FOOTSTRIKE PATTERNS DURING RUNNING OVER OBSTACLES OF DIFFERENT HEIGHTS

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INTRODUCTION

Previous research has focused on mechanisms to safely overcome obstacles and how vision can influence the locomotor act (Patla et al, 1996). Less attention has been directed towards the landing of the leading leg after obstacle clearance while running. Research on running has evaluated the ground reaction forces (GRF) of foot strike patterns (Cavanagh & Lafortune, 1980), and suggested that 90% of the population use a heel-to-toe landing pattern. However, during sprinting many of these runners will change to a toe only (forefoot) strike. Research on landing after vertical jumps has identified a toe-to-heel type of landing which was attributed to increased GRF (Dufek & Bates, 1990). Much research has been produced on changes such as the walk-to-run or run-to-sprint. However, limited research exists on running over high enough obstacles to cause a change of the footstrike pattern. Thus, the purpose of this study was to examine the different footstrike patterns and strategies used during running over obstacles of various heights.

PROCEDURES

Ten heelstrike subjects ran at a self-selected pace under seven conditions: unperturbed running (no obstacle present) and over obstacles of six different heights (10%, 12.5%, 15%, 17.5%, 20%, and 22.5% of their standing height). The obstacle was placed directly before a Kistler force platform so that the subject had to clear the obstacle with the right leg and land on the platform. Ground markers ensured that stride length was kept the same for all conditions. GRF data from 10 trials per condition were sampled at 900Hz. Parameters analyzed were the heel impact peak from the vertical GRF (Fh), times for braking (TB) and propulsion (TS) periods, minimum braking (FY1) and maximum propulsion (FY2) peaks from the anterior posterior GRF, and an index of the anterior posterior position of the center of pressure (ICOP). One-way repeated measures ANOVAs were performed on the subject means for all parameters. A Tukey test was performed in comparisons that resulted in a significant F-ratio ($p<0.05$).

RESULTS AND DISCUSSION

The group analysis results are presented in Table 1. ANOVAs identified significant differences for all parameters. TB had an inverse linear relationship with obstacle height and 12 out of 21 possible post-hoc comparisons were significant, while TP was less affected (1/21). However, opposite to TB, TP inceased which was expected since the speed was kept constant between conditions. FY2 revealed a direct linear relationship with obstacle height (20/21), while FY2 showed less changes (2/21). After clearing an obstacle, both braking and propulsion are more demanding which explains the above results. The ICOP had an inverse linear relationship with obstacle height (13/21), while the opposite was true for Fh (14/21). The Fz curves illustrated that the increase in obstacle height resulted in the appearance of an additional impact peak

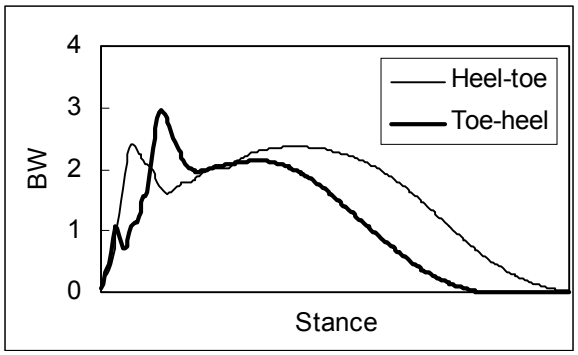

Figure 1: Representative Fz curves.

prior to Fh (Figure 1). This peak was caused by the change to a toe-to-heel landing. The group changed at a height of 15%. At that height the ICOP decreased below 0.07 m indicating a more closed path for the COP. The new pattern was similar to the footstrike patterns found in jumping activities. Thus, the subjects eventually changed from running over the obstacles to jumping. This new strategy might have helped them to absorb the increased impact forces. The toe-to-heel pattern might have increased the involvement of the ankle joint and the calf muscles in shock absorption. Even that Fh increased with obstacle height, these increases might have been larger and possibly injurious if the subjects were forced to run over the obstacles and land on their heels. Lastly, not all subjects changed at the same height. Differential strategies were revealed as an earlier or later change, underlining the importance of individual variability (Dufek & Bates, 1990).

SUMMARY

Running over high enough obstacles can cause a behavioral change of the footstrike pattern from heel-to-toe to toe-to-heel. The obstacle height for this change seems to be 15% of the runner's standing height. Individual differences however, do exist.

REFERENCES

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Table 1: Parameters evaluated with superscripts indicating post-hoc differences ($p<0.05$).

Variables	0%	10%	12.50%	15%	17.50%	20%	22.5%
FY1	$0.424^{17.5\%,20\%}$	0.516	0.509	0.507	0.533	0.534	0.522
(BW)	0.074	0.163	0.177	0.173	0.189	0.177	0.220
FY2	$0.278^{10\%-22.5\%}$	$0.330^{12.5\%-22.5\%}$	$0.339^{15\%-22.5\%}$	$0.355^{20\%,22.5\%}$	$0.355^{20\%,22.5\%}$	$0.369^{22.5\%}$	0.389
(BW)	0.027	0.045	0.059	0.053	0.069	0.060	0.064
TB	$0.139^{10\%-22.5\%}$	$0.122^{20\%-22.5\%}$	$0.121^{20\%-22.5\%}$	$0.113^{22.5\%}$	$0.114^{22.5\%}$	0.110	0.104
(sec)	0.023	0.023	0.023	0.025	0.025	0.023	0.021
TP	$0.132^{22.5\%}$	0.135	0.137	0.138	0.136	0.141	0.142
(sec)	0.020	0.018	0.019	0.022	0.020	0.023	0.022
Fh	$1.715^{10\%-22.5\%}$	$2.490^{17.5\%-22.5\%}$	$2.482^{17.5\%-22.5\%}$	$2.668^{20\%,22.5\%}$	2.914	3.037	3.098
(BW)	0.276	0.539	0.526	0.469	0.511	0.395	0.433
ICOP	$0.111^{10\%-22.5\%}$	$0.088^{15\%-22.5\%}$	$0.083^{17.5\%-22.5\%}$	0.066	0.062	0.060	0.054
(m)	0.016	0.034	0.033	0.032	0.030	0.030	0.024