

SUDDEN WALK-TO-RUN TRANSITIONS: MOVING THE CENTRE OF PRESSURE OR THE CENTRE OF MASS?

¹ Veerle Segers, ^{1,2}Peter Aerts and ¹ Dirk De Clercq

¹Ghent University, Department of Movement and Sports Sciences, Watersportlaan 2, B-9000 Ghent, Belgium;

²University of Antwerp, Laboratory of Functional Morphology, Antwerp, Belgium; email: Veerle.Segers@UGent.be

INTRODUCTION

Gait transition research mainly focussed upon the gradual accelerations across transition speed [1]. However, although providing fundamental insights in the neuromechanics of gait transitions, such a protocol might be less representative for many real life situations in which gait changes abruptly in response to an external (often threatening) stimulus [1]. For humans, burst walk-to-run transitions or explosive transitions from a steady strolling pace into maximal sprinting usually occur in response to an exteroceptive stimulus (e.g. sports or traffic situations). To maximize acceleration the point of application of the ground reaction force (the centre of pressure- COP) has to be located behind the centre of mass (COM). Theoretically, this can be realized in two manners: (a) moving the COM in front of the COP or (b) moving the COP behind the COM [2]. The choice of either one of these strategies is most likely depending on the moment of stance at which the signal to accelerate is given. The aim of the present study is to examine how humans realize the burst transitions using a visual signal that is lit at different moments in stance. In this abstract we focus on kinematics and performance and energetical measures of burst transitions.

METHODS

20 active female subjects (1.70 ± 0.10 m; 63.5 ± 7.7 kg) participated in the present study. Speed was measured at 1000Hz using a Noptel distance laser. 3D Kinematics were recorded using 8 Pro Reflex cameras and Qualisys software. A Kistler force plate was used to trigger the visual signal. The visual signal was randomly lit (a) slightly after heel contact (set-off 10N on Kistler force plate) (b) at midstance (c) at heel off. Given the goal of the task is to accelerate as quick as possible realize peak acceleration and timing of this acceleration with respect to the instance of the visual trigger are obtained after double numerical integration of the filtered Noptel distance measurements. The energetics of walk-to-run burst transitions are assessed by calculating the work ($W_{\text{objective}}$) essentially required to realize the fundamental objective of the task and the mechanical work delivered by the subjects ($W_{\text{mechanical}}$) assuming maximal energy transfer and dissipation of negative work. Work was calculated between the instant of the visual stimulus (t_0) and the first (t_1) and second (t_2) footfall after the first floating phase.

RESULTS AND DISCUSSION

Two main classes for burst transition can be discriminated.

Strategy 1. Moving the COM in front of the COP: This type of burst transition is characterized by a forward rotation of the trunk and flexion of the knee during the second part of stance (front leg). *Strategy 1* only appears when a signal is given at heel contact (reaction category 1.1) or at heel off (reaction category 1.2).

Strategy 2. Moving the COP behind the COM: The foot is placed behind the 'normal' position at touch down by a backward rotation of the swing leg. Reaction occurs in the step after the signal. *Strategy 2* burst transitions appear when the signal is given at heel contact, midstance or heel off. In reaction category 2.1 retraction of the swinging leg is initiated during swing, whereas in reaction category 2.2 initial ground contact is made, the foot is lifted again and retraction occurs.

The actual realization of transition (i.e. first step with a flight phase) occurs later in strategy 2 burst transitions but the reaction is more explosive. This is reflected in the acceleration and the timing of the peak acceleration (see Table 1). Besides the explosivity of the reaction, the energy requirements have been calculated indicating that energy requirements of the transition step (i.e. generation first flight phase) are equal for both type of burst transitions. The first actual sprinting step however is more energy consuming in strategy 1 burst transitions. As such, strategy 2 burst transitions are characterized by a higher efficacy and better (or least equal) performance measures.

CONCLUSIONS

In conclusion, using a 'seemingly contraproductive' backwards swinging leg (strategy2) leads to a higher initial acceleration. Since strategy 2 burst transition are in addition energetically less consuming, actively trying to adopt this type burst transitions could give rise to energetical benefits and performance enhancements.

ACKNOWLEDGEMENTS

This research was supported by BOF08/PDO/069.

REFERENCES

1. Segers V, et al., *J Exp Biol.* **210**: 578-585, 2007.
2. Kraan, et al., *J Biomech.* **34**: 211-215, 2001

Table 1. Performance measures and energy requirements for burst transitions

| | | Performance measures | | Work measures ($W_{\text{mechanical}} - W_{\text{objective}}$)/m | |
|----------|-----|--------------------------------------------|---------------------------------|-----------------------------------------------------------------------|-----------------------------|
| | | Peak Acceleration (m.s^{-2}) | Timing peak acceleration (s) | Interval t_0-t_1 (J/m) | Interval t_0-t_2 (J/m) |
| strategy | 1.1 | 2.65 d | 1.13 b,c,d | 114.14 c,d | 149.18 c,d |
| | 1.2 | 2.62 c,d | 0.91 a | 125.82 c,d | 206.43 c,d |
| strategy | 2.1 | 3.17 b | 0.82 a | 53.25 a,b | 69.54 a,b |
| | 2.2 | 3.63 a,b | 0.79 a | 42.95 a,b | 27.55 a,b |

significant differences ($p < 0.05$) from (a) reaction strategy 1.1, (b) reaction strategy 1.2, (c) reaction strategy 2.1, (d) reaction strategy 2.2