Functional Reach and Dynamic Balance of Healthy 11-Year-Old Children

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INTRODUCTION

Standing balance depends on the adequate integration of sensory information and the support area [1]. Functional reach (FR) test [2] is applied for dynamic balance assessment of different age groups. Three strategies of FR have been reported: ankle, hip and mixed [3], defined by the changes in the ankle and hip joints during reach.

AIM

To compare the reaching strategies and dynamic balance of healthy 11-year-old children and adult controls and to assess children's ability to adapt to different task conditions.

SUBJECTS

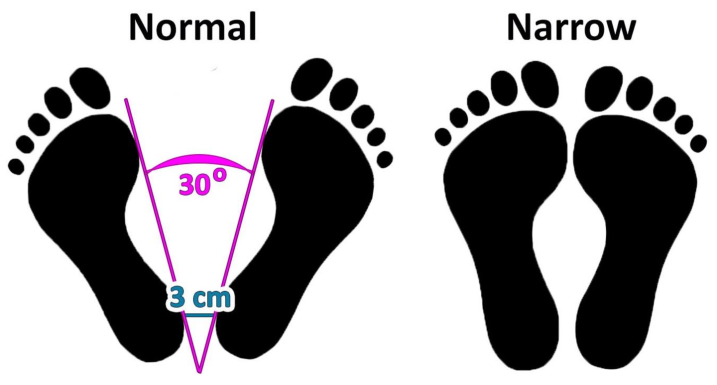
Eighteen children – boys and girls (mean age 11 ± 0.2 years) and 19 adults (mean age 32.4 ± 4.9 years)

EXPERIMENTAL SETUP &PROCEDURE

- Two trials of FR per task condition
- Four sensory conditions:

- eyes open (EO) – all sensory information available
- eyes closed (EC) – no visual information
- eyes open, head extended (EOHE) – altered vestibular information
- eyes closed, head extended (ECHE) – no visual and altered vestibular information

- Two types of support area (SA):



- Pedobarographic platform Tekscan: recording center of pressure (COP) sway, 30 fps, 30s.
- GoPro Hero 5 Black camera: video recording of kinematic data, 1280x720 px, 60 fps.
- Specialized software:

- Kinovea v0.8.26 for automatic object tracking
- custom-made programs in MatLab for 2D kinetic and kinematic analysis [4].

EVALUATED MEASURES

- Medio-lateral sway of COP
- FR length
- FR normalized by height
- Changes in the hip and ankle joint angles before and during FR

	Hip strategy	Ankle strategy
Adults	16	3
Children	13	5

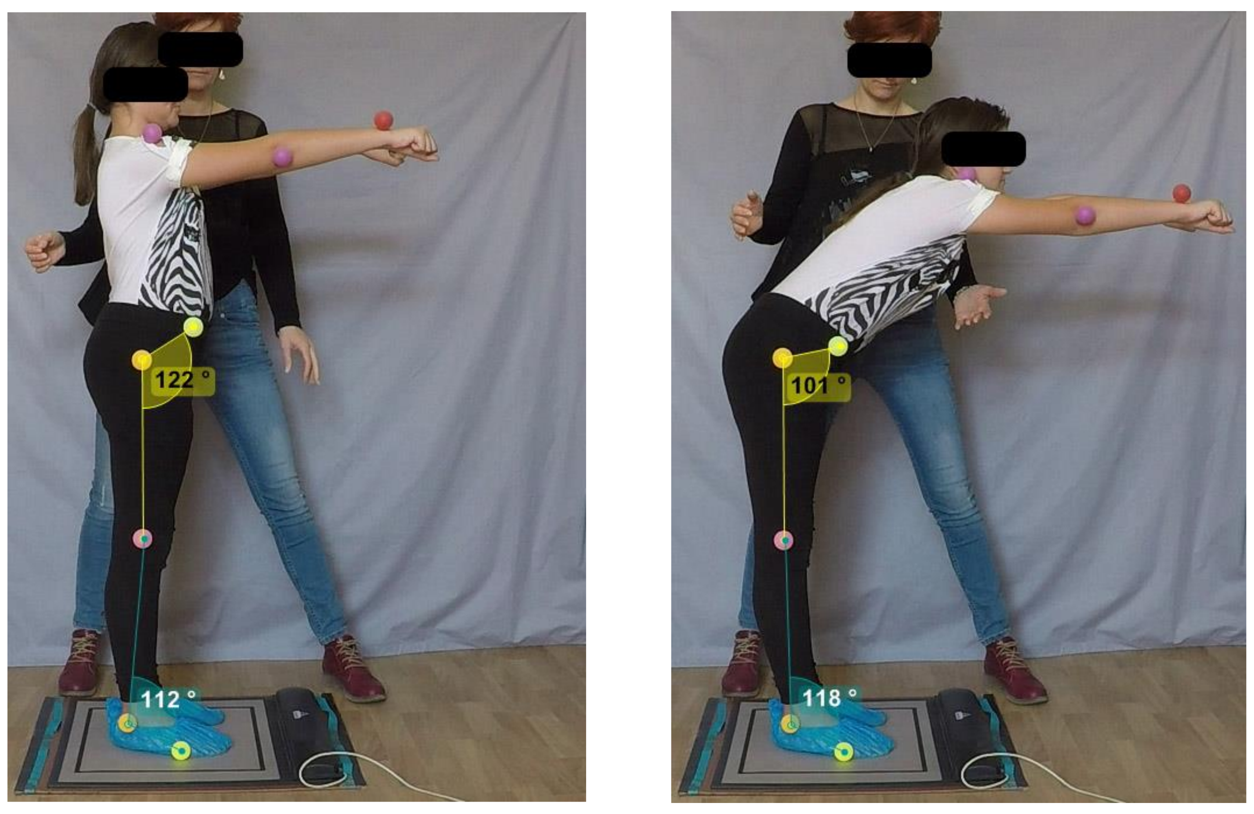
Table 1: Number of people of each group and adopted FR strategies.

RESULTS AND DISCUSSION

We defined two strategies – hip and ankle (see photos below) by the differences in the ankle and hip joints during the maximal forward reach and the initial body position. Almost all subjects adopted the hip strategy (Table 1). Subjects were rather consistent in their choice of reaching strategy in all task conditions (Table 2). As few people adopted the ankle strategy, FR and medio-lateral COP sway were further evaluated only for the subjects with hip strategy.

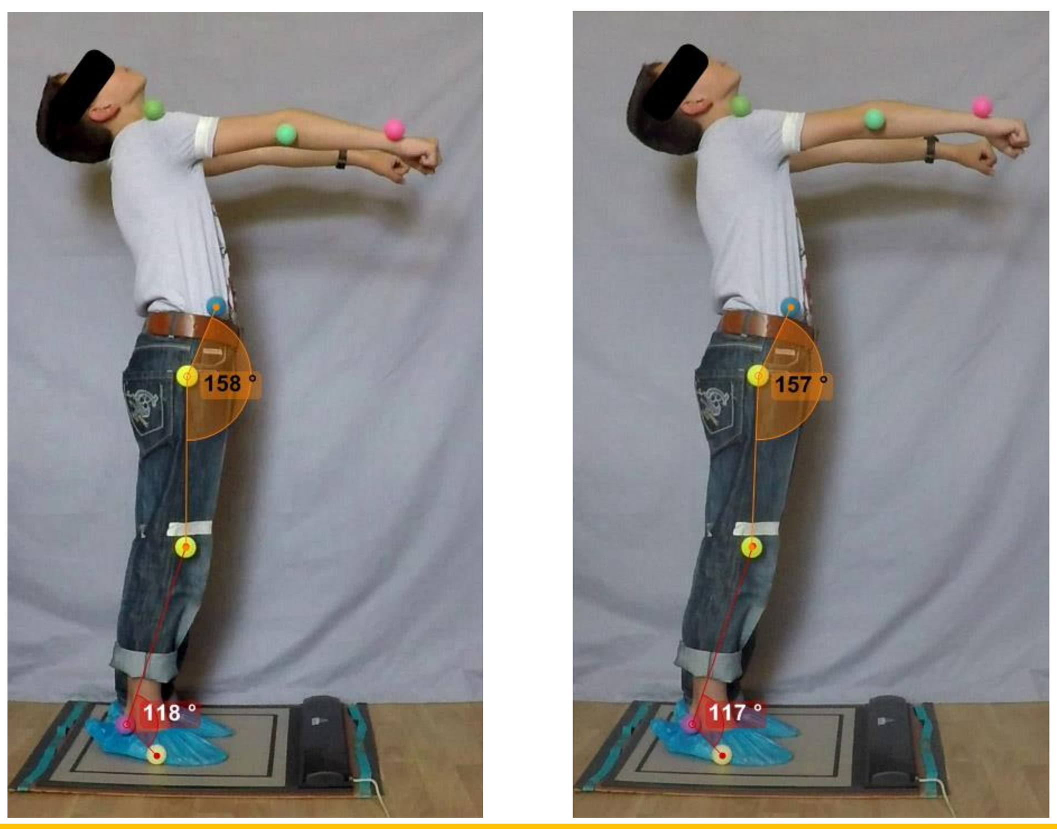
HIP STRATEGY

Hip angle considerably decreases. Ankle angle increases.



ANKLE STRATEGY

Smaller changes in hip angle. Ankle angle decreases.



Hip angle changes during FR (hip strategy)

		Normal support				Narrow support			
		EO	EC	EO HE	EC HE	EO	EC	EO HE	EC HE
Adults n = 16	mean	-22.9	-22.8	-22.4	-22.8	-22.0	-21.5	-21.3	-21.6
	min	-43.2	-40.1	-42.9	-42.4	-37.5	-39.6	-36.9	-42.8
	max	-8.0	-7.2	-5.2	-4.3	-6.8	-7.2	-4.1	-5.6
	SEM	2.135	2.239	2.317	2.119	1.850	1.989	1.904	1.976
Children n = 13	mean	-26.0	-24.3	-26.4	-25.0	-26.8	-24.2	-24.5	-23.5
	min	-49.5	-42.5	-53.2	-42.3	-50.0	-54.3	-54.1	-44.2
	max	-10.8	-8.8	-10.2	-12.0	-16.0	-11.0	-12.0	-11.9
	SEM	3.120	2.572	3.629	2.807	2.699	2.779	2.966	2.307

Hip angle changes during FR (ankle strategy)

		Normal support				Narrow support			
		EO	EC	EO HE	EC HE	EO	EC	EO HE	EC HE
Adults n = 3	mean	-3.0	-3.4	-2.0	-3.4	-2.6	-2.6	-1.4	-3.5
	min	-6.5	-6.9	-5.5	-8.2	-5.3	-5.0	-3.9	-6.5
	max	1.5	2.3	2.3	2.4	1.9	1.6	1.8	0.8
	SEM	0.937	1.135	0.908	1.225	0.891	0.841	0.673	0.871
Children n = 5	mean	1.1	0.3	0.7	-1.3	0.3	0.7	1.2	-0.8
	min	-2.7	-1.4	-1.8	-7.3	-2.4	-0.9	-0.4	-2.6
	max	6.5	3.1	2.3	2.0	2.2	2.3	3.5	0.7
	SEM	1.499	0.811	0.694	1.583	0.797	0.579	0.749	0.598

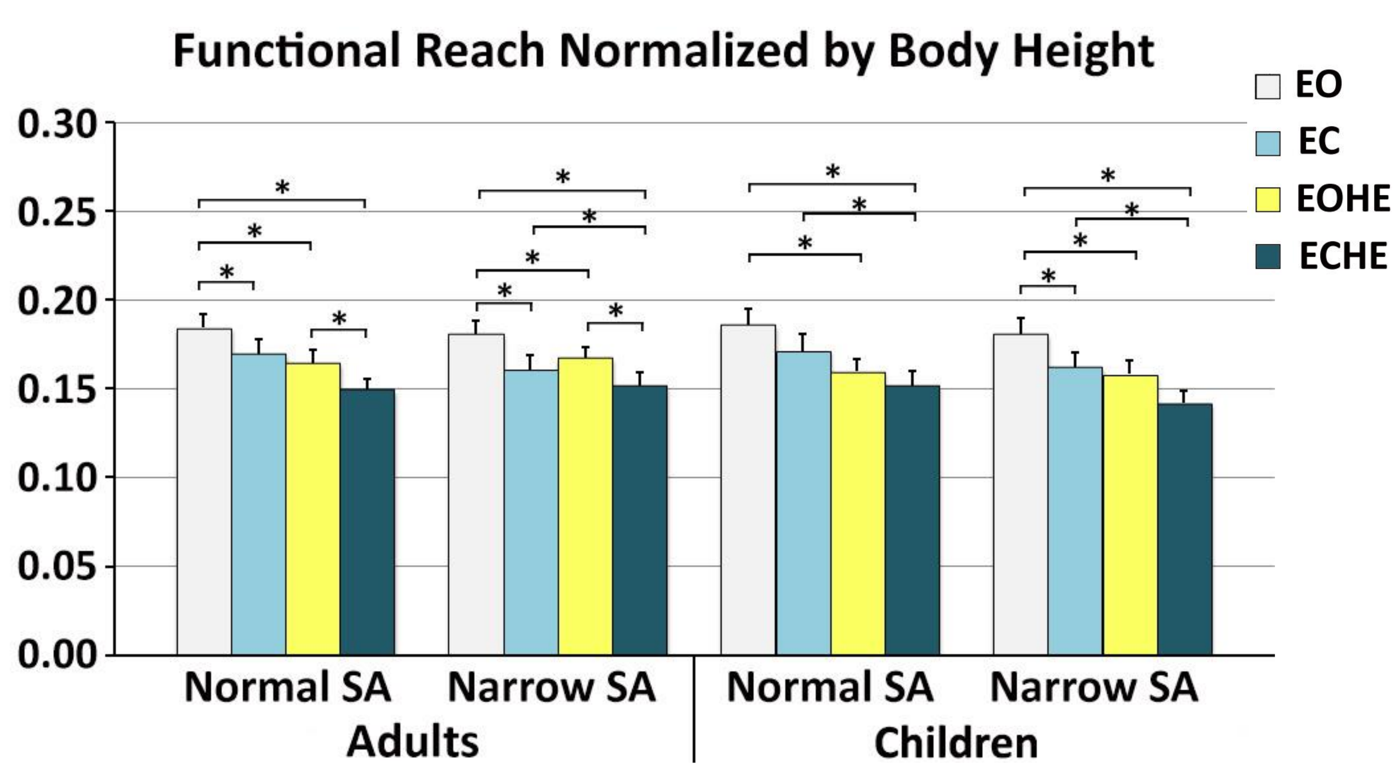
Ankle angle changes during FR (hip strategy)

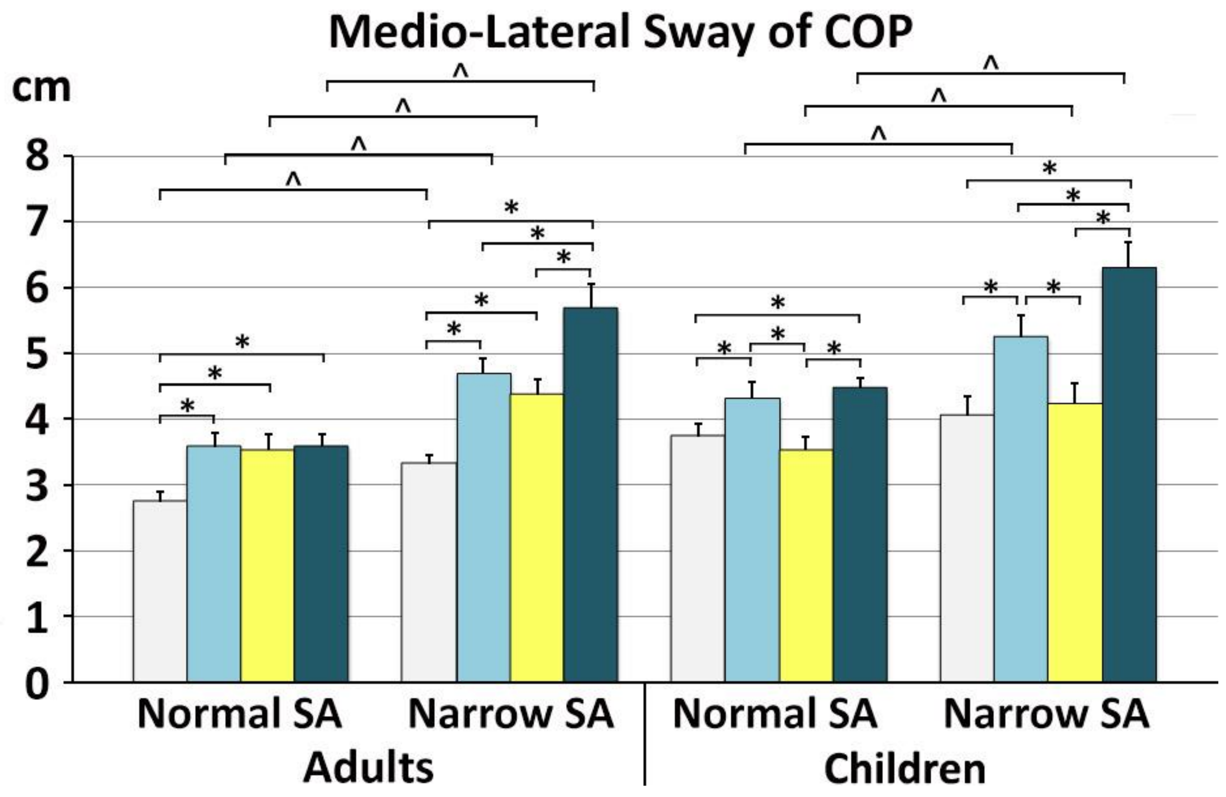
		Normal support				Narrow support			
		EO	EC	EO HE	EC HE	EO	EC	EO HE	EC HE
Adults n = 16	mean	8.4	8.6	8.6	8.6	9.6	10.0	9.9	9.7
	min	4.4	5.4	5.0	4.1	5.7	5.5	5.8	5.8
	max	13.7	12.4	11.5	11.4	14.3	16.6	13.0	12.6
	SEM	0.649	0.588	0.570	0.541	0.641	0.743	0.533	0.569
Children n = 13	mean	10.0	10.4	8.9	9.3	12.1	11.5	11.6	10.9
	min	6.2	4.3	5.0	4.5	6.1	6.6	5.4	5.8
	max	17.1	19.5	15.0	14.1	20.6	19.6	19.5	16.0
	SEM	0.842	0.940	0.715	0.780	0.971	1.082	1.127	0.837

Ankle angle changes during FR (ankle strategy)

		Normal support				Narrow support			
		EO	EC	EO HE	EC HE	EO	EC	EO HE	EC HE
Adults n = 3	mean	-0.6	-0.6	-1.4	0.2	-0.3	-0.4	-1.4	0.5
	min	-1.6	-2.0	-3.6	-1.0	-2.4	-2.1	-2.9	-1.1
	max	0.8	1.4	1.5	0.9	1.8	1.8	1.1	2.4
	SEM	0.294	0.399	0.599	0.252	0.481	0.460	0.502	0.411
Children n = 5	mean	-2.3	-2.6	-2.6	-3.2	-2.1	-3.0	-2.9	-1.8
	min	-5.5	-3.9	-3.9	-4.2	-4.1	-4.3	-4.8	-3.4
	max	1.8	-1.2	-0.7	-2.2	0.0	-2.3	0.2	0.0
	SEM	1.182	0.612	0.591	0.377	0.655	0.339	0.864	0.713

Table 2. Descriptive statistics of the changes in the hip (up) and ankle (down) joint angles before and during FR in all task conditions for hip (left) and ankle (right) strategies.





*Mean values of FR normalized by height (left) and M-L COP sway of the groups with hip strategy on normal and narrow support area (SA) in the four sensory conditions (see text). * - differences between sensory conditions; ^ - differences between series on normal and narrow support, $p < 0.05$ (paired t-test).*

Sensory conflict diminished FR length similarly in both age groups. Task performance was not affected by the narrow support.. Children had shorter FR length in general, but when normalized by body height, their performance didn't differ significantly from the adult controls. Children's lateral sway was slightly greater in general. Sensory conflict and/or narrowing the support increased the lateral COP sway in both age groups. The results are in line with previous studies [5, 6] that also found adult-like postural behavior in children. However, children's dynamic balance seems to be more visually dependent.

CONCLUSIONS

The sensory conflict and narrow support deteriorate the dynamic standing balance of both children and adults. The 11-year-old children showed adult-like adaptation to the different task constraints.

ACKNOWLEDGEMENTS

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