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LONG-TERM EFFECTS OF DIFFERENT TRAINING SURFACES ON ANAEROBIC POWER AND LEG STRENGTH IN ATHLETES

DOLGOROČNI UČINKI RAZLIČNIH VADBENIH POVRŠIN NA ANAEROBNO MOČ IN MOČ NOG PRI ŠPORTNIKIH

ABSTRACT

The purpose of this study was to investigate the long-term effect of training surfaces on anaerobic power and leg strength of athletes.

Forty-four male team sports athletes (Basketball: n=12; Soccer: n=20; Volleyball: n= 12) were recruited from university student population for this study. All players were well trained and with their age averaging 23.2±3.2 yrs (range 18-28 yrs). They were assigned to three experimental groups according to natural grass, wooden parquet and tartan training surface types. Every group participated in the similar strength and condition training programs apart from match games, technical and tactical training on the different training surface 4–6 times per week during training seasons (3 yrs). Moreover, anthropometrics (height, body mass, BMI, leg length and circumference), field tests (standing long jump, vertical jump, and vertical jump power) and force (leg power) measurements were taken.

No significant differences were found between experimental groups in terms of the mean age, leg circumference and vertical jump *($p > .05$).* Significantly differences were found the mean body mass, height, BMI, leg length, standing long jump, leg power and vertical jump power between training surface groups *($p < .05$).*

Our results indicated that the tartan training surface group had significantly higher standing long jumps performance than other groups. However, the natural grass training surface group had significantly lower vertical jump power and leg strength than other groups. As a result, tartan training surface is the most beneficial surface for vertical jump power in comparison to natural grass and wooden parquet surface.

Keywords: training; surface, power, athlete, sports.

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IZVLEČEK

Namen te raziskave je bil raziskati dolgoročne učinke vadbenih površin na anaerobno moč in moč nog pri športnikih.

Vzorec v raziskavi je obsegal 44 moških športnikov iz populacije univerzitetnih študentov, ki trenirajo ekipni šport (košarka: n = 12, nogomet: n = 20, odbojka: n = 12). Vsi igralci so bili dobro pripravljeni, stari pa so bili povprečno 23,2 ± 3,2 leta (skupina 18–28 let). Razdelili smo jih v tri eksperimentalne skupine glede na vrsto vadbene površine: naravna trava, lesen parket in tartan. Vsaka skupina je v sezonah treninga (3 leta) 4–6-krat na teden poleg igranja tekem opravila še podobne programe treninga za moč in kondicijo ter tehnični in taktični trening na različnih vadbenih površinah. Poleg tega smo opravili tudi antropometrične meritve (višina, telesna masa, BMI, dolžina in obseg noge), testiranje na terenu (skok v daljino z mesta, vertikalni skok in moč pri vertikalnem skoku) ter meritve moči (moč nog).

Med eksperimentalnimi skupinami ni bilo značilnih razlik glede povprečne starosti, obsega noge in vertikalnega skoka (p > ,05). Med skupinami, ki so trenirale na različnih površinah, smo ugotovili značilne razlike v povprečni telesni masi, višini, BMI, dolžini noge, skoku v daljino z mesta, moči nog in moči pri vertikalnem skoku (p > ,05).

Naši rezultati so pokazali, da so bili v skupini, ki je trenirala na tartanu, skoki v daljino z mesta značilno višji kot v drugih skupinah. Vendar pa sta bili moč pri vertikalnem skoku in moč nog v skupini, ki je trenirala na naravni travi, značilno nižji kot v drugih skupinah. To pomeni, da je za moč pri vertikalnem skoku tartan najugodnejša vadbena površina v primerjavi z naravno travo in lesenim parketom.

Ključne besede: trening, površina, moč, športnik, šport

INTRODUCTION

Athletic performance has been defined as the level of accomplishment of athletes who performed skills and tasks expected of them during a match, competition or training. In recent years, the increasing of competition and innovations in many sports has lead to raise the efforts and the performance of athletes. In this context, many researchers have implemented different training programs and examined a various factors that affect athletic performance (Binnie, Dawson, Pinnington, Landers and Peeling, 2013; Savoie, Kenefick, Ely, Cheuvront and Goulet, 2015). Physical performance of the athletes is influenced by both individual factors; such as the genetic characteristics and psychological state, and environmental factors; such as the ambient temperature and humidity (Dick, 2007). The basic determinant of physical performance is the physical capacity of individual (Hoeger and Hoeger, 2013; Nieman, 2003). Basketball, soccer and volleyball are sport disciplines that require both the technical, tactical, psychological skills, and physical attributes such as cardiorespiratory and muscular endurance, strength, speed, power and coordinative skills (Whyte, Spurway and Maclaren, 2006). In these sports, power is considered one of the basic factors for high-level physical performance. Especially, anaerobic and lower limb power are highly effective on the athletic performance in the basketball, soccer and volleyball that requires the varied functional movements (sprint, jumping and hopping) executed at a high intensity (Stølen, Chamari, Castagna and Wisløff, 2005; Savoie et al., 2015).

Scientific studies revealed that athletic performance had been also affected except for individual factors by environmental factors such as temperature, humidity and altitude (Hoeger and Hoeger, 2013; Whyte et al., 2006). One of these environmental factors is also the surface on which the athletes play sports (Binnie et al., 2013). Many researchers indicated that athletic performance is influenced by the amount of energy returned to the athlete from the different playing or training surfaces depending on the stiffness of the surface (Zamparo, Perini, Orozio, Sacher, and Ferretti, 1992; Martin and Prioux, 2016).The recoil energy of playing/training surface together with the residual momentum of athlete contributes to the optimum performance. The one of the major difference between the basketball, soccer and volleyball is the playing and training surface. Basketball is played on a wooden parquet surface, soccer on a natural grass surface and volleyball on a tartan surface according to the rules or instructions decelerated by the international sport federations (Hanlon, 2009). For this reason, the athletes and coaches generally have a preference to work on a standard sport surface, but not different surfaces. On the other hand, training on different surface may cause different effects on human metabolism. The effects of surface on athletic performance in the basic physical skills such as running, jumping and hopping are a scientific fact (Hardin, van den Bogert and Hamill, 2004; Dixon, Collop and Batt, 2014; Stefanyshyn and Nigg, 2003). However, previous studies that examined the effects of playing surface on athletes have been commonly focused on the sport injuries (Dragoo, Braun and Harris, 2013; Girard, Eicher, Fourchet, Micallef and Millet, 2007; Orchard, 2002; Ekstrand, Timpka and Hägglund, 2006). A few experimental studies have investigated that the effect of different surfaces on the performance of athletes. These studies have usually focused the short-term effect of the surface on physical performance based on the data obtained from a competition such as tennis and athletics or physical performance tests performed on different surfaces (Binnie et al., 2013; Forrester and Johnson, 2011; Katkat, Bulut, Demir and Akar, 2009). Therefore, the long-term effect of playing and training surface on the athletic performance is a required issue to investigate. In this context, the purpose of this study was to investigate the long-term effect of training surfaces on anaerobic power and leg strength of athletes.

METHODS

Participants

A total of forty-four (12 basketball, 20 soccer and 12 volleyball players) well trained male athletes, aged between 18 and 28 years (M= 23.2, SD= 3.22), participated in this study. The participants voluntarily consented to participate in the study. They were assigned to three experimental groups that based on the sports: soccer players for the natural grass, basketball players for the wooden parquet and volleyball players for the tartan training surface.

Study Procedure

This study was conducted in the city of Kayseri in Turkey between 2013 and 2016. Every group participated in the similar strength and condition training programs apart from match games, technical and tactical training on the different training surface 2–3 times per week during training seasons (3 yrs). Before testing, written informed consent was obtained from each participant after participants had been informed about the instruments. The experiments were conducted in accordance with the Declaration of Helsinki.

Data Collection

Anthropometry and body composition

We used the "National Identity Card" information to determine the age of the participants. Participants' ages were calculated from date of birth on the card. Body mass and height measurements of participants were measured after an overnight fast. Measures of body mass (in light clothing) and height (without shoes) were determined to the nearest 0.1 kg and 0.1 cm by "SECA, Germany" device. Body mass index (BMI) for each participant was also calculated using the following formula: body mass (kg) / height2 (m). The leg length and circumference measurements of volunteers who participated in the study were made to nearest millimeter by using the tape measure. The leg length (LL) measurements were taken on standing participants; the distance from the anterior inferior iliac spine to the lateral malleolus was measured. The leg circumference (LC) was measured on standing participants with the measurement tape placed around the mid-thigh, perpendicular to the long axis of the femur bone (McDowell, Fryar, Ogden, and Flegal, 2008).

Standing long jump

All participants were allowed to 5-10 min warm-up and stretching before the jump tests. They were requested to stand behind the starting line marked, with feet together, and pushed off vigorously and jumped forward as far as they can. They were allowed to use arm swing during the test. The participant had to land with the feet together and to stay upright. The distance is measured from the take-off line to the point where the back of the heel nearest to the take-off line lands on the mat or nonslippery floor. The test was repeated twice with a 2 min rest between trials, and recorded longest distance jumped. Measurements were taken to the nearest cm using a tape measure (Castro-Pinero et al., 2009).

Vertical jump

The vertical jump (VJ) test was measured by using a Takei digital jump meter (5414 jump-DF, Takei, Japan). The participants were instructed to stand on both feet in the center of an elastic mat in an upright extended position with a special digital belt tightly wrapped around their

waist. Jump technique was demonstrated to each participant. The jump belt was connected to the elastic mat by a cord. The participants performed a countermovement jump as high as possible. They were allowed to use both arms and legs to assist in projecting the body upwards, but not an approach step. The test was repeated three times with 10-15 seconds rest between each trial. The vertical jump test scores were determined from the digital display screen on the belt and their highest score recorded. The highest jump score was used for determination of anaerobic power output. The vertical jump test is commonly using device to measure the anaerobic power. Vertical jump power (VJP) was derived from the equation of Lewis: $Average\ Power_{(kg/m/sec\text{-}1)} = ((\sqrt{4,9} * Body\ Mass_{(kg)}) * \sqrt{Jump\ distance_{(m)}})$ (Manning et al., 1988).

The Lewis Formula expressed is: Average Power = (square root of 4.9) x body mass (kg) x (square root of jump distance (m))

Leg strength

Leg *strength* (LS) was measured with a leg dynamometer (Takei Instruments Ltd, Tokyo, Japan). The participant was requested stood on dynamometer table in their knees bent position at approximately 100 degrees and their hands grabbed the dynamometer bar in arm stretched position. For the inactivation of back muscles, the hips were positioned directly over the ankle joints and the back kept straight. In this position, the participant pulled the bar in front of the body upwards as much as possible. The test was repeated three times with a 2 min rest between each trial, and recorded the maximum pull out of three trials (Katkat et al., 2009).

Statistical Analysis

Statistical analyses of the all obtained data were analyzed on computer. Data analysis were performed with the software package Statistical Package for the Social Sciences (SPSS, Inc, Chicago, IL, USA).The results are given as means (M) and standard deviation (SD). "Skewness and Kurtosis" scores, visual explanations of histogram plots and "Shapiro-Wilk W" tests within normality analysis were used to determine that data was acceptable with regard to homogeneity. As variances showed a normal distribution, "One-Way ANOVA" was used to examine differences between groups. A Least Significant Difference *(LSD)* test was used to define the differences between the groups. The significance level was set at 5% for all inferential statistics.

RESULTS

A summary of the anthropometric characteristics of the participants is illustrated in Table 1.

Table 1 depicts the mean age and physical characteristics of the athletes according to the three sports. The athletes from the three disciplines displayed some different physical characteristics. The mean age for the natural grass training surface (NGTS), the wooden parquet training surface (WPTS) and the tartan training surface (TTS) groups were 23.80±3.40 yr, 23.92±4.21 yr, 21.58±1.93 yr respectively. There was no significant difference between the groups in terms of age *($p > .05$).* The mean height, body mass and BMI were respectively 177.65±4.33 cm, 73.05±8.83 kg, 22.95±1.96kg/m2 for NGTS group, 189.83±5.32 cm, 83.00±7.74 kg, 22.50±1.31 kg/m2 for TTS group. 192.42±5.82 cm, 92.42±10.88 kg and 24.79±1.90 kg/m2 for WPTS group. Significant differences were found on the mean height [$F(2, 41) = 39.79$, $p = .001$], body mass [$F(2, 41) = 17.12$, $p = .001$] and BMI [$F(2, 41) = 5.74$, $p = .006$] between the groups. Post Hoc (LSD) analysis showed that

Table 1. Anthropometric Differences Between Training Surface Groups.

Variable	Group			F(2, 41)	*p*
	WTS (n = 12)	NGTS (n = 20)	TTS (n = 12)		
	M (SD)	M (SD)	M (SD)		
Age (Years)	21.58 (1.93)	23.80 (3.40)	23.92 (4.21)	2.014	.15*
Height (cm)	192.42 (5.82)[a]	177.65 (4.33)[b]	189.83 (5.32)[a]	39.791	.00*
Body mass (kg)	92.42 (10.88)[ac]	73.05 (8.83)[b]	83.00 (7.74)[bc]	17.120	.00*
BKI ((kg/m^2)	24.79 (1.90)[a]	22.95 (1.96)[b]	22.50 (1.31)[b]	5.737	.01*
LL (cm)	107.00 (2.80)[ac]	99.15 (3.64)[b]	112.17 (6.01)[bc]	37.526	.00*
LC (cm)	60.83 (5.04)	55.60 (7.30)	56.25 (3.54)	3.159	.06*

The mean height of male and female athletes were 1.73 ± 0.09 m and 1.66 ± 0.08 m, respectively.The mean height of male and female athletes were 1.73 ± 0.09 m and 1.66 ± 0.08 m, respectively.

*Statistically significant difference p < .05

[a]Group differs statistically significantly from type (in row) where [b] is indicated.

[b]Group differs statistically significantly from type (in row) where [c] is indicated.

NGTS group were significantly shorter and lighter than other groups. However, WPTS group was heavier than TTS group *(p < .05)*. The mean LL and LC were respectively 107.00±2.80, 60.83±5.04 cm for WPTS group, 99.15±3.64, 55.60±7.30 cm for football and 112.17±6.01, 56.25±3.54 cm for volleyball players. The Anova analyses for the athlete groups showed statistically significant differences on mean LL [F(2, 41) = 37.53, *p* = .001] , but not on mean LC [F(2, 41) = 3.1, *p* = .06]. TTS group' the mean LL was longer than WPTS and NGTS groups respectivelly *(p < .05)*. TTS group' the mean LL was also longer than WPTS group *(p < .05)*.The relationship between training surface and performance variables levels was further analysed using ANOVA. The results of the ANOVA analysis and LSD multiple comparison tests are presented Table 2.

Table 2. Comparison of Performance Data According to Training Surface.

Variable	Groups			F(2, 41)	*p*
	WPTS (n = 12)	NGTS (n = 20)	TTS (n = 12)		
	M (SD)	M (SD)	M (SD)		
SLJ (cm)	224.67 (18.75)[a]	219.40 (20.22)[a]	246.41 (15.48)[b]	8.157	.00*
VJ (cm)	59.17 (7.40)[a]	54.75 (8.08)a	58.41 (7.03)[a]	1.559	.223
VJP (kg-m/sn)	162.83 (8.80)[b]	139.43 (15.45)[a]	153.48 (6.81)[b]	15.116	.00*
LS (kg)	128.67 (17.95)[b]	92.30 (17.07)[a]	114.08 (13.28)[b]	19.522	.00*

*Statistically significant difference p ≥ .05

[a]Group differs statistically significantly from type (in row) where [b] is indicated.

[b]Group differs statistically significantly from type (in row) where [c] is indicated.

Table 2 show that statistically significant differences exist between the three groups who training on the different surfaces. There were significant difference on the mean scores of SLJ [F(2, 41) = 8.16, *p* = .00] , VJP [F(2, 41) = 15.12, *p* = .00] and LP [F(2, 41) = 19.52, *p* = .00], but no significant difference on the mean score of VJ between the three groups *(p > .05)*. TTS group who training on the tartan surface had significantly higher SLJ than other groups. However, the NGTS group had significantly lower VJP and LS than others [F(2, 41) = 1.56, *p* = .22].

DISCUSSION AND CONCLUSIONS

In many sports disciplines, players interact with elastic or viscoelastic surfaces, e.g. wooden or tartan indoor sports halls and natural grass or artificial turf outdoor pitches. It is well known that the human metabolism adjusts their mechanics based on the types of surface. In this study, we investigated the effects of training surface on athletic performance by means of anaerobic and leg strength. In the present study, the mean body mass, height, BKI and LL values significantly differed between the three groups ($p < .05$). NGTG had significantly the shortest while WPTG displayed the higher means of body mass and BKI values than NGTG and TTG. The mean LL value of TTG was higher than others ($p< .05$). The present results are in accordance with the literature regarding athletes' physical characteristics features (Gasparini, 2016. Peña, Moreno-Doutres, Coma, Cook and Buscà, 2016; Teixeira, Carvalho, Moreira, Carneiro and Santos, 2015; Toriola, Adeniran and Ogunremi, 1987)

Athletic performance is dependent on the conditional and coordinative skill such as; strength, endurance, speed, agility and power (Dick, 2007).These skills are impacted by physical structure of playing or training surface because the amount of recoil energy returning from the surface to athlete can change. Moreover, athlete's power abilities may change based on types of training and playing surface. Nigg (1997) claimed that running on different surface conditions influences the activity of lower-limb muscles because of different kinematic requirements on different surfaces. According to surface properties, athletes need a specific and chronic adaptation in order to maintain performance output at a maximum level (Behm and Sale, 1993; Katkat et al., 2009; Stefanyshyn and Nigg, 2003). In this regard, our main finding revealed that training on the tartan surface had more effective on the improving SLC performance than NGTS and WPTS. TTS to improve the SLJ performance of athletes has provided a more effective training as compared to training WPTS and NGTS. Another main finding of the present study was that participants who trained on tartan and wooden parquet training surface had significantly higher VJP and LS values than NGTS. Our findings are consistent with other studies that have reported the effect of different playing/training surfaces on performance and physical attributes of athletes (Brechue, Mahyew and Piper, 2005; Gains, Swedenhjelm, Mayhew, Bird and Houser, 2010; Katkat et al., 2009). Brechue et al. (2005) claimed that natural grass surfaces impair sprint performance in college football players.. A study completed by Gains et al. (2010) found that the kinds of surface influenced college football players' speed and agility abilities. Katkat et al. (2009) suggested that muscular performance was found to be affected by the compliance of a playing surface. Their results demonstrated that WPTS was more compliant and less fatiguing surfaces than NGTS.

In conclusion, the types of training surface have the potential effect on SLJ, VJP and LS performance of athletes. It appears that tartan training surface is the most beneficial surface for the improvement vertical jump power of athletes in comparison to natural grass and wooden parquet training surface. It is recommended that training on tartan surface is suggests for athletes to improve vertical jump height. Because of the small sample size in this study and the order of testing, these results are not totally conclusive. Future researches should examine use greater numbers of participants in a single sport discipline and employ longitudinal designs.

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