Institute of Neurobiology
Bulgarian Academy of Sciences

Postural and Motor Coordination during Sensory Conflict across the Life Span

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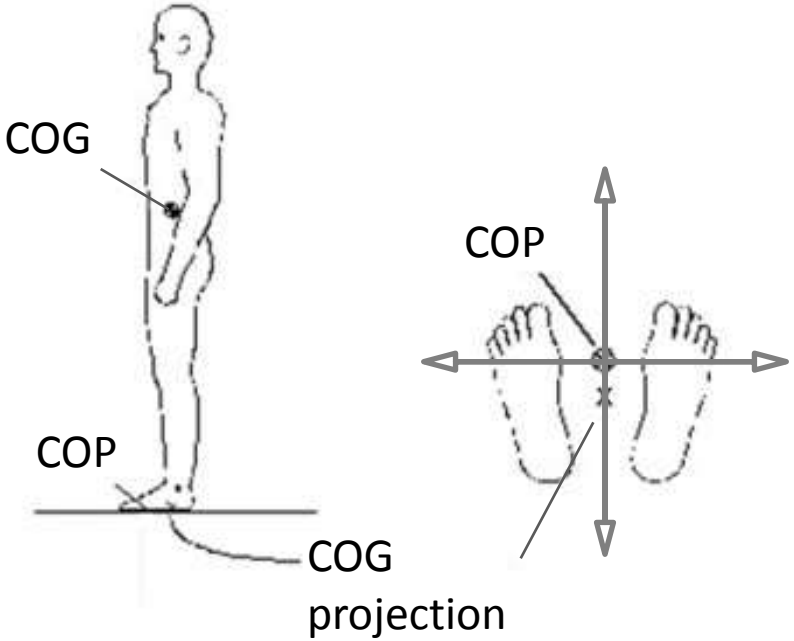
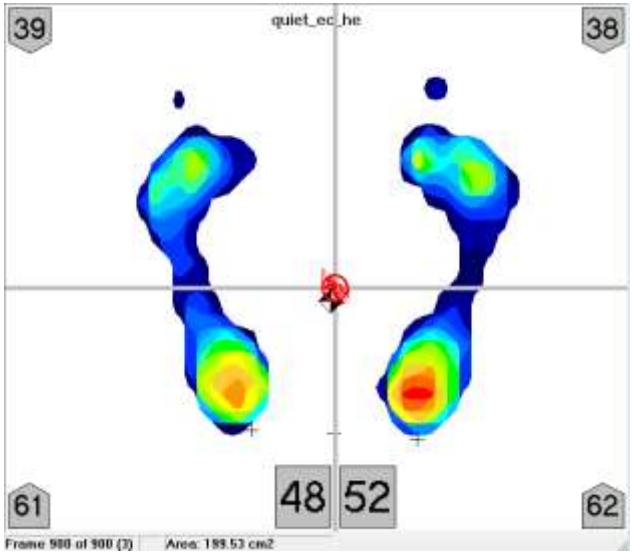
Standing balance

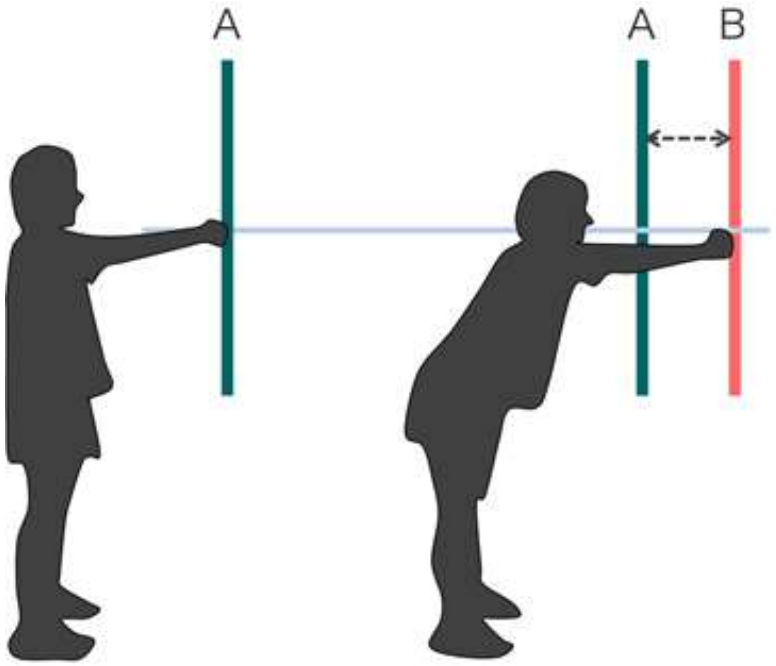
- Physiological significance of postural balance
- Static and dynamic balance
- Standing balance - definition
  - COG – center of gravity
- Methods for evaluation of the kinetic (force) characteristics of standing balance
  - COP – center of pressure
  - stabilography
  - pedobarography





- Development of the postural and motor coordination
- Sensory integration
  - Vestibulars
  - Vision
  - Proprioception
- Sensory conflict

Functional reach



- Developed by Duncan et al, 1990
- Definition – the maximal forward reach without lifting the heels and changes in the knee angle (length between A and B)
- Original purpose: risk of falls assessment (elderly people)
- Other applications:

assessment of the psychomotor development of children, the postural and motor coordination of athletes, etc.

- Modifications – **lateral reach**

Aim

Studying the postural and motor coordination of the static and dynamic standing balance of healthy children and adults during sensory conflict of visual and/or vestibular origin, using the frames of functional and lateral reach and pedobarography

Work program

1. Development of methods for the evaluation of dynamic standing balance using the frames of functional and lateral reach and pedobarography
2. Studying the static standing balance of healthy children and adults by the kinetic measures during quiet and sensory-conflicted stance
3. Studying the dynamic balance of healthy children and adults by the kinetic measures during functional and lateral reach in the same experimental conditions
4. Studying the performance of functional and lateral reach (the maximal reach) of healthy children and adults in the same experimental conditions

Subjects

Adults: 15 (6 females)

	Age(years)	Height(cm)	Weight(kg)
mean	28.5	174.4	83.6
SD	3.9	13.4	22.7

Children: 8 (4 females)

	Age(years)	Height(cm)	Weight(kg)
mean	9.4	134.3	32.9
SD	2.3	12.1	9.5

- Inclusion/exclusion criteria
- Modified Annett's test for laterality
- Anthropometric data

Experimental setup and procedure

Postural balance → Static
Postural balance → Dynamic → Functional reach
Dynamic → Lateral reach → Left
Lateral reach → Right

Experimental series:

1. eyes-open 
2. eyes-closed 
3. eyes-open with head-extended
4. eyes-closed with head-extended

Sensory conflict:
series 2, 3 and 4

2 trials of each series, 2-3 min. rest in sitting position between the series

Materials and methods

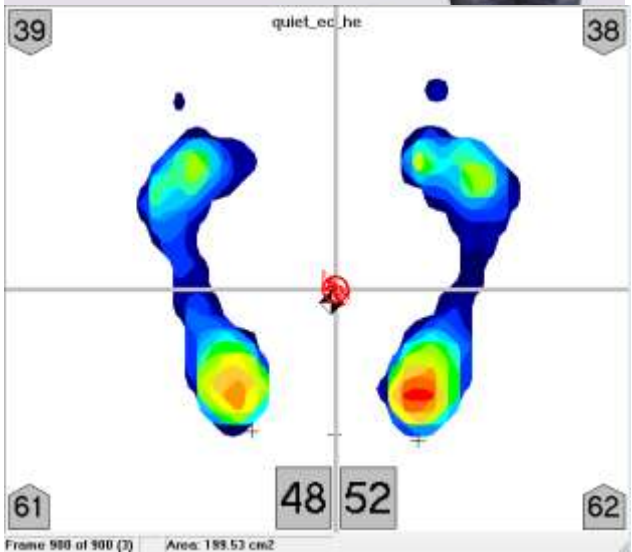
- Pedobarographic platformTekscan (30 s.; 30 frames/s.) (Research Software & Sway Analysis Module Matscan)
- A ruler fixed on the wall at shoulder height (1,5 cm length)

Evaluated measures:

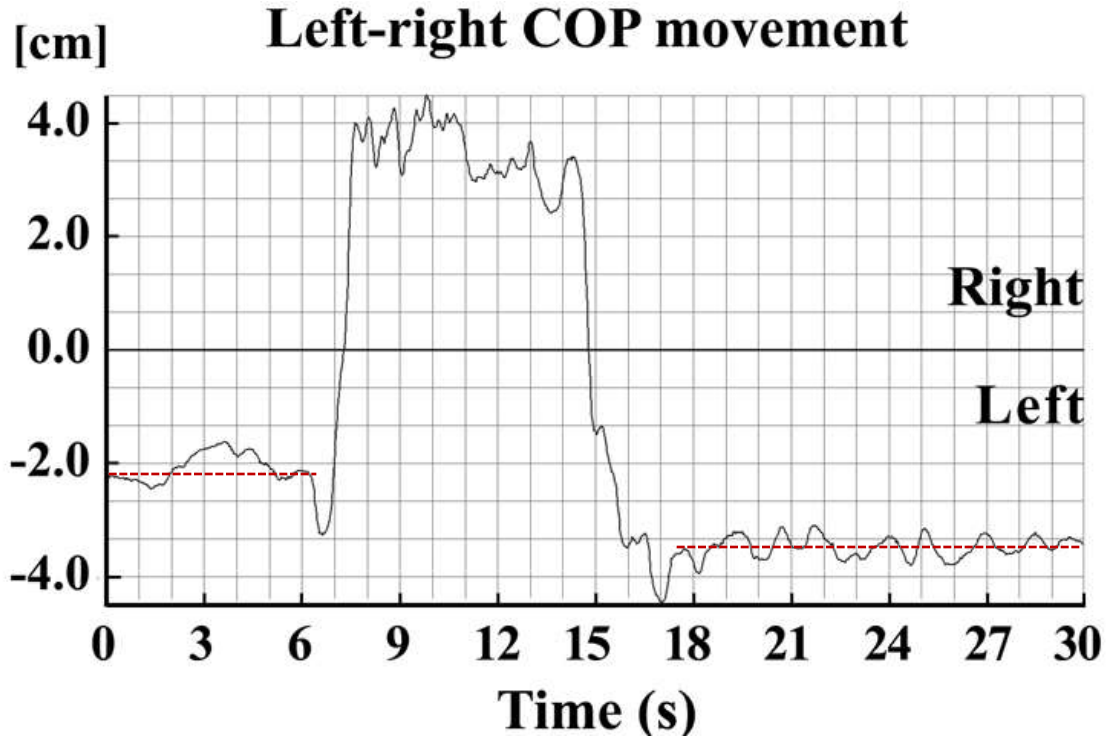
- Performance – length of the maximal functional or lateral reach

Kinetic measures:

- COP sway path
- Difference between the mean positions of COP before and after the dynamic task (reach)



Difference between the mean positions of COP before and after the dynamic task



Recording of one trial of right reach, eyes-open

The mean positions of COP before and after the dynamic task, as well as the difference between them are evaluated by our custom-made program in Matlab 7.13.

Statistical evaluation

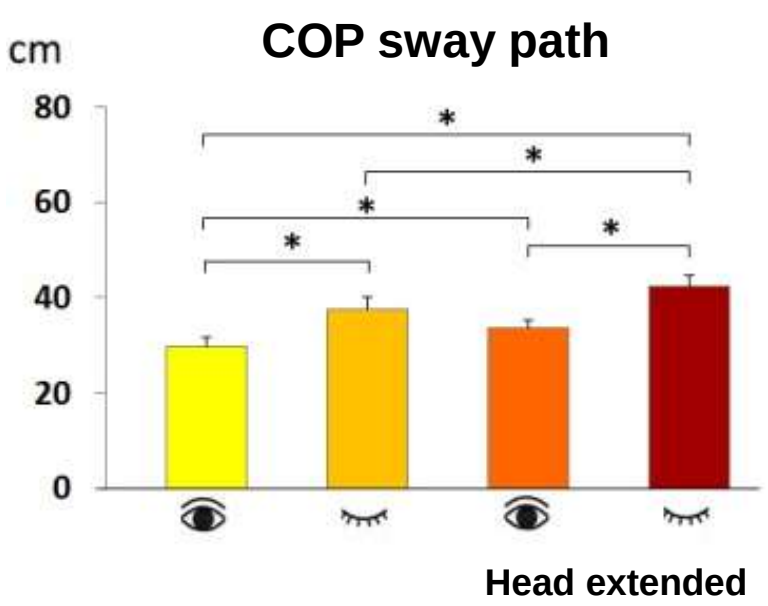
- Statistical software used:
  - Sigmaplot 12.5
  - IBM SPSS 22

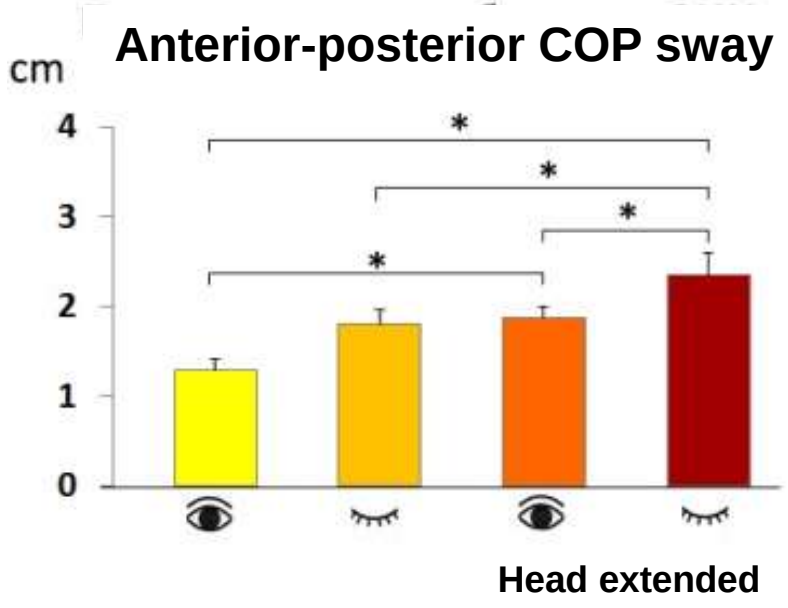
- Descriptive statistics (mean values, SD, SEM)
- Repeated measures (RM) ANOVA
- Post hoc analysis: Student-Newman-Keuls (SNK)
- One sample t-test (against 0)
- t-test

- Level of statistical significance: **$p < 0,05$**

Static standing balance (adults)

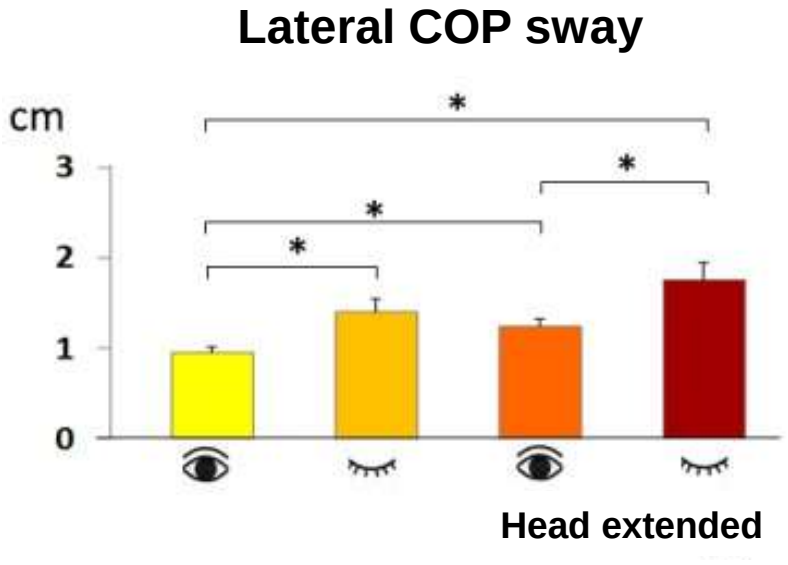
Kinetic measures





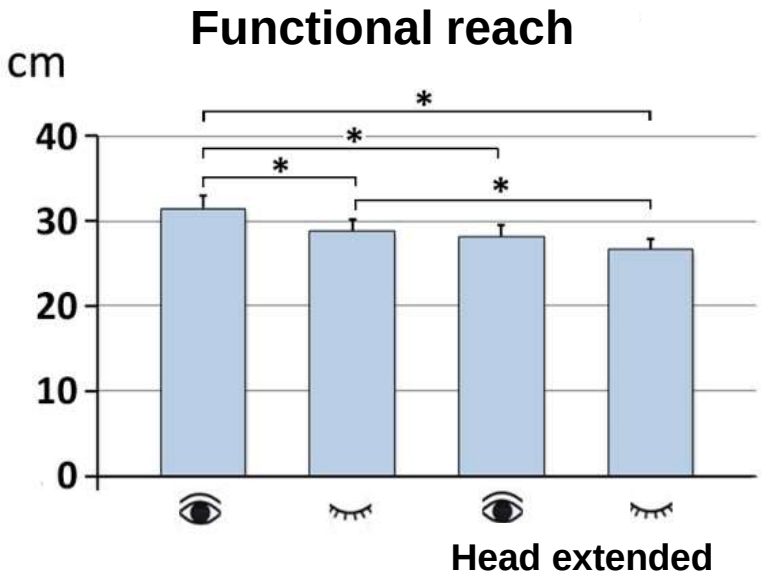
Two-way RM ANOVA, factors: visual and vestibular input. Both factors were significant. No significant interactions between factors were found.

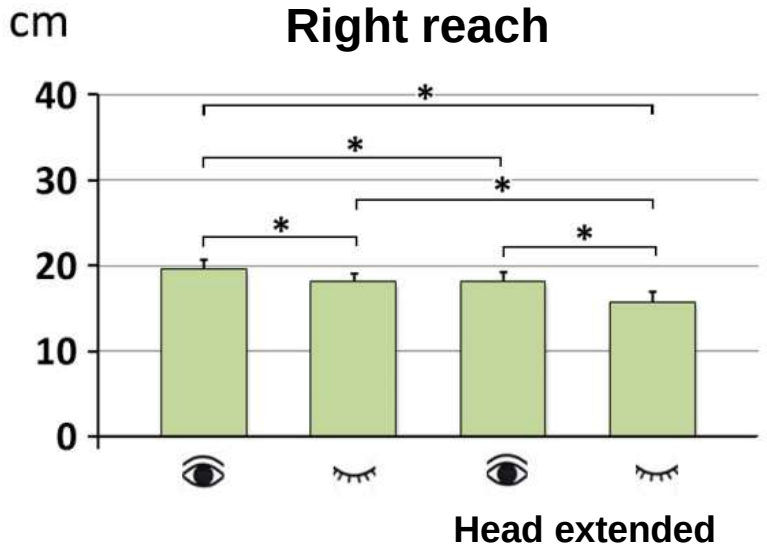
* - significant differences between series ($p<0.05$, post hoc analysis - SNK)



Dynamic standing balance (adults)

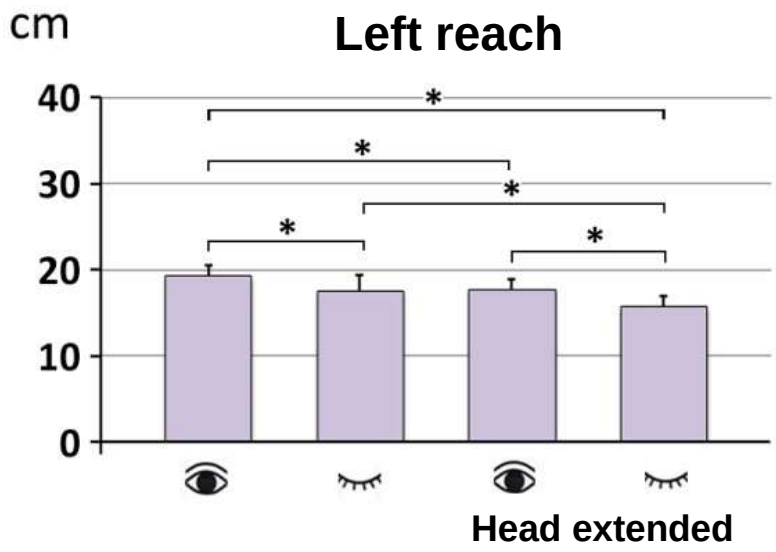
Performance (length of the maximal reach)



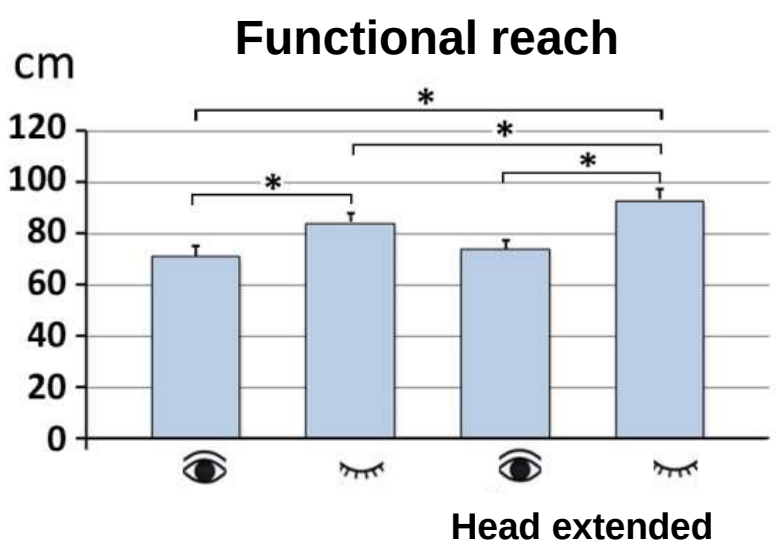


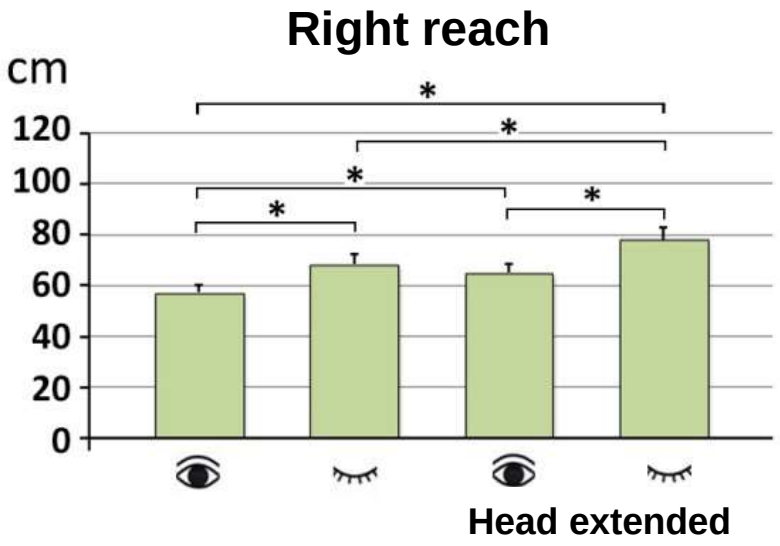
Two-way RM ANOVA, factors: visual and vestibular input. Both factors were significant. A significant interaction between factors was found in the right reach series.

* - significant differences between series ($p<0.05$, post hoc analysis - SNK)



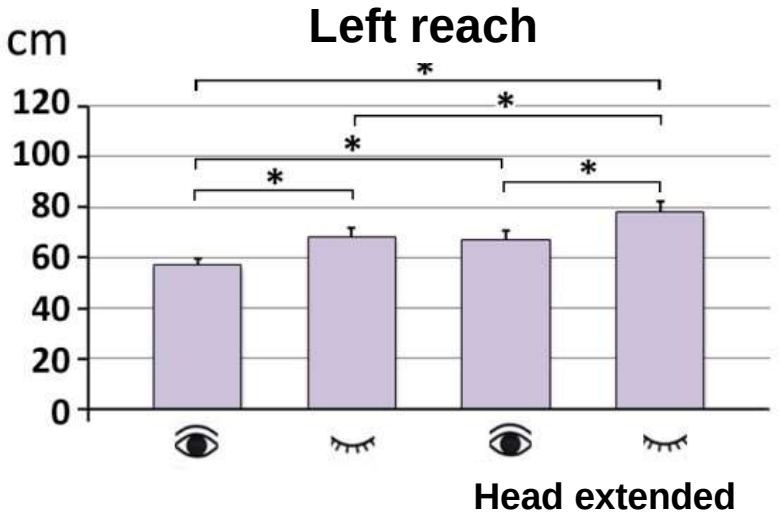
Kinetic measures
COP sway path





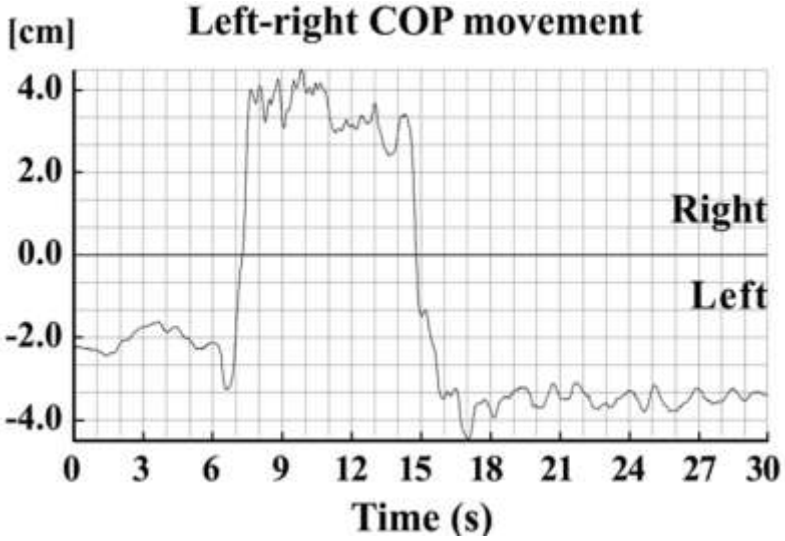
Two-way RM ANOVA, factors: visual and vestibular input. Both factors were significant. No significant interactions between factors were found.

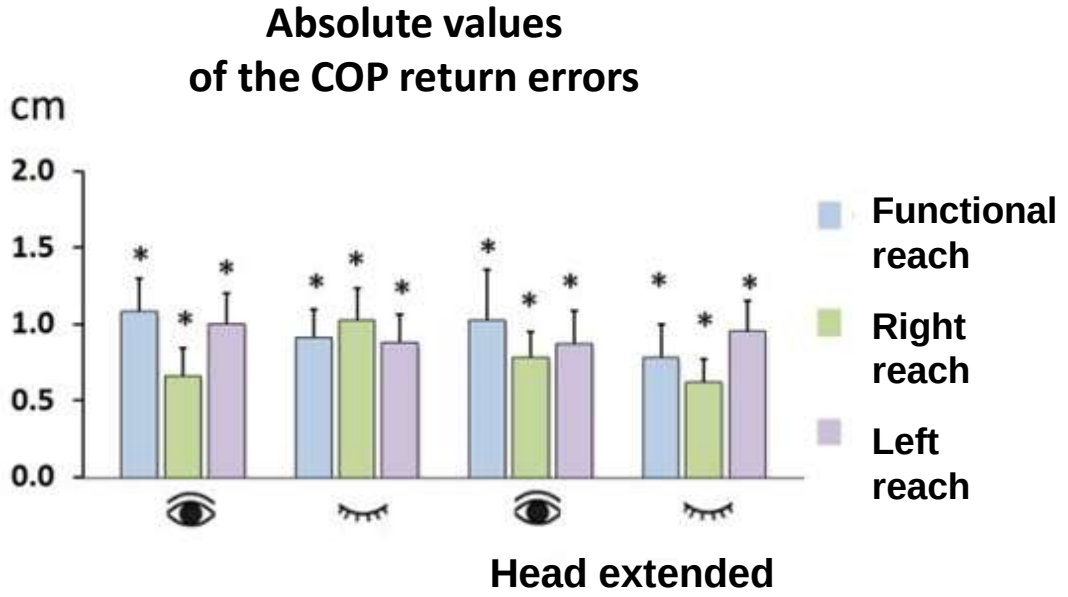
* - significant differences between series ($p<0.05$, post hoc analysis - SNK)



Kinetic measures

Difference between the mean positions of COP before and after the dynamic task



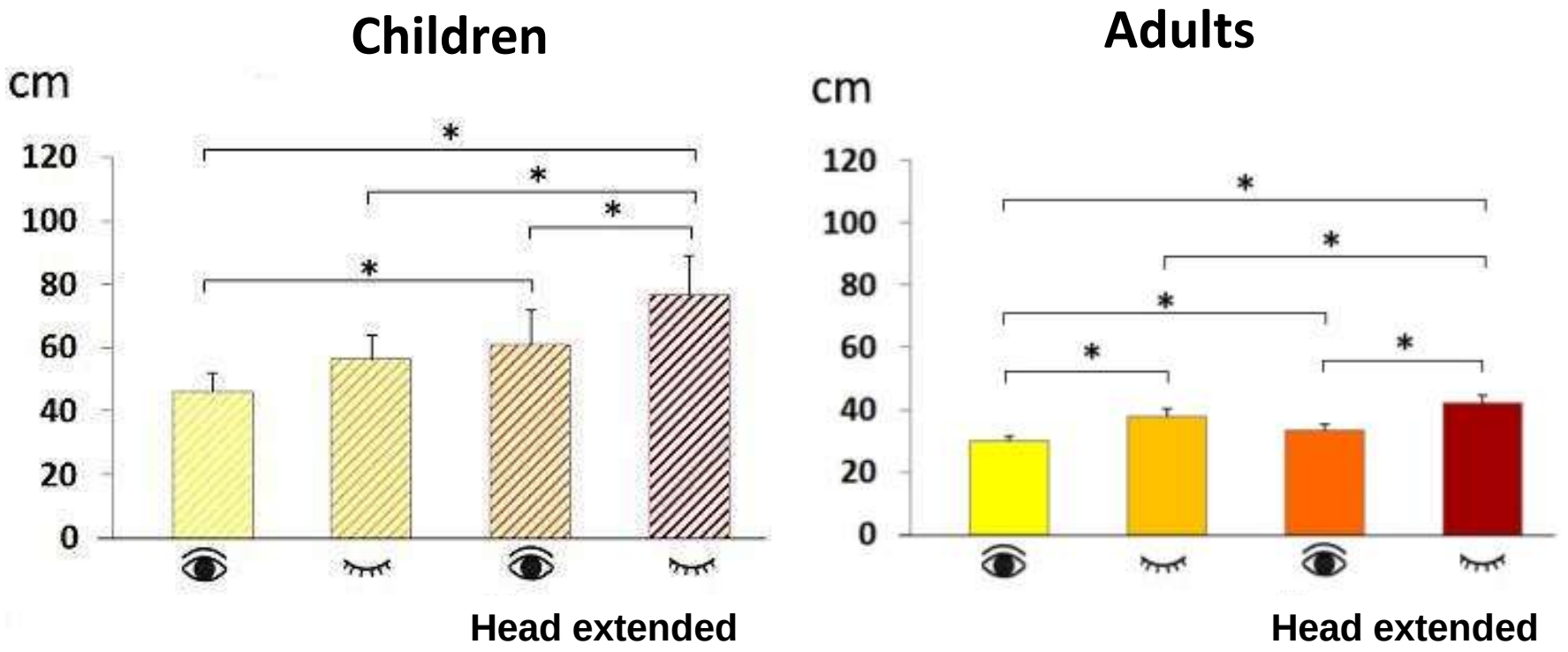


The mean positions of COP before and after the dynamic task, as well as the difference between them are evaluated by our custom-made program in Matlab 7.13. In all series the error when COP returns to its initial position is not a coincidence.

* - significant difference between series and 0 ($p<0.05$, One sample t-test against 0)

Static standing balance

COP sway path

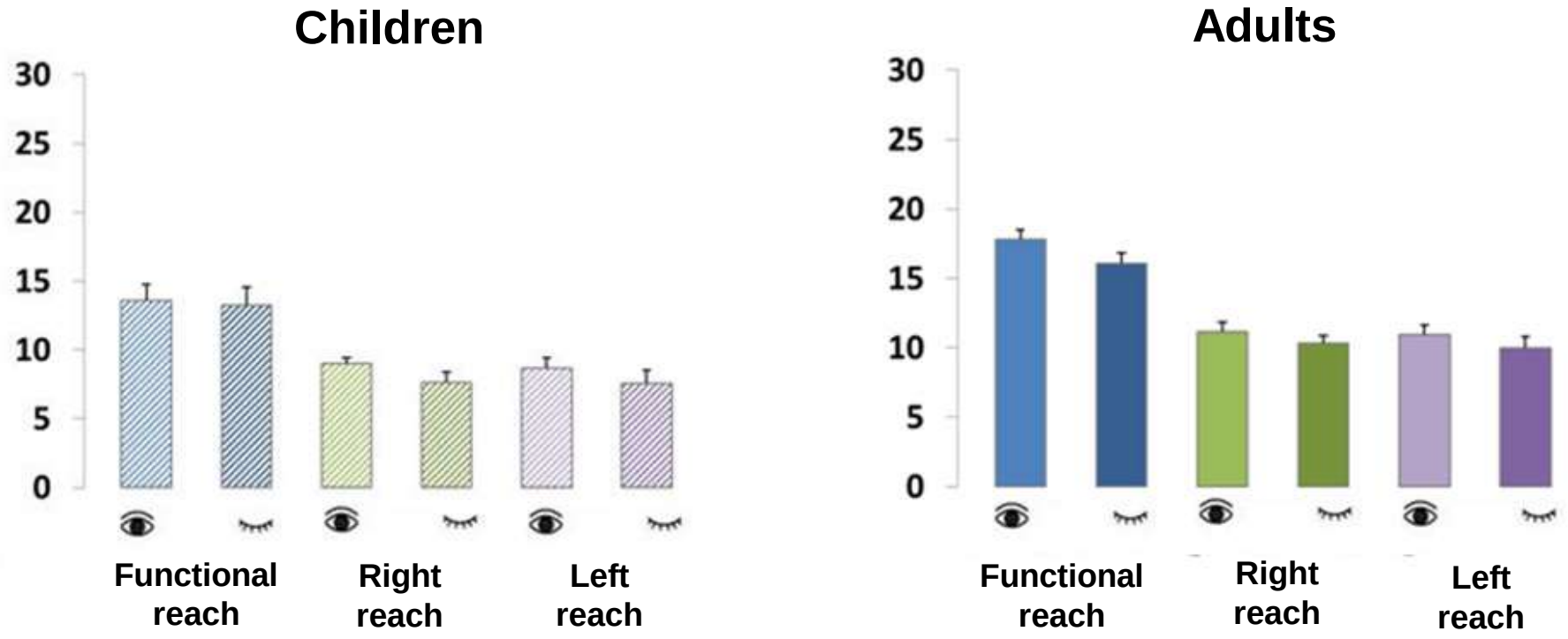


Two-way RM ANOVA, factors: visual and vestibular input. Both factors were significant. No significant interactions between factors were found.

* - significant differences between series ($p<0.05$, post hoc analysis - SNK)

Dynamic standing balance

Maximal reach normalized by height



Mean values and SEM of the maximal reach normalized by height during functional and lateral reach with eyes-open and eyes-closed.

t-test: Adults perform significantly better than children during functional and lateral reach.

Conclusions

- The greater COP sway during sensory conflict suggest that static and dynamic standing balance are visual- and vestibular-dependent.
- Children and adults' standing balance deteriorated the most when sensory conflict was caused via both modalities.
- Three-way RM ANOVA showed symmetry in the performance and kinetic measures during lateral reach in all sensory conditions.
- The interaction between factors visual and vestibular input during lateral reach with the right (dominant) arm in adults is an interesting finding which can be explained by better collaboration between the two senses concerning the postural and motor coordination of the dominant arm.

Conclusions (continued)

- The statistically significant overshoot in the return of COP after functional or lateral reach despite the sensory task conditions, is probably due to a deficits in the evaluation of the applied force and changes in the postural alignment.

- In all sensory conditions, children's reach normalized by height is shorter than adult's normalized reach.

- Functional and lateral reach during sensory conflict are applicable frames for better, more sensitive evaluation of static and dynamic standing balance of healthy adults and children.

- Pedobarography is a sensitive and informative method for evaluation of the static and dynamic standing balance.

Contributions

- A visual and vestibular dependence of static and dynamic standing balance during sensory conflict was proved.
- Visual-vestibular interaction in adults unlike in children when performing right reach was proved.
- We found a statistically significant overshoot during dynamic standing when subjects returned to their starting position after performing functional and lateral reach, independent of the sensory task conditions.
- A set of methods for evaluation of dynamic standing balance of adults and children using the frames of functional and lateral reach complemented by pedobarography was developed.

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Scientific publications

1. Kirilova, Gatev. **Lateral Reach Performance and Dynamic Standing Balance during Sensory Conflict**. Comptes Rendus de l'Académie Bulgare des Sciences, IF: 0.233 (2015) – in press

2. Gatev P, Kirilova K. **Sensory Conflict Influence on Functional Reach Performance and Dynamic Standing Balance**. In: Gatev P, Hatzitaki V, editorss. Proceedings of the International Workshop “Posture, Balance and the Brain”, 13th September 2014, Thessaloniki, Greece, Procon Ltd., Sofia, Bulgaria 2015, p. 22-28

Presentations at Scientific Meetings

1. XI Congress of the Bulgarian Association of Physiological Sciences, 9-11 Oct 2015, Medical University, Plovdiv. Oral presentation: "Lateral Reach Performance and Standing Balance during Sensory Conflict" (Kirilova, Gatev)

2. 7th International Posture Symposium, Smolenice Castle, Slovak Republic, September 6-9, 2015, Institute of Normal and Pathological Physiology, Slovak Academy of Sciences. Poster presentation: „Functional and Lateral Reach Performance and Standing Balance during Sensory Conflict" (Kirilova, Gatev)

3. Scientific Conference 145 years since the Establishment of the Bulgarian Academy of Sciences "Neuroscience - from Theory to Experiment". 4th Dec 2014, Institute of Neurobiology, BAS. Oral presentation: "Normal Human Types of Foot Arches and Steadiness of Standing Balance" (Kirilova, Gatev)

4. 1st Control of Movement and Posture Conference / EMG and Posturography Workshop, Faculty of Physical Education and Physiotherapy, Opole University of Technology, Oct. 9-10, 2014, Opole, Poland. Poster presentation: "Pedobarographic Measures of Functional Reach during Sensory Conflicted Stance" (Kirilova, Gatev) - awarded with first prize.

5. International Workshop on Posture, Balance and the Brain, Faculty of Physical Education and Sport Sciences, Aristotle University, Sept. 13, 2014, Thessaloniki, Greece. Oral presentation: "Kinetic Measures of Functional Reach during Sensory Conflicted Stance" (Kirilova, Gatev)

6. National Conference of Neurology with International Participation, June 12-14, 2014, Golden Sands, Varna. Poster presentation: „Functional Reach Evaluation during Sensory-conflicted Stance" (Kirilova, Gatev)

Thank you for your attention!