Ergonomıc Sport Surfaces In Terms Of Lıfe-Long Sports

D. Katkat

Dept. of Sports Sciences, Ataturk University, Erzurum, Turkey

Abstract: The aim of the study was to examine different sport surfaces in term of on life-long sports. 196 sedanter, aged between 25 and 40, participated in this study. This study was executed on 8 different sport surfaces: asphalt, synthetic grass, natural grass, tile powder, soil, wooden parquet, full polyurethane and EPDM (Ethylene Propylene Diene Monomer). Leg strength (LS), back strength (BS) and vertical jumping height (VJH) were measured at rest and after a given training protocol on each surface. The results of the study, wooden parquet, EPDM, natural grass and polyurethane are ergonomıc sport surfaces in terms of life-long sports.

[D. Katkat. **Ergonomıc Sport Surfaces In Terms Of Lıfe-Long Sports.** *Life Sci J* 2013;10(12s):288-292]. (ISSN:1097-8135). http://www.lifesciencesite.com. 50

Keywords: life-long sports- ergonomic sport surfaces

Introduction

Life-long sport is one of the most favourable recreational activities. Today, humans living in big cities need recreation in order to regain physical and spiritual energy after an intense daily working. If one participates in his sport longer, he will getrid of his stress quicker. The duration of exercise is inversely related to quality of life-long sports.

There are different kinds of surfaces on which the subjects life-long sports, e.g. natural grass, asphalt and wooden parquet. Besides, synthetic surfaces for sport and recreational usage have been manufactured. One of the important aspects in construction of sport surfaces is to improve life-long sports [4,14,30]. It has been suggested that the main feature of a sport surface that can affect the life-long sports is to storage and return energy [4,14] have argued that if some of the energy that a sedanter requires for each step, stride, jump, landing, etc. can be reused, through energy return from the surface, the athlete can perform the same movement more efficiently. In other words, one can achieve a given physical activity by using less energy and, therefore, he continues his activity during a longer period.

Several studies have revealed a relationship between the compliance of the sport surface and quality of life-long sports. The analytic model of McMahon and Greene [31] has predicted a slight speed enhancement on tracks of intermediate compliance by comparison with running on a hard surface. Kerdok et al. [26] have postulated that an increased energy rebound from the compliant surfaces contributes to the enhanced running economy. It has been also reported that the reuse of elastic energy increases the muscular work efficiency in jumping [6].

If there is a relationship, whether it is positive or negative, between surface compliance and life-long sport, the same relationship is expected to exist between surface compliance and muscle performance. That is to say, the effect of a given training programme on life-long sports activities will be different on surfaces having distinct compliance.

According to the authors' knowledge, a noticeable feature of the existant studies in the literature, except few [15,39], is that they deal with experimental surfaces not with real sport surfaces. The aim of the study was to search the effects of different real sport surfaces on life-long sports activities by means of muscle performance and, therefore, to determine the most appropriate material(s) in building of sport surfaces.

Materials and Methods

Subjects: One hundred nintysix sedanter, aged between 25 and 40, participated in this study. Subjects volunteered to participate in this study after they had been fully informed of the nature of the test and of the associated risks in agreement with the recommendations of the local Ethics Committee.

Procedure

General: This study was executed on 8 different sport surfaces: asphalt, synthetic grass, natural grass tile powder, soil, wooden parquet, full polyurethane and EPDM. Leg strength (LS), back strength (BS) and vertical jumping height (VJH) were measured at rest twice, and the greater value was taken for further analyses. The same measurements were made after a given training protocol (described below) on 8 different sport surfaces, on separate days for each surface. The procedure was repeated once again on separate days for all surfaces. Then, the mean values calculated for each surface.

The subjects were asked to avoid vigorous activities for 24 h before each test, to have a good sleep, to consume same foods in the mornings of the test days, and to wear the same sportswear and shoes on all surfaces.

Training protocol for sedanter: At the beginning, participants were given the opportunity to warm up:

1) Jogging exercise: 800 m in 5 min
2) A 10-minute shuttle run test: 20 m x 30 times; completed by all the subjects in equal time, i.e. in 6 minutes.
3) Double-leg hop test: Jumping onto a stepper that was 20 cm in height and landing (Fig. 1); repeated 30 times.
4) Jump rope test: [500 times in 5 minutes; repeated 2 times]

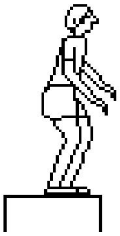

Fig. 1 Double-leg hop test

Measurements

Leg Strength (LS)/Back Strength (BS): Back/leg dynamometer (Takei Kiki Kogyo, Japan) was used to measure leg strength and back strenght. After familiarization with the test, the subject stood on a platform with their feet apart at a comfortable distance of shoulder width for balance. Their hands grasped each end of a bar. The subject was asked to flex at their knees to approximately 110 degrees. The back was kept straight and the hips were positioned directly over the ankle joints. In this way, the activation of back muscles was eliminated. The chest was kept forward and the head was held in an erected position. The subject took in a large breath and slowly exhaled as they attempted to extend their knees smoothly and as forcefully as possible. LS/BS was expressed as kilogram.

Vertical jumping height (VJH): The vertical jumping test consisted of leg flexion from the standing position immediately followed by a maximal jump with the hands free. These jump test were monitored with a digital jump meter (Takei Kiki Kogyo, Japan), which recorded the jump height.

Statistics: Ordinary statistical methods including means and standard deviations were used.

Results

The mean values of leg strength, back strength and vertical jumping height, obtained at rest and on 8 different sport surfaces were presented in Table 1.

Table 1. The leg strengths, back strength and vertical jumping distances of sedanter [mean (SD)] obtained at rest and after sport activites on different sport surfaces

Sportive Surface		Leg Strength-LS (kg)	Back Strength-BS (kg)	Vertical Jumping Heigt-VJH (cm)
At Rest	Mean	73,9031	56,5918	32,6786
	N	196	196	196
	Std. Deviation	14,31427	16,25965	8,23672
Asphalt	Mean	57,5357	42,7041	22,2704
	Std. Deviation	14,44046	16,29580	5,58692
Synthetic Grass	Mean	61,3214	45,0969	23,1888
	Std. Deviation	14,51167	16,02549	5,77084
Natural Grass	Mean	63,3520	46,5663	25,2194
	Std. Deviation	14,69811	15,97147	5,64213
Tile Powder	Mean	60,6786	45,2347	23,9949
	Std. Deviation	14,62151	16,06736	5,63096
Soil	Mean	59,8469	45,1837	23,8980
	Std. Deviation	14,56117	16,07313	5,90348
Full Polyurethane	Mean	62,1939	48,5918	29,1071
	Std. Deviation	14,29481	16,22681	6,96024
Wooden Parquet	Mean	64,1735	50,0714	29,4694
	Std. Deviation	14,35022	16,20336	6,97939
EPDM	Mean	63,0816	46,7653	26,4031
	Std. Deviation	14,40703	16,05107	6,29577

For the mean LS; at rest (m:73,9031; SD:14,31427) > wooden parquet (m:64,1735; SD:14,35022) > natural grass (m:63,3520; SD:14,69811) > EPDM (m:63,0816; SD:14,40703) > full polyurethane (m:62,1939; SD:14,29481) > synthetic grass (m:61,3214; SD:14,51167) > tile powder (m:60,6786; SD:14,62151) > soil (m:59,8469; SD:14,56117) > asphalt (m:57,5357; SD:14,44046).

For the mean BS; at rest (m:56,5918; SD:16,25965) > wooden parquet (m:50,0714; SD:16,20336) > full polyurethane (m:48,5918; SD:16,22681) > EPDM (m:46,7653; SD:16,05107) > natural grass (m:46,5663; SD:15,97147) > tile powder (m:45,2347; SD:16,06739) > soil (m:45,1837; SD:16,07313) > synthetic grass (m:45,0969; SD:16,02549) > asphalt (m:42,7041; SD:16,29580).

For the mean VJH; at rest (m:32,6786; SD:8,23672) > wooden parquet (m:29,4694; SD:6,97939) > full polyurethane (m:29,1071; SD:6,96024) > EPDM (m:26,4031; SD:6,29577) > tile powder (m:23,9929; SD:5,63096) > soil (m:23,8980; SD:5,90348) > natural grass (m:25,2194; SD:5,64213) > synthetic grass (m:23,1888; SD:5,77084) > asphalt (m:22,2704; SD:5,58692).

LS and BS and VJH measured on asphalt were lower than those measured on the other surfaces. The mean LS and BS and VJH recorded on wooden parquet were greater as compared to those noted on other surfaces.

Discussion

The purpose of this paper was to investigate the effect of different sport surfaces on life-long sport activities by means of leg strength and vertical jumping height after a given activity programme. In the study, the mean LS, BS and VJH values before training were significantly higher than those obtained on all surfaces after training. These findings showed that the activity programme was fatiguing.

The mean LS, BS and VJH obtained on asphalt were lower than those obtained on all other surfaces. On the other hand, wooden parquet were the least fatiguing surfaces. The mean LS, BS and VJH achieved on parquet were higher from those recorded on asphalt, soil, tile powder, synthetic grass, natural grass, EPDM and full polyurethane.

If a surface is less fatiguing, one can achieve a given training programme on that surface with less oxygen consumption compared with a more fatiguing one, i.e. sport surfaces affect athletic performance. The most important characteristic of a sport surface which may be related to performance seems to be its compliance. A person increases his leg stiffness (the stiffness of the integrated musculoskeletal system that behaves as a single linear spring during locomotion) when he is running or hopping on a compliant surface compared with running or hopping on a hard one [6,21,22,26,32,33]. Similarly, Daniel et al. [13] have reported that runners adjust leg stiffness for their first step on a new running surface. They found a %29 decrease in leg stiffness between the last step on a soft surface and the first step on a hard surface (from 10.7 kN m-1 to 7.6 kN m-1, respectively). On the other hand, Tillman et al. [39] have found that the kind of surface have no significant effect on lower extremity kinematics in running. The results of a recent study have also suggested that it is not possible to generalize the effects of sports surfaces on lower extremity kinematics [15]. At least for Tilmann et al's study, a possible reason of this inconsistency is the relative similarity in hardness of the surfaces used in that study.

The majority of the studies have revealed that an increase in leg stiffness enhances running speed [7-9,20,27] or jumping performance [1-3,8,16,18,19]. Leg stiffness was also found to be associated with running economy, as measured by oxygen consumption, [17,26,30]. McMahon et al. [30] have reported that running with increased knee flexion (Groucho running) requires an increase of as much as 50% in the rate of oxygen consumption compared to normal running with greater leg stiffness. In another study, it has been concluded that non-pathological musculoskeletal tightness was associated with a decreased steady-state VO2 for treadmill walking and jogging [23]. Similarly, in a recent study the greater energy cost during running compared to the energy cost during walking was explained by the use of more flexed knee joint during running versus walking [5].

On the other hand, some investigators have found no relationship between leg stiffness and aerobic demand [25] or jumping and running performance [36]. In one study, a relationship has been found between the leg stiffness and the energy cost of running only in one subject who consumed less oxygen when he could maintain his stiffness [12]. All participants in the one-leg jump task were found to decrease their leg stiffness by about 15% when imposed height changed from 55 to 95% [28]. These contradictions can be explained by the style of the tasks performed [28], the difference in running speed, and the difference in surfaces selected. Indeed, the results of Farley et al's [19] study have indicated an increase in leg stiffness with increase in hopping height in the two-leg jump. The increased stiffness of the leg spring on compliant surfaces may lead to a lower energetic cost compared with hopping or running on hard surfaces. The results of Kerdok et al.'s study [26] have suggested that the spring stiffness of the leg is progressively increased and that the metabolic cost of running is progressively reduced as surface stiffness is decreased from 945.7 to 75.4 kN/m. Arampatzis et al. [1,2] have suggested that an increase in leg stiffness causes an increase in the energy transmitted to and recovered from the sprung surface and simultaneously a decrease in the energy produced by the subjects.

The data obtained in this study support the results of the previous ones which have found a negative relationship between surface compliance and oxygen consumption [1,2,9]. It has been proposed that a compliant elastic surface will passively store and return energy with each step, reducing the mechanical work performed by the runner's muscles [22]. In the same way, Kerdok et al. [26] have suggested that a reduction in metabolic cost occurs as the elastic rebound provided by a compliant surface replaces that otherwise provided by a runner’s leg. The results of one study have suggested that inflexibility in certain areas of the musculoskeletal system may enhance running economy by increasing storage and return of elastic energy and minimizing the need for muscle-stabilizing activity [11].

On the other hand, Hardin et al. [24] have found a decrease in oxygen uptake as the leg stiffness increased, but, with increasing surface hardness. Therefore, they have suggested that metabolic cost is higher in more compliant surfaces. They have explained this inconsistency by differences in surface construction because their subjects mentioned a sensation of “running on sand” indicating that the surface may have had too much damping or inertia to effectively produce a “rebound” effect as in other surfaces used. Indeed, running on sand increases energy expenditure compared to running on hard surfaces [29,38,40], grass [37] and force platform [35] because sand doesn’t return energy absorbed in the earlier phase of each step and, thus, this lost energy must be replaced by the muscles’ activities at later phase of each step [10,29]. This is also true for jumping on the surfaces with very high shock absorption other than sand [16,33].

In locomotion the energy cost is thought to be determined by two factor together: the energy required for performing mechanical work and the energy required for generating muscular force [10,11]. By increasing leg stiffness on a compliant elastic surface, the human reduces the mechanical work done by the leg and increases the mechanical work done by the surface, and lowers the energy cost of generating muscular force. Because both the amount of work done by the person and the amount of force generated by the muscles would be reduced, the energetic cost of hopping or running is likely to be lower on a compliant elastic surface than on a hard surface [21].

Conclusion

In urban areas, one of the most important recreational activities is life-long sport. If one participates in his life-long sport longer, he will enjoys it more. This will help him to regain physical and spiritual energy that he lost during intense daily working. The duration of exercise is inversely related to quality of life-long spor activities and muscle performance and fatique. In this study, life-long sport activities was found to be effected by the compliance of a sport surface. Wooden parquet full polyurethane and EPDM were more compliant and less fatiguing surfaces, whereas asphalt, synthetic grass, soil and tile powder were hard and most fatiguing ones. The results of the present study suggest that it is better to use parquet and EPDM in building of indoor sport surfaces. Because parquet is not suitable for outdoor surfaces, they must be built with EPDM and natural grass. In addition, the usage of natural grass will have aesthetic and visual impacts and contribute to the amount of urban green area.

References

1. Arampatzis A., F.Schade, M.Walsh, G.P. Bruggemann (2001) Influence of leg stiffness and its effect on myodynamic jumping performance. J. Electromyogr.Kinesiol. 11:355-364
2. Arampatzis A., G.P.Bruggemann, G.M.Klapsing (2001) Leg stiffness and mechanical energetic processes during jumping on a sprung surface. Med.Sci.Sports Exerc. 33:923-931
3. Arampatzis A., S.Stafilidis, G.Morey-Klapsing, G.P. Bruggemann (2004) Interaction of the human body and surfaces of different stiffness during drop jumps. Med.Sci.Sports Exerc. 36(3):451-459
4. Baroud G, BM.Nigg D.Stefanyshyn (1999) Energy storage and return in sport surfaces. Sports Engin. 2:173-180
5. Biewener A.A, C.T.Farley, T.J.Roberts, M. Temaner (2004) Muscle mechanical advantage of human walking and running: implications for energy cost. J.Appl.Physiol. 97:2266-2274
6. Bosco C., R.Saggini, A.Viru (1997) The influence of different floor stiffness on mechanical efficiency of leg extensor muscle. Ergonomics 40:670-679
7. Bret C., A.Rahmani, A.B.Dufour, L. Messonnier, J.R. Lacour (2002) Leg strength and stiffness as ability factors in 100 m sprint running. J.Sports Med. Phys.Fitness 42:274-281
8. Butler R.J., H.P. 3rd Crowell, I.M.Davis (2003) Lower extremity stiffness: implications for performance and injury. Clin.Biomech. 18:511-517
9. Chelly S.M., C.Denis (2001) Leg power and hopping stiffness: relationship with sprint running performance. Med.Sci.Sports Exerc. 33:326-333
10. Chet T.M., T.F.Claire (2003) Human hopping on damped surfaces: strategies for adjusting leg mechanics. Proc.Biol.Sci; 22(270):1741–1746

11. Craib M.W., V.A.Mitchell., K.B.Fields, T.R. Cooper, R.Hopewell D.W.Morgan (1996) The association between flexibility and running economy in sub-elite male distance runners. Med. Sci. Sports Exerc. 28:737-743
12. Dalleau G., A.Belli, M.Bourdin, J.R.Lacour (1998) The spring-mass model and the energy cost of treadmill running. Eur.J.Appl.Physiol. 77:257-263
13. Daniel P.F., K.Liang, T.F.Claire (1999) Runners adjust leg stiffness for their first step on a new running surface. J.Biomech. 32:787-794
14. Daren J.S., B.M.Nigg (2003) Energy and Performance Aspects in Sport Surfaces. Third Symposium on Sports Surfaces (August), Calgary, Canada
15. Dixon S.J., A.C.Collop, M.E.Batt (2000) Surface effects on ground reaction forces and lower extremity kinematics in running. Med.Sci.Sports Exerc. 32:1919-1926
16. Durá J.V., L.Hoyos, J.V.Lozano, A.Martínez (1999). The effect of shock absorbing sports surfaces in jumping. Sports Engin. 2:103-108
17. Dutto D.J., G.A.Smith (2002) Changes in spring–mass characteristics during treadmill running to exhaustion. Med.Sci.Sports Exerc. 34:1324-1331
18. Farley C.T., D.C.Morgenroth (1999) Leg stiffness primarily depends on ankle stiffness during human hopping. J.Biomech. 32:267-273
19. Farley C.T., H.H.Houdijk, C.Van Strien, M.Louie (1998) Mechanism of leg stiffness adjustment for hopping on surfaces of different stiffnesses. J. Appl. Physiol. 85:1044-1055
20. Farley C.T., O.Gonzalez (1996) Leg stiffness and stride frequency in human running. J.Biomech. 29:181-186
21. Ferris D.P., C.T.Farley (1997) Interaction of leg stiffness and surface stiffness during human hopping. J.Appl. Physiol. 82:15-22
22. Ferris D.P., M.Louie, C.T.Farley (1998) Running in the real world: adjusting leg stiffness for different surfaces. Proc.Biol.Sci. 265(1400):989-994
23. Gleim G.W., N.S.Stachenfeld, J.A.Nicholas (1990) The influence of flexibility on the economy of walking and jogging. J.Orthop.Res. 8:814-823
24. Hardin E.C., A.J.Van Den Bogert, J.Hamill (2004) Kinematic Adaptations during Running: Effects of Footwear, Surface, and Duration. Med. Sci. Sports Exerc. 36:838-844
25. Heise G.D., P.E.Martin (1998) "Leg spring" characteristics and the aerobic demand of running. Med. Sci. Sports Exerc. 30:750-754
26. Kerdock A.E., A.A. Biewener, T.A. McMahon, P.G. Weyand, H.M.Herr (2002) Energetics and mechanics of human running on surfaces of different stiffnesses. J.Appl.Physiol. 92:469-478
27. Kuitunen S., P.V.Komi, H.Kyrolainen (2002) Knee and ankle joint stiffness in sprint running. Med. Sci. Sports Exerc. 34:166-173
28. Laffaye G., B.G.Bardy, A.Durey (2005) Leg stiffness and expertise in men jumping. Med. Sci. Sports Exerc. 37:536-543
29. Lejeune T.M., P.A.Willems, N.C.Heglund (1998) Mechanics and energetics of human locomotion on sand. J. Exp.Biol. 201:2071-2080
30. McMahon T.A., G.Valiant, E.C.Frederick (1987) Groucho running. J.Appl.Physiol. 62:2326-2337
31. McMahon T.A., P.R.Greene (1979). The influence of track compliance on running. J.Biomech. 12:893-904
32. Moritz C.T., C.T.Farley (2004) Passive dynamics change leg mechanics for an unexpected surface during human hopping. J.Appl.Physiol. 97:1313-1322
33. Moritz C.T., C.T.Farley (2005) Human hopping on very soft elastic surfaces: implications for muscle pre-stretch and elastic energy storage in locomotion. J.Exp.Biol. 208:939-949
34. Moritz C.T., S.M.Greene, C.T.Farley (2004) Neuromuscular changes for hopping on a range of damped surfaces. J.Appl.Physiol. 96:1996-2004
35. Muramatsu S., A.Fukudome, M.Miyama, M.Arimoto, A.Kijima (2006) Energy expenditure in maximal jumps on sand. J.Physiol.Anthropol. 25:59-61
36. Owen G., J.Cronin, N.Gill, P.McNair (2005) Knee extensor stiffness and functional performance. Phys. Ther. Sport 6:38-44
37. Pinnington H.C., B.J.Dawson. (2001) The energy cost of running on grass compared to soft dry beach sand. J.Sports Sci.Med. 4:416-430
38. Pinnington H.C., D.G.Lloyd, T.F.Besier, B. Dawson (2005) Kinematic and electromyography analysis of submaximal differences running on a firm surface compared with soft, dry sand. Eur. J. Appl. Physiol. 94:242-253
39. Tillman M.D., P.Fiolkowski, J.A.Bauer, K.D. Reisinger (2002) In-shoe plantar measurements during running on different surfaces: changes in temporal and kinetic parameters. Sports Engin. 5:121-28.
40. Zamparo P., R.Perini, C.Orizio, M.Sacher, G. Ferretti (1992) The energy cost of walking or running on sand. Eur.J.Appl.Physiol. 65:183-187.

9/12/2013