

# **Relation between cognitive function and baseline concentrations of hemoglobin in prefrontal cortex of elderly people**

## **measured by time-resolved near-infrared spectroscopy**

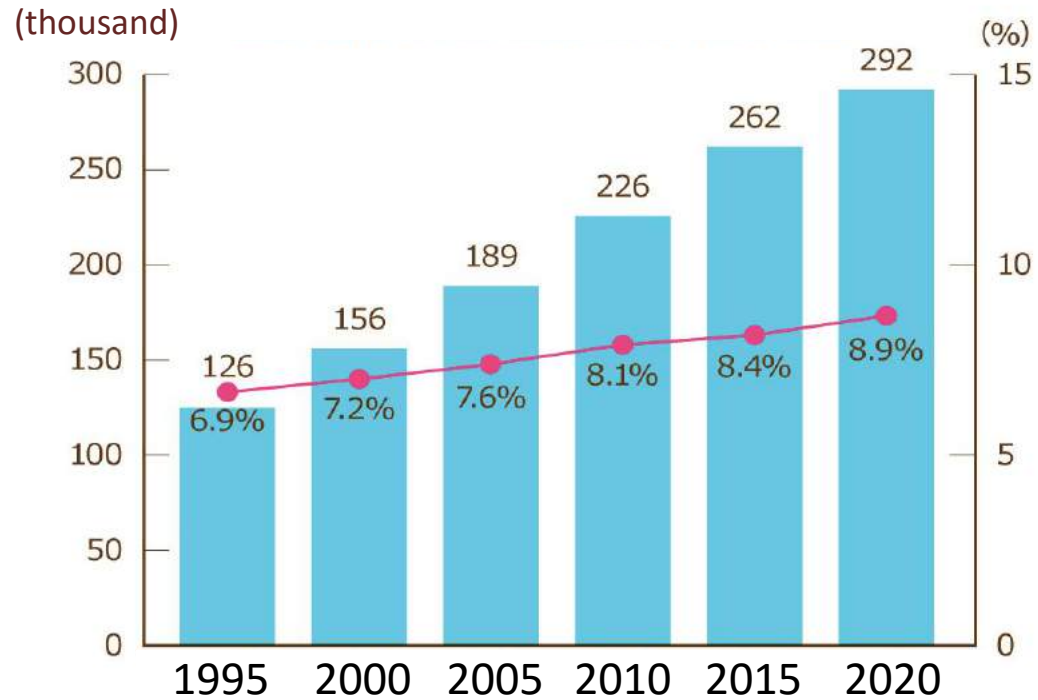
**Y Murayama <sup>a</sup>, Y Sato <sup>a</sup>, L Hu <sup>a</sup>, K Sakatani <sup>a, b</sup>**

<sup>a</sup> NEWCAT Research Institute, Department of Electrical and Electronic Engineering,  
College of Engineering, Nihon University, Japan

<sup>b</sup> Department of Neurological Surgery, School of Medicine, Nihon University, Japan

# 1. Introduction

## Change of number of dementia in the elderly in Japan



Ministry of Health, Labour and Welfare, Japan

### Our goal

Develop a simple, non-invasive method for screening test of cognitive function.

# Diagnosis of dementia at present

## Functional Neuroimaging



- Big size
- Expensive
- Complex

## Various screening test

The mini mental state examination	
<b>Orientation</b>	
Year, month, day, day, season	___/5
Country, county, town, hospital, ward (if in)	___/5
<b>Registration</b>	
Count on fingers three down (for example, apple, apple, one, and table) Patient asked to repeat objects, one point for each	___/3
<b>Attention</b>	
Subtract 7 from 100 five successive results; stop after five subtractions (Answers: 93, 86, 79, 72, 65) If unable to perform correct subtraction, get them to spell world backwards: D I E C W Score best performance on either task	___/5
<b>Recall</b>	
Ask for the names of the objects learned earlier	___/3
<b>Language</b>	
Name a pencil and a watch	___/2
Repeat: "The ft, and of tree"	___/1
Give a three-stage command. Give one for each stage. For example: "Take this piece of paper in your right hand, fold it in half and place it on the table"	___/3
Ask patient to read and obey a written command on a piece of paper and say "Close your eyes"	___/1
Ask patient to write a sentence. Score correct if it has a subject and a verb.	___/1
<b>Copying</b>	
Ask patient to copy intersecting pentagons. Score as correct if they overlap and each has five sides.	___/1
<b>Total score:</b>	___/30

- MMSE
- HDS-R
- WCST
- FAB
- ...etc.

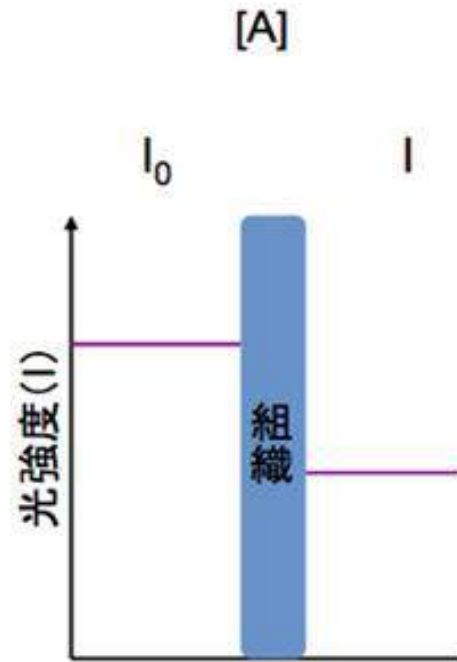
- Difficult for the elderly
- There is the difference in the doctor's subjective.

# Near-infrared spectroscopy (NIRS)



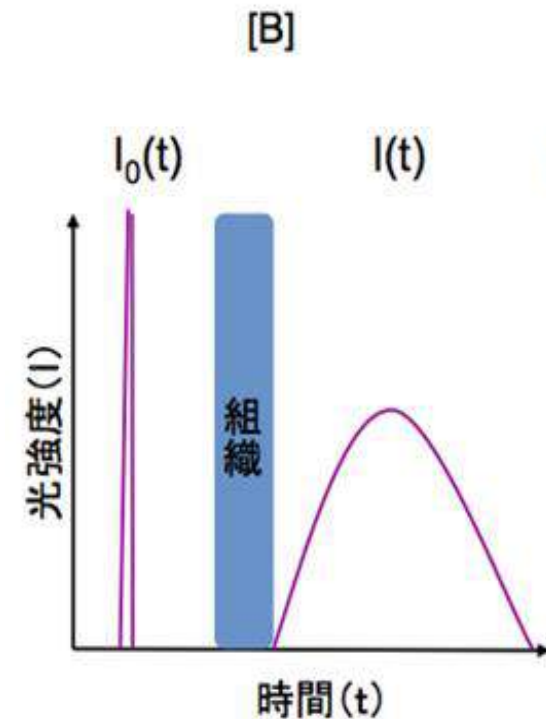
Compact and less expensive

# Contrast between CW-NIRS and TNIRS



Continuous-Wave Near-Infrared Spectroscopy: CW-NIRS

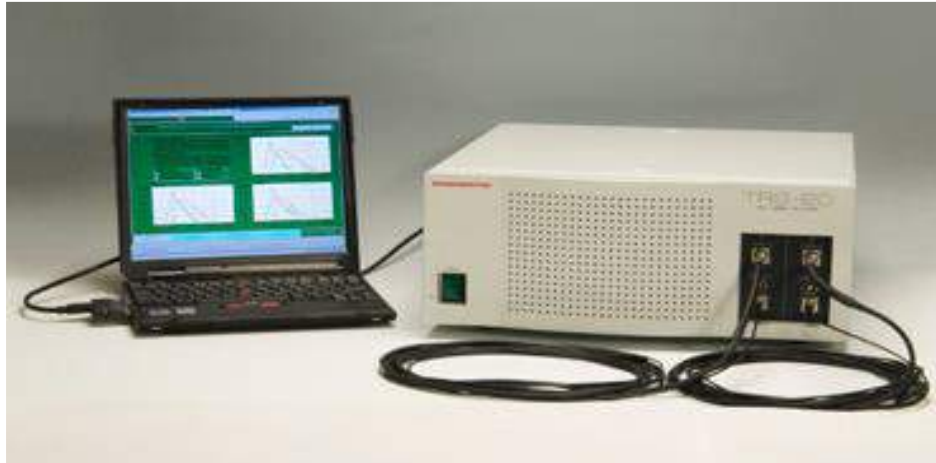
[A] Employs continuous-wave (CW) light, measures relative changes of hemoglobin (Hb) concentration.



Time-resolved Near-Infrared Spectroscopy: TNIRS

[B] Employs picosecond light pulses, permits quantitative measurements of the Hb concentrations at rest.

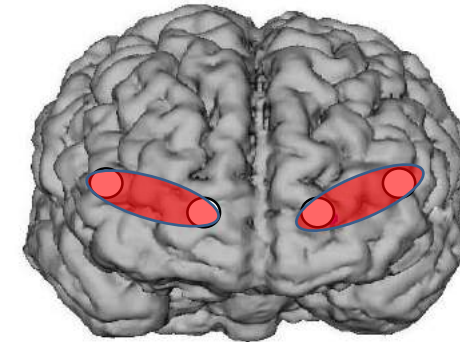
# 3. Methods (1): TNIRS



TNIRS

- TRS-21 (Hamamatsu Photonics K.K., Japan)
- Light source (760nm, 800nm, 830nm)

- Positioning of the probes



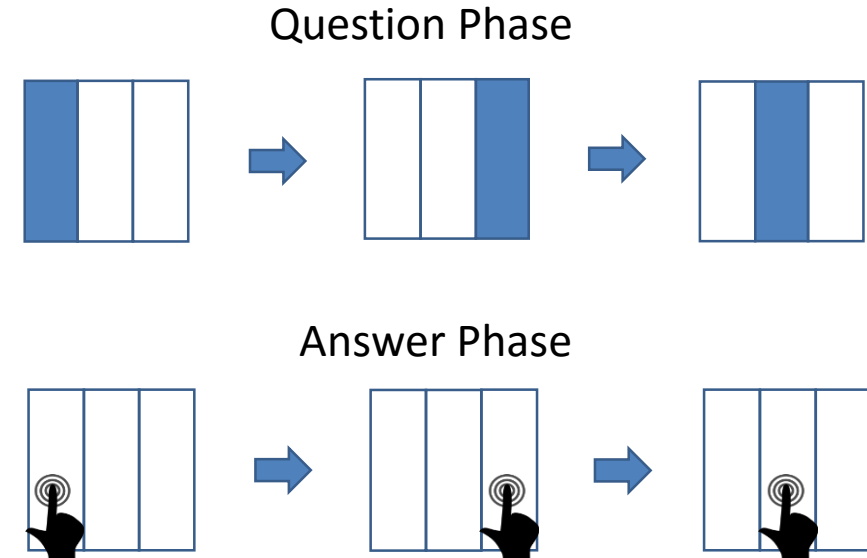
The emitter-detector was located over the dorsolateral and frontopolar areas.

Measures the absolute concentration of Hb

# Methods (2): Touch M



Touch M



Ave  $41.3 \pm 22.1$  (Max 100)

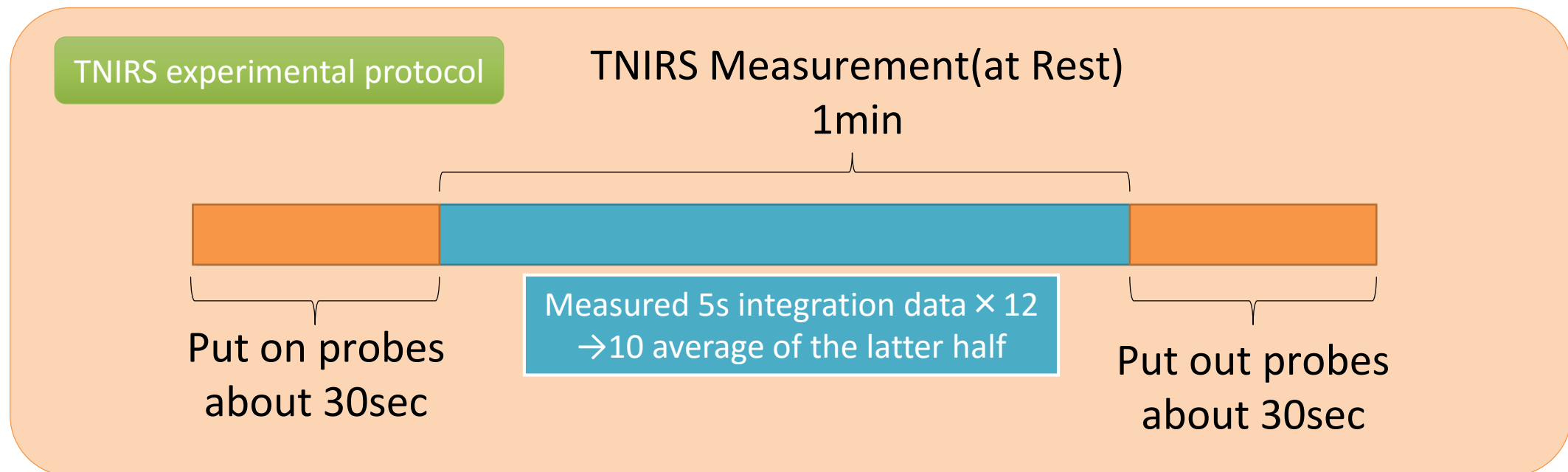
Evaluates working memory function quantitatively and semi-automatically on a touchscreen.

# Methods (3): Subjects and Experimental protocol

- Subjects : Outpatients of neurosurgery 78 subjects  
(male 41, female 37, age  $71.5 \pm 10.7$ , MMSE score  $25.3 \pm 4.0$ )

Inpatients of neurosurgery 35 subjects  
(male 19, female 16, age  $72.9 \pm 14.8$ , MMSE score  $23.7 \pm 5.7$ )

**Total 113 subjects**





# Methods (4): Acquisition of data

## TNIRS measurement values

(at rest)

Oxyhemoglobin (oxy-Hb)

Deoxyhemoglobin(deoxy-Hb)

Total hemoglobin(total-Hb)

SpO<sub>2</sub>

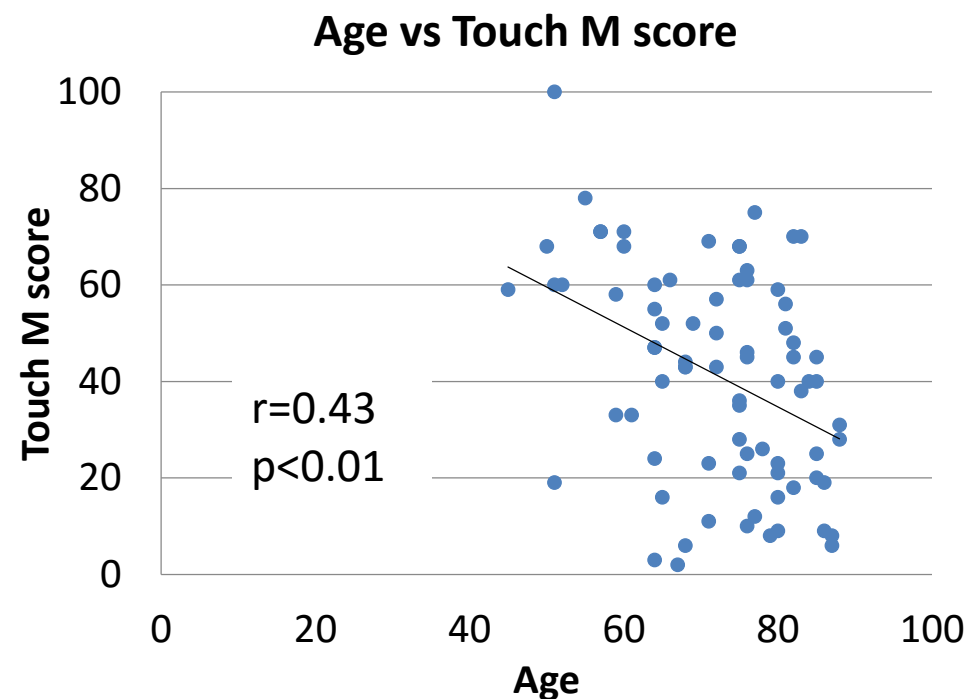
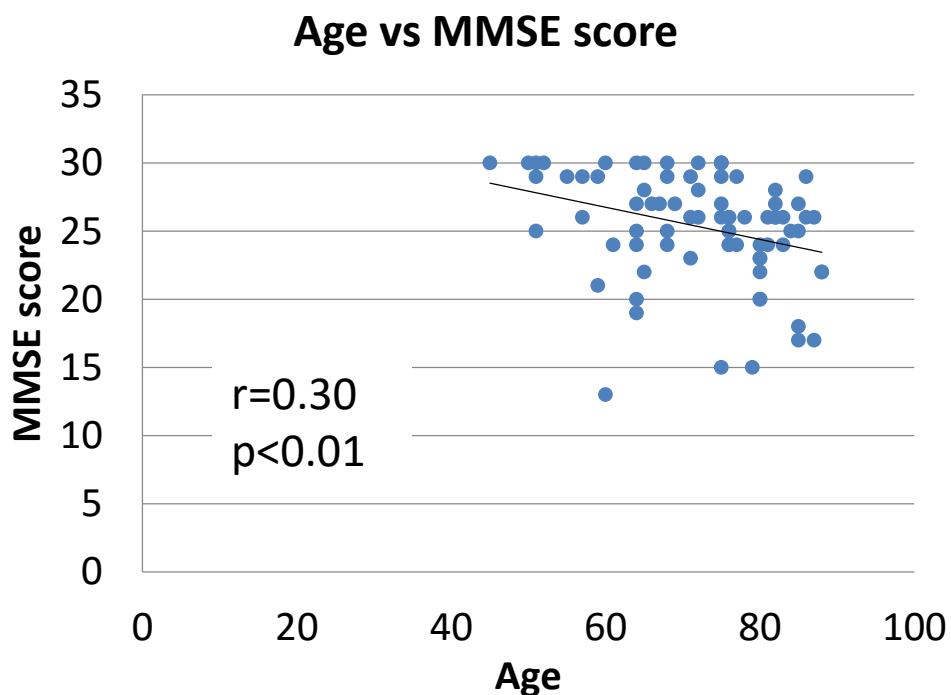
## Dementia screening test

Mini Mental State  
Examination (MMSE)

Touch M

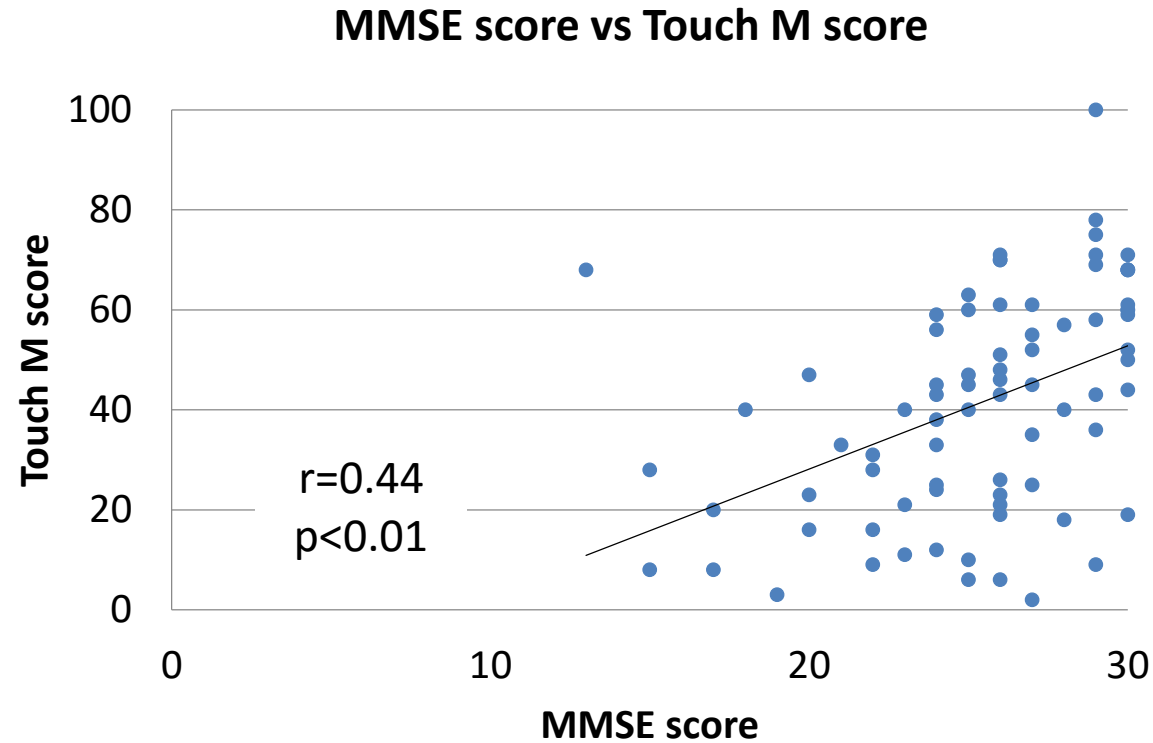
## 4. Results

# Relation between Age and MMSE, TouchM



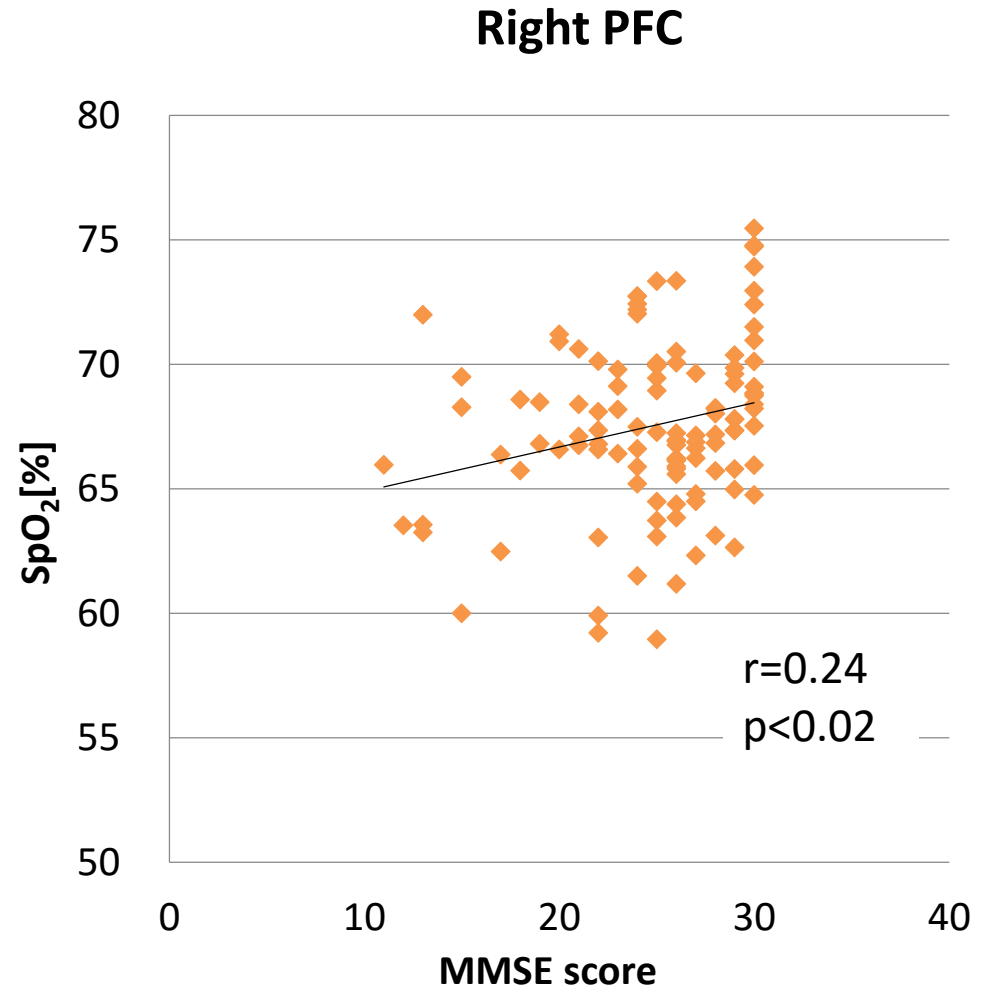
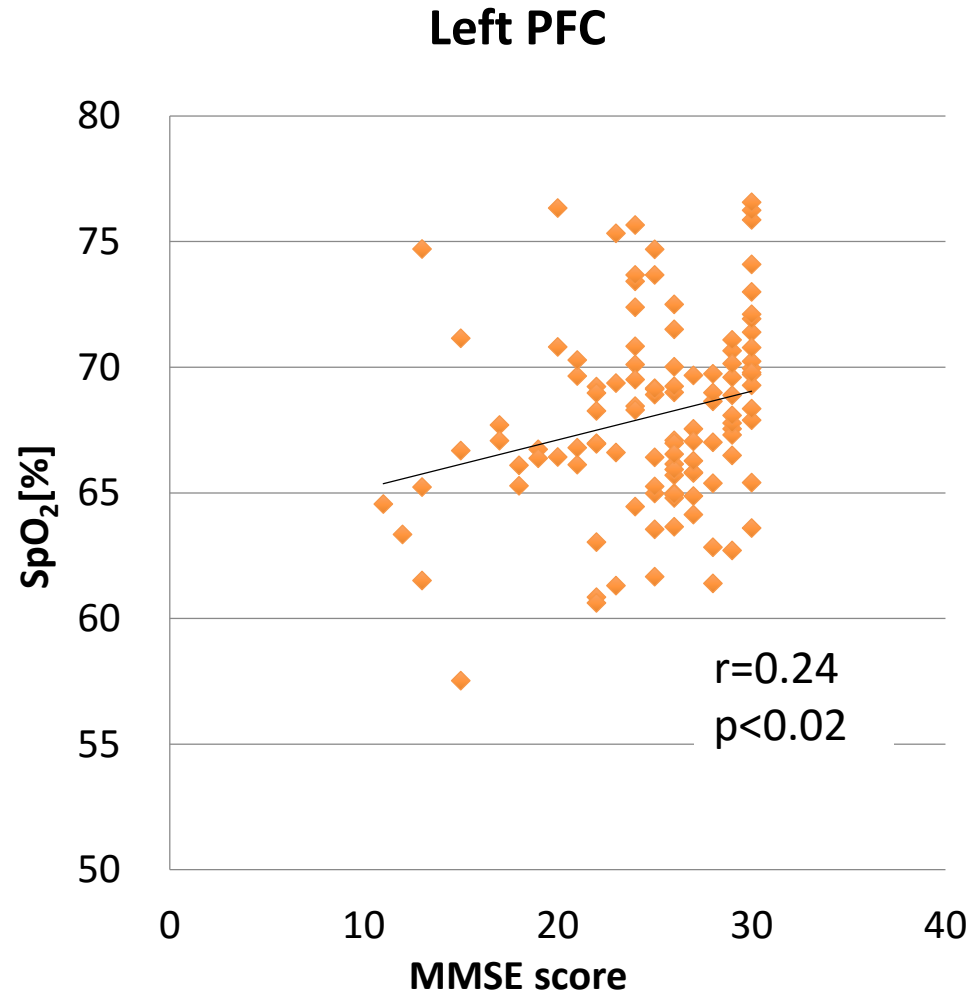
There was a statistically significant negative correlation between Age of subjects and MMSE score, TouchM score.

# Relation between MMSE and TouchM



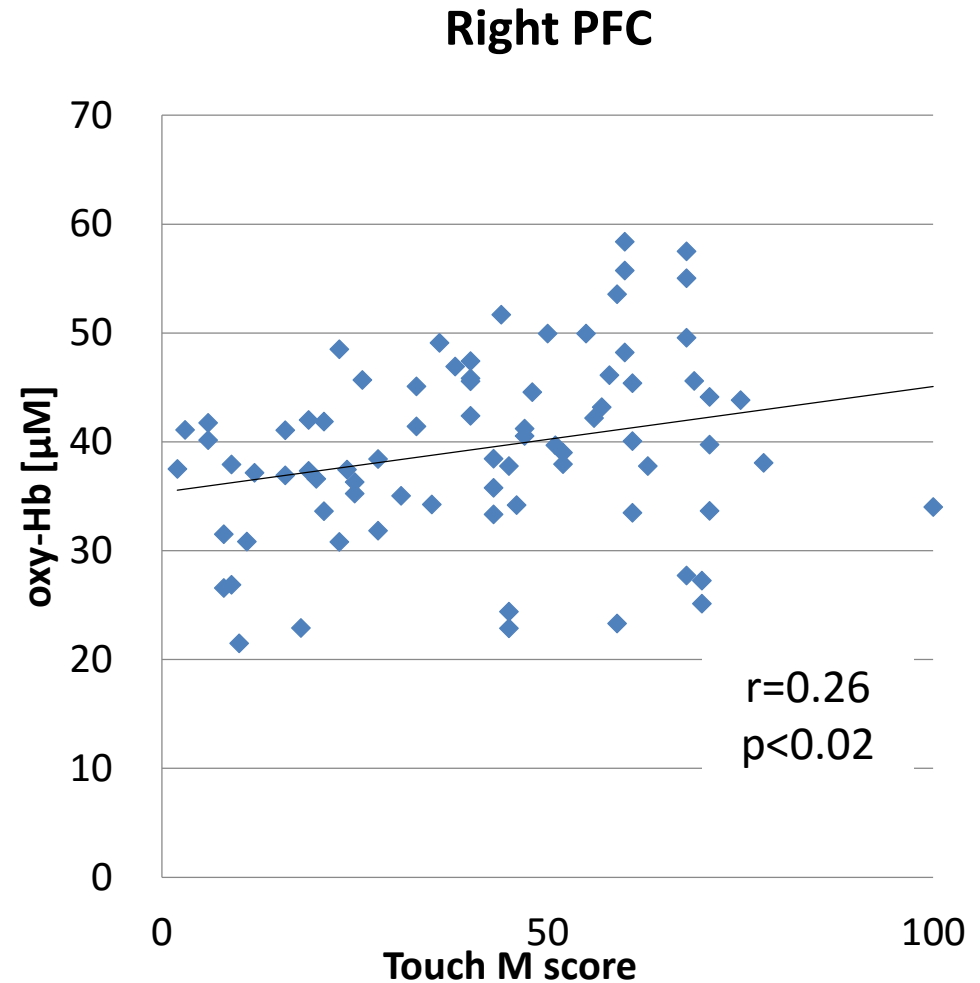
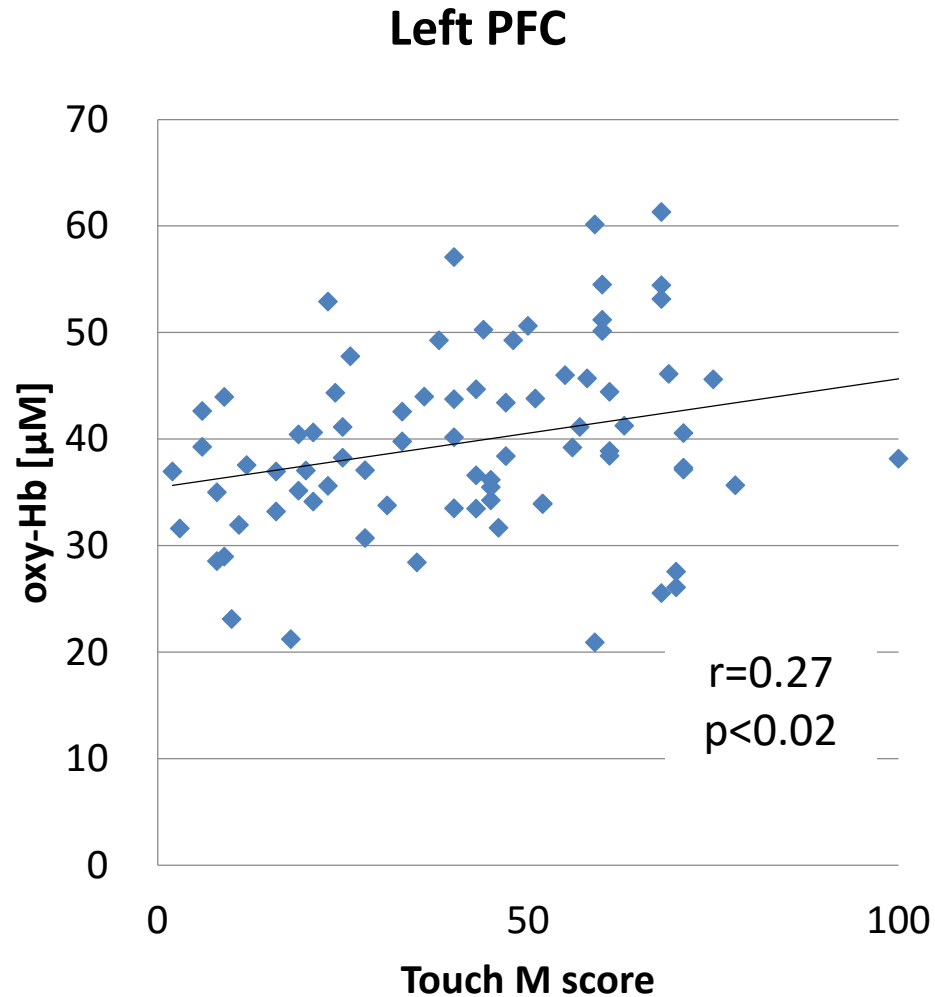
There was a statistically significant positive correlation between MMSE score and TouchM score.

# Relation between MMSE and SpO<sub>2</sub>



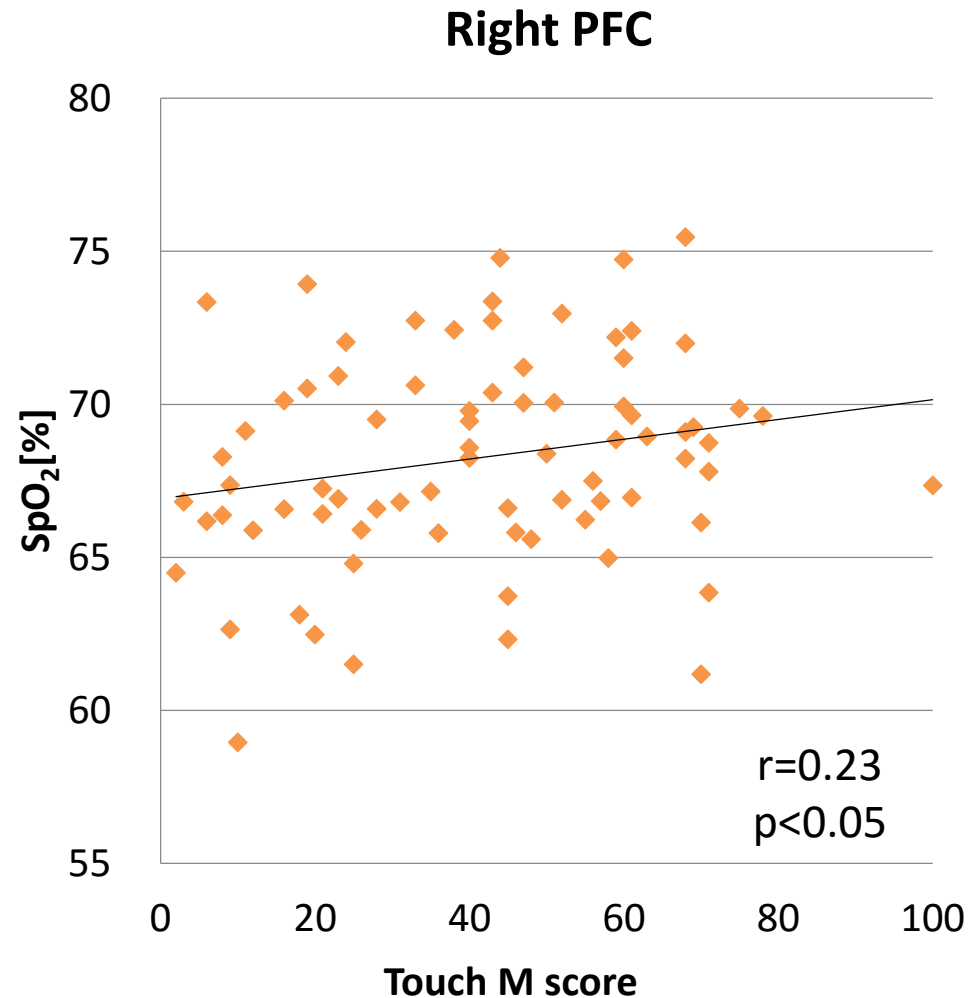
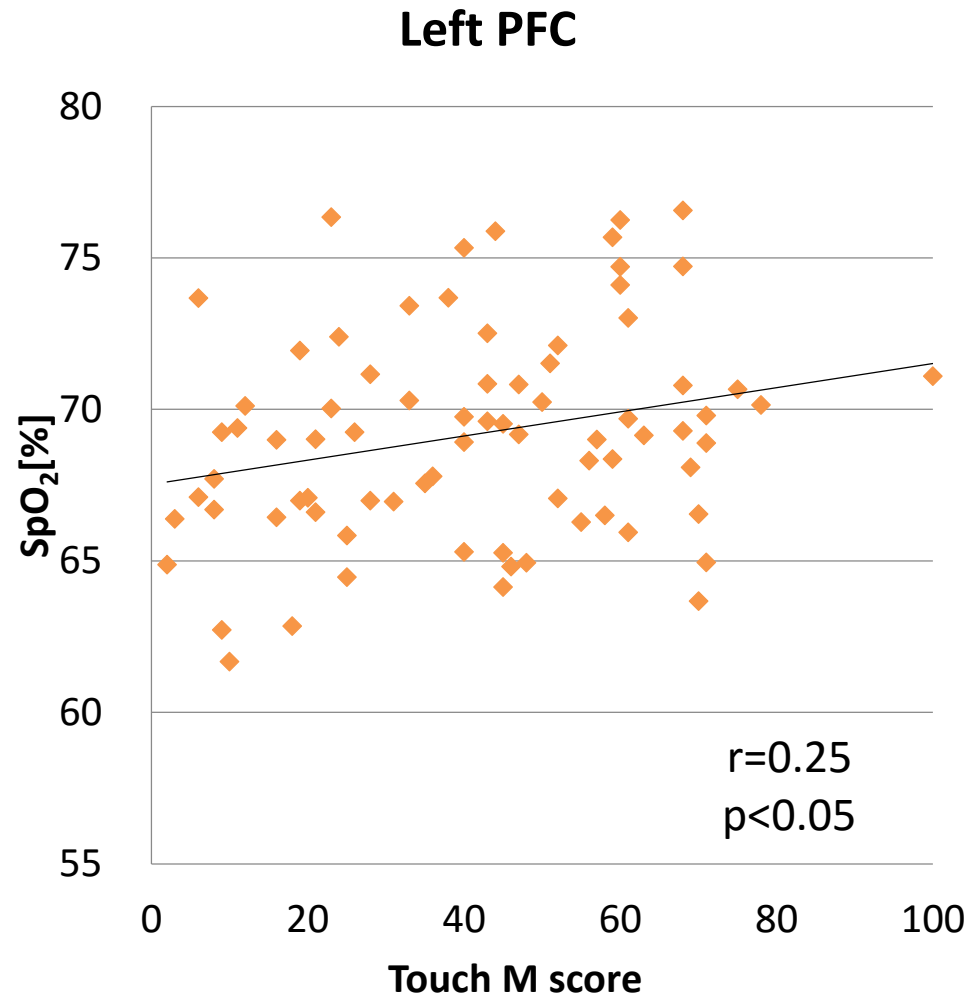
There was a statistically significant positive correlation between MMSE score and SpO<sub>2</sub> at rest in the bilateral PFC.

# Relation between TouchM and oxy-Hb



There was a statistically significant positive correlation between Touch M score and oxy-Hb concentration at rest in the bilateral PFC.

# Relation between TouchM and SpO<sub>2</sub>



There was a statistically significant positive correlation between Touch M score and SpO<sub>2</sub> at rest in the bilateral PFC.

## 5. Discussion



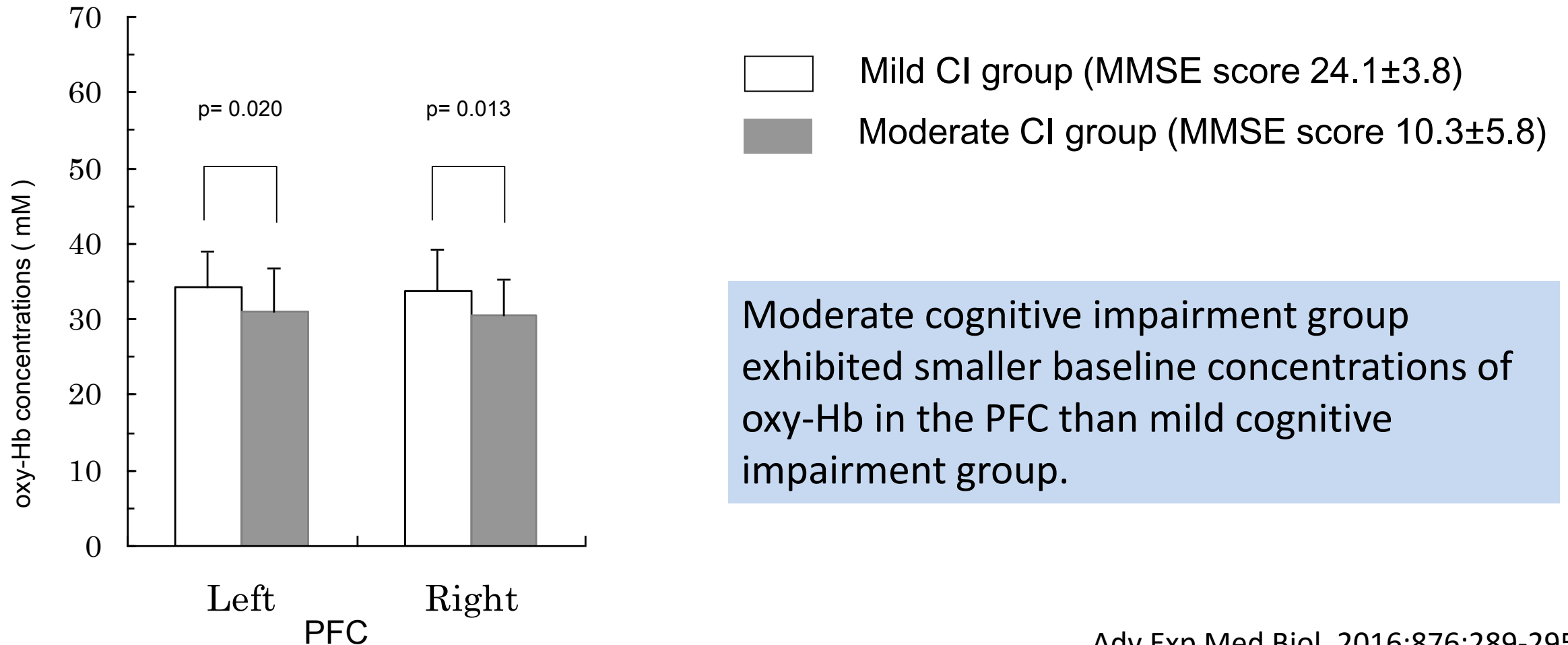
The present study demonstrated that SpO<sub>2</sub> in the bilateral PFC at rest was significantly correlated with both MMSE and Touch M scores in elderly people.

In addition, the baseline concentrations of oxy-Hb at rest were significantly correlated with Touch M scores.



These results are consistent with our recent TNRS study on aged women.

# Effects of Cosmetic Therapy on Cognitive Function in Elderly Women Evaluated by Time-Resolved Spectroscopy Study. (Adv Exp Med Biol. 2016;876:289-95)



# Physiological basis of the relation between TRS measurements and cognitive function

- Simultaneous measurements of TRS and PET demonstrated that t-Hb and  $SO_2$  measured by TNIRS significantly increased associated with increases of regional cerebral blood flow (rCBF) and volume (rCBV) induced by acetazolamide.
- In addition, dementia exhibited decreased rCBF in various brain regions including the frontal cortex, particular patients with frontal dysfunction such as apathy.



We suggest that the baseline concentrations of Hb in the PFC measured by TRS correlate with the CBF and CBV in the PFC at rest which reflect cognitive functions related with the PFC such as working memory.

# The advantage of the present method

- The advantage of the present method is that it does not require any cognitive task; therefore, it allows us to assess cognitive function in the subject who can not perform cognitive tasks.
- In addition, the method requires less time for measurements compared with the measurement of evoked responses. This method, therefore, may be suitable for screening test for many subjects.

# Limitations of the present study

- Finally, it should be noted that the pattern of decreased rCBF in the dementia varies among the type of dementia or the associated psychological disorders.
- Therefore, TNIRS measurements of the frontal area may underestimate decreased rCBF in dementia who exhibit reduction of rCBF in other regions.
- Further studies are necessary to compare TNIRS measurements and other modalities such as PET in elderly subjects with cognitive dysfunction.

# Summary

- We investigated relationships between Hb concentration in prefrontal cortex at rest and cognitive function measured by Touch M and MMSE.
- The present study demonstrated that SpO<sub>2</sub> in the bilateral PFC at rest was significantly correlated with both MMSE and Touch M scores in elderly people. In addition, the baseline concentrations of oxy-Hb at rest were significantly correlated with Touch M scores.
- The results suggest that TRS may be a useful tool as a screening test of cognitive function, particularly working memory function, in the elderly.
- It should be emphasized that the present method is suitable for elderly subjects with cognitive dysfunction, who cannot response to cognitive tasks.