Can Running Technique Influence Performance Independently of Running Economy?

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Summary

Fifty-five male runners had their sustainable endurance speeds established and represented using the 'classical' physiological model of endurance performance as the product of: maximal oxygen uptake; fractional utilisation; and running economy. Correlation coefficients were calculated between spatiotemporal gait parameters and model components. Parameters indicative of higher mass-specific vertical ground forces – higher flight time and lower duty factor - had the strongest relationships with sustainable speed. These components were also related to the product of maximal oxygen uptake and fractional utilisation, but not to running economy. It is unclear whether technique directly influenced oxygen uptake, but athletes who applied larger mass-specific vertical ground forces sustained higher running speeds.

Introduction

In the 'classical' physiological model of endurance performance, maximum sustainable running speed (S_s) can be expressed using three parameters [1]:

$$S_s = V\dot{O}_{2\,max} \times \%V\dot{O}_{2\,max} \times RE, \qquad (1)$$

where $V\dot{O}_{2\,max}$ is maximal oxygen uptake (in ml.kg^{-1}.min^{-1}), $\%V\dot{O}_{2\,max}$ is the percentage of $V\dot{O}_{2\,max}$ at S_s, and RE is running economy [in km.h^{-1}. $V\dot{O}_2^{-1}$ (ml.kg^{-1}.min^{-1})].

Typically, it is thought that running technique influences performance via RE, however different elements of technique have been shown to relate to performance than to RE [2]. The study aim was to relate technique to the components of Equation 1 and to competition running performance.

Methods

Fifty-five healthy male endurance runners (age: 27.1 ± 7.4 yrs; height: 1.79 ± 0.06 m; mass: 67.2 ± 6.4 kg) performed an incremental treadmill running test during which speed at lactate turnpoint (S_{LT}) was determined from analysis of blood lactate, and RE, $V\dot{O}_{2\,peak}$, and $\%V\dot{O}_{2\,peak}$ were established from pulmonary gas exchange data. Peak $V\dot{O}_2$ values were used as estimates of maximum values and S_{LT} as an estimate of S_s. Spatiotemporal variables stride length (SL), stride rate (SR), stance time (ST), flight time (FT), and duty factor (DF) were calculated using 3D kinematics. The highest speed at which all subjects were at or below S_{LT} (16 km.h^{-1}) was analysed to avoid the confounding effect of comparing technique parameters at different speeds. Runners' season's best times for distances from 1500 m to marathon were collected and converted using IAAF points to an equivalent speed over 10 km (S_{BT}). Theoretical speed at peak oxygen uptake ($S_{V\dot{O}2\,max} = V\dot{O}_{2\,max} \times RE$), and rate of oxygen uptake at S_s ($V\dot{O}_2 = V\dot{O}_{2\,max} \times \%V\dot{O}_{2\,max}$) were also derived from Equation 1. Spatiotemporal parameters were then correlated to $V\dot{O}_{2\,max}$, $\%V\dot{O}_{2\,max}$, RE, $S_{V\dot{O}2\,max}$, $V\dot{O}_2$, S_s, and S_{BT} using Pearson correlation coefficients.

Results and Discussion

Parameters indicative of higher mass-specific vertical ground reaction forces (higher FT and lower DF) had the strongest relationships with better S_s and S_{BT}, displaying consistently stronger relationships with S_{BT} than S_s (Table 1). No spatiotemporal parameters were individually related to $V\dot{O}_{2\,max}$, $\%V\dot{O}_{2\,max}$, or RE. However, the product of $V\dot{O}_{2\,max}$ and $\%V\dot{O}_{2\,max}$ - $V\dot{O}_2$ - was also correlated to FT and DF. Therefore, relationships between spatiotemporal parameters and S_s seem to have been driven by relationships with $V\dot{O}_{2\,max}$ and $\%V\dot{O}_{2\,max}$, and were independent of RE.

Table 1: Pearson correlation coefficients (r) between spatiotemporal parameters, and performance and physiological parameters.

	SL	SR	ST	FT	DF
$V\dot{O}_{2\,max}$	0.10	-0.10	-0.15	0.18	-0.18
$\%V\dot{O}_{2\,max}$	0.09	-0.09	-0.21	0.22	-0.24
RE	-0.03	0.03	0.11	-0.09	0.10
$S_{V\dot{O}2\,max}$	0.07	-0.07	-0.04	0.08	-0.07
$V\dot{O}_2$	0.17	-0.17	-0.31*	0.35**	-0.36**
S_s	0.19	-0.19	-0.26	0.33*	-0.33*
S_{BT}	0.36**	-0.36**	-0.29*	0.48***	-0.45***

* p<0.05, ** p<0.01, *** p<0.001

Conclusions

Of the components in the classical model of endurance performance, the product of $V\dot{O}_{2\,max}$ and $\%V\dot{O}_{2\,max}$ was related to spatiotemporal gait parameters, but RE was not. It is unclear whether duty factor directly influenced oxygen uptake and performance, as has been observed in isolated limb exercises [3], or if other factors mediated this relationship. Regardless, athletes who applied larger mass-specific vertical ground forces sustained higher running speeds.

References

[1] Joyner, MJ. (1991). *J Appl Physiol*, **79(2)**: 683-687.
[2] Folland, JP., et al. (2017) *Med Sci Sports Exerc*, **49(7)**: 1412-1423.
[3] Broxterman, R.M., et al. (2014) *Respir Physiol Neurobiol*, **192**: 102-111.