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# Genu Arthro





# **Clinical Study Summaries**

This document summarizes clinical studies conducted with the Genu Arthro. The included studies were identified by a literature search made on PubMed and within the journals Orthopädie-Technik, Medizinisch Orthopädische Technik, Neurologie & Rehabilitation and Journal of Pediatric Orthopaedics.

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# 1 Overview table

The summaries are organized in three levels depending on the detail of information. The overview table (Level 1) lists all the relevant publications dealing with a particular product (topic) as well as researched categories (e.g. gait analysis, clinical effects, satisfaction, etc). By clicking on underlined categories, a summary of all the literature dealing with that category will open (Level 2).

For those interested to learn more about individual studies, a summary of the study can be obtained by clicking on the relevant reference (Level 3).

D.		Category						
Referer	ıce	Functions and Activities		Participation				
Author	Year	<u>Biomechanics –</u> Static measures	<u>Biomechanics –</u> <u>Gait analysis</u>	X-Ray	EMG	Functional tests	Clinical effects	Satisfaction
<u>Engel</u>	2015	x						
<u>Fantini-Pagani</u>	2013		x					
<u>Fantini-Pagani</u>	2012				x			x
<u>Kutzner</u>	2011	x	x			x		
<u>Schmalz</u>	2010		x				x	x
<u>Fantini-Pagani</u>	2010		x			x	x	
<u>Fantini-Pagani</u>	2010		x					
Total number: 7		2	5	0	1	2	2	2

# 2 Summaries of categories

On the following pages you find summaries of categories researched in several studies (e.g. gait analysis, clinical effects, satisfaction, etc.). At the end of each summary you will find a list of reference studies contributing to the content of the particular summary.

## **Biomechanics – Static measures**

**Major Findings** 

#### With Genu Arthro:

- → Higher knee flexion leads to an increase of the medial compartment loading (varus and valgus alignment)
- → Counteracting abduction moments have a higher positive influence on the force in the medial knee joint compartment than adduction moments for the lateral compartment.
- → The same level of counteracting moment in valgus alignment results in a much higher shift of the COP (center of pressure) than in varus alignment.



The applied counteracting abduction moments led to higher redistributions than the applied adduction moments. (Engel, 2015)

Clinical Relevance	Osteoarthritis (OA) is the most common type of articular joint disease and will be- come a larger public health problem as a function of the aging demographic (Ehr- lich, 2003). It has been experimentally demonstrated that the use of special knee orthoses can modify the resulting net moment of the knee joint during walking and running. Reduction of the knee adduction moment and decreased medial compart- ment forces were observed after the application of external abduction moments. (Fantini-Pagani, 2010).
Summary	With increasing knee flexion angles the forces in the medial compartment loading increase in knee joints with all mediolateral alignments (varus, neutral, valgus) (Engel, 2015).
	The knee joints with varus and neutral alignment show higher loading in the medial compartment, whereas more load is transferred through the lateral compartment in knee joints with valgus alignment. These results indicate that the motion of the bones affects the relationship between the levers and the orthosis (Engel, 2015).

	The applied counteracting abduction moments lead to higher redistributions than the applied adduction moments. Furthermore, the largest COP shift effect of 4.3 mm to the medial side is found in the joint in valgus alignment when 5 Nm ad- duction moment are applied. In comparison, the highest COP shift to the lateral side is 1.8 mm (Engel, 2015).
	The spring constant of the Genu Arthro and MOS Genu (Bauerfeind) was in focus in another study (Kutzner, 2011). For MOS Genu the spring constant was 145% higher than of Genu Arthro. Due to the author herself calls this study a case report with a limited number of 3 subjects; the results do not allow general conclusions.
References of summarized studies	Engel, K., Brüggemann, GP., Heinrich, K., Potthast, W., & Liebau, C. (2015.) Do counteracting external frontal plane moments alter the intraarticular contact force distribution in the loaded human tibiofemoral joint? <i>The Knee</i> 22: 68–72.
	Kutzner, I., Kuther, S., Heinlein, B., Dymke, J., Bender, A., Halder, A. M., & Berg- mann, G. (2011). The effect of valgus braces on medial compartment load of the knee joint– in vivo load measurements in three subjects. <i>Journal of Biomechanics</i> ; 44: 1354–1360.
Other References	Ehrlich, G. E. (2003). The rise of osteoarthritis. Bull World Health Org; 81:630.
	Fantini-Pagani, C. H., Potthast, W., & Brüggemann, GP. (2010). The effect of valgus bracing on the knee adduction moment during gait and running in male subjects with varus alignment. <i>Clin Biomech</i> 2010; 25:70–6.

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## Biomechanics – Gait analysis

Major Findings	With Genu Arthro:
	→ Faster walking speed by 7.1% (Schmalz et al., 2010)
	→ Cadence (steps/min) increased by 2.8% (Schmalz et al., 2010)
	→ Genu Arthro raises the first vertical force maximum while walking by 4.8% (Schmalz et al., 2010)
	<ul> <li>→ Knee lever arm with Genu Arthro at 20-30% and 70-80% of the stance phase was</li> <li>9-12% shorter than without orthosis (20-30% of the stance phase)</li> <li>19-21% shorter than without orthosis (70-80% of the stance phase)</li> </ul>
	The effect was twice to three times bigger than with the lateral wedge insoles.
	→ If a valgus moment is applied to the knee: External knee adduction moments are reduced up to 21% in walking (compared to wearing no orthosis) and up to 15% (compared to wearing insoles) (Fantini- Pagani et al., 2012)
	Net knee adduction moments are reduced up to 36.3% in walking and up to 23% in running (Fantini-Pagani et al., 2010a)
	→ Greater valgus adjustments of the orthosis produce greater valgus mo- ments (Fantini-Pagani et al., 2010a)
	Reduction of the net peak adduction moments
	250
	230



Fantini-Pagani, 2010a.

**Clinical Relevance** 

Osteoarthritis (OA) is characterized by irreversible damage to joint structures; including cartilage, bone, and joint capsule (Felson et al., 2004). Nonpharmacological therapies or mechanical interventions, such as use of knee orthoses and laterally wedged insoles, act on the underlying disease mechanisms to decrease or redistribute the mechanical load in the musculoskeletal system (Pollo et al., 2002).

Knee braces (such as Genu Arthro) are designed to reduce the loading of an affected knee compartment by application of a valgus moment directly to the knee through a three point bending system (Pollo et al., 1998).

Summary	Compared to walking without orthosis, the walking speed as well as the cadence increased significantly by 7.1% or 2.8% (Schmalz et al., 2010), respectively. Fantini-Pagani et al. (2010a) reported a significant difference in gait velocity only between the neutral and no orthosis condition.				
	With respect to the forces occurring during gait, Schmalz et al. (2010) documented an increase in the first vertical force maximum by 4.8%. As opposed to this, Kutzner et al. (2011) recorded a slight, but not significant decrease (up to 3%) in the vertical force with Genu Arthro (8° valgus). Furthermore, a reduction of the medial force by 7% was measured in this condition.				
	The knee lever arm with Genu Arthro at 20-30% and 70-80% of the gait cycle was 9-12% and 19-21% shorter than without orthosis. Compared to lateral wedge insoles, the effect was two to three times bigger (Fantini-Pagani et al., 2012).				
	With a valgus moment applied to the knee, the external knee adduction moments are reduced by up to 21% in walking (compared to wearing no orthosis) and by up to 15% (compared to wearing insoles) (Fantini-Pagani et al., 2012). Two other studies of Fantini-Pagani et al. support these results for walking, with increases by up to 18.6% (2010a) and 16.7% (2010b), respectively.				
	Also, the net knee adduction moments are reduced by up to 36.6% in walking and by up to 23% in running (Fantini-Pagani et al., 2010a). These results are again supported by the two other studies of Fantini-Pagani et al. (2010b & 2012).				
	All results of Fantini-Pagani et al. (2010a, 2010b, 2012) showed that greater valgus adjustments of the orthosis produce greater valgus moments.				
References of summarized studies	Fantini-Pagani, C. H., Potthast, W., & Brüggemann, GP. (2010a). The effect of valgus bracing on the knee adduction moment during gait and running in male subjects with varus alignment. <i>Clinical Biomechanics</i> ; 25:70-76.				
	Fantini-Pagani, C. H., Böhle, C., Potthast, W., & Brüggemann, GP. (2010b). Short-Term Effects of a Dedicated Knee Orthosis on Knee Adduction Moment, Pain, and Function in Patients with Osteoarthritis. <i>Arch Phys Med Rehabil</i> ; 91:1936-41.				
	Fantini-Pagani, C. H., Hinrichs, M., & Brüggemann, GP. (2012). Kinetic and Kin- ematic Changes with the Use of Valgus Knee Brace and Lateral Wedge Insoles in Patients with Medial Knee Osteoarthritis. <i>Journal of Orthopaedic Research</i> ; 30:1125-1132.				
	Kutzner, I., Kuther, S., Heinlein, B., Dymke, J., Bender, A., Halder, A. M., & Berg- mann, G. (2011). The effect of valgus braces on medial compartment load of the knee joint– in vivo load measurements in three subjects. <i>Journal of Biomechanics</i> ; 44: 1354–1360.				
	Schmalz, T., Knopf, E., Drewitz, H., & Blumentritt, S. (2010). Analysis of biome- chanical effectiveness of valgus-inducing knee brace for osteoarthritis of knee. JRRD; 47 (5): 419-29.				
Other References	Felson, D. T. (2004). Risk factors for osteoarthritis. Clin Orthp Relat Res 427S:16–21.				
	Pollo, F. E. (1998). Bracing and heel wedging for unicompartimental osteoarthritis of the knee. Am J Knee Surg 11: 47–50.				
	Pollo, F. E., Otis, J. C., Backus, S. I., Warren, R. F., & Wickiewicz, T. L. (2002). Reduction of medial compartment loads with valgus bracing of the osteoarthritic knee. <i>The American Journal of Sports Medicine</i> , <i>30</i> (3), 414-421.				

Major Findings	With Genu Arthro:					
	→ Muscle activity of rectus femoris (RF), lateral gastrocnemius (GL) and lateral hamstring (LH) decreased					
	Pre-activation phase:	RF with neutral adjustment:	13.6% decrease			
	Loading phase:	GL with 4° valgus adjustment:	23.8% decrease			
	Early stance phase:	GL with neutral adjustment:	16.0% decrease			
		GL with 4° valgus adjustment:	17.7% decrease			
	Late stance phase:	RF with neutral adjustment:	18.5% decrease			
		RF with 4° valgus adjustment:	16.3% decrease			
		LH with neutral adjustment:	35.8% decrease			
		LH with 4° valgus adjustment:	31.3% decrease			
	→ Co-contraction ratio	os of the medial/lateral (M/L), flo	exor/extensor (F/E)			
	muscle groups decr	eased				
	Loading phase:	F/E with 4° valgus adjustment:	15.1% decrease			
	Late stance:	M/L with 4° valgus adjustment:	12.3% decrease			
		F/E with 4° valgus adjustment:	21.5% decrease			
	Loading phase:	VM/MH with 4° valgus adjustment VL/GL with 4° valgus adjustment	19.0% decrease it: 10.4% decrease : 28.4% decrease			
	Rectus femoris musc	le activity				
	70					
	ā 60		RF witho			
	nete					
	ar 50		■ RF with			
	<u>ë</u> 40		adjustm			
			RF with			
	Ĕ 20		adjustm			
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	× 10 ·····					
		andian Fashertenan Midlatenan				
	Fie-activation L	Loading Early stance Mid-stance	Late stance			
linical Relevance	Knee osteoarthritis (OA)	is a degenerative disease charact	erised by irreversible join			
		iage ioss and changes in bone a	mu joint capsule (reiso			
	2004). To counteract	joint instability, increase in the	muscle activity and C			

2004). To counteract joint instability, increase in the muscle activity and cocontraction of agonist and antagonist muscles have been observed in OA patients and associated to a strategy used to stabilise the joint (Heiden et al., 2009; Childs et al., 2004; Lewek et al., 2005; Hortobágyi et al., 2005). Therefore, knee braces may possibly reduce knee loading by decreasing muscle activation and cocontraction levels.

#### Summary

	Muscle activity and co-contraction ratios were measured for 4 phases of the gait (Pre-activation, loading, early stance and late stance phase). The difference of the 2 orthosis adjustments (4° valgus and neutral) are compared to the condition without orthosis.
	A significant muscle activity decrease was reported for rectus femoris (up to 18.5%), gastrocnemius lateralis (up to 23.8%) and lateral hamstring (up to 35.8%) at minimum in one of the four walking phases.
	Regarding the Co-contractions ratios of the loading and late stance phase, signifi- cant decreases of 15.1% and 21.5% for the flexor/extensor muscle groups were reported with the valgus adjustment. Additionally, a reduction of the medial/lateral muscle group activation by 12.3% (4° valgus) was observed during late stance phase.
	For the pre-activation phase, decreases of the co-contractions ratios up to 19.6% were reported for 2 muscle pairs. During loading phase, reductions for the lateral vastus /lateral gastrocnemius were observed (28.4% with 4° valgus).
	Significant decreases in muscle activity and co-contraction ratios were observed with the use of the knee brace in both adjustments, due to a mechanical stabilization of the knee by the brace. (Fantini-Pagani, 2013)
References of summarized studies	Fantini-Pagani, C. H., Willwacher, S., Kleis, B., & Brüggemann, GP. (2013). In- fluence of a valgus knee brace on muscle activation and co-contraction in patients with medial knee osteoarthritis. <i>Journal of Electromyography &amp; Kinesiology</i> , 23(2):490-500.
Other References	Childs, J. D., Sparto, P. J., Fitzgerald, G. K., Bizzini, M., & Irrgang, J. J. (2004). Alterations in lower extremity movement and muscle activation patterns in individuals with knee osteoarthritis. <i>Clinical Biomechanics</i> , <i>19</i> (1), 44-49.
	Felson, D.T. (2004). Risk factors for osteoarthritis: understanding joint vulnerability. Clin Orthop Relat Res: S16–21.
	Heiden, T. L., Lloyd, D. G., & Ackland T.R. (2009). Knee joint kinematics, kinetics and muscle co-contraction in knee osteoarthritis patient gait. <i>Clinical Biomechanics</i> ; 24:833–41.
	Hortobágyi, T., Westerkamp, L., Beam, S., Moody, J., Garry, J., Holbert, D., & DeVita, P. (2005). Altered hamstring-quadriceps muscle balance in patients with knee osteoarthritis. <i>Clinical Biomechanics</i> , <i>20</i> (1), 97-104.
	Lewek, M. D., Ramsey, D. K., Snyder-Mackler, L., & Rudolph, K. S. (2005). Knee stabilization in patients with medial compartment knee osteoarthritis. <i>Arthritis &amp; Rheumatism</i> , <i>52</i> (9), 2845-2853.

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### Functional tests

Major Findings	<ul> <li>With Genu Arthro (Fantini-Pagani et al., 2010)</li> <li>→ Stair climbing is faster 19.5% faster (4° valgus), 18.7% faster (neutral)</li> <li>→ No significant changes during 6 minute walk test.</li> <li>With Genu Arthro (GA) compared to MOS Genu (MOS) and wearing no orthosis: (Kutzner et al., 2011)</li> <li>&gt; Stair accent:</li> </ul>						
					GA (0°. 8° valgus):	Fmed:	2-9% lower
					MOS (0°, 8° valgus):	Fmed:	-2% higher - 26% lower
		→ Stair descent:					
		GA (0°, 8° valgus):	Fmed:	5-7% lower			
		Fz:	3-7% lower				
	MOS (0°, 8° valgus):	Fmed:	2-24% lower				
		⊢z	6-16% lower				





Kutzner et al., 2011.

#### **Clinical Relevance**

Osteoarthritis (OA) is the most common joint disease, associated with pain and loss of mobility. Besides surgical treatments, several conservative methods, such as lateral shoe wedges and valgus bracing (such as Genu Arthro) are common to reduce the axial tibial force and/or to shift it laterally. Reduced loading of the affected compartment is related to pain reduction and improved function and may thus delay the need for joint replacement. (Kutzner et al., 2011)

Stair-climbing and walk tests are tasks widely used to evaluate functional capacities and quality of life. (Harada et al., 1999; Kirkley et al., 1999)

Summary	Compared to wearing no orthosis, stair climbing is 19.5% (4° valgus) and 18.7% faster (neutral) with Genu Arthro. (Fantini-Pagani et al., 2010)
	Kutzner et al. (2011) analysed the medial and vertical force (Fmed and Fz) during stair ascent as well as descent with 2 orthoses. 7 of 8 results for Fmed showed decreases while ascending stairs. Genu Arthro improved by 2-9%. The highest reduction was reported for MOS Genu (8° valgus). In descending stairs, decreases were reported for Fmed and Fz. GA showed slight reductions in Fmed (5-7%) and Fz (3-7%). Greater improvements were achieved by MOS with increases between 2-24% (Fmed) and 6-16% (Fz). Discomfort was reported when walking with the MOS brace in 8° valgus. Since the chosen valgus settings of 8° with the MOS brace would probably not have been tolerated for a long duration by the subjects, medial load reductions of more than 25% cannot be expected permanently.
	During a 6 minute walk test, no significant changes were reported (Fantini-Pagani et al., 2010).
References of summarized studies	Fantini-Pagani, C. H., Böhle, C., Potthast, W., & Brüggemann, GP. (2010). Short- Term Effects of a Dedicated Knee Orthosis on Knee Adduction Moment, Pain, and Function in Patients with Osteoarthritis. <i>Arch Phys Med Rehabil</i> ; 91:1936-41.
	Kutzner, I., Kuther, S., Heinlein, B., Dymke, J., Bender, A., Halder, A. M., & Berg- mann, G. (2011). The effect of valgus braces on medial compartment load of the knee joint– in vivo load measurements in three subjects. <i>Journal of Biomechanics</i> ; 44: 1354–1360.
Other References	Harada, N. D., Chiu, V., & Stewart, A. L. (1999). Mobility-related function in older adults: assessment with a six-minute walk test. <i>Arch Phys Med Rehabil</i> : 80:837-41.
	Kirkley, A., Webster-Bogaert, S., Litchfield, R., Amendola, A., MacDonald, S., McCalden, R., & Fowler, P. (1999). The Effect of Bracing on Varus Gonarthrosis. <i>The Journal of Bone &amp; Joint Surgery</i> , <i>81</i> (4), 539-48.

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## **Clinical Effects & Satisfaction**

Major Findings

#### With Genu Arthro:

→ Pain while walking is significantly reduced by 51.6%

(Schmalz, 2010)

→ Pain and stiffness are significantly reduced, physical function improved WOMAC total score improved by ca. 44% under both adjustments

(Fantini-Pagani et al., 2010)



#### Pain, stiffness and physical function improved significantly

Fantini-Pagani et al., 2010.

# **Clinical Relevance** Osteoarthritis is a degenerative disorder characterized by cartilage breakdown causing pain, deformity, and dysfunction of the affected joint (Glass et al., 2006). To avoid disease progression and its symptoms, mechanical interventions (like Genu Arthro) are used to redistribute the mechanical loading to the musculoskeletal system (Fantini-Pagani et al., 2010). This should lead to pain reduction and functional improvement as well as satisfaction of the user.

#### **Summary**

After walking on even ground and stairs with Genu Arthro (neutral and 4° valgus), a WOMAC-questionnaire was filled in. Compared to wearing no orthosis, both Genu Arthro alignments produced similar effects on pain reduction and an improvement in function. Pain (50%) and stiffness (33.3% - 44.4%) was reduced. Additionally, physical function is significantly improved by 44.8%.

Schmalz et al. (2010) performed gait analysis with 16 users with Genu Arthro. Two questionnaires were completed about pain and general satisfaction. Pain is significantly reduced by 51.6% by Genu Arthro use. Furthermore, the mean scores for fit of the brace, appearance and ease of use were between 4.3 ("good") and 4.9 ("very good").

References of summarized studies	Fantini-Pagani, C. H., Böhle, C., Potthast, W., & Brüggemann, GP. (2010). Short- Term Effects of a Dedicated Knee Orthosis on Knee Adduction Moment, Pain, and Function in Patients with Osteoarthritis. <i>Arch Phys Med Rehabil</i> ; 91:1936-41.
	Fantini-Pagani, C. H., Willwacher, S., Kleis, B., & Brüggemann, GP. (2013). In- fluence of a valgus knee brace on muscle activation and co-contraction in patients with medial knee osteoarthritis. <i>Journal of Electromyography &amp; Kinesiology</i> , 23(2):490-500.
	Schmalz, T., Knopf, E., Drewitz, H., & Blumentritt, S. (2010). Analysis of biome- chanical effectiveness of valgus-inducing knee brace for osteoarthritis of knee. JRRD; 47 (5): 419-29.

**Other References** 

Glass, G. G. (2006). Osteoarthritis. Dis Mon;52:343-62.

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# 3 Summaries of individual studies

On the following pages you find summaries of studies that researched Genu Arthro. You find detailed information about the study design, methods applied, results and major findings of the study. At the end of each summary you also can read the original study authors' conclusions.

Engel, K., Brüggemann, G.-P., Heinrich, K., Potthast, W., & Liebau, C.

Institute of Biomechanics and Orthopedics, German Sport University Cologne, Am Sportpark Müngersdorf 6, 50933 Cologne, Germany.

## Do counteracting external frontal plane moments alter the intraarticular contact force distribution in the loaded human tibiofemoral joint?

The Knee 2015; 22: 68-72

Products	Genu Arthro				
Major Findings	With Genu Arthro:				
	<ul> <li>→ A higher knee flexion, leads to an increase of the medial compartment loading (varus and valgus alignment)</li> <li>→ Counteracting abduction moments have a higher positive influence on the force in the medial knee joint compartment than adduction moments for the lateral compartment.</li> </ul>				
	→ The same level of counteracting moment in valgus alignment results in a much higher shift of the COP than in varus alignment.				
	Average of medio-lateral force ratio in dependence of the counteracting frontal plane moments				

The applied counteracting abduction moments led to higher redistributions than the applied adduction moments.

-2.5

0

Counteracting moments [Nm]

**Population** 

Ex vivo:

0

-5

Adduction

6 cadaver legs (4 female, 2 male) (59-101 yrs) SP1-3: varus joint SP4-5: neutral SP6: valgus joint

2.5

Abduction

5

#### **Study Design**

Interventional, comparative:



One cylinder on top of the simulator was used for the up and down movements of the sliding bar. The steel cylinder with the femur was attached to a ball joint fixed to this sliding bar. A predefined range of motion from 10° to 40° flexion of the knee joint was measured on the lateral side of the legs using a goniometer. A reference trial without any applied frontal plane moments was captured of all joints. With Genu Arthro counteracting abduction moments of 2.5 and 5 Nm were applied to the varus joints, adduction moments to the valgus joint, respectively. The neutral aligned joints were tested under all conditions. Each condition was repeated five times. The negative sign indicates applied abduction moments.

Results									
Functions and Activit	ies							Participat	tion
Biomechanics – Static measures	Biomechanics – Gait analysis		Ray EMG Functional tests Clinical effects Satisfa						
Category	Outcomes	F	Results	for Genu	Arthro				Sig.*
Biomechanics – Static measure	Knee flexion angle	increasin ment incr	increasing knee flexion angles, the forces in the medial compart- ment increase, even for the knee joint aligned in varus						
		I	Aedio-la	teral for	ce ratio (	>1 <del>→</del> med	. knee joi	nt comp.)	
		Flexion	SP1	SP2	SP3	SP4	SP5	SP6	
		10°	1.8	5.1	1.5	0.8	1.3	0.2	-
		20°	2.1	5.4	1.7	1.8	1.5	0.3	-
		30°	2.8	5.9	2.2	2.7	2.2	0.5	-
		40°	3.2	6.3	2.5	3.9	3.0	0.6	-
		The joint higher loa transferre aligned ir	s aligned ading in ed through valgus	d in varu the med gh the I (SP6).	us (SP1–3 ial compai ateral cor	3) and ne rtment, w npartmen	eutral (SP4 hereas mo t in the I	1-5) show re load is knee joint	
	Medio-lateral force-ratio	The appl redistribu	lied cou itions tha	nteracting In the app	g abducti plied addu	on mome	ents lead ments.	to higher	n.a.
	Shift of the COI (centre of pres- sure)	The large in the joir applied. I is 1.8 mm	est COP nt in valg By comp n.	shift effe us alignn arison, th	ct of 4.3 m nent when ne highest	a 5 Nm a COP shi	medial sid adduction r ft for the la	e is found noment is ateral side	n.a.

\* no difference (0), positive trend (+), negative trend (-), significant (++/--), not applicable (n.a.)

#### Author's Conclusion

"The current study demonstrated that direct intraarticular measurements could be used to study the relationship between knee joint compartment loading and mechanically induced external moments. The presented findings have clinical relevance and offer novel insights to guide development and optimization of mechanical aids for the treatment of the osteoarthritic knees. Future of load redistributing knee orthotics should consider adaptive approaches to apply frontal plane moments dependent on the movement phase since the intraarticular load is related to the knee joint flexion angle." (Engel et al. 2015)

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Fantini-Pagani, C. H., Willwacher, S., Kleis, B., & Brüggemann, G.-P.

Institute of Biomechanics and Orthopaedics, German Sport University Cologne, Germany.

## Influence of a valgus knee brace on muscle activation and co-contraction in patients with medial knee osteoarthritis

Journal of Electromyography & Kinesiology 2013; 23(2):490-500.

Products	Genu Arthro		
Major Findings	With Genu Arthro:		
	→ Muscle activity of re lateral hamstring (L	ectus femoris (RF), lateral gastroo H) decreased	cnemius (GL) and
	Pre-activation phase: Loading phase: Early stance phase: Late stance phase:	RF with neutral adjustment: GL with 4° valgus adjustment: GL with neutral adjustment: GL with 4° valgus adjustment: RF with neutral adjustment: RF with 4° valgus adjustment: LH with neutral adjustment: LH with 4° valgus adjustment:	13.6% decrease 23.8% decrease 16.0% decrease 17.7% decrease 18.5% decrease 16.3% decrease 35.8% decrease 31.3% decrease
	→ Co-contraction ratio muscle groups decr	os of the medial/lateral (M/L), fle eased	xor/extensor (F/E)
	Loading phase: Late stance:	F/E with 4° valgus adjustment: M/L with 4° valgus adjustment: F/E with 4° valgus adjustment:	15.1% decrease 12.3% decrease 21.5% decrease
	→ Co-contraction ration lateral vastus/lateral string (VM/MH) mu	os of the lateral vastus/lateral ga I hamstring (VL/LH) and medial scle pairs decreased	strocnemius (VL/GL), vastus/medial ham-
	Pre-activation phase:	VL/LH with neutral adjustment: VL/LH with 4° valgus adjustment: VM/MH with neutral adjustment: VM/MH with 4° valgus adjustment	16.8% decrease 5.9% decrease 19.6% decrease
	Loading phase:	VL/GL with 4° valgus adjustment:	28.4% decrease
	Rectus femoris musc	le activity	
	70 60 60 60 60 60 60 60 60 60 6		<ul> <li>RF withou orthosis</li> <li>RF with 4 valgus adjustmer</li> <li>RF with 4 valgus adjustmer</li> <li>RF with adjustmer</li> </ul>

#### **Population**

Subjects: Mean age: Mean body mass: Inclusion criteria: 12 patients (7 female, 5 male)  $56.0 \pm 4.6$  yrs  $80.9 \pm 13$  kg medial knee osteoarthritis from grade II to IV

#### **Study Design**

Observational, comparative:



The patients were not informed about the different adjustments of the orthosis.

Results								
Functions and Activ	ities						Participa	tion
	Biomechanics – Gait analysis	X-Ray		EMG	Functional tests	Clinical effects	Satisfac	tion
Category	Outcomes		Results	for Genu Arth	iro			Sig.*
EMG	Amplitude param Quadriceps grou	ieters – Ip	In the activity neutral	pre-activation of the rectus adjustment.	phase of the femoris decrea	gait cycle the sed by 13.6% v	muscle vith the	++
			In the la femoris 18.5% w	ate stance ph decreased b vith the neutra	ase the muscle y 16.3% with t l adjustment.	e activity of the the 4° valgus	rectus and by	++
			In all other phases of the gait cycle no significant changes found for the rectus femoris, vastus lateralis and vastus n is.				es were medial-	0
	Amplitude param Hamstrings grou	eters – p	<ul> <li>The muscle activity of the lateral hamstring was significantly lower with the 4° valgus (31.1%) and the neutral adjustment (35.8%) in the late stance phase.</li> </ul>					
			The mus the med	scle activity in t ial hamstring d	he other phases id not differ signi	of the gait cycle ficantly.	e and of	0
	Amplitude param Gastrocnemii gro	eters – oup	<ul> <li>S - The muscle activity of the lateral gastrocnemius was nificantly lower in the loading phase with the 4° valadjustment (23.8%). In the early stance phase the 4° gus (17.7%) and the neutral adjustment (16%) led to creased muscle activity of the lateral gastrocnemius.</li> </ul>				as sig- valgus 4° val- to de- s.	++
			The mus the med	scle activity in t ial gastrocnem	he other phases us did not differ	of the gait cycle significantly.	e and of	0

Functions and Activ	ities		Partici	pation
	Biomechanics – X-Ray Gait analysis	EMG Function	nal tests Clinical effects Satisfa	action
Category	Outcomes	Results for Genu Arthro		Sig.*
	Co-contraction ratios Medial/lateral	The co-contraction ratios we 4° valgus adjustment in the la	re 12.3% lower with the ate stance phase.	++
		Inter individual differences:		
		4° Valgus vs without orthosis	Neutral vs without orthosis	
		83%*: decrease 17%: increase *of patients	50%: decrease 17%: no change 33%: increase	
	Co-contraction ratios Flexors/extensors	The co-contraction ratios we phase and 21.5% lower in th 4° valgus adjustment.	re 15.1% lower in the loading ne late stance phase with the	++ }
		Inter individual difference was h	nigh.	0
	Co-contraction ratios (late stance phase) <i>Muscle pairs</i>	<i>Loading phase:</i> Lateral Vastus / lateral gas (4° valgus)	strocnemius: 28.4% decrease	++
		Pre-activation phase: Lateral Vastus / lateral han 16.8% (neutral) decrease Medial Vastus / medial ham 19.6% (neutral) decrease	nstring: 5.9% (4° valgus) and Istring: 10.4% (4° valgus) and	I ++ I
		No significant differences for trocnemius and medial hamstrin	r medial vastus / medial gas ng/lateral hamstring.	- 0
Satisfaction	Questionnaire about comfort, acceptance and subjective changes in gait	Perception of comfort during r cantly between the 4° valgus perception of changes in gain option.	rest or gait did not differ signifi and neutral condition nor the t and acceptance as treatment	- 0

Author's Conclusion

"In summary, significant decreases in muscle activity and co-contraction ratios were observed with the use of the knee brace in both adjustments, indicating a mechanical stabilization of the knee by the brace. The results of our study support the theory of a possible beneficial effect of knee braces in reducing knee loading by decreasing muscle activation and co-contraction levels. This additional mechanism of loading reduction in conjunction with the load reduction induced by the three-pointbending system of valgus braces could further contribute to avoid disease progression in patients with knee osteoarthritis." (Fantini-Pagani et al. 2012)

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Products	Genu Arthro vs Lateral Wedge Insoles			
	Journal of Orthopaedic Research 2012; 30:1125-1132.			
	Kinetic and Kinematic Changes with the Use of Valgus Knee Brace and Lateral Wedge Insoles in Patients with Medial Knee Osteoarthritis			
	Institute of Biomechanics and Orthopaedics, German Sport University Cologne, Germany.			
Reference	Fantini-Pagani, C. H., Hinrichs, M., & Brüggemann, GP.			

 Major Findings
 With Genu Arthro compared to lateral wedge insoles and wearing no orthosis:

→ External knee adduction moments with Genu Arthro at the second peak of the gait cycle were

18-21% lower than without orthosis

11-15% lower than with lateral wedge insoles

→ Knee lever arm with Genu Arthro at 20-30% and 70-80% of the stance phase was

9-12% shorter than without orthosis (20-30% of the stance phase) 19-21% shorter than without orthosis (70-80% of the stance phase)

The effect was twice to three times bigger than with the lateral wedge insoles.





#### **Population**

Subjects: Mean age: Mean body mass: Inclusion criteria: 10 patients (8 female, 2 male)  $57.5 \pm 7.1$  yrs  $78.8 \pm 12.2$  kg age over 50 yrs, diagnosis of medial osteoarthritis grade II or III

#### **Study Design**

#### Observational, comparative:



The patients were not informed about the different adjustments of the orthosis.

The moments calculated using the kinematic and GRF data collected during these trials were defined as external knee adduction moments. For the conditions with orthosis (neutral, 4° and 8°), net moments were calculated by subtracting the orthosis moments from the external knee adduction moments.

Results								
Functions and Activit	es					Participatio	n	
Biomechanics – Static measures	Biomechanics – X-Ray Gait analysis	EMG	Functi		Clinical effects	s Satisfactio		
Category	Outcomes	Results fo	r Genu Arth	ıro			Sig.*	
Biomechanics – Static measure	External knee adduction moments	The externation of the differ signif	al peak knee ficantly.	e adductio	n moment (fir	rst peak) dic	l not	
		The external peak knee adduction moment (second peak) was significantly lower with Genu Arthro with both ad- justments:						
		4° valgus vs no*	8° valgus vs no	Insoles vs no	<b>4° valgus</b> vs insoles	<b>8° valgus</b> vs insoles		
		18% lower ++	21% lower ++	7% lower ++	11% lower ++	15% lower ++		
		The knee adduction angular impulse was also significant- ly lower under almost all conditions:						
		4° valgus	8° valgus	Insoles	4° valgus	8° valgus		
		vs no	vs no	vs no	vs insoles	vs insoles		
		14%	18%	7%	8%	12%		
		lower	lower	lower	lower	lower		
		++	++	++	+	++		
	Orthosis moment	8° vs 4° valgus: 32% higher (first peak), 30° higher + (second peak)						
	Net knee adduction mo- ment	8° vs 4° valgus: 14.7% lower (first peak), 14.8% lower + (second peak)						
	Net knee adduction an- gular impulse	8° vs 4° va	lgus: <b>22.2%</b>	lower			++	

Functions and Activ	ities			Participation			
Biomechanics – Static measures	Biomechanics – X-Ray Gait analysis	EMG	Functional tests Clin	nical effects Satisfaction			
Category	Outcomes	Results for Gen	u Arthro	Sig.*			
	Knee lever arm         The knee lever arm at 20-30% of the stance phase was with both adjustments:						
		4° valgus vs no	8° valgus vs no	Wedges vs no			
		9%	12.6%	5.4%			
		lower	lower	lower			
		+	++	+			
		The knee lever arm at 70-80% of the stance phase was significantly lower with both adjustments:					
		4° valgus vs no	8° valgus vs no	Wedges vs no			
		19.3%	21.4%	7.1%			
		lower	lower	lower			
		++	++	++			

\* no difference (0), positive trend (+), negative trend (-), significant (++/--), not applicable (n.a.) no = without orthosis

Author's Conclusion "In conclusion, the knee orthosis tested in this study and 4° laterally wedged insoles were effective in reducing knee lever arm in the frontal plane, knee adduction moment, and possibly joint load. However, a small effect size was observed with the insoles. The knee orthosis was more effective than 4° wedged insoles in reducing the external knee adduction moment." (Fantini-Pagani et al. 2012)

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Reference	Kutzner, I., Kuther, S., Heinleir mann, G.	ı, B., Dyr	nke, J., Bender, A.,	Halder, A	M., & Berg-		
	Julius Wolff Institute, Charité – Universitaetsmedizin Berlin, Augustenburger Platz 1, 13353 Berlin, Germany.						
	The effect of	valgı	us braces	on	medial		
	compartment load	of the	e knee joint	– in v	rivo load		
	measurements in t	hree s	subjects				
	Journal of Biomechanics 2011;	44: 1354	-1360.				
Products	Genu Arthro (Otto Bock)						
	MOS Genu (Bauerfeind)						
Major Findings	With Genu Arthro (GA) compared to MOS Genu (MOS) and wearing no orthosis:						
	ightarrow Stiffness (measured by spring constant) of MOS is 145% higher than of GA						
	→ Wearing GA or MOS has no significant influence on walking speed and stride length during level walking.						
	→ Overall: forces (Fmed & F measurements. MOS lead GA.	<sup>-</sup> z) are r s for alm	educed by both o nost all conditions	rthoses i to lower	n 88% of 52 forces than		
	$\rightarrow$ Level walking:						
	GA (8° valgus):	Fmed:	7% lower				
	MOS (0°, 4°, 8° valgus):	Fmed:	9-30% lower				
		Fz	2-9% lower				
	→ Stair ascent:		/ -				
	GA (0°, 8° valgus): MOS (0°, 8° valgus):	Fmed: Emed:	2-9% lower -2% higher - 26%	lower			
	→ Stair descent:						
	GA (0°, 8° valgus):	Fmed:	5-7% lower				
		Fz:	3-7% lower				
	MOS (0°, 8° valgus):	Fmed: Fz	2-24% lower 6-16% lower				

<u>Caution</u>: The author herself calls this study a case report with a limited number of 3 subjects, which does not allow general conclusions. Differences in 21% of 52 force measurements were significant. Moreover: the methods do not explain why an additional valgus angle of  $4^{\circ}$  was used only for MOS during level walking.



# Reduction of the medial force (Fmed) during stair ascent (orthosis compared to wearing no orthosis)





The braces were first fitted to the leg in a neutral position to examine whether the brace itself already has an influence on joint loading. After performing the activities with the brace in neutral position, additional valgus angles of 4° (for MOS and level walking only) and 8° (MOS and GA) were adjusted. Three activities of daily living were investigated: walking at a self-selected speed on level ground, ascending stairs, and descending stairs. An implanted, instrumented tibial tray was developed to measure the 6 components (3 forces and 3 moments) of the knee contact loading in vivo. Additionally, the stiffness of the braces in the frontal plane was determined by a testing machine with a maximum test load of 100N.

#### Results

Functions and Activit	ies				P	articipation
Biomechanics – Static measures	Biomechanics – X-Ray Gait analysis	EMG	Function	nal tests Clin	ical effects S	
Category	Outcomes	Results for Ge	enu Arthro (G	A) & MOS G	enu (MOS)	Sig.*
Biomechanics – Static measures	Stiffness	The spring con <b>GA</b> .	stant of the M	<b>OS</b> is 145%	higher than th	at of n.a.
Biomechanics – Gait analysis	Fmed 1 <sup>st</sup> peak	<b>GA (0°)</b> vs without	<b>GA (8°)</b> vs without	MOS (0°) vs without	MOS (4°) vs without	MOS (8°) vs without
		1% higher -	7% lower +	10% lower ++	18% lower ++	23% lower ++
	Fmed 2 <sup>nd</sup> peak	<b>GA (0°)</b> vs without	GA (8°) vs without	MOS (0°) vs without	MOS (4°) vs without	MOS (8°) vs without
		4% higher -	7% lower ++	9% lower +	24% lower ++	30% lower ++
	Fz	With GA (0°) F	z increases by	y 2-3%.		-
		During usage c	2-3%	+		
		Fz is reduced b	4°, 8°).	+		
	Walking speed	No significant o	differences.			0
	Stride length	No significant or orthosis.	g with or with	out O		
Functional tests	Stair ascending – Fmed 1 <sup>st</sup> peak	<b>GA (0°)</b> vs without	<b>GA (8°)</b> vs without		MOS (0°) vs without	MOS (8°) vs without
		2% lower	6% l	ower	2% higher	11% lower
		+		F	-	+
	Stair ascending – Fmed 2 <sup>nd</sup> peak	GA (0°) vs without	GA (8°) vs without		MOS (0°) vs without	MOS (8°) vs without
		6% lower	9% I	ower	5% lower	26% lower
	Stair ascending - Fz	+ No significant o	- differences for	all conditions	+ 5.	++ 0
	Stair descending – Fmed 1 <sup>st</sup> peak	<b>GA (0°)</b> vs without	<b>GA</b> vs wi	(8°) thout	<b>MOS (0°)</b> /s without	MOS (8°) vs without
		5% lower +	7%   -	ower 1 ⊦	2% lower +	24% lower +
	Stair descending – Fmed 2 <sup>nd</sup> peak	GA (0°) vs without	GA vs wi	(8°) thout	MOS (0°) /s without	MOS (8°) vs without
		7% lower	6% I	ower	2% lower +	17% lower +
	Stair descending -	With <b>GA (0°, 8</b>	•) Fz is reduce	ed by 3-7%	· ·	+
	Fz	Fz is decreased <b>2<sup>nd</sup> peak of M</b>	d by 6-16% w <b>OS 8° (-16%)</b>	ith MOS (0°, is significan	8°) t.	+

\* no difference (0), positive trend (+), negative trend (-), significant (++/--), not applicable (n.a.)

"Since the patient's acceptance of the brace and the wearing comfort is of major importance, the amount of applicable external valgus moment is limited. Whereas no major discomfort was reported by the subjects when wearing the GA brace, discomfort was reported when walking with the MOS brace in 8° valgus. Since the chosen valgus settings of 8° with the MOS brace would probably not have been tolerated for a long duration by the subjects, medial load reductions of more than 25% cannot be expected permanently. ... Due to the variability between the subjects, the authors suggest that valgus braces should only be used if a patient reports pain relief. The unloading effect of braces must furthermore be compared to other more comfortable conservative methods such as forearm crutches, laterally wedged shoes or weight reduction." (Kutzner et al. 2011)

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Reference	Schmalz, T., Knopf, E., Drewitz, H., & Blumentritt, S.					
	Analysis of biomechanical effectiveness of valgus-inducing knee brace for osteoarthritis of knee					
	JRRD: Journal of Rehabilitation Research & Development 2010; 47 (5): 419-29					
Products	Genu Arthro					
Major Findings	With Genu Arthro:					
	→ Faster walking speed by 7.1%					
	→ Cadence (steps/min) increased by 2.8%					

- → Genu Arthro raises the first vertical force maximum while walking by 4.8%. (Increase can be influenced by changes in walking speed)
- → Pain is significantly reduced by 51.6%



#### Significant decrease of pain by use of Genu Arthro

#### **Population**

Subjects: Mean age: Mean body mass: Inclusion criteria: 16 (8 male, 8 female) 56 ± 9 years 83 ± 12 kg Osteoarthritis grade I to IV

#### **Study Design**

Interventional, comparative:



At the beginning of the treatment phase, the brace adjustment was optimized for each patient according to his or her individual needs. After the patients were recruited into this study, the individual adjustment of the valgus force was evaluated and modified as needed before the measurement session began. Besides the biomechanical investigations (with and without brace), the patients were surveyed before about their medical history and perceptions of the quality of brace fitting.

#### **Results**

Functions and Activiti	es		Participatio	on			
Biomechanics – Static measures	Biomechanics – X-Ray Gait analysis	EMG Functional t	ests Clinical effects Satisfacti	on			
Category	Outcomes	<b>Results for Genu Arthro</b>		Sig.*			
Biomechanics – Static measure	Walking speed	The walking speed signific Arthro by 7.1%	antly increases with Genu	++			
	Cadence (steps/min)	Users raise their number of steps per minute by 2.8% wearing Genu Arthro.					
	Step length	No significant difference between walking with or without orthosis.					
	Ground reaction force	The first vertical force maximum is also significantly increased by 4.8% with the orthosis compared to con- dition without orthosis. (Increase can be influenced by changes in walking speed)					
		First horizontal force maximum of the contralateral limb a orthosis condition are comparable:					
		Contralateral limb vs. no orthosis	Contralateral limb vs. Genu Arthro				
		25.2% higher ++	9.1% higher +				

No systematic differences could be identified in the mediolateral forces.

Functions and Activit	ies		Participatio	n		
Biomechanics – Static measures	Biomechanics – X-Ray Gait analysis	EMG Functional te	ests Clinical effects Satisfaction	on		
Category	Outcomes	Results for Genu Arthro		Sig.*		
	Knee Joint	The knee flexion moment incre wearing no orthosis:	eased with Genu Arthro comp	ared to		
		Contralateral limb vs. no orthosis	Contralateral limb vs. Genu Arthro			
		95.7% higher ++	36.4% higher +			
		During stance phase flexion as mum values of the external va cant difference between the co	s well as extension the maxi- rus moment show no signifi- onditions.	0		
		For the mean maximum value of there is no significant different with or without orthosis.	of the external varus moment nce between the conditions	0		
	Effect on knee joint of moments created by the orthosis	Moderate increase of the external knee moment by the brace. 9% (mean maximum value) and 10% (mean value) are provided by the brace.				
Clinical effects	Pain-while-walking visual analog scale (VAS) (0 "no pain" – 10 "worst pain imaginable"	The pain is significantly reduced by 51.6% due to Genu Arthro.				
Satisfaction	Questionnaire (0 "very poor – 6 "very good")	Mean scores between 4.3 ("g for fit of the brace, appearance	good") and 4.9 ("very good") and ease of use.	n.a.		

Author's Conclusion "The results from this study show that the studied valgus-inducing knee brace can compensate for approximately 10 percent of the external genu varus moment. This compensation appears to be the main biomechanical mechanism that results in a reduction of joint force within the medial joint compartment. This biomechanical effect is an essential requirement for the reduced pain and improved overall function (such as a more symmetrical gait pattern) that result from the use of such braces. Orthotic treatment can effectively manage patients at early and middle stages of osteoarthritis or when other treatment methods are not applicable" (Schmalz et al. 2010)

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Fantini-Pagani, C. H., Böhle, C., Potthast, W., & Brüggemann, G.-P.

Institute of Biomechanics and Orthopedics, German Sport University Cologne, Germany.

## Short-Term Effects of a Dedicated Knee Orthosis on Knee Adduction Moment, Pain, and Function in Patients with Osteoarthritis

Archives of Physical Medicine & Rehabilitation 2010; 91:1936-41.

Products	Genu Arthro							
Major Findings	With Genu Arthro:	With Genu Arthro:						
	ightarrow Net knee adduction moment is decreased (second peak of gait cycle)							
	With 4° valgus adjustment:	29% lower						
	With neutral adjustment:	15% lower						
	→ Stair climbing is faster							
	With 4° valgus adjustment:	19.5% faster						
	With neutral adjustment:	18.7% faster						
	ightarrow Pain and stiffness are sigr	nificantly reduced, physical function improved						
	WOMAC total score improve	ed by about ca. 44 % under both adjustments						
	Pain, stiffness and physic	al function improved significantly						
	90							
	80							
	70							
	60							
	2 0 50	■ Without orthosis						
	40	Genu Arthr						

#### **Population**

Subjects: Mean age: Mean body mass: Inclusion criteria:

40

30

20 10 0

Pain

11 subjects (8 female, 3 male)  $55.5 \pm 5.5$  yrs 79.8 ± 14.3 kg symptomatic medial knee osteoarthritis grade II or III, absence of other musculoskeletal disorders and lower-limb surgery

Total Score

**Physical Function** 

Stiffness

4° valgus

Genu Arthro neutral

#### **Study Design**

Interventional, single crossover with randomization and blinding:



Patients were randomly assigned to the order of the neutral or 4° valgus condition. They were also blinded and did not know which adjustment was made.

The moments calculated using the kinematic and GRF data collected during these trials were defined as external knee adduction moments. For the conditions with orthosis (neutral and  $4^{\circ}$ ), net moments were calculated by subtracting the orthosis moments from the external knee adduction moments.

Results						
Functions and Activit	ies					Participation
Biomechanics – Static measures	Biomechanics – 2 Gait analysis		EMG	Functional tests	Clinical effects	Satisfaction
Category	Outcomes	R	esults for Genu Art	hro		
Biomechanics – Gait analysis	External knee ac duction moment	d- Th s sig	ne external peak kn gnificantly.	ee adduction m	noment (first p	eak) did not differ
		Th si	ne external peak gnificantly lower:	knee adductio	n moment (se	econd peak) was
		4	4° valgus vs without	Neutral vs v	without 4° v	algus vs neutral
			16.7% lower ++	12.5% lo ++	wer	4.2% lower +
		Tł lo	ne external knee a wer:	adduction ang	ular impulse	was significantly
		4	4° valgus vs without	Neutral vs v	without 4° v	algus vs neutral
			13.1% lower	13.1% lo	wer	No difference
			++	++		0
	Orthosis momer	nt Th fro fro pe	ne orthosis valgus om 0.009 Nm/kg ( om 0.015 Nm/kg ( eak of the stance p	moment varied neutral) to 0.06 (neutral) to 0.0 hase.	significantly 65 Nm/kg (4°) 64 Nm/kg (4°	in the first and ) in the second
	Net knee adduc	tion Re	eductions of the net	knee adduction a	angular impulse	9:
	moments	4	4° valgus vs without	Neutral vs v	without 4° va	algus vs neutral
			29.0 % lower ++	15% lov ++	ver 1	.6.5 % lower ++

Functions and Activit	ies					Participation	
Biomechanics – Static measures	Biomechanics – Gait analysis	X-Ray	EMG	Functional tests	Clinical effects	Satisfaction	
Category	Outcomes	Resu	Ilts for Genu Arti	nro			
		The u signif <b>The u</b>	net peak adductio ficantly. <b>net peak adducti</b>	on moments of on moments o	the first peak	did not decrease eak decreased	
		4° \	<b>algus</b> vs without	Neutral vs v	vithout 4° va	4° valgus vs neutral	
			25% lower ++	12.5% lo ++	wer 1	14.3% lower ++	
Functional tests	Stairs - Velocit	y <b>4</b> ° <b>v</b>	algus vs without	Neutral vs v	without 4° va	4° valgus vs neutral	
			19.5% faster ++	18.7% faster N +		No significant differ- ence (0)	
	6 min walk tes	t No si	gnificant differenc	es were found.		0	
Clinical effects	WOMAC ques	stion- The J	The pain was significantly lower:				
	naire	4° \	<b>algus</b> vs without	Neutral vs v	vithout 4° va	4° valgus vs neutral	
			50 % lower ++	50 % lov ++	ver N	No difference 0	
		The s	The stiffness was significantly lower:				
		4° \	algus vs without	Neutral vs v	without 4° va	4° valgus vs neutral	
			33.3% lower ++	44.4% lower ++		20% higher -	
		The j	The physical function was significantly better:				
		<b>4</b> ° \	algus vs without	Neutral vs v	vithout 4° va	algus vs neutral	
			44.8% better	44.8% be	etter N	lo difference	

Author's Conclusion "In patients with moderate medial knee OA, a 4° valgus orthosis was more effective in decreasing net knee adduction moment and net knee adduction angular impulse than a more flexible orthosis". Both orthosos produced similar effects on pain re-

than a more flexible orthosis<sup>\*)</sup>. Both orthoses produced similar effects on pain reduction and improvement in function." (Fantini-Pagani et al. 2010)

\*) Genu Arthro with neutral adjustment

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#### Fantini-Pagani, C. H., Potthast, W., & Brüggemann, G.-P.

Institute of Biomechanics and Orthopaedics, German Sport University Cologne, Germany.

## The effect of valgus bracing on the knee adduction moment during gait and running in male subjects with varus alignment

Clinical Biomechanics 2010; 25:70-76.

Products	Genu Arthro
Major Findings	With Genu Arthro:
	→ A valgus moment is applied at the knee External knee adduction moments are reduced up to 12.5% in walking
	Net knee adduction moments are reduced up to 36.6% in walking and up to 23% in running
	ightarrow Greater valgus adjustments of the orthosis produce greater valgus moments



#### **Reduction of the net peak adduction moments**

The adduction moments of the second peak at the stance phase were measured and compared under the four different conditions.

Population	Subjects: Mean age: Mean body mass: Inclusion criteria:	<ul> <li>16 healthy, male subjects</li> <li>26.7 ± 3.9 yrs</li> <li>74.3 ± 8.6 kg</li> <li>varus knee alignment (mean 8° ± 4°)</li> <li>absence of clinical diagnosis of osteoarthritis, rheumatoid arthritis, history of knee trauma, surgery or pain</li> <li>free from activity-restricting medical or</li> </ul>
		<ul> <li>free from activity-restricting medical or musculoskeletal condition</li> </ul>

#### **Study Design**

#### Observational, comparative:



Each condition (without orthosis, Genu Arthro with neutral adjustment, 4° and 8° valgus adjustment) was tested at two velocities: Walking at self-selected velocity and running at 3 m/s.

The moments calculated using the kinematic and GRF data collected during these trials were defined as external knee adduction moments. For the conditions with orthosis (neutral, 4° and 8°), net moments were calculated by subtracting the orthosis moments from the external knee adduction moments.

Results							
Functions and Activi	ities					Partici	pation
Biomechanics – Static measures	Biomechanics – Gait analysis	X-Ray		Functional tests	Clinical effec	ts Satisf	action
Category	Outcomes	Results for G	ienu Arthro			S	ig.*
Biomechanics –	External knee	The external k	nee adduction	angular impulse	e was significa	ntly lower:	
Gait analysis	adduction moments dur- ing walking	Neutral vs without	4° vs without	8° vs without	4° vs neutral	8° vs neutral	8° vs 4°
		9.7% lower ++	10.2% lower ++	12.5% lower ++	0.5% lower	3.1% lower	2.6% lower
		The external lower:	peak knee ad	duction momer	nt (second pe	ak) was si	ignificantly
		Neutral vs without	4° vs without	8° vs without	4° vs neutral	8° vs neutral	8° vs 4°
		15.3% lower	15.3% Iower	18.6% Iower	No difference	4% lower	4% lower
		++	++	++	0	+	+
	Orthosis mo- ment during walking	The orthosis tral) and 0.1	valgus mom Nm/kg (8°) in	ent varied sign the first and s	nificantly fron econd peak o	n 0.03 Nm of the stand	/kg (neu- ce phase.

Functions and Activ	vities					Partici	pation			
Biomechanics – Static measures	Biomechanics – Gait analysis	X-Ray	EMG	Functional tests	Clinical effects	Satisf				
Category	Outcomes	Results for C	Genu Arthro			S	ig.*			
	Net knee ad-	Reductions o	Reductions of the net knee adduction angular impulse:							
	duction mo- ments during walking	Neutral vs without	4° vs without	8° vs without	4° vs neutral	8° vs neutral	<mark>8</mark> ° vs 4°			
		11% lower ++	25.2% lower ++	36.3% Iower ++	16% lower ++	28.5% lower ++	15% lower ++			
		Also the net p	Also the net peak adduction moments (second peak) decreased:							
		Neutral vs without	4° vs without	8° vs without	4° vs neutral	8° vs neutral	8° vs 4°			
		13.6% lower	22.0% lower	33.9% Iower	9.8% lower	23.5% lower	15.2% lower			
	Gait velocity	Only betwee (1.6 m/s) the	en the neutra ere was a sign	al (1.55 m/s) a ificant difference	nd without o ce in gait veloc	++ rthosis :ity.	condition			
	External knee adduction moments dur- ing running	No significan	t differences							
	Orthosis mo- ment duringThe orthosis valgus moment varied significantly from 0.05 tral) and 0.1 Nm/kg (8°).runningThis was a significant change in the first peak of the stand not in the second peak.									
	Net knee ad- duction mo-	Neutral vs without	4° vs without	8° vs without	4° vs neutral	8° vs neutral	8° vs 4°			
ments du running	ments during running	9% lower	18% lower	23% lower	9% lower	16% lower	6% lower			

#### **Author's Conclusion**

"In conclusion, the data of this study support the use of this orthosis model from a mechanical point of view. Significant reductions in the net knee adduction angular impulse were found during walking and running using this type of orthosis. During the walking trials, a reduction in the peak knee adduction moment was also detected; indicating effectiveness in reducing joint load. Future studies with OA patients need to be made and evaluation of joint mechanical load in combination with function and pain outcomes would complement the findings of this study." (Fantini-Pagani et al. 2010)

**<u> A Back to overview table</u>** 

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