RELATIONSHIP OF SHOE IMPACT, BRAKING AND PROPULSIVE FORCES

Andrew Mitchell, Rosemary Dyson, Terence McMorris, Neal Smith, Paul Hurrion.

Chichester Institute of Higher Education, College Lane, Chichester, West Sussex. United Kingdom.

INTRODUCTION

The existence of high impact force in running is thought to contribute to the occurrence of injury (Van Mechelen, 1995). Attenuation of this force to lessen the risk of injury is generally considered preferable (Segresser & Nigg, 1993), though there are concerns expressed (Robbins & Gouw, 1991 cited in Van Mechelen, 1995) about reduction of sensory feedback at impact and the potential loss of the protective muscular response.

Van Mechelen (1992) reported that runners having no preferred shoe brand sustained significantly fewer injuries. The current study aimed to investigate the influence of shoe type (circa 1995) on ground reaction forces experienced by males and females during jogging at preferred speed.

METHODS

Twelve sports students, six male (age 20.17 ±0.75 years; height 1.80 ±0.07 m; weight 81.2 ±7.0 Kg (mean, S.D)) and six female (age 19.7 ±0.52 years; height 1.58 ±0.15 m; weight 61.0 ±8.2 Kg (mean, S.D.)) were the subjects of the study. Ten shoes were assessed. Males wore six pairs of shoes (Adidas Response Lite; Adidas Torsion Advance; Adidas Tech Performance; Mizuno Mondo Elite; Puma Disc System TX4000; Puma Viento;) and females four pairs of shoes (Adidas Response Lite, Adidas Lady Tech Performance, Puma T-400; Puma Liberte II). All shoes were new before the study began. All subjects wore the shoe size which they found most suitable in terms of fit.

Ground reaction forces (vertical, anterior-posterior, and medio-lateral) were measured as the foot struck a 9581 Kistler force platform (0.6 x 0.4m) mounted in an outdoor proflex artificial track surface. The aluminium top plate surface of the force platform was covered by 0.004m aluminium base plate and a proflex covering of 0.009m which fitted neatly into the surrounding proflex track surface. Forces were sampled at 500 Hz and stored using Orthodata Provec software running on a Viglen 386 IBM compatible computer system with integral Amplicon twelve bit analogue to digital converter. Jogging speeds were measured between positions 1 metre before and 1 metre after the 0.6m long force platform using Chichester Institute infrared timing devices measuring to an accuracy of 1 millisecond.

Following shoe habituation subjects jogged at preferred pace naturally in mild, dry conditions across the platform until five recordings of natural right foot strike at preferred jogging speed were obtained. The preferred jogging speed for each subject being similar for all shoes. Shoes were worn by each subject in an individual random order (Altman, 1991).

Subsequently peak forces were read from the computer screen using cursor measurement to locate peak forces. Following initial evaluation analysis was focused on the vertical and anterior-posterior forces. Mean peak vertical impact and maximal vertical forces, mean peak braking and propulsive forces were calculated relative to each subject's body weight (BW). (Note: the maximal vertical force was the landing force recorded other than the impact force). Correlations between peak forces were investigated using a Pearson two-tailed test.

RESULTS

Table 1. Mean peak ground reaction forces (BW ± standard error) of the male subjects wearing different shoes while jogging at preferred speed.

Shoe	Vertical impact	Vertical maximum	Braking	Propulsive
Adidas 1	2.573 ± 0.073	2.948 ± 0.048	0.667 ± 0.031	0.425 ± 0.015
Adidas 2	2.507 ± 0.091	2.966 ± 0.045	0.651 ± 0.028	0.407 ± 0.011
Adidas 3	2.531 ± 0.072	3.000 ± 0.044	0.616 ± 0.022	0.443 ± 0.015
Mizuno 1	2.782 ± 0.076	2.987 ± 0.049	0.702 ± 0.034	0.421 ± 0.012
Puma 1	2.768 ± 0.111	2.964 ± 0.054	0.700 ± 0.048	0.402 ± 0.013
Puma 2	2.551 ± 0.059	2.909 ± 0.049	0.642 ± 0.023	0.421 ± 0.016

Note:
Adidas 1 - Adidas Response Lite.
Adidas 2 - Adidas Torsion Advance.
Adidas 3 - Adidas Tech Performance
Mizuno 1 - Mizuno Mondo Elite
Puma 1 - Puma Disc System TX4000
Puma 2 - Puma Viento.

In the male subjects a low mean peak braking force and low mean peak vertical force was associated with a high mean peak propulsive force (Adidas Tech Performance: braking 0.616BW, impact 2.531BW, propulsive 0.443BW). Similarly a high mean peak braking force and high mean peak impact force was associated with a low mean peak propulsive force (Puma Disc system TX4000:braking 0.700BW, impact 2.768BW, propulsive 0.402BW). Correlation analysis between vertical maximum forces and propulsive forces indicated significant positive correlations of 0.49, 0.48, 0.54, 0.65, 0.65 for A1, A2, A3, M1, P1, P2 respectively (all $P < 0.0001$ except A3 which was $P < 0.002$) . This suggests that the basic relationship between vertical maximum forces and propulsive forces is modified by forces experienced at impact and during the braking phase.

Table 2. Mean peak ground reaction forces (BW ±standard error) of the female subjects wearing different shoes while jogging at preferred speed.

Shoe	Vertical impact	Vertical maximum	Braking	Propulsive
Adidas 1	2.072 ± 0.068	2.748 ± 0.039	0.572 ± 0.030	0.409 ± 0.012
Adidas 2	2.482 ± 0.090	2.781 ± 0.044	0.591 ± 0.032	0.379 ± 0.009
Puma 1	2.308 ± 0.062	2.769 ± 0.036	0.592 ± 0.030	0.384 ± 0.011
Puma 2	2.274 ± 0.080	2.754 ± 0.031	0.575 ± 0.028	0.381 ± 0.011

Note:
Adidas 1 - Adidas Response Lite
Adidas 2 - Adidas Lady Tech Performance.
Puma 1 - Puma T-400.
Puma 2 - Puma Liberte II.

Mean peak vertical impact forces, vertical maximum forces and braking forces tended to be less in the females than the males. For the female subjects significant correlations of 0.44, 0.50, 0.42, between vertical maximal and propulsive forces were found for shoes A1, A2, P1 respectively ($P < 0.01$). The correlation for shoe P2 was not significant, though impact-maximum and impact-braking forces were ($P < 0.0001$). The Adidas Response Lite showed how lower impact and braking forces were associated with higher propulsive force.

Whether the higher propulsive force noted for the male Adidas Tech Performance shoe and female Adidas Response Lite shoe was directly linked to the lower impact and braking forces, or to shoe design factors (e.g. pronation control) is not clear. However further analysis of the original trace data has indicated that when low correlations for the impact-braking and/or vertical maximum-propulsive peak forces existed there were often indications of difficulty with mediolateral stability which resulted in a loss of propulsive force.

CONCLUSION

Low peak vertical impact force and low peak braking force was associated with greater propulsive force in two of the shoes studied.

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