



ÉCOLE DE
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SUPÉRIEURE
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LIO
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Quantitative Evaluation of Evoke orthosis

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CRCHUM

General objective

- The purpose of this presentation is to show the results of the evaluation of the Evoke knee prosthesis during squat movement as assessed by low-dose biplanar X-ray imaging techniques (EOS™)

General purpose of knee unloading brace

- Articular Alignment
 - Distribution of load into the lateral and medial compartments
 - Reduction of load into the medial compartment by increasing the joint space narrow at the medial level
 - Increase of knee stability
 - Decrease of knee muscular co-contraction
 - Enhance proprioception
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- Moyer R.E. et al., 2015. Biomechanical effects of valgus knee bracing: a systematic review and meta-analysis. *Osteoarthritis & Cartilage* 23, 178-188.
 - M. Maitre M., Brunon A., Pélissier J. Les orthèses de genou dans la gonarthrose. In *L'arthrose du genou* , C.Hérisson, P. Codine, V. Brun. Edition Masson, Paris, 2004. pp.84-92.

Methodology

Patients: (N=16, 9 right knee, 7 left knee, 5 Males, 11 Females)

Exclusion : No.7 (Incomplete data)

ID	Date Fitting	Age	Sex	Weight	Height	Leg	Date of experiment	CHUM number	NIU subject	translation	correction	
1. Patient A	2017-07-05	62	M	194lb	5p 9.5po	D	01.10.2017, 09:30	1378446	PJ110-01	-4	Valgisation 5(+)	Correction probablement
2. Patient B	2017-07-26	73	F	145lbs	5p 3po	D	01.10.2017, 11:30	884892	PJ110-02	-4	Valgisation 5(+)	Correction probablement
3. Patient C	2017-06-28	68	F	198lbs	5p 7po	G	01.10.2017, 13:00	2186466	PJ110-03	-4	Valgisation 5(+)	Correction probablement
4. Patient D	2017-07-03	55	F	280lbs	5p 10po	G	01.10.2017, 14:30	1171540	PJ110-04	-4	Valgisation 5(+)	(correction effectué)
5. Patient E	?	54	F	176lbs	5p 2po	D	01.10.2017, 16:00	384696	PJ110-05	-4	Valgisation 7(+)	(correction effectué)
6. Patient F	2017-06-19	77	F	190lbs	5p 1po	D	03.10.2017, 16:30	820045	PJ110-06	-4	Varisation 5(-)	Correction probablement
7. Patient G	2017-07-06	59	M	245lbs	5p 10po	D	08.12.2018, 9:00	565181	PJ110-07	-4	Valgisation 7(+)	(correction effectué)
8. Patient H	11.03.2019	64	M	100Kg	1,80 m	G	22.06.2019, 9:00	5547839	PJ110-08	-4	Valgisation 5(+)	(correction effectué)
9. Patient I	24.05.2019	50	F	57 Kg	1.62 m	G	22.06.2019, 11:00	5548176	PJ110-09	-4	Valgisation 5(+)	(correction effectué)
10. Patient J	19.03.19 D et 03.05.19 G	33	F	85Kg	1,68 m	D	22.06.2019, 13:00	5484917	PJ110-10	-4	Varisation 5(-)	(correction effectué)
11. Patient K	04.04.2019	54	F	84 Kg	1,65 m	G	22.06.2019, 15:00	1031550	PJ110-11	-4	Valgisation 5(+)	(correction effectué)
12. Patient L	21.06.2019	68	F	57Kg	1,68 m	G	10.08.2019 8:00	5536687	PJ110-12	-4	Valgisation 5(+)	(correction effectué)
13. Patient M	21.06.2019	82	F	58Kg	1,56 m	D	10.08.2019 10:00	5561469	PJ110-13	-4	Valgisation 6(+)	(correction effectué)
14. Patient N	25.06.2019	64	M	106Kg	1,80 m	G	10.08.2019 12:00	89995	PJ110-14	-4	Valgisation 5(+)	(correction effectué)
15. Patient O	17.07.2019	41	F	73Kg	1,68 m	D	04.09.2019 17:00	5566881	PJ110-15	-4	Valgisation 5(+)	(correction effectué)
16. Patient P	26.07.2019	42	M	109Kg	1,83 m	D	21.09.2019 11:00	1068473	PJ110-16	-4	Valgisation 5(+)	(correction effectué)

Experimental protocol

- Patients selection from Dr Lavoie, Orthopedic Surgeon at the CHUM (typical meniscal tear pain and cartilage degradation due osteoarthritis progression in the medial side)
- Use of the orthosis at least one month
- Low-dose biplane X-ray imaging techniques in 5 postures without and 5 postures with the use of the Evoke orthosis.
- During X-ray ground reactions forces under the instrumented knee using AMTI force platform under the EOS Cabine
- Noraxon wifi 3D inertial sensors (trunk, thigh and shank) to measure and control the trunk and the knee flexion during the acquisition of x-ray images.

Development of new technique of multi-view segmentation using Idefix (EOS) software. Fastidious work and the reconstruction error is below 1 mm.



Typical Reconstruction of 3D lower limb from two 45 deg views using evoke orthosis



Biomechanical parameter estimation

- 3D Distance between femur and tibia in medial and lateral compartment
- 3D Position of contact points in the medial and lateral compartment
- Knee joint angular displacement measurement using the recommended standard of the International Society of Biomechanics
- Ground reaction forces under the braced knee from the standing posture P0 and the final squated posture P4
- External measurement of knee flexion as well as trunk flexion to validate the control of posture during the data acquisition in EOS x-ray cabine imaging

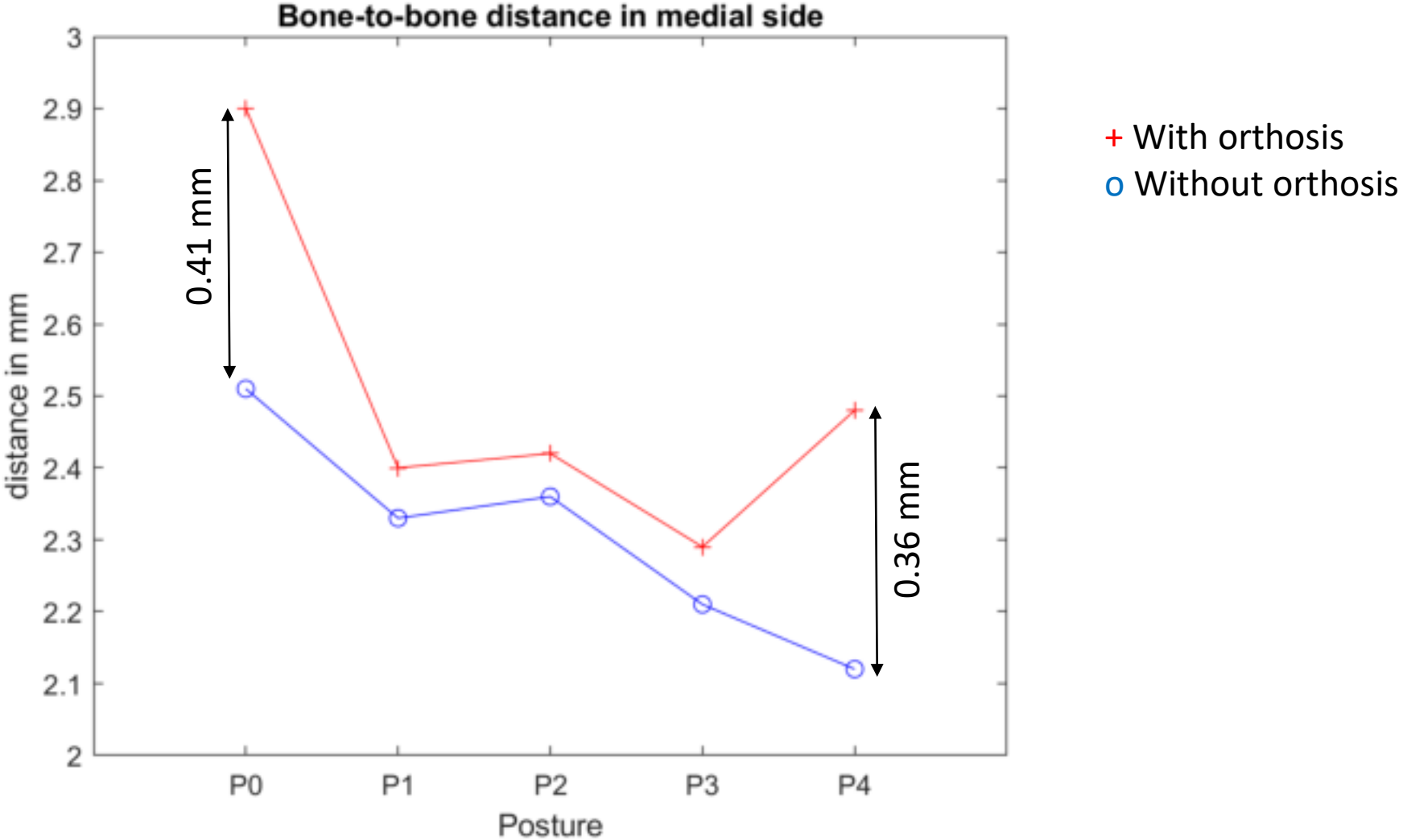
Clinical parameter

- KOOS questionnaire has been administered during the pre and post.

Results:

Bone-to-bone distance between femur and tibia in medial compartment (Average of N=15 patients)

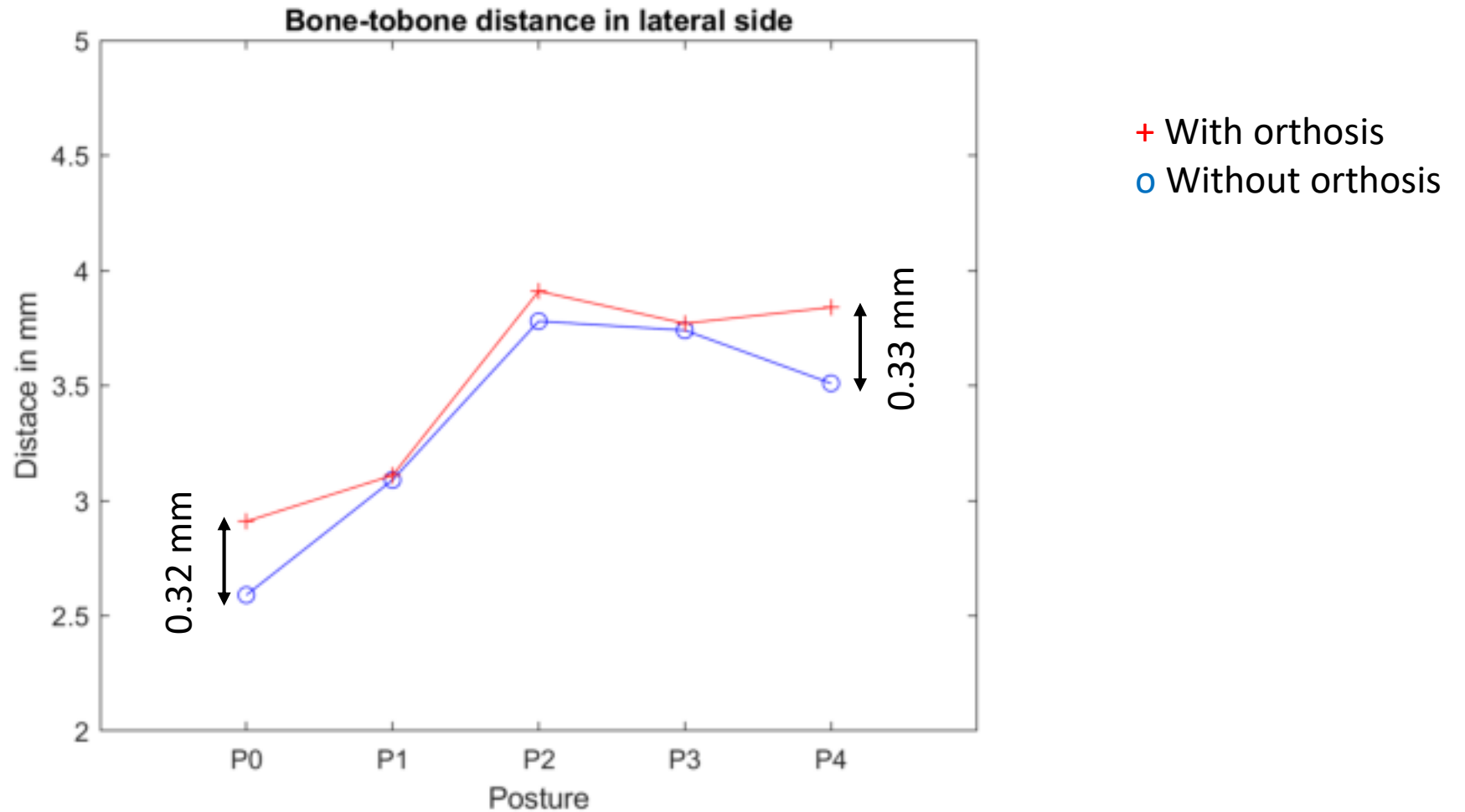
Beneficial effect of the Evoke orthosis since the increase of 0.41 mm



Results:

Bone-to-bone distance between femur and tibia in lateral compartment (Average of N=15 patients)

Beneficial effect of the Evoke orthosis since the increase of 0.33 mm



Comparison with the study of Dennis et al. (2006)

Evaluation of Off-Loading Braces • Dennis et al 3

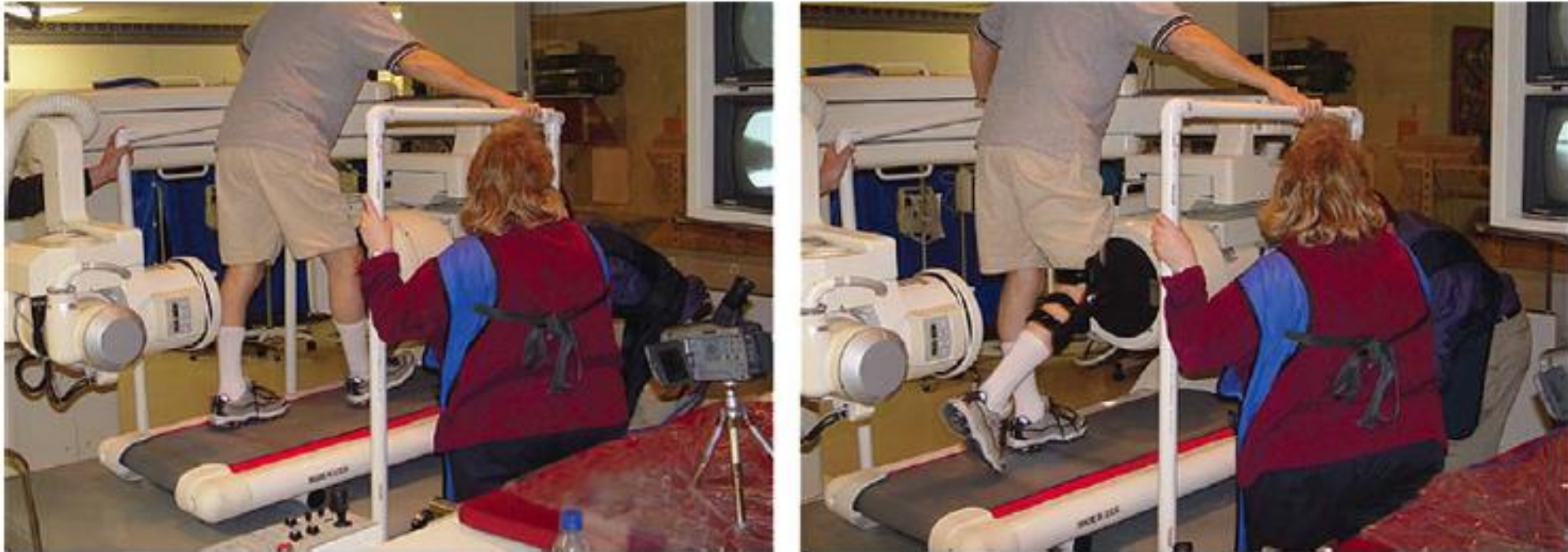


Fig. 1. Subject performing normal gait on a level treadmill with (right) and without (left) an off-loading knee brace.

Dennis D.A., Komistek R.D., Nadaud M.C., Mahfouz M. Evaluation of Off-Loading Braces for treatment of unicompartmental knee arthrosis. *J. Arthroplasty* vol.21, No.4, 2-8,2006.

Study of Dennis et al. (2006). Measurement of joint space narrowing using fluoroscopic imaging (low accuracy)

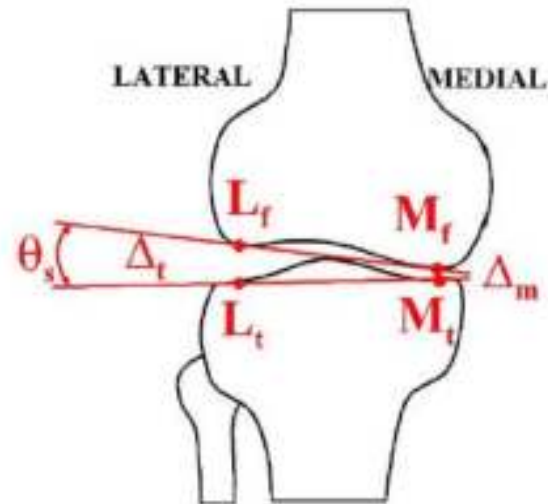


Fig. 2. Diagram demonstrating the digitized points on the femoral and tibial condyles that were used in determination of the magnitude and angle of medial condylar separation.



Fig. 3. Fluoroscopic images of a randomly selected subject at heel strike without (A) and with (B) an applied off-loading knee brace, demonstrating medial condylar separation after brace application.

Dennis et al. (2006).

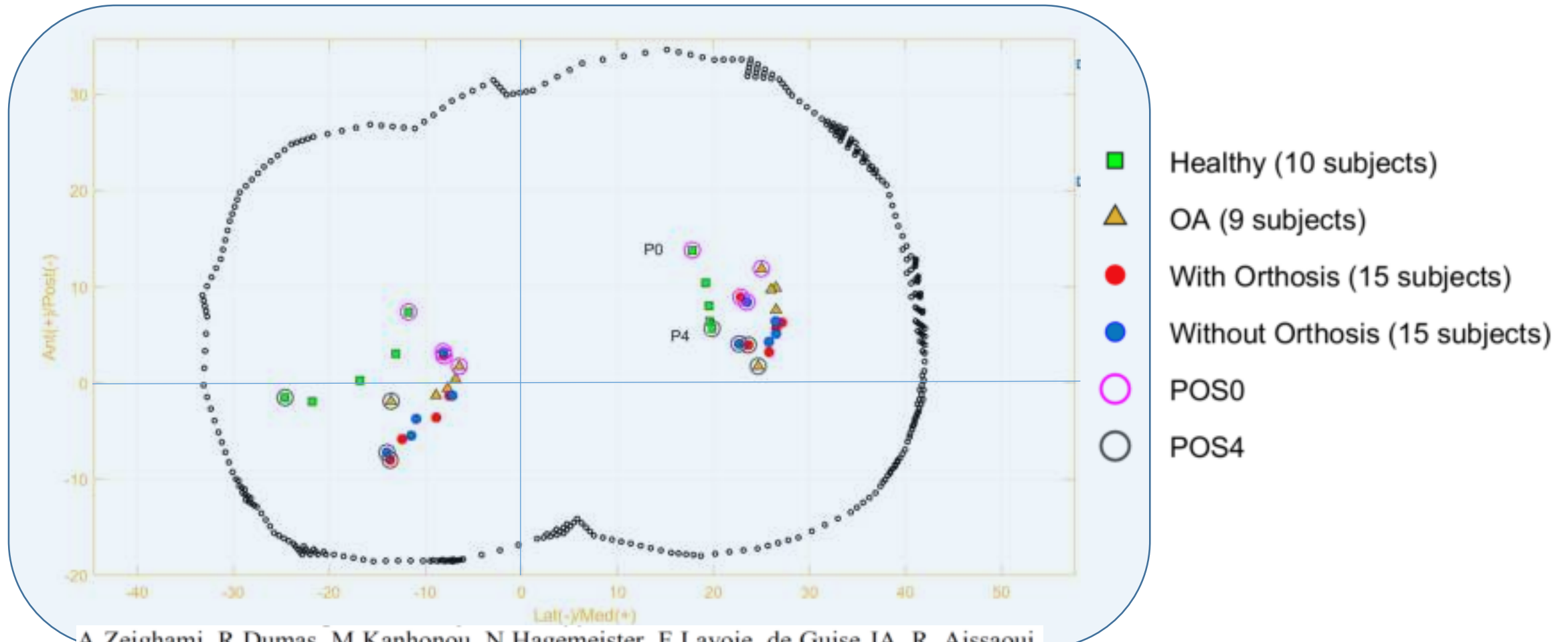
Comparison of 6 orthosis (N=45), however only 78% of the population demonstrate an increase in joint space narrowing

Table 2. Average, Range, and SD Values of Medial Condylar Separation (in millimeters) for All Subjects at 3 Different Locations of the Stance Phase of Gait

Brace type	Heel strike	Midstance	Toe-off
Bledsoe	1.3 (0-2.3), SD = 1.1	0.6 (0-1.6), SD = 0.8	1.3 (0-1.7), SD = 1.0
DJ Ortho	1.2 (0-2.4), SD = 1.3	0.3 (0-1.0), SD = 0.5	0.4 (0-0.8), SD = 0.8
Breg	0.7 (0-2.7), SD = 1.2	0.1 (0-1.3), SD = 0.7	0.2 (0-0.7), SD = 0.4
Isports	0.7 (0-2.1), SD = 1.0	0.0 (0-0.8), SD = 0.5	0.0 (0-0.2), SD = 0.2
Gen II	0.7 (0-3.4), SD = 1.6	0.2 (0-1.3), SD = 0.8	0.1 (0-0.9), SD = 0.5
ACL	0.2 (0-0.4), SD = 0.3	0.0 (0-0.3), SD = 0.2	0.0 (0-0.3), SD = 0.3

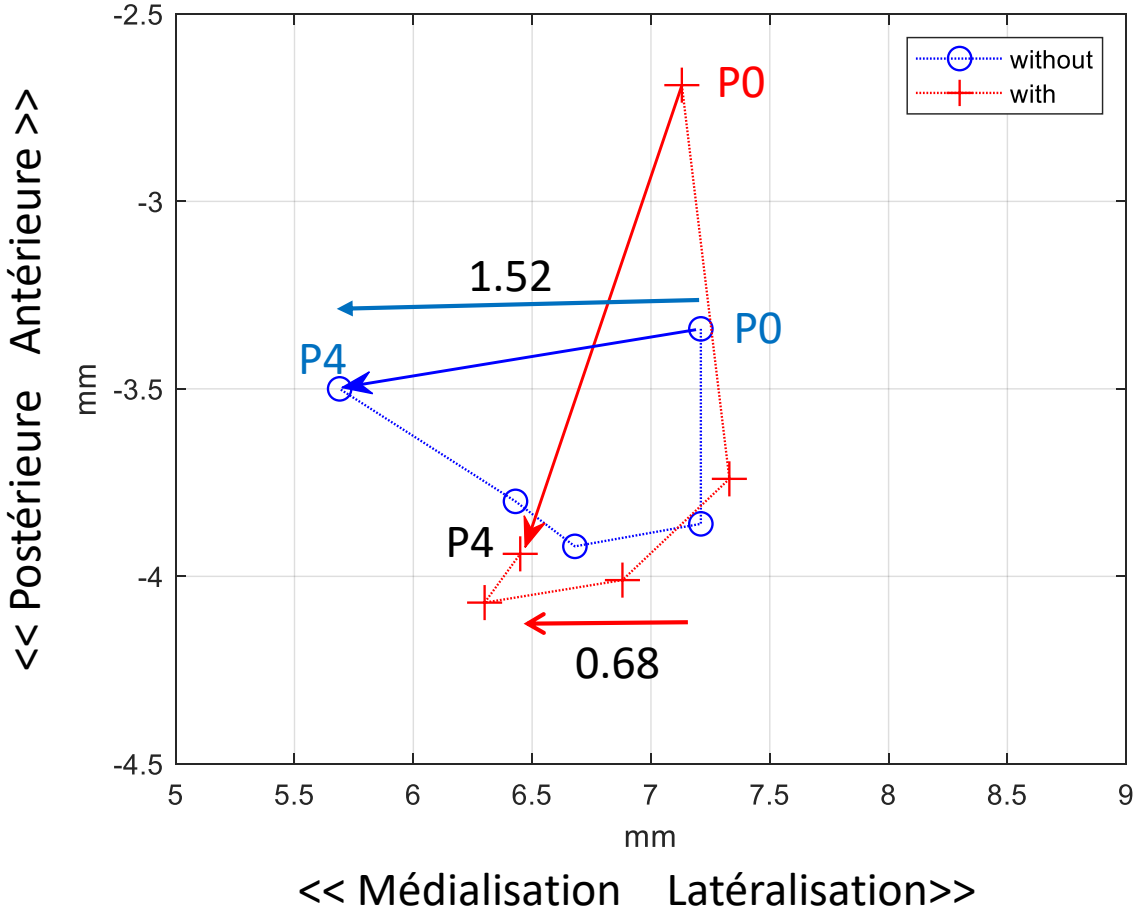
EVOKE orthosis : .41mm

Results : Projection of the contact point on transverse plane of tibia from P0 to P4 superimposed with the data base from our laboratory



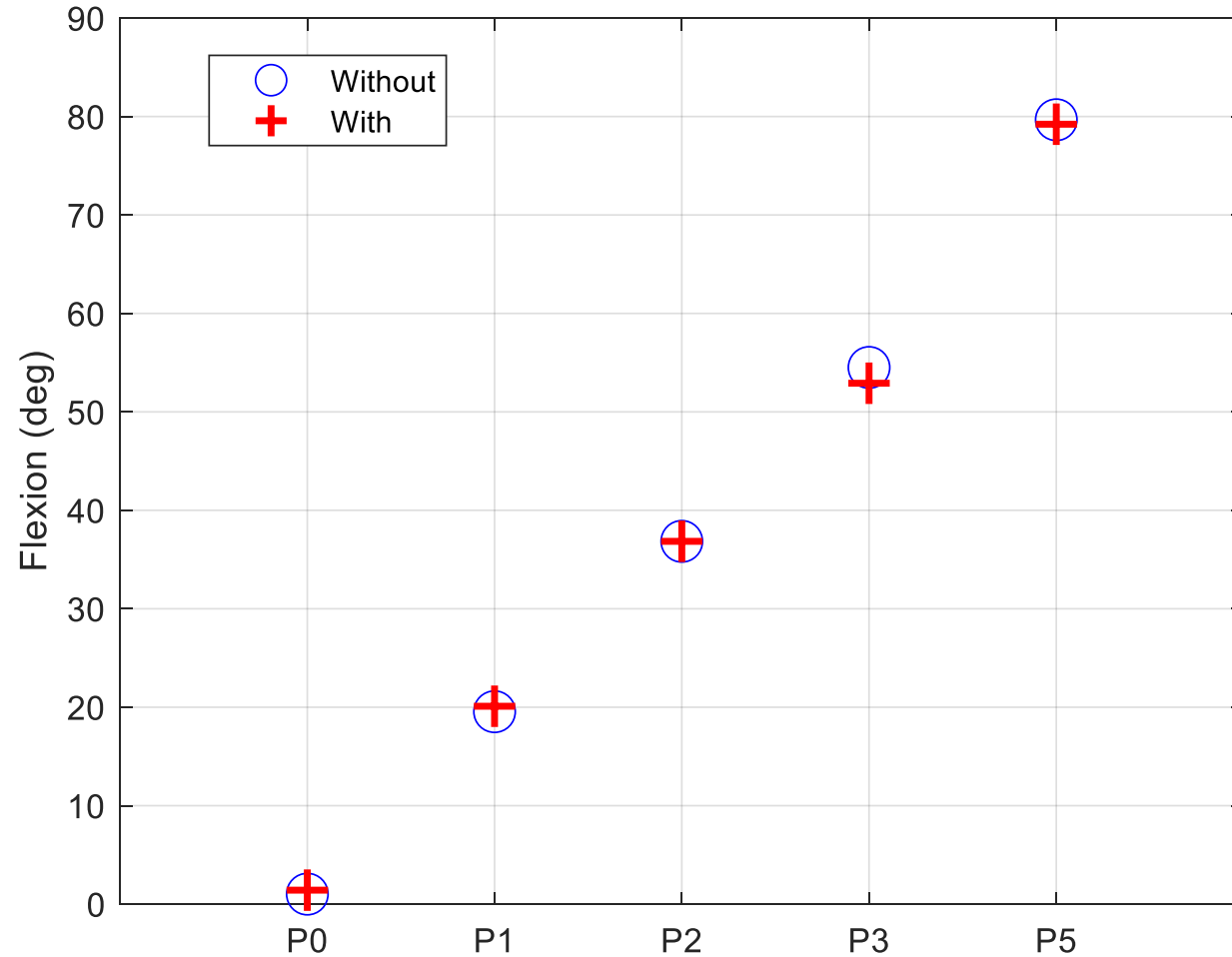
A Zeighami, R Dumas, M Kanhonou, N Hagemester, F Lavoie, de Guise JA, R. Aissaoui. Tibio-femoral joint contact in healthy and osteoarthritic knees during quasi-static squat: A bi-planar X-ray analysis. Journal of biomechanics 2017; 53, 178-184.

Projection of the position of distal origin of the femur on the the tibia transverse plane. The displacement of the origin is bigger in medial direction than when using orthosis

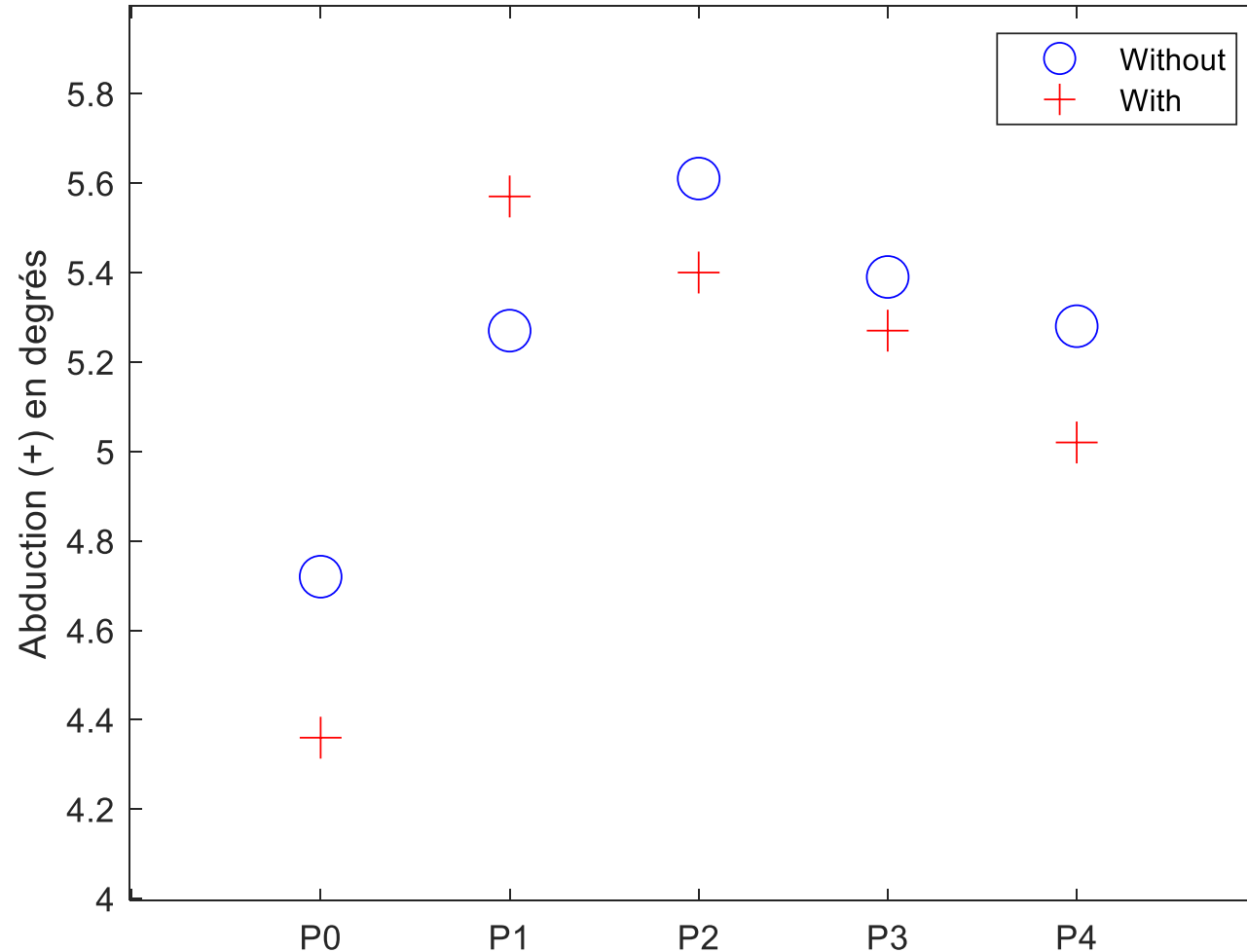


Beneficial effect:
 Restriction of medialisation
 Lateralisation of P0-P1 with Evoke
 Half of the medialisation of p4 with Evoke

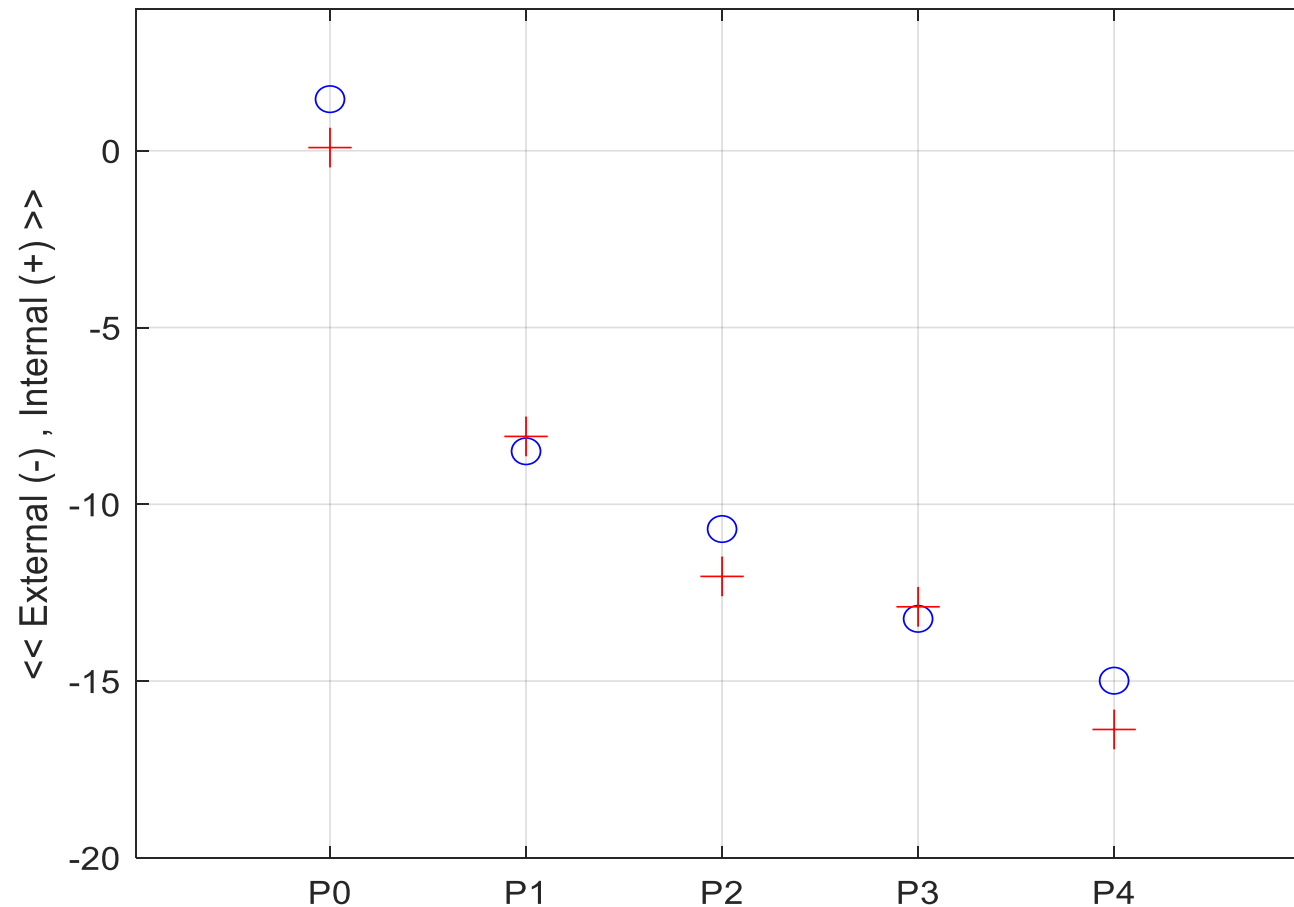
knee flexion angle was not altered during squat flexion
from P0 to P4



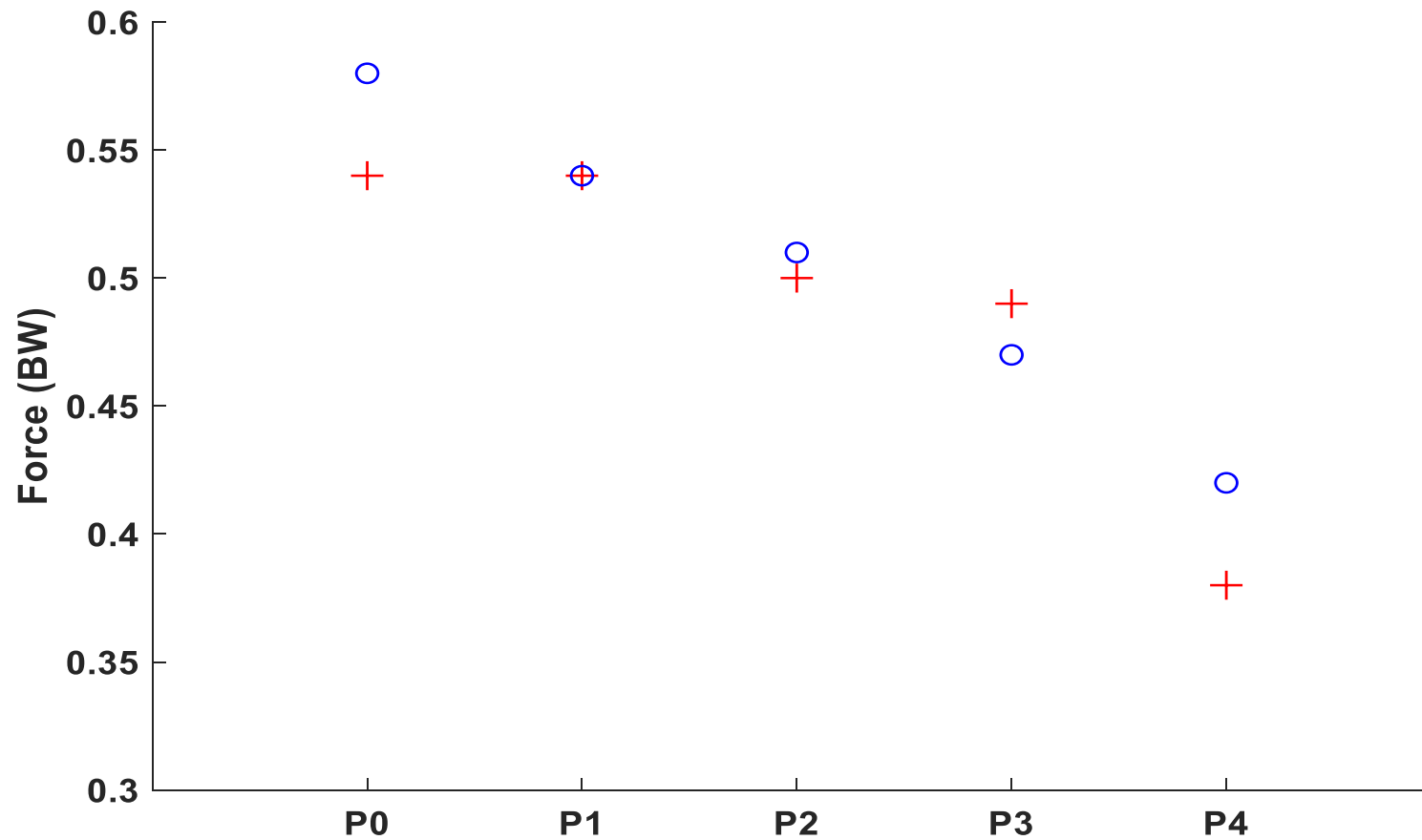
Reduction of the abduction angle of the tibia with the use of orthosis



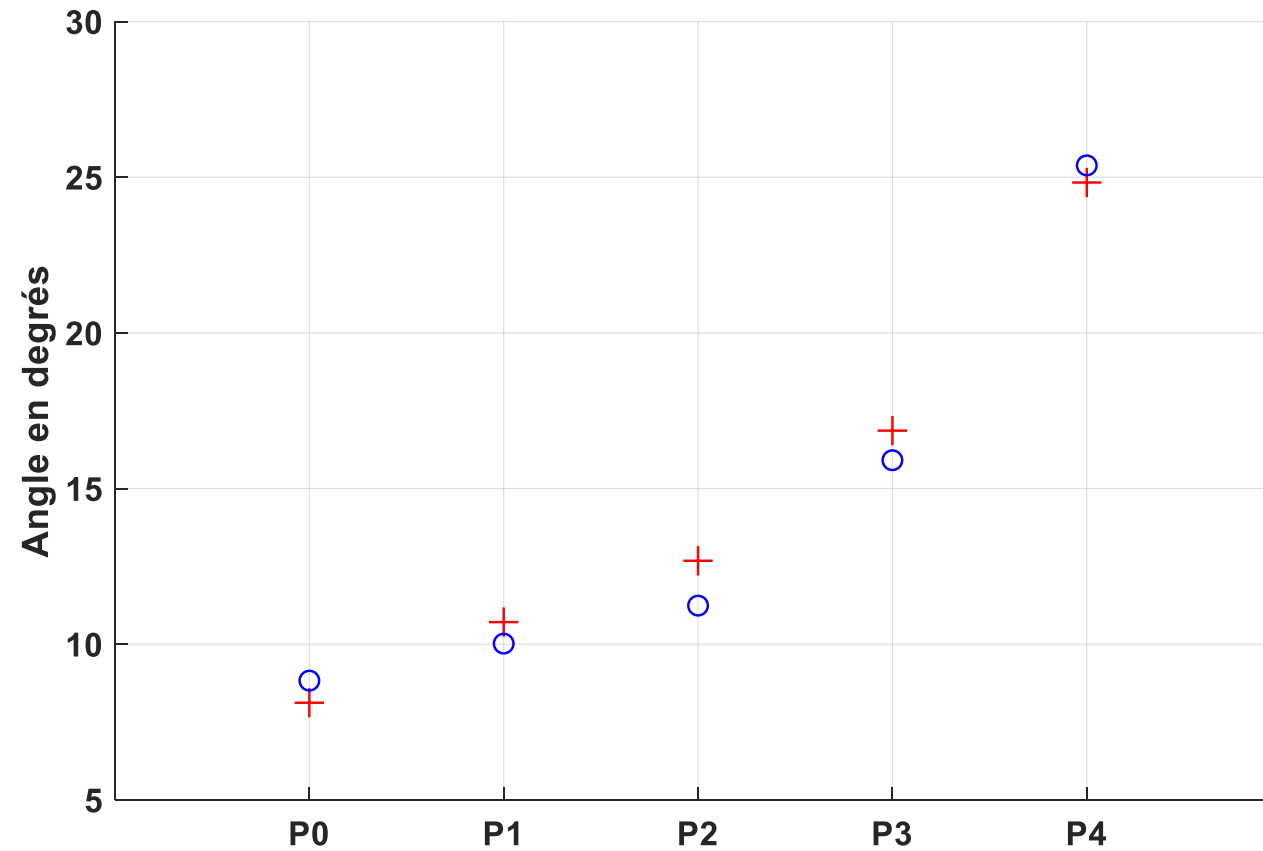
Small reduction of Ext-Int rotation of du tibia with respect to fémur with the use of orthosis (red)



Reduction of ground reaction forces by 4 body-weight (unloading). (Red: Orthosis; Blue :without)



Control of trunk flexion posture during the X-ray acquisition by using the IMU noraxon in real-time



Control of knee flexion posture during the X-ray acquisition by using the IMU noraxon in real-time

