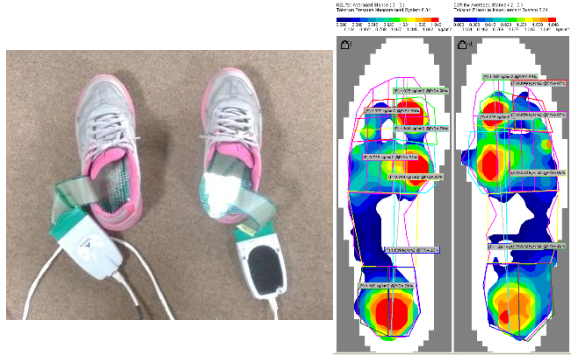
New evaluation tools for the foot and ankle disorders

충남의대 재활의학교실 안소영

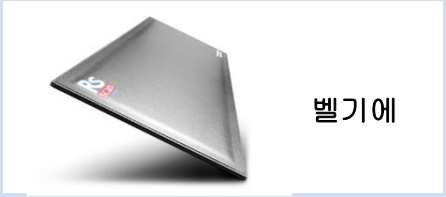
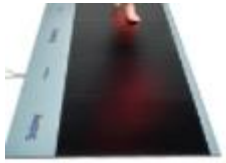
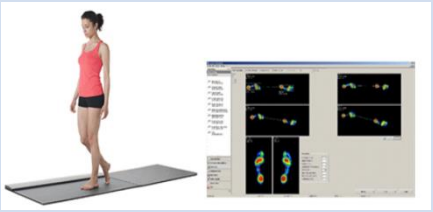
Evaluation for the foot and ankle disorders

- Physical examination: Inspection, palpation, neurological examination, biomechanical examination
- Podoscope
- Radiologic measurement
- Foot pressure analysis: static/dynamic, in-shoe/barefoot
- Gait analysis



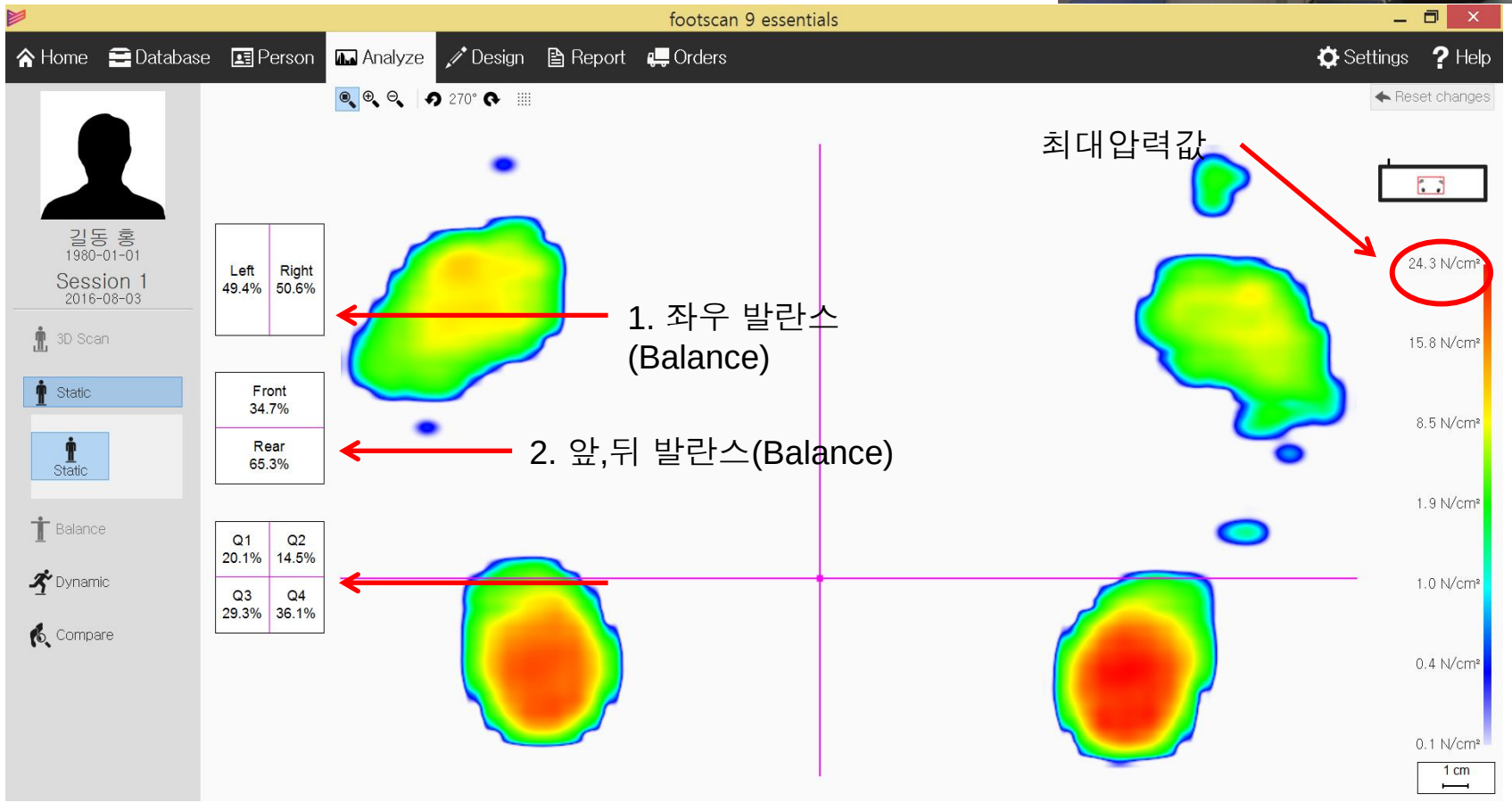
Foot Pressure Analysis

Foot pressure analysis- barefoot

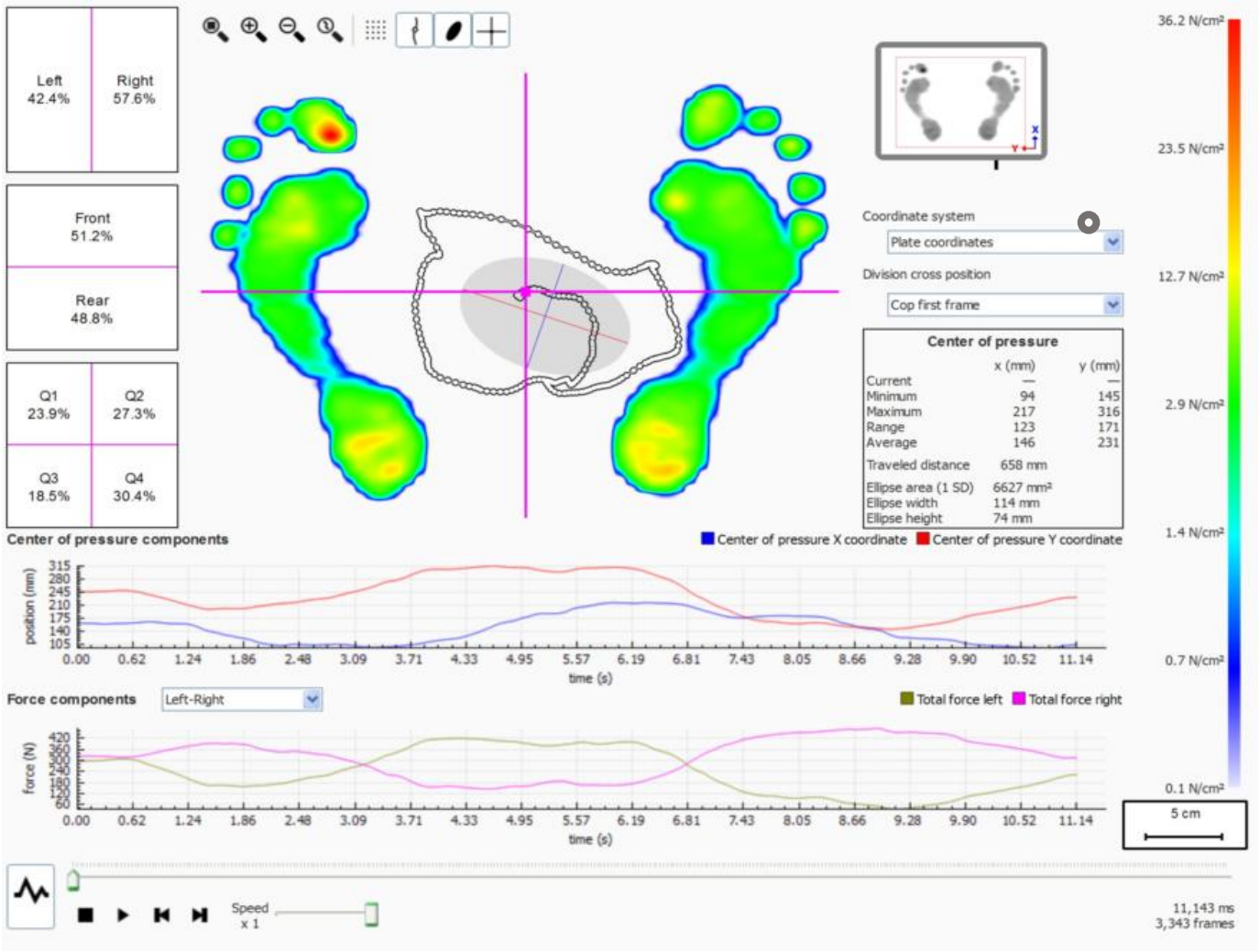
구분	**Materialise Motion** https://www.materialise.com	**Tekscan** https://www.tekscan.com	**Novel** https://www.novel.de/products/eme	**Sensormedica** https://www.sensormedica.com/
Foot pressure +Spatiotemporal gait parameter	 벨기에	 미국	 독일	
	RS Scan footscan	**Strideway (High-resolution)**	**Emed xl**	**FreeMed**
	크기: 1605X469mm 데이터 샘플링주파수: 200 Hz, 3D프린팅 맞춤 인솔(insole) 설계 및 주문 소프트웨어 내장	크기: 1300X650mm, 데이터 샘플링주파수: 250 Hz	크기: 1440x440mm, 데이터 샘플링 주파수: 100Hz	크기: 1800x500 mm, 데이터 샘플링 주파수: 200-400Hz 맞춤 인솔(insole) 설계 프로그램 연동
	force and plantar pressure gait spatiotemporal parameters Synchronize with gait lab product			
Foot pressure				
	The plug and play footscan® system	**MatScan®**	**emed®**	
	plantar pressure mapping Balance CoF trajeculatory			

Static evaluation

영역별 압력 분포율의 확인



Static evaluation

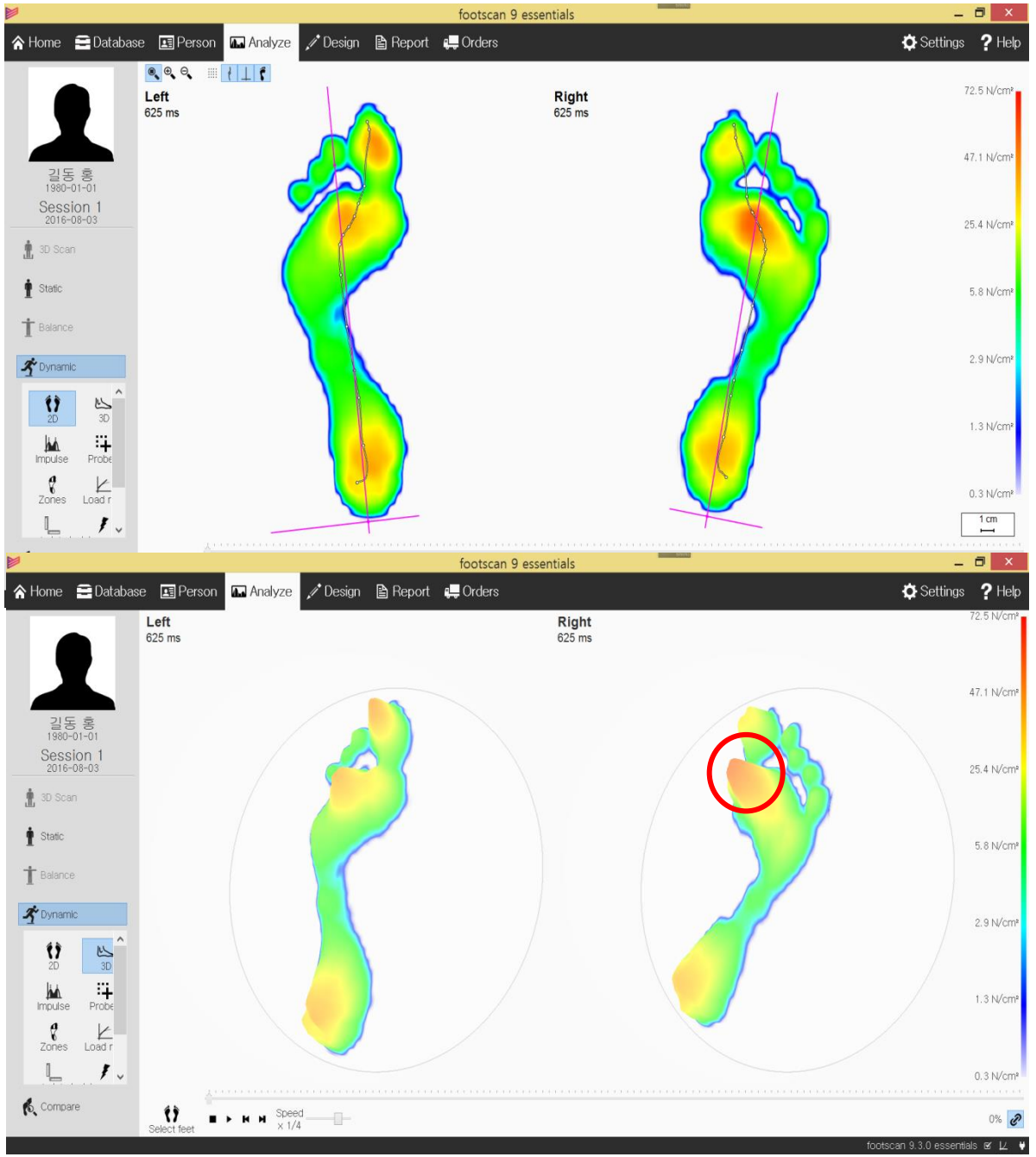


COP(Center of Pressure)의 이동 거리와 이동궤적

Dynamic evaluation

2D &3D Pressure analysis

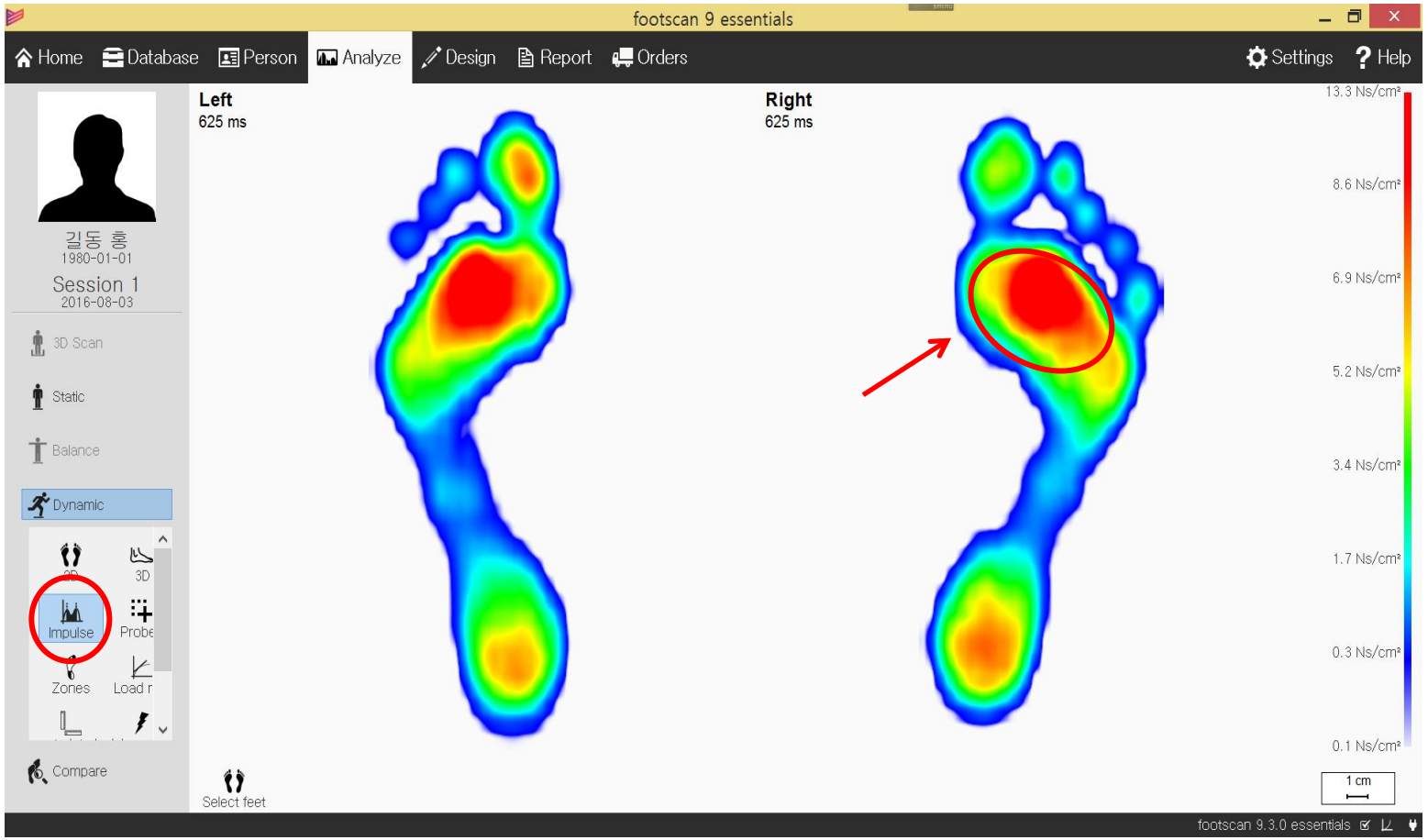
COP(Center Of Pressure)



Dynamic evaluation

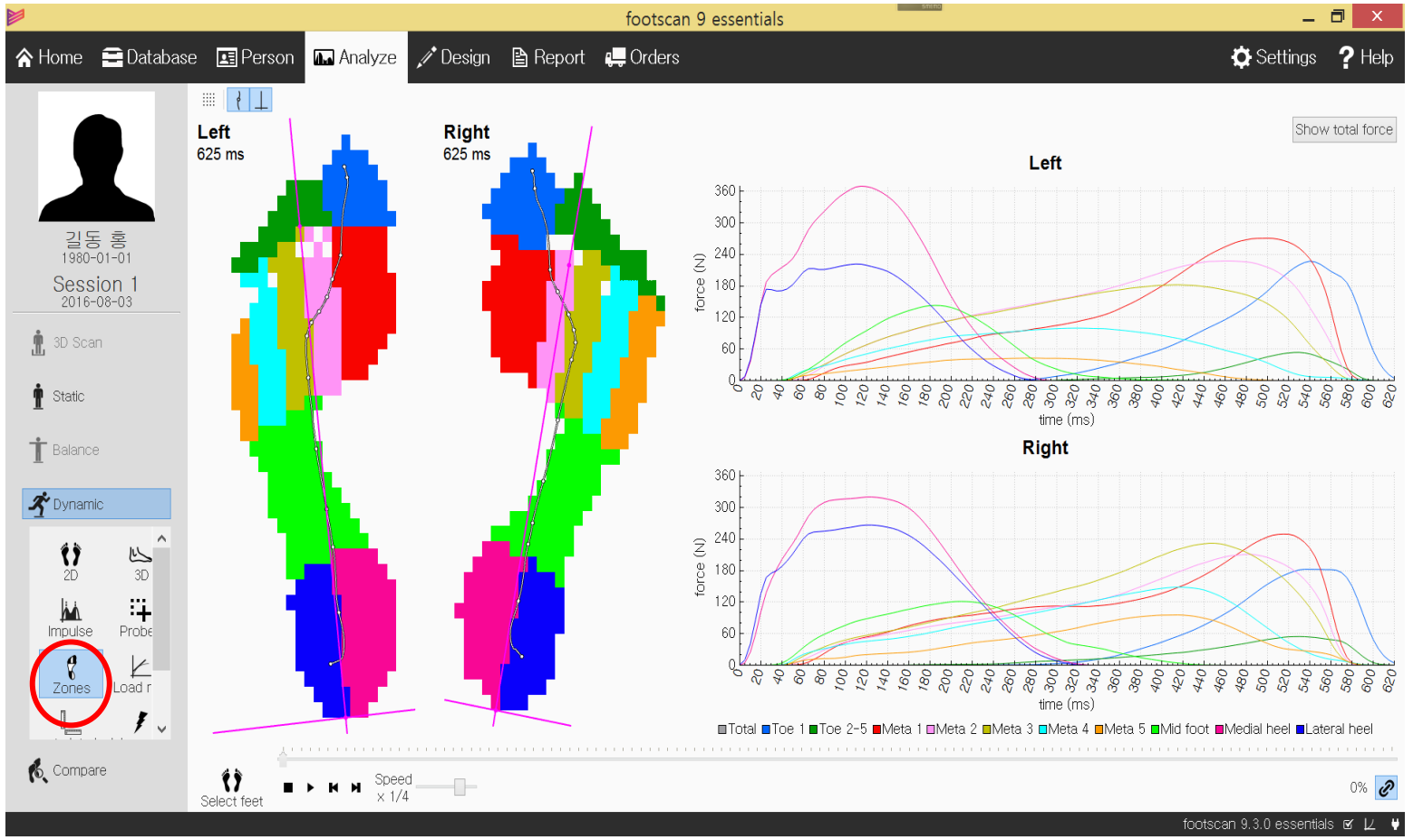
- 당뇨족부궤양 발생 위험 추측

Impulse
Force(N) x Time(s)

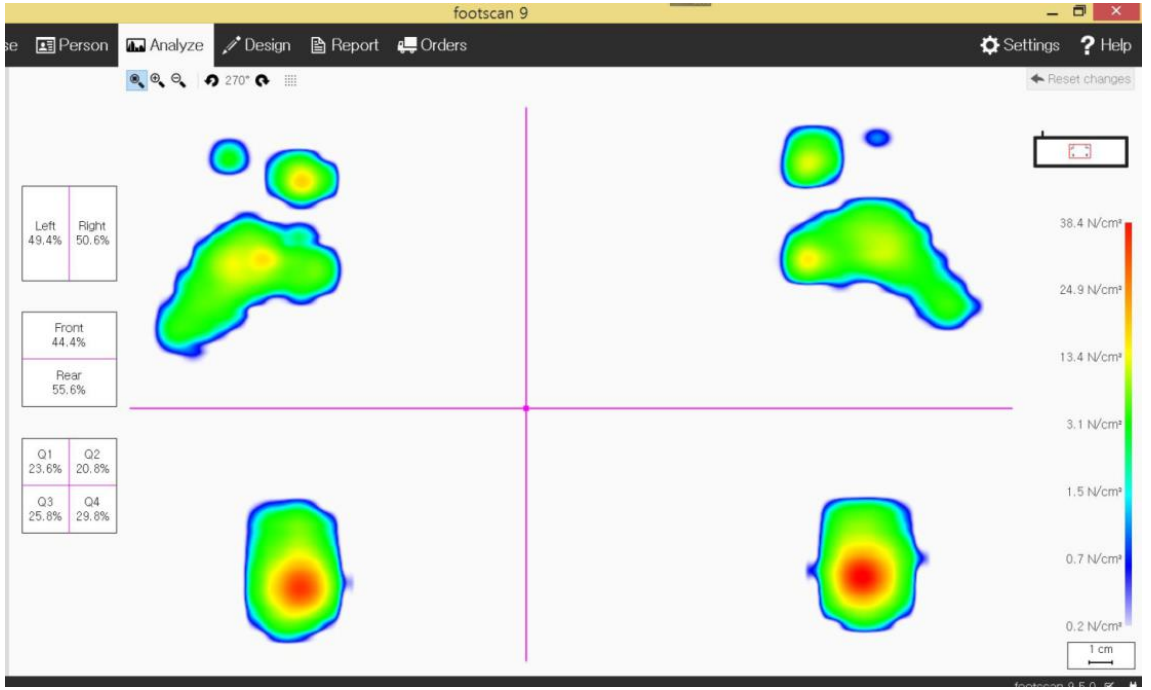


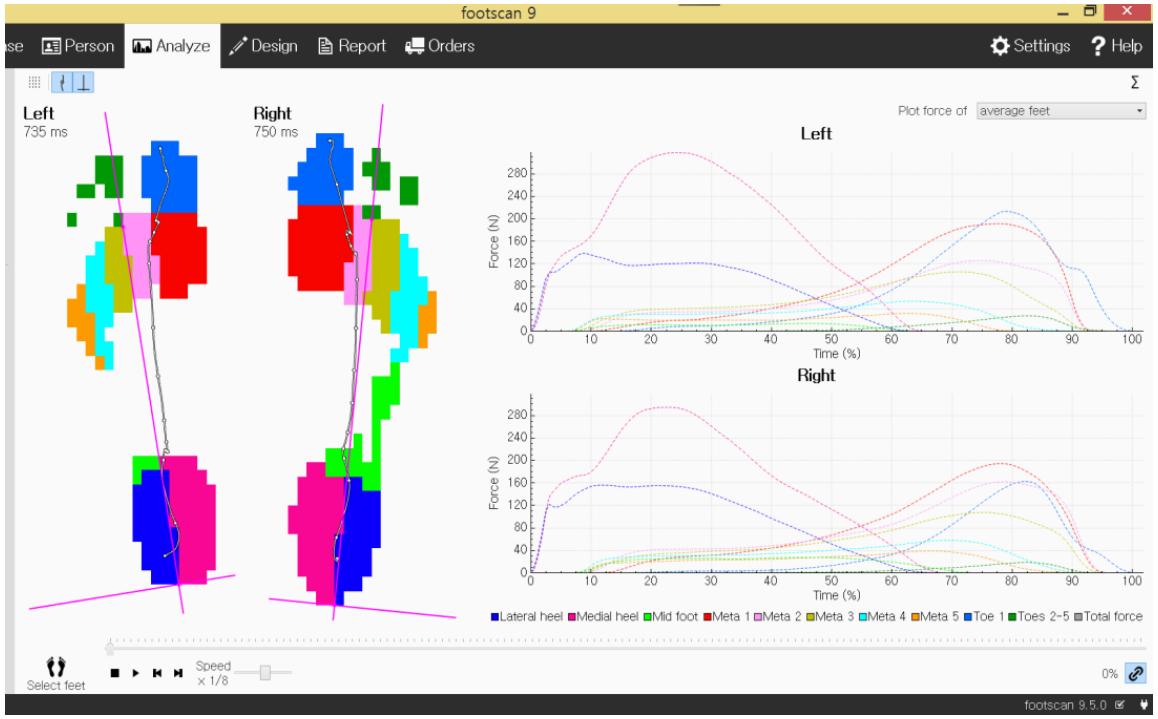
Dynamic evaluation

Zone분석

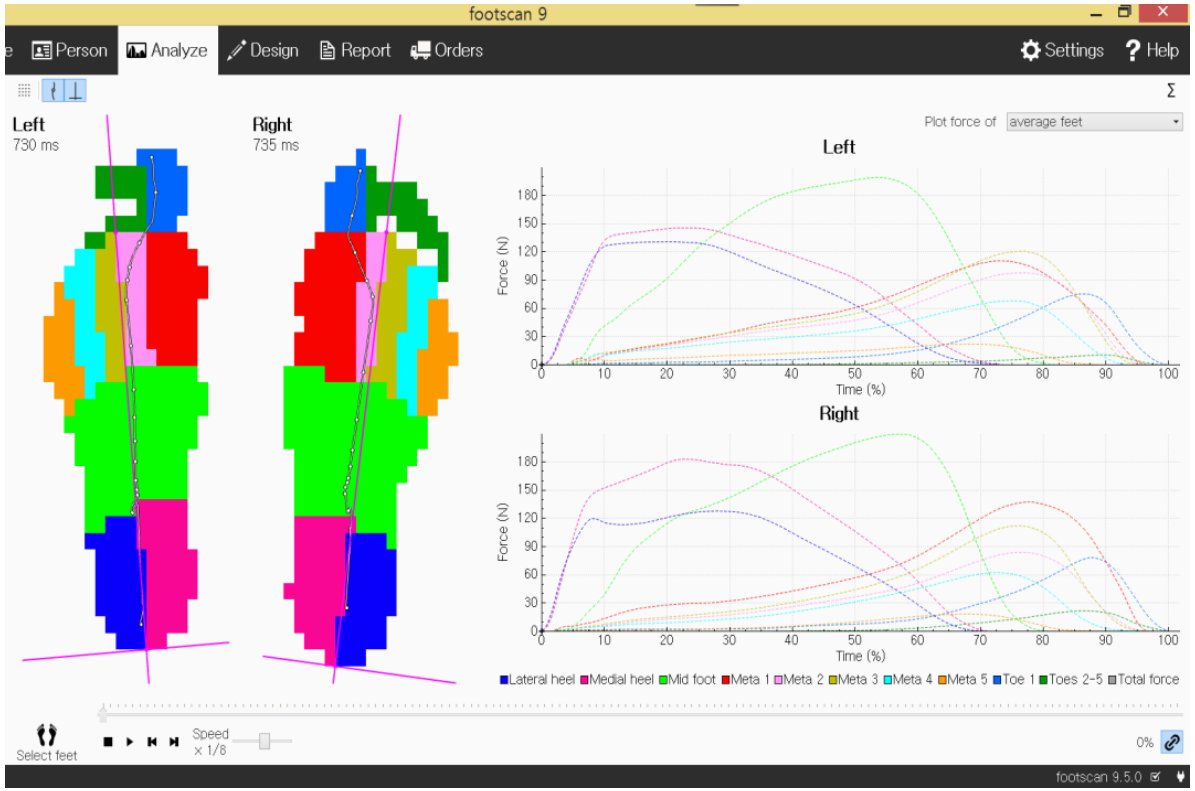


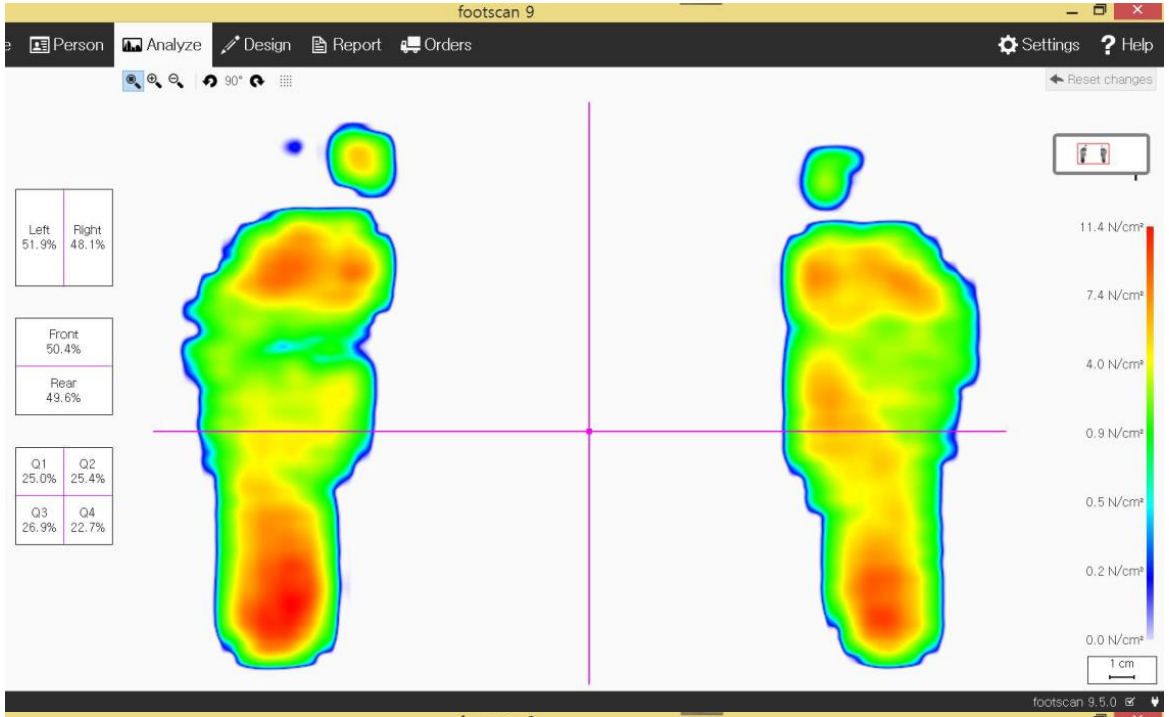
Patient 1Pes cavus



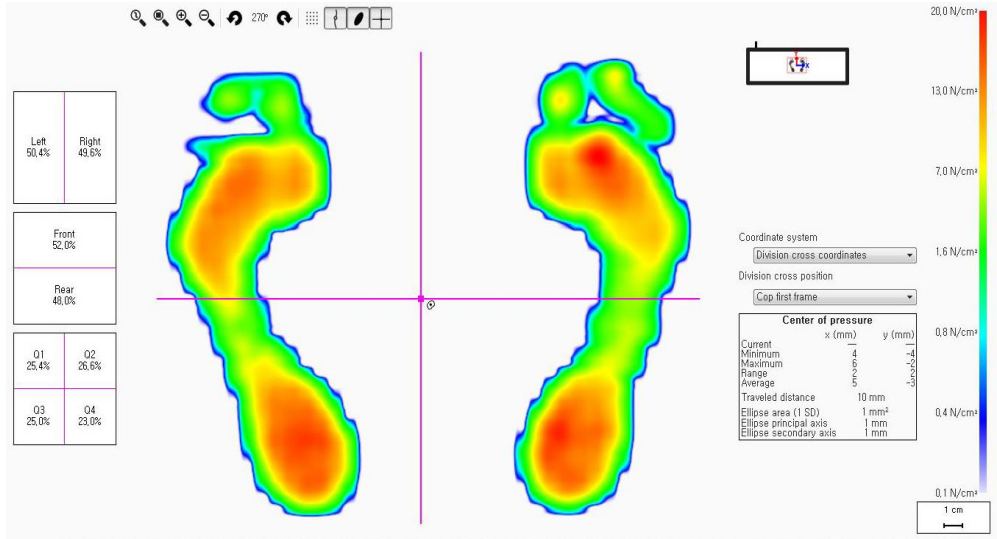


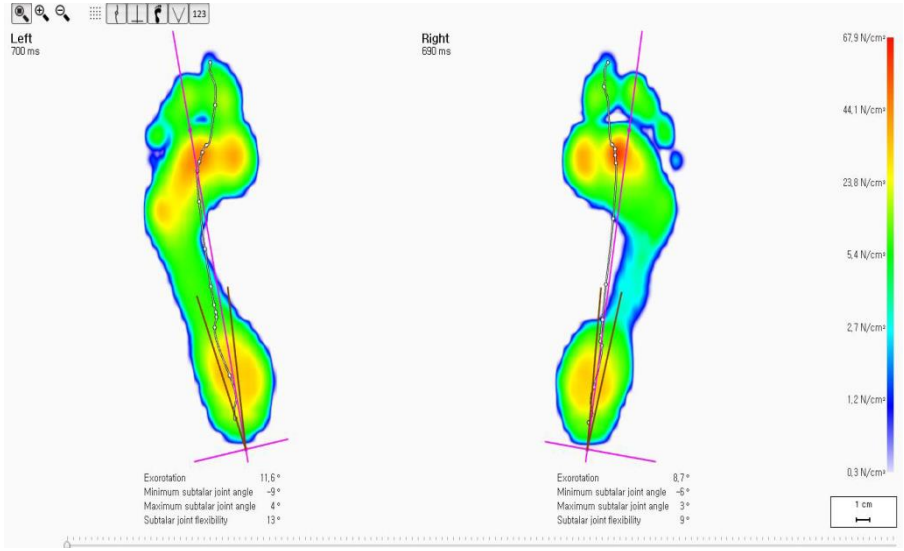
Patient 2 Pes planus

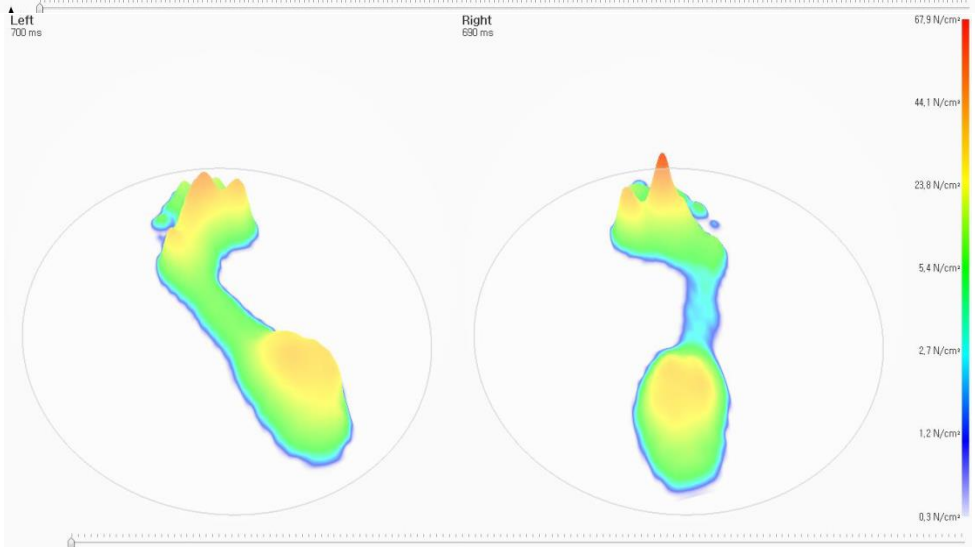


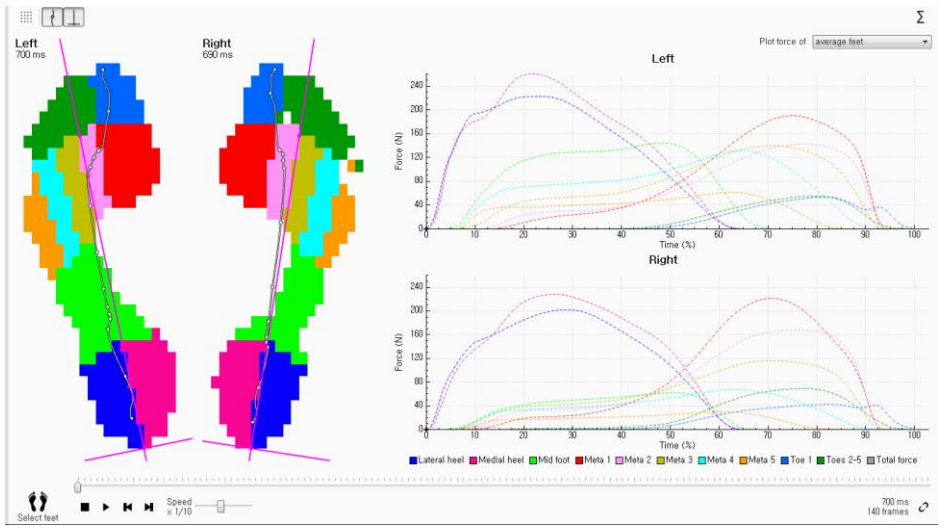


Patient 3 Hallux valgus









Foot pressure analysis- in-shoe

Tekscan https://www.tekscan.com	**Novel** https://www.novel.de/products/eme	**Noraxon** https://www.noraxon.com/
		
F-Scan System **F-Scan64**	**pedar®**	**Medilogic Insoles**
Temporal parameter, force, pressure CoF trajectories Synchronize with gait lab product		

Type of system	Advantage	Disadvantage
Plantar platform system	- Rigid platform. - Flat surface. - Large sensor area according to platform size (higher resolution). - Pressure sensors are positioned parallel to the supporting surface	- Limited length (0.5 m, 1 m, 2 m) depending on laboratory size area. - - A large number of foot steps required for data collection. - Need to target foot land in the platform surface (normal gait affected). - Normal gait patterns not guaranteed.
In-shoe system	- Flexible and embedded in shoes. - Applicable on various shoes and heel height. - Need not target foot landing at particular area - Data collection within the shoe	- Sensitivity of the sensor affected while insert into the shoes. - Heat trapped. - Limited sensor space area; restricted to insole size. - Normal gait patterns not guaranteed.

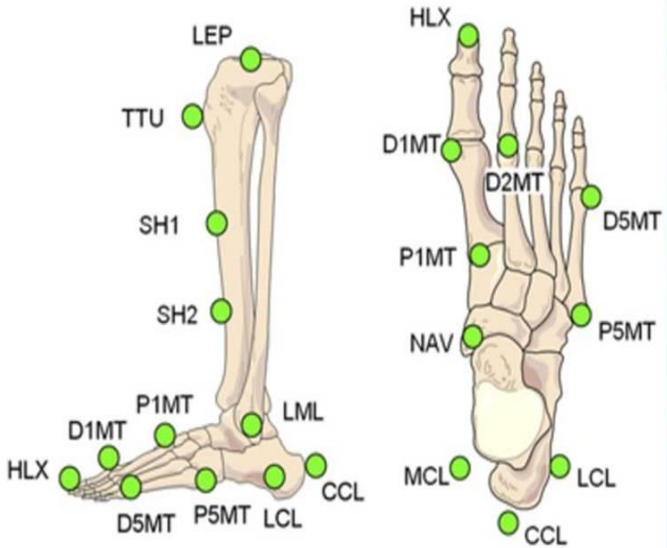
Siti Syazni Zulkifli, Wei Ping Loh, A state-of-the-art review of foot pressure, Foot and Ankle Surgery, Volume 26, Issue 1, 2020, Pages

Foot pressure analysis with treadmill

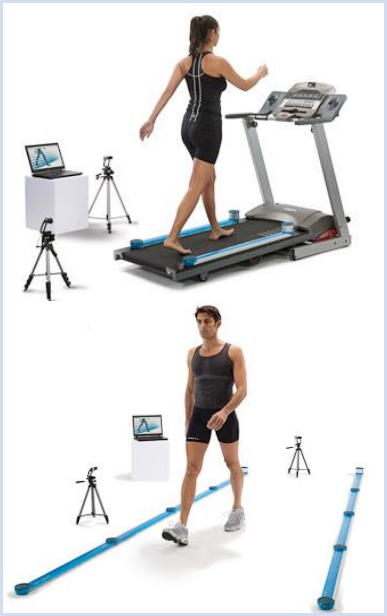
Sensormedica https://www.sensormedica.com/	Noraxon https://www.noraxon.com/	**지하이웰** **http://www.ghiwell.co.kr/**
		
Runtime ™ Treadmill	**Gaitway 3D Pressure/Force Treadmill**	**GHT2200**
Spatiotemporal gait parameter Foot load distribution Gait line		

Gait Analysis

Vicon 3D motion capture system (Oxford Metrics, Oxford, England) oxford foot model



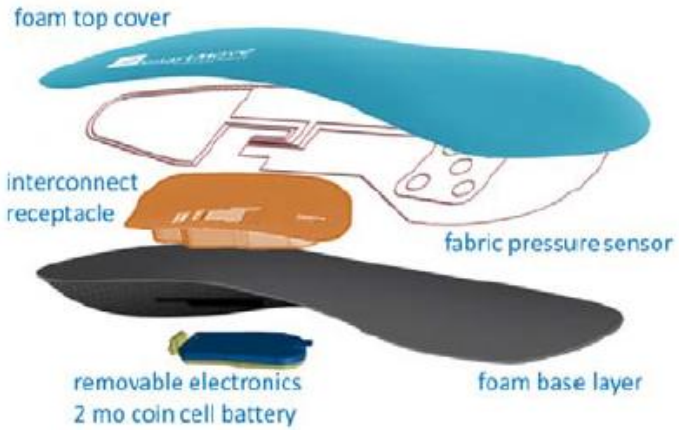
Gait analysis

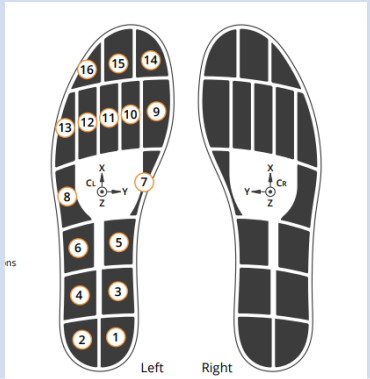
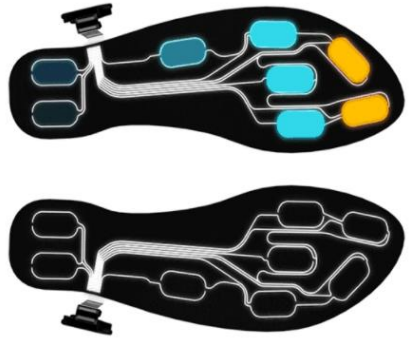
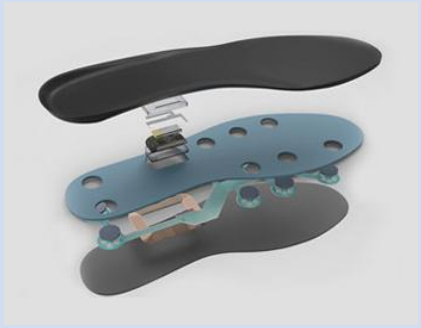
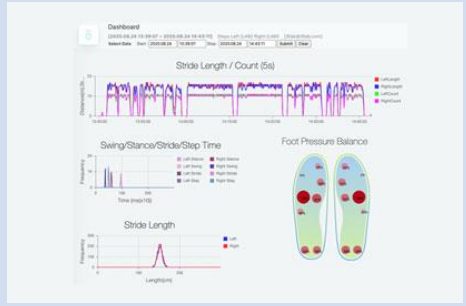
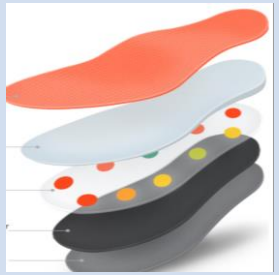
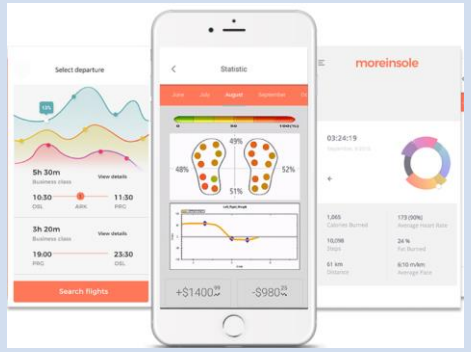
Microgait http://www.optogait.com/	**Motek** https://www.motekmedical.com/	**TecnoBody** **https://www.tecnobody.com/**	**알바이오텍** **http://www.humantrack.co.kr/**
	 		 
Optogait	**Grail/Caren**	**Walker view**	Human track
바(Bar)의 적외선 송수신을 이용한 시간, 공간 데이터 취득 비디오 연동을 통하여 Biofeedback 통한 보행훈련	Immersive VR environment 3D motion capture system Instrumented dual belt treadmill Integrated force plate	Position detection in front of the 3D camera Sensorized base with load cells Real time bio-feedback	IMU(관성측정장치) Stereo Camera를 이용한 융합 센서 시스템

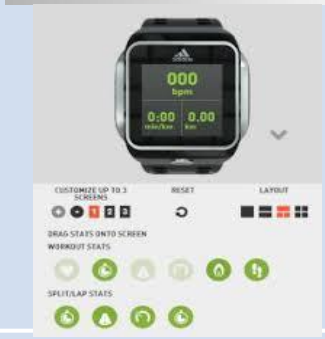
Smart Shoe/Insole

Smart insole

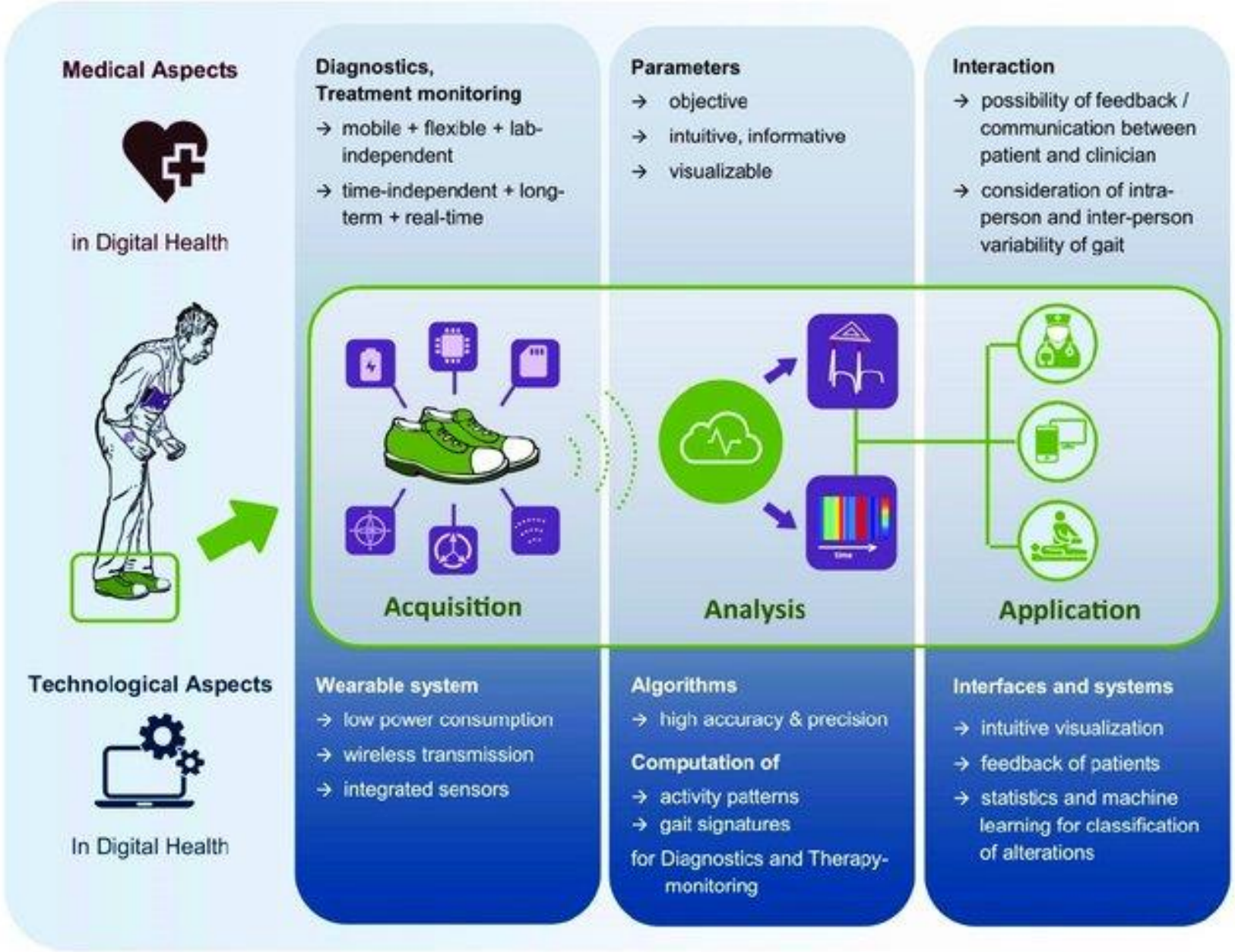
- 보행분석: 가속도계, 자이로스코프, 자력계
- 실시간 위치정보: GPS와 같은 위성 내비게이션 시스템
- 압력센서: 보행중 체중분포
- 내부상태센서: 배터리 및 메모리용량
- 주변환경센서: 대기압, 조명, 소리



RUNVI https://runvi.io/	OpenGO https://moticon.com/	ARION (ATO-GEAR) https://www.arion.run/	Foot logger(3L Labs) http://www.footlogger.com/	Moreinsole http://www.morethings.net/
	 	 	 	 
30 pressure-sensor 2 accelerometer Basic metrics: distance, duration, pace, calories Advanced metrics: cadence, foot strike pattern, asymmetry, gait analysis Algorithm: AL, Machin learning Realtime coaching	16 pressure-sensor 6 axis IMU plantar pressure distribution and vertical GRF Capturing foot trajectories and rotation for spatial and temporal motion metrics	8 pressure-sensor Multi-axis accelerometer Gyroscope spatial and temporal motion metrics balance, stability Realtime feedback,	8 pressure-sensor 3-axis accelerometer 보행거리, 속도, 걸음수, 칼로리 압력분포, 균형 Spatio temporal 보행지표 AI기반 퇴행성 질환 평가	10 pressure-sensor 3 axis accelerometer Foot pressure map steps, balance, gait pattern, calories, distance Coaching correct posture, Prediction of spinal disease Monitoring balance Monitoring rehabilitation

나이키+(2008) HyperAdapt (2016)	아디다스 마이코치(2010)	Digitsole(2014)	Xiaomi 리닝 스마트 (2014)	Underarmour(2017) HOVR Phantom HOVR Sonic
	 			
● 가속도 센서를 장착하여 보행 속도와 운동량 등을 센싱하여 스마트 폰으로 정보를 제공 ● 애플의 스마트폰과 연동하여 음악을 들으면서 운동을 할 수 있는 기능을 제공	● 전용 축구화 또는 운동화에 센서를 장착하여 거리, 러닝 페이스, 칼로리 측정 ● 애플(APPLE)의 iPhone, 전용 스마트워치 등으로 데이터 확인(음성 피드백 지원) ● 러닝, 축구, 사이클, 농구, 테니스 등에서 사용	● 인솔에 온도, 압력, 가속도센서를 장착하여 발의 온도를 조절하는 제품과 러닝, 사이클 등 운동 수행에 대한 정보를 측정하는 제품이 있음 ● 3D position of your feet: contact zones, balance, pronation/supination, flight/contact ratio, stride length and stability, propulsion level ● 맞춤형 feedback	● 전용 신발에 센서를 삽입하여 거리, 속도 스텝, 운동량 측정 ● 모바일 어플리케이션으로 데이터 확인 ●신발을 흔들어서 앱과 연결 및 동기화	● 센서가 장착된 전용 신발(일체형)에서 거리, 속도, 보폭, Cadence, 스텝 등을 측정 ● 모바일 어플리케이션으로 데이터 확인
				
●신발의 밑창의 압력 센서가 발을 안에 넣을 때를 감지하고, 자동으로 신발끈을 조여줌.				

Medical and technological requirements for Internet of Health Things (IoHT)



Eskofier et al. An Overview of Smart Shoes in the Internet of Health Things: Gait and Mobility Assessment in Health Promotion and Disease Monitoring. Appl. Sci. 2017, 7, 986

Thank you!