TITLE

Evaluation of plantar pressure and force in diabetes using Tekscan F-Scan in-shoe foot force and gait analysis system

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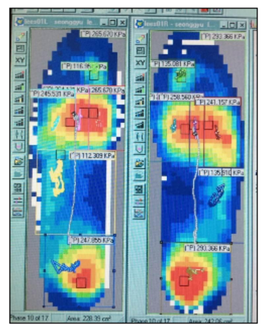
OBJECTIVES

Evaluation of plantar pressure is useful for detecting functional abnormality of foot, especially in diabetic patients. The aims of this study were to evaluate characteristics of the stress distribution on the subarea of foot in-shoe during gait by diabetes status using TekScan F-Scan and to investigate differences in stress on foot comparing both side feet and forefoot to rearfoot ratio by diabetes status

METHODS

Plantar pressure and force were measured by selecting an area of interest under the six areas of the foot: hallux, 1st metatarsal, 2nd metatarsal, 3-5 metatarsal, midfoot and heel based on previous reports.
65 diabetic patients and sex, age-matched 25 controls were enrolled. Mean age of diabetic patients was 58.7±6.4 years, diabetic duration 9.058.39±5.26 years, and mean A1C 7.7±1.3 %, and female 43.1% (28/65).
Of the included 65 patients, 16 had diabetic polyneuropathy (DPN), 12 had cardiac autonomic neuropathy (CAN), 31 were without CAN, and 18 had inconclusive tests.



- **Procedure**
  - For each recording of plantar pressure, the patient walked normally along with exercise running machine with compatible speed. We asked as a “walk”, and wait until compatible condition. Usually, 4-5 min later, we measured the plantar pressure. We evaluated the plantar pressure in 1.8 km/hr and in 3.6 km/hr in some subjects. Evaluation total times was less than 10 min.

RESULTS

		Actual			Weight- adjusted*		
side	Plantar region	NDG	DG	P value	NDG	DG	P value
Left	Hallux	40.912(24.107)	63.629(37.052)	**0.006**	0.675(0.386)	0.915(0.528)	0.061
	MPJ1	145.328(61.981)	184.934(73.735)	**0.019**	2.376(0.973)	2.647(0.872)	0.098
	MPJ2	72.176(21.733)	109.444(43.804)	**0.000**	1.213(0.428)	1.575(0.564)	**0.002**
	MPJ345	165.616(72.199)	175.297(59.191)	0.516	2.758(1.228)	2.519(0.725)	0.707
	Midfoot	137.236(45.733)	171.489(77.124)	**0.040**	2.237(0.653)	2.448(0.965)	0.405
	Condyle	236.996(69.477)	302.606(105.551)	**0.005**	3.933(1.118)	4.362(1.342)	0.193
	Total	798.264(178.402)	1007.88(253.534)	**0.000**	13.190(2.684)	14.466(2.463)	**0.004**
Right	Hallux	35.632(23.072)	53.851(27.763)	**0.005**	0.587(0.335)	0.769(0.374)	**0.009**
	MPJ1	141.272(62.571)	164.077(56.284)	0.099	2.322(0.959)	2.349(0.541)	0.541
	MPJ2	68.492(21.303)	106.812(35.608)	**0.000**	1.132(0.339)	1.532(0.402)	**0.000**
	MPJ345	145.748(54.130)	167.828(70.510)	0.161	2.388(0.761)	2.381(0.758)	0.895
	Midfoot	125.612(40.934)	165.273(73.485)	**0.013**	2.067(0.619)	2.364(0.952)	0.222
	Condyle	231.780(70.029)	283.780(98.428)	**0.018**	3.802(0.915)	4.096(1.249)	0.561
	Total	748.536(147.869)	941.621(247.175)	**0.000**	12.298(1.503)	13.493(2.296)	**0.017**

Table 1. Difference of Maximal Force (N) between non-diabetic (NDG) and diabetic group (DG)

		Actual			Weight- adjusted*		
side	Plantar region	NDG	DG	P value	NDG	DG	P value
Left	Hallux	109.372(60.939)	140.165(69.870)	0.056	1.829(1.053)	2.048(1.057)	0.247
	MPJ1	132.854(48.013)	180.928(58.723)	**0.000**	2.206(0.815)	2.264(0.843)	**0.013**
	MPJ2	136.534(40.364)	168.687(44.182)	**0.002**	2.294(0.755)	2.463(0.641)	0.331
	MPJ345	135.176(39.527)	153.955(40.240)	**0.049**	2.281(0.765)	2.252(0.629)	0.950
	Midfoot	99.645(29.246)	102.611(30.655)	0.678	1.656(0.493)	1.492(0.421)	0.135
	Condyle	118.123(29.128)	153.053(44.223)	**0.000**	1.988(0.578)	2.229(0.639)	0.205
	Total	731.704(174.219)	899.301(193.942)	**0.000**	12.255(3.319)	13.128(2.798)	0.124
Right	Hallux	100.599(55.827)	111.213(40.461)	0.321	1.675(0.848)	1.612(0.586)	0.886
	MPJ1	133.537(46.574)	153.294(43.245)	0.061	2.213(0.726)	2.230(0.622)	0.979
	MPJ2	126.757(34.961)	153.294(43.245)	**0.011**	2.096(0.548)	2.182(0.539)	0.579
	MPJ345	130.387(34.094)	150.325(39.801)	0.329	2.216(0.545)	2.025(0.568)	0.251
	Midfoot	95.107(28.908)	98.916(38.171)	0.653	1.574(0.464)	1.437(0.527)	0.099
	Condyle	116.300(32.554)	137.068(40.4664)	**0.024**	1.931(0.533)	1.998(0.597)	0.872
	Total	702.686(145.049)	790.489(163.897)	**0.021**	11.652(2.230)	11.494(2.184)	0.707

Table 1. Difference of Peak pressure (kPa)) between non-diabetic (NDG) and diabetic group (DG)

Patients with diabetes mellitus have high plantar force and pressure values on certain area of foot supporting the finding of other studies. Especially, 1ST MPJ, 2nd MPJ, condyle have significantly high values in diabetic patients. 2) Patients with diabetes mellitus show the deviation of plantar force and pressure on certain regions between both-side feet, especially, 1st MPJ or 2nd MPJ or condyle. 3) Both the forefoot and rearfoot pressures are increased in the diabetic patients, but did not showed that the deviation of plantar toward forefoot or rearfoot. 4) Although previous studies have demonstrated forefoot-to-rearfoot ratio(F/R ratio) is increased in diabetic neuropathy, in our study, F/R ratio is higher tendency on non-diabetic group than diabetic group.

Conclusions

1) Plantar force and pressure distributions in diabetics are higher than those in controls, especially, in 2nd metatarsal and condyle area.

2) Diabetic foot with peripheral neuropathy change foot loading distribution, and increase repetitive stress on particular subarea of foot, causing of plantar ulcers and deformities, these lead to vicious cycle. Therefore, we need to predict the change of foot in early stage for protecting diabetic foot complication. Evaluation of plantar forces and pressures distribution is useful to predict the risk of diabetic foot being non-invasive, convenient.

References

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Diabetes (complications & therapy)

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DOI: 10.3252/pso.eu.17ece.2015

Poster presented at: ECE2015 16-20 May 2015 DUBLIN, IRELAND 17th EUROPEAN CONGRESS OF ENDOCRINOLOGY