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Automaticity with Balance in Dual-Task Tests in Healthy Adolescents

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Abstract

BACKGROUND/CONTEXT: The hallmark of healthy postural control in adolescents is automaticity which is the ability of the nervous system to successfully coordinate posture with minimal use of attention-demanding executive control resources. Automaticity plays an important role in adolescents because it is necessary to perform motor skills, motor learning and reduce the risk of sport injury. Research has shown in dual-task (DT) paradigms that the ability to use postural control and cognitive skills of the brain uses both local and global functional connectivity in the Prefrontal Cortex, which controls a healthy adolescent's ability to perform a dual-task test with adequate balance.

PURPOSE: The purpose of our study is to examine if healthy adolescents show strong functional connectivity to compensate for the deficit in their postural control. Automaticity can be measured by presenting a healthy adolescent with a dual-task test, and observing if the brain activity is impacted in the Prefrontal Cortex (PFC), inferring a significant deficit in their postural control. The use of force plates are used to measure the sway area and the average velocity of the participants when they are given a single-task test and a dual-task test. Smaller sway area and average velocity presents a better performance in the local and global functional connectivity between regions of the brain. We hypothesized that there is no significant difference in terms of single or dual-task tests in their functional connectivity.

METHODS: 15 healthy adolescents (12 male (80%), age: 16.33±0.94 years, height: 1.69±0.10 m, mass: 64.08±9.81 kg) were recruited. Activity of the left/right prefrontal cortex (dorsal lateral and dorsal medial regions) were monitored using fNIRS, sampling rate of 20.3 Hz. The AMTI force plate is used to measure the center of pressure (CoP), sampling rate of 2000 Hz. Participants performed two standing trials on force plates for 30 seconds in single task (ST) and dual task (DT: concurrent cognitive task subtracting by 7’s) conditions. There was a 10-second quiet standing before each trial to serve as the baseline for the fNIRS signals. Our dependent variable included the HbO_2 level, local and global efficiency of the prefrontal cortex and the 95% sway area and average CoP velocity. Three two-way MANOVA with repeated measures were used to examine the task difference (alpha level = 0.05).

OUTCOMES: There was no significant task effect on balance performance ($F_{3,12} = 4.048$, $p = 0.033$). Post pairwise tests indicated that single-task tests presented a smaller average CoP velocity in the anterior posterior ($p = 0.037$, ST vs DT: 6.78 ± 2.39 vs. 10.22 ± 5.80 cm/s) and medial lateral ($p = 0.048$, ST vs DT: 4.38 ± 1.44 vs. 6.31 ± 3.79 cm/s) directions than in dual-task test. There was no significant task effect on HbO2 level, local and global efficiency ($p > 0.05$).

IMPACT: There was no significant task effect on brain efficiency in balance performance. We observed a worse balance performance under dual-task tests compared to single-task tests while the functional connectivity remains the same. These results suggest that adolescents are still developing their automaticity in balance when compared to the healthy young adults who would have the same balance performance under the dual-task tests.

Automaticity with Balance in Dual-Task Tests in Healthy Adolescents

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Introduction

- Automaticity plays an important role in adolescents because it is necessary to perform motor skills, motor learning and reduce the risk of sport injury.
- Research has shown that in dual-task (DT) paradigms, the ability to use postural control and cognitive skills uses both local and global functional connectivity in the Prefrontal Cortex of the brain. This controls a healthy adolescent's ability to perform a dual-task test with adequate balance.
- **The purpose of our study is to examine if healthy adolescents show strong functional connectivity under the dual task paradigm.**

Methods

Participants

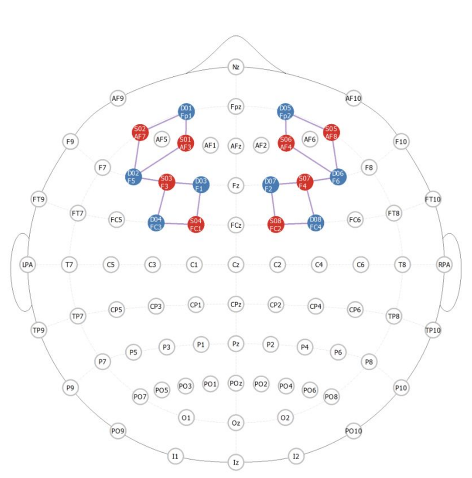
- Fifteen healthy adolescents. Demographics in Table 1.

Table 1. Participant Demographics

Demographics	Values
Age (Years)	16.33 ± 0.94
Height (m)	1.69 ± 0.10
Mass (kg)	64.08 ± 9.81
Sex	80% Male; 20% Female

Equipment

- A portable fNIRS device (NIRSport2, NIRx Medical Technologies, Berlin, Germany) was used to record activity of the left/right prefrontal cortexes.
- The sampling rate for monitoring activity was 20.3 Hz.
  - Left Prefrontal Cortex:
    - Dorsal Lateral and Dorsal Medial regions.
  - Right Prefrontal Cortex:
    - Dorsal Lateral and Dorsal Medial regions.
- AMTI force plates was used to measure the center of pressure (CoP).
- The sampling rate for the CoP was 2000 Hz.



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Methods Continued

Procedures

- Participants performed two standing trials on force plates for 30 seconds in single task (ST) and dual task (DT).
  - ST: Standing still on the force plates.
  - DT: Concurrent cognitive task subtracting by 7's.
- A 10-second quiet standing before each trial to serve as the baseline for the fNIRS signals.

Data Analysis

- Our dependent variable included the HbO_2 level, local and global efficiency of the prefrontal cortex and the 95% sway area and average CoP velocity.
- Three two-way MANOVA with repeated measures were used to examine the task difference (alpha level = 0.05).

Conclusions

- No significant task effect on brain efficiency.
- We observed worse balance performance under dual-task compared to single-task while the functional connectivity remains the same.
- **These results suggest that adolescents are still developing in automaticity in balance when compared to the healthy young adults who would have the same balance performance under the dual-task.**

References

Keatley, David A, et al. "A Consideration of What Is Meant by Automaticity and Better Ways to Measure It." *Frontiers in Psychology*, U.S. National Library of Medicine, 12 Jan. 2015, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4290469/.

Van Den Heuvel, Martijn P., and Hilleke E. Hulshoff. "Exploring the Brain Network: A Review on Resting-State FMRI Functional Connectivity." *European Neuropsychopharmacology*, Elsevier, 14 May 2010, https://www.sciencedirect.com/science/article/pii/S0924977X10000684?casa_token=o0ldUClGY-IAAAAA%3AAh7Aklfxenl4tC3uDeQH71nJ5SI1Pdoqsn6TEGy1OYSysyc6ywhhtL89blVwB-DoUAvN7mDe.

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Results

- No significant task effect on HbO_2 level, local and global efficiency ($p > 0.05$). Results are presented in Table 2.

Table 2. Mean Hemoglobin (HbO_2) Values for Single and Dual Task Tests by Brain Region.

Cortex	Region	Single Task (Mean ± SD) (μm)	Dual Task (Mean ± SD) (μm)
Left Prefrontal Cortex	Dorsal Lateral	0.0090 ± 0.061	0.015 ± 0.11
	Dorsal Medial	–0.031 ± 0.82	0.030 ± 0.057
Right Prefrontal Cortex	Dorsal Lateral	–0.00051 ± 0.059	0.037 ± 0.12
	Dorsal Medial	0.0012 ± 0.041	0.043 ± 0.11

Balance Performance

- There was no significant task effect on balance performance ($F_{3,12} = 4.048$, $p = 0.033$).

Table 3. Average Velocity and Sway Area for Single and Dual Task Tests in Anterior/Posterior and Medial/Lateral Directions.

	Single Task (Mean ± SD) (μm)	Dual Task (Mean ± SD) (μm)
Average Velocity in the Anterior/Posterior Direction (cm/s)	6.78 ± 2.39	10.22 ± 5.80
Average Velocity in the Medial/Lateral Direction (cm/s)	4.38 ± 1.44	6.31 ± 3.79
Sway Area (cm^2)	376.47 ± 338.58	317.35 ± 175.63

Global and Local Efficiency

- There was no significant task effect on local and global efficiency ($p > 0.05$).

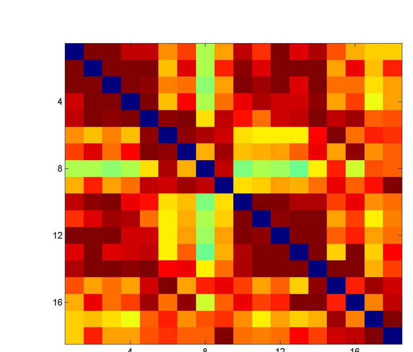

Table 3. Neural Efficiency of Single and Dual Task Tests.

Neural Efficiency	Single Task (Mean ± SD) (μm)	Dual Task (Mean ± SD) (μm)
Global Efficiency	0.19 ± 0.017	0.18 ± 0.016
Local Efficiency	0.26 ± 0.015	0.27 ± 0.028