Cypriot Journal of Educational Sciences

Volume 12, Issue 1, (2017) 23-31

www.cjes.eu

The study of the impacts of 'Running' on the contact area of soles and maximal strength among elite middle distance runners

Ahmet Uzun*, Faculty of Education, Necmettin Erbakan University, 42090 Konya, Turkey.
Latif Aydos, Faculty of Sport Sciences, Gazi University, 06560 Ankara, Turkey.
Metin Kaya, Faculty of Sport Sciences, Gazi University, 06560 Ankara, Turkey.
Mehmet Fatih Yuksel, Faculty of Education, Necmettin Erbakan University, 42090, Konya, Turkey.
Hacı Ahmet Pekel, Faculty of Sport Sciences, Gazi University, 06560 Ankara, Turkey.

Suggested Citation:

Uzun, A., Aydos, L., Kaya, M. & Yuksel, M.F. & Pekel, H.A (2017). The study of the impacts of 'Running' on the contact area of soles and maximal strength among elite middle distance runners. *Cypriot Journal of Educational Science*. *12*(1), 23-31.

Received November 23, 2016; revised December 10, 2016; accepted January 23, 2017.
Selection and peer review under responsibility of Prof Dr. Huseyin Uzunboylu & Assoc. Prof. Dr. Cigdem Hursen, Near East University.

Abstract

It is possible that running training for many years in athletics affects athletes' running patterns and sole structure. The main aim of this study is to examine the effect of maximal force applied to the floor area and contact area of the athletes with related to mid-distance training for athletics. 18 male athletes who represent Turkey on the International area and another 25 male volunteers who form the control group from the participants of the study. The sole pressure measurement of the participants was performed through the use of EMED-SF (Novel H, Munich, Germany) plantar pressure analysis system (pedobarographic analysis). In the study, significant differences were found in heel medial, heel lateral, foot middle, 2nd, 3rd and 4th metatars heads and left foot 3rd, 4th, 5th finger in the contact area values of the right and left foot averages. Besides, significant differences were found in heel medial, middle part of feet, 2nd and 3rd metatars heads and 2nd, 3rd, 4th and 5th fingers in maximal force values. Athletes have pressed on sole of the feet more as a result of long-term training and as a consequence this pressure caused a change of the soles contact area and maximal strength. Also it can be said that they have used forefront part of soles more actively during running and walking.

Keywords: runner foot sole, contact area, middle distance, pedobarographic.

* ADDRESS FOR CORRESPONDENCE: **Ahmet Uzun,** Faculty of Education, Necmettin Erbakan University, 42090 Konya, Turkey.
E-mail address: ahmetuzun42@gmail.com

1. Introduction

Athleticism, which is in the Centre of Olympics and consists of the most basic natural movements of human beings such as running, walking, jumping and throwing, is the head of basic sports (Yapici & Ersoy, 2003). Middle-distance running includes the 800 and 1500-meter races. In addition to being considered technically a sprint, middle distance running is based on the combination of speed and endurance along with a good strategy and it also takes place in the main race of the Olympic Games and athletics championships (Wikipedia, 2015). Running which we can define as body's rapid leaning forward with the repetitive practice of movements that the lower extremities have done with each other is seen to be in almost all athletic activities. As the running speed increases, stance phase decreases and recovery phase extends. Stance phase begins when the feet touch the ground and it continues till the feet are no longer on the ground. Foot contact continues till the plantar surface of the foot contacts with the ground. After the initial contact, which is the first phase of stance phase, mid-stance phase follows. In this duration till the heel gets off the ground, weightlifting in overly-forward lean is performed as rolling. The last phase is the swing phase which starts from the lifting of the heel and continues till the toes are cut off the contact with the ground (Inal, 2004). Physical activity can be defined as an important component for preventing diseases. Overuse injuries are common in the continuation of exercise, in sport activities and especially among runners. To prevent injury and provide treatment, orthosis and prescribed footwear are common beliefs (Razeghi & Batt, 2000).

Although few risk factors about running injuries are identified, etiology of running injuries is considered to include many factors (Meeuwisse, 1994; Novacheck, 1998; Van Mechelen, Hlobil & Kemper, 1992; Willems, De Ridder & Roosen, 2012). Most of the researches believe that injuries are resulted from external factors such as training errors, poor quality shoes and surface as well as internal factors such as poor flexibility, anthropometric structure, previous injuries and running experience (Macintyre, Taunton, Clement, Lloyd-Smith, McKenzie & Morrell, 1991; Taunton, Ryan, Clement, McKenzie, Lloyd-Smith & Zumbo, 2002). The pronation of the foot is responsible for all ailments of the lower extremities in sports medicine literature. Abnormal movements occurring in the joints are felt. Many feet and ankle biomechanics were examined normally and pathologically (Novacheck, 1998). In the medial part of the lower extremity, foot pronation runners often have tendencies towards injuries such as tibial stress syndrome, patella-femoral pain syndrome and posterior tibial tendinit (McKenzie, Clement & Taunton, 1985). Metatarsalgia is the head of the soles disorder (Kang, Chen, Chen & Hsi, 2006). Metatarsalgia that appears after the occurrence of recurrent metatarsal head, is a common problem in society. That the amount of load in each metatarsal heads for the healthy people and pressure distribution is known, contribute a lot to the determination of the diagnosis and treatment of metatarsalgia programs (Eils, Nolte, Tewes, Thorwesten, Volker & Rosenbaum, 2002; Kilicoglu, 2009). In line with the growing popularity of the new methods developed in plantar pressure measurement recently, the number of the studies on the measurement of the load in each metatarsal head has also increased (Aydos, Uzun, Kaya, Kanatli, Esen & Uslu 2012; Hughes, Clark, Linge & Klenerman, 1993; Kaya, Uzun, Aydos, Kanatli & Esen, 2012; Luger, Nissan, Karpf, Steinberg & Dekel, 1999; Uzun, 2013). Despite the rapid improvement of these devices, information about pressure distribution patterns in the metatarsal head is still controversial (Kanatli, Yetkin, Simsek, Ozturk, Esen & Besli 2008). Foot pressure measurement can provide specific information about the interaction of the foot and the ground with different shoes. Pressure measurement provides an understanding of the interaction among the human body, shoe and the ground. Because of the difference in the shoes, there can be significant differences in the relation of high pressure and the load. Also, it can try to identify changes in the shoe features and the usage of plantar pressure measurement (Hennig & Milani, 2000). With the measurement of foot pressure patterns, prevention of diseases, their treatments, rehabilitations and supply of appropriate shoe became important (Patil, Thatte & Chaskar, 2009). Middle distance races (800-1500 m) are accepted as one of the most difficult category in athletics, and an athlete needs to train continuously and for long years to become elite. It causes changes in the pressure on the sole change for them to do exercises helping the improvement of strength like long distance runners, and exercises including sprints and technique arrangement like short distance runners. Moreover, they need to do combined exercises including running drills (abc), running coordination, and various jumping movements; and especially using special running shoes frequently leads to the pressure on the soles change. Detection of these changes can play an active role in increasing running performance and improving running comfort.

The purpose of this study is to explore the effect of athletics on the contact area of the soles and maximal strength. Moreover, this study aims to further contribute to the research about the use and improvement of the appropriate shoes designed for the middle distance branches in athletics by identifying the amount of load on each metatarsal head among middle distance runners.

2. Method

2.1. Subjects

The study group consisted of 18 male middle distance (800-1500 m) runners, athletes of Turkish University National Team, who previously had no foot injury or complaints (aged 20,25 ±3,6 years) and 25 male volunteers (aged 26,10 ± 2,40 years) who formed the control group. The average training age of the athletes is 11 years. The athletes with foot disorders, neurological diseases that affect the movement system, peripheral neuropathy, runners with histories of foot or ankle surgeries or fractures were excluded from the study group. Table 1 presents the age, height, weight and BMI values of the participants.

2.2. Instruments

The pedobarographic (sole pressure measurement) measurements of the study group were conducted at Gazi University Faculty of Medicine Department of Orthoepy and Traumatology walking laboratory through the use of EMED-SF (Novel GmbH, Munich, Germany) plantar pressure analysis system. The system performs on a 71 Hz sampling frequency; with dimensions of 44.4 × 22.5 cm; and includes two receptors per cm^2; mounted on a wooden platform of 7 × 1 m and it is covered by a thin layer of leather.

2.3. Experimental Procedures

This study was approved by The Local Ethics Committee of the Faculty of Medicine, T.R. Gazi University (February 25, 2008; approval number 074 for non-pharmacological clinical studies). Before stepping on the pedograph, the participants walked on a seven meter walking band, and they were not informed regarding the area of measurement. The measurements were conducted with naked feet; two dynamic measurements were conducted for each foot. The sole was divided into 11 areas.

Figure 1. Mask areas in pedobaography (M01: medial of heel, M02: lateral of heel, M03: midfoot, M04: 1st metatarsal head, M05: 2nd metatarsal head, M06: 3rd metatarsal head, M07: 4th metatarsal head, M08: 5th metatarsal head, M09: pollex M10: 2nd finger, M11: 3rd 4th and fifth fingers).

2.4. Statistical Evaluations

The obtained data was analyzed through the use of SPSS sofware (Version 16). The averages of the measurements of both experiment and control groups were calculated and non-parametrical Mann Whitney-U test was executed to test if there was a significant difference between the averages. The extent of the linear relationship between physical structure and the variables for each sole measurement was examined by calculating the Pearson coefficient (r). A 95% reliability interval was used and the level of significance was accepted to be $p < 0.01 – 0.05$.

3. Results

Table 1. Physical characteristics of male athletes (1) and control group (2)

Variables	Gender	Art. Mean.	S.D	X1 - X2	Min.	Max	t.	P
Age (year)	1	20,25	3,678	- 5,85	16,00	27,00	34,000	000[a]**
	2	26,10	2,403		22.00	29.00		
Height (cm)	1	174,37	5,863	- 7,93	164,00	183,00	64,000	,002**
	2	182,30	8,574		164,00	192,00		
Weight (kg)	1	66,25	3,714	- 21,75	58,00	71,00	30,000	,000**
	2	88,00	3,142		64,00	110,00		
BMI (kg/m²)	1	21,66	1,824	- 4,93	19,60	25,00	40,000	,000**
	2	26,59	3,375		19,11	30,86		

**P<0.01, *P<0.05

The standard deviation of age, height, body weight and BMI of the elite middle distance runners and the control group is $p < 0.01$. It was found that age, height, body weight and body mass index value of the athletes in the control group is higher than the athletes' in the experimental group (Table 1).

Table 2. Comparison of right and left feet contact areas of male athletes (1) and control group (2) (cm²)

		Right Foot				Left Foot			
Variables	Group	Mean	S.D	Mann Whitney U	P	Mean	S.D	Mann-Whitney U	P
Foot- TOTAL	1	144,28	15,480	69,000	,004**	138,79	15,09	43,500	,003**
	2	164,35	16,85			160,35	16,73		
MO1: The medial part of heel	1	19,25	1,591	81,000	,012**	18,29	2,435	46,500	,004**
	2	21,10	2,204			21,10	1,895		
MO 2: The lateral part of heel	1	19,15	1,814	86,500	,019**	18,75	1,685	44,500	,003**
	2	20,92	2,369			21,17	2,312		
MO 3: midfoot	1	23,81	9,966	75,000	,007**	20,70	9,264	35,000	,001**
	2	32,25	8,346			32,17	8,352		
MO 4: The 1st metatarsal head of foot	1	14,06	2,072	87,000	,020**	14,62	2,805	85,000	,171
	2	15,77	2,478			15,65	1,828		
MO 5: The 2nd metatarsal head of foot	1	10,75	1,538	53,000	,001**	10,12	1,772	51,500	,007**
	2	12,95	1,700			12,17	1,914		
MO 6 The 3rd metatarsal head of foot	1	12,28	,855	46,000	,000**	11,79	1,437	41,000	,002**
	2	14,12	1,467			13,67	1,515		
MO 7: The 4th metatarsal head of foot	1	10,46	1,056	58,000	,001**	9,87	,856	23,500	,000**
	2	11,70	,879			11,35	,727		
MO 8: The 5th	1	7,59	,986	102,500	,063	6,45	,752	30,000	,000*

metatarsal head of foot	2	8,12	,723			7,87	,958		*
MO 9: pollex	1	12,62	1,284			12,79	1,789		
	2	13,57	2,838	120,500	,207	13,45	2,181	96,000	,348
MO 10: 2nd finger of foot	1	4,78	,836	151,500	,781	4,87	1,089	83,500	,149
	2	4,75	1,261			4,32	,949		
MO 11 : 3.4.5. fingers of foot	1	9,50	2,677	158,500	,962	10,41	1,564	62,000	,023*
	2	9,05	4,189			7,37	3,516		

**P<0.01, *P<0.05

In the comparison of maximal strength of the total right-left feet of the control group and elite middle distance runners and the 11 contact areas, the results of the standard deviation in right foot medial-lateral heel, medial foot, 1st, 2nd, 3rd, and 4th metatarsal heads with left foot medial-lateral heel, medial foot are statistically significant (p<0.01-0.05). Accordingly, the values of the 3rd, 4th and 5th toes are found to be high in favor of the athletes whereas the values of the control group are found to be higher than the experimental group in all other significant results (Table 2).

Table3. Comparison of right and left feet maximal forces of male athletes (1) and control group (2) [N]

Variables	Group	Right Foot Mean	S.D	Mann-Whitney U	P	Left Foot Mean	S.D	Mann-Whitney U	P
Foot- TOTAL	1	910,28	46,13	22,000	,000**	893,9	39,45	13,000	,000**
	2	1150,83	179,6			1170,0	176,2		
MO1: The medial part of heel	1	320,84	49,96	58,500	,001**	339,7	58,62	62,000	,006**
	2	428,90	97,55			431,8	120,2		
MO 2: The lateral part of heel	1	273,62	42,41	79,000	,010**	288,3	33,47	95,000	,115
	2	336,77	77,50			328,8	71,72		
MO 3: midfoot	1	127,03	84,03	96,000	,042*	96,9	55,81	53,000	,002**
	2	180,67	68,59			185,4	75,06		
MO 4: The 1st metatarsal head of foot	1	142,14	80,70	78,000	,009**	192,5	85,87	138,000	,944
	2	213,23	84,63			194,7	69,48		
MO 5: The 2nd metatarsal head of foot	1	167,98	37,01	24,000	,000**	159,5	45,82	32,500	,000**
	2	259,96	54,69			252,6	64,21		
MO 6 The 3rd metatarsal head of foot	1	182,98	46,78	56,000	,001**	181,4	51,46	36,000	,000**
	2	251,36	57,72			270,4	64,14		
MO 7: The 4th metatarsal head of foot	1	155,64	70,54	155,000	,874	125,6	45,98	81,000	,039*
	2	157,65	40,41			166,9	47,33		
MO 8: The 5th metatarsal head of foot	1	89,48	43,76	148,000	,702	73,33	41,77	82,500	,044*
	2	84,90	27,96			105,0	48,30		
MO 9: pollex	1	168,48	83,51	148,000	,702	161,4	66,26	115,000	,382
	2	185,81	91,35			197,2	85,40		
MO 10: 2nd finger of foot	1	47,01	16,59	119,000	,192	39,08	12,03	76,500	,026*
	2	39,01	21,93			29,50	13,05		
MO 11 : 3.4.5. fingers of foot	1	56,29	22,39	145,500	,644	50,30	16,33	69,000	,013**
	2	49,40	36,48			28,20	22,55		

**P<0.01, *P<0.05

In the comparison of maximal strength of the total right feet of the control group and elite middle distance runners and the 11 contact areas, the results of the standard deviation in right foot medial-lateral heel, medial foot, 1st, 2nd, 3rd metatarsal heads with left foot medial heel, medial foot and 2, 3, 4, and 5 metatarsal heads with the results of the 2, 3, 4, and 5 toes are statistically significant (p<0.01-0.05). Accordingly, within the significant values, the value of the left foot is found to be high in favor of the athletes while it is determined that the values of the control group are found to be higher than the experimental group in all other significant results (Table 3).

Table 4. Correlation between physical structure and foot-sole variables of male athletes (1) and control group (2)

	Age		Height		Body Weight		BMI	
Variables	1	2	1	2	1	2	1	2
Right Feet Contact Areas Total	,120	-,208	,347*	,603**	,568**	,374	,484**	-,028
	,484	,379	,038	,005	,000	,105	,003	,906
Left Feet Contact Areas Total	,069	-,204	,388*	,626**	,602**	,393	,489**	-,022
	,706	,389	,028	,003	,000	,086	,005	,928
Right Feet Maximal Forces Total	,544**	,468*	,560**	,476*	,947**	,920**	,841**	,747**
	,001	,037	,000	,034	,000	,000	,000	,000
Left Feet Maximal Forces Total	,639**	,393	,541**	,413	,944**	,931**	,848**	,814**
	,000	,086	,001	,070	,000	,000	,000	,000

As for the categorical comparisons among the variables belonging to soles and physical structure of the elite middle distance runner and the control group, the magnitude of the linear relationship among the continuous measurement of variables was investigated by calculating the coefficient of Pearson (r). Statistically significant and positive correlation was identified in the comparisons of the age, height, weight and BMI (P <0, 01-0, 05).

4. Discussion

In the study, 11 sole contact areas of the middle distance runners and their maximal strength were examined and they were compared with control group that is consisted of healthy individuals.The variation among age, height and body weight and body mass index of the middle distance runners participated in the study was found to be statistically significant. When the age is analyzed, it is seen that athletes are younger. Similarly, when the height and body weight are analyzed, height and body weight of the mid-distance runners are lower than the control groups' and also height and body weight have increased in proportion to each other. When the body mass index is examined, mean values of the control group is found to be quite higher than the athletes'. As this can be as a result of height and body weight's being different from each other, it can also be said that the subjects of the control group have a lifestyle lacking of physical activity which causes a significant difference within body mass index (BMI).

The variation in the comparison of 11 right and left sole contact areas of the middle distance runners and the control group (Table 2) is determined as 2nd toes of the right foot being 0.63%, 3rd, 4th, 5th toes 4.97% and 2nd toes of the left foot 12.73 %, 3rd, 4th, 5th toes 41.24% greater in athletes' group than the control group. In the other contact areas of right and left foot, control group was determined to have a higher value. This may be because control group is 32.83% heavier than the athletes'. That the metatarsal heads of the control group have more contact area can be considered as a sign of the collapse of the lateral longitudinal arch.

It is stated in a study, which analyzed the feet contact area of the elite basketball players, that in terms of the standard deviation, basketball players' 2nd and 3rd metatarsal heads of the right foot, medial left foot and 2nd and 3rd metatarsal heads of the left foot were appeared to be smaller than they were in healthy individuals who did not exercise. In addition, it is stated that their 2nd toe contact area of the left foot is bigger than the control groups' and the exercise does not damage their sole; they resemble control group and there has been changes in a few parameters (Uzun, 2013). When Aydos et al. have studied the effect of volleyball on the contact area of the sole, they have stated that in the comparison of right and left feet sole contact area of the volleyball players and healthy women who do not exercise, the value of the sole contact area of the volleyball players is lower; however, there is not statistically any significant differences between them (Aydos et al., 2012). In another study on the men's national Ice hockey team athletes, the sole of the athletes was examined and although the value is higher in 3rd, 4th and 5th toes of the left foot, in other parts of the sole the value is higher in control group, but it is stated to be statistically insignificant (Kaya, Uzun, Aydos, Kanatli & Esen, 2012). Contrary to the studies stated above, in the analyses of 17 male wrestlers' sole whose average age is 21.90 and in the comparison of 11 contact areas, the standard deviation is found to be 4.74% for right media heel, 5.35% for left lateral heel, 11% for 3rd metatarsal head of the right foot and 10.77% cm^2 for the 4th metatarsal head of the left foot, which is higher in the control group than national wrestlers and wrestling and it is said to have an effect on sole contact area for various reasons such as the width of foot process and feet's straining in various positions (Aydos, 2011). In the study we have conducted in a similar way, in the comparison of the contact areas, significant differences between control group and athletes were found. That the value of the control group was found to be high and also that 2nd, 3rd, 4th and 5th metatarsal heads of both right and left foot of middle-distance runners were high can be said to have been resulted from athletes' especially middle-distance runners' running technically on their forefeet. In addition to this, while the impact of sports on sole contact area, such as basketball, volleyball and ice hockey, is insignificant (Aydos et al., 2012; Kaya et al., 2012; Uzun, 2013), it can be said that middle distance running has more impact on sole contact area.

The standard deviation in terms of the comparison of maximal strength which is about total feet of the middle distance runners and control group is more in athletes group than it is in control group as the 5th metatarsal heads of the right foot is 5.39%, 2nd toes 20,50%, 3rd, 4th, 5th toes 13.94%, 2nd toes of the left feet 32.47% and 3rd, 4th, 5th toes are 78.36% bigger whereas the value of the control group is significantly higher in other sole contact areas. Kaya et al (2012) found in their study about ice hockey that the standard deviation in terms of the comparison of maximal strength is more among athletes as the medial right foot is 22.12%, metatarsal head 1,23%, lateral heel of the left foot 0.03%, medial 21,25%, 4th metatarsal head 4.49%, 5th metatarsal head 2.07% and 3rd, 4th, 5th toes are 54.43% times bigger whereas the value of the control group is significantly higher in other sole contact areas. In another study on female soccer players, maximal strength of the 11 contact area and total number of right and left feet of the female soccer players and control group were compared and then the standard deviation of 2 and 3 metatarsal heads, total number of left feet, 3, 4, 5 toes and 2. 3. 4. metatarsal heads is identified to be statistically significant (Uzun, Kaya, Aydos, Kanatli & Esen, 2012). This study is consistent with the results of the research we have done. When the literature is handled, it is seen that the value of control group is higher in maximal strength of the 11 contact areas; nevertheless, contrary to the results we gained in our study the data of the experimental and control group is quite similar to each other (Aydos, 2011; Uzun, 2013). When the results of our study and other studies are considered, it is seen that there has been a parallelism in the increase of maximal strength and contact areas. Besides, unlike the sports such as ice hockey, basketball, volleyball and wrestling, in the comparison of maximal strength of the sole contact of athletes and control group, much lower values are observed in favor of the athletes in terms of being statistically significant. Accordingly, middle distance runners are seen to be affected by the training they have done in terms of the sole contact area of the sports and their impact on maximal strength. In addition, at the end of our study and in other sports, higher values were found in the athletes' experimental groups in sole contact area, lateral heel, medial heel, medial foot and metatarsal heads while in the control group only the values of 2 3 4 and 5 toes were found to be higher among middle-distance runners. In addition, fixed running styles which result from the long term trainings affect soles and ergonomic design seen in the production of running shoes can be said to occur in a manner unique to this branch. The main reason for this can be explained as a result of the middle distance runners' heel not touching the ground during the run. According to the survey results, a positive linear correlation (0.01 and 0.05) was found in the comparison between maximal strength and age, height, body weight, body mass index and right-left foot contact area. In a study conducted by a dynamic pedobarographic method on obese and non-obese adults positive relation between body mass index, total plantar force (r=0.50, P=0.000) and total contact area (r = 0.33, P = 0.019) and was found and it was seen that it goes parallel with the results of the studies we have done (Birtane & Tuna, 2004). The reasons for the lowliness of the pedobarographic records of middle distance runners can be resulted from body weight, the body mass index, lower extremities being powerful and also balanced functions' being improved.

5. Conclusion

Foot pretension strength, which the sole applied to the ground, has a great importance in the production of the necessary power for the middle distance runners to run faster. Although especially athletes have lower power values in the emergence of this power than the control group has, the force that they (athletes: 13,78 N/kg, control group: 13,06 N/kg) pressured on the ground is seen to be more than the control group (individuals who do not exercise) did. This shows that athletes have pressed on sole of the feet more as a result of long-term training and as a consequence this pressure caused change the soles contact area and maximal strength , also it can be said that they have used forefront part of soles more actively during running and walking.

References

Aydos, L. (2011). Effect of wrestling on the foot sole of elite wrestlers. *International Journal of the Physical Sciences, 6*(13), 3143-3154.

Aydos, L., Uzun, A., Kaya, M., Kanatli, U., Esen, E., & Uslu, S. (2012). The effect of volleyball on the sole contact areas and maximal forces of female volleyball players. *Homo Sporticus, 14*(1), 5-11.

Birtane, M., & Tuna, H. (2004). The evaluation of plantar pressure distribution in obese and non-obese adults. *Clinical Biomechanics, 19*(10), 1055-1059.

Eils, E., Nolte, S., Tewes, M., Thorwesten, L., Volker, K., & Rosenbaum, D. (2002). Modified pressure distribution patterns in walking following reduction of plantar sensation. *Journal of biomechanics, 35*(10), 1307-1313.

Hennig, E. M., & Milani, T. L. (2000). Pressure distribution measurements for evaluation of running shoe properties. *Sportverletzung Sportschaden: Organ der Gesellschaft fur Orthopadisch-Traumatologische Sportmedizin, 14*(3), 90-97.

Hughes, J., Clark, P., Linge, K., & Klenerman, L. (1993). A comparison of two studies of the pressure distribution under the feet of normal subjects using different equipment. *Foot & Ankle International, 14*(9), 514-519.

Inal, S. (2004). *Spor Biyomekanigi Temel Prensipler*: Nobel Yayin Dagitim, Ankara.

Kanatli, U., Yetkin, H., Simsek, A., Ozturk, A. M., Esen, E., & Besli, K. (2008). Saglikli kisilerde metatars baslarinda dinamik basinc dagilim sekilleri. *Acta Orthop Traumatol Turc, 42*(1), 26a30.

Kang, J.H., Chen, M.D., Chen, S.C., & Hsi, W.L. (2006). Correlations between subjective treatment responses and plantar pressure parameters of metatarsal pad treatment in metatarsalgia patients: a prospective study. *BMC musculoskeletal disorders, 7*(1), 95.

Kaya, M., Uzun, A., Aydos, L., Kanatli, U., & Esen, E. (2012). Investigation of the Effect of Skate-Use on the Sole Contact Areas and Maximal Forces of Ice Hockey Players. *Journal of Sport and Exercise, 14*(3), 29-35.

Kilicoglu, O. (2009). Sporcularda Ayak ve Ayak Bilegi Sorunlari. *Klinik Gelisim, 22*(1), 78-87.

Luger, E., Nissan, M., Karpf, A., Steinberg, E., & Dekel, S. (1999). Patterns of weight distribution under the metatarsal heads. *Journal of Bone & Joint Surgery, British Volume, 81*(2), 199-202.

Macintyre, J., Taunton, J., Clement, D., Lloyd-Smith, D., McKenzie, D., & Morrell, R. (1991). Running injuries: a clinical study of 4,173 cases. *Clinical Journal of Sport Medicine, 1*(2), 81-87.

McKenzie, D., Clement, D., & Taunton, J. (1985). Running shoes, orthotics, and injuries. *Sports Medicine, 2*(5), 334-347.

Meeuwisse, W.H. (1994). Assessing causation in sport injury: a multifactorial model. *Clinical Journal of Sport Medicine, 4*(3), 166-170.

Novacheck, T.F. (1998). The biomechanics of running. *Gait & Posture, 7*(1), 77-95.

Patil, S., Thatte, M. A., & Chaskar, U. (2009). Development of planter foot pressure distribution system using flexi force sensors. *Sensors Transducers Journal, 108*(9), 73-79.

Razeghi, M., & Batt, M. E. (2000). Biomechanical analysis of the effect of orthotic shoe inserts - A review of the literature. *Sports Medicine, 29*(6), 425-438.

Taunton, J. E., Ryan, M. B., Clement, D., McKenzie, D. C., Lloyd-Smith, D., & Zumbo, B. (2002). A retrospective case-control analysis of 2002 running injuries. *British journal of sports medicine, 36*(2), 95-101.

Uzun, A. (2013). The effect of basketball on the sole contact areas and maximal forces of elite basketball players. *Energy Education Science and Technology Part B: Social and Educational Studies, 5*(1), 633-640.

Uzun, A., Kaya, M., Aydos, L., Kanatli, U., & Esen, E. (2012). The effect of football on the sole contact areas and maximal forces of female football players. *Prime Res. Med, 2*(4), 102-109.

Van Mechelen, W., Hlobil, H., & Kemper, H. C. (1992). Incidence, severity, aetiology and prevention of sports injuries. *Sports Medicine, 14*(2), 82-99.

Willems, T.M., De Ridder, R., & Roosen, P. (2012). The effect of a long-distance run on plantar pressure distribution during running. *Gait & Posture, 35*(3), 405-409.

Wikipedia.org. (2015). Atletizm. Retrieved February 02, 2015 from: http://tr.wikipedia.org/wiki/Atletizm

Yapıcı, K., & Ersoy, A. (2003). Modern olimpiyat oyunlarinda atletizm rekorlarini hazirlayan faktorler. *Dumlupinar Universitesi Sosyal Bilimler Dergisi, 8,* 373-390.