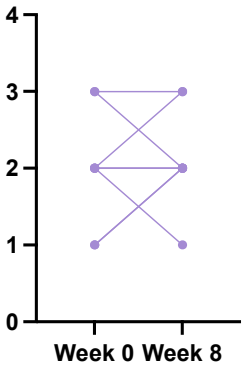
Q2 Attentie to BW changes



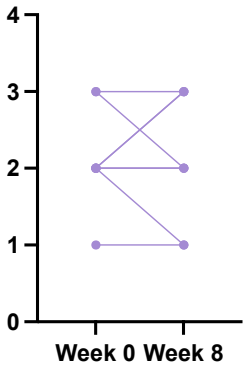
Q3 Food and BW awareness



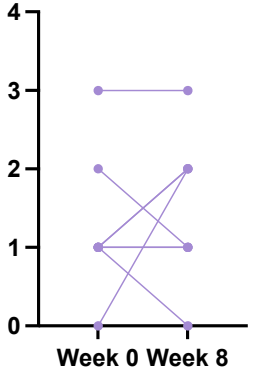
Q4 Avoid sweat food/ drinks



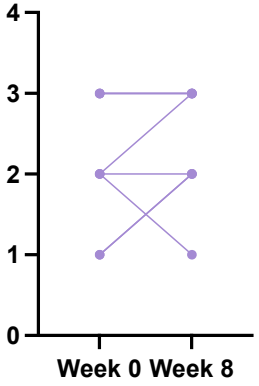
Q5 Regular meal patterns



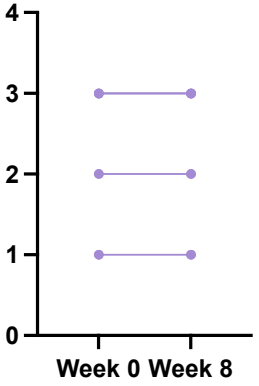
Q6 Plan regular PE



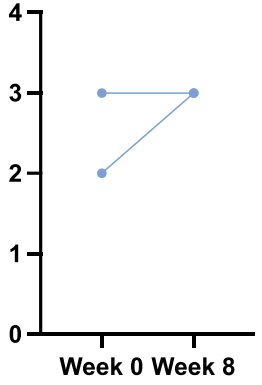
Q7 Enjoy PE



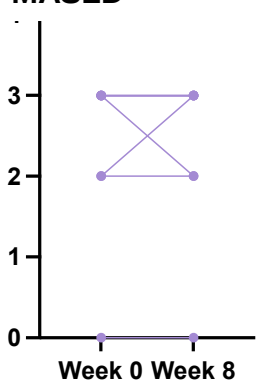
Q8 Alcohol Consciousness



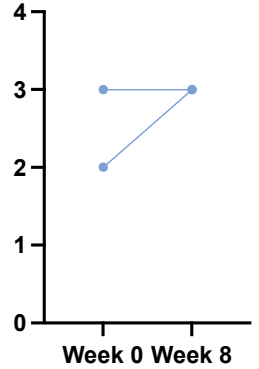
Q9 Aware of excessive liver fat



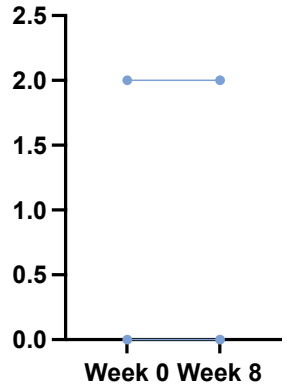
Q10 Knowledge about MASLD



Q11 Self-efficacy

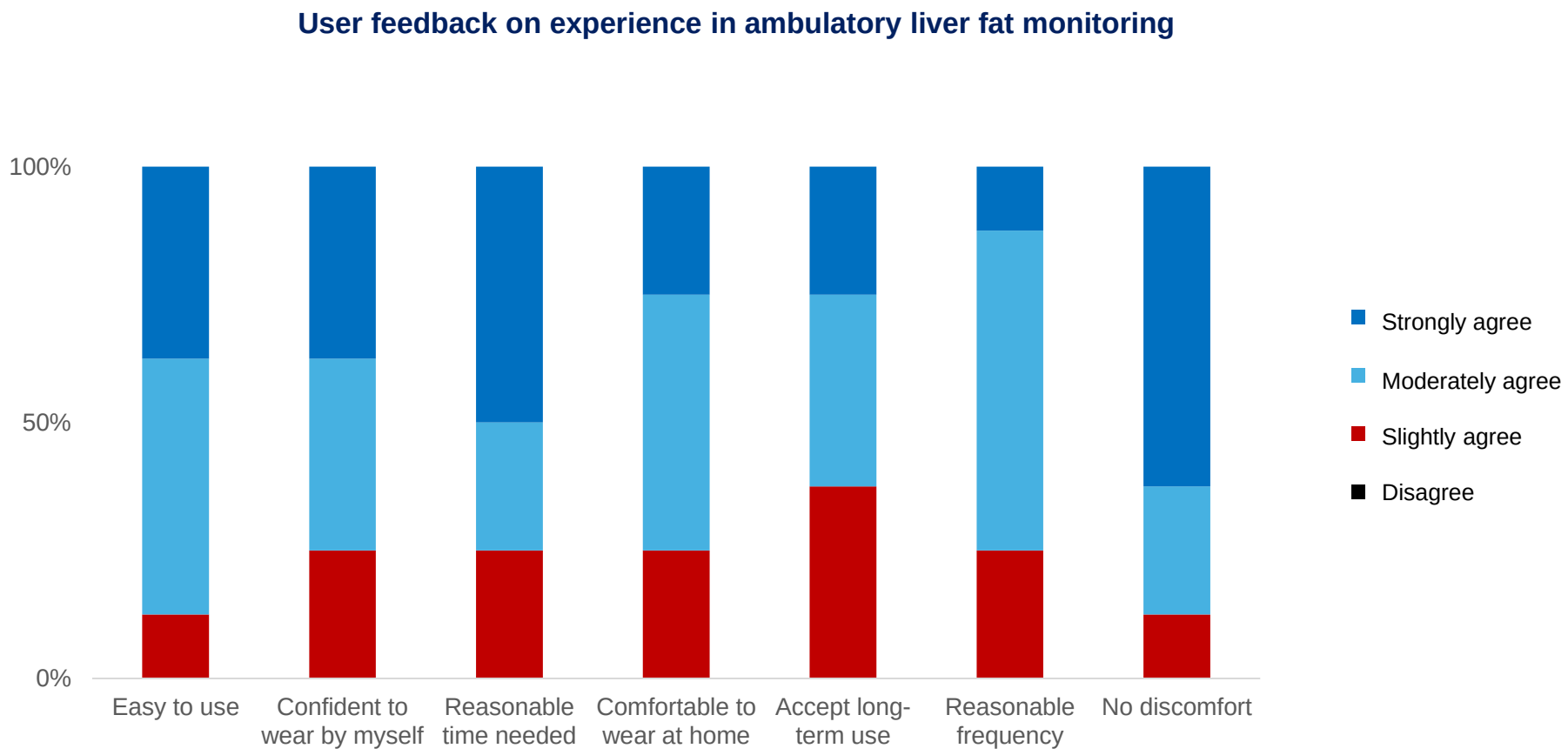


Q12 satisfied for healthcare



Results (part 2)

- No subjects experience intractable discomfort.



Summary/ Key Take-Aways

- The novel portable device using EIT technique can accurately quantify the degree of hepatic steatosis and identify significant liver fibrosis.
- The device is safe, well-tolerated and easily operated by patients without the need of assistance from healthcare practitioners.
- Ambulatory liver fat monitoring by EIT scan is feasible and demonstrated improvement in hepatic steatosis and health perception scores among MASLD subjects.

Future directions

- Optimization of EIT platform to further improve hepatic steatosis and liver fibrosis quantification against VCTE and MRI metrics
- Larger scale clinical trial with longer follow-up to confirm efficacy and sustainability of ambulatory monitoring
- Detailed analysis on the mechanisms leading to observed efficacy (body weight changes, behavioural changes)

Acknowledgements

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- The Innovation and Technology Fund, HKSAR (PRP/048/21FX)
- The HKU Seed Fund for Basic Research
- Queen Mary Hospital Hepatology Team
- All participating subjects

Thank you ☺