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Plantar Pressure Differences between Male Footballers and Sedentary Elders

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Abstract

In our study that we aimed to see the differences between footballers' plantar pressure distribution and sedentary individuals' in total 31 males [(FG)n=19; age=20.66±1.31 years; body length=178.7±4.64 cm; body weight=75,3±6.1kg), 12 sedentary volunteers (n=12; age= 21.05±2.3 years; body length=177.5±4.8cm; body weight=73.55±8.69 kg)] participated. Right, and left foot dynamic plantar pressures were obtained at 100Hz sample speed with the method of 5 steps dynamic walking. The foot was separated into masks by being divided into 14 different pieces. "MH1: 1. Metatarsal head, MH2: 2. Metatarsal head, MH3: 3. Metatarsal head, MH4: 4. Metatarsal head, MH5: 5. metatarsal head, big toe, 2nd toe, 3rd 4th 5th toes, forefoot, mid foot, hind foot and total foot". Peak pressure (PP – kPa), maximal force (MF-N), contact area (CA - cm2), contact time (CT– ms) Maximal force normalized to body weight (MFNBW) values were calculated for total foot. Whether there are significant differences between the groups were tested with independent sample t-tests by using SPSS 20.0 software. It is seen that statistically significant differences between football and sedentary groups are in the parameters of MH1 left foot peak pressure (FG:177,8947±76,87; SG:270,9091±161,83), MH4 mean pressure right foot (FG:113,1444±27,75; SG:88,8058±37,41), MH5 max force right foot (FG:42,3667±10,33; SG:29,9917±12,94) and MH5 mean pressure right foot (FG: 66,5156±18,85; SG:46,94±19,36). It might be reached as a result that the main reason of differences in plantar pressure distribution emerged between FG and SG groups is the intense workout and these pieces' being used much.

Keywords: plantar pressure, foot, pedography

Introduction

Human walking, running or just standing up are the simplest of the main movement skills. Even as performing these main forms, foot might be exposed to various plantar loads. In football which is one of the most popular sports and played in almost all countries with nearly 240 million participants all over the world, these main movement forms become more complicated. As a result of this, the producing power skill duration and working in high-intensity skill duration of the lower extremity prolong and this affects plantar pressure. It is known that on plantar load points of foot some changes happen in sports branches which involve movements such as sprint, overuse syndromes and injuries that arise out of pressure on metatarsal bones (Malliaropoulos et al., 2017).These movements cause increasing plantar loads on foot or the exact opposite. As a result of structural changes on joints, constant changes in a negative way of plantar pressure may cause overuse injuries. Overuse injuries bring along micro trauma and mechanical traumas (Saragiotto et al., 2014). Plantar load changes and participation level of these loads to dynamic movements during walking can lighten abnormal situations and injuries on foot. To be able to find functional mistakes and correct them, movements patterns and to reform postures productively will fix joint- muscle regression relation in a positive way (Malliaropoulos et al., 2017).

Even if plantar pressure is evaluated as the force seen on the plantar part of the foot, peak plantar pressure being on high levels is generally associated with problems related to injuries or diabetes problems (Naemi et al.,2013). Plantar pressure data undergo changes depending on overuse, decreasing on bone mass or types of feet (Nunns et al., 2016). Thus it is important to investigate pedobarographic variables among individuals whom foot is exposed to excessive forces constantly.

In a kind of sports such as football that there are almost 70- 90 contacts with the ball in a match and this contact lasts 1, 5- 4minIt requires to determine power distribution performed on plantar and to research its effects on normal walking cycle (Bokuvka, 2015). Starting from this point, our study focused on observing differences of dynamic plantar pressure parameters on chosen parts of foot between football players and sedentary individuals.

Materials and Method

Cross-sectional data were obtained from 31 healthy males. By dividing the participants into two independent groups (Football group (FG), Sedentary Group (SG) their dynamic plantar pressure values for right and left foot was recorded as maximum force (MF-N), peak pressure (PP-kPa), contact area (CA-cm2), contact time (CT– ms) mean pressure (MP-N/cm2) and maximum force normalized to body weight (MFNBW-N). The study has been approved by the local ethical committee.

Participants of the Study

To our research 31 volunteers totally participated. While 19 individuals were forming the football group (FG) (n=19; age=20.66±1.31 years; height=178.7±4.64 cm; weight=75,3±6.1kg), 12 individuals were involving the control group (n=12; age= 21.05±2.3 years; height=177.5±4.8cm; weight=73.55±8.69 kg) composed of sedentary individuals.

FG consists of football players of Anadolu University Sports Club Football Team. None of the participants who attended voluntarily to our research have a chronical foot injury or lower

extremity pathological problem. Also, participants were chosen from individuals who did not get injured in last three months at all.

Data Collection Protocol

Dynamic foot pressure was recorded by using EMED-XL (Novel GmbH, Munich, Germany) plantar pressure system with 100Hz sample frequency. Participants were requested to walk barefoot with their own pace on the platform. Familiarization protocols were conducted for the dynamic walking test. By using five steps, method dynamic foot pressure data was evaluated (Keenan, et al., 2010). By being masked foot separated into 14 parts; "MH1: 1st Metatarsal head, MH2: 2nd Metatarsal head, MH3: 3rd Metatarsal head, MH4: 4th metatarsal head, MH5: 5th metatarsal head, big toe, 2nd toe, 3rd 4th 5th toes, forefoot, mid foot, hind foot and total foot". Peak pressure (PP – kPa), maximal force (MF-N), contact area (CA - cm2), contact time (CT– ms) maximum force normalize to body weight (MFNBW) were calculated for the whole foot.

Statistical Analysis

For each masked part of foot data average of five tests was calculated automatically with Emed scientific software. The data were analyzed using SPSS Statistics 20.0 (SPSS Inc., Chicago, IL). Before statistical analysis, by using Shapiro-Wilk test, it was determined whether all measurements distributed normally or not. In the evaluation of the statistical difference between research and control groups independent sample t-test was used. The confidence interval of measurements was approved as % 95 and p-value as "$P < 0.01 – 0.05$".

Results

For total foot mask, results presented in Table 1. Statistically significant results have been found for MH1 (left foot peak pressure), MH4 (right foot mean pressure), MH5 (right foot mean pressure) between football and sedantery groups.

Table 1. Variables of Dynamic Walking Test

Variables	*Football Group (FG) left foot*	*Sedentary Group (SG) left foot*		*Football Group (FG) right foot*	*Sedentary Group (SG) right foot*	
Total Object	*Mean ± SD*	*Mean ± SD*	*P Value*	*Mean ± SD*	*Mean ± SD*	*P Value*
Max Force	716,9737±83,64	689,0455±101	0,421	707,7222±74,37	673,45±53,84	0,181
Peak Pressure	371,8421±80,12	399,5455±159,88	0,531	390±140,44	440,8333±207,66	0,429
Contact Area	154,9879±19,16	156,2909±19,95	0,861	159,6744±13,83	165,8192±25,27	0,397
Mean Pressure	95,0068±11,27	92,5982±10,43	0,567	92,1356±11,29	89,29±14,65	0,553
Max Force Normalize to Body	96,1526±6,04	99,2545±3,82	0,138	96±4,17	100,1±4,97	0,021

Weight						
Fore Foot	***Mean ± SD***	***Mean ± SD***	***P Value***	***Mean ± SD***	***Mean ± SD***	***P Value***
Max Force	570,4111±73,80	552,8364±96,41	0,584	573,6778±63,52	550,25±96,97	0,429
Peak Pressure	333,8889±81,37	333,1818±141,46	0,986	348,6111±126,52	403,3333±218,99	0,392
Contact Area	57,4022±5,62	57,7636±6,42	0,875	59,4133±4,78	62,0133±8,55	0,295
Mean Pressure	111,1406±12,41	107,9545±16,97	0,565	108,5472±13,51	103,76±16,39	0,39
Max Force Normalize to Body Weight	77,2944±7,32	79,4636±5,68	0,41	77,5167±5,59	79,6417±6,96	0,364
Mid Foot	***Mean ± SD***	***Mean ± SD***	***P Value***	***Mean ± SD***	***Mean ± SD***	***P Value***
Max Force	148,3111±42,58	121,7909±60,18	0,176	140,1722±40,49	122,275±52,50	0,301
Peak Pressure	130,9444±27,94	116,8182±27,50	0,195	125,8333±38,24	115±26,11	0,400
Contact Area	33,2139±4,47	30,5582±7,87	0,255	33,8994±4,09	35,4983±11,82	0,599
Mean Pressure	49,5672±11,02	44,7845±12,52	0,291	47,8439±10,87	40,9592±13,44	0,133
Max Force Normalize to Body Weight	20,0833±5.47	17,2636±7,59	0,256	20,0722±3,54	17,675±7,39	0,243
Hind Foot	***Mean ± SD***	***Mean ± SD***	***P Value***	***Mean ± SD***	***Mean ± SD***	***P Value***
Max Force	432,6526±74,96	418,9182±47,77	0,59	424,2±55,15	417,9667±69,33	0,786
Peak Pressure	285,7895±75,48	291,3636±102,66	0,866	269,4444±54,98	287,9167±126,26	0,586
Contact Area	39,4663±4,03	38,4809±3,43	0,503	39,7117±4,55	39,3158±3,74	0,805
Mean Pressure	133,7463±24,06	133,3345±19,06	0,962	129,2033±23,49	130,425±22,47	0,888
Max Force Normalize to Body Weight	58,2±7,37	60,7091±6,16	0,35	57,3111±4,69	60,6833±7,67	0,146
Toes	***Mean ± SD***	***Mean ± SD***	***P Value***	***Mean ± SD***	***Mean ± SD***	***P Value***

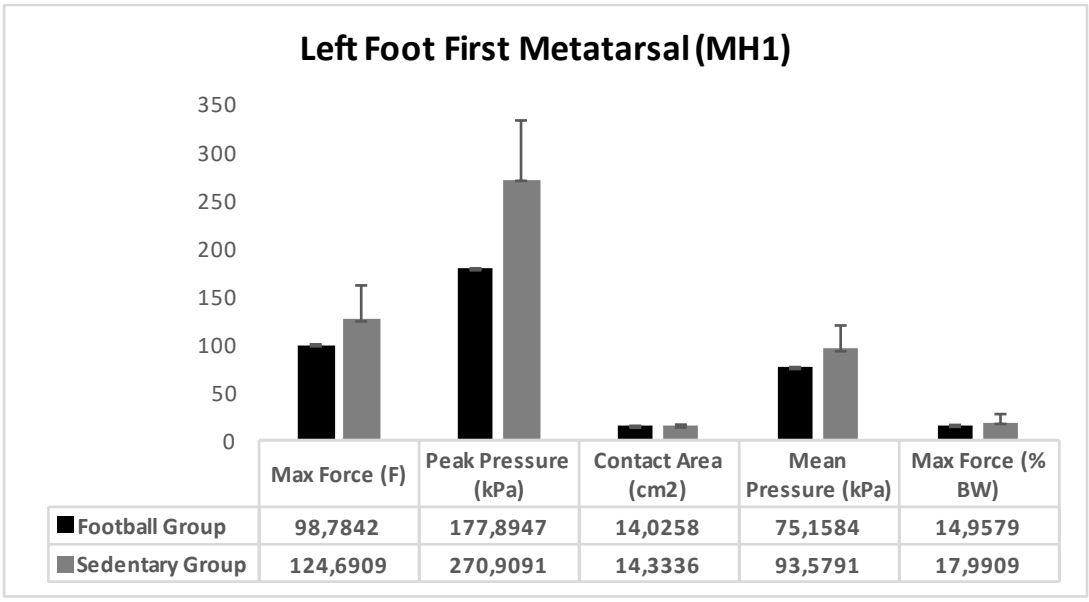
Max Force	141,0211±58,05	156,6727±44,26	0,447	142,55±57,52	150,025±57,24	0,729
Peak Pressure	265,2632±115,848	310,4545±154,16	0,37	260,2778±138,89	308,75±194,03	0,431
Contact Area	27,3316±6,58	28,9118±5,96	0,518	26,5272±5,32	28,6467±6,86	0,35
Mean Pressure	55,7895±15,14	58,4264±12,47	0,629	56,4394±14,179	57,8492±18,92	0,817
Max Force Normalize to Body Weight	18,8263±7,79	22,6273±6,14	0,177	19,2278±7,74	21,7417±7,55	0,387
MH1	***Mean ± SD***	***Mean ± SD***	***P Value***	***Mean ± SD***	***Mean ± SD***	***P Value***
Max Force	98,7842±33,79	124,6909±36,43	0,059	120,9556±47,93	143,8455±42,67	0,205
Peak Pressure	177,8947±76,87	270,9091±161,83	0,041*	232,2222±142,21	258,2082±225,94	0,706
Contact Area	14,0258±1,89	14,3336±1,96	0,675	15,1694±1,71	75,5791±1,91	0,201
Mean Pressure	75,1584±25,13	93,5791±25,87	0,066	85,2383±31,12	115,9636±86,88	0,18
Max Force Normalize to Body Weight	14,9579±4,92	17,9909±9,27	0,326	16,7167±6,99	20,4182±5,87	0,155
MH2	***Mean ± SD***	***Mean ± SD***	***P Value***	***Mean ± SD***	***Mean ± SD***	***P Value***
Max Force	48,1895±12,68	140,5818±35,37	0	144,7889±25,94	152,8083±41,08	0,516
Peak Pressure	289,4737±56,93	297,2727±91,47	0,775	279,1667±60	325,8333±151,62	0,247
Contact Area	11,7742±1,42	12,0118±1,72	0,686	12,6767±1,64	13,2±2,84	0,528
Mean Pressure	129,0437±17,16	129,1573±33,14	0,99	124,9417±17,49	126,25±47,72	0,916
Max Force Normalize to Body Weight	21,2579±9,55	20,1273±3,30	0,709	19,85±2,81	22,075±4,79	0,12
MH3	***Mean ± SD***	***Mean ± SD***	***P Value***	***Mean ± SD***	***Mean ± SD***	***P Value***
Max Force	180,2778±37,26	156,0364±34,55	0,092	168,1889±31,31	152,8417±40,97	0,255
Peak Pressure	318,3333±82,55	262,7273±69,43	0,073	286,3889±71,94	271,25±90,80	0,615

Contact Area	13,4806±1,32	13,4682±1,46	0,981	13,76±1,03	13,9783±1,47	0,637
Mean Pressure	146,715±23,57	129,4836±27,81	0,086	135,6678±25,28	122,7492±34,45	0,246
Max Force Normalize to Body Weight	24,3±3,52	22,3818±3,15	0,152	22,7444±3,22	22,025±4,21	0,601
MH4	***Mean ± SD***	***Mean ± SD***	***P Value***	***Mean ± SD***	***Mean ± SD***	***P Value***
Max Force	120,55±23,81	105,7455±16,40	0,081	113,7611±28,23	90,8833±37,74	0,068
Peak Pressure	270,5556±78,25	225±55,72	0,104	258,6111±100,1	221,6667±117,55	0,363
Contact Area	11,1917±1,25	11,1645±1,46	0,958	10,8878±1,076	11,3808±1,07	0,229
Mean Pressure	118,135±18,31	105,4245±17,69	0,077	113,1444±27,75	88,8058±37,41	0,05*
Max Force Normalize to Body Weight	16,2278±2,62	15,3±1,91	0,319	15,3111±3,35	13,175±5,47	0,195
MH5	***Mean ± SD***	***Mean ± SD***	***P Value***	***Mean ± SD***	***Mean ± SD***	***P Value***
Max Force	46,1611±10,76	40,7091±12,26	0,22	42,3667±10,33	29,9917±12,94	0,007*
Peak Pressure	187,5±59,39	145±49,54	0,057	188,3333±93,39	107,9167±59,56	0,013
Contact Area	6,79±1,05	6,7845±1,01	0,989	6,9194±0,93	6,8283±1,11	0,81
Mean Pressure	72,6772±13,15	64,5845±17,12	0,163	66,5156±18,85	46,94±19,36	0,01*
Max Force Normalize to Body Weight	6,3±1,45	5,8182±1,21	0,366	5,6778±1,39	4,3333±1,85	0,032

*p < 0.05.

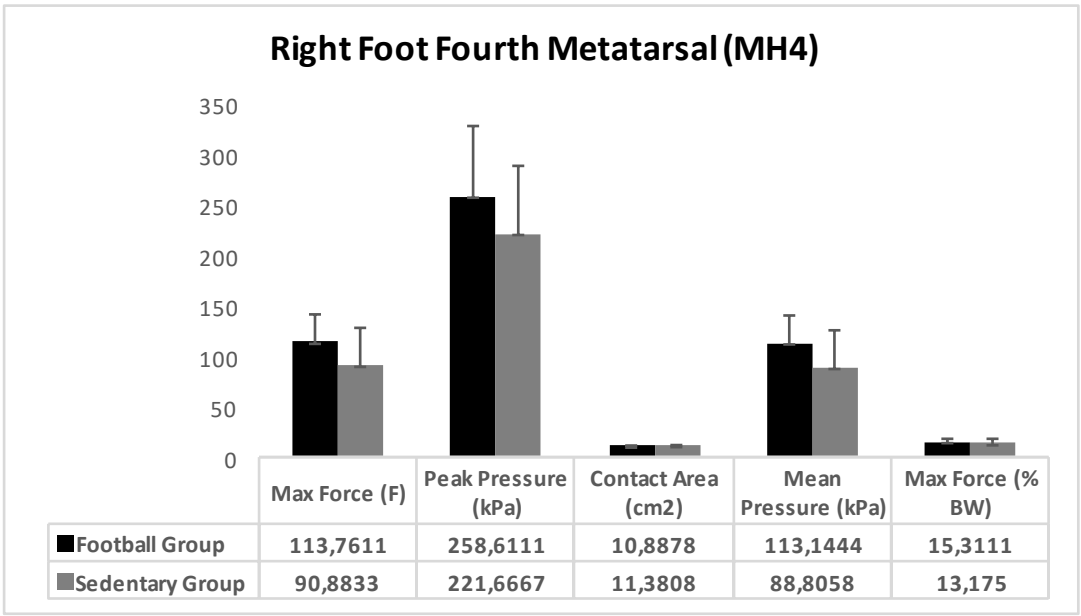
When the table is analyzed, it is seen that statistically significant differences between football and sedentary groups are in the parameters of MH1 left foot peak pressure (FG:177,8947±76,87; SG:270,9091±161,83), MH4 right foot mean pressure (FG:113,1444±27,75; SG:88,8058±37,41), MH5 max force right foot (FG:42,3667±10,33; SG:29,9917±12,94) and MH5 right foot mean pressure (FG: 66,5156±18,85; SG:46,94±19,36).

Figure 2, Figure 3, and Figure 4 indicate column chart of the statistically significant variables.



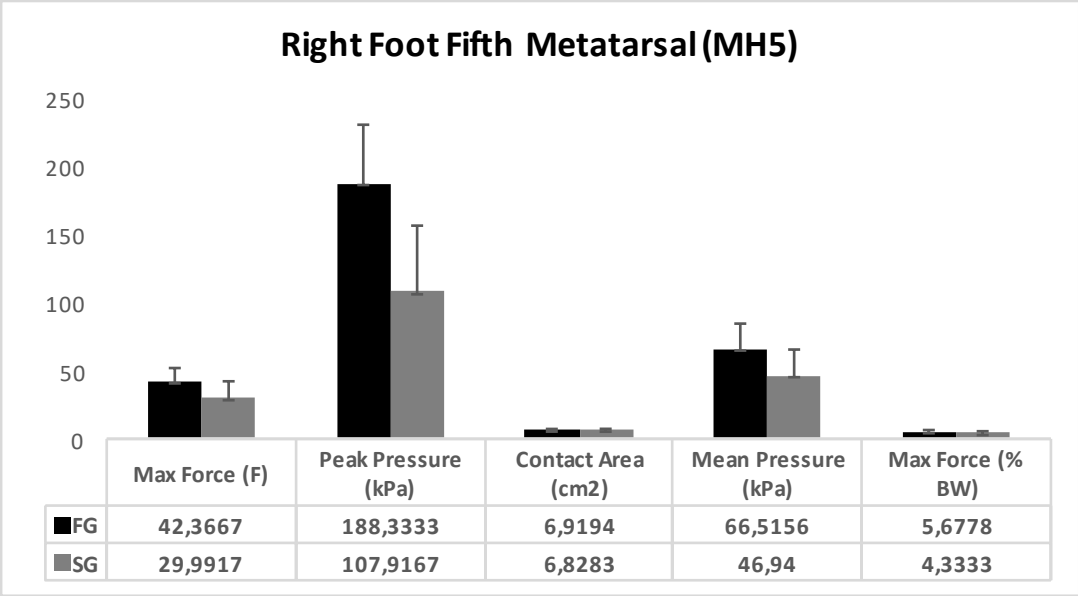
	Max Force (F)	Peak Pressure (kPa)	Contact Area (cm2)	Mean Pressure (kPa)	Max Force (% BW)
Football Group	98,7842	177,8947	14,0258	75,1584	14,9579
Sedentary Group	124,6909	270,9091	14,3336	93,5791	17,9909

Figure 2. Left Foot First Metatarsal (MH1)



	Max Force (F)	Peak Pressure (kPa)	Contact Area (cm2)	Mean Pressure (kPa)	Max Force (% BW)
Football Group	113,7611	258,6111	10,8878	113,1444	15,3111
Sedentary Group	90,8833	221,6667	11,3808	88,8058	13,175

Figure 3. Right Foot Fourth Metatarsal (MH4)



	Max Force (F)	Peak Pressure (kPa)	Contact Area (cm2)	Mean Pressure (kPa)	Max Force (% BW)
FG	42,3667	188,3333	6,9194	66,5156	5,6778
SG	29,9917	107,9167	6,8283	46,94	4,3333

Figure 4. Right Foot Fifth Metatarsal (MH5)

Discussion and Condusion

Football requires repetitive movement patterns such as jumping, running and leg swing and those movements may lead to temporary changes and mechanical injuries in some body limbs or soft tissues. The foot is one these body parts as it is exposed to the impact of weight bearing in almost every movement pattern specific to soccer. The purpose of this study was to examine the pedobarographic distribution of male soccer players during self-paced barefoot gait and compare with sedentary adults.

The main differences between football players and sedentary individuals were found in metatarsals. Sedentary individuals demonstrated higher the peak pressure values of the first metatarsal in non-dominant leg. Niu et al. (2015) described the first metatarsal as the shortest and less injury prone among all other metatarsals. Hence, it has an important function to transferring forces between hind and fore areas of the foot during gait. However, soccer players demonstrated less usage of the first metatarsal during gait. This can be possibly explained by higher plantar pressure on the medial side of the foot during soccer related movements (Wong et al. 2007). Specifically, Eils et al. (2004) demonstrated that plantar pressure distribution on the supportive leg is higher in the medial part of the foot during football shot. Thanks to that tend footballers might refrain from using their first metatarsal during gait.

Weist et al., (2004) mentioned about in kicking phase, frequently repeated in football lateral metatarsal pressure increases depending on fatigue and also Sims et al (2008) refers that this increasing plantar pressure causes 5th metatarsal stress fractures in the lateral area of foot and ascending load distributions. In our study, the data we obtained regarding MH5 showed similar characteristics. In another study observing plantar load distribution on MH5 during the movements special to football, it is seen that the greatest stress emerges during acceleration (20 ± 13.1 N/cm2), (Orendurff et al, 2009).

Eils et al. (2004) also executed a research study to present plantar pressure distribution at the movements peculiar to football. They observed increasing load distribution on MH5 in the phase of kicking the ball and on MH2 in the course of the sprint. Much as our research focuses on only walking data, it is seen that high plantar pressure values are on increasing load distributions when previous studies executed during movements peculiar to football are based on. This situation emerged even in the static movements between FG and SG might be explained with MH2 and MH5 areas of the foot being used much. In the literature in plantar pressure values obtained by creating fatigue increasing pressure values especially in the area of MH was attained. (Bisiaux and Moretto, 2008). Plantar pressure differences seen in MH4 and MH5 areas between FG and SG can be explained with that football players are in workout period and chronical fatigue forms in this area. Fitts (1994) said that fatigue prevents muscle mechanism from being stimulated and this affects walking pattern in a mechanically and physiologically negative way.

Consequently; frequently repeated movements based on football caused by excessive loading activation in the area of MH4, MH5 of the dominant foot. The main reason of plantar pressure distribution differences emerged between FG and SG groups intense workout and using this area much. For future studies, football based movements may apply athletes off-season for prevent fatigue distribution.

Conflict of Interest

The authors have not declared any conflicts of interest.

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