

Modulating Cerebral Metabolic Rate:

Exploring the Impact of tDCS in Healthy Controls and Patients with Multiple Sclerosis

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BACKGROUND & HYPOTHESES

- Clinical improvements using tDCS have been reported in several conditions, including **multiple sclerosis (MS)**^[1-3].
- The corresponding biophysiological changes due to tDCS are still to be fully elucidated.
- Technological advancements such as **real-time tDCS-MRI** allow for investigations of **simultaneous** and treatment-related **cumulative** changes in cerebrovascular and metabolic processes.

We therefore **hypothesize**:

1. Increased vascular and neuronal activity during tDCS in both healthy controls (HC) and MS patients (**simultaneous effects**)
2. Persistence of these effects linked to repeated tDCS sessions in MS patients (**cumulative effects**)

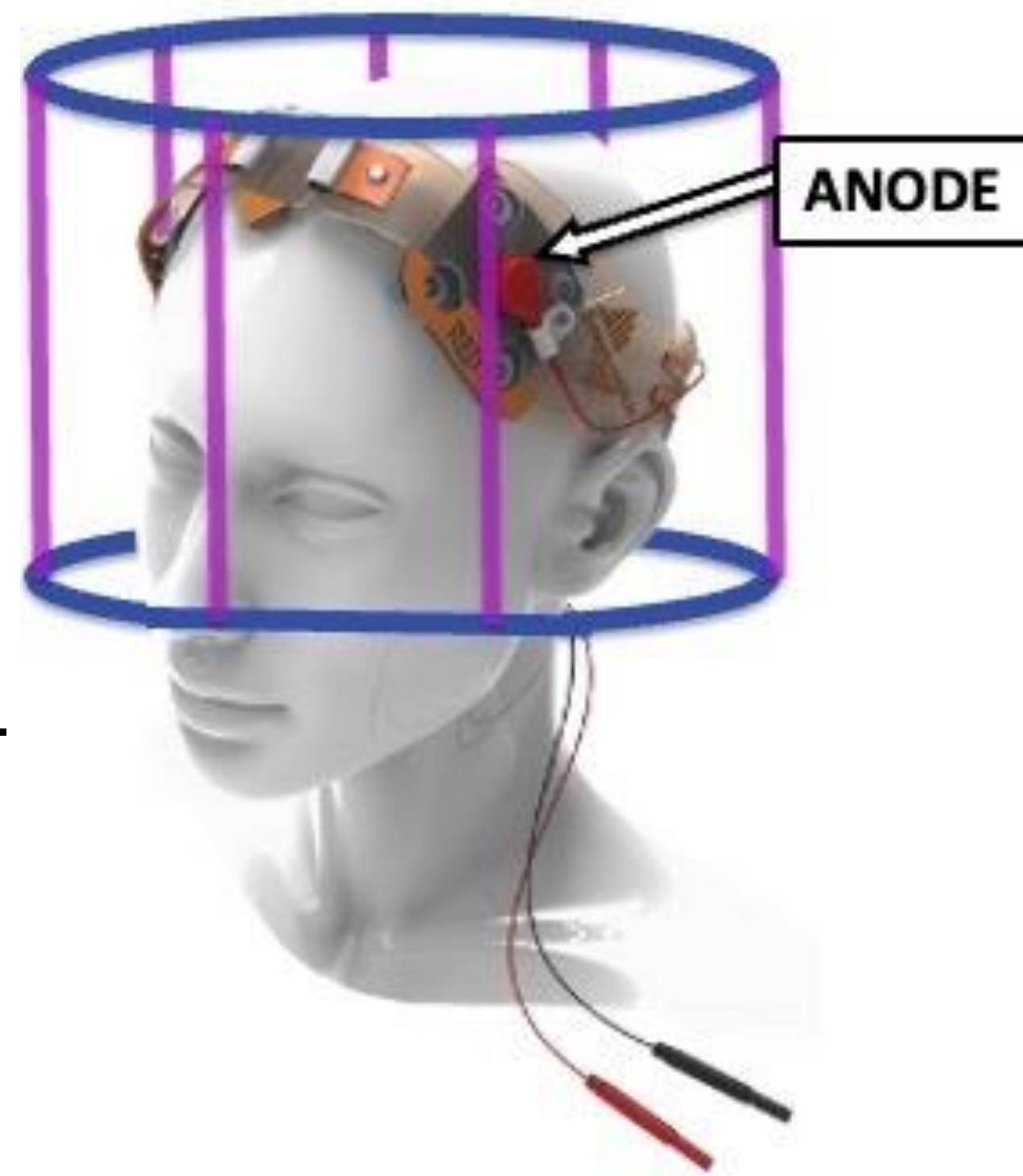
MATERIALS & METHODS

Participants:

- 20 MS patients (45±13 years, 7 males)
- 23 healthy controls (35±15 years, 10 males)

Instrumentation:

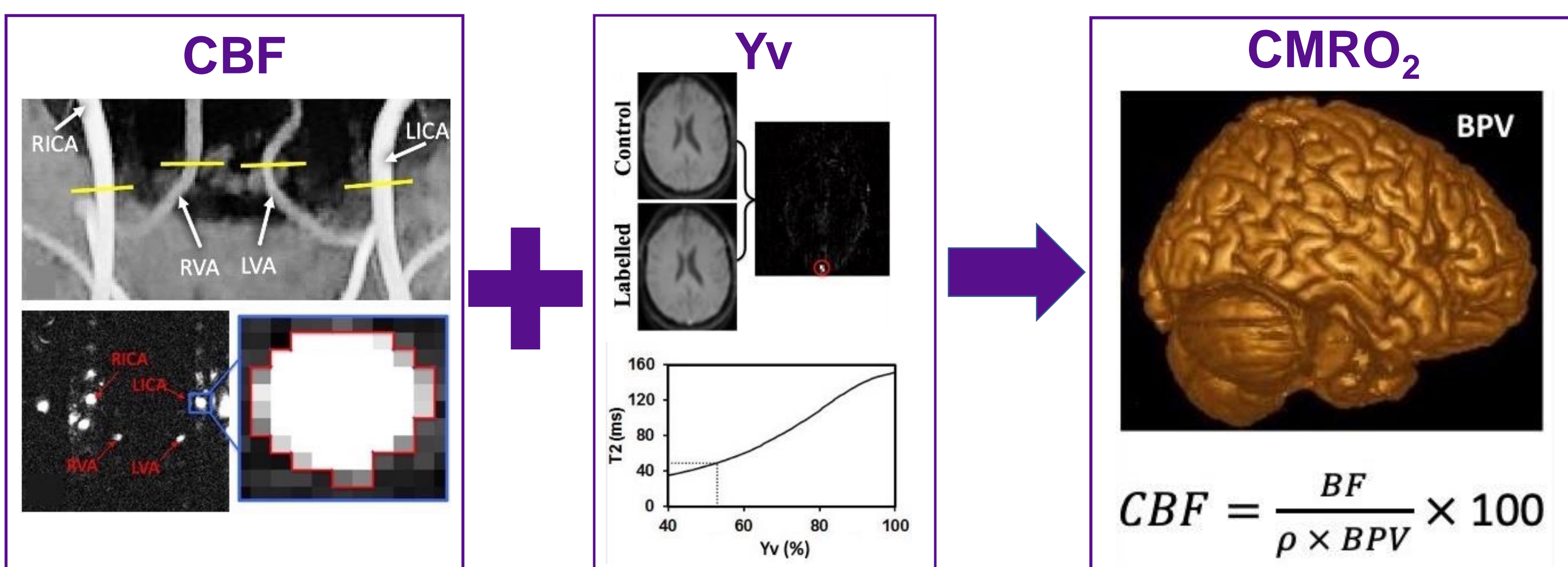
- 3T MRI scanner with a 64 channels head coil
- MRI-compatible tDCS device (Soterix Medical) with a **left anodal dorsolateral prefrontal cortex (DLPC)** montage.
- 2.0mA direct current stimulation for 15 minutes.



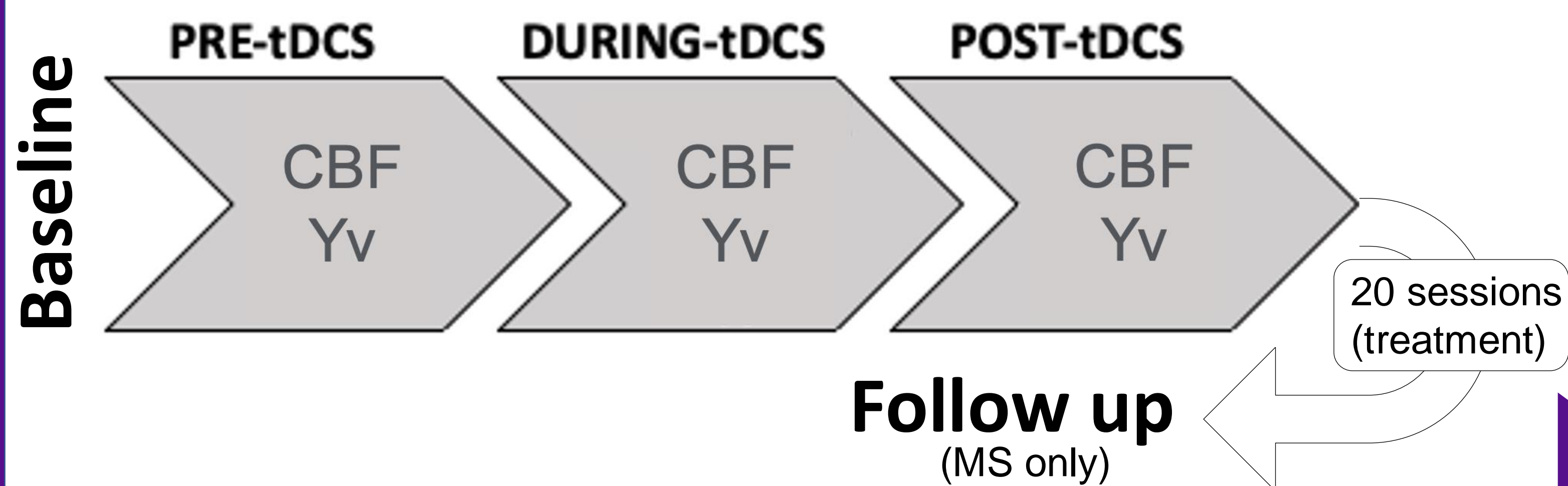
Imaging Measurements:

We collected measurements of:

- Global cerebral blood flow (CBF),
- Venous blood oxygenation (Yv),
- Calculated cerebral metabolic rate of O₂ (CMRO₂), neuronal activity index.



Scanning procedure:



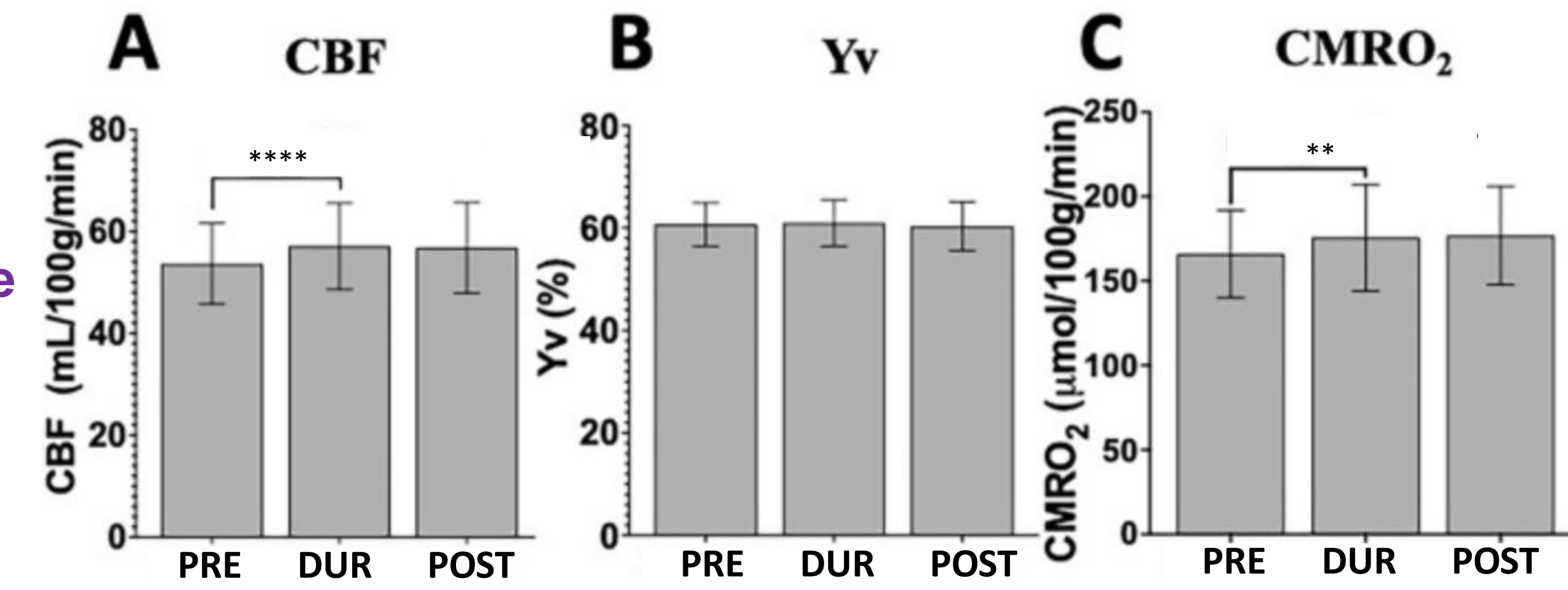
Statistical analysis:

- Paired t-test comparing pre- vs during and during- vs post in HC and MS.
- Paired t-test was also used to compare each session measurements at baseline vs follow up in MS patients.
- Wilcoxon matched-pairs rank test was used for analysis involving non-normally distributed measurements (CBF pre and during-tDCS).

RESULTS

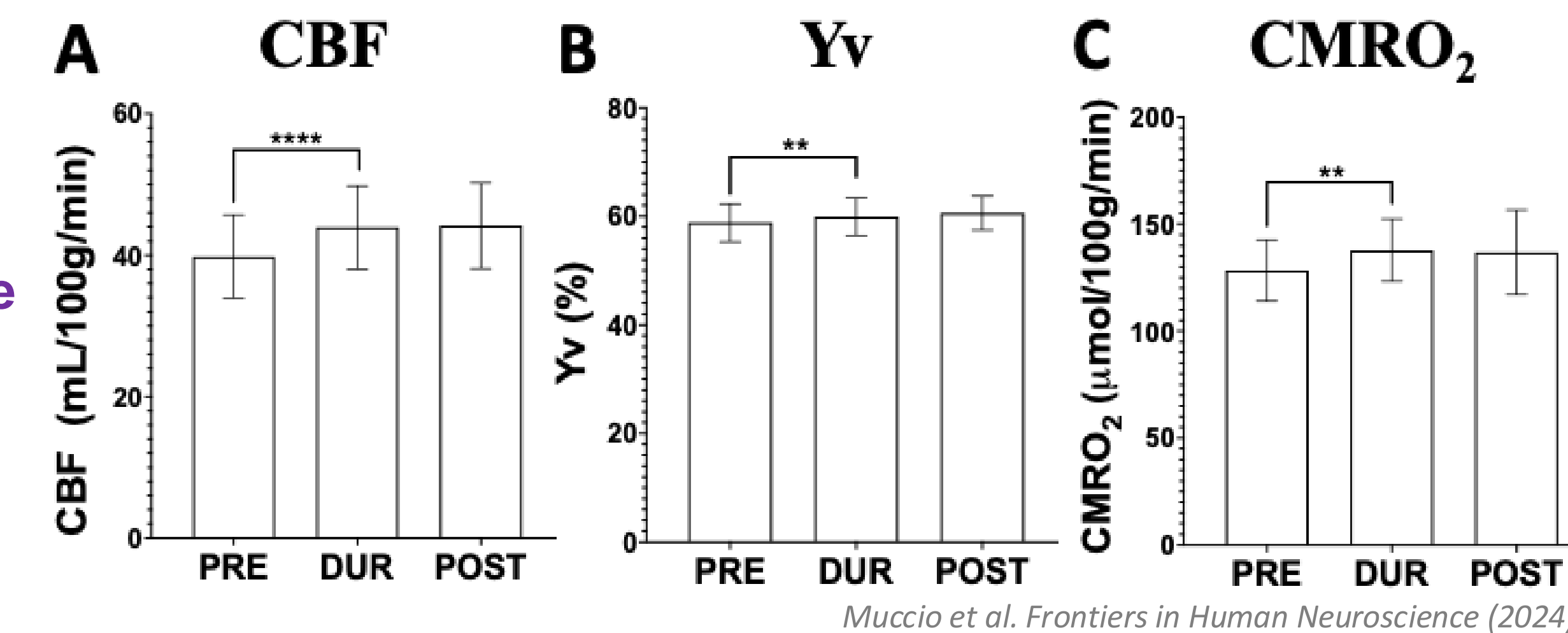
Healthy Controls - Simultaneous effects

- CBF: 6.5% **increase**
- Yv: no changes
- CMRO₂: 5.9% **increase**
- Measurements **remain elevated** in post-tDCS



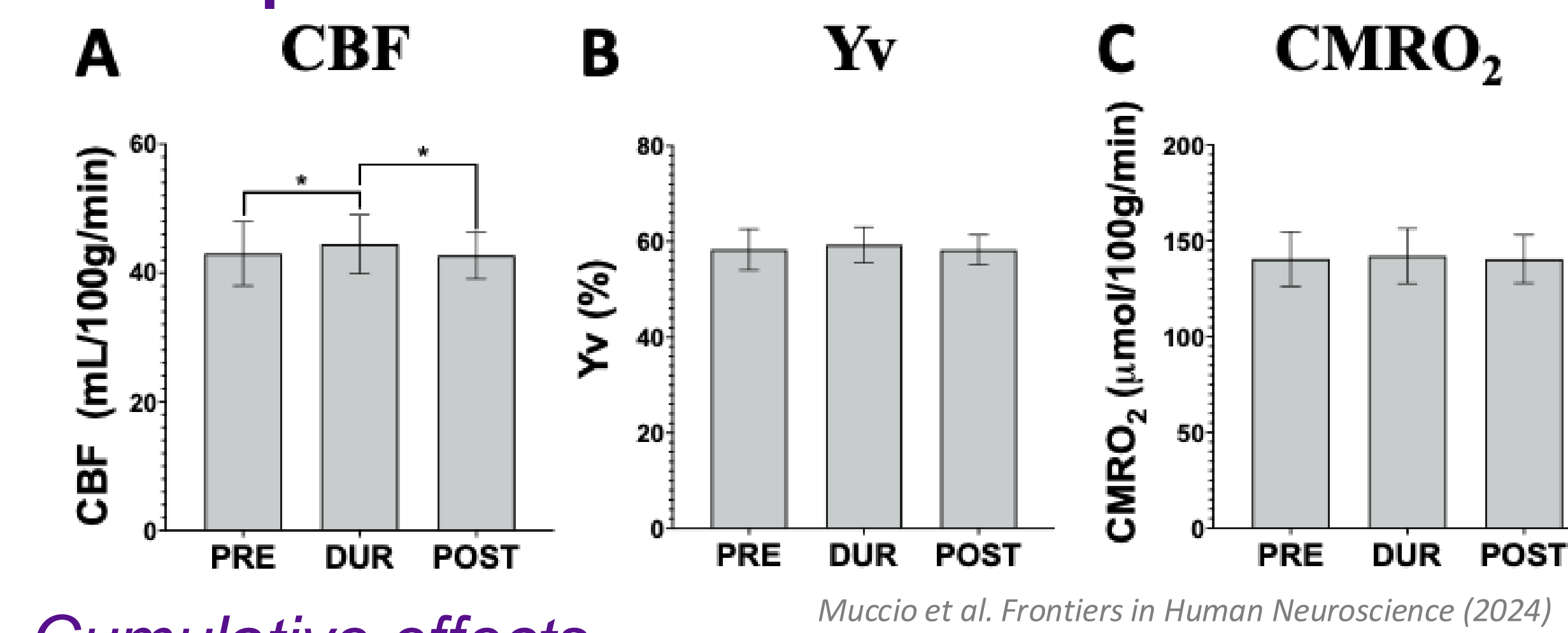
MS Patients Baseline - Simultaneous effects

- CBF: 11.0% **increase**
- Yv: 1.9 % **increase**
- CMRO₂: 7.6% **increase**
- measurements **remain elevated** in post-tDCS



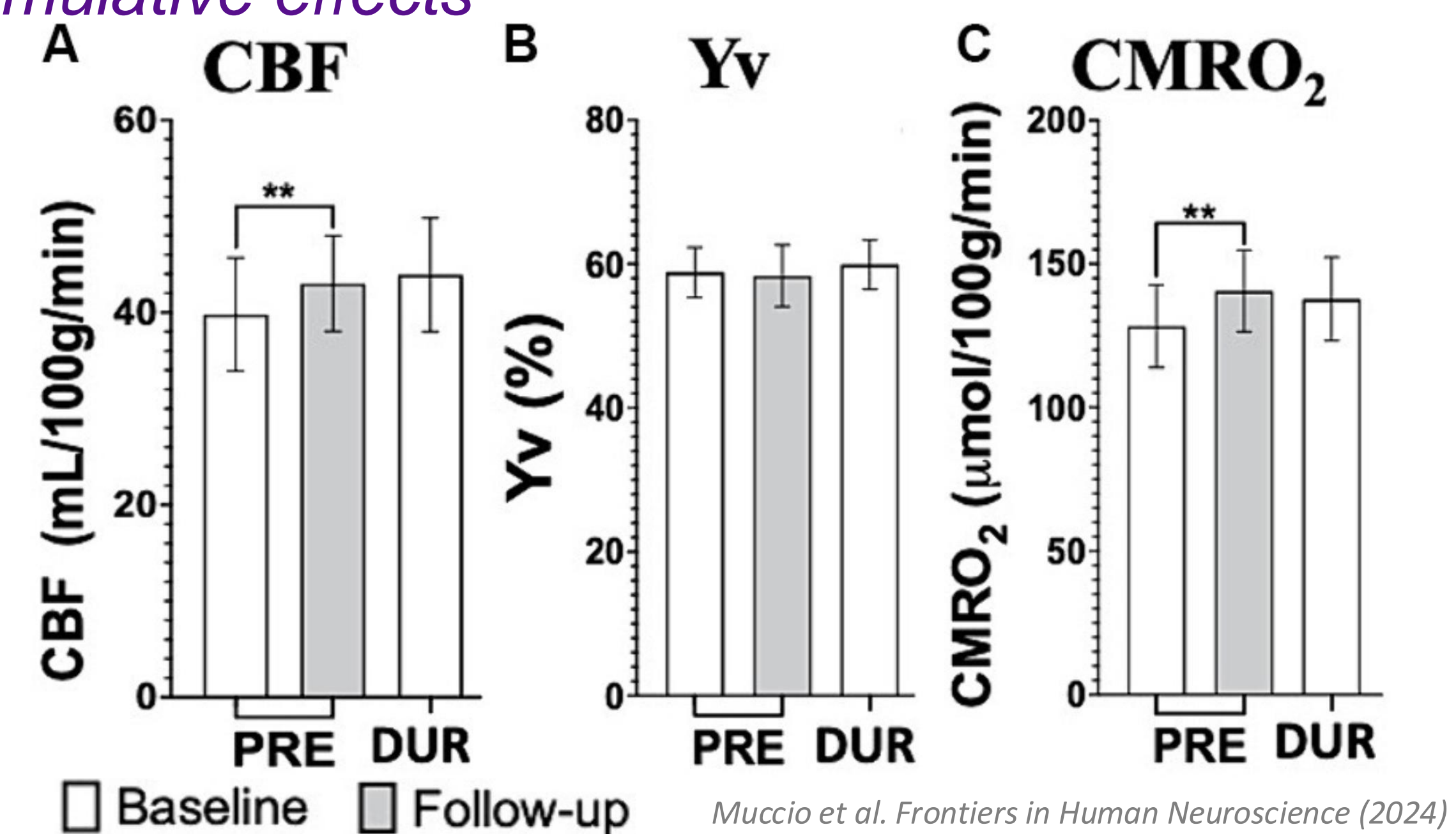
MS Patients Follow up - Simultaneous effects

- CBF: 3.6% **increase**
- Yv: no changes
- CMRO₂: no changes
- Yv and CMRO₂ **remain constant** in post-tDCS



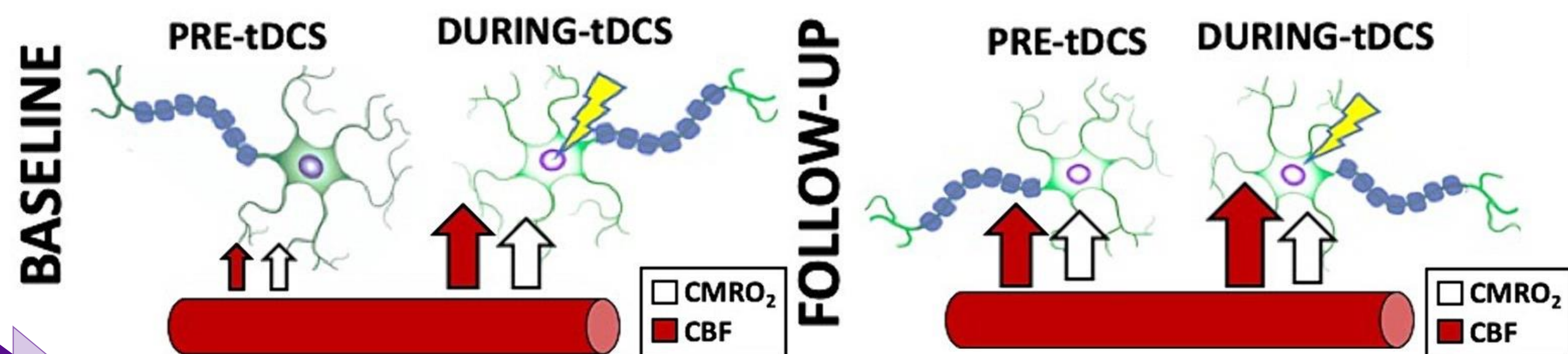
MS Patients - Cumulative effects

- Pre-tDCS from baseline to follow up:
- CBF: 10.9% **increase**
 - Yv: no changes
 - CMRO₂: 9.6% **increase**
- Follow up pre-tDCS at similar levels of baseline dur-tDCS.



DISCUSSION

- In both **HC** and **MS**, Immediate increase during tDCS (both CBF and CMRO₂), which remains constant in post-tDCS.
- In **MS follow-up**, no changes throughout MRI session (except for CBF)
- In MS, **repeated tDCS sessions** cause increased pre-tDCS CBF and CMRO₂ at follow up, reaching levels similar to baseline dur-tDCS.



TDCS induces an **immediate** cerebrovascular and metabolic response in both HC and MS that **lingers** into post-tDCS. In MS, repeated tDCS sessions cause **long-lasting effects** as demonstrated by pre-tDCS measurements at follow up having **similar magnitude of dur-tDCS** at baseline. This also suggests a possible **plateau** of tDCS treatment efficacy.

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References

1. Charvet LE, Dobbs B, Shaw MT, Bikson M, Datta A, Krupp LB. Mult Scler. 2018;24(13):1760-9.
2. Charvet L, Shaw M, Dobbs B, Frontario A, Sherman K, Bikson M, et al. Neuromodulation. 2018;21(4):383-9.
3. Chalah MA, Riachi N, Ahdab R, Mhalla A, Abdellaoui M, Creange A, et al. J Neurol Sci. 2017;372:131-7.

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