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Eye movement control after COVID-19 disease: a pilot study

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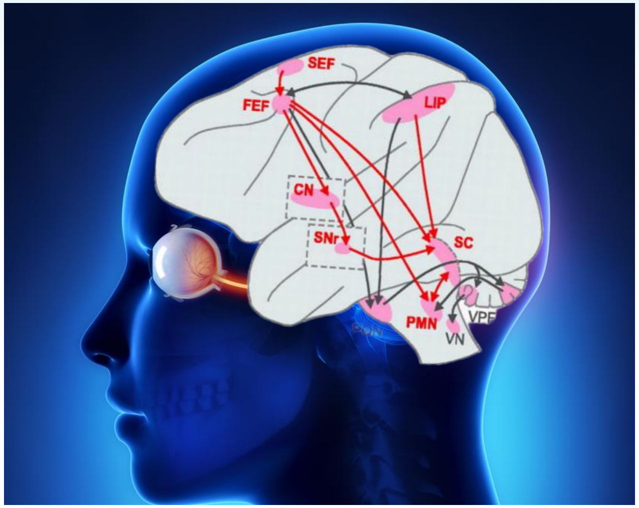
1. Introduction: Eye movements

- Appropriate eye movements are essential for vision.
- Eye movements are mainly used to reposition the fovea, allowing the "best vision" of an object of interest.
- There are different type of eye movements that account for different purposes:
  - Saccades
  - Fixations
  - Smooth pursuits
  - Vergence
  - Physiological nystagmus/OKN
  - VOR

1. Introduction: Eye movements and the brain

- The execution of eye movements is a complex mechanism that involves multiple regions of the human brain.
- Eye movements can be an invaluable source of information about brain functionality and useful from the clinical and scientific points of view.



Saccadic pathway diagram adapted from Krauzlis [1]

Measurement and characterization of eye movements may provide important information in several neurological disorders:

Alzheimer's dementia,[2] Parkinson's disease,[3] multiple sclerosis supranuclear progressive palsy,[3] cognitive impairment,[4] etc.

Early diagnosis | **Cost and time effective diagnosis** | **Disease monitoring** | **Improved Prognosis**

1. Krauzlis R. Recasting the Smooth Pursuit Eye Movement System. Journal of Neurophysiology. 2004;91(2):591-603.
2. Javaid F, Brenton J, Guo L, Cordeiro M. Visual and Ocular Manifestations of Alzheimer's Disease and Their Use as Biomarkers for Diagnosis and Progression. Frontiers in Neurology. 2016;7.
3. Jung I, Kim J. Abnormal Eye Movements in Parkinsonism and Movement Disorders. Journal of Movement Disorders. 2019;12(1):1-13.
4. Yang Q, Wang T, Su N, Xiao S, Kapoula Z. Specific saccade deficits in patients with Alzheimer's disease at mild to moderate stage and in patients with amnestic mild cognitive impairment. Age. 2013;35(4):1287-8.

1. Introduction: Eye movements and COVID-19

- COVID-19 was initially described as a respiratory syndrome after SARS-COV-2 infection.
- A number of studies have reported neurological deficits and affectations(e.g. 5, 6) resulting from COVID-19 disease including:
  - altered mental status
  - cerebrovascular events
  - new onset or breakthrough seizures
  - headaches
  - cognitive abnormalities.

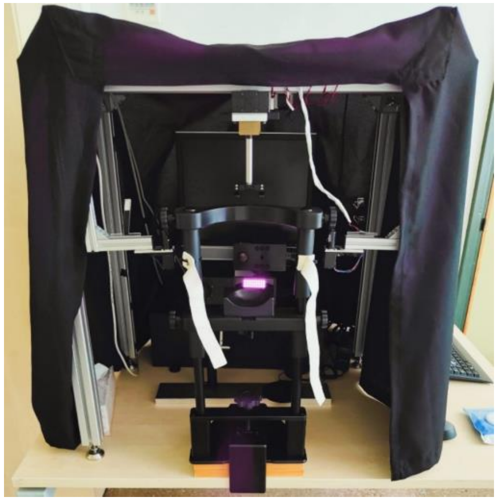
5. Pinna P, Grewal P, Hall J, Tavarez T, Dafer R, Garg R et al. Neurological manifestations and COVID-19: Experiences from a tertiary care center at the Frontline. Journal of the Neurological Sciences. 2020;415:116969.
6. Varatharaj A, Thomas N, Ellul M, Davies N, Pollak T, Tenorio E et al. Neurological and neuropsychiatric complications of COVID-19 in 153 patients: a UK-wide surveillance study. The Lancet Psychiatry. 2020;7(10):875-82.

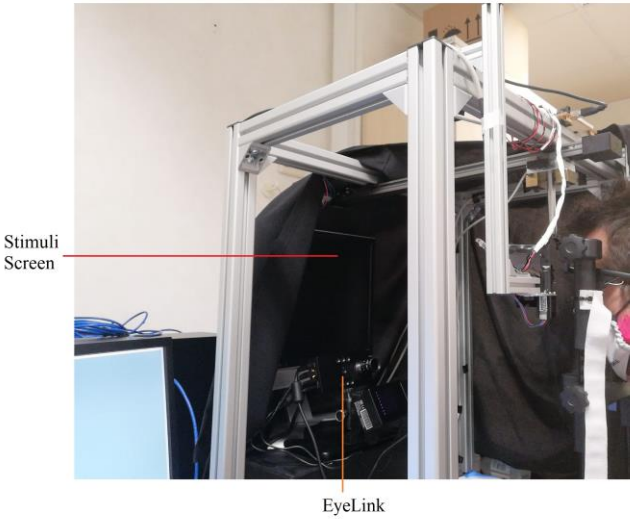
2. Study aims

To investigate possible differences in oculomotor function and control in individuals who suffered COVID-19 disease and individuals who have not suffered the condition.

3. Methods:

- Using the EyeLink 1000 eye movements were recorded binocularly in volunteer adult participants who suffered and recovered from COVID-19 disease and participants who have not suffered the condition.
- Eye movements were recorded while participants conducted a series of visual tasks to elicit saccadic, smooth pursuit and fixational eye movements.

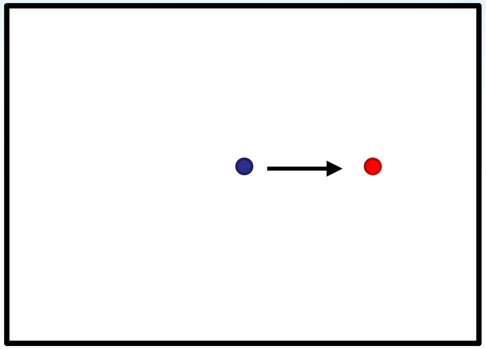




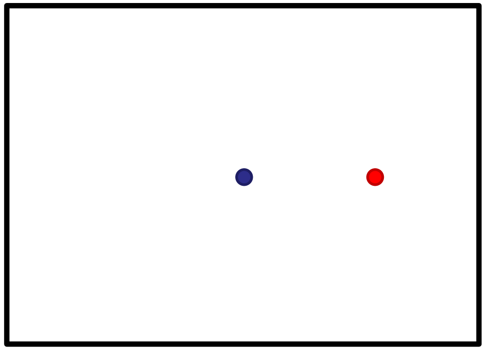
3. Methods:

- Saccades: Prosaccades

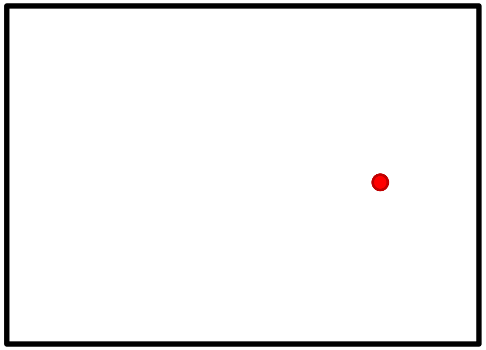
Posner overlap paradigm



Overlap paradigm



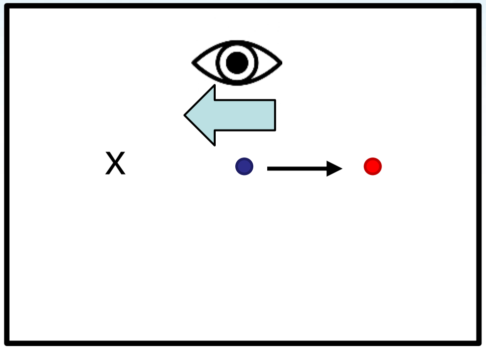
Gap paradigm



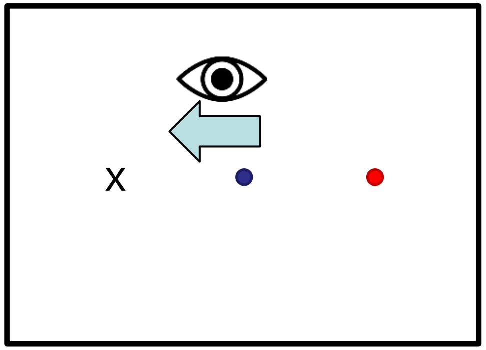
3. Methods:

- Saccades: Antisaccades

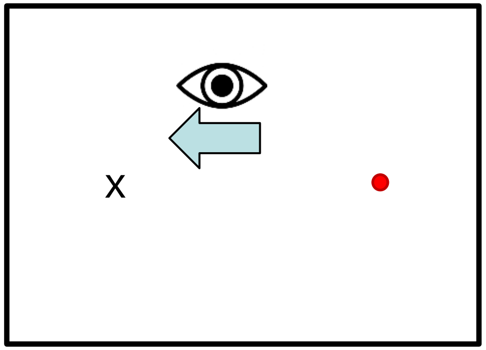
Posner overlap paradigm



Overlap paradigm

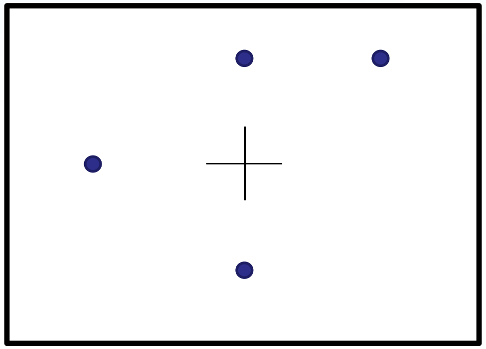


Gap paradigm



3. Methods:

- Fixation:

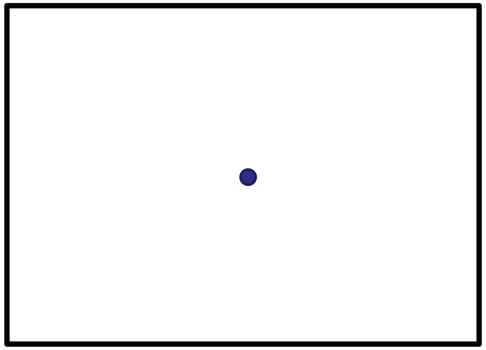


3. Methods:

- Smooth pursuit:

Sinusoudal paradigm

Lineal constant velocity paradigm



3. Results: Participants

COVID group (n=20)

Control group (n=8)

COVID (mild)
n = 10
Age 49.68 ± 6.02

- Symptomatic acute phase
- Recovered within last 12 months
- PCR+ or alternative diagnostic test
- No hospital admission

COVID (ICU)
n = 10
Age 51.75 ± 4.50

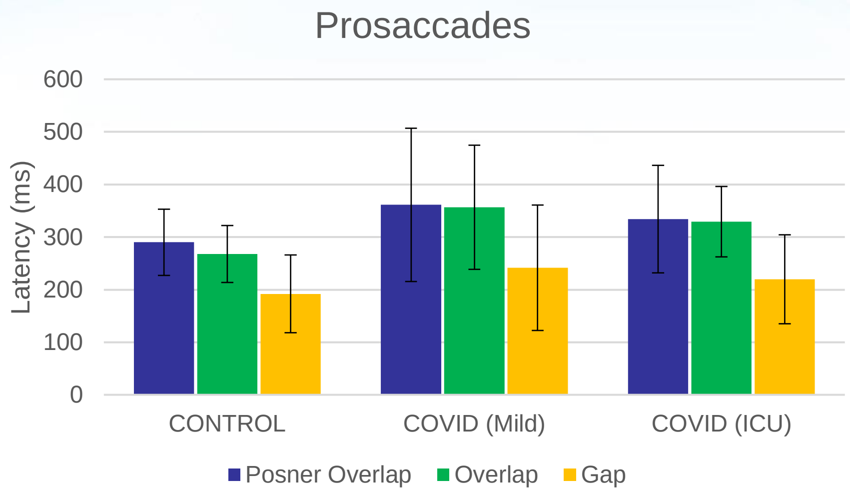
- Symptomatic acute phase
- Recovered within last 12 months
- PCR+ or alternative diagnostic test
- Admitted ICU

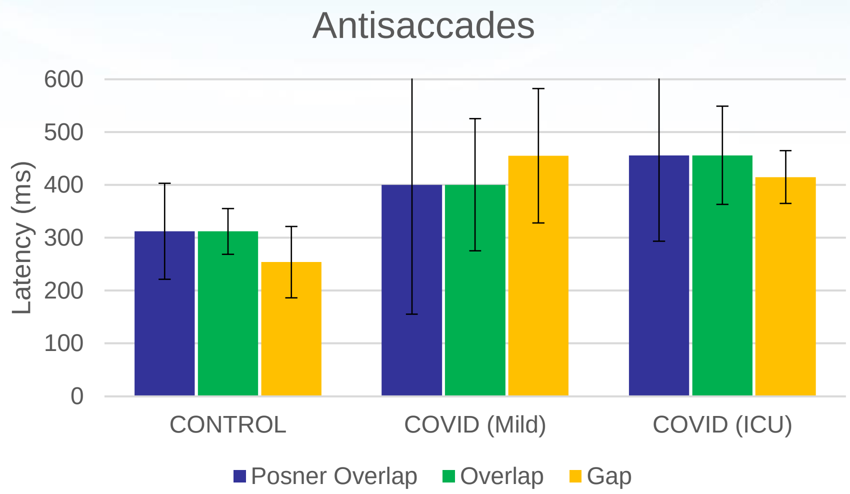
Control
n = 8
Age 45.02 ± 9.52

- No previous known SARS-COV-2 infection

* A total of 39 participants (26 COVID and 13 Controls) were recruited, but data from 8 participants (6 COVID and 3 control participants) were discarded due to poor quality eye movement recording, reduced vision, ocular misalignment or history of previous ocular conditions.

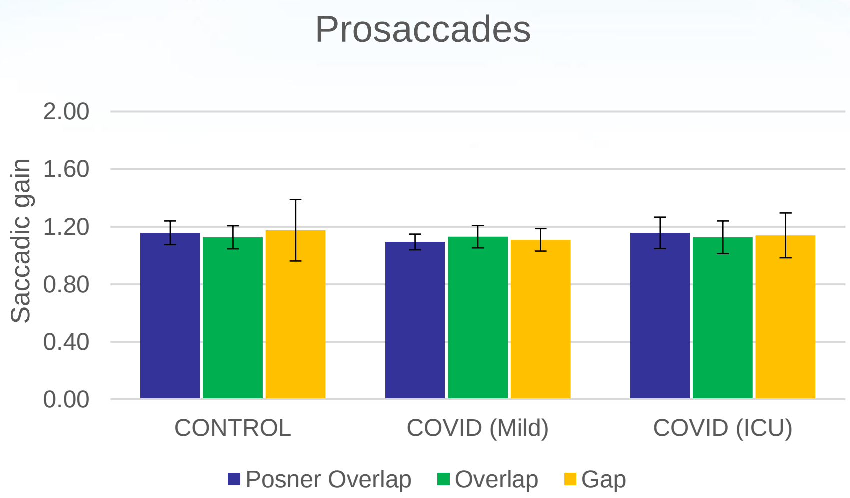
3. Results: Saccades (latency)

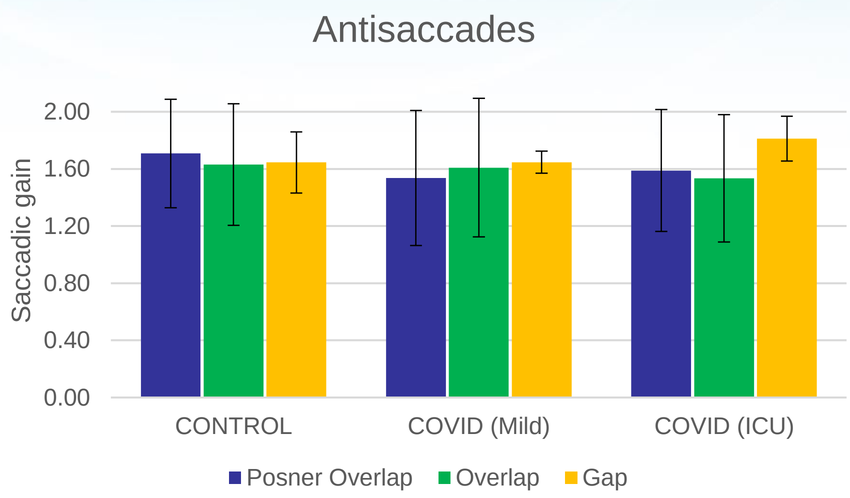




- Prosaccadic tasks: differences in saccadic latencies of ~50ms between Control and COVID groups.
- Antisaccadic tasks: differences in saccadic latencies of ~100ms between Control and COVID groups.
- Increased SD in COVID groups.

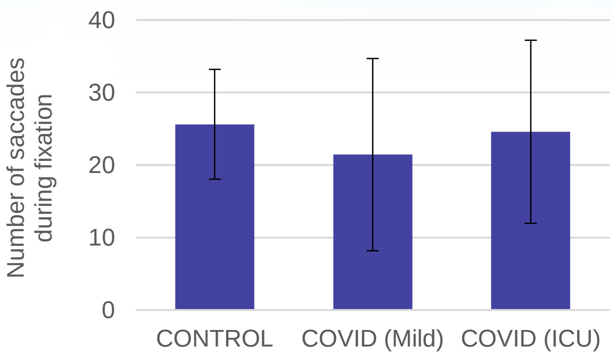
3. Results: Saccades (accuracy)

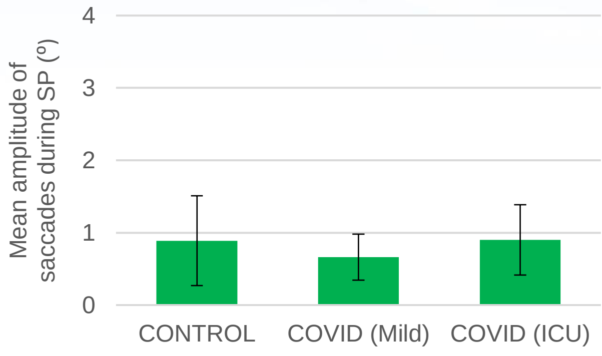


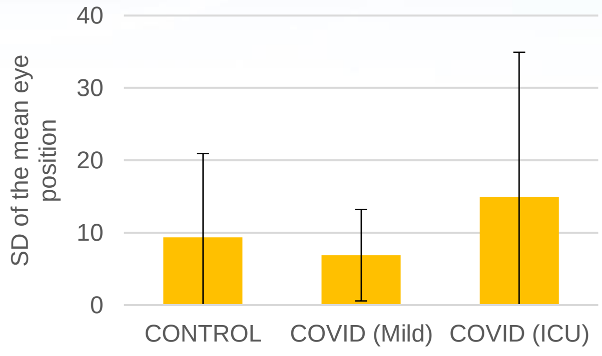


- Prosaccades were more accurate than antisaccades in all groups.
- No obvious differences in saccadic accuracy between the control group and the COVID groups.
- Increased SD in antisaccades for all groups.

3. Results: Fixation







- No differences in saccadic events during fixation.
- Increased standard deviation of the mean eye position in the COVID UCI group compared to COVID mild and control group.

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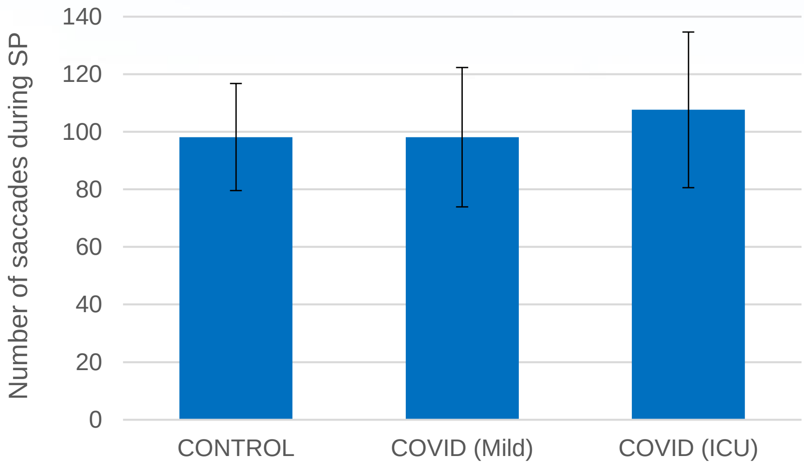
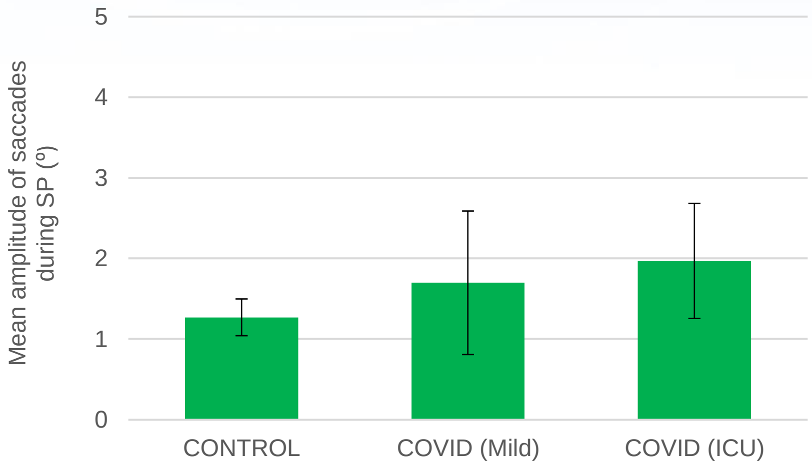
3. Results: Smooth pursuit





- Differences in number of saccades during smooth pursuit of <10 saccades between groups.
- Differences in mean amplitude of saccades during SP of <1º.

5. Conclusions

- COVID-19 may have an impact on saccadic eye movement function and control, particularly on antisaccadic latency.
- Further eye movement studies are warranted, specially in people who have developed cognitive deficits post-COVID and long-COVID.
  - Increasing the sample size, focusing on antisaccadic tasks, linking cognitive abilities with eye movement function.
- Eye-tracking may be a valuable tool to understand COVID-19 affectations beyond the respiratory syndrome and to possibly identify people with such affectations (long-COVID).

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We gratefully acknowledge Daniel Sánchez, Oriol Fígols, and Marina Bou for their collaboration and support with the data collection.

Valldeflors Vinuela-Navarro is funded by the “Ministerio de Universidades” and “NextGenerationEU”:

This publication is part of the project PID2020-112527RB-I00, funded by MCIN/AEI/10.13039/501100011033.
Proyecto PID2020-112527RB-I00 financiado por:

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3. Results: Fixation

	Fixation		
	Control	**COVID (Mild)**	**COVID (UCI)**
Number of saccades mean ± SD [min; max]	25.63 ± 7.58 [36; 11]	21.45 ± 13.26[44; 6]	24.60 ± 12.63 [56; 15]
Mean amplitude of saccades mean ± SD [min; max]	0.88 ± 0.62 [2.31; 0.36]	0.66 ± 0.31 [1.38; 0.43]	0.90 ± 0.48 [2.19; 0.43]
Standard deviation of mean eye position mean ± SD [min; max]	9.36 ± 11.56 [37.72; 2.65]	6.87 ± 6.31 [25.03; 2.88]	14.91 ± 22.82 [68.91; 2.36]

- No differences in saccadic events during fixation
- Increased standard deviation of the mean eye position in the COVID UCI Group compared to COVID mild and Control Group

3. Results: Smooth pursuit

	Sinusoidal Smooth pursuit		
	Control	**COVID (Mild)**	**COVID (ICU)**
Number of saccades mean ± SD [min; max]	56.5 ± 13.36 [82; 37]	57.45 ± 17.77[95; 37]	64.5 ± 19.43[92; 41]
Mean amplitude of saccades mean ± SD [min; max]	0.98 ± 0.17 [1.32; 0.81]	1.49 ± 1.19 [5.05; 0.71]	1.48 ± 0.57 [2.80; 0.77]

	Lineal Smooth pursuit		
	Control	**COVID (Mild)**	**COVID (UCI)**
Number of saccades mean ± SD [min; max]	41.75 ± 6.88 [52; 30]	40.72 ± 7.10 [56; 32]	44.80 ± 8.29 [59; 32]
Mean amplitude of saccades mean ± SD [min; max]	1.68 ± 0.53 [2.84; 1.10]	1.98 ± 0.72 [3.23; 1.26]	2.58 ± 1.06 [5.21; 1.50]

- Differences in number of saccades during smooth pursuit of <10 saccades between groups
- Diifferences in mean amplitude of saccades during SP of <1º