Feasibility and reproducibility of using an exoskeleton able to emulate muscle contractures during walking.

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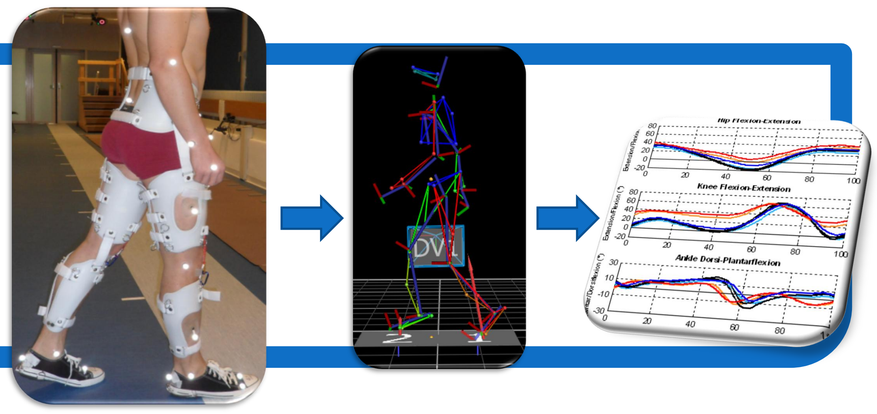
INTRODUCTION

Contracture is a permanent shortening of muscle-tendon-ligament complex limiting joint mobility. Contracture is involved in many diseases (cerebral palsy, stroke, etc.)

Purpose: 1)To develop an exoskeleton able to emulate contractures during walking
2)To quantify the reproducibility of this tool



METHODS

Design

An exoskeleton "**MIkE**" was built with the following criteria:

- Adjustable to different morphologies
- Respect the principal lines of muscular actions
- Placement of reflective markers on anatomical landmarks
- Ability to replicate contractures of 8 muscles of the lower limb unilaterally and bilaterally

Protocol

- Nine healthy participants
- Two sessions of gait analysis were performed with one week interval to assess the reproducibility
- Sixteen combinations of contracture were emulated

Muscles	Contracture(°)	Movements
Peroneus	Maximum	Foot eversion
Tibialis posterior	Maximum	Foot inversion
Soleus	-10°	Dorsiflexion (knee in flexion)
Gastrocnemius	-20°	Dorsiflexion (knee in extension)
Hamstring	95°	Unilateral popliteal angle
Rectus femoris	-40°	Hip extension (knee in flexion)
Hip adductor	Maximum	Hip abduction (hip in extension, knee in flexion)
Psoas-iliac	-30°	Hip extension (knee in extension)

Parameters

Range of motion (ROM) and mean position of pelvis and hip angles in 3 planes. Flexion at initial contact, maximum of flexion at stance, mean position at stance and ROM in sagittal plane of knee and ankle angles. Mean foot progression angles and Gait Profile Score (GPS) [1] were extracted.

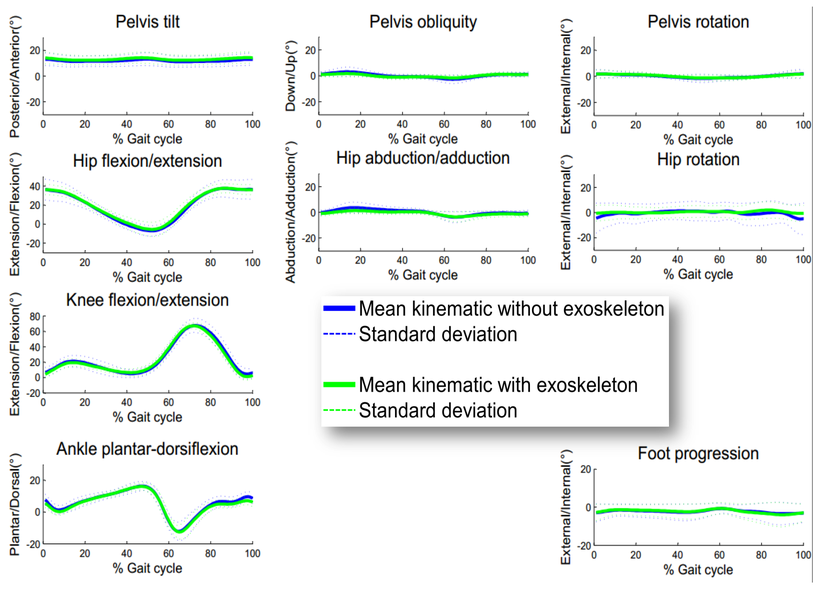
Statistics

Intraclass correlation coefficient (ICC), standard error of measurement (SEM) and smallest detectable change (SDC) of the mean of all kinematics variables were computed to estimate the repeatability of emulated contractures. A Wilcoxon test on gait variable scores (GVS) and visual kinematic observation was used to evaluate the influence of exoskeleton on normal gait without contracture.

RESULTS

Comparison with and without exoskeleton

Visual interpretation



Wilcoxon test

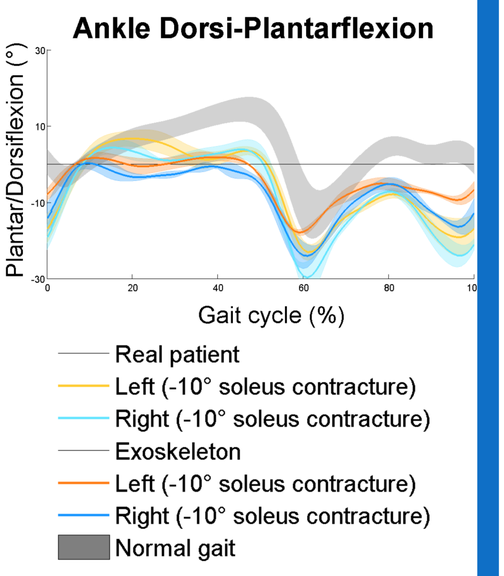
	p-value
Pelvis Tilt	0.184
Pelvis Obliquity	0.948
Pelvis Rotation	0.472
Hip Flex/Ext	0.913
Hip Abd/Add	0.528
Hip Rotation	0.231
Knee Flex/Ext	0.913
Ankle Flex/Ext	0.913
Foot Progression	0.845
GPS	0.983

p< 0.05 : significant difference

Reproducibility of gait with emulated contractures

	Mean variables		
	ICC	SEM(°)	SDC(°)
Without exoskeleton	0.71	1.95	5.41
With exoskeleton	0.62	2.13	5.89
Gastrocnemius bilateral	0.69	2.39	6.63
Gastrocnemius unilateral	0.60	2.79	7.73
Soleus bilateral	0.78	2.07	5.74
Soleus unilateral	0.62	3.01	8.33
Hamstring bilateral	0.68	2.83	7.86
Hamstring unilateral	0.74	2.17	6.00
Rectus femoris bilateral	0.62	3.33	9.22
Rectus femoris unilateral	0.57	3.86	10.69
Psoas bilateral	0.70	3.50	9.44
Psoas unilateral	0.66	3.40	9.44
Adductor bilateral	0.56	4.01	11.11
Adductor unilateral	0.67	3.36	9.31
Tibial posterior bilateral	0.74	5.36	14.87
Tibial posterior unilateral	0.58	2.92	8.09
Peroneus bilateral	0.60	3.84	10.64
Peroneus unilateral	0.53	2.94	8.15

Example of comparison of a real patient and the exoskeleton.



ICC<0.4 poor reliability
ICC 0.4-0.75 good reliability
ICC>0.75 excellent reliability [2]

➢ ***Excellent reproducibility***
➢ ***Good reproducibility***

DISCUSSION/CONCLUSION

➢The emulation of contractures on healthy participants with an exoskeleton is feasible and reliable.
➢A reproducibility from good to excellent was showed for different gait conditions.

➢ This new approach will permit to better understand the gait deviations related to contractures by a better discrimination between alterations and compensations.

REFERENCES

[1] Baker R et al. 2009
[2] Shrout PE and Fleiss JL, 1979

ACKNOWLEDGMENTS

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