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A COMPARISON OF PLANTAR PRESSURES BETWEEN TWO DIFFERENT PLAYING SURFACES IN TENNIS

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The purpose of this study was to compare two different playing surfaces in tennis – clay vs hard-court (OptiCourt) – in order get more insight on the influence of the effect of surface on load. Eight male tennis players performed two types of tennis specific motions. Inside plantar pressure was measured for the right foot during these movements. Higher maximum forces could be observed for the OptiCourt for the baseline play. In more detail, maximum force, peak and mean pressure were higher for the heel region on the hard-court. Higher values were found on clay for the hallux and lesser toe region. These results are in agreement with those of previous studies as they give evidence that playing surface affects loading in tennis.

KEY WORDS: tennis court, insole pressure, injury.

INTRODUCTION: Artificial playing surfaces are widely used in a variety of sports. The properties of these surfaces not only influence performance, but also affect injury rates (Dragoo & Braun, 2010; Girard, et al., 2007). In tennis, the results of several studies indicate that clay is significantly safer than grass or hard-court surfaces. Respective conclusions should, however, be considered with caution (Dragoo & Braun, 2010), as the characteristics of the playing surface cannot be taken isolated when assessing injury risk. Girard et al. (2007) and Girard, Micallef and Millet (2010) have compared plantar pressures between clay and Greenset in order to assess loading. They concluded that foot loading is affected by playing surface during tennis activities. Moreover, they inferred from their analysis results that Greenset induced higher loading in the hallux and lesser toes areas but lower relative load on the midfoot than clay (Girard et al., 2007).
In the present study, plantar pressures between OptiCourt and clay have been compared. OptiCourt is a specific type of hard-court surface, which has been used during the last years in the ATP-tournaments in Vienna, Austria. It was of interest, if a comparison of clay to another hard-court surface (OptiCourt uses fixed silica sand for the top layer) resulted in analogous findings to those from the study by Girard et al. (2007).

METHODS: Eight right handed male tennis players of similar playing style (age: 22 ± 2.6 years; body mass: 65 ± 3.2 kg; height: 1.73 ± 0.05 m) with an International Tennis Number of 6 or better participated in the study. None of the subjects was restrained by injury or fatigue.
Two different tennis specific movements were performed with own shoes (seven players: all-court; one player: clay, also for hard-court use) on the two playing surfaces, a baseline play comprising eight shuttle runs as described by Girard et al. (2007) and a sequence of forehand strokes. Within this sequence players had to try to reach and return ten tennis-balls following one after the other, which were thrown at a defined speed from a ball machine. Players stood in the middle of the court behind the baseline. Balls were thrown diagonally from the opposite side of the court into the right half of the court of the player's side and bounced about three metres before the baseline and one metre to the side line. Players started when the ball left the ball machine. After every attempt to reach and possibly return the ball they had to go back to their starting position. Measurement started with the first step heading to the first ball thrown out of the ball machine and ended with the last step after reaching/returning the tenth ball. The players were instructed to hit the ball as good as possible. It therefore appears not to be of much relevance, if the return was successful or not.

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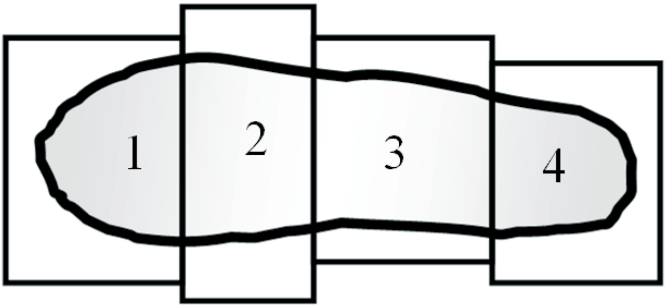
After warming up the players performed two trials to get accustomed to the conditions of the baseline play. A third trial was used for data recording and evaluation. The measurement of the forehand sequence was preceded by five forehand strokes, which were not evaluated.
Inside plantar pressure was recorded using the X-Pedar insole (Novel GmbH, Munich, Germany). The insole was placed between the foot and the plantar surface of the right shoe. The following parameters were determined for the whole foot and for four defined regions (heel, midfoot, forefoot, hallux and lesser toes; see Figure 1): Maximum force, peak pressure, mean pressure and mean area. All runs and steps were included in the parameter estimation.
Mean values and standard deviations were calculated for all variables on both surfaces for both movements. Statistical significance was set at the 0.05 probability level. Statistical analyses were performed using SPSS 17 (SPSS Inc, Chicago, IL, USA). Paired t-Tests were used to identify the differences between the two surface conditions.



1 – hallux and lesser toes, 2 – forefoot
3 – midfoot, 4 – heel

Figure 1: Regions defined for the X-Pedar insole.

RESULTS: Plantar pressure parameters for both types of movements and both playing surfaces are presented for the whole foot (Table 1), the heel, midfoot and forefoot regions (Tables 2, 3 and 4) and the region of hallux and lesser toes (Table 5). The concrete number of steps performed per trial was quite similar for all players and surfaces (e. g. 33 on average for the baseline play both on hard-court and on clay) and should be irrelevant for the parameters determined.

Table 1
Plantar pressure parameters for the whole foot

	Baseline play		*Forehand play*	
	OptiCourt	Clay	OptiCourt	Clay
Maximum force (N)	1204 (134)	964 (64) *	969 (64)	1001 (47)
Peak pressure (kPa)	398 (53)	460 (46) *	358 (38)	458 (38) *
Mean pressure (kPa)	152 (8)	131 (10) *	132 (6)	132 (5)

*Results are expressed as mean values (SD). *p<0.05*

Considering the whole foot, maximum force and mean pressure were significantly lower on clay for the baseline play, whereas peak pressure was significantly higher for both tennis specific movements (Table 1). Regarding the four defined regions, maximum force, peak and mean pressure were higher on hard-court for the heel region (Table 2) and higher on clay at the hallux and lesser toes region (Table 5) both for baseline and forehand play. No significant differences could be found for the midfoot region (Table 3). Significantly higher values could be observed on clay for the forefoot region during forehand play (Table 4).

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Table 2
Plantar pressure parameters for the heel

	Baseline play		*Forehand play*	
	OptiCourt	Clay	OptiCourt	Clay
Maximum force (N)	702 (77)	464 (30) *	645 (70)	532 (65)
Peak pressure (kPa)	329 (46)	218 (26) *	298 (45)	238 (21) *
Mean pressure (kPa)	212 (23)	140 (9) *	195 (21)	161 (20)

*Results are expressed as mean values (SD). *p<0.05*

Table 3
Plantar pressure parameters for the midfoot

	Baseline play		*Forehand play*	
	OptiCourt	Clay	OptiCourt	Clay
Maximum force (N)	241 (27)	207 (36)	236 (65)	275 (26)
Peak pressure (kPa)	134 (17)	132 (21)	124 (26)	116 (7)
Mean pressure (kPa)	40 (4)	34 (6)	39 (11)	45 (4)

*Results are expressed as mean values (SD). *p<0.05*

Table 4
Plantar pressure parameters for the forefoot

	Baseline play		*Forehand play*	
	OptiCourt	Clay	OptiCourt	Clay
Maximum force (N)	664 (66)	588 (52)	507 (48)	550 (13) *
Peak pressure (kPa)	312 (38)	350 (37)	255 (16)	289 (25) *
Mean pressure (kPa)	135 (14)	120 (11)	103 (11)	112 (3) *

*Results are expressed as mean values (SD). *p<0.05*

Table 5
Plantar pressure parameters for the hallux and lesser toes

	Baseline play		*Forehand play*	
	OptiCourt	Clay	OptiCourt	Clay
Maximum force (N)	393 (58)	419 (25)	367 (23)	427 (17) *
Peak pressure (kPa)	373 (64)	458 (44)	351 (35)	458 (38) *
Mean pressure (kPa)	136 (20)	144 (8)	127 (8)	147 (6) *

*Results are expressed as mean values (SD). *p<0.05*

DISCUSSION: Plantar pressure measurements have been performed in order to get more insight into the effect of the playing surface on the load in tennis. There are some indications which can be derived from this investigation. Significantly higher force and pressure values could be observed for the heel region on the hard-court. In the hallux and lesser toe as well as the forefoot region the results partly show significantly higher values on clay. A possible explanation for these results could be the eventual need of higher pressure and force for starting movements on the more slippery clay. Because of the properties of the hard-court the heel has to absorb higher forces when running. On clay the foot is able to roll more smoothly resulting in more balanced force and pressure values.
Higher loads for the hallux and lesser toe region on hard-court, as observed by Girard et al. (2007), could not be confirmed. Girard et al. (2007) gave a more aggressive play with an intensified forefoot running strategy as possible explanation for their finding. A more detailed analysis of the single steps within a movement (force curves) might gain more insight into these discrepancies. There are indications, for example, that on OptiCourt very high force values occur during the change of the running direction (in the heel region), while on clay they can be observed during acceleration of the players (on the hallux and lesser toe region).

CONCLUSION: This study shows that type of court surface affects plantar pressure distribution on the foot during tennis specific movements. A separation of the foot into four regions reveals different running styles during tennis specific movements depending on the court surface.

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