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Characteristics of lower limb skeletal muscle activity by walking in knee osteoarthritis patients with knee extensor weakness

- Comprehensive assessment of muscle activity using positron emission tomography-

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COI disclosure of the authors

We declare that there is no COI

Introduction

The association between knee osteoarthritis (KOA) and knee extensor strength has been reported in numerous studies.

(Spinoso DH, et al. Adv Rheumatol. 2018)
(Tawy GF, et al. Gait Posture. 2018)

Decreased knee extensor strength is associated with decreased gait function, with a weight-bearing index (WBI) of 0.45.

(Yamamoto T, et al. Sportsmedicine)

However, how a reduction in knee extensor strength due to KOA alters other muscle activities during gait remains unclear.

Introduction

Surface electromyography is a typical assessment tool used to evaluate muscle activity during gait

(Robbins SM, et al. Osteoarthr Cartil. 2019)
(Lohnes J, et al. Gait Posture. 2023)

➡ **Difficult to assess deep muscles**

We focused on

18F-Fluorodeoxyglucose (FDG)-Positron Emission Tomography (PET)-Computed Tomography (CT),

which evaluates muscle activity from glucose metabolism.

Introduction

Aim

To determine knee joint extensor muscle strength affects whole body muscle metabolism after walking in patients with KOA.

※ This prospective study was approved by the Ethics Review Committee for Clinical Trials of our hospital (2021-007) and Advanced Medical Centre (6137).

Methods -subjects-

KL grade Ⅱ
22 patients

WBI ≧ 0.45

Group A
n=7
male : 5, female : 2

≦ 0.45

Group B
n=15
male : 6, female : 9

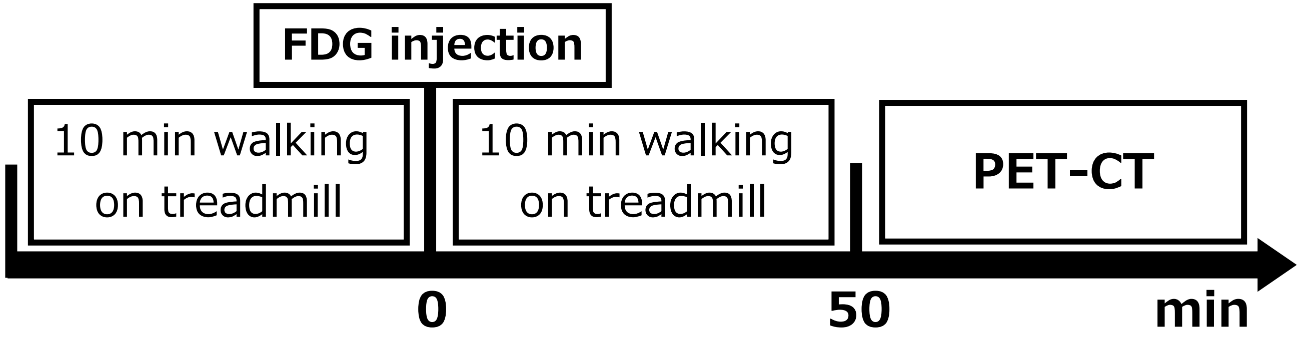
<u>Exclusion criteria</u>

- ☐ HbA1c≥6.5
- ☐ neurological impairment
- ☐ History of cardiac disease
- ☐ History of lower limb surgery

Knee extensor strength

Methods -measurement-

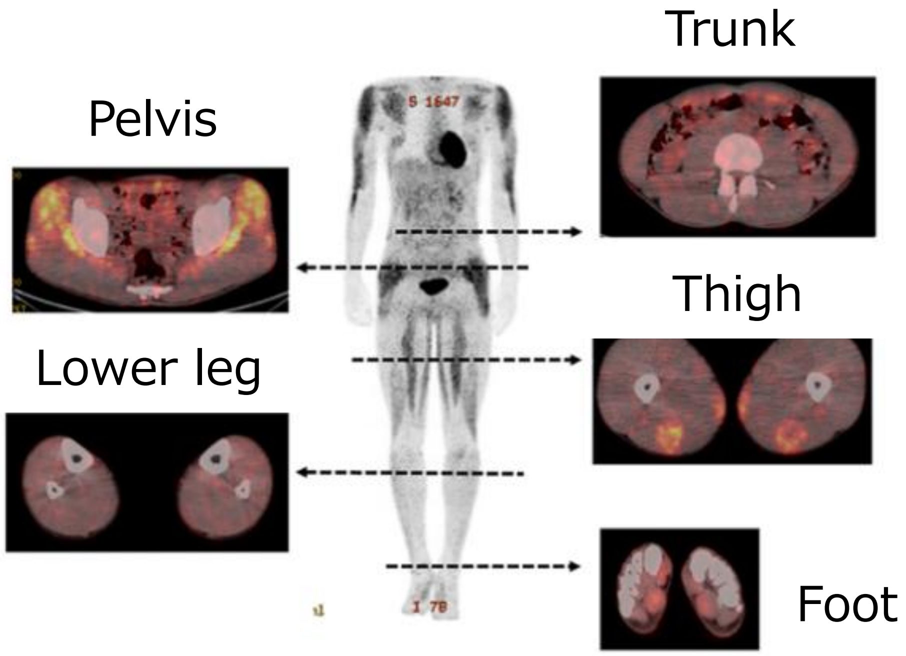
Protocol



Target

- ☐ Pelvis (8)
- ☐ Thigh (10)
- ☐ Lower leg (10)
- ☐ Foot (7)

Total **35** muscles



(Oshima T, et al. J Orthop Surg. 2019)

The region of interest was determined from the cross-sectional view of the muscle abdomen and the FDG standardised uptake value (SUV) of muscle tissue per unit area was determined.

Comparison between two groups using Wilcoxon test and calculation of effect size (*d*)

Results

		Group A (n=7)	Group B (n=15)	p value	ES (*d*)
Sex (male:female)		5:2	6:9	0.17	-
Age (year)		64.3±4.9	64.8±6.2	0.70	-
Height (cm)		1.65±0.1	1.61±0.1	0.22	-
Weight (kg)		66.5±11.8	60.9±9.0	0.42	-
BMI (kg/m²)		24.3±3.5	24.6±4.0	0.94	-
VAS (mm)		7.9±10.9	28.7±24.3	0.06	1.10
WBI	Knee extensor (kgf/kg)	0.54±0.04	0.36±0.09	<0.01	2.58
	Hip abductor (kgf/kg)	0.23±0.06	0.18±0.05	0.08	0.91

Mean ± standard deviation, median (min-max)

BMI; body mass index, VAS; visual analogue scale, WBI; weight bearing index

Results LSI of peak torque

Area	Muscles	Group A (n=7)	Group B (n=15)	P-value	ES (*d*)
Pelvis	Iliacus	0.99 ± 0.17	1.01 ± 0.16	0.72	0.12
	Gluteus maximus	0.81 ± 0.22	1.02 ± 0.46	0.67	**0.58**
	Gluteus medius	1.25 ± 0.40	1.23 ± 0.54	0.58	0.04
	Gluteus minimus	1.60 ± 0.83	1.47 ± 0.96	0.83	0.14
	Piriformis	0.85 ± 0.27	0.92 ± 0.20	0.44	0.29
	Obturator internus	0.84 ± 0.12	0.87 ± 0.15	0.60	0.22
	Obturator externus	0.96 ± 0.13	1.04 ± 0.21	0.48	0.45
	Tensor fasciae latae	0.48 ± 0.07	0.73 ± 0.48	0.20	**0.73**
Thigh	Rectus femoris	0.57 ± 0.10	0.59 ± 0.10	0.72	0.20
	Vastus lateralis	0.67 ± 0.07	0.67 ± 0.12	0.72	0.0
	Vastus intermedius	0.81 ± 0.11	0.79 ± 0.17	0.32	0.14
	Vastus medialis	0.64 ± 0.08	0.65 ± 0.10	0.70	0.11
	Sartorius	0.66 ± 0.20	0.75 ± 0.21	0.36	0.44
	Gracilis	0.68 ± 0.16	0.85 ± 0.38	0.32	**0.58**
	Semimembranosus	0.66 ± 0.12	0.83 ± 0.39	0.48	**0.59**
	Semitendinosus	0.55 ± 0.06	0.68 ± 0.21	0.084	**0.84**
	Biceps femoris	0.63 ± 0.23	0.69 ± 0.23	0.94	0.26
	Adductor muscles	0.85 ± 0.12	0.88 ± 0.17	0.92	0.20

Results *LSI of peak torque*

Area	Muscles	Group A (n=7)	Group B (n=15)	P-value	ES (*d*)
Lower leg	Popliteus	1.14 ± 0.12	1.52 ± 0.92	1.00	**0.58**
	Tibialis anterior	1.25 ± 0.24	1.97 ± 0.92	0.12	**1.07**
	Extensor hallucis longus	1.41 ± 0.39	2.01 ± 1.33	0.23	**0.89**
	Extensor digitorum longus	1.69 ± 0.82	1.89 ± 1.30	0.67	0.18
	Peroneus longus	1.18 ± 0.36	1.41 ± 0.55	0.53	0.49
	Peroneus brevis	1.03 ± 0.30	1.21 ± 0.34	0.31	**0.56**
	Flexor digitorum longus	1.10 ± 0.15	1.19 ± 0.35	0.57	0.33
	Tibialis posterior	1.26 ± 0.27	1.34 ± 0.48	0.86	0.21
	Flexor hallucis longus	0.99 ± 0.23	1.21 ± 0.46	0.26	**0.60**
	Triceps surae	1.13 ± 0.18	1.23 ± 0.38	0.62	0.36
Foot	Abductor hallucis	1.96 ± 0.45	1.85 ± 0.86	0.48	0.16
	Quadratus plantae	1.46 ± 0.46	1.61 ± 0.75	0.57	0.24
	Flexor digitorum brevis	1.95 ± 0.93	1.98 ± 1.09	1.00	0.03
	Abductor digiti minimi	1.37 ± 0.41	1.75 ± 1.10	0.83	0.46
	Flexor hallucis brevis	2.10 ± 0.43	2.13 ± 0.90	0.89	0.04
	Adductor hallucis	2.17 ± 0.65	2.19 ± 1.15	0.72	0.02
	Interosseous	1.59 ± 0.55	1.69 ± 0.86	1.00	0.14

Discussion

Tensor fasciae latae, gracilis, semimembranosus, semitendinosus

Group B patients tend to have more knee joint pain and stronger bicipital muscles that contribute to the rotation of the knee joint.

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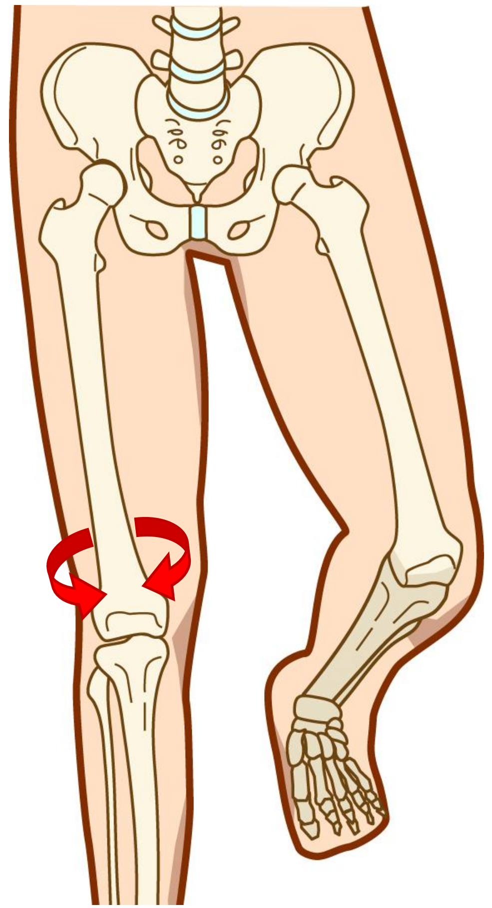
Stabilization of rotational instability

(Toor AS, et al. Knee Surg Sports Traumatol Arthrosc, 2019)



Tibialis anterior, extensor hallucis longus

In the lower leg, the ankle joint and toe dorsiflexors tend to work harder.

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Increased muscle activity and stabilization around the knee joint resulted in the need to gain **toe clearance** when walking.

(Guadagnin EC, et al. Gait Posture, 2019)

Conclusion

Patients with KOA with decreased knee extensor strength

may achieve joint stability through sustained bi-articular

muscle activity across the hip and knee joints during walking.

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