EFFECT OF FORCE PLATFORM SURFACE ON GROUND REACTION PEAK FORCE

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Repeated running and walking at a preferred speed across the two alternative surface covers was the basis of a comparison of peak force measures. These were obtained using a polyflex surface mounted on two force platforms, within a polyflex track system, with those obtained with a metal surface interface. When both the first and second foot strikes were considered within a stride, measures of peak impact and peak propulsion were almost the same. Mean ±s.e. measures were 2.021±0.068 BW and of 2.620±0.033 BW respectively for the polyflex and 1.987±0.066 BW and 2.607±0.031 BW respectively for the metal cover at a running speed of 3.9±0.09ms^{-1}. Peak braking forces did not differ significantly between the surface coves. In running, the 0.017m of polyflex on the 0.004m aluminium base plate did not significantly attenuate peak vertical forces or braking forces.

KEY WORDS: artificial, cover, ecological, polyflex, sport, track

INTRODUCTION: Force platforms are often used to assess the ground reaction forces occurring in sports performance. The top plate struck by the foot is usually constructed of metal. Although training shoes are often worn, there are many athletic and field sports which require the use of spiked shoes. To measure ground reaction force in athletic and field situations it is necessary to have a surface covering which allows the subject to use normal sports footwear. Knowledge of the effect of using an ecological surface cover upon primary ground reaction force measures is necessary to aid scientific experimental analysis. Although static electromechanical tests are used to assess force platform measurement performance, there is a role for dynamic ecological measurement studies (Nigg,1990). The concept of population preferred cadence and associated speed (Murray et al. 1966) was an underlying concept of the proposed study and was adopted in an effort to improve the reproducibility of ecological testing. However, in the experimental design it was also recognised that adoption of preferred cadence may result in individual preferred speeds which arise because of anthropometry and environmental factors. This study aimed to investigate the effect on peak ground reaction force measures of covering a force platform, mounted within a polyflex track, with a polyflex sports surface (International Amateur Athletic Federation standard) using an aluminium base plate interface. It was hypothesised that there would be no difference in the peak ground reaction force measures when the specially constructed polyflex cover was used in comparison to a metal top plate.

METHODS: Testing took place outdoors in fine weather on a 25m long polyflex track surface. Two 0.6m by 0.4m Kistler type 9851B piezoelectric force platforms (Kistler, Alton, UK) were located within a section of the track. A specially designed force platform mounting rig allowed the position of the force platforms to be moved relative to each other to account for the different stride lengths associated with individual gait characteristics and sports activities. The ability to adjust the platforms' positions to meet the needs of the individual subjects in this study allowed the ground reaction forces occurring during left and right foot strike to be measured within the same stride. During data acquisition the two force platforms were covered by either a polyflex surface cover, which consisted of a 0.017m polyflex layer upon a 0.004m aluminium sheet, or a 0.020m aluminium plate. The polyflex cover was exactly level with the track surface and was constructed at the time of the track. The aluminium plate was also machined to fit level within the track. The covers were fixed to the top of the Kistler force platforms with four M10 screws. Both types of platform cover were physically isolated from the surrounding track by a gap of approximately 0.003m.

The experimental design required the subjects to run and walk along the track at their own preferred running and walking speeds, within their natural stride pattern. During running and walking, ground reaction force measures were compared within each subject when the force platforms were covered with either the polyflex cover or aluminium plate cover. The ability to allow both the right and left foot strike, during the same stride, to be measured provided a check of the integrity of the data. In total, each subject was required to perform until five natural strides were recorded for both types of platform cover. For both running and walking this allowed five left and right foot strikes recorded with the polyflex cover to be compared to five strides recorded with the aluminium plate cover. Five male college students of mass 71.4±40.6kg (mean, S.D.) wearing their own training shoes gave informed consent to participate in the study. During a warm up and practice period each subject's stride length at preferred running and walking speed was visually assessed. Whether a subject performed the running or walking testing first was randomized. The approach speed to and through the measurement area was recorded by an infrared light multiple gate timing system (University College Chichester, Chichester, UK), which utilised 3m gate separations and detectors located at hip level. As a check for data integrity of platform strike a video camcorder was focused on each force platform mounting area 1m from the side of the track.
Ground reaction forces were sampled at 500 Hz for each platform and stored using a 12 bit Amplicon analogue to digital converter (Amplicon, Brighton, UK) and Orthodata Provec software (MIE Medical Research Ltd. Leeds, UK) running on a Viglen 486 IBM compatible computer (Viglen, Alperton, UK). The acquired 3 second data sample was then printed and recorded from the computer screen trace data using cursor measurement to locate peak forces. For running the vertical peak impact, propulsive forces and peak braking force were compared. For walking the vertical landing and propulsion peak forces and peak braking force were compared for the two types of force platform cover. All peak forces were then expressed relative to each subject's body weight (BW), and standard errors calculated from the standard deviation divided by the square root of the number of samples. Data was analysed using an analysis of variance model with two fixed factors (polyflex/ metal cover and first/second platform) and two random factors (variation between subjects and variation between 5 repeat trials by a subject). Significant differences were identified when $P>0.05$.

RESULTS AND DISCUSSION: As shown in Table 1, the approach speeds were very similar when both the polyflex and aluminium surfaces were under test. Table 2 indicated that when all subjects were considered there was no significant difference between the running speeds during the polyflex cover and aluminium plate cover tests.

Table 1 Preferred Mean Running and Walking Speeds (mean±S.E.) of the Five Subjects

Subject	Running speed ms^{-1}		Walking speed ms^{-1}	
	Polyflex	Aluminium	Polyflex	Aluminium
1	3.669±0.013	3.693±0.02	1.450±0.009	1.443±0.003
2	3.717±0.22	3.724±0.021	1.734±0.007	1.742±0.012
3	3.772±0.040	3.809±0.078	1.371±0.017	1.333±0.017
4	4.749±0.035	4.703±0.014	1.967±0.018	1.945±0.013
5	3.499±0.035	3.568±0.365	1.518±0.015	1.539±0.003

Table 2 indicated that for all subjects during running, the mean peak vertical forces were almost the same when the two different surfaces were used; this was supported by comparison of the individual subject data shown in table 3. However, for all the heel strike runners, greater mean peak braking force was achieved on the polyflex surface, though this was not statistically significant. The mean peak vertical propulsion achieved from the first and second platform in the same stride were similar and not significantly different (P=0.984) for polyflex (2.623 BW and 2.604 BW respectively) and for aluminium (2.604 BW and 2.610 BW). There was also no significant difference in peak measures between the polyflex and aluminium covers (P=0.984). Overall the data suggests that for running activity the use of the polyflex surface cover with a 0.004m aluminium base plate did not appear to influence the measurement of peak vertical ground reaction force.

Table 2 Mean Peak Preferred Running Forces (±S.E.) for the Left and Right Foot Strike in the Same Stride Expressed Relative to Body Weight for All Subjects

	Vertical Impact BW	Vertical Propulsion BW	Braking BW	Speed ms^{-1}
Polyflex	2.021±0.068	2.620±0.033	0.531±0.025	3.887±0.091
Aluminium	1.987±0.066	2.607±0.031	0.506±v0.017	3.900±0.085
P value	0.354	0.388	0.072	0.598
Degrees of freedom	49	49	49	24

Table 3 Mean Peak Preferred Vertical Running Forces (±S.E.) for the Left and Right Foot Strikes in the Same Stride for the Five Subjects

Subject	Polyflex		Aluminium	
	Vertical Impact BW	Vertical Propulsion BW	Vertical Impact BW	Vertical Propulsion BW
1	2.380±0.046	2.903±0.028	2.253±0.030	2.832±0.016
2	1.621±0.036	2.508±0.029	1.653±0.019	2.525±0.037
3	1.617±0.069	2.290±0.017	1.515±0.044	2.264±0.024
4	2.652±0.105	2.759±0.046	2.673±0.053	2.736±0.032
5	1.851±0.090	2.642±0.018	1.842±0.117	2.678±0.026

For all subjects at the beginning of the foot contact in walking (Table 4) the mean peak vertical landing force and braking force were similar, and not significantly different, when the two different surfaces were used. This was supported by the individual subject data (Table 5 and 6). Table 4 indicated that during walking greater mean peak propulsion was achieved from the polyflex surface than from the aluminium surface. This might have arisen because of reduced subject motivation during attention to the walking task, or it may have been associated with differences in the shoe sole and surface interface between the subjects as it was most notable in subjects 4 and 5. This effect was not observed in running which suggests that a motivational influence may have been involved. There was not a significant difference between the first and second platform measures (P=0.356).

Table 4 Mean Preferred Walking Peak Forces (±S.E.) for the Left and Right Foot Strike in the Same Stride for All Subjects

	Vertical landing BW	Vertical Propulsion BW	Braking BW	Speed ms^{-1}
Polyflex	1.255±0.024	1.187±0.012	0.265±0.009	1.619±0.046
Aluminium	1.255±0.024	1.166±0.012	0.271±0.010	1.611±0.045
P value	0.980	<0.001	0.409	0.871
Degrees of freedom	48	48	48	23

Table 5 Mean Preferred Walking Peak Forces (±S.E.) for the Left and Right Foot Strike in the Same Stride for Five Subjects

Subject	Polyflex		Aluminium	
	Vertical Landing BW	Vertical Propulsion BW	Landing BW	Propulsion BW
1	1.183±0.009	1.218±0.012	1.166±0.007	1.218±0.008
2	1.156±0.007	1.308±0.012	1.180±0.008	1.282±0.015
3	1.150±0.013	1.093±0.009	1.153±0.028	1.087±0.006
4	1.564±0.025	1.148±0.017	1.564±0.023	1.107±0.012
5	1.212±0.009	1.159±0.006	1.201±0.009	1.129±0.007

Table 6 Mean Peak Braking Forces (±S.E.) in a Stride for Each Subject

Subject	Running		Walking	
	Polyflex BW	Aluminium BW	Polyflex BW	Aluminium BW
1	0.452±0.010	0.434±0.015	0.220±0.006	0.205±0.006
2	0.397±0.006	0.407±0.003	0.223±0.003	0.260±0.003
3	0.459±0.019	0.451±0.013	0.236±0.010	0.230±0.014
4	0.820±0.064	0.705±0.024	0.372±0.017	0.380±0.015
5	0.527±0.019	0.534±0.020	0.270±0.005	0.273±0.006

CONCLUSION: In running the 0.017m of polyflex on the 0.004m alumuminium base plate did not significantly attenuate peak vertical forces or braking force. Further testing of this type should involve a greater number of subjects wearing the same shoe type, and give consideration to using only running speed.

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