

Manuscript titled “Effects of shoe longitudinal bending stiffness and runner level on Achilles tendon loading in experienced and novice male runners: a musculoskeletal modelling study”

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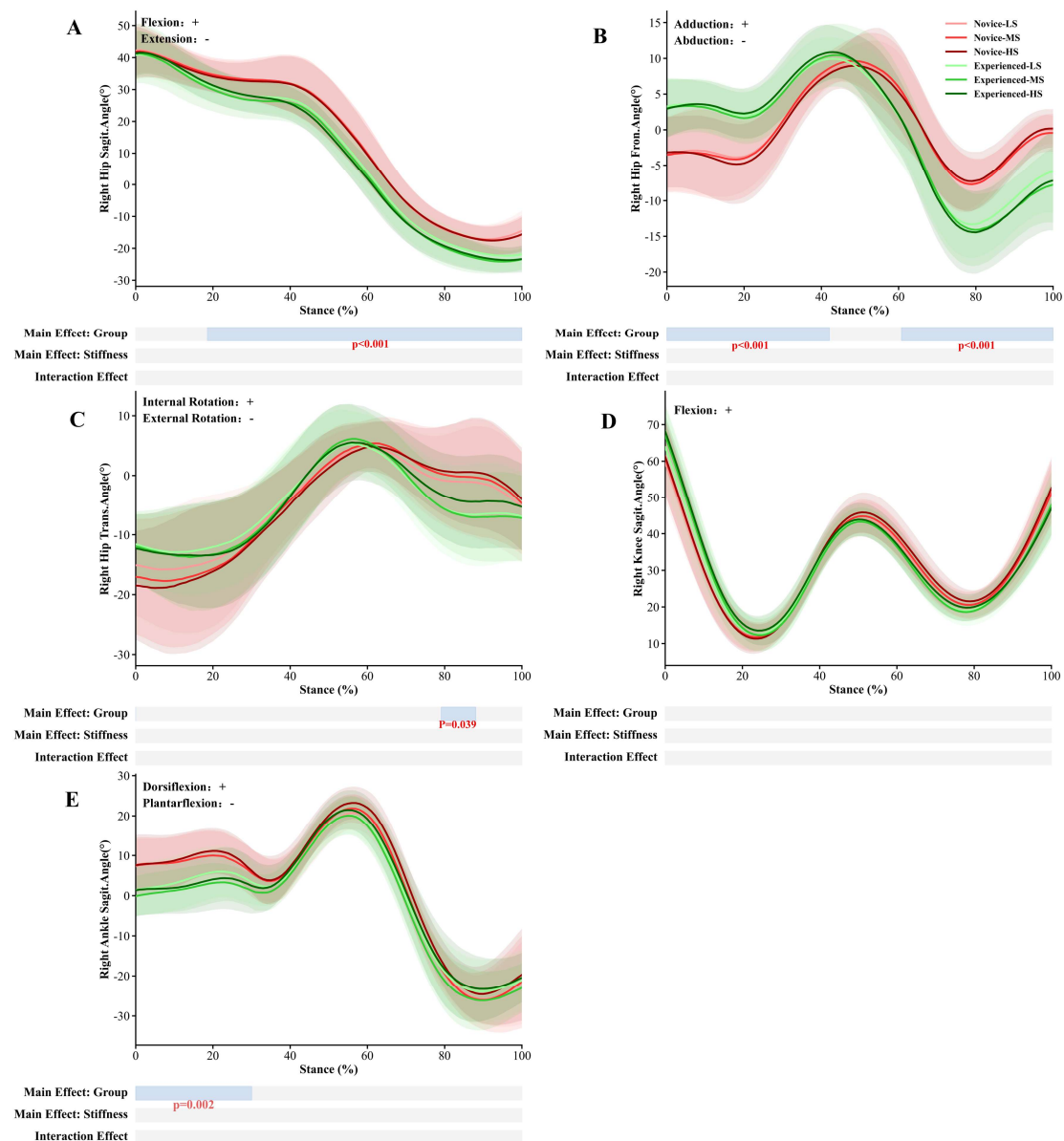


Figure 1: Statistical Parametric Mapping results for lower limb kinematics during the stance phase. (A) Right hip flexion(+)/extension(-) angle; (B) Right hip adduction(+)/ abduction(-) angle; (C) Right hip internal rotation(+)/ external rotation(-) angle; (D) Right knee flexion(+)/extension(-) angle; (E) Right dorsiflexion(+)/plantarflexion(-) angle. The solid lines represent group means, with shaded areas indicating the standard deviation. Grey horizontal bars and shaded regions denote supra-threshold clusters where significant differences between experienced and novice runners were observed ($p < 0.05$). The horizontal axis represents the normalized stance phase from initial contact (0%) to toe-off (100%).

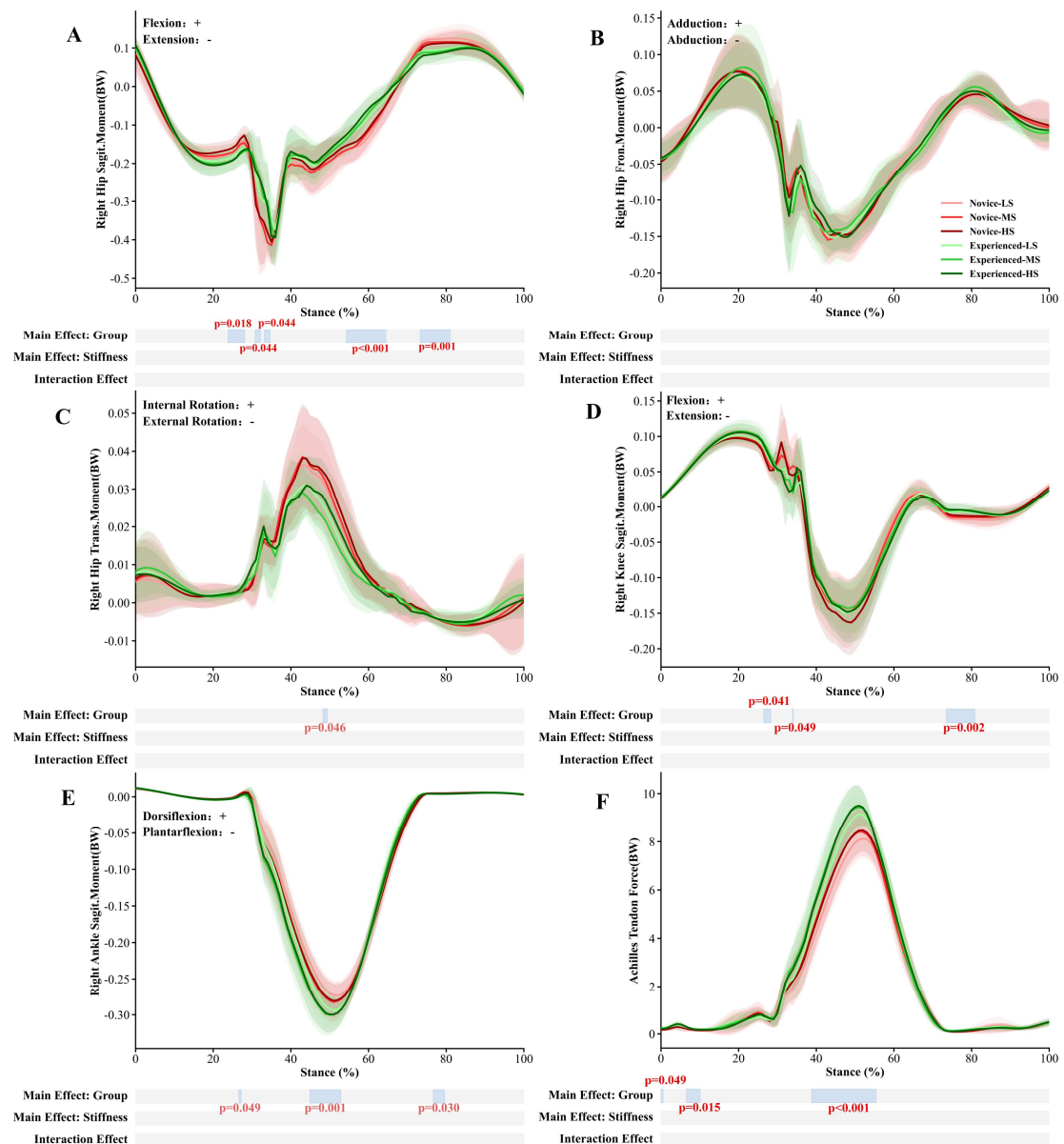


Figure 2: Statistical Parametric Mapping results for lower limb kinetics during the stance phase. (A) Right hip flexion(+)/extension(-) moment; (B) Right hip adduction(+)/abduction(-) moment; (C) Right hip internal rotation(+)/external rotation(-) moment; (D) Right knee flexion(+)/extension(-) moment; (E) Right ankle dorsiflexion(+)/plantarflexion(-) moment; (F) Right Achilles tendon force. The solid lines represent group means, with shaded areas indicating the standard deviation. Grey horizontal bars and shaded regions denote supra-threshold clusters where significant differences between experienced and novice runners were observed ($p < 0.05$). The horizontal axis represents the normalized stance phase from initial contact (0%) to toe-off (100%).

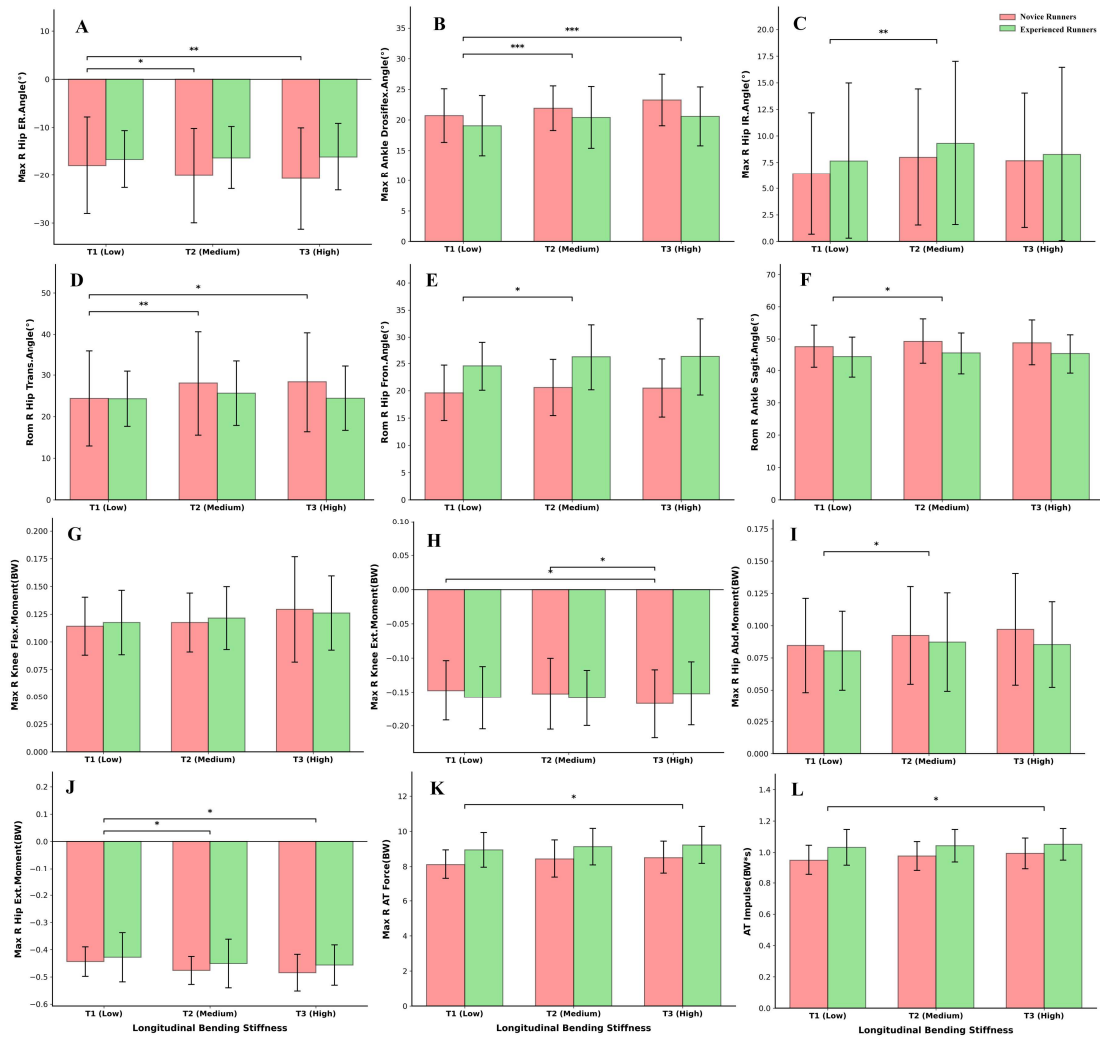


Figure 3: Post-hoc comparisons of lower limb kinematic and kinetic parameters during the stance phase. (A) Max hip external rotation angle; (B) Max ankle dorsiflexion angle; (C) Max hip internal rotation; (D) Range of motion in hip transverse plane; (E) Range of motion in hip frontal plane; (F) Range of motion in ankle sagittal plane; (G) Max knee flexion moment; (H) Max knee extension moment; (I) Max hip abduction moment; (J) Max hip extension moment; (K) Max Achilles tendon (AT) force; (L) Achilles tendon impulse. T1, T2, and T3 represent low, medium, and high longitudinal bending stiffness (LBS), respectively. Bars represent mean values, and error bars indicate one standard deviation. Asterisks and horizontal lines denote statistically significant differences between groups or conditions (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

Table 1: Effects of runner level, shoe stiffness and their interaction on lower limb kinematic parameters

Variable	Novice Group			Experienced Group			<i>p-value</i>		
	T1	T2	T3	T1	T2	T3	G	S	G*S
H.F/E _{IC}	34.26 (5.14)	34.21 (5.78)	33.65 (5.37)	31.12 (5.75)	31.79 (5.89)	31.63 (5.83)	0.221	0.522	0.291
H.Add/Abd _{IC}	-3.35 (4.77)	-3.56 (5.57)	-4.28 (5.62)	1.53 (4.26)	1.51 (4.56)	1.88 (3.83)	0.003	0.859	0.143
H.ERot _{IC}	-13.72 (11.10)	-15.02 (10.91)	-15.41 (11.67)	-11.34 (7.57)	-11.63 (7.88)	-12.03 (9.11)	0.382	0.130	0.575
K.F _{IC}	11.89 (3.78)	12.98 (4.43)	11.71 (4.58)	12.31 (4.64)	13.22 (4.53)	13.54 (4.13)	0.452	0.217	0.211
A.Dorsi/Plantar _{IC}	10.83 (5.65)	9.82 (6.38)	11.06 (5.92)	5.20 (6.92)	5.91 (7.37)	4.52 (7.93)	0.035	0.818	0.060
H.F/E _{ROM}	61.24 (4.61)	61.99 (5.90)	60.49 (4.78)	65.68 (6.75)	67.61 (6.18)	66.51 (5.23)	0.006	0.290	0.276
H.Add/Abd _{ROM}	19.61 (5.08)	20.60 (5.15)	20.49 (5.34)	24.56 (4.48)	26.27 (6.06)	26.29 (7.09)	0.009	0.034	0.726
H.Rot _{ROM}	24.35 (11.42)	28.08 (12.53)	28.37 (12.01)	24.28 (6.65)	25.61 (7.73)	24.40 (7.72)	0.529	0.003	0.013
K.F _{ROM}	48.76 (7.38)	51.15 (5.69)	51.27 (7.42)	52.02 (9.66)	53.20 (8.53)	53.75 (6.80)	0.326	0.095	0.827
A.Dorsi/Plantar _{ROM}	47.61 (6.68)	49.22 (7.02)	48.79 (7.11)	44.24 (6.34)	45.37 (6.49)	45.20 (6.08)	0.129	0.042	0.911

T1, low stiffness; T2, medium stiffness; T3, high stiffness; IC, initial contact; ROM, range of motion; H.F/E: right hip flexion (+)/extension (-); H.Add/Abd: right hip adduction (+)/abduction (-); H.ERot: right hip internal rotation (+)/external rotation (-); K.F, right knee flexion (+)/extension (-); A.Dorsi/Plantar, right ankle dorsiflexion (+)/plantarflexion (-); H.Rot: right hip rotation; G, runner level group; S, shoes-stiffness condition; G*S, the interaction effect between runner level and shoe stiffness.

Table 2: Effects of runner level, shoe stiffness and their interaction on lower limb kinetic parameters

Variable	Novice Group			Experienced Group			<i>p-value</i>		
	T1	T2	T3	T1	T2	T3	G	S	G*S
Max H.F	42.92 (7.02)	42.71 (8.06)	42.38 (7.40)	43.35 (8.03)	44.63 (8.32)	43.89 (7.84)	0.647	0.425	0.380
Max H.Add	10.24 (2.78)	10.72 (3.58)	10.31 (3.82)	11.23 (3.28)	11.69 (4.29)	12.18 (3.48)	0.315	0.198	0.329
Max H.IRot	6.43 (5.74)	7.98 (6.44)	7.67 (6.36)	7.65 (7.34)	9.30 (7.71)	8.26 (8.19)	0.685	0.004	0.709
Max K.F	60.18 (8.90)	62.43 (8.08)	62.39 (9.88)	63.60 (10.69)	65.64 (9.15)	66.67 (7.02)	0.235	0.053	0.887
Max A.Dorsi	20.70 (4.38)	21.91 (3.65)	23.26 (4.21)	19.06 (4.93)	20.42 (5.06)	20.57 (4.81)	0.248	<0.001	0.062
Max H.E	-18.32 (5.09)	-18.29 (5.28)	-18.11 (4.86)	-22.34 (6.66)	-22.98 (5.96)	-22.62 (6.84)	0.047	0.572	0.632
Max H.Abd	-9.37 (4.24)	-9.88 (4.76)	-10.18 (4.56)	-13.33 (4.52)	-14.53 (5.18)	-14.11 (6.10)	0.022	0.151	0.719
Max H.ERot	-17.92 (10.12)	-20.10 (9.88)	-20.69 (10.61)	-16.64 (5.99)	-16.31 (6.52)	-16.13 (6.99)	0.284	0.192	0.006
Max A.Plantar	-26.91 (7.36)	-27.30 (7.59)	-25.54 (7.65)	-25.17 (7.81)	-24.96 (8.20)	-24.62 (7.22)	0.547	0.100	0.345

T1, low stiffness; T2, medium stiffness; T3, high stiffness; Max, maximum; H.F/E, right hip flexion(+)/extension(-); H.Add/Abd, right hip adduction(+)/ abduction(-); H.IRot/ERot, right hip internal(+)/ external(-) Rotation; K.F, Knee flexion is positive, with 0° at the anatomical position; R Ankle.F/E, right ankle dorsiflexion (+)/extension(-); G, runner level group; S, shoes-stiffness condition; G*S, the interaction effect between runner level and shoe stiffness.

Table 3: Effects of runner level, shoe stiffness on Achilles tendon loading and lower limb kinetic parameters

Variable	Novice Group			Experienced Group			<i>p-value</i>		
	T1	T2	T3	T1	T2	T3	G	S	G*S
AT Impulse	0.95	0.98	0.99	1.03	1.04	1.05	0.065	0.007	0.321
(BW-S)	(0.09)	(0.09)	(0.10)	(0.11)	(0.10)	(0.10)			
Max H.FM	0.135	0.124	0.124	0.117	0.118	0.117	0.227	0.339	0.175
(BW)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)			
Max H.AddM	0.085	0.092	0.097	0.080	0.087	0.085	0.588	0.019	0.381
(BW)	(0.037)	(0.038)	(0.043)	(0.031)	(0.038)	(0.033)			
Max H.IRotM	0.039	0.040	0.042	0.038	0.040	0.038	0.716	0.310	0.266
(BW)	(0.010)	(0.013)	(0.013)	(0.012)	(0.013)	(0.010)			
Max K.FM	0.114	0.117	0.129	0.118	0.122	0.126	0.900	0.023	0.579
(BW)	(0.026)	(0.027)	(0.048)	(0.029)	(0.028)	(0.033)			
Max A.DorsiM	0.012	0.012	0.012	0.012	0.012	0.012	0.768	0.262	0.720
(BW)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)			
Max H.EM(BW)	-0.444	-0.476	-0.484	-0.428	-0.451	-0.456	0.359	0.004	0.812
	(0.054)	(0.051)	(0.067)	(0.090)	(0.089)	(0.074)			
Max H.AbdM(BW)	-0.170	-0.178	-0.179	-0.192	-0.192	-0.186	0.348	0.790	0.486
	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)			
Max H.ERotM(BW)	-0.010	-0.010	-0.010	-0.008	-0.008	-0.008	0.115	0.736	0.844
	(0.005)	(0.004)	(0.005)	(0.005)	(0.003)	(0.004)			
Max K.EM(BW)	-0.148	-0.153	-0.167	-0.159	-0.159	-0.152	0.972	0.538	0.003
	(0.044)	(0.052)	(0.050)	(0.046)	(0.041)	(0.047)			
Max A. PlantarM(BW)	-0.274	-0.283	-0.283	-0.291	-0.294	-0.296	0.122	0.104	0.552
	(0.022)	(0.029)	(0.024)	(0.025)	(0.028)	(0.026)			
Max AT Force	8.11	8.43	8.51	8.95	9.13	9.23	0.038	0.004	0.756
(BW)	(0.84)	(1.08)	(0.93)	(0.99)	(1.04)	(1.05)			

T1, Low Stiffness; T2, Medium Stiffness; T3, High Stiffness; Max, Characteristic Peak; H.FM/EM, Right Hip Flexion Moment(+)/Extension Moment(-); H.AddM/AbdM, Right Hip Adduction Moment(+)/Abduction Moment(-); H.IRotM/ERotM, Right Hip Internal (+)/External(-) Rotation Moment; K.F/EM, Right Knee Flexion Moment(+)/Extension Moment(-); A.DorsiM/PlantarM, Right Ankle Dorsiflexion Moment(+)/Plantarflexion Moment(-); AT Force, Achilles Tendon Force; AT Impulse, Achilles Tendon Impulse; G, Runner Level Group; S, Shoes-stiffness condition; G*S, Interaction Effect Between Runner Level And Shoe Stiffness.