Measurement of Body Composition by Dual-energy X-ray Absorptiometry in Single- and Multi-site Trials: Lessons from MoTrPAC

Wendy M Kohrt, PhD
Distinguished Professor of Medicine, Division of Geriatric Medicine
Nancy Anschutz Chair in Women's Health Research
University of Colorado – Anschutz Medical Campus

Division of Geriatric Medicine
SCHOOL OF MEDICINE
UNIVERSITY OF COLORADO **ANSCHUTZ MEDICAL CAMPUS**

Nutrition Obesity Research Center
UNIVERSITY OF COLORADO **ANSCHUTZ MEDICAL CAMPUS**

oTrPAC

Outline

1. Overview of body composition measurement by DXA

2. Challenges in the use of DXA in single-site trials

3. Challenges in the use of DXA in multi-site trials

Measurement of Body Composition by DXA

Dual-energy X-ray absorptiometry (DXA) – introduced in 1987

- Replaced dual-photon absorptiometry
- More stable energy source (X-ray vs ^{153}gadolinium)
- Reduced radiation exposure
- Higher resolution and faster scanning time (3-13 min vs 30-60 min)
- Enhanced measurement of soft tissue composition

Measurement of Body Composition by DXA

> J Appl Physiol (1985). 1993 Feb;74(2):770-5. doi: 10.1152/jappl.1993.74.2.770.

Age-related differences in body composition by hydrodensitometry and dual-energy X-ray absorptiometry

D B Snead [1], S J Birge, W M Kohrt

Review > Med Sci Sports Exerc. 1995 Oct;27(10):1349-53.

Body composition by DXA: tried and true?

W M Kohrt [1]

Clinical Trial > J Appl Physiol (1985). 1998 Jan;84(1):372-7. doi: 10.1152/jappl.1998.84.1.372.

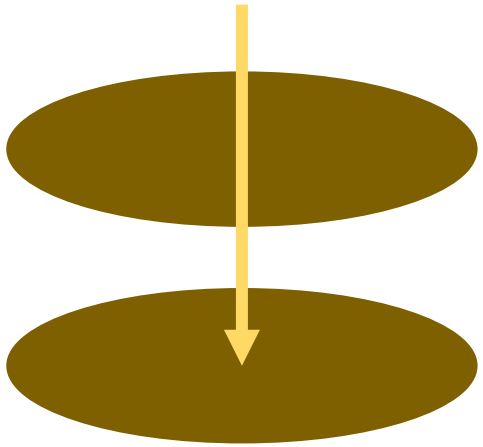
Preliminary evidence that DEXA provides an accurate assessment of body composition

W M Kohrt [1]

Measurement of Body Composition by DXA

Single Beam

A = A’

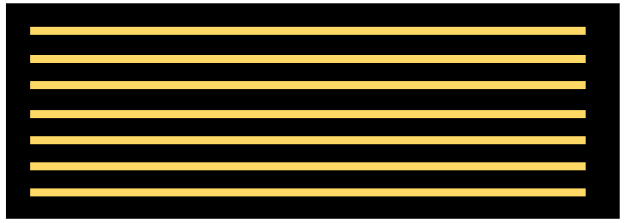


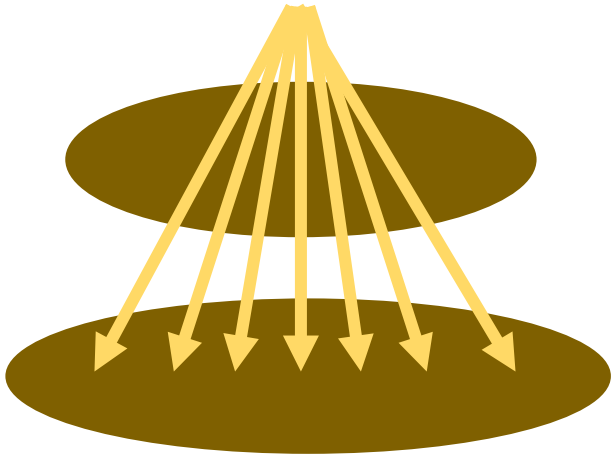
A = Area of Object

A’ = Projected Area of Object

Fan Beam

A < A’

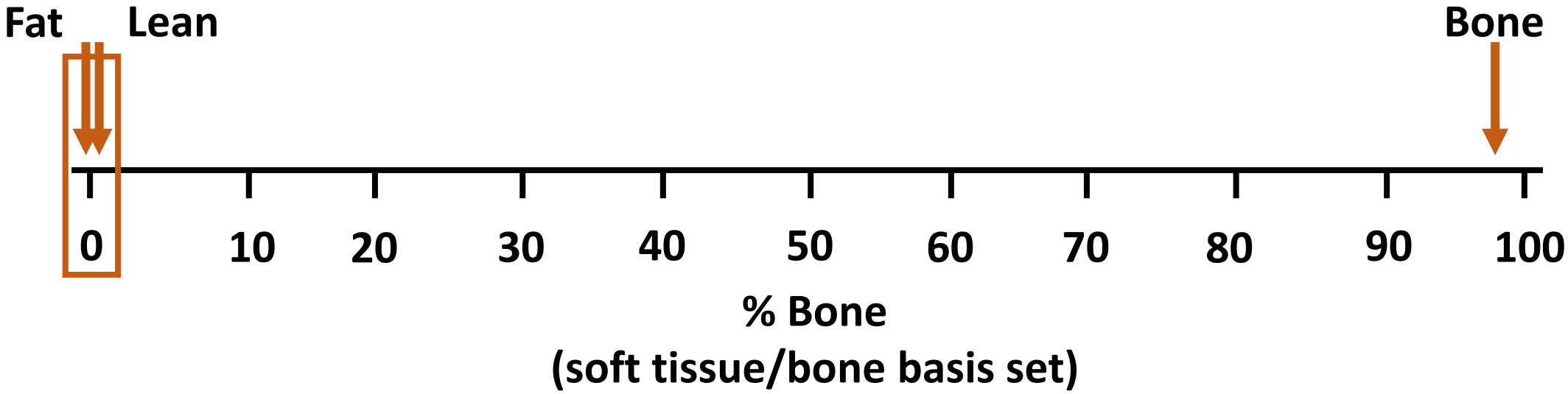




A = Area of Object

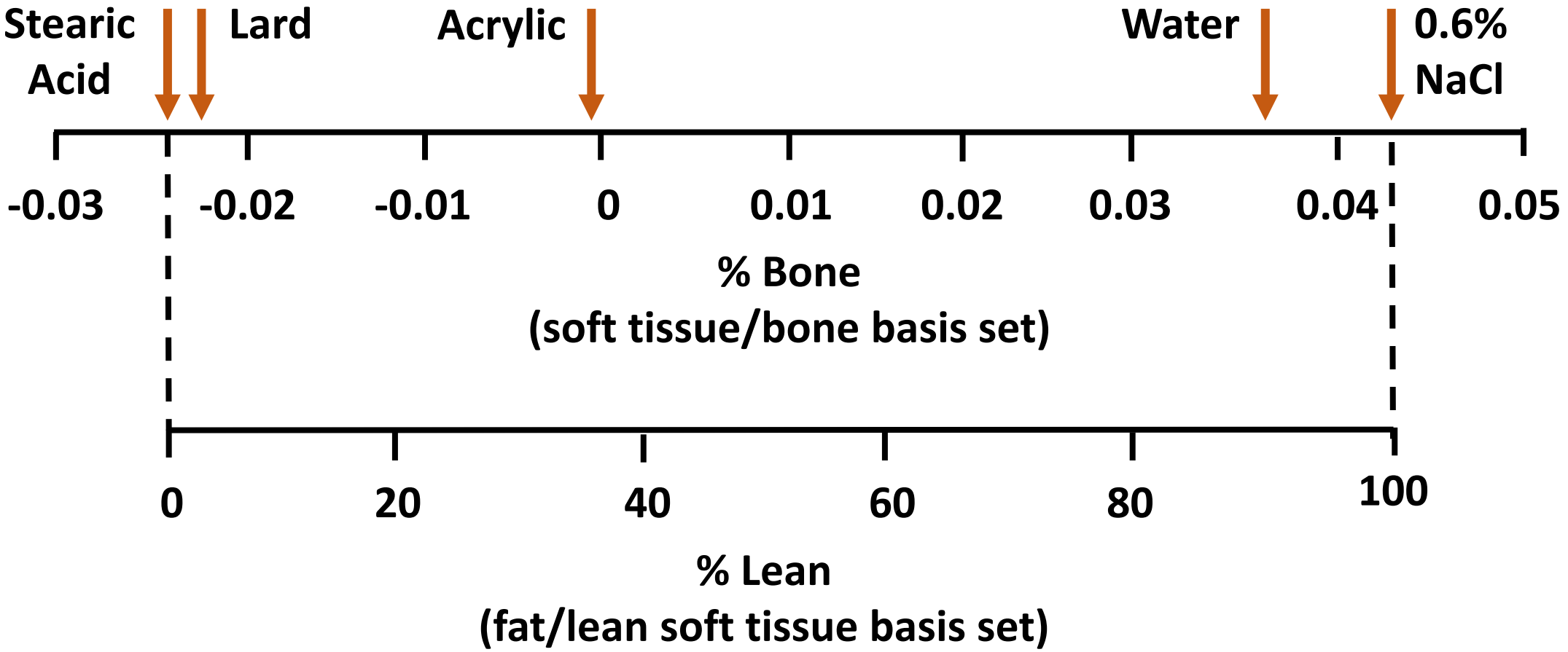
A’ = Projected Area of Object

Measurement of Body Composition by DXA



- Attenuation of X-ray by bone is ~4 orders of magnitude greater than attenuation by soft tissue
- The large difference in attenuation between soft tissue and bone enables edge detection for bone regions
- Composition of some soft tissue over- or underlying bone-containing pixels cannot be measured (extrapolated from adjacent soft tissue region)

Measurement of Body Composition by DXA



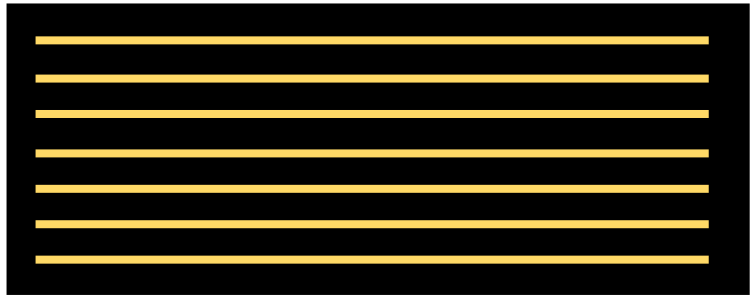
Measurement of Body Composition by DXA

	Hologic			GE HealthCare
	Horizon A	Horizon W	Horizon C	Lunar iDXA
Detectors	216	128	64	staggered array
Regional Scans	10 seconds	10 seconds	10 seconds	30 seconds
Total Body Scan	3 minutes 3 passes (perpendicular, 30 degrees right, 30 degrees left)*	6 minutes 7 passes (perpendicular)*	6 minutes 7 passes (perpendicular)	4 – 13 minutes ?

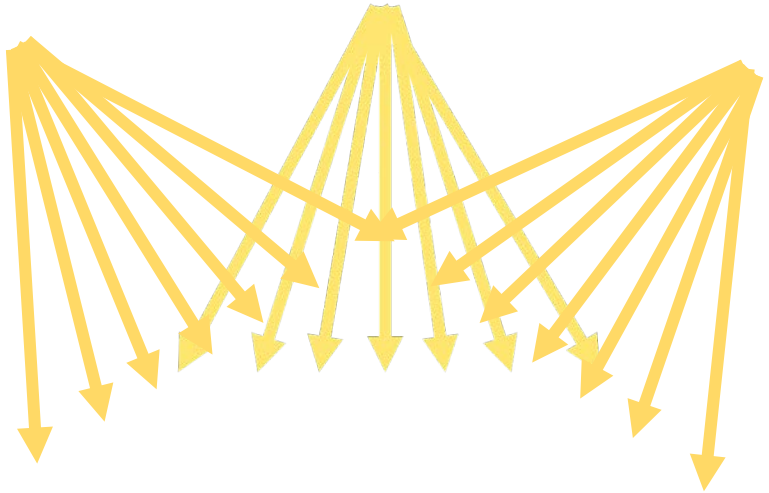
* Hologic has not compared the measurement of body composition on Horizon A and Horizon W instruments, but does not expect there to be differences (communication with Tom Kelly, Hologic Senior Principal Scientist)

Measurement of Body Composition by DXA

Horizon W



Horizon A



Challenges for Single-site Trials

If the same DXA instrument is used for all assessments in a single-site trial, one challenge is to ensure that instrument performance does not change after software updates or maintenance visits

Statement of Equivalency

APEX™ Version 5.6.1.3 to APEX Version 5.6.1.2

Background

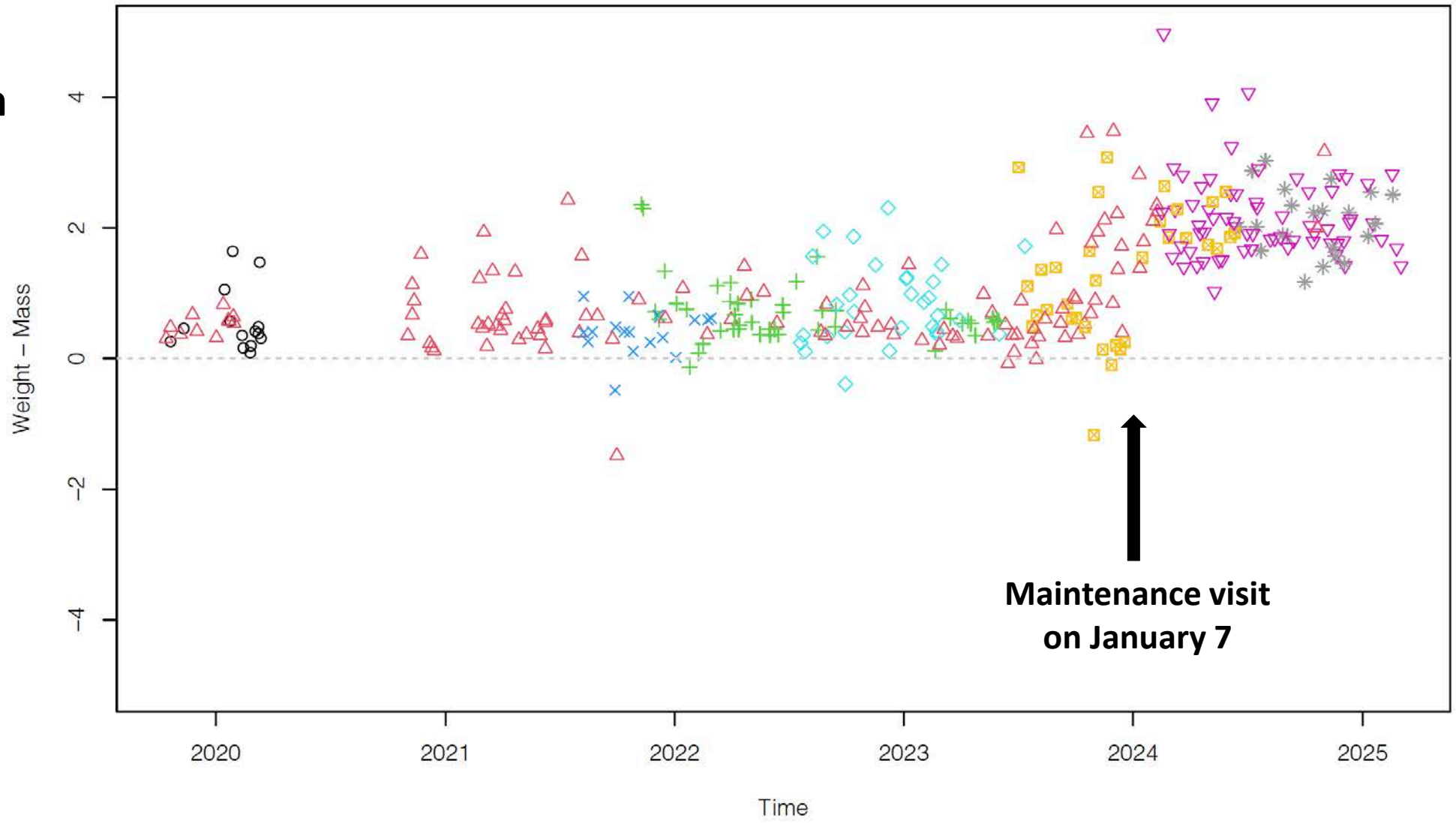
APEX software runs on various hardware platforms of Hologic® Horizon® Densitometers. The APEX 5.6.1.3 software has been updated to support two different types of stepper motors. Also, it contains enhancements that are not present in earlier releases and resolves anomalies. Please review the APEX 5.6.1.3 Release Notes for a description of these changes.

Analysis

APEX 5.6.1.3 analysis results are identical to results obtained with APEX 5.6.1.2.

Challenges for Single-site Trials

Difference between scale weight and DXA-measured total mass



Challenges for Single-site Trials

Because the accuracy of measuring total mass by DXA is ± 2 kg, DXA-measured masses should be adjusted to scale weight using the percent fat/lean masses generated by DXA

MoTrPAC plans to publish a methods paper to document the recommended approach

Challenges for Multi-site Trials

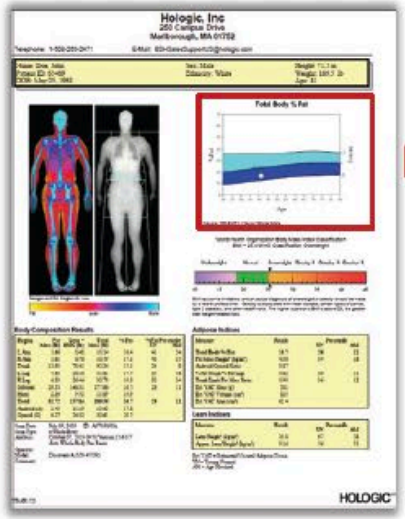
Because DXA outcomes vary between manufacturers and instrument models, the best option is to use the same make and model across sites

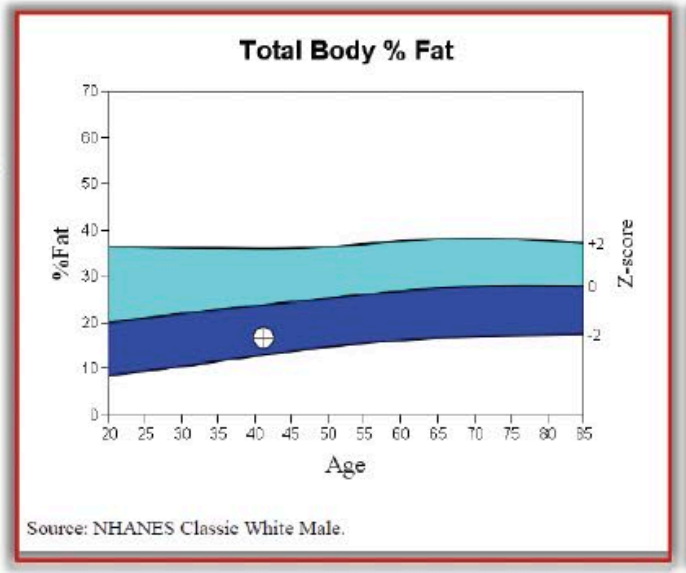
Even when the same make and model is used across sites, outcomes are influenced by factors that must be controlled

- **positioning for image acquisition (e.g., inter-operator variability)**
- **scan mode**
- **analysis mode (e.g., classic vs NHANES)**

Challenges for Multi-site Trials

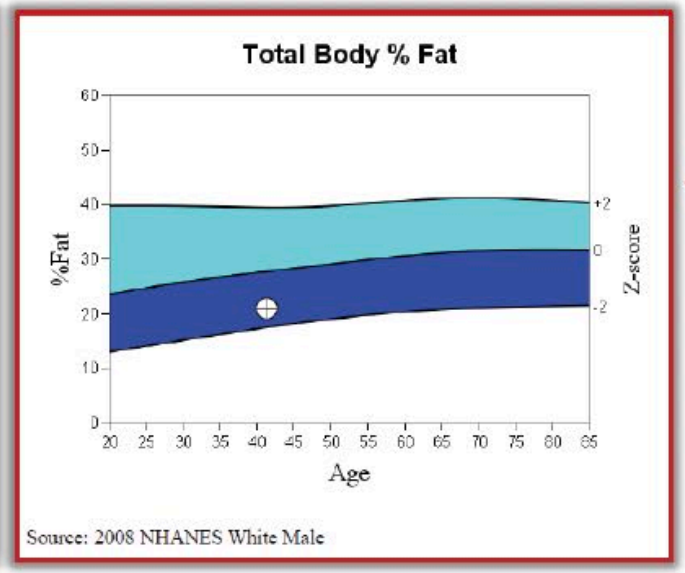
Classic Calibration

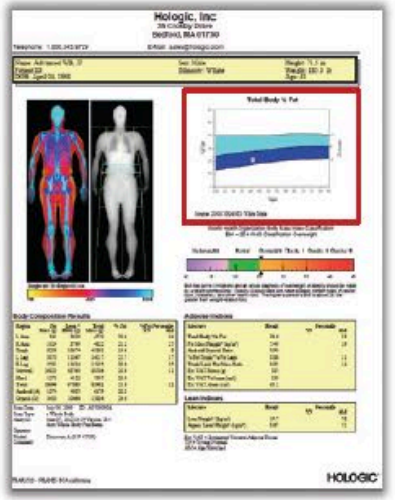




Total Body Fat: 16.7%

NHANES Calibration





Total Body Fat: 21.0%

Challenges for Multi-site Trials

If it is not possible to standardize the make and model of DXA instruments across sites, cross-calibration procedures must be implemented to harmonize data

In the past, this was done by scanning a whole-body phantom at all clinical sites and using results to apply appropriate correction factors

Challenges for Multi-site Trials

E-mail communication from Hologic:

I have reached out to our Science department again to see if they can offer some explanation. Just as an FYI the WB phantom was found not to be compliant for use with Horizon systems. I know that does not address the issue reported.

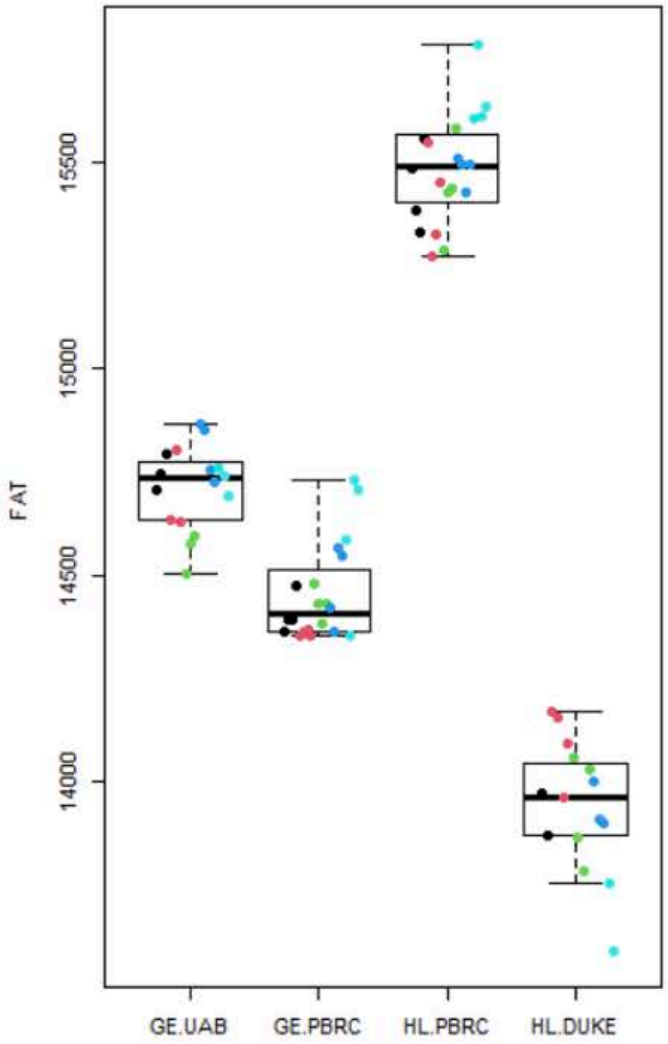
Thanks,
Jim Rowan
Support Specialist
Hologic, Inc.

Challenges for Multi-site Trials

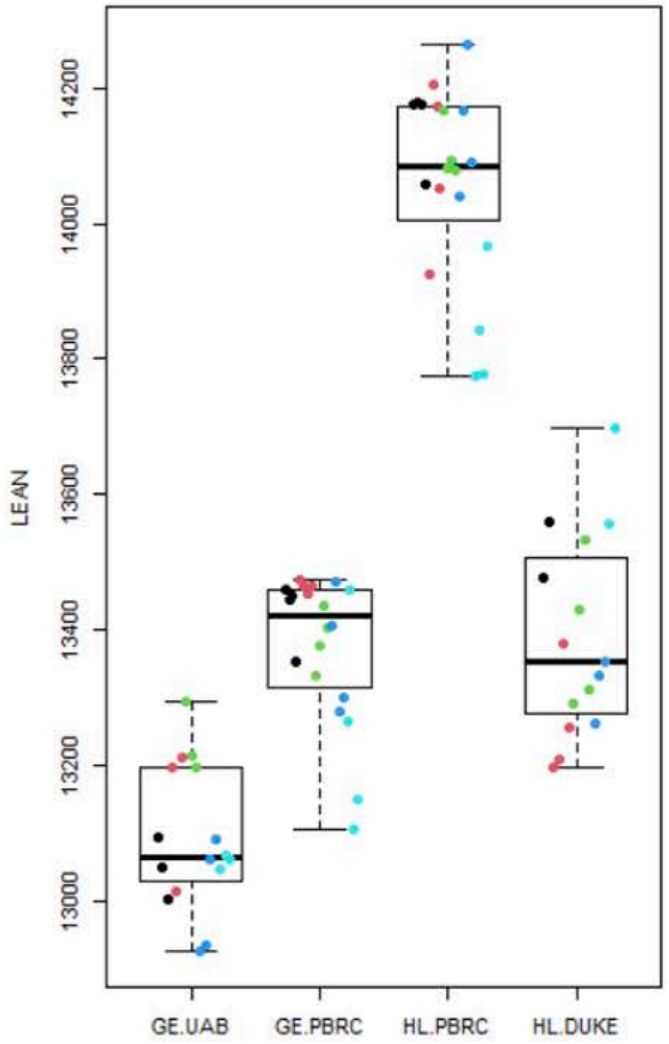
Whole-body Phantom Data From Four Sites

- **2 GE**
- **2 Hologic**

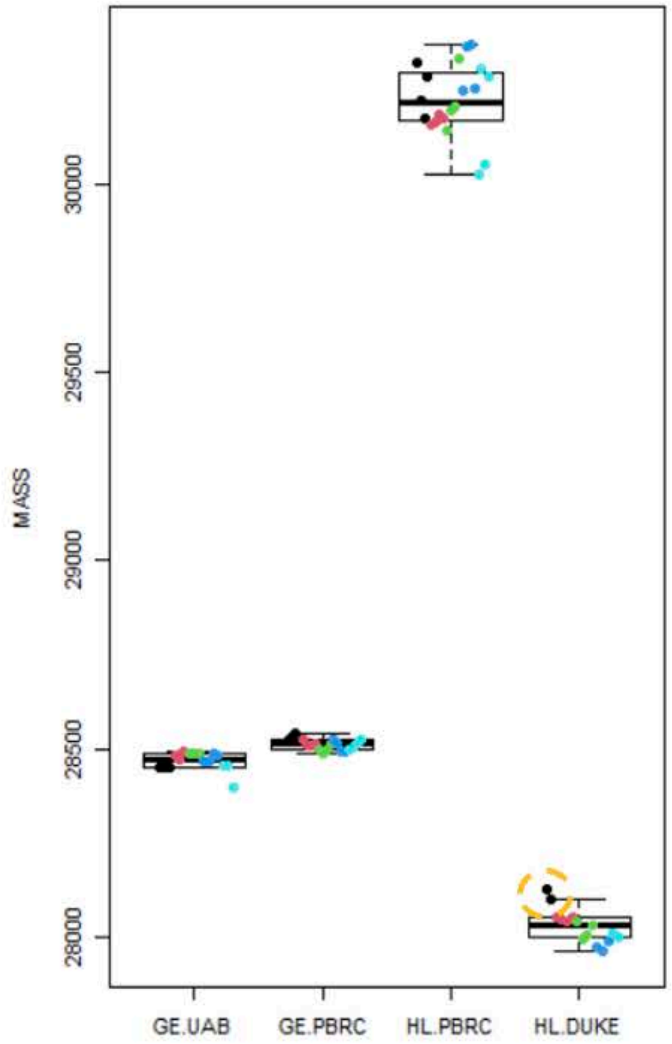
Fat Mass



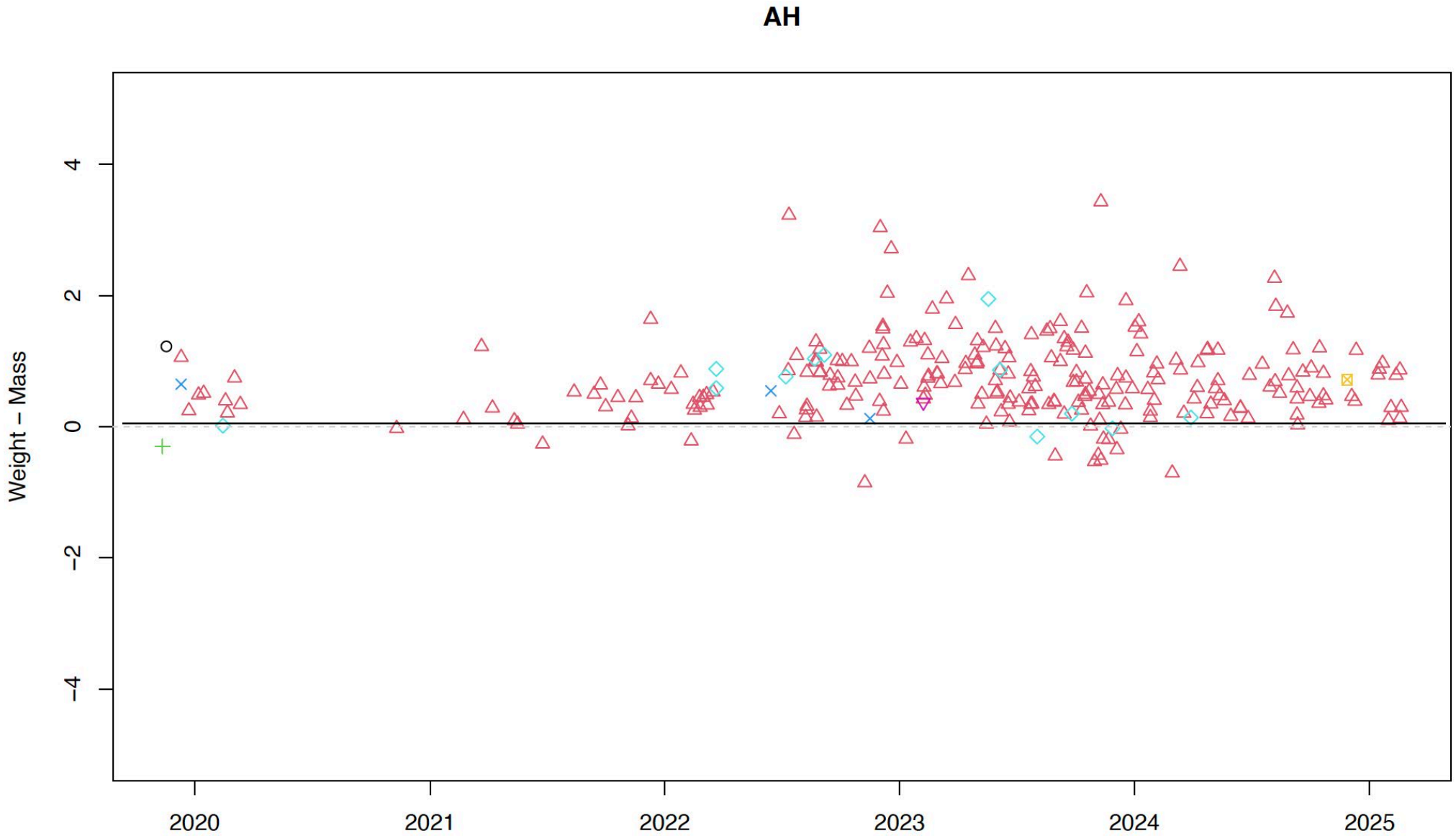
Lean Mass



Total Mass

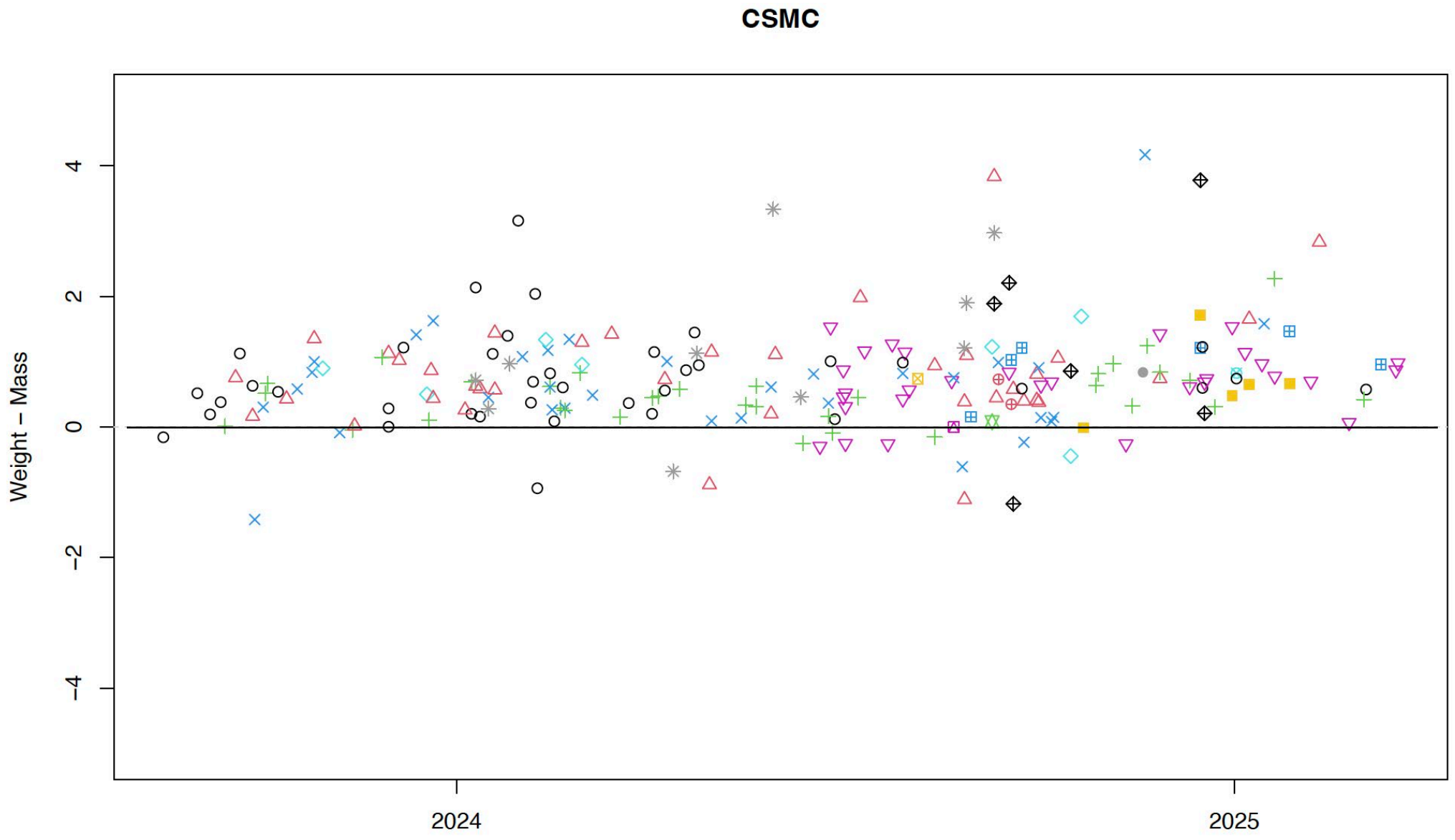


Challenges for Multi-site Trials

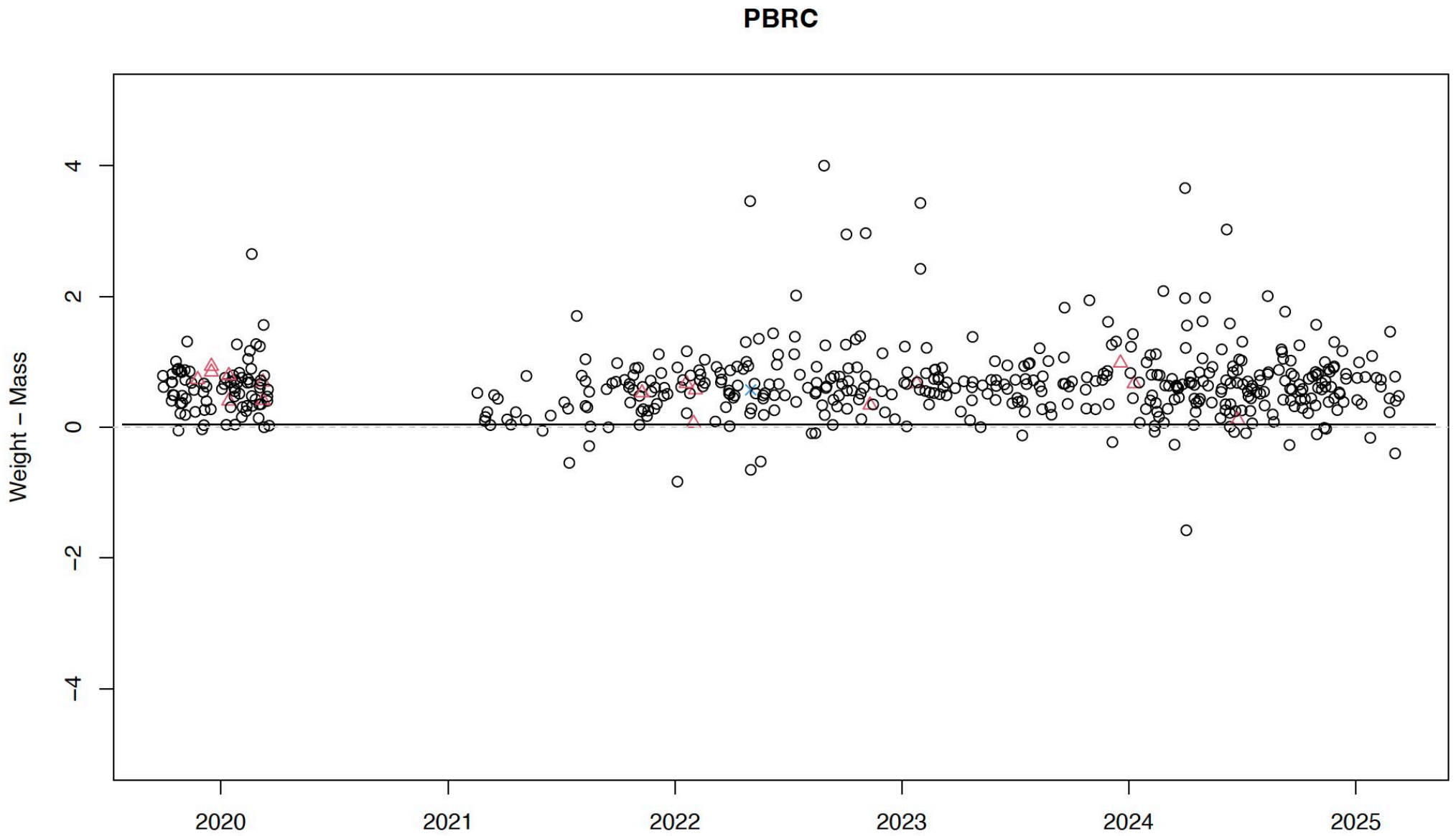


Challenges for Multi-site Trials

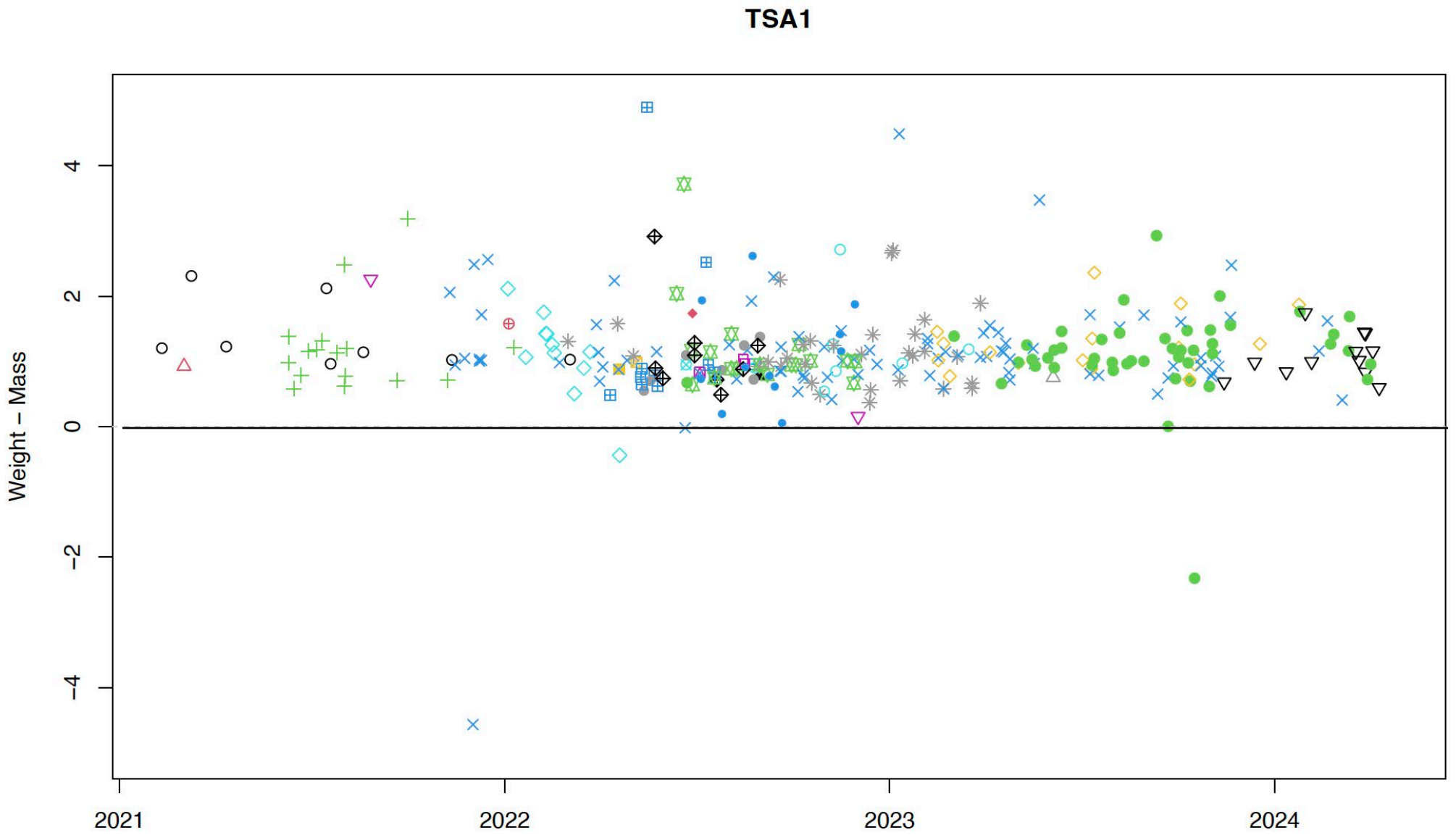
Challenges for Multi-site Trials



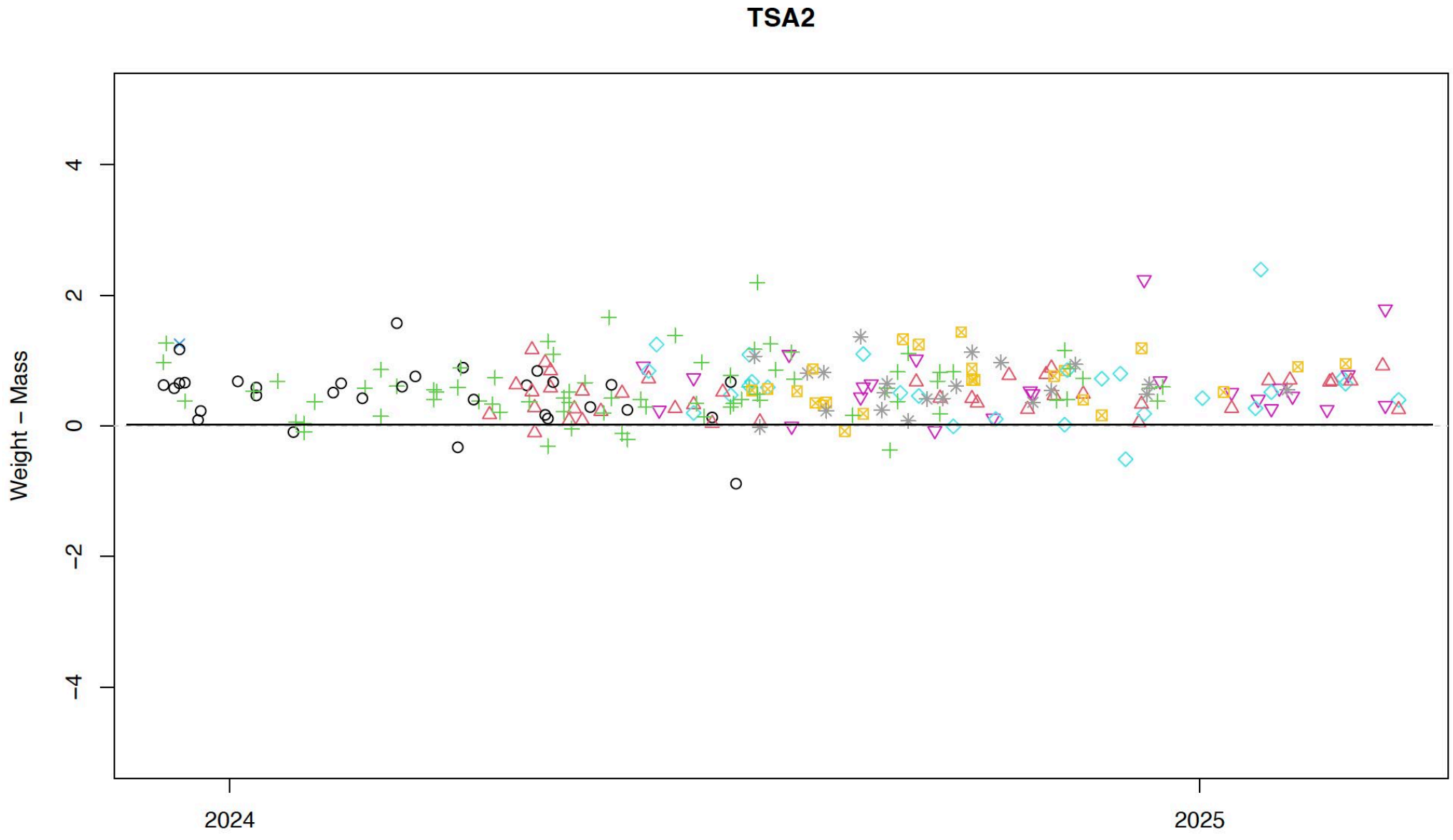
Challenges for Multi-site Trials



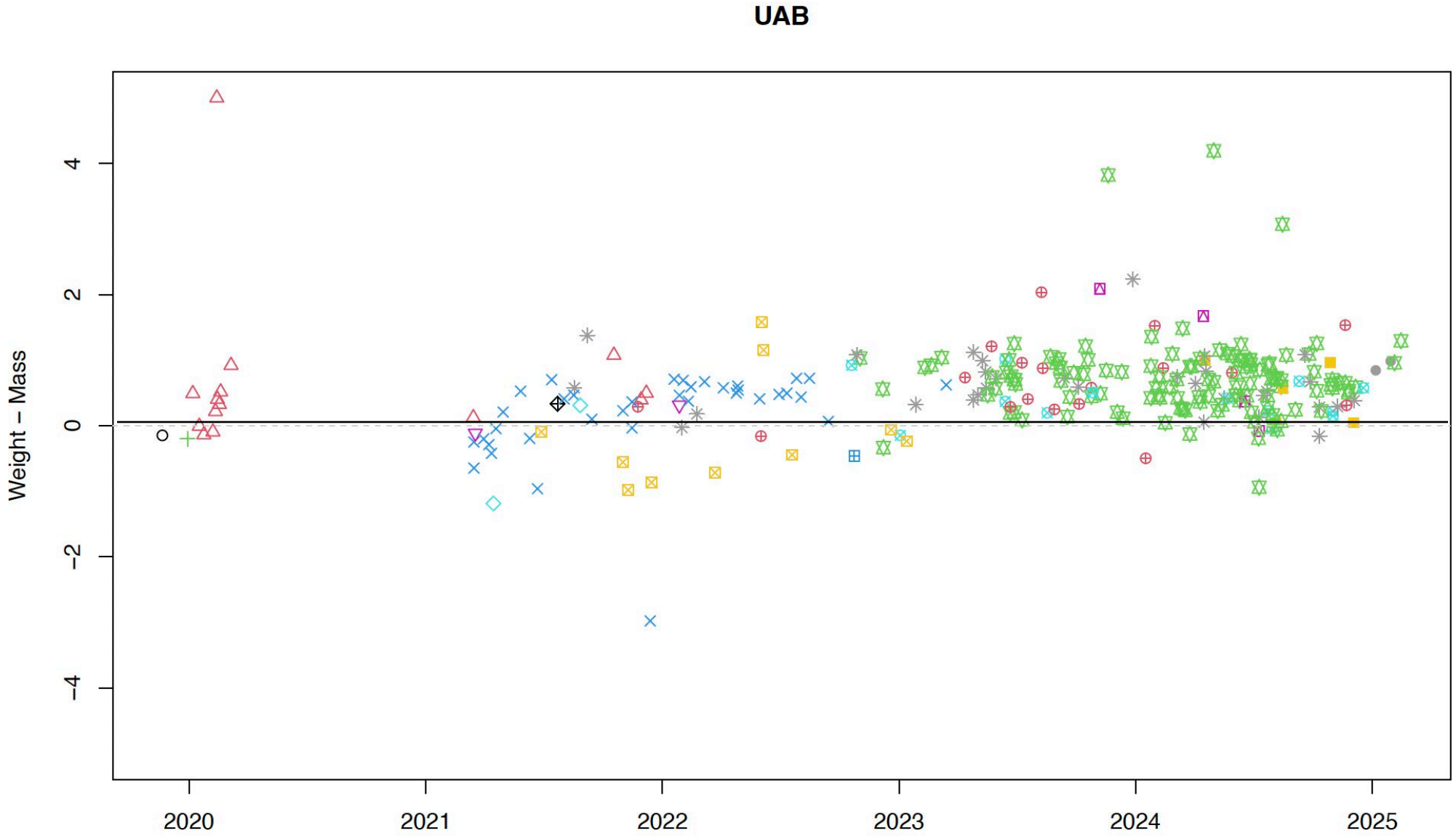
Challenges for Multi-site Trials



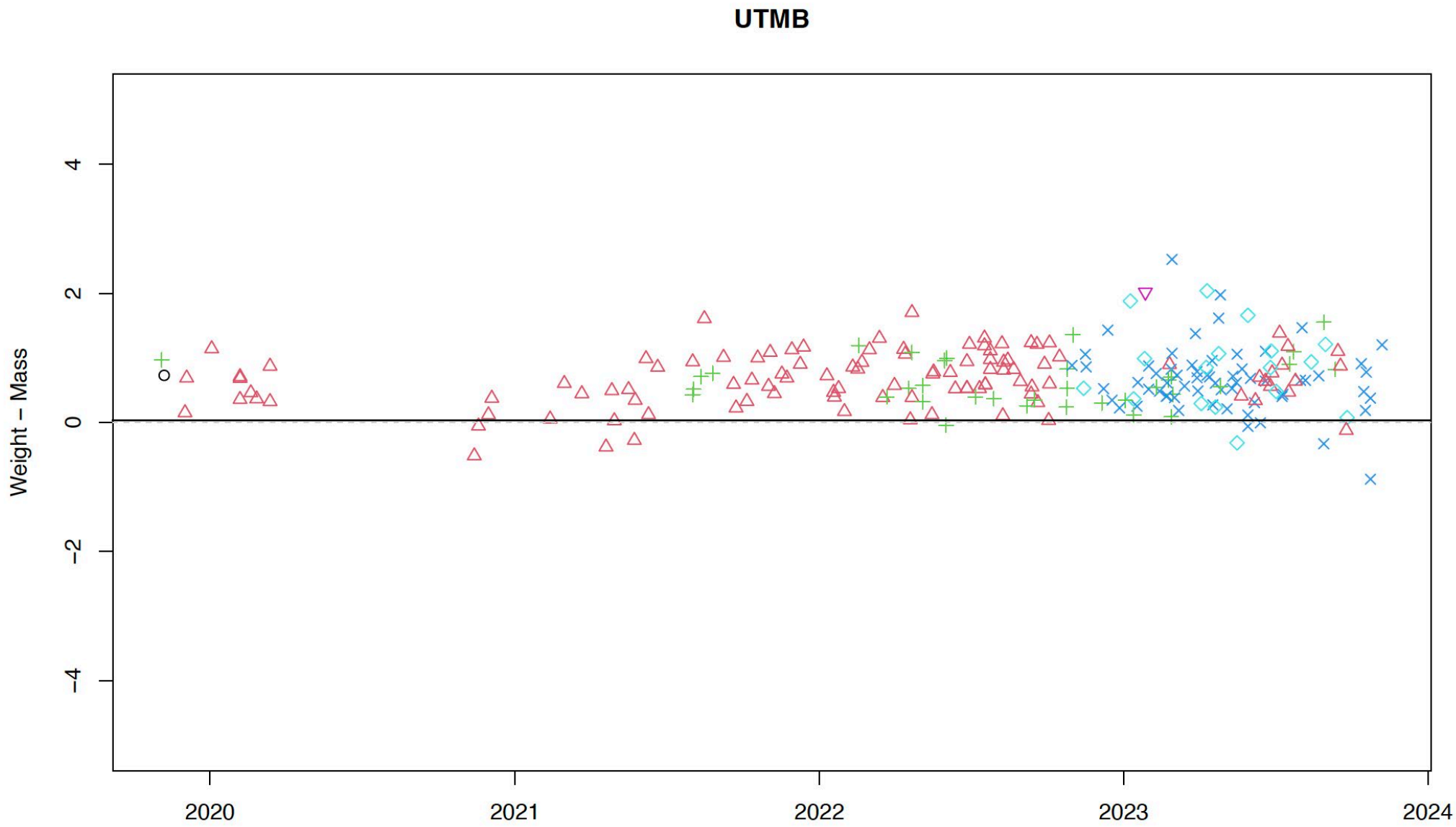
Challenges for Multi-site Trials



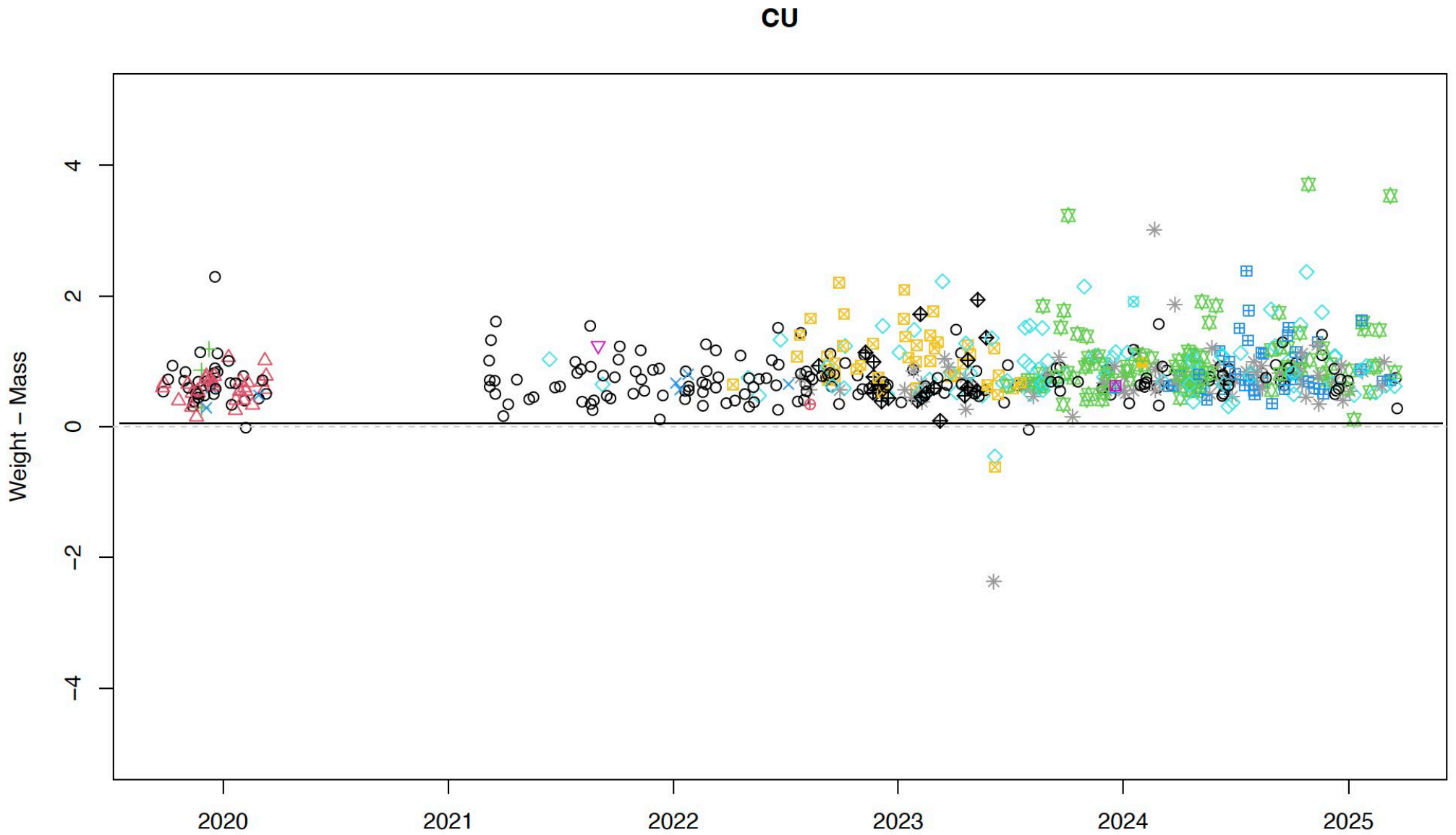
Challenges for Multi-site Trials



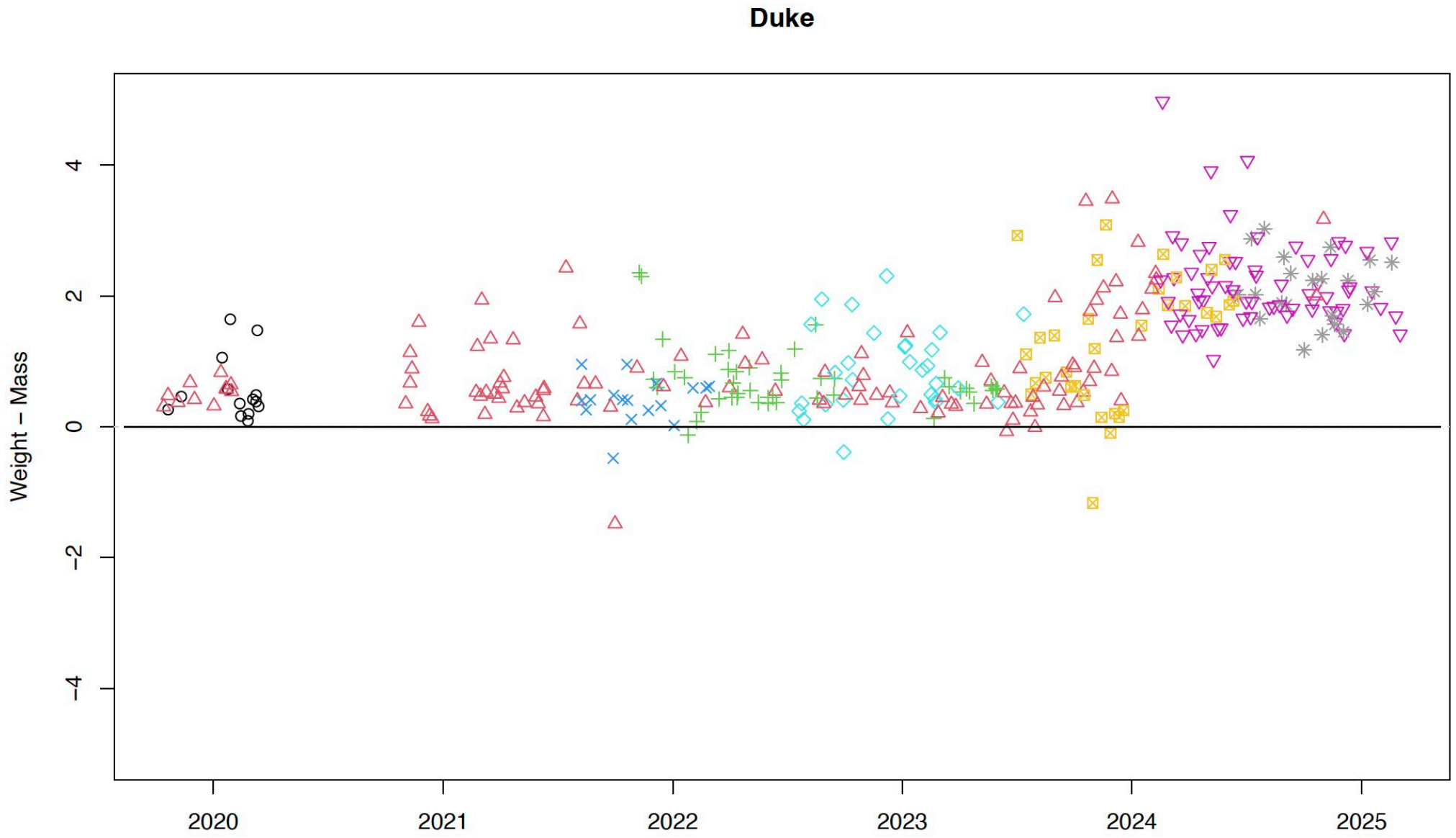
Challenges for Multi-site Trials



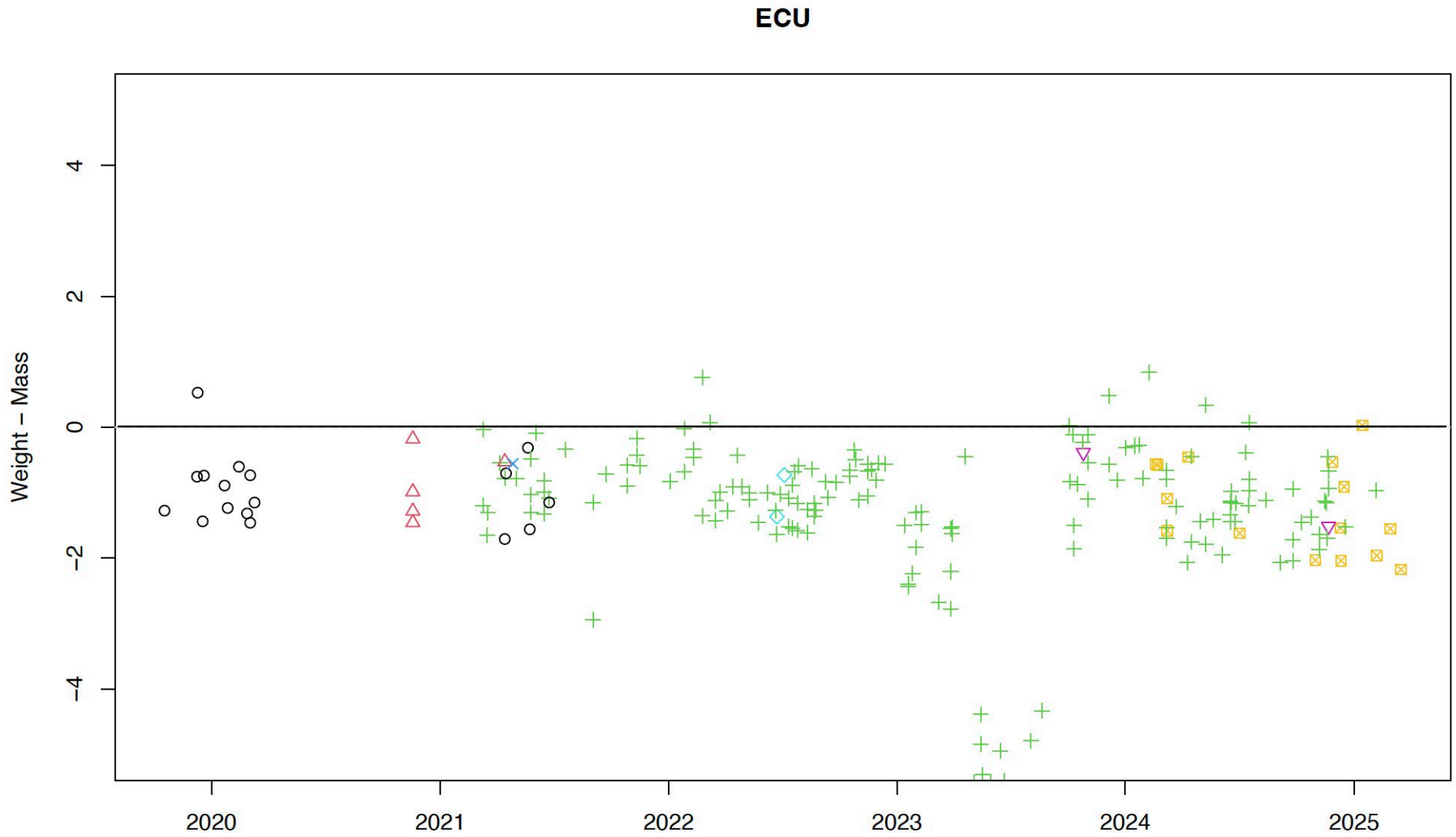
Challenges for Multi-site Trials



Challenges for Multi-site Trials



Challenges for Multi-site Trials



Challenges for Multi-site Trials

Same Day Measurements of Body Composition on Hologic W and Hologic A Instruments (n=6)

	Horizon W	Horizon A
Total mass, kg	75.85	79.13
Fat mass, kg	18.33	20.89
Fat-free bone-free mass, kg	54.63	55.48
Bone mass, kg	2.90	2.76
Fat, % of body mass	24.2	26.4
Lean, % of body mass	75.8	73.6

Conclusions

DXA has been considered the reference method of assessing body composition for 25 years.

The inability to use a whole-body phantom to cross-calibrate body composition measurements across study sites raises concerns about the use of DXA in multi-site studies.

MoTrPAC plans to publish a methods paper on harmonizing DXA data across makes and models.