THE VARIABILITY OF DYNAMIC AND SPATIO-TEMPORAL PARAMETERS OF THE RUNNING STRIDE

[1]Marina Gouvali and [2]John H. Challis
[1]Department of Sports Medicine and Exercise Biology, University of Athens, Greece; email: mgouvali@phed.uoa.gr
[2]Biomechanics Laboratory, The Pennsylvania State University, USA; email: jhc10@psu.edu

INTRODUCTION

Variability associated with individual running performance is apparent when an effort has to be repeated, even though conditions remain the same. Variability seems to increase when time between sessions increases [1] suggesting higher biological rather than methodological variability. Previous studies examining day-to-day variability have only measured a limited number of steps, for example 5 or 10 [2], which may not adequately sample the variability which exists in one day. The purpose of this study was to examine the variability of dynamic and spatio-temporal parameters of the running stride between sessions conducted on different days for 90+ steps per day.

METHODS

Seven females and six males voluntarily participated in the study (Age F: 25.8±3.3 yrs, M: 26.9±3.6 yrs, Height F: 167.3±2.3 cm, M: 184.8±5.3 cm, Mass F: 62.9±6.7 kg, M: 83.3±10.7 kg). All subjects provided informed consent for all procedures, which were approved by the Institutional Review Board.

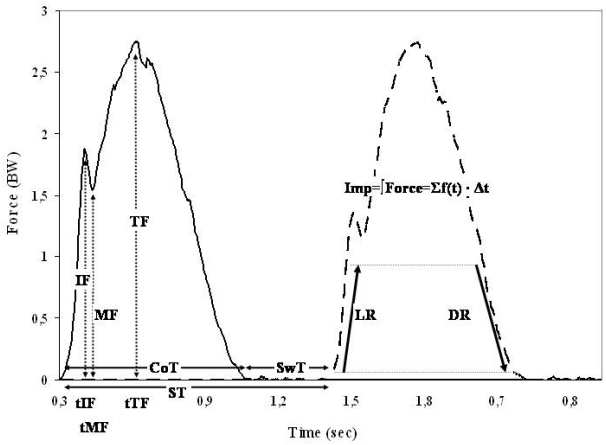

Figure 1: Key variables selected for analysis from a force-time curve.

Vertical ground reaction forces (GRF) and temporal parameters were collected with the aid of a Gaitway Instrumented Treadmill (Kistler Instrument Corporation) with two built-in force plates and were further analyzed with Gaitway Software 1.0 and MATLAB 6.5. Data were sampled at 500 Hz and filtered with a Butterworth filter (2nd order, cutoff frequency 30Hz). They were normalized for force by dividing by body weight. The protocol included 2 sessions separated by a day. Each session consisted of 4 running trials (5 min each) at 4 different speeds (F: 2, 3, 4 m/s, preferred speed, M: 3, 4, 5 m/s, preferred speed). GRF and spatio-temporal parameters for both legs were collected between the 4th and 5th min (~100 strides). The following variables were selected for analysis: *IF*: impact force (BW), *tIF*: time of IF (s), *MF*: minimum force (BW), *tMF*: time of MF (s), *TF*: thrust force (BW), *tTF*: time of TF (s), *Imp*: impulse (BW·s), *LR*: loading rate (BW·s^{-1}), *DR*: decay rate (BW·s^{-1}), *ST*: step time (s), *CoT*: contact time (s), *SwT*: swing time (s), *SL*: step length (m), *SF*: step frequency (steps·s^{-1}) (Figure 1).

Assessment of intra-day variability was evaluated using the coefficient of variation for the whole curve (*CoV*), as well as for each parameter (*CV*). Inter-day effect was tested by multivariate analysis of variance with repeated measures ($p<0.05$).

RESULTS

The coefficient of variability for the whole curve ranged between 4.5-6.0%. Variability between consecutive strides was higher when calculated separately for each parameter (2-20%) and was the least for *ST* and *SF*. Regarding the force variables, the force acting to propel the body (*TF*) was less variable (2.5%) than the force acting to absorb the impact (*IF*) (9.7%).

Table 1: Means and CV of the GRF and temporal parameters. (*p<0.05)

Day	1		2	
	Mean	**CV**	**Mean**	**CV**
IF	1.73	10.0	1.73	9.2
tIF	0.036	16.7	0.035	16.1
MF	1.49	11.4	1.46	10.6
tMF	0.047	13.3	0.047	12.7
TF*	2.47	2.6	2.44	2.4
tTF	0.107	7.0	0.106	6.9
Imp*	0.36	1.7	0.35	1.4
LR	63.04	12.1	66.13	12.5
DR	4.58	2.6	4.59	2.2
ST	0.366	3.6	0.363	3.2
CoT	0.237	7.8	0.238	7.7
SwT	0.129	18.4	0.125	16.9
SL	1.249	20.1	1.242	19.8
SF	2.75	2.7	2.77	2.4

The results produced no significant differences for most GRF and temporal means and *CV* between sessions separated by a day; significant, but small, differences existed only for *TF* and *Imp* (Table 1).

CONCLUSIONS

Variability in the force-time pattern between consecutive strides is high and dependent on the nature of the variable, indicating that the number of trials to be analyzed should be determined according to which parameters are of interest. Running performance can be replicated without significant systematic error after one day. In conclusion, one session can be considered as satisfactory for analyzing the dynamic and temporal characteristics of the running stride.

REFERENCES

1. DeVita P, et al. *Hum Mov Sci* **7**, 73-85, 1988.
2. Diss CE, et al. *Gait and Posture* **14**, 98-103, 2001.