Kinetic Ergocise based on Movement Analysis

Interesting Articles for KEMA Members

[RESEARCH REPORT]

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Loading of the Knee Joint During Ergometer Cycling: Telemetric In Vivo Data

Joint loading is an influential factor in the development and progression of osteoarthritis (OA).[1,15] Unfavorable loading conditions, such as increased medial compartment forces due to varus malalignment, are known to increase the risk of unicompartmental knee OA.[22,27] Furthermore, the durability of total knee replacements (TKRs) is influenced by loading of the implant. Osteolysis due to wear debris is a common reason for aseptic implant loosening.[19] Following cartilage repair, cruciate ligament reconstruction, or TKR surgery, patients are commonly advised against activities that may endanger the healing process of the affected structures in the early postoperative period.[10,23,24]

STUDY DESIGN: Within-subject, repeated-measures design.

OBJECTIVES: To measure tibiofemoral contact forces during cycling in vivo and to quantify the influences of power, pedaling cadence, and seat height on tibiofemoral contact forces.

BACKGROUND: Cycling is usually classified as a low-demand activity for the knee joint and is therefore recommended for persons with osteoarthritis and rehabilitation programs following knee surgery. However, there are limited data regarding actual joint loading.

METHODS: Instrumented knee implants with telemetric data transmission were used to measure the tibiofemoral contact forces. Data were obtained in 9 subjects, during ergometer cycling and walking, 15 ± 7 months after total knee arthroplasty. Tibiofemoral forces during cycling at power levels between 25 and 120 W, cadences of 40 and 60 rpm, and 2 seat heights were investigated.

RESULTS: Within the examined power range, tibiofemoral forces during cycling were smaller than those during walking. At the moderate condition of 60 W and 40 rpm, peak resultant forces of 119% of body weight were measured during the pedal downstroke. Shear forces ranged from 5% to 7% of body weight. Forces increased linearly with cycling power. Higher cadences led to smaller forces. A lower seat height did not increase the resultant force but caused higher posterior shear forces.

CONCLUSION: Due to the relatively small tibiofemoral forces, cycling with moderate power levels is suited for individuals with osteoarthritis and rehabilitation programs following knee surgery, such as cartilage repair or total knee replacement. The lowest forces can be expected while cycling at a low power level, a high cadence, and a high seat height. *J Orthop Sports Phys Ther 2012;42(12):1032-1038, Epub 5 September 2012. doi:10.2519/jospt.2012.4001*

KEY WORDS: *force, telemetry, tibiofemoral, TKR*

Cycling to improve physical fitness, muscle strength, and function after injury or surgery is a common exercise in rehabilitation programs. With regard to tibiofemoral contact forces and ligament strains, cycling is typically classified as a low-demand activity and therefore recommended in rehabilitation protocols.[10,14,17,18,20] However, cycling for more than 30 minutes per day has been found to be a risk factor for OA.[5]

Valid data regarding tibiofemoral joint loading during cycling are lacking. Recommendations are based mainly on calculations using gait analyses and analytical models.[4,9,12,26] However, these models have various limitations. Joint loading primarily is caused by external forces and muscle forces. Though external loads, such as ground reaction forces, can be measured, the determination of muscle forces remains challenging. In most studies, an inverse dynamic approach is used to calculate joint contact forces. However, due to the complexity of the models and

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고정식 자전거 (ergometer cycle) 타는 동안 무릎 관절의 부하

Loading of the Knee Joint

During Ergometer Cycling

Telemetric In Vivo Data

그러나, 현재까지 자전거 타기와 관련하여 무릎관절에 발생되는 힘을 측정한 연구는 제한적이다. 따라서 본 연구는;

1. 무릎 삽입물을 이용하여 자전거를 타는 동안 경대퇴골 접촉력 측정
2. power, cadence, seat height에 따른 접촉력측정
3. 자전거를 탈 때와 걸을 때 접촉력 측정 및 비교
4. 자전거를 탈 때와 걸을 때의 접촉력 비교를 하였다.

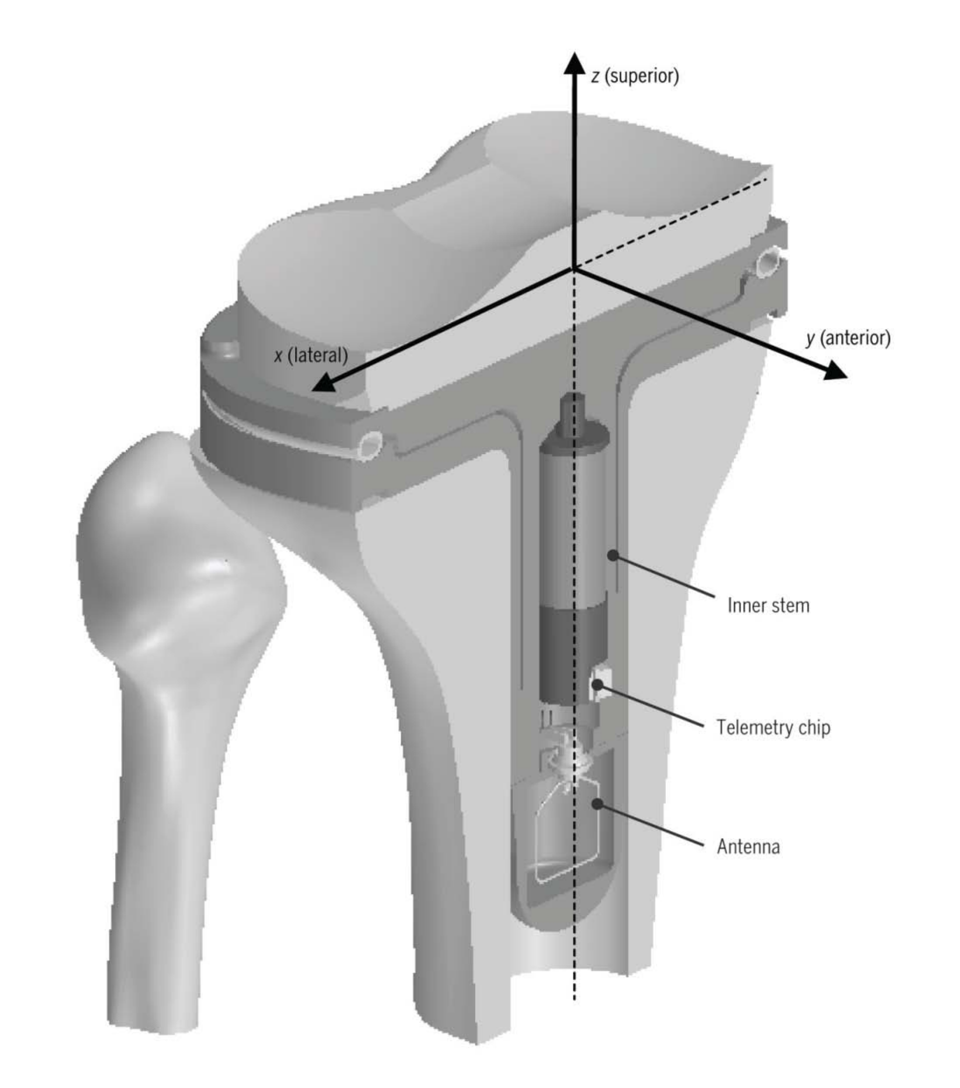
ergometer cycle

관절염이 있는 6명의 남자와 3명의 여자에게 instrumented tibial tray(ITT)를 삽입.

ITT는 경골에 삽입되어 무릎관절에서 발생되는 힘들을 측정하여 송출할 수 있도록 설계 된 장비.

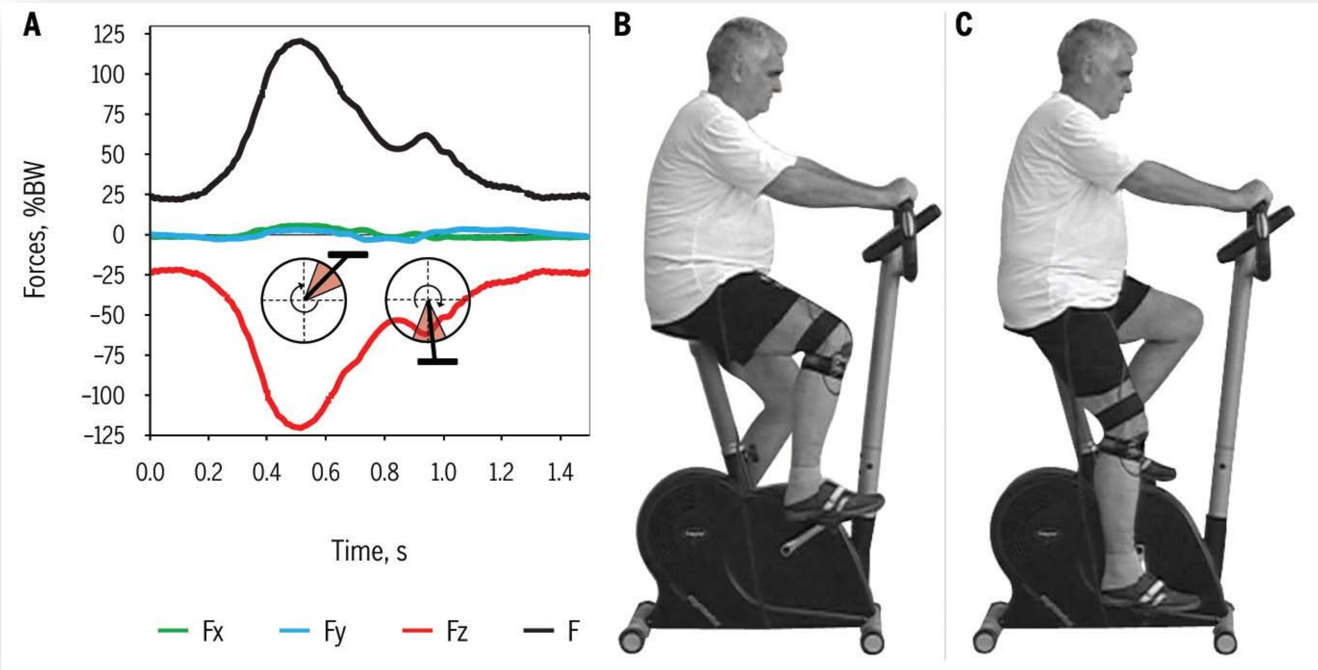
측정

1. 표준 의자 높이, 40rpm 고정-> power 25, 35, 50, 60, 70, 85, 95 W 시 접촉력 측정 (W : 힘든 정도 / rpm : 분당 회전 속도)
2. 표준 의자 높이, 60rpm 고정 -> 50, 75, 95, 120 W 시 접촉력 측정
3. 낮은 의자, 40rpm 고정 -> power 25, 35, 50, 60, 70, 85, 95 W 시 접촉력 측정
4. 걸을 때의 접촉력 측정



instrumented tibial tray 도식

실험결과



* 페달을 한바퀴 돌리는 동안 발생되는 접촉력 : A

– 오른발 기준, 페달을 아래로 밟을 때 무릎관절 70~80도에서 최고 접촉력

(119% ± 20% 체중) 발생 : B

* 무릎 관절의 최대 신전 시 두번째 높은 접촉력 발생 : C

* 전단력(shear force)은 유의한 차이 없음

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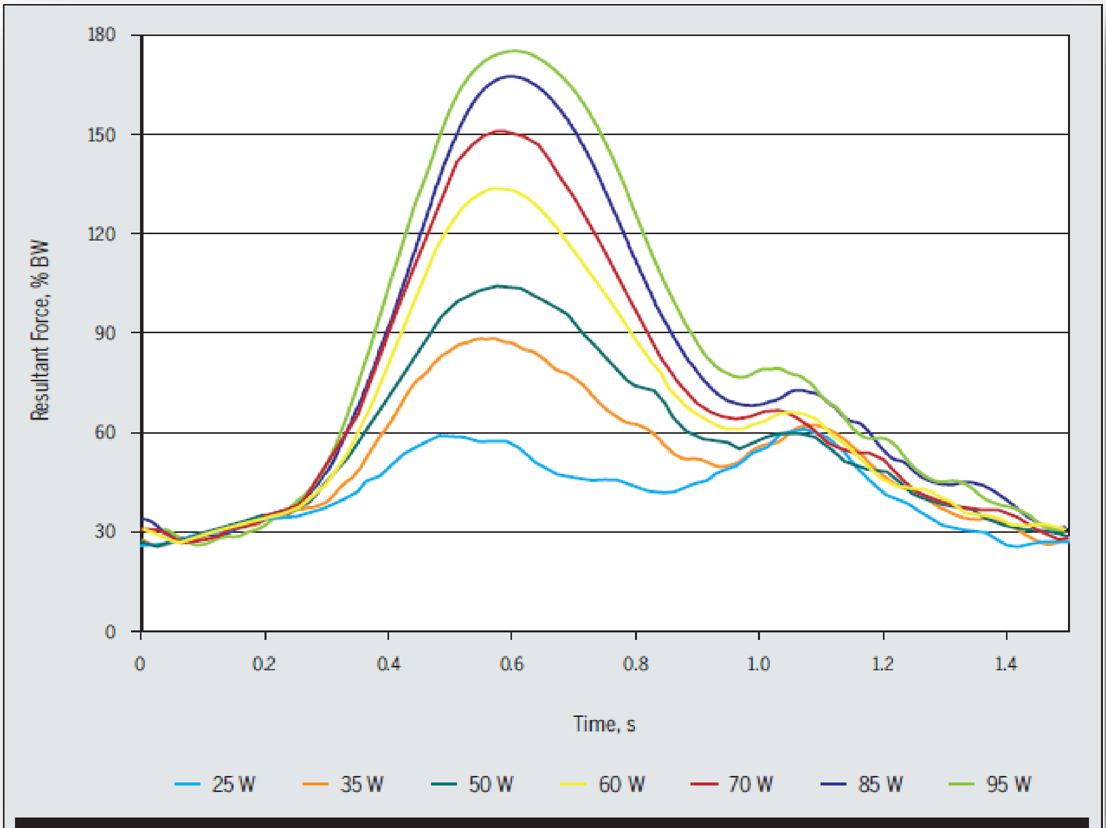
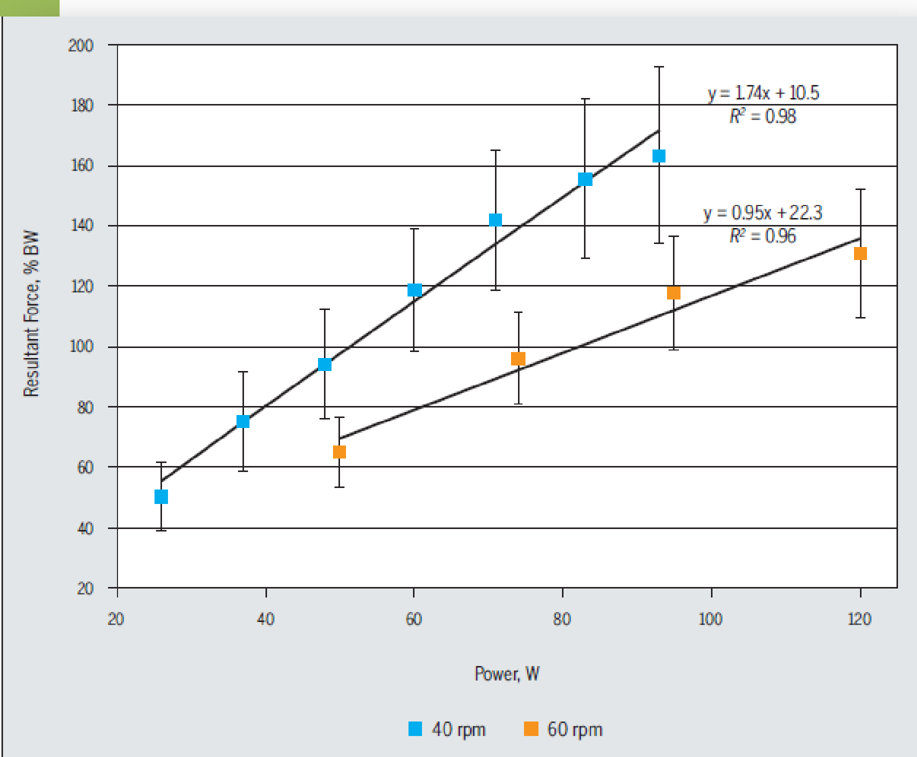


파워가 증가 할 수록 최고 접촉력 증가

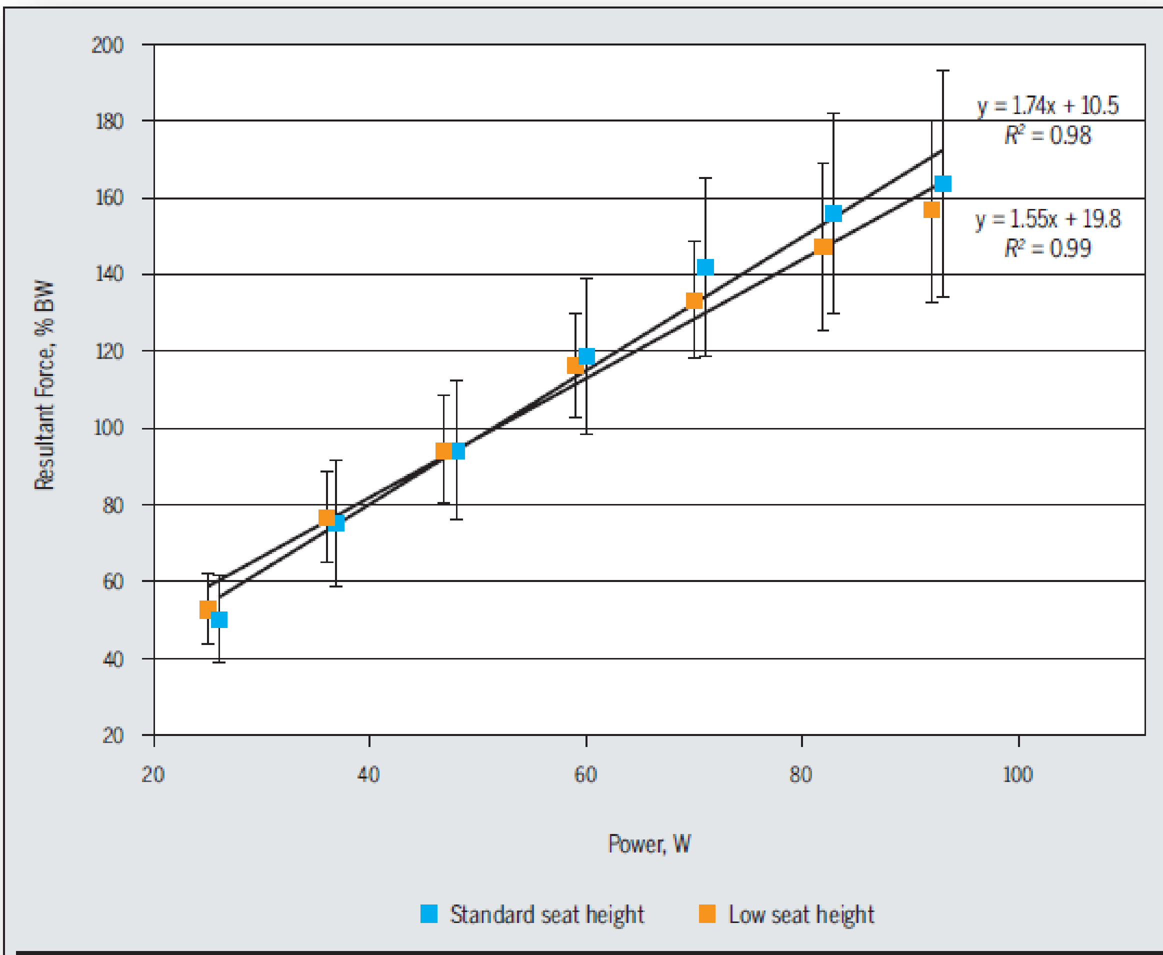


60rpm이 40rpm보다
동일 power 시 더 작은
접촉력을 보임

TABLE 1 Average Peak Forces During Walking and Cycling With a Cadence of 40 rpm and a Standard Seat Height*

Cycling	$+F_x$	$-F_x$	$+F_y$	$-F_y$	F_{res}
25 W	2 ± 1 (22)	4 ± 2 (33)	3 ± 3 (21)	6 ± 3 (25)	50 ± 11 (20)
35 W	3 ± 2 (33)	4 ± 2 (33)	4 ± 3 (29)	6 ± 3 (25)	75 ± 16 (30)
50 W	5 ± 2 (56)	4 ± 2 (33)	5 ± 3 (36)	6 ± 3 (25)	94 ± 18 (37)
60 W	6 ± 3 (67)	5 ± 2 (42)	6 ± 3 (43)	7 ± 3 (29)	119 ± 20 (47)
70 W	7 ± 3 (78)	5 ± 2 (42)	6 ± 3 (43)	7 ± 3 (29)	142 ± 23 (56)
85 W	8 ± 3 (89)	5 ± 2 (42)	7 ± 2 (50)	8 ± 3 (33)	156 ± 26 (62)
95 W	8 ± 3 (89)	5 ± 2 (42)	8 ± 2 (57)	8 ± 3 (33)	163 ± 29 (65)
Walking	9 ± 7	12 ± 8	14 ± 4	24 ± 11	252 ± 38

평균 의자 높이와 40rpm에서 여러 power에 따른 접촉력과 걸을 때의 접촉력 비교
➔ 자전거를 탈 때보다 걸을 때 접촉력이 증가



의자 높이에 따른 접촉력은 유의한 차이를 보이지 않았다.
대신, 낮은 의자 높이에서 뒤쪽 방향으로의 전단력이 평균 의자 높이보다 30% 더 증가하였다.

결론

결과적으로, 중간 정도의 파워 수준으로 자전거를 탈 때의 경대퇴골 접촉력은 건기에 비해 더 작았으며, 가장 작은 경대퇴골 접촉력은 낮은 power에서 높은 cadence와 평균 의자 높이에서 측정되었습니다.

이 연구의 저자들은 자전거 타기가, 결과에서 보는 것과 같이, 낮은 접촉력을 보이기 때문에 무릎 손상 또는 수술 뿐만 아니라 퇴행성 관절염 또는 TKR에 따른 재활 프로그램으로 적절하다고 제시하였습니다.

➔ 무릎 수술 또는 OA에 환자들에게 자전거 타기를 처방할 때 좋은 근거 자료로 활용될 수 있을 것 같습니다.

-KEMA 책임 연구원 정성대-

-문의사항은 **KEMA** 홈페이지 기사에 댓글로 남겨주세요-

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