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Effect of Altered Knee Joint Loading Pattern in Gait Biomechanics of Total Knee Arthroplasty Patients

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COI Disclosure Information

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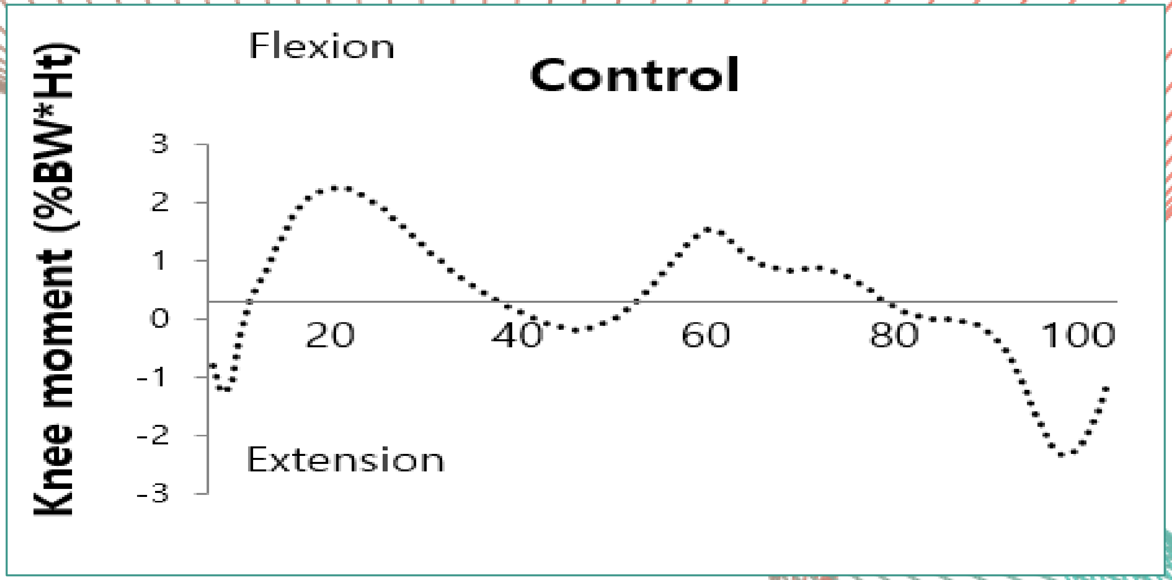
I have no financial relationships to disclose

knee joint moment



- Gait after TKA
  - Slow walking / Limited knee excursion
  - Decreased knee flexion moment (KFM)
  - Monophasic pattern of knee adduction moment

Ro 2020, Han 2018

- Consistent knee flexion & extension moment
  - Sustained quadriceps & hamstring activity
  - Biphasic moment group did not

Wilson 1996

Aim of the study

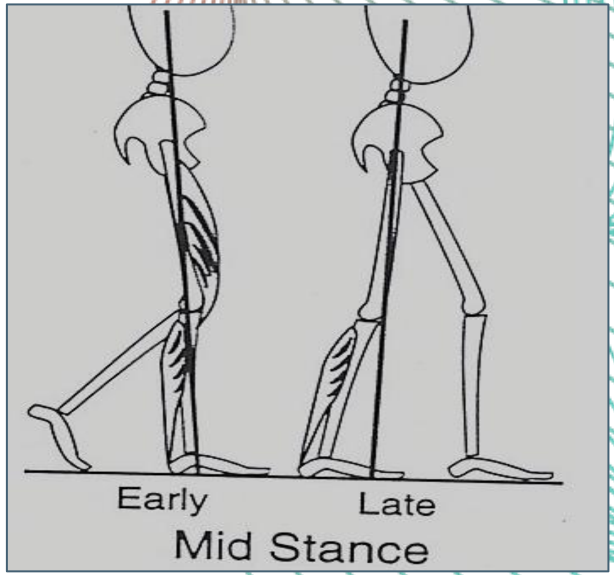
- Previous studies did not discuss
  - When peak loading happens
  - Biomechanical changes by altered timing of peak knee joint loading
- Compare the gait mechanics b/w groups distinguished by peak timing of KFM
- Whether altered knee joint loading pattern could be associated with pre-surgery gait function and how changed in adjacent joints

Classification of Groups

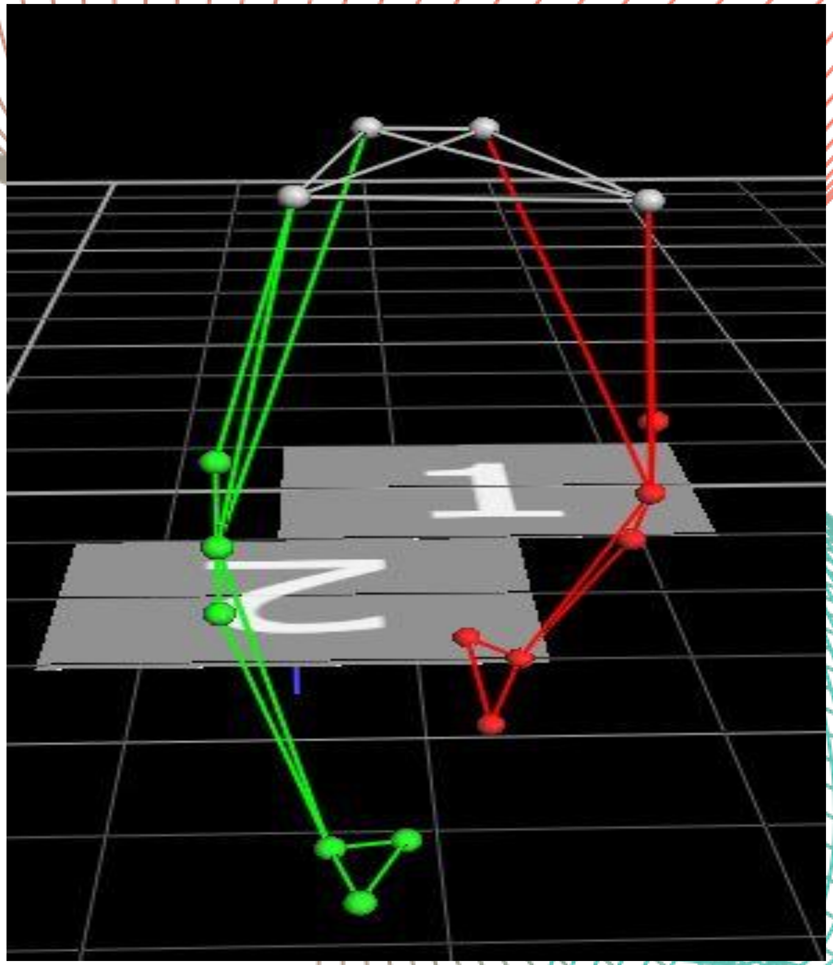
- Subject
  - Retrospectively review / TKA
  - KOOS, Gait analysis at preop. & one-year follow up
  - 43 patients / 60 TKAs / 9 control individuals
- Peak external KFM in gait cycle (GC)
  - Generally early mid stance phase (~25% GC)
  - 23% GC → body vector in line with knee axis
  - Cut off → Early peak (EP) – less than 23% GC, 30 TKAs

    Later peak (LP) – more than 23% GC, 30 TKAs

Perry 2010



Gait analysis



- 3D gait biomechanics
  - 16 markers on lower limbs & 2 force plate
- Spatiotemporal, kinetic, kinematic data
  - Walking speed, step length,
  - % of stance phase, excursion, moment, power

→ Normalized to the gait cycle (GC)

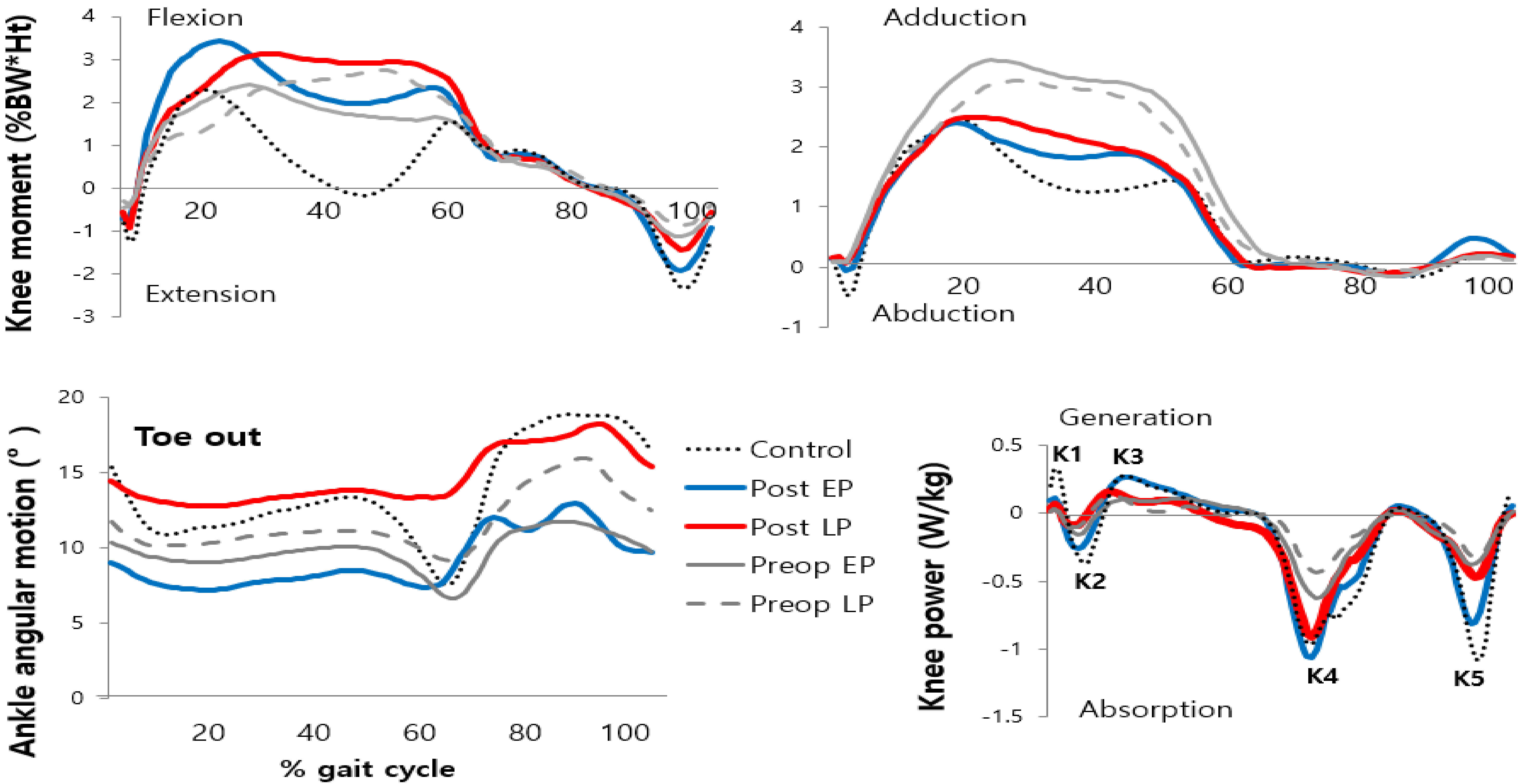
→ Timing of peak loading – percentage of the GC

Results

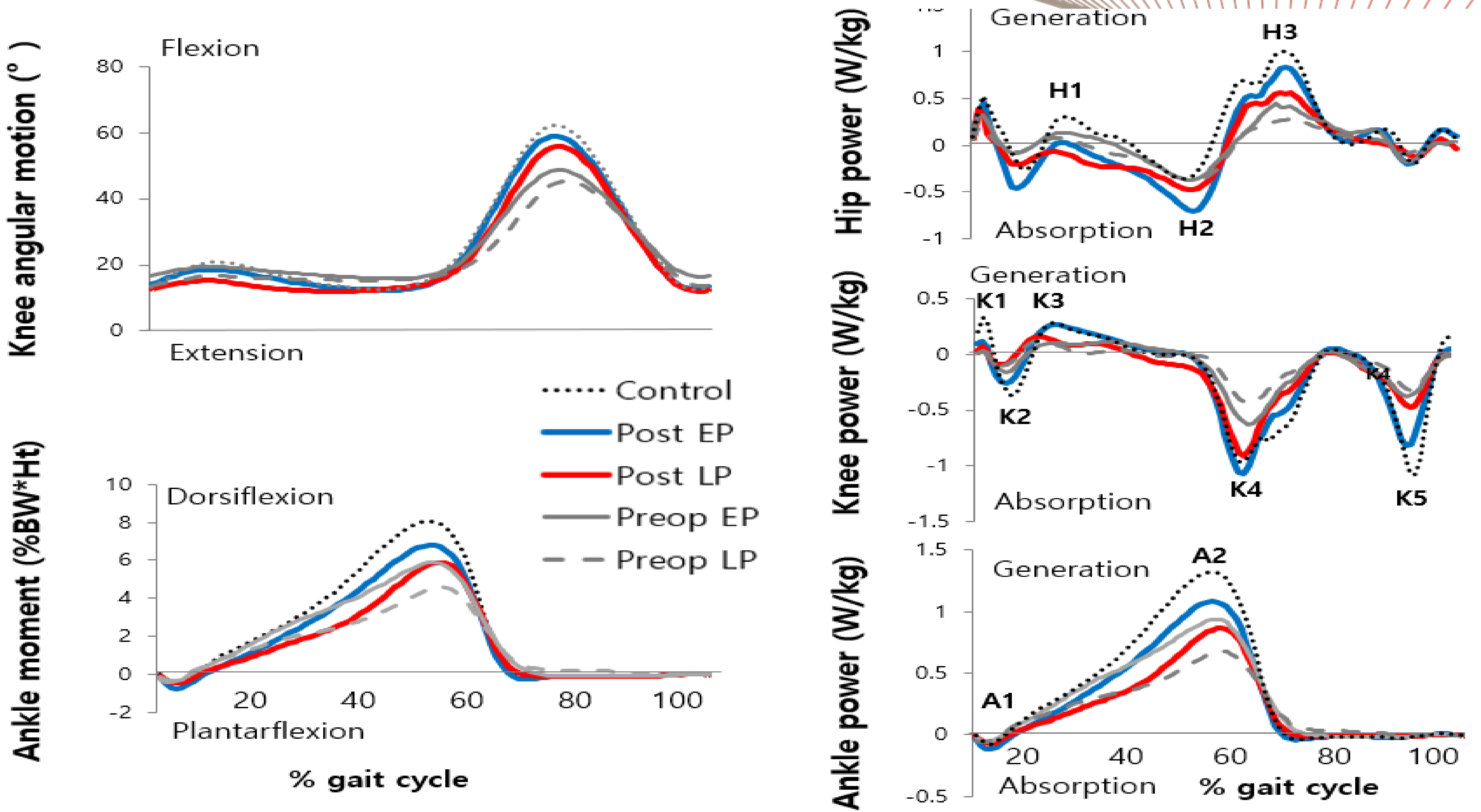
Between surgical groups (pre versus post, LP vs. EP)

	EP (30 TKAs)		LP (30 TKAs)		Within group difference	Between group difference	effect of interaction
	Preop.	Postop.	Preop.	Postop.			
KOOS Pain	**58.94** (16.04)	89.46 (11.76)	**47.22** (15.03)	87.36 (11.10)	0.000	**0.038**	0.078
KOOS Activities of daily living	**59.66** (18.97)	87.53 (9.08)	**48.26** (16.58)	84.86 (10.66)	0.000	**0.049**	0.119
Timing of peak KFM (%GC)	34.30 (17.57)	**15.93** (4.23)	38.87 (16.26)	**39.43** (14.24)	0.002	0.000	**0.001**
Mean foot progress angle during Stance (°)	9.33 (8.26)	**8.22** (6.39)	**10.63** (9.42)	**13.37** (7.57)	0.272	0.100	**0.011**
K5 power absorption (W/kg)	0.49 (0.27)	**0.96** (0.40)	0.42 (0.33)	**0.66** (0.36)	0.000	0.012	**0.030**

Results


Knee moment (%BW*Ht)
Flexion
Extension
4
3
2
1
0
-1
-2
-3
20
40
60
80
100
Adduction
Abduction
4
3
2
1
0
-1
20
40
60
80
100
Ankle angular motion (°)
Toe out
20
15
10
5
0
20
40
60
80
100
% gait cycle
Control
Post EP
Post LP
Preop EP
Preop LP
Knee power (W/kg)
Generation
Absorption
0.5
0
-0.5
-1
-1.5
K1
K2
K3
K4
K5

Results



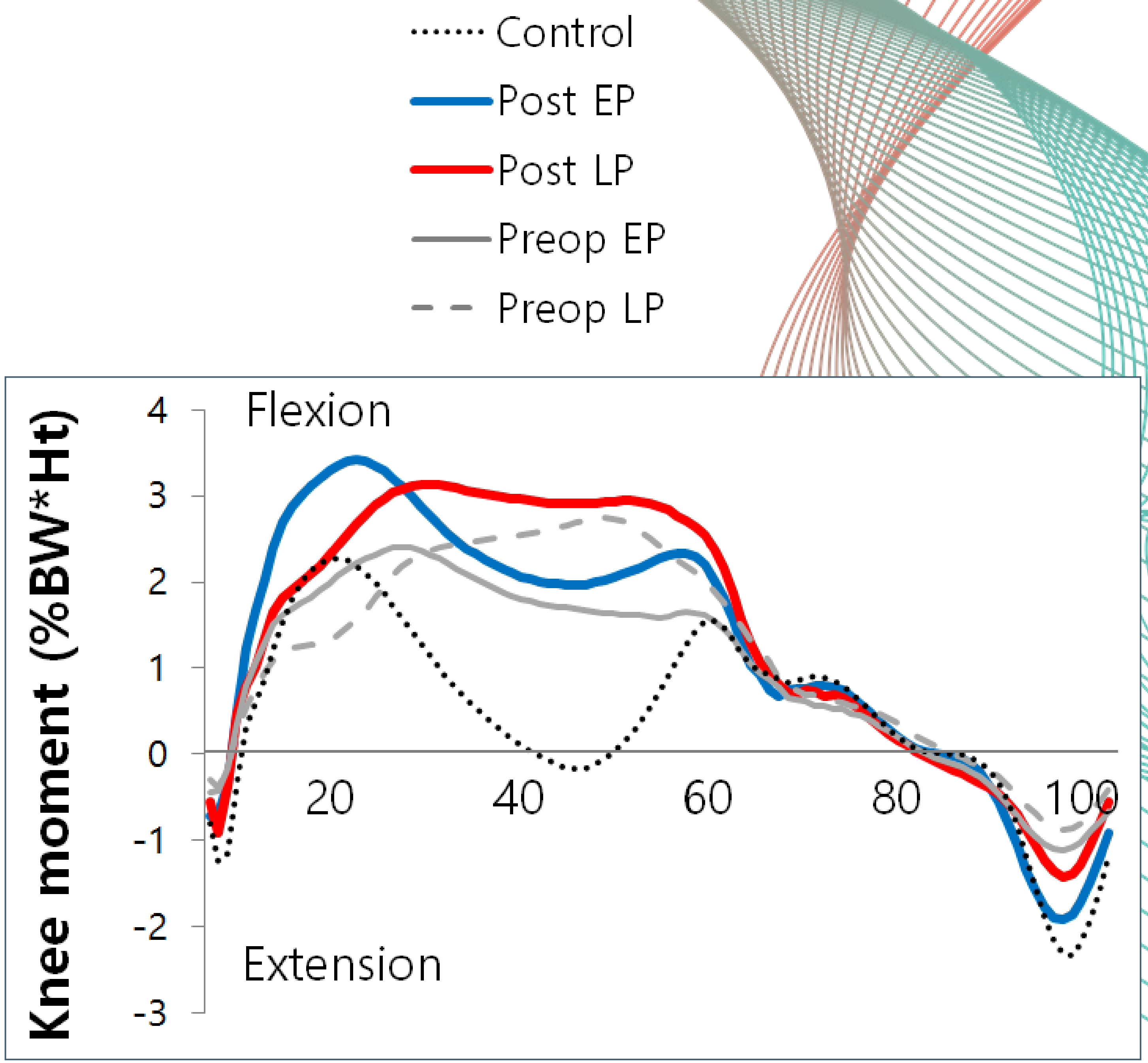
Knee angular motion (°)
Flexion
80
60
40
20
0
Extension
Control
Post EP
Post LP
Preop EP
Preop LP
Ankle moment (%BW*Ht)
10
8
6
4
2
0
-2
Dorsiflexion
20
40
60
80
100
Plantarflexion
% gait cycle
Hip power (W/kg)
Generation
1
0.5
0
-0.5
-1
H1
H2
H3
Absorption
Knee power (W/kg)
Generation
0.5
0
-0.5
-1
-1.5
K1
K3
K2
K4
K5
Absorption
Ankle power (W/kg)
1.5
1
0.5
0
-0.5
Generation
A1
A2
20
40
60
80
100
Absorption
% gait cycle

Discussion

- **KFM & KAM (knee adduction moment)**
  - Typical biphasic pattern in EP
  - No biphasic in LP

  → Force is continuously loaded on knee joint with no release

  - Reversely changed (Preop. → Postop.)



	EP (30 TKAs)		LP (30 TKAs)	
	Preop.	Postop.	Preop.	Postop.
Timing of peak KFM (%GC)	34.30 (17.57)	**15.93** (4.23)	38.87 (16.26)	**39.43** (14.24)

Discussion

- **Toe-out angle**
  - Out-toeing gait in OA patients *Tazawa 2014*
    → reduction of KAM during late stance
  - Decreased med./lat. hamstring activation ratio in medial knee OA *Lynn 2008*
  - Moving ground reaction force (GRF) vector close to the center of knee joint
    → Reducing KAM

Conclusion

- The persistent gait abnormalities including toe out gait and reduction of knee absorption power during terminal swing were more noticeable in LP group
- Patients who had more pain and less daily activity were included in LP group
- Peak timing of KFM could be helpful to understand the abnormal gait pattern and to develop the targeted rehabilitation after TKA
  → Hip and knee muscle strengthening for EP group
  → Balanced exercise between medial and lateral muscles as well as hip, knee and ankle muscle strengthening for LP group

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