# PHYSICAL ACTIVITY MONITORING THROUGH A WEARABLE TECHNOLOGICAL DEVICE

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# Overview

- Introduction
  - *Type 2 Diabetes Mellitus*
  - *Prediabetes*
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  - *Importance of Physical Activity and Nutrition*
  - *Technology*
  - *Lifestyle Interventions*
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- Results
- Conclusions
- Future Directions

# Type II Diabetes Mellitus (T2DM)

- Global incidence: 425 million[1]
- United States incidence: 30 million or 10.7% of the adult population
  - *1.7 million new cases diagnosed each year*[2]
- Complications:
  - *Seventh leading cause of death in the US*
  - *Cause of non-traumatic amputations of the lower extremities*
  - *Blindness*
  - *Permanent renal failure*[3]
  - *Coronary risk equivalent and important cardiometabolic risk factor*

[1]International Diabetes Federation
[2]Centers for Disease Control and Prevention
[3]Cowie CC, Rust KF, Byrd-Holt DD, et al. Diabetes Care

# Prediabetes

- Prevalence: 35% of adults over the age of 20 and 50% of all adults over the age of 65[1]
- Cost of T2DM in the US was estimated at $327 billion in 2017, an increase of >5% per year from 2007[2]
  - *By 2045, diabetes-related health expenditure will exceed $776 billion*
- Individuals with prediabetes may progress to diabetes at varying rates, depending on genetic or environmental factors[3]
- T2DM diagnosis is usually delayed around 4 to 7 years after disease onset due to a lack of symptoms[4]
- The American Diabetes Association estimated that up to 70% of individuals with prediabetes will eventually progress to T2DM[5]

[1]National Diabetes Prevention Program, 2014. CDC
[2]Dall TM et al. Diabetes Care
[3]Fonseca V Diabetes Care
[4]Harris MI et al. Diabetes Care
[5]Nathan DM et al. Diabetes Care

# Macro-level Reasons for T2DM Increase

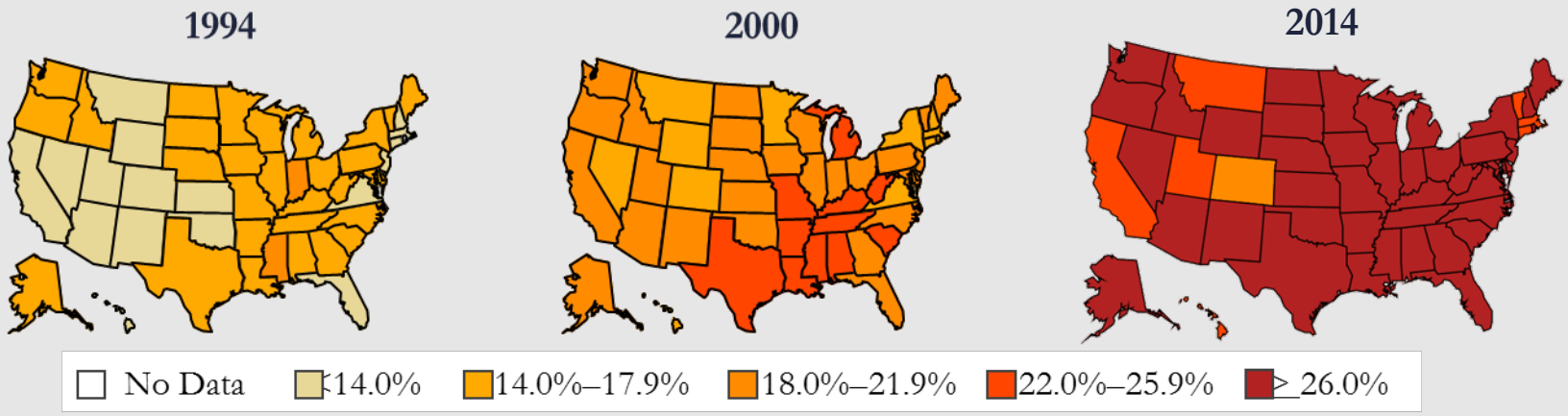
- Urbanization and environmental transitions
  - *Including vocation changes from heavy labor to sedentary occupations*
- Increased technology
- Improved transportation
- Changes in food production, processing, and distribution

Popkin BM et al. Nutr Review

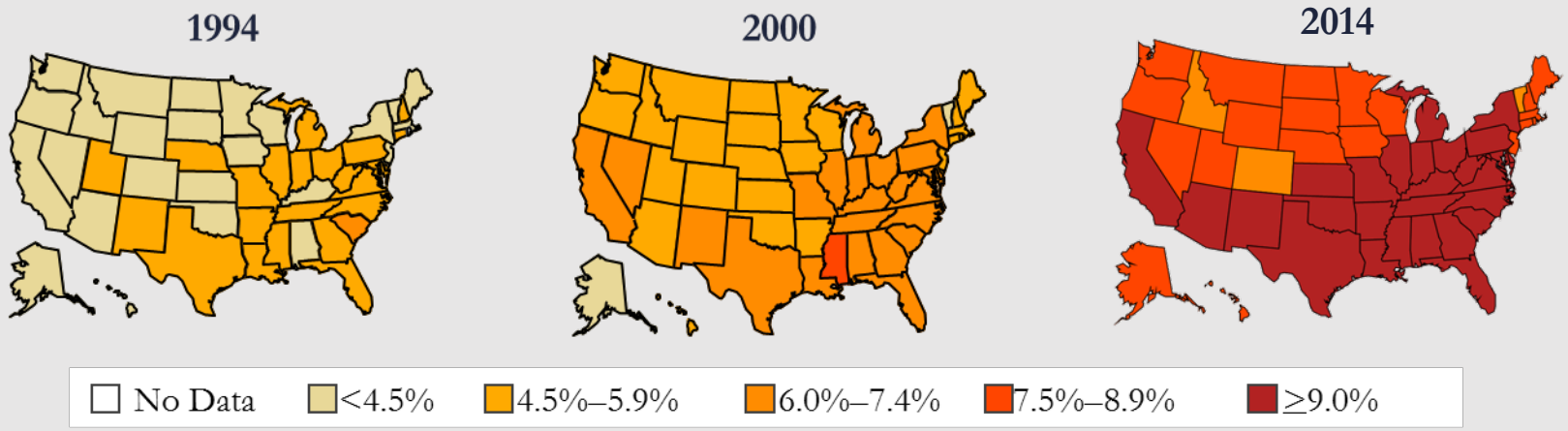
# T2DM Prevention Goals

- T2DM prevention could have an enormous impact on general well-being and quality of life
- Reduction of long-term morbidity and mortality
- Decrease health care costs

## Obesity (BMI ≥30 kg/m$^2$)

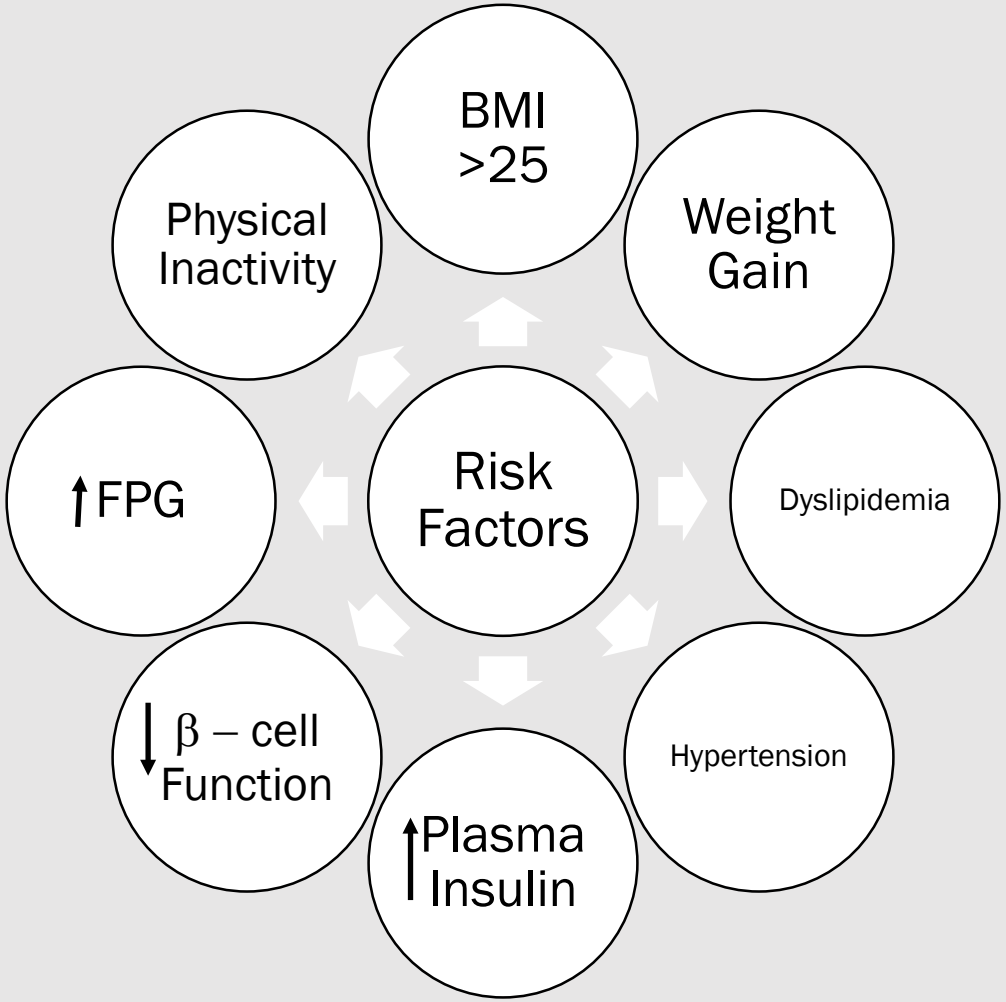



## Diabetes

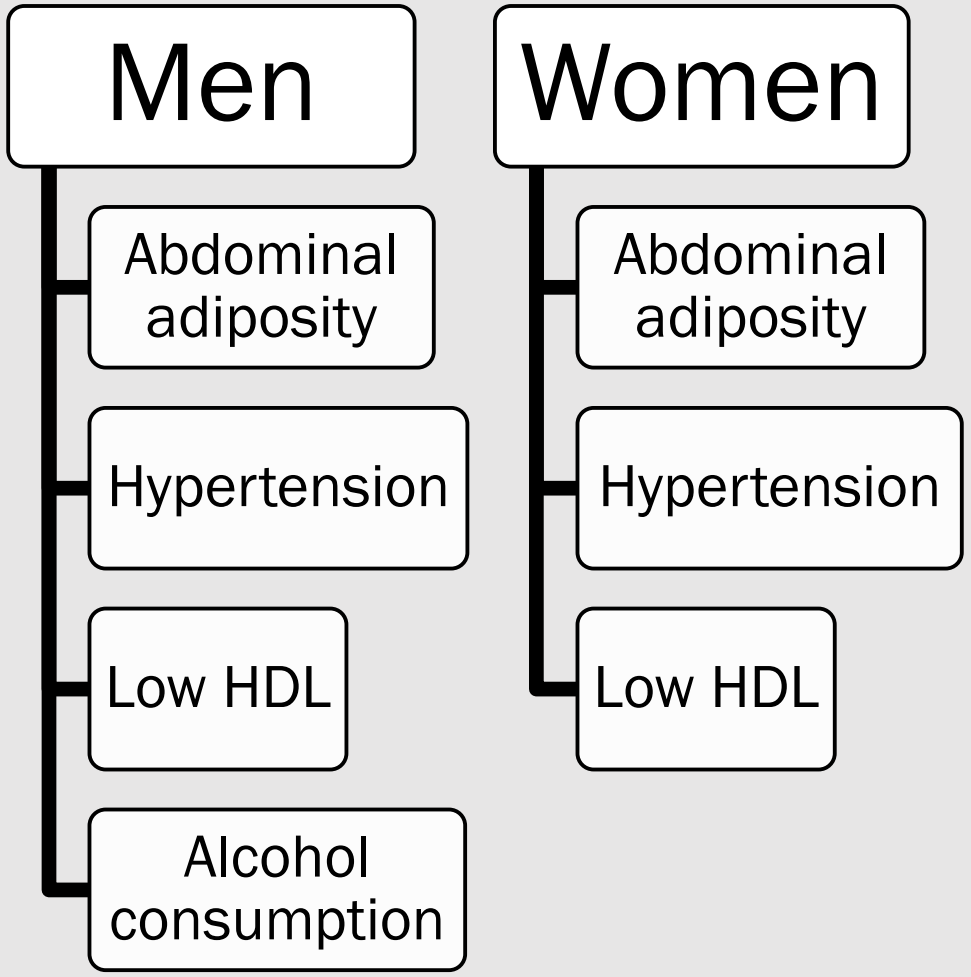



CDC's Division of Diabetes Translation. National Diabetes Surveillance System available at http://www.cdc.gov/diabetes/statistics

# T2DM Progression Risk Factors



# Modifiable Prediabetes Risk Factors



# Physical Activity

- The combination of excess weight and lack of PA is associated with T2DM[1]
- Half of the U.S. adult population does not meet the recommended levels of 150 minutes per week of moderate intensity PA[2]
- Studies have shown a strong inverse association between PA and the risk of diabetes[3]
- The American College of Sports Medicine, the Centers for Disease Control and Prevention, the National Institutes of Health, and the U.S. Department of Health and Human Services have concluded that routine moderate intense exercise was an effective means to reduce the overall risk of chronic disease states
  - *Individuals should participate in at least 30 minutes of moderate intensity PA on most if not all days of the week*[4]

[1]Bassuk SS et al. J Appl Physiol.
[2]Troiano RP et al. Med Sci Sports Exerc.
[3]Kriska AM et al. Med Sci Sports Exerc
[4]CDC, National Center for Chronic Disease Prevention and Health Promotion, 1996.

# Electronic PA Trackers

- PA trackers improve on standard pedometers by providing automated feedback and interactive behavior change tools via mobile device or personal computer
- According to the Intercontinental Marketing Services (IMS) Institute for healthcare informatics, as of 2015, there were 165,000 health related mobile phone apps on android and iPhone operating systems with around 110,000 of these related to health and fitness
- Sales of wearable technology grew to almost $30 billion by 2017-2018
- Technologies have the potential to give healthcare professionals better insight into patients' overall health and fitness patterns
  - *PA data can be aggregated with other healthcare data*

IMS Health. http://www.theimsinstitute.org

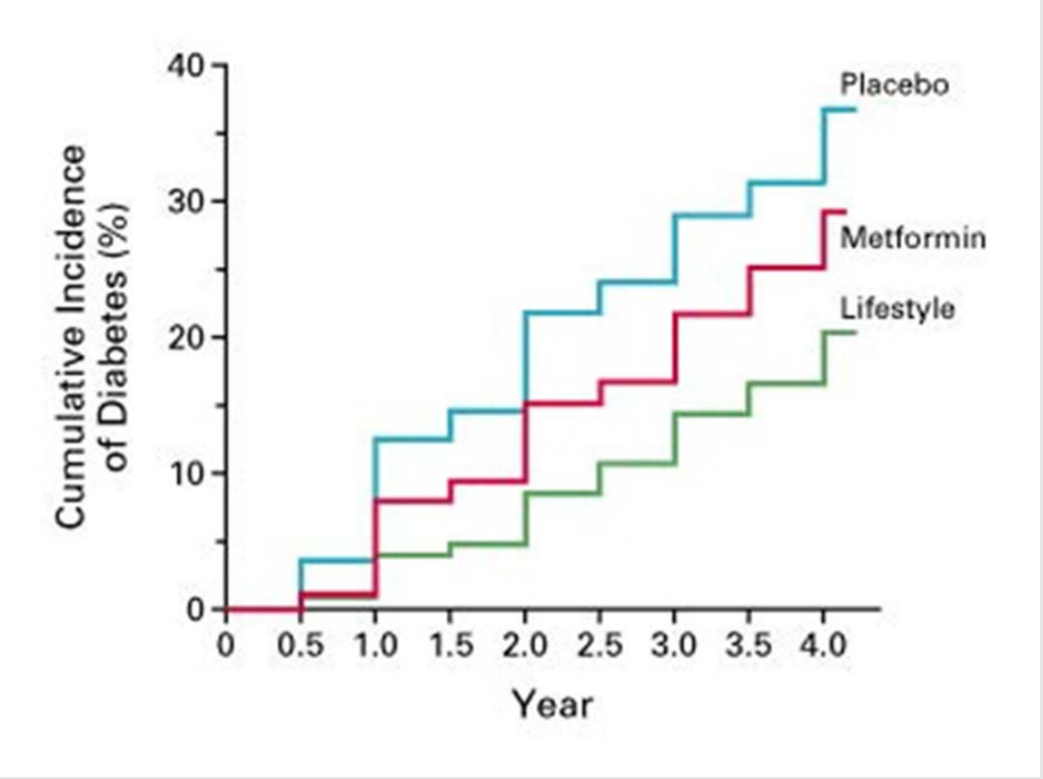
# Lifestyle Intervention Programs

- Lifestyle intervention programs that focus on decreasing body weight and increasing PA are effective at decreasing the risk of progression toward T2DM
- The ADA recommends that individuals with impaired glucose tolerance or impaired fasting glucose should be referred to an on-going support program for weight loss of 5 – 10% and increasing PA to at least 150 minutes per week

Singh K et al. Can J Diabetes

# Diabetes Prevention Program Results

- Lifestyle intervention program - 58% rate of reduction of T2DM incidence
- Metformin - 31% rate of reduction of incidence
- Every 1 kg reduction in weight was an associated 16% reduction of incidence




The DPP Research Group, *NEJM* **346:393-403**, 2002

# Diabetes Prevention Program - Group Lifestyle Balance (DPP-GLB)

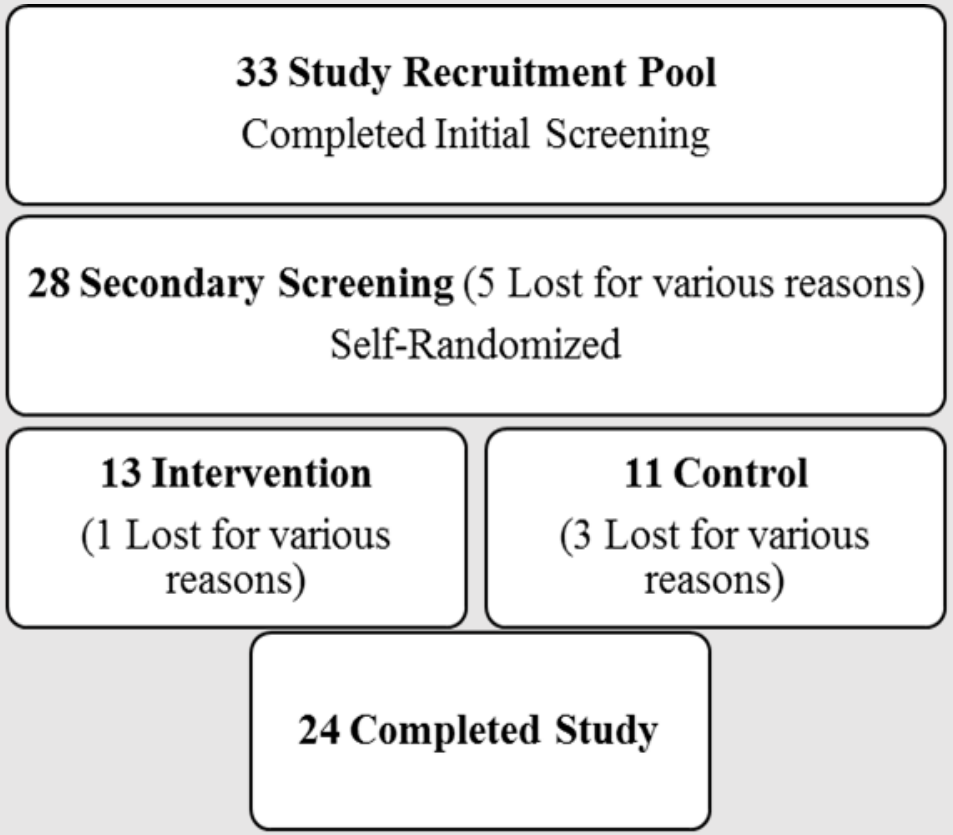
- Originates from the DPP as a cost effective lifestyle intervention
- Year-long program outcome goals remains the same as DPP:
  - *Weight loss of >7%*
  - *PA attainment of 150 minutes of moderate intensity/week*
- The GLB program is unique, however, in its emphasis on group sessions
- Intervention requires intensive involvement of lifestyle coaches
- Manual recordings of food intake, physical activity and weight

# Study Summary

- Little information about the feasibility of offering a lifestyle intervention with the addition of technology to improve GLB program outcomes
- Primary objective was to test the effects of a technology-based intervention that utilized self-monitoring
  - *Primary outcomes: Attainment of 150 minutes of PA per week and weight loss trending toward 7%.*
  - *Secondary outcomes: Evaluation of percent body fat, blood pressure, waist circumference, and body mass index*
- Hypothesis: Integrating technology into the GLB program would show improved primary and secondary outcomes and would be more effective than the standard GLB protocol at reducing the risk of T2DM

# Participants

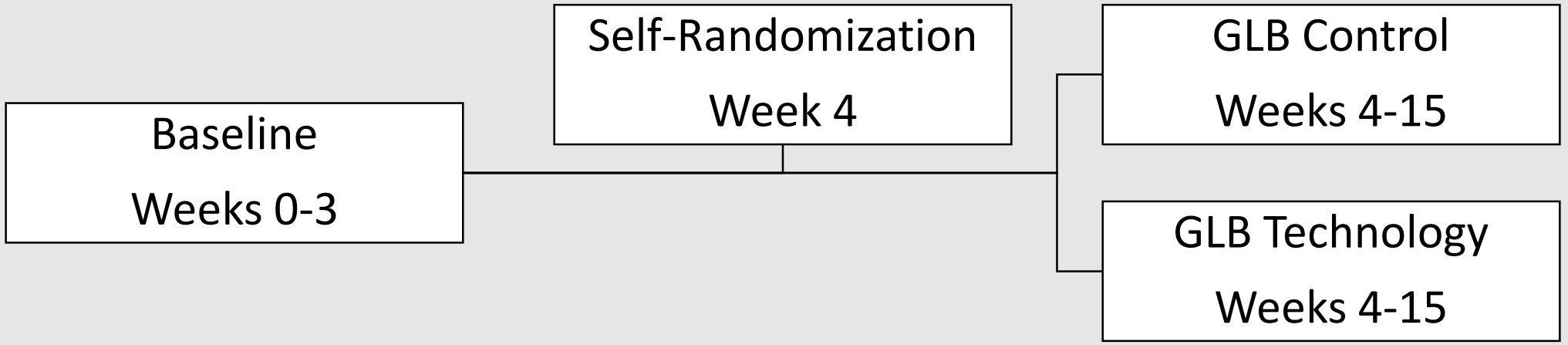
- 40 years of age or older
- BMI ≥24 kg/m$^2$
- No current or prior diagnosis of diabetes
- Had risk of developing diabetes
  - *History of gestational diabetes*
  - *Score of ≥9 on the Centers for Disease Control (CDC) Prediabetes Screening Test*
- Completed PAR-Q form
- 27% attrition rate (77% due to family member needing extra care)



# Demographics

| | **Technology (n = 13)** | **Control (n = 11)** |
|---|---|---|
| Age | 65.31 ± 8.34 | 67.91 ± 7.05 |
| Race<br>Caucasian | 13 | 11 |
| CDC Prediabetes Screening Test | 14.23 ± 2.09 | 14.45 ± 1.75 |
| Gender<br>Male<br>Female | 3<br>10 | 2<br>9 |
| Sibling with diabetes | 6 | 5 |
| Parent with diabetes | 6 | 4 |
| Currently, or has had high blood pressure | 5 | 7 |
| Currently, or had had high cholesterol | 7 | 4 |

# Four Month Study



# Study Groups

- Control Group
  - *Met once weekly for 12 weeks*
  - *Nutritional intake monitored through Keeping Track Booklets and the 'CalorieKing'*
  - *PA monitored through Keeping Track Booklets and a pedometer*
  - *Received feedback once/week via Keeping Track Booklets*
    - Given one week after booklets were turned in
- Technology Group
  - *Met once weekly for 12 weeks*
  - *Nutritional intake monitored through MyFitnessPal app*
  - *PA monitored through Fitbit Flex*
  - *Received feedback once/week via SMS text message*
    - Given mid-way through the week
  - *More likely to receive feedback*

# Data Collection

Continuous data collection

- Weekly Weight
- Daily Steps
- Weekly Minutes of PA
- Daily Calories
- Daily Fat Grams

Data collected at weeks 0, 4, and 15

- Height
- Weight
- Blood Pressure
- Body Mass Index
- % Body Fat
- Waist Circumference
- Patient Confidence Tool Questionnaire

# Weight Change

- A generalized estimating equation (GEE) model was used to estimate average weight lost
- All participants lost 0.46 pounds/week
- The technology group lost 17 pounds more over the study
- 100% of technology participants lost weight
- 73% of control participants lost weight
- 7.7% of technology participants reached the 7% goal weight
- 27.2% of control participants reached the 7% goal weight
- Technology group lost an average of 7.35 pounds
- Control group lost an average of 7.79 pounds

# Body Mass Index Results

Baseline

- 21% Overweight
  - *Technology: 23%*
  - *Control: 18%*
- 79% Obese
  - *Technology: 77%*
  - *Control: 82%*

End of Study

- 37% Overweight
  - *Technology: 38%*
  - *Control: 36%*
- 63% Obese
  - *Technology: 62%*
  - *Control: 64%*

# Physical Activity Change

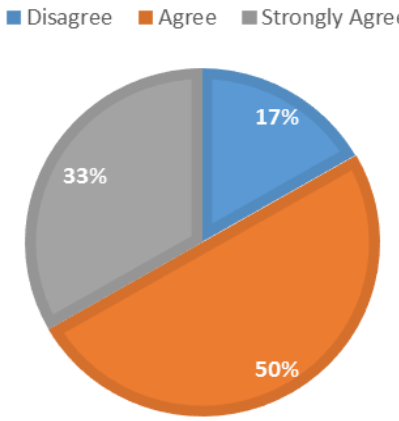
- 63% self-reported inactivity during the initial meeting
- A GEE was conducted to test PA affects between technology and control groups
- Technology: decrease in PA of 114 minutes over 11 weeks compared to control
- Challenging to accurately assess PA change as objective and subjective methods of measurement were used:
  - *The Fitbit Flex was used to objectively assess weekly minutes of PA*
  - *The control group subjectively measured weekly minutes of PA through self-monitoring*

# Data Collection Advantages

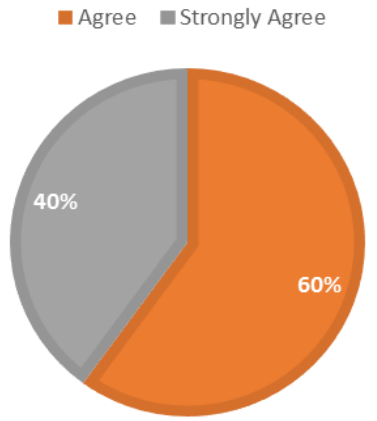
- The Fitbit Flex technology allowed for collection of up to 77 days of PA
- Technology: averaged PA tracking for 72.5 days
- Control: averaged 47.7 days of PA tracking

- Participants missed 12.8% of sessions
  - *Technology: 8.3%*
  - *Control: 18.2%*

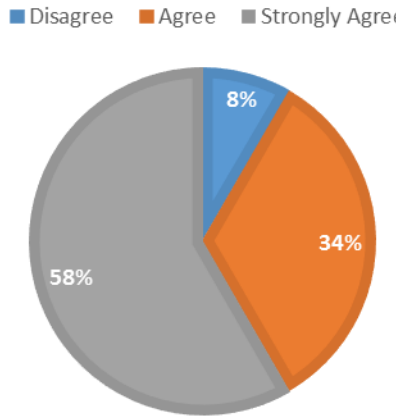
## PRE-INTERVENTION: CONFIDENCE IN ABILITY TO ACHIEVE 150 MINS PA TECHNOLOGY



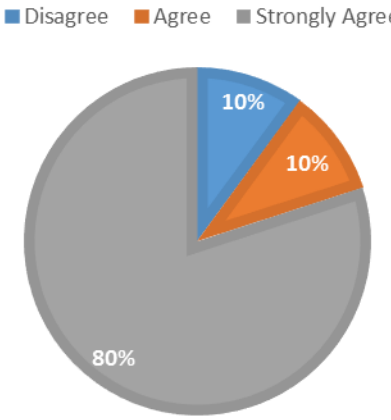

## PRE-INTERVENTION: CONFIDENCE IN ABILITY TO ACHIEVE 150 MINS PA CONTROL




## POST-INTERVENTION: CONFIDENCE IN ABILITY TO ACHIEVE 150 MINS PA TECHNOLOGY




## POST-INTERVENTION: CONFIDENCE IN ABILITY TO ACHIEVE 150 MINS PA CONTROL

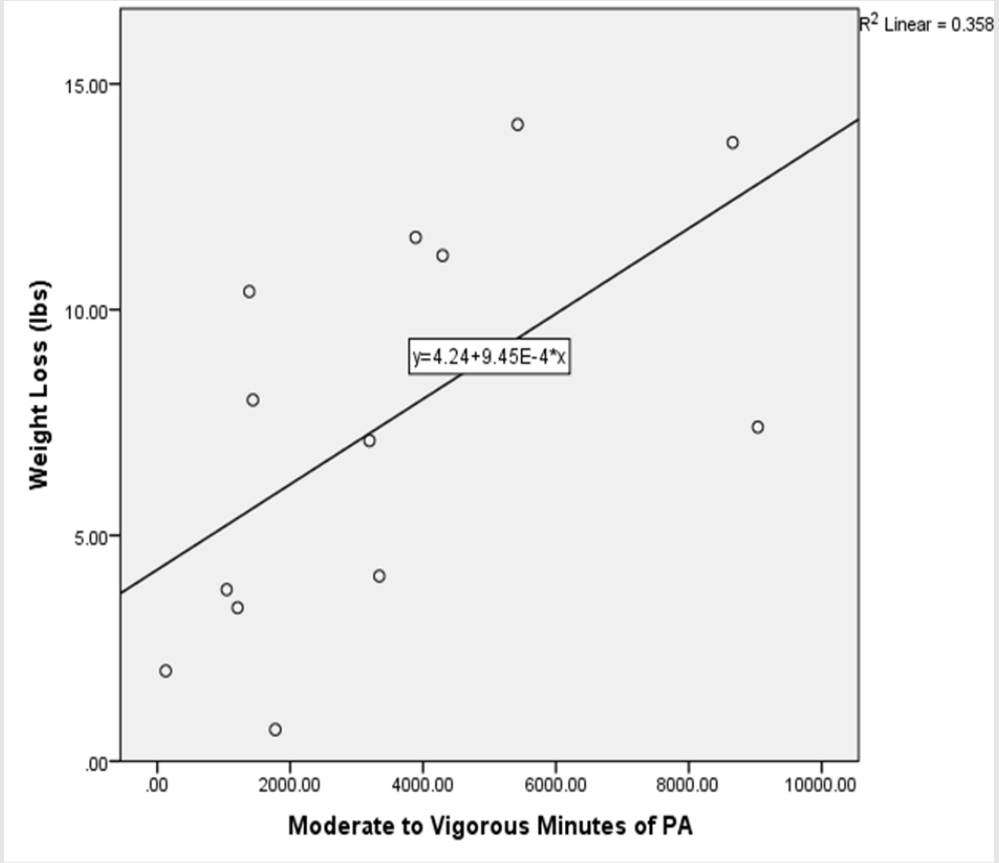


# PA Monitored by a Fitbit Flex

- Baseline: 220.8 (SD = 249.0) minutes per week of moderate intensity PA
- During the study, moderate intensity PA increased to 243.3 (SD = 198.8) minutes per week
  - *This was not statistically significant with p = 0.631*
  - *Considered to be clinically significant; moved into the PA time range for promoting clinically significant weight loss*
- Baseline: 7511.6 steps/day (SD = 3271.2)
- During study: increasing to 8177.6 steps/day (SD = 3078.9)
  - *The increase was not significant with p = 0.317*

# Weight Loss and PA Correlation

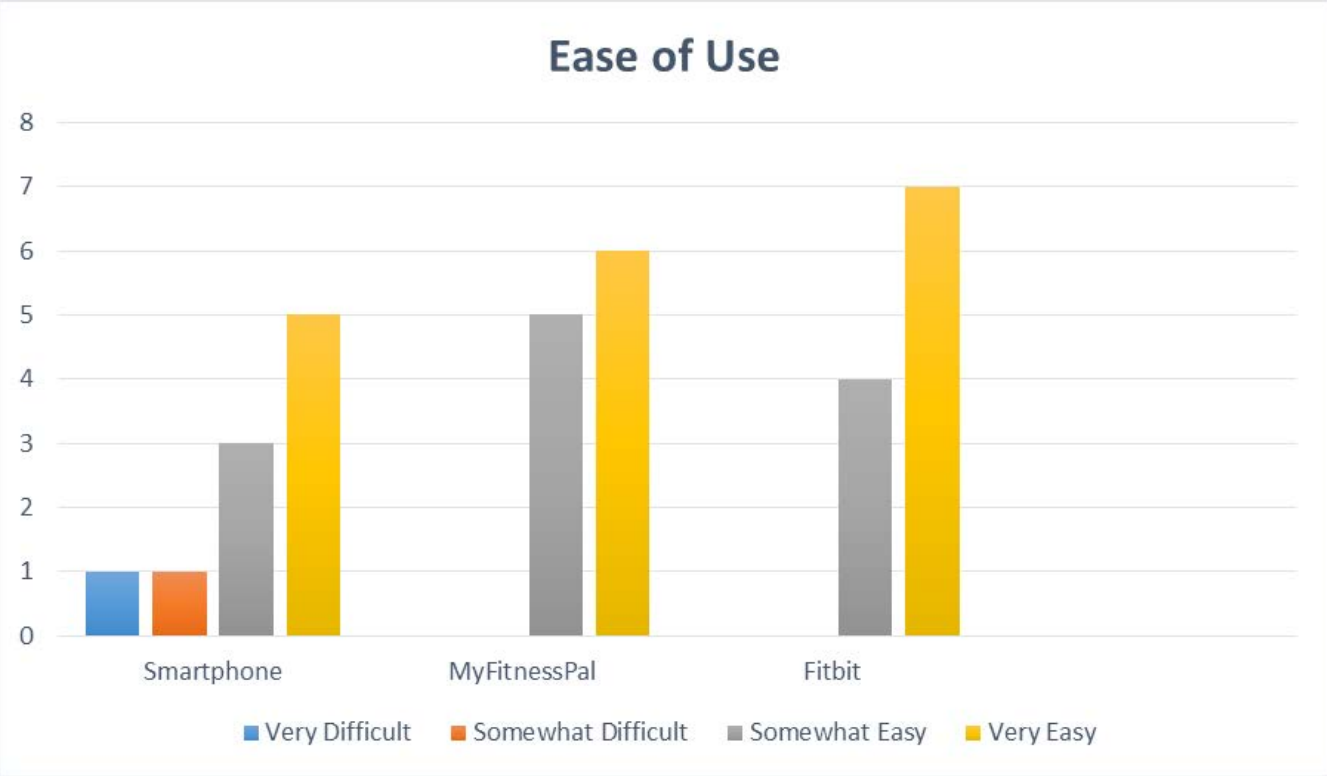
- A Pearson Correlation Coefficient showed a positive trend with minutes of moderate-to-vigorous activity and weight loss
- The Pearson CC = 0.598 showing a moderate association between weight loss and minutes of PA
- $p = 0.031$
- $R^2 = 0.357$
  - *About 36% of weight loss was influenced by minutes of PA*

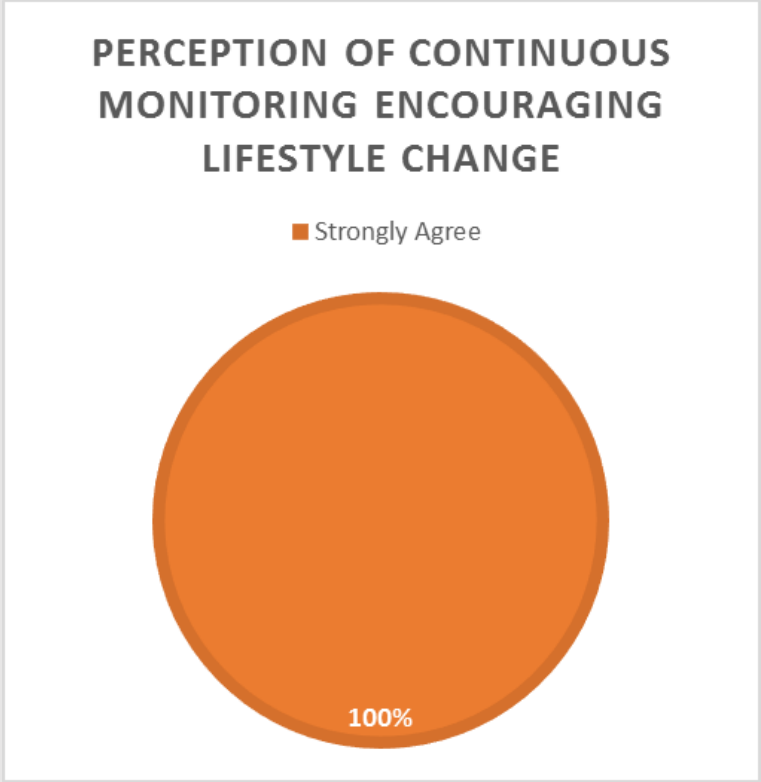


# Fitbit Use

- Compliance to wearing the Fitbit was very good with 93.1% of the weeks having data tracked for at least ≥ 6 days/week
- Of the 1415 tracked days, only 9.3% days recorded were of less than 2000 steps
- Barriers were low:
  - *84.6% had no smart phone issues*
  - *76.9% reported no technical difficulty with the tracker*
  - *92.3% had no issues with a lost/broken tracker*

# Technology Acceptance



# Conclusions

- Both groups were able to be successful with weight loss
  - *The addition of technology is not necessary for positive outcomes*
- All technology participants lost weight
- Overall, control participants lost a greater amount of weight
- Technology participants were more aware of activity and nutritional intake
  - *This did not translate into a greater amount of weight lost*
- Technology participants adhered well to wearing the Fitbit
- Both groups showed a positive short-term effect on weight and BMI, which could be interpreted as proxy of regression to T2DM

# Limitations

- This study was underpowered, which increases the potential for type II errors
- We were limited by comparing the PA of the control group vs. the PA of the technology group
  - *It is possible to compare the pedometer vs. Fitbit, however there are many errors that take place when comparing weekly PA minutes tracked by the Fitbit vs. self-tracking*
- Age range
- Improvements are needed electronic monitoring methodologies for more accurate measurements across various modalities of activities (e.g., cycling and water activities)

# Future Directions

- Studies to assess populations for whom utilizing technology may be inappropriate
  - *It is recommended that future studies research the effects of the aging brain, to determine appropriateness when implementing technology with a program*
- A blinded to activity study would be ideal. A PA tracking device other than the Fitbit Flex may need to be utilized for this to occur
- More research is needed to determine best practice when implementing through a clinical setting.
  - *Integrating healthcare teams when using technology, could provide great insight to the medical community in the prevention of not only diabetes, but other disease states.*
- More recent literature has suggested monitoring various sphingolipids as biomarkers of T2DM progression

# QUESTIONS?