Cross-sectional in vivo Biomechanical Effects of Meniscus Tears on ACL-deficient Knees versus Isolated ACL Tears:

A Systematic Review of Motion Analysis Studies

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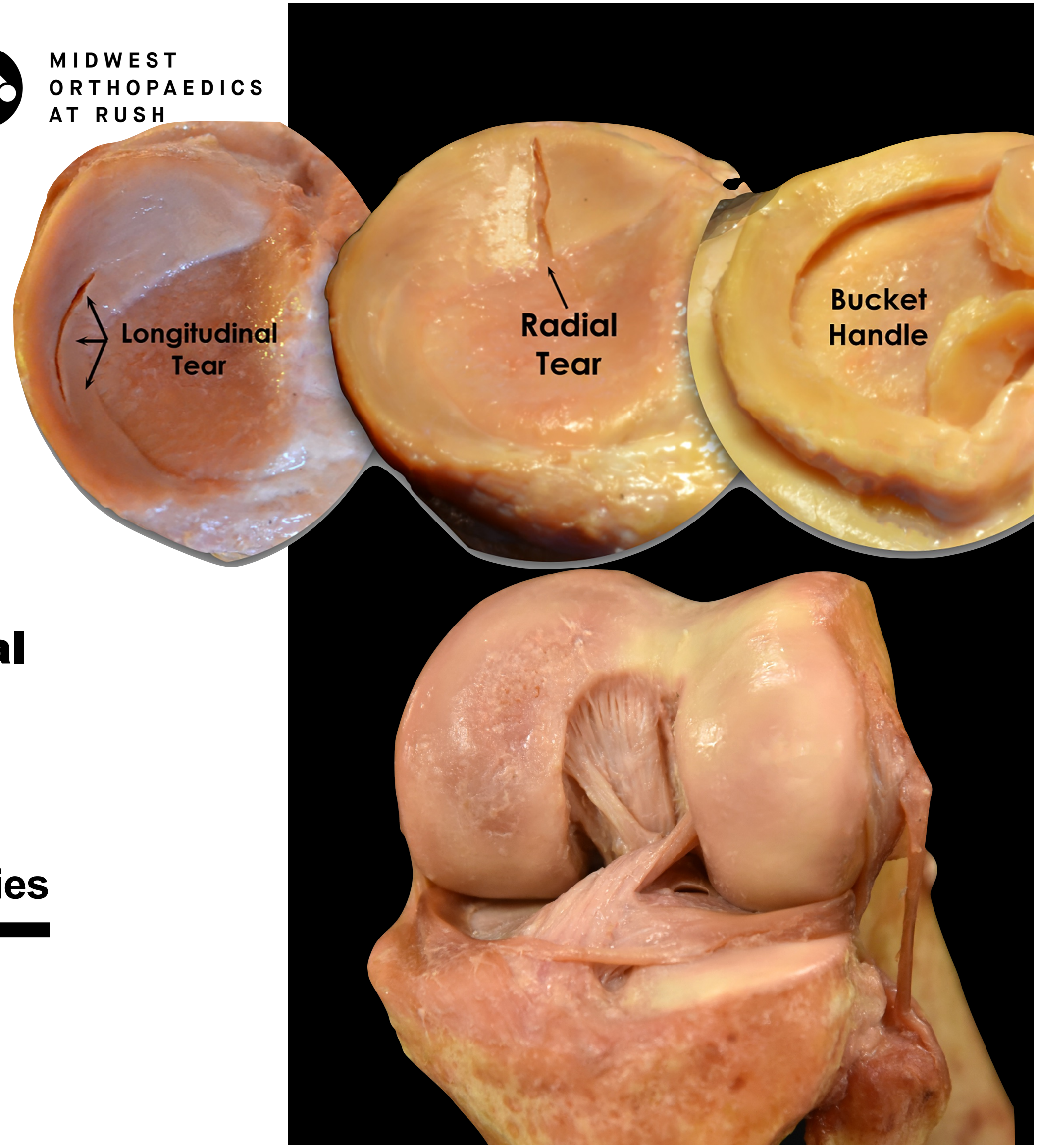

DISCLOSURES

- Enzo Mameri *MD MSc* [1,2,3] - NONE
- Garrett Jackson MD [1] - NONE
- Harkirat Jawanda BS [1] - NONE
- Jonathan Gustafson PhD [1] - NONE
- Gustavo Leporace, *PhD* [2] - NONE
- Leonardo Metsavaht *MD MSc* [2] *– Paid Consultant: APTISSEN*
- Jorge Chahla *MD PhD* [1] *- Paid Consultant: CONMED, LINVATEC, OSSUR, SMITH & NEPHEW;*

  Board Committee Member: AOSSM, AANA, ISAKOS

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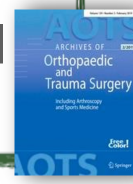
BACKGROUND

ACL: ATT and rotational stability

High incidence of concomitant Meniscal injuries



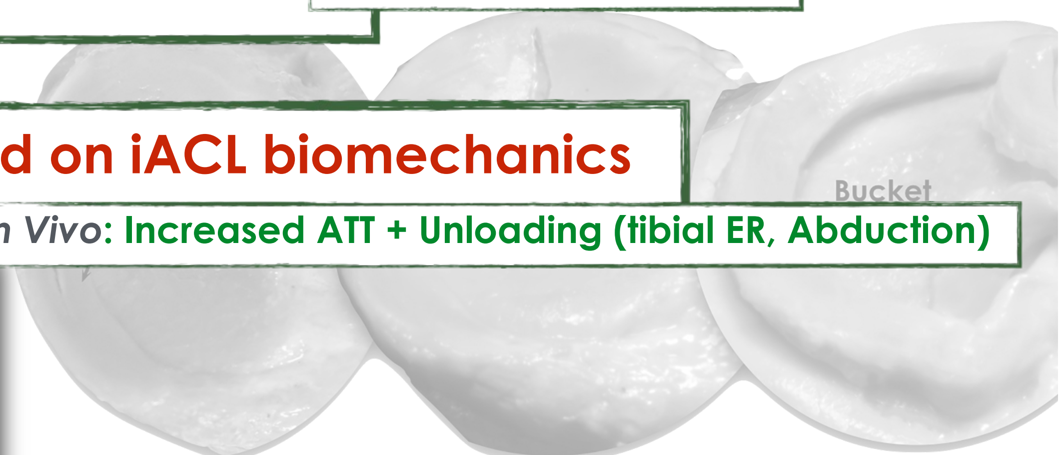
72% in Acute, 85% in Chronic ACL

Meniscal tears associated with anterior cruciate ligament injury

Tetsuo Hagino[1] · Satoshi Ochiai[1] · Shinya Senga[1] · Takashi Yamashita[1] · Masanori Wako[2] · Takashi Ando[2] · Hirotaka Haro[2]

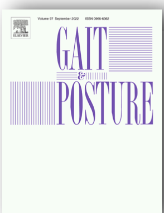
Meniscus: secondary knee stabilizer

MM = AP / LM = Rotation



In vivo studies have largely focused on iACL biomechanics

***In Vivo*: Increased ATT + Unloading (tibial ER, Abduction)**



Six degrees-of-freedom kinematics of ACL deficient knees during locomotion—compensatory mechanism

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OBJECTIVE

Systematically review literature on the Effects of meniscal tears in ACL-deficient knee vs iACL on in vivo knee biomechanics

METHODS

PubMed, Scopus, Cochrane
≤ Dec/2021

SEARCH TERMS

MENISCUS	ACL	DISORDER	IN VIVO BIOMECHANICS
Meniscus	ACL	Tear	Kinematics
Menisci	Anterior Cruciate Ligament	Injury	Kinetics
Meniscal		Lesion	Motion Analysis
			Gait
			Angle
			Moment

ELIGIBLITY CRITERIA

Level I-III
(1) in vivo motion analysis
(2) ACL+Meniscus and iACL cohorts
(3) kinetics, kinematics outcomes

DATA EXTRACTION

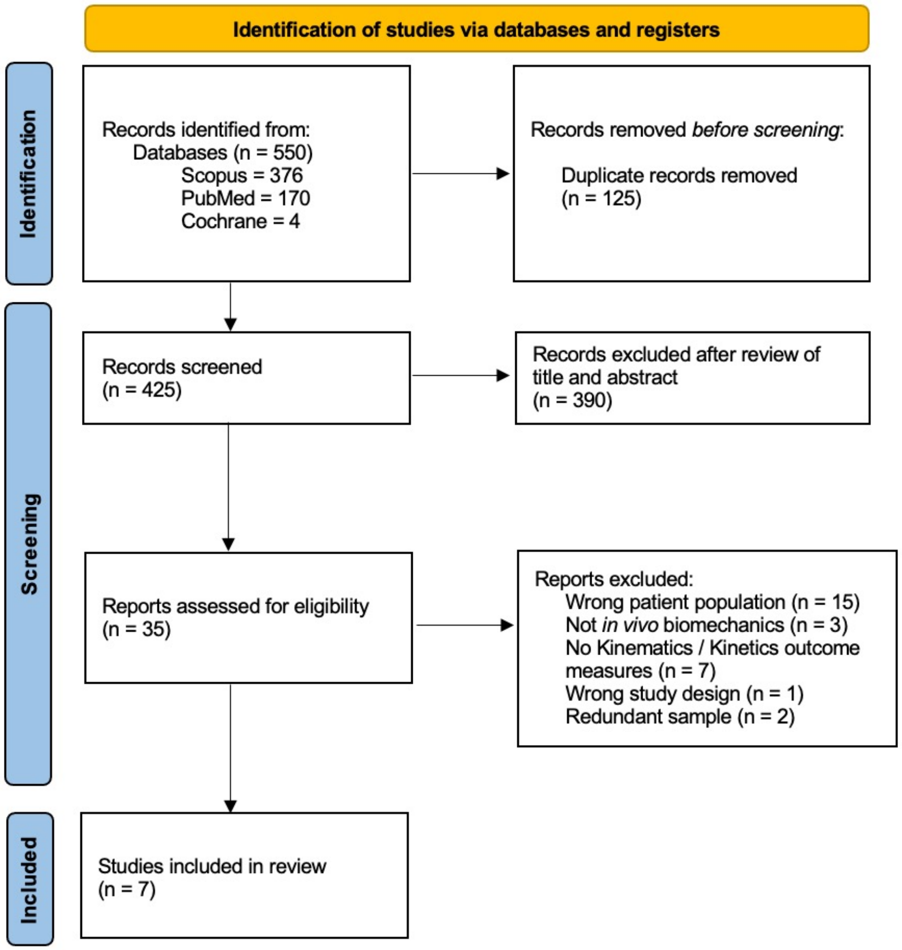
Lvl of Evidence
Sample and Control Group characteristics
System used for Motion Analysis
Marker set used for Motion Analysis
Tasks Performed
Kinetics / Kinematics Outcome Measures

DATA ANALYSIS

Qualitative Synthesis
(Meniscus disorder, motion analysis methods, outcomes)

Metanalysis - SMD and Effect Estimates of numerical variables
(Random effects inverse variance model)

RESULTS

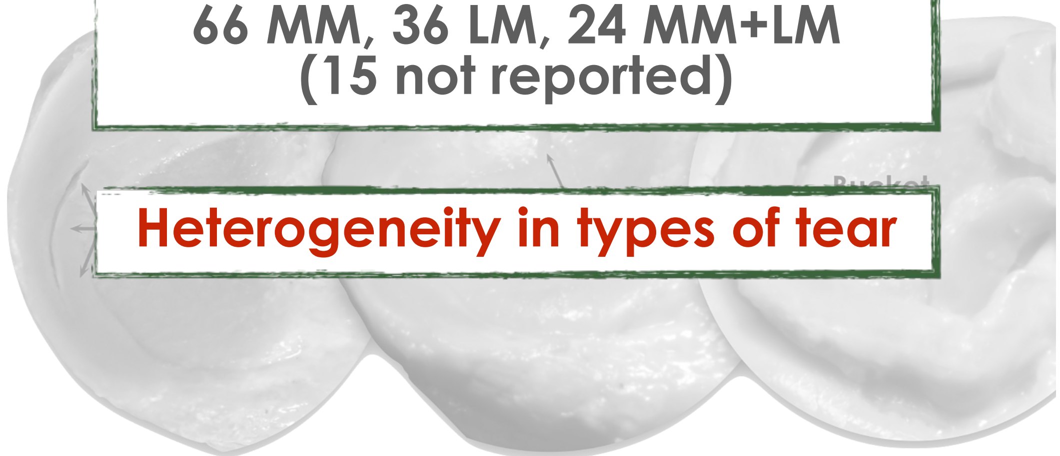


7 studies, 14 cohorts

n = 141 meniscus tear patients

66 MM, 36 LM, 24 MM+LM (15 not reported)

Heterogeneity in types of tear



RESULTS

TASKS PERFORMED

- GAIT (n = 5)
- STAIR-ASCENT (n = 2)

METHOD OF MOTION ANALYSIS

KINETICS

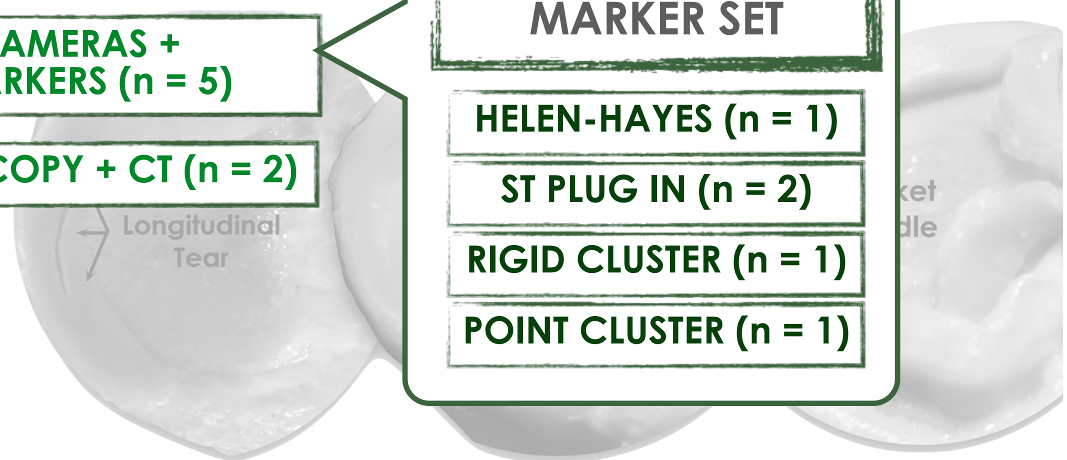
- FORCE PLATES (n = 3)

KINEMATICS

- INFRARED CAMERAS + REFLECTIVE MARKERS (n = 5)
- BIPLANE FLUOROSCOPY + CT (n = 2)

MARKER SET

- HELEN-HAYES (n = 1)
- ST PLUG IN (n = 2)
- RIGID CLUSTER (n = 1)
- POINT CLUSTER (n = 1)



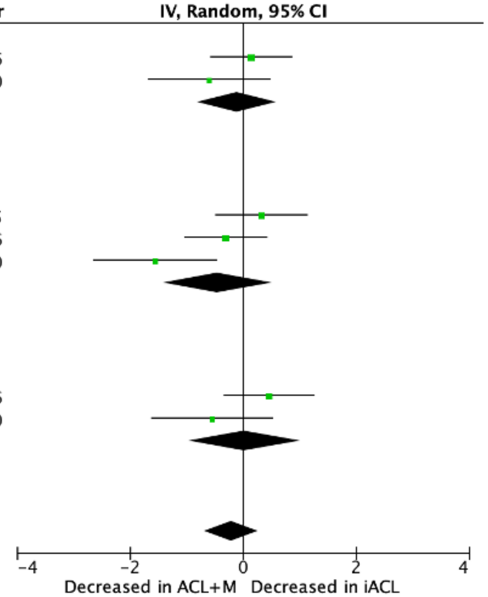
RESULTS

METANALYSIS - KINEMATICS

Range of Knee FLEXION-EXTENSION - Gait Cycle

Study or Subgroup	ACL+Meniscus Tear Mean	SD	Total	Isolated ACL Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI	Year
1.1.1 Lateral Meniscus Tear									
Zhang et al., 2016 - LM Cohort	51.02	18.33	15	48.83	10.82	15	17.2%	0.14 [-0.58, 0.86]	2016
Liu et al., 2020 - LM Cohort	56.73	11.51	5	61.1	4.05	12	11.5%	-0.60 [-1.67, 0.47]	2020
Subtotal (95% CI)			**20**			**27**	**28.7%**	**-0.12 [-0.82, 0.58]**	
Heterogeneity: $Tau^2 = 0.06$; $Chi^2 = 1.29$, df = 1 (P = 0.26); $I^2 = 22\%$									
Test for overall effect: Z = 0.34 (P = 0.73)									
1.1.2 Medial Meniscus Tear									
Harato et al., 2015	60.9	7.1	10	58.5	7.3	15	15.5%	0.32 [-0.48, 1.13]	2015
Zhang et al., 2016 - MM Cohort	43.65	20.38	15	48.83	10.82	15	17.1%	-0.31 [-1.03, 0.41]	2016
Liu et al., 2020 - MM Cohort	54.03	4.8	7	61.1	4.05	12	11.3%	-1.56 [-2.65, -0.47]	2020
Subtotal (95% CI)			**32**			**42**	**43.9%**	**-0.45 [-1.41, 0.50]**	
Heterogeneity: $Tau^2 = 0.52$; $Chi^2 = 7.44$, df = 2 (P = 0.02); $I^2 = 73\%$									
Test for overall effect: Z = 0.93 (P = 0.35)									
1.1.3 Medial and Lateral Menisci Tear									
Zhang 2016 - MM+LM Cohort	53.75	9.63	11	48.83	10.82	15	15.8%	0.46 [-0.33, 1.25]	2016
Liu et al., 2020 - MM+LM Tear	58.95	2.47	5	61.1	4.05	12	11.6%	-0.55 [-1.62, 0.51]	2020
Subtotal (95% CI)			**16**			**27**	**27.4%**	**0.02 [-0.96, 1.00]**	
Heterogeneity: $Tau^2 = 0.28$; $Chi^2 = 2.24$, df = 1 (P = 0.13); $I^2 = 55\%$									
Test for overall effect: Z = 0.04 (P = 0.97)									
Total (95% CI)			**68**			**96**	**100.0%**	**-0.22 [-0.68, 0.25]**	
Heterogeneity: $Tau^2 = 0.20$; $Chi^2 = 12.15$, df = 6 (P = 0.06); $I^2 = 51\%$									
Test for overall effect: Z = 0.90 (P = 0.37)									
Test for subgroup differences: $Chi^2 = 0.49$, df = 2 (P = 0.78), $I^2 = 0\%$									

Std. Mean Difference
IV, Random, 95% CI



NO SIGNIFICANT DIFFERENCE (p ≥ 0.05)

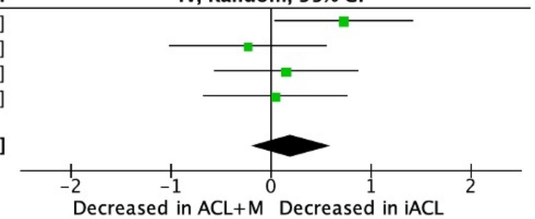
RESULTS

METANALYSIS - KINEMATICS

Range of Knee INTERNAL-EXTERNAL Rot - Gait Cycle

Study or Subgroup	ACL+Meniscus Tear Mean	ACL+Meniscus Tear SD	ACL+Meniscus Tear Total	Isolated ACL Mean	Isolated ACL SD	Isolated ACL Total	Weight	Std. Mean Difference IV, Random, 95% CI
Harato et al., 2015	24.2	11.4	15	18	5.2	21	27.2%	0.73 [0.04, 1.41]
Zhang 2016 – MM+LM Cohort	8.9	5.43	11	10.34	6.42	15	22.0%	−0.23 [−1.01, 0.55]
Zhang et al., 2016 – LM Cohort	11.69	10.21	15	10.34	6.42	15	25.4%	0.15 [−0.56, 0.87]
Zhang et al., 2016 – MM Cohort	10.76	10.3	15	10.34	6.42	15	25.4%	0.05 [−0.67, 0.76]
Total (95% CI)			**56**			**66**	**100.0%**	**0.20 [−0.20, 0.60]**

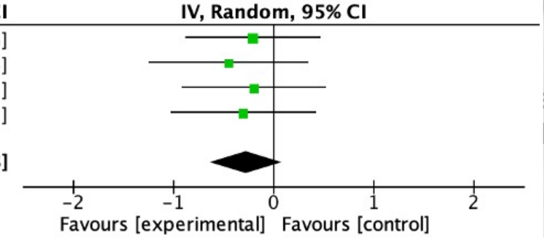
Heterogeneity: $Tau^2 = 0.03$; $Chi^2 = 3.63$, df = 3 (P = 0.30); $I^2 = 17\%$
Test for overall effect: Z = 0.98 (P = 0.33)



Range of Knee ADDUCTION-ABDUCTION - Gait Cycle

Study or Subgroup	ACL+Meniscus Tear Mean	ACL+Meniscus Tear SD	ACL+Meniscus Tear Total	Isolated ACL Mean	Isolated ACL SD	Isolated ACL Total	Weight	Std. Mean Difference IV, Random, 95% CI
Harato et al., 2015	11.1	4.1	15	11.9	3.6	21	29.3%	-0.21 [-0.87, 0.46]
Zhang 2016 – MM+LM Cohort	5.71	3.77	11	8.27	6.49	15	20.7%	-0.45 [-1.24, 0.34]
Zhang et al., 2016 – LM Cohort	7.17	4.16	15	8.27	6.49	15	25.1%	-0.20 [-0.91, 0.52]
Zhang et al., 2016 – MM Cohort	6.28	6.28	15	8.27	6.49	15	24.9%	-0.30 [-1.02, 0.42]
Total (95% CI)			**56**			**66**	**100.0%**	**-0.28 [-0.64, 0.08]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.28$, df = 3 (P = 0.96); $I^2 = 0\%$
Test for overall effect: Z = 1.52 (P = 0.13)



NO SIGNIFICANT DIFFERENCE ($p \geq 0.05$)

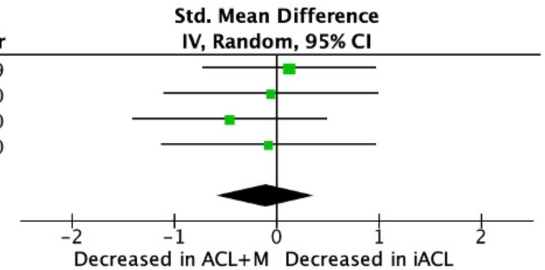
RESULTS

METANALYSIS - KINETICS

Peak Knee Flexion Moment - Gait Cycle

Study or Subgroup	ACL+Meniscus Tear Mean	SD	Total	Isolated ACL Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI	Year
Huang et al., 2019	0.18	0.1	10	0.16	0.19	12	32.4%	0.12 [−0.72, 0.96]	2019
Liu et al., 2020 – LM Cohort	1.53	1.31	5	1.62	1.54	12	21.0%	−0.06 [−1.10, 0.99]	2020
Liu et al., 2020 – MM+LM Tear	0.93	1.2	7	1.62	1.54	12	25.5%	−0.46 [−1.41, 0.49]	2020
Liu et al., 2020 – MM Cohort	1.5	1.2	5	1.62	1.54	12	21.0%	−0.08 [−1.12, 0.97]	2020
Total (95% CI)			**27**			**48**	**100.0%**	**−0.11 [−0.58, 0.37]**	

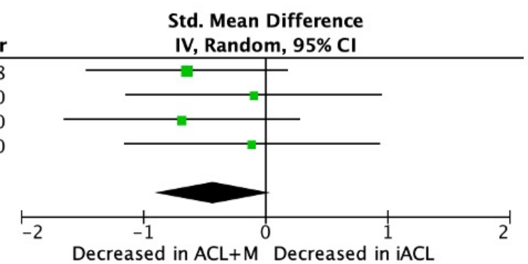
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.84$, df = 3 (P = 0.84); $I^2 = 0\%$
Test for overall effect: Z = 0.44 (P = 0.66)



Peak Knee Internal Rot Moment - Gait Cycle

Study or Subgroup	ACL+Meniscus Tear Mean	SD	Total	Isolated ACL Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI	Year
Ren et al., 2018	0.02	0.03	10	0.04	0.03	15	33.6%	−0.64 [−1.47, 0.18]	2018
Liu et al., 2020 – LM Cohort	1.29	0.63	5	1.41	1.33	12	20.9%	−0.10 [−1.14, 0.95]	2020
Liu et al., 2020 – MM+LM Tear	0.48	1.22	7	1.41	1.33	12	24.5%	−0.69 [−1.65, 0.28]	2020
Liu et al., 2020 – MM Cohort	1.26	1.02	5	1.41	1.33	12	20.9%	−0.11 [−1.16, 0.93]	2020
Total (95% CI)			**27**			**51**	**100.0%**	**−0.43 [−0.91, 0.05]**	

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.28$, df = 3 (P = 0.73); $I^2 = 0\%$
Test for overall effect: Z = 1.76 (P = 0.08)



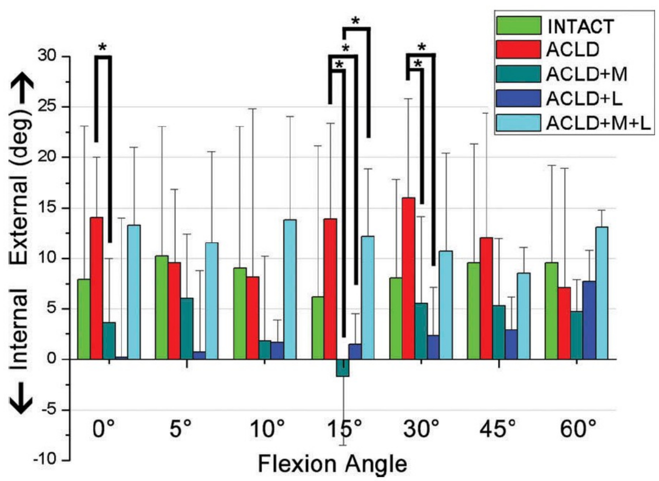
NO SIGNIFICANT DIFFERENCE ($p \geq 0.05$)

RESULTS

QUALITATIVE EVIDENCE - BIOMECHANICS

Zhang 2017 - STAIR ASCENT: **(MM, LM groups) Decreased KERA vs iACL at 0º, 15º, 30º**

Hosseini 2014 - STAIR ASCENT: **(MM, LM groups) Decreased KERA vs iACL**



DISCUSSION

Quantitative analysis failed to demonstrate differences in GAIT KINEMATICS / KINETICS for ACL+M vs iACL

Different types of Meniscus tears, including “more benign" tears

Different Tears = Different Biomechanical Impact

Gait: most common task, but often not symptomatic / complaint

Qualitative Evidence of different biomechanical profile in a more demanding STAIR-ASCENT task

+ Abundant in vitro evidence of significant impact of Meniscus tears

ANALYSES OF MORE DEMANDING TASKS ARE NEEDED TO ACCURATELY REFLECT THE BIOMECHANICAL IMPAIRMENT OF MENISCAL TEARS ON ACL-d KNEES

CONCLUSION

AVAILABLE LITERATURE on the effects of Meniscus Tears on ACL-d

Qualitative Evidence of altered axial plane biomechanics during STAIR-ASCENT

No Quantitative Evidence of altered GAIT biomechanics

ANALYSES OF MORE DEMANDING TASKS WILL LIKELY REVEAL SIGNIFICANT IMPACT