



ACT U19 Project 1: Physical activity, sedentary behavior and sleep (24-hour activity cycle)

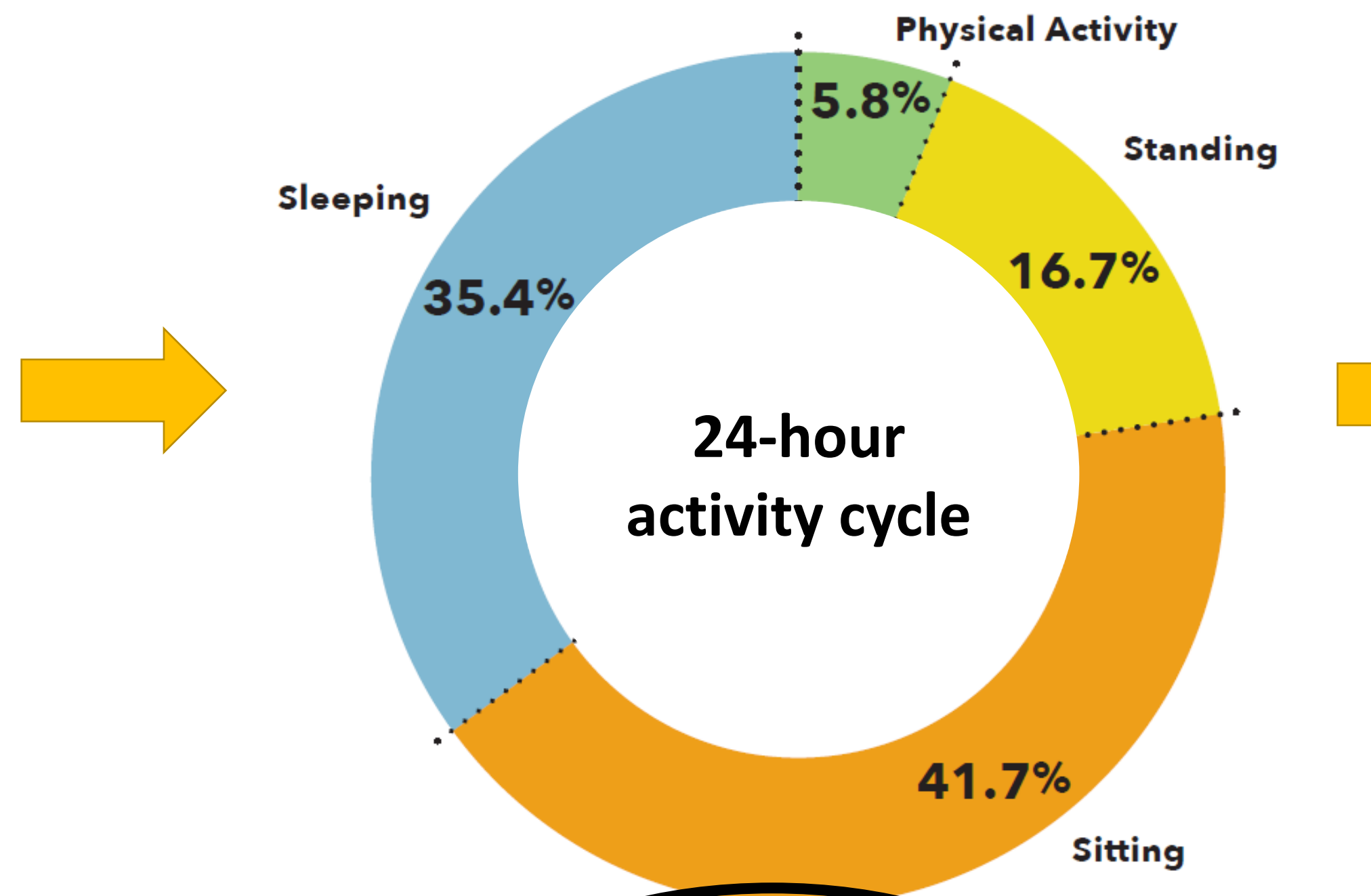
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Project 1 (U19): Overall Goal

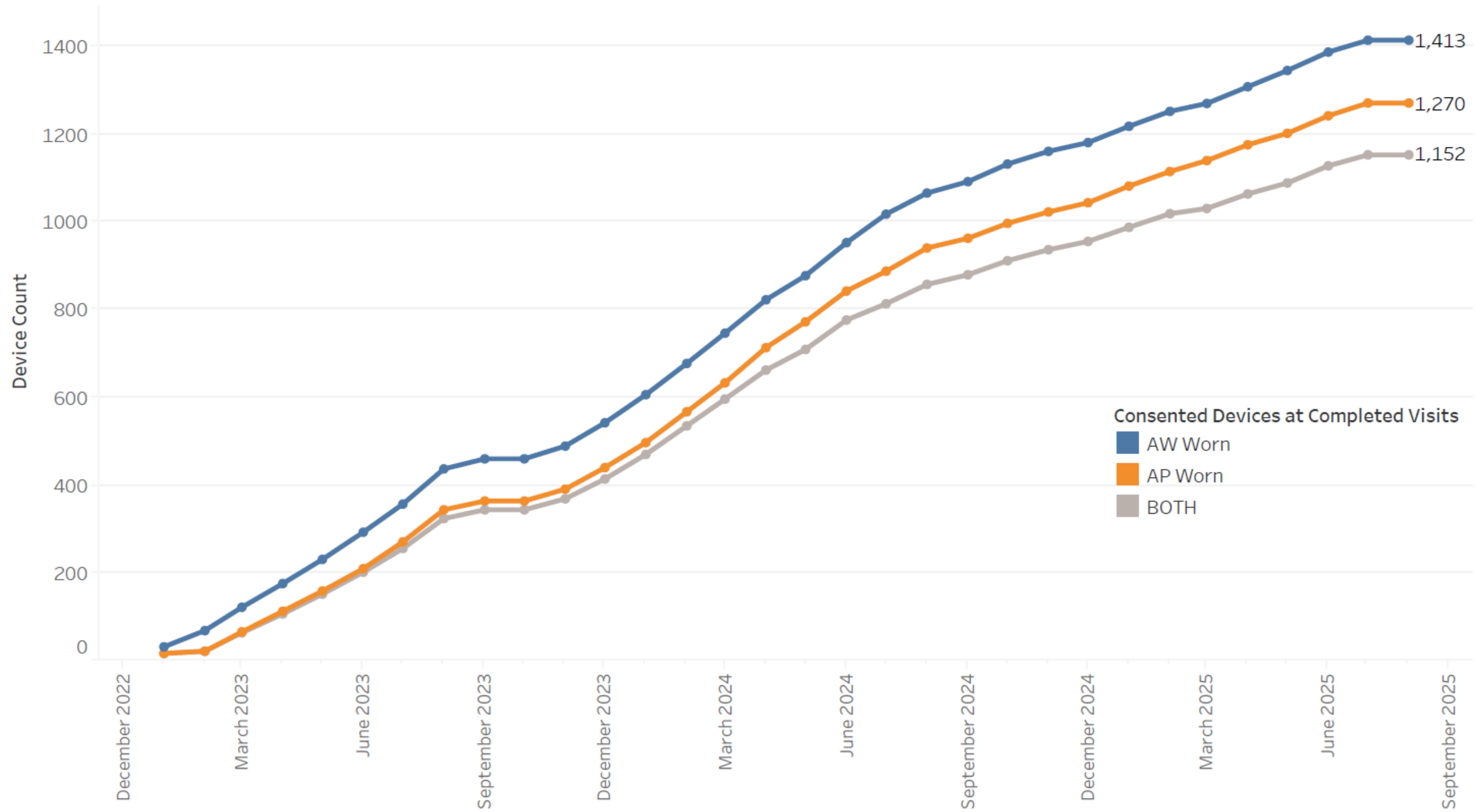
Cognition and function as historical predictors of behavior



Future changes in cognition and function



Final Data Collection Counts for Project 1



Actiwatch Description and Summary Sleep Data

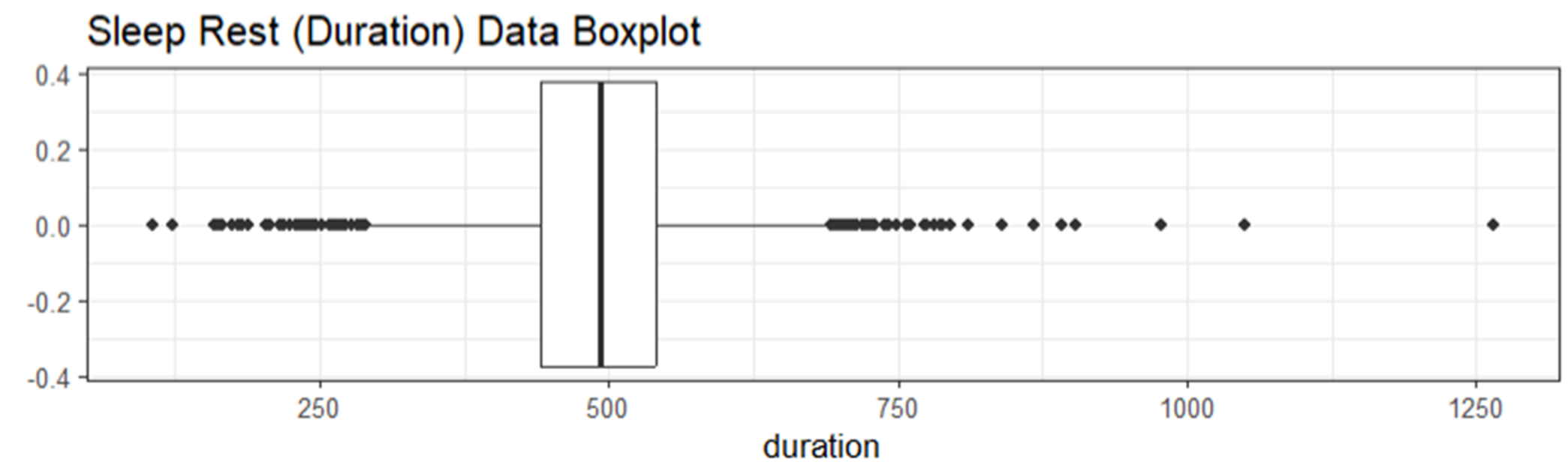
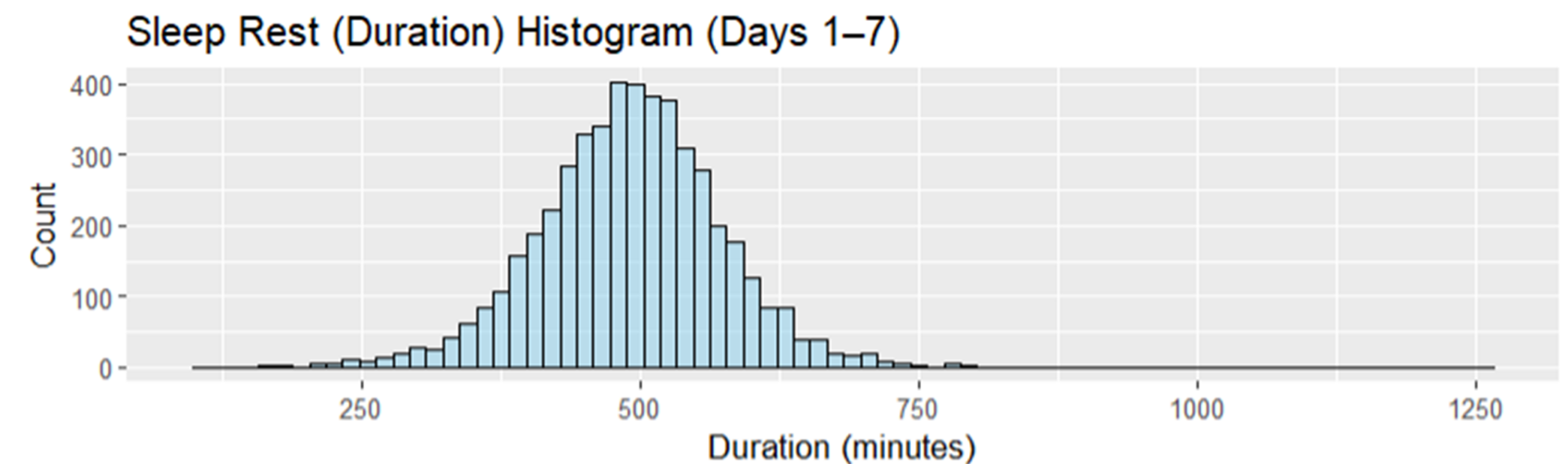
Actiwatch Spectrum Plus

- Rechargeable battery, water resistant
- Worn on non-dominant wrist, collected data in 30 sec epoch lengths
- N = 1,413 wears from N=1,377 unique participants
- Sleep statistic and circadian rest-activity data



Preliminary Sleep Actiwatch Data (n = 727)

Sleep statistic variable	Mean (SD)
Time in bed (hr)	8.2 (1.6)
Sleep latency (min)	3.6 (14.3)
Total wake time (min)	46.7 (31.9)
Total sleep time (hr)	7.4 (1.6)
Sleep percent (%)	90.4 (6.2)



Comparison of Participant Characteristics Between Those Who Did and Did Not Wear Actiwatch*

ACT Participant Characteristics	Analytic Cohort (N=706)	Non-analytic Cohort (N=681)
Age, in years, mean (SD)	77.3 (6.2)	79.6 (7.0)
	N (%)	N(%)
Women	377 (53%)	408 (60%)
Race		
Asian	69 (10%)	67 (10%)
Black or African American	27 (4%)	29 (4%)
White	524 (76%)	518 (77%)
Mixed race or some other race	69 (10%)	56 (8%)
Hispanic ethnicity	31 (4%)	33 (5%)
Years of Education	17.0 (2.5)	17.0 (2.6)
Depressive symptoms per CES-D	67 (10%)	73 (11%)
Cerebrovascular disease	70 (10%)	79 (12%)
Coronary artery disease	83 (12%)	104 (16%)

Comparison of Sleep Characteristics Data Measured by Actiwatch

ACT Participant Characteristics (N=706)	Average Sleep Time, minutes	Average Wake After Sleep Onset, minutes
	Mean (95% CI)	
Overall	442 (438, 447)	46 (44, 48)
Age		
65-74	431 (423, 439)	46 (43, 50)
75-84	443 (437, 449)	45 (42, 48)
85+	466 (454, 477)	49 (44, 54)
Sex		
Men	438 (431, 444)	50 (47, 52)
Women	446 (440, 452)	43 (40, 54)
Depressive Symptoms per CESD		
No	442 (437, 446)	45 (43, 47)
Yes	444 (429, 458)	53 (47, 59)
STOP-BANG Score		
0-2 (Low risk of OSA)	450 (443, 457)	42 (39, 45)
3-4 (Intermediate risk of OSA)	441 (433, 448)	47 (44, 50)
5-8 (High risk of OSA)	422 (409, 435)	54 (49, 59)



24HAC & Trajectories of Future Cognition & Function

Background

- Studies show that physical activity, sedentary time, and sleep are independently associated with cognitive function and physical function.
- However, few studies have examined joint associations between 24-hour activity cycle behaviors – yet they are inherently related
- Newer statistical methods leverage compositional data analysis to better understand the 24-hour activity cycle and its relationship with aging outcomes
- Few known studies have examined whether 24-hour activity cycle compositions are associated with prospective longitudinal changes in cognition and function

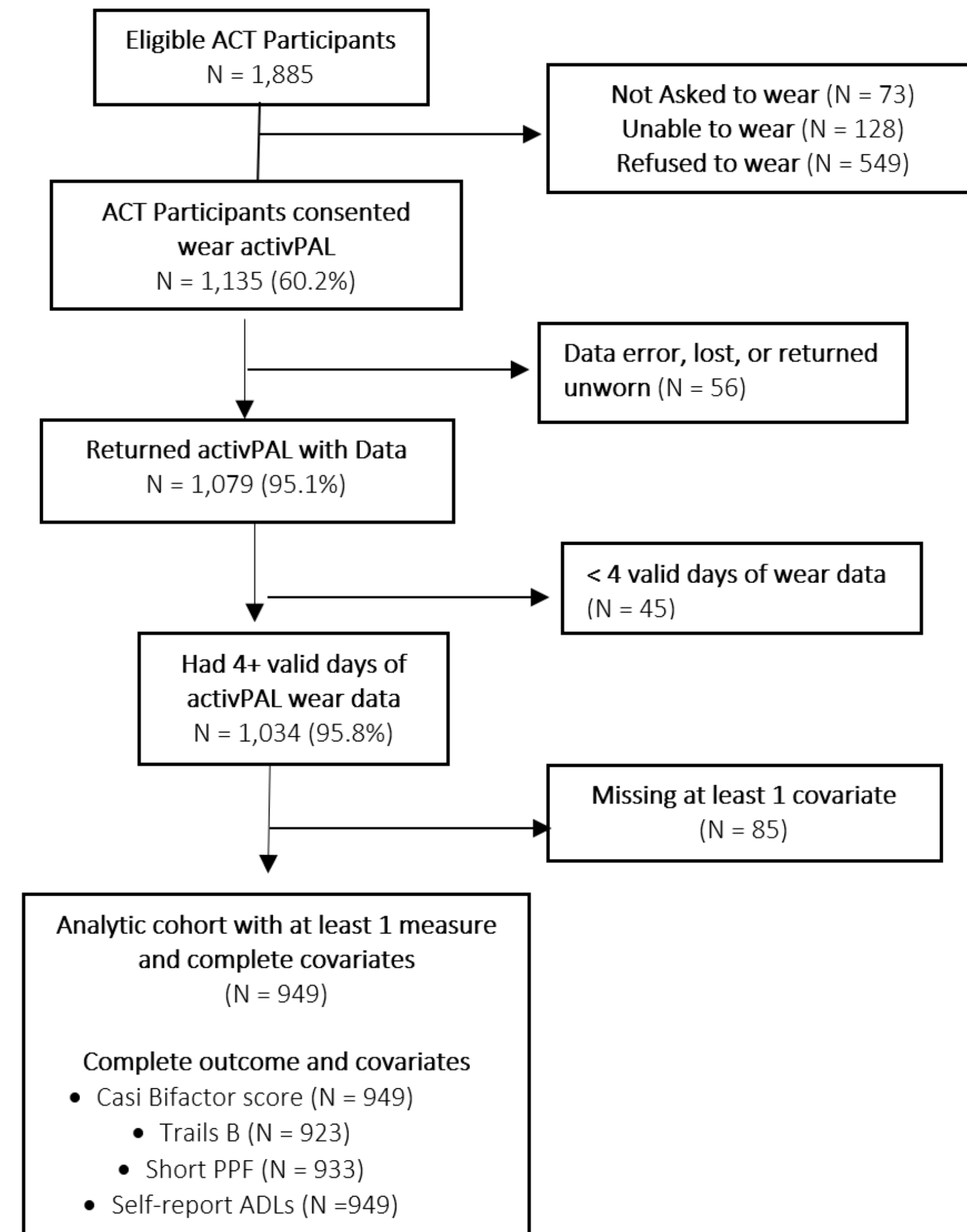
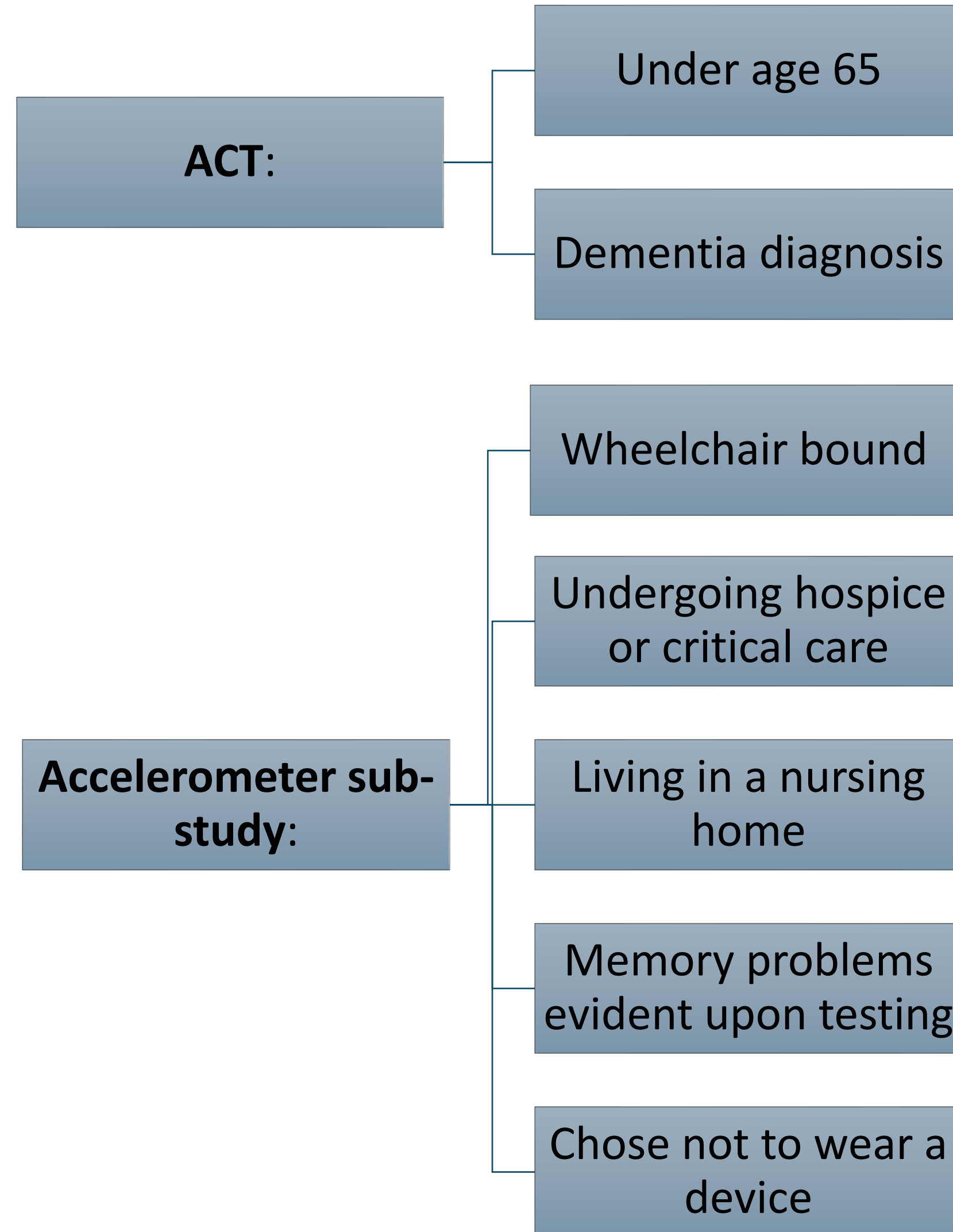


Goal of This Study

- Leverage extensive historic data available in the Adult Changes in Thought (ACT) cohort study
- Examine whether compositions of the 24-hour activity cycle are associated with longitudinal changes in cognitive and physical function in a sample of community dwelling older adults



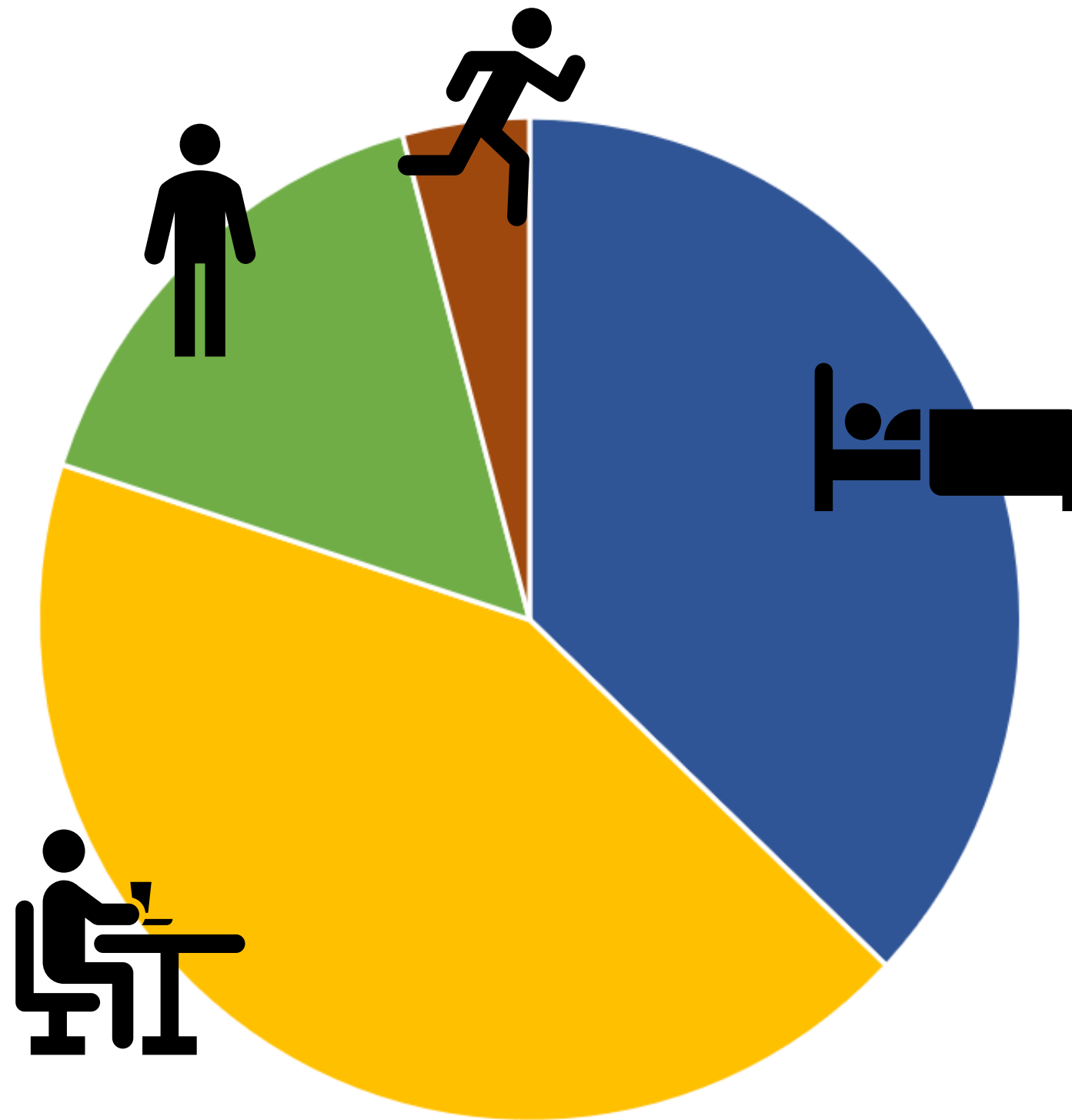
Exclusion Criteria



The 24-hour Activity Cycle – Measurement

Activity:

- activPAL (thigh)
 - Sitting
 - Standing
 - Stepping



Sleep:

- Time-in-bed from sleep log

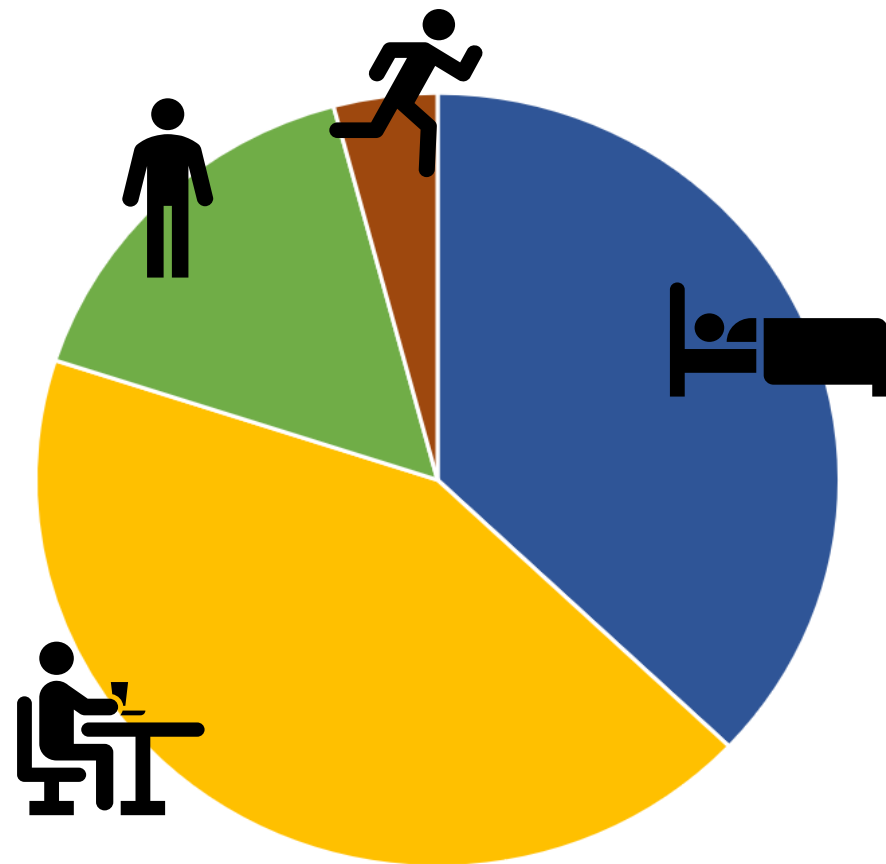
Outcome Measures

- CASI Bifactor Score
 - Global cognition measure
 - 39 items transformed via a 2-level item response theory (IRT) model
 - Comparable to z-scores (mean=0, SD=1)
- sPPF
 - Grip strength
 - Chair Stands
 - Gait speed
 - Scores range from 0-12

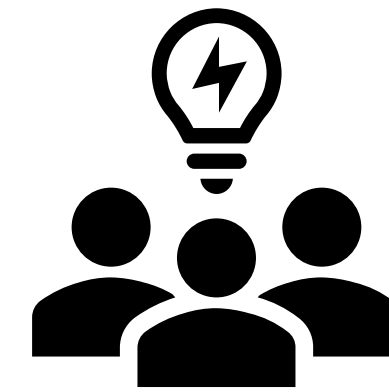
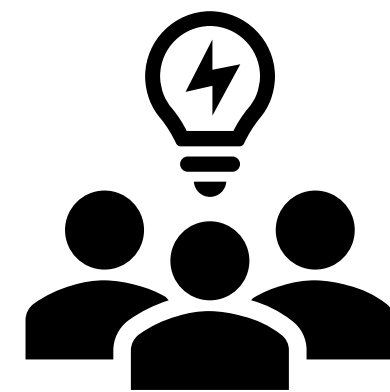
Data Availability Timeline

2016-2018	2018-2020	2020-2022	2022-2024	2024-2026
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BL 24-hour activity cycle compositions (activPAL)

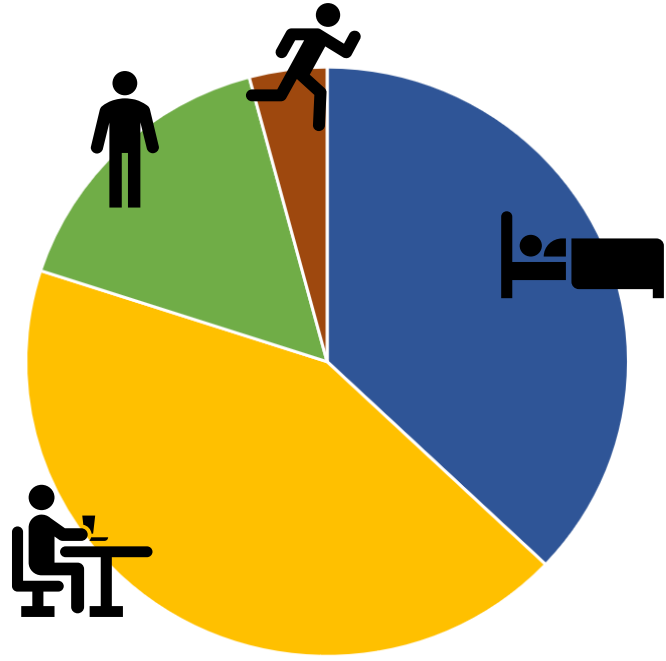


Cognition & physical function measured at each ACT biennial visit where available (up to 4 time points)

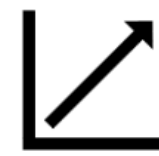


Statistical Analyses

Main Predictor (24 HAC)



Outcome (CASI-IRT)



Trajectory of Cognitive & Physical Function (up to 8 years after device wear)

Covariates

Main Predictors	Covariates
total, sleep, sit, stand, step (3 of the 4 levels)	Age, gender, living alone, employment status, years of education (fixed)

Statistical Analyses

- **Model the 24HAC exposure:**

- Compositional data analysis (CoDA) used to model 24HAC exposure
 - Non-linear, requires ilr transformation to geometric means
- Include all activity components (step, stand, sit, sleep) as a compositional exposure
 - Used “profiles” of these behaviors from prior work in our sample to choose example compositions to compare

	Sleep	Sit	Stand	Step
	hrs/day			
Average profile*	8.9	10.3	3.5	1.3
Active profile	8.5	7.0	6.3	2.1
Inactive profile	8.7	12.6	2.2	0.7

- **Joint modeling approach**

- Separate longitudinal mixed models for trajectories of each outcome (CASI, sPPF) over time
 - Integrated 24-hour activity compositions using CoDA
 - Included interaction between time and 24-hour composition
- Simultaneous survival model to account for informative missingness and/or censoring due to death/terminal illness or dementia (loss to follow-up)

Results

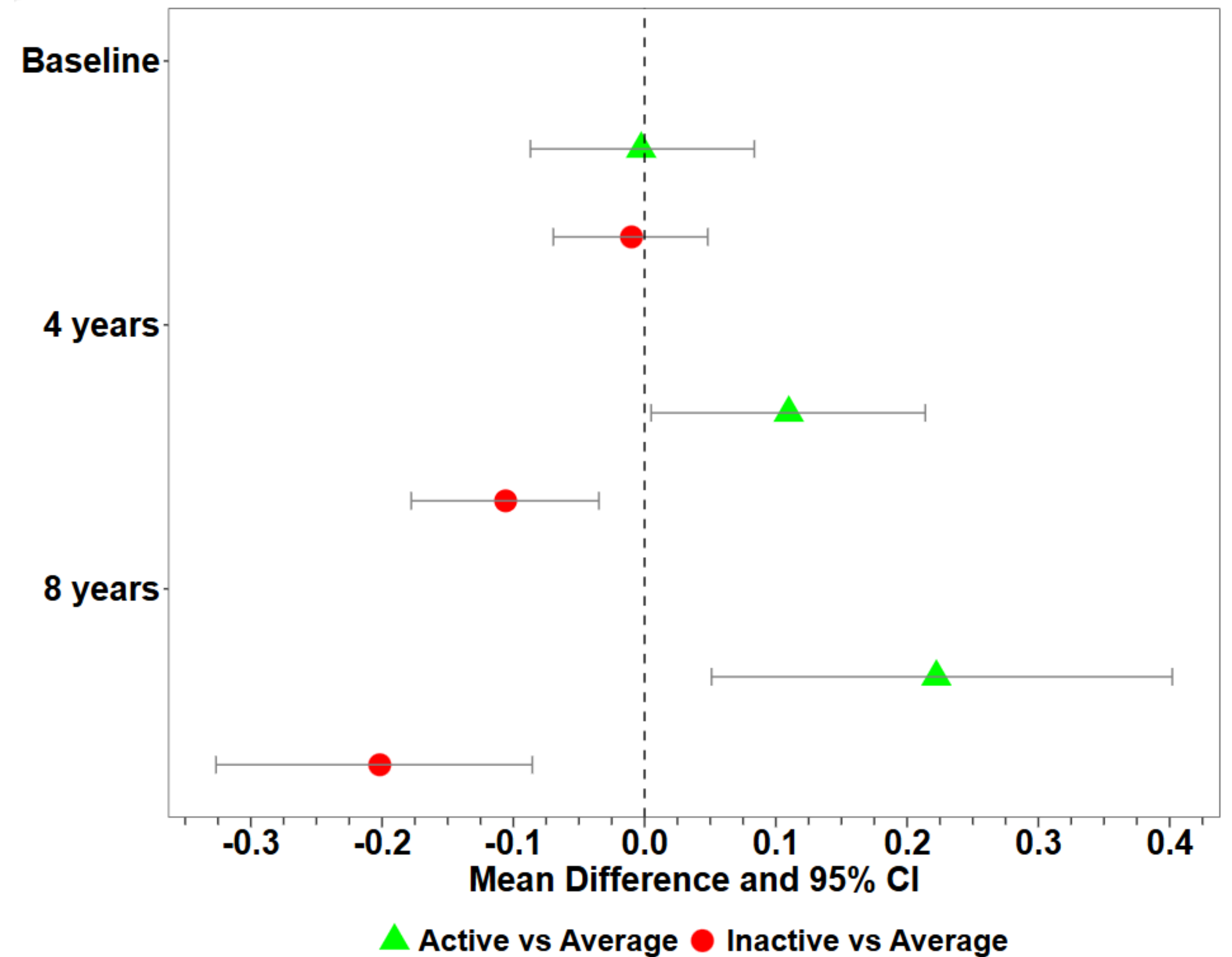
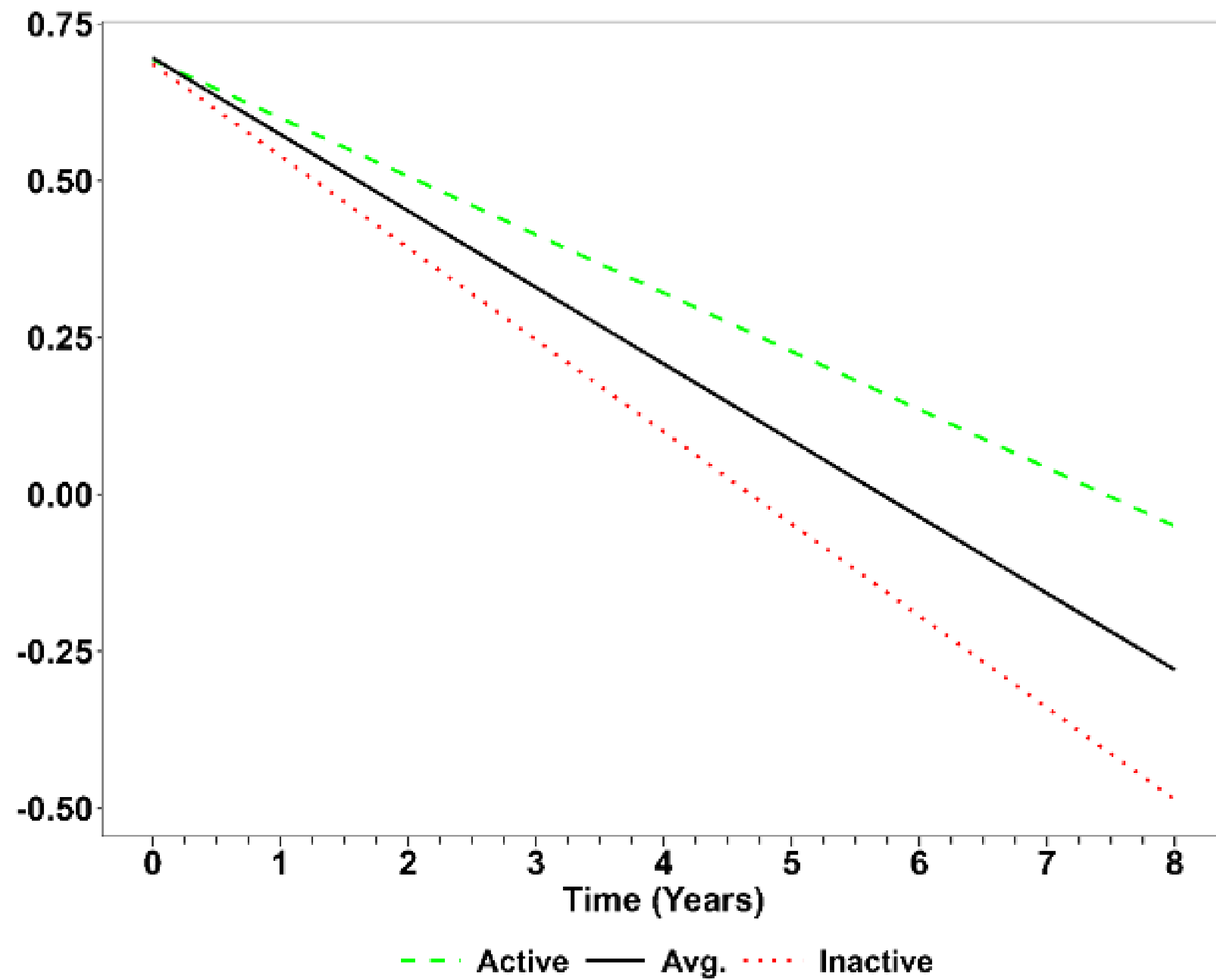


Participant Characteristics

	N	Mean (SD)
Cognition Function		
CASI Bifactor score	941	0.64 (0.93)
Physical Function		
sPPF (score)	933	8.70 (2.55)

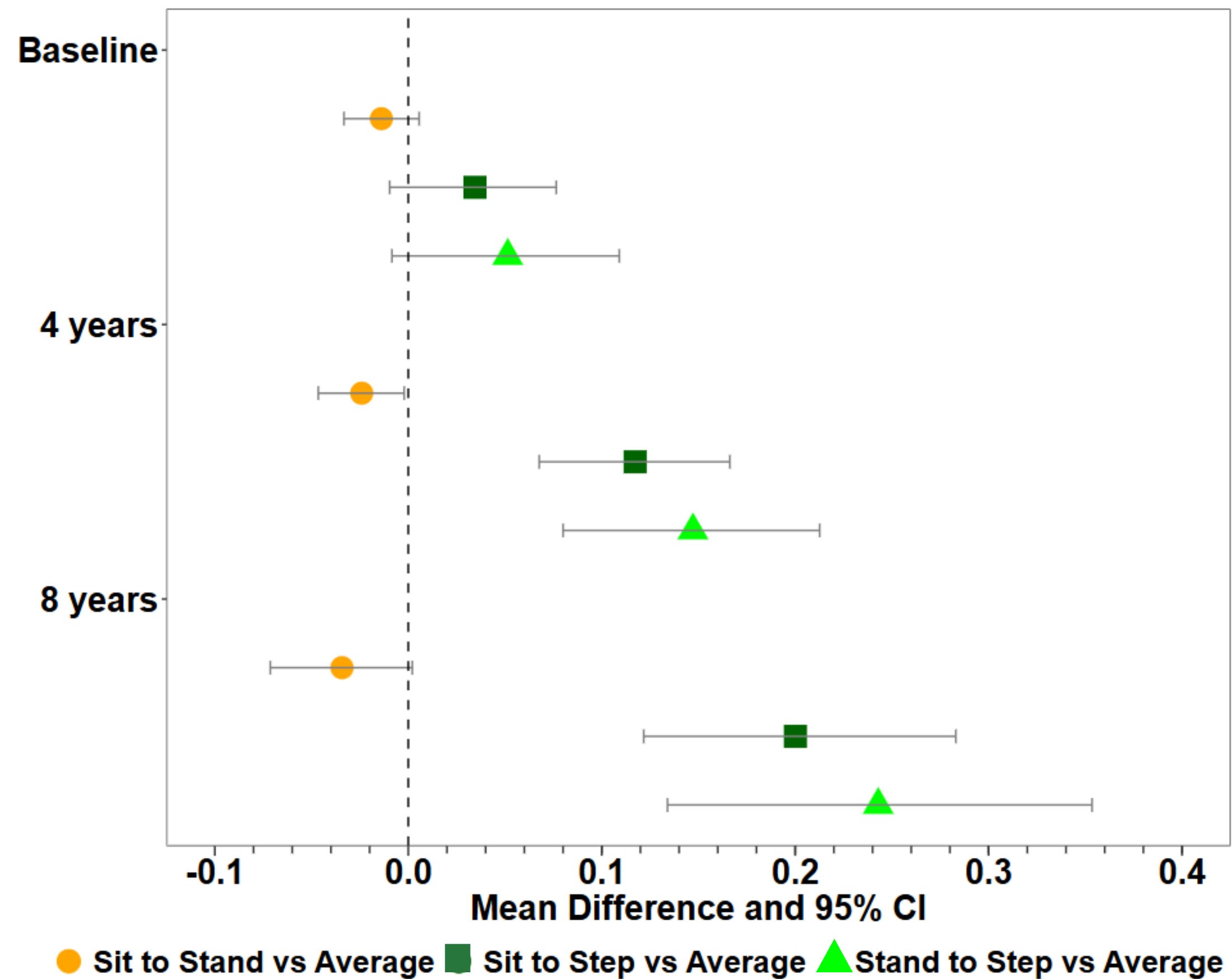
	Overall sample (N=949) % or mean (SD)
Age (years)	76.8 (6.9)
Female	56%
Race	
Asian	3%
Black	2%
White	90%
Other, including mixed	5%
Unknown	<1%
Hispanic Ethnicity (Yes)	2%
College degree or more (16+ years)	58%
Currently Employed	17%
BMI	27.1 (4.9)
Depressive symptoms (CESD Score \geq 10)	9%
Live alone	34%
Fair/Poor self-rated health	8%
Ability to walk ½ mile	76%
CCI (0-1)	72%
activPAL Measures (hr/day)	
Sitting time	10.0 (1.9)
Standing time	4.0 (1.6)
Stepping time	1.5 (0.6)
Sleep log time in bed (hr/day)	8.5 (1.1)

Results: CASI Main Models



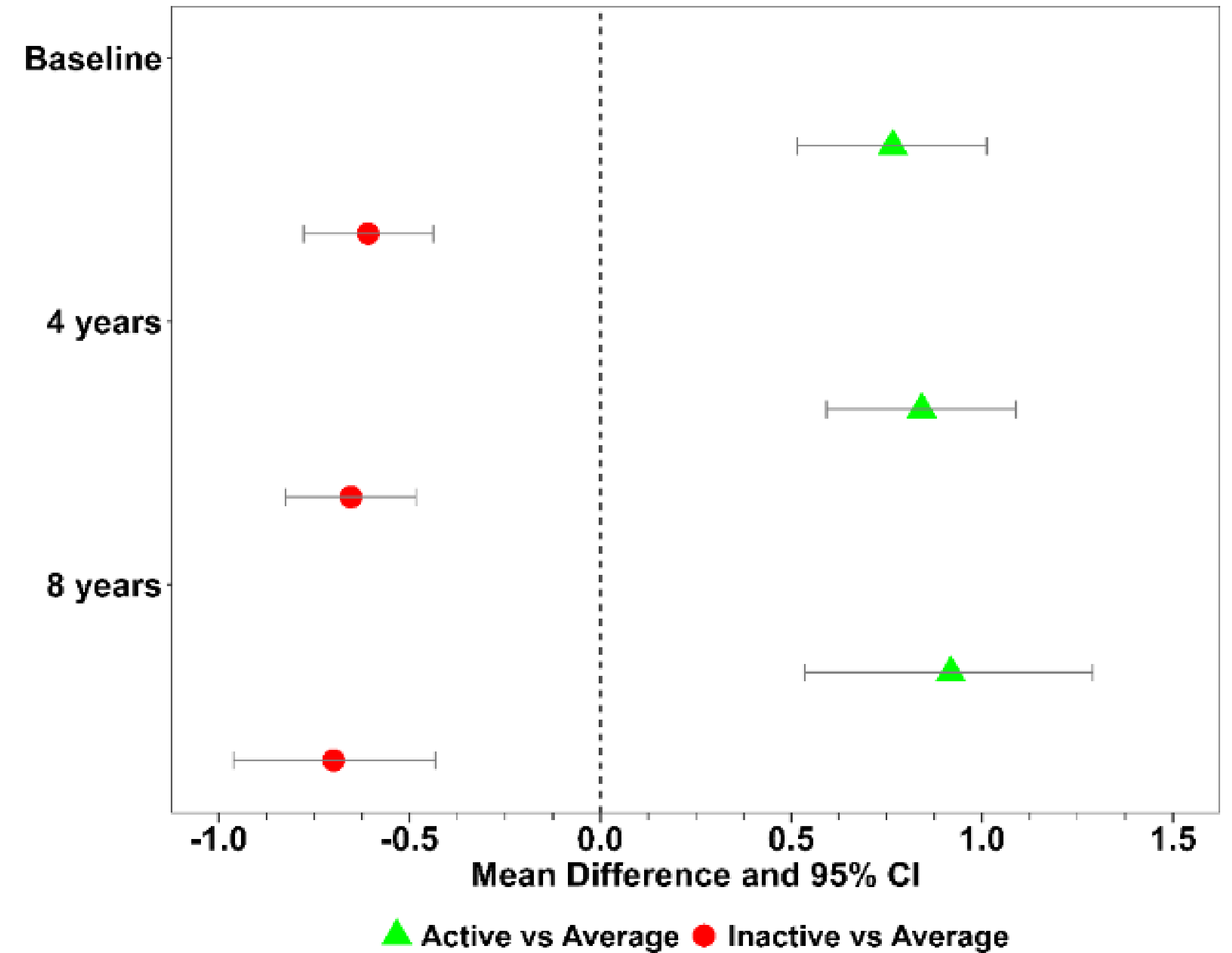
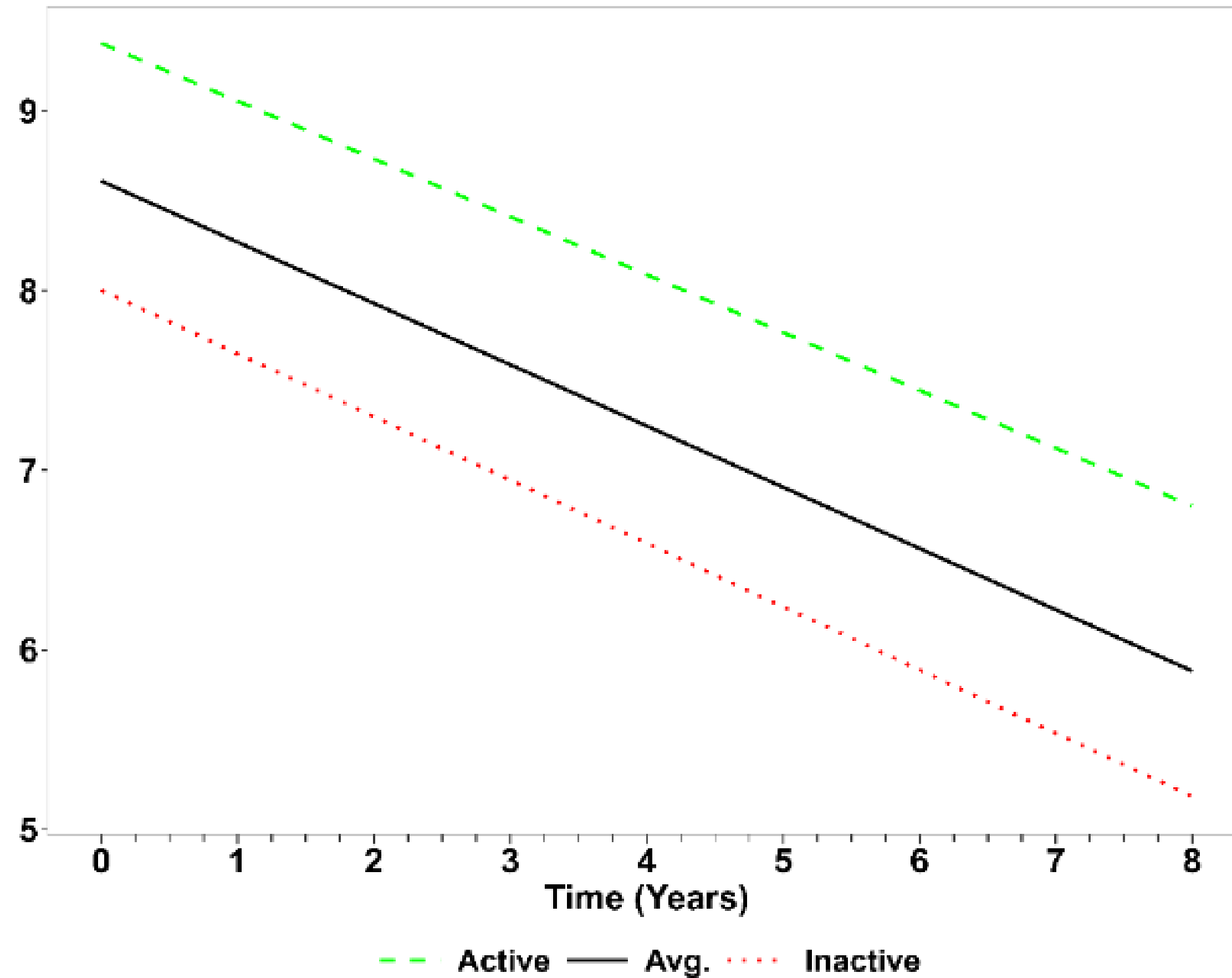
Results: CASI Substitution Models

30 minute activity substitutions vs the average profile



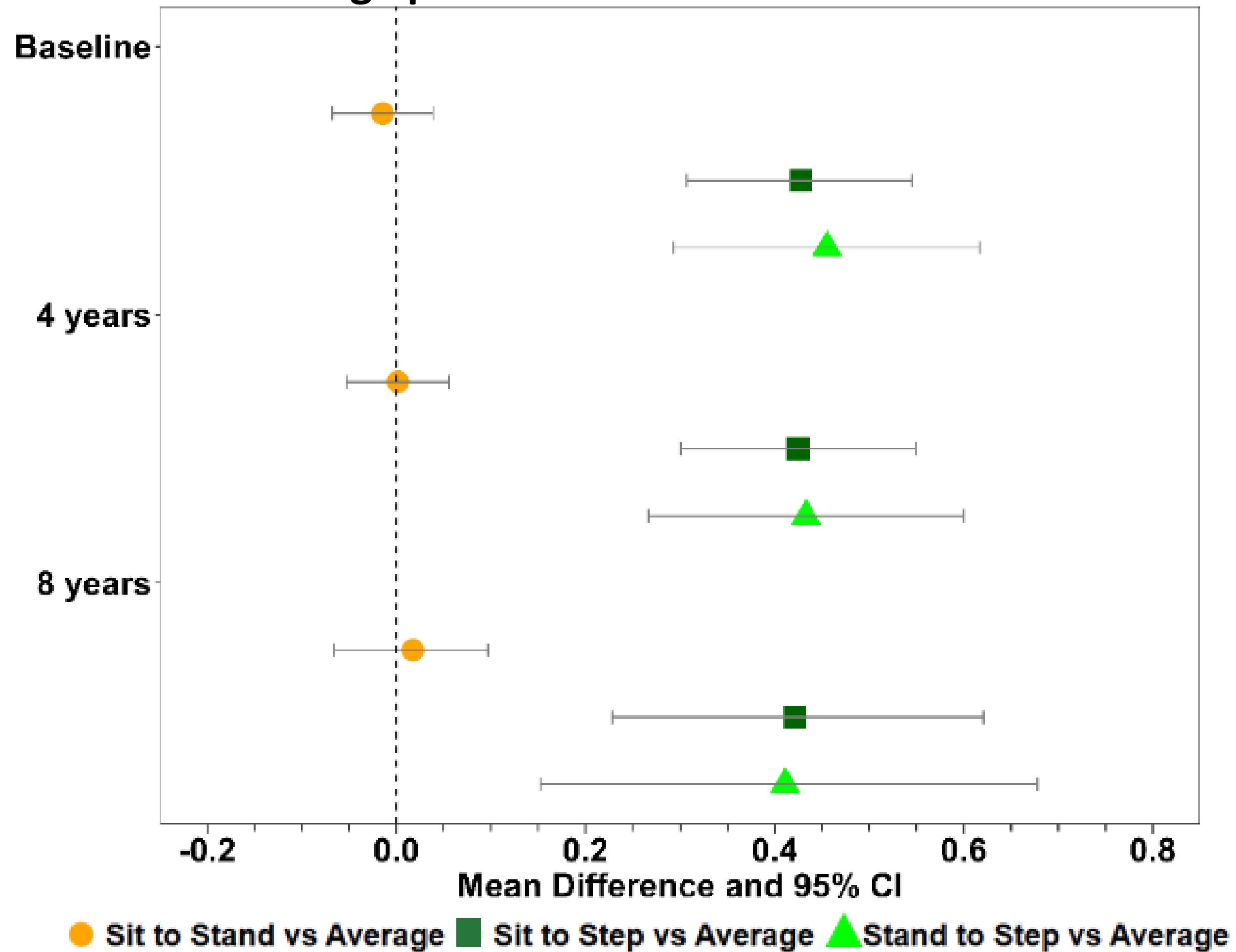
	Sleep	Sit	Stand	Step
Average profile	8.9	10.3	3.5	1.3
Substitution profile:	8.9	9.8	4.0	1.3
30 min sit to stand				
Substitution Profile:	8.9	9.8	3.5	1.8
30 min sit to step				
Substitution profile:	8.9	10.3	3.0	1.8
30 min stand to step				

Results: sPPF Main Models



Results: sPPF Substitution Models

30 minute activity substitutions vs the average profile

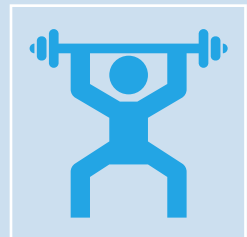


	Sleep	Sit	Stand	Step
Average profile	8.9	10.3	3.5	1.3
Substitution profile:	8.9	9.8	4.0	1.3
30 min sit to stand				
Substitution Profile:	8.9	9.8	3.5	1.8
30 min sit to step				
Substitution profile:	8.9	10.3	3.0	1.8
30 min stand to step				

Conclusions



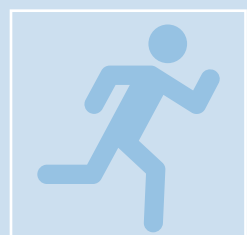
24-hour compositions are predictive of rate of cognitive decline



Compositions are associated with baseline physical function but not with rate of decline



Reallocating 30 minutes of sitting or standing with stepping was associated with less cognitive decline and better physical function



Findings support need for considering 24-hour activity cycle patterns & developing interventions that target daily life behaviors

Limitations of these analyses

- Sleep did not vary by profile type which limited our ability to draw conclusions about sleep's role in cognition and physical function
 - ACT sample generally has good sleepers
 - Paradigm only considers sleep duration
 - Device-based measures can further elucidate whether aspects of sleep quality impact cognition and function
- activPAL sitting time does not distinguish cognitively engaging vs passive behaviors which could differentially impact outcomes
- Physical activity, sedentary behavior, and sleep assessed at one time point for 7-days
 - Assumes that 7-day snapshot is an accurate pattern of someone's true behavior
 - Does not reflect changes over time
- We used a hypothesis generating approach
 - Substitution models should be interpreted cautiously
- Non-participants were less healthy which could make our results more conservative

Conclusions and Future Directions

- Device-based measures of the 24-hour activity cycle provide novel information about aging-related outcomes
- Studies can build on this work by examining multiple dimensions of 24-hour activity cycle behavior
 - ACT Ancillary Studies will leverage the newly collected Actiwatch and activPAL data to link multidimensional behavioral constructs to aging-related outcomes
- Renewal will continue activPAL data collection; Actiwatch discontinued
- Results can be used to inform RCTs that intervene on the 24-hour activity cycle

A tremendous thank you to our ACT participants and staff, without whom this data collection would not be possible!

KP Data Collection:

- Dori Rosenberg, co-lead (U19 P1)
- Mikael Anne Greenwood-Hickman
- Leonardo Colemon
- Yishi Xian
- John Ewing
- Tyler Barrett
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- Nora Van Doren
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- Holly Roberts
- Kelsey Aaronson
- Luke Burke
- Maiya Love
- Margie Wilcox
- Tiffany Gaines
- Marilyn Nguyen
- Kelsey Aaronson
- Carrie Shriver

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- Amy Cunningham
- Martha Cagley
- Bob Burr
- Cathy Hutchison
- Duryah Mohamath
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- Jared Lopes
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Thank

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Analysis Team:

- Pamela Shaw
- Abisola Idu
- Rod Walker
- Weiwei Zhu
- Yinxiang Wu
- Jake Ku



THANK YOU!

Questions & Comments

Statistical Analyses

Joint modeling approach

- Conducted separate longitudinal mixed-effects models for CASI and sPPF (continuous outcomes)
- Integrated 24-hour activity profiles using compositional data analysis (CoDA)
- Included interaction between time and 24-hour composition and multiple predictors (age, gender, living alone, employment status, years of education)
- Used survival analysis within joint modeling to account for informative censoring/MNAR bias (due to death, dementia, disenrollment (loss to follow-up))
- Implemented within a Bayesian framework