STRENGTH AND POWER CHARACTERISTICS FOR ELITE ATHLETES FROM DIFFERENT SPORTS

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INTRODUCTION

Strength and power requirements to maximise performance are sport-specific. Previous studies comparing strength and power in athletes from different sports have generally focused on single isolated movements, e.g. 1 RM squat, bench press, maximum jump height [1]. The specificity of the strength–speed relationship [2] indicates that care is required in extrapolating single measurements to more relevant conditions. Nevertheless assessing how well adapted the strength–speed relationship of an athlete is to the specific demands of their sport has implications in talent identification and athlete development. This study aimed to determine whether there are differences in the strength–speed and power–speed characteristics of elite athletes from five sports. A further aim was to assess how well these relationships matched sport-specific demands.

METHODS

Five elite male athletes (Table 1) gave informed consent. Maximal effort extension and flexion of the knee and hip, five isometric trials and eight eccentric-concentric trials from 50° s^{-1} to 400° s^{-1} [3], were conducted on a Cybex NORM dynamometer. Maximum torque for each isometric trial and maximum isovelocity torque for each eccentric and concentric velocity were determined from the dynamometer data. A 7 parameter strength model was fitted to the maximum torque–velocity data for each joint [3]. RMS difference between model torque–velocity and experimental data was compared based on the subject's model and each of the other subjects' models. This was repeated for both absolute torques and normalised torques (normalised to maximum isometric torque) to allow differences in the shape of the curves to be differentiated from those due purely to absolute strength. Comparisons utilized one-sided independent samples t-tests with significance set at $p = 0.05$.

Table 1. Characteristics of the five elite athletes

Subject	Sport	Age	Height (m)	Mass (kg)
TJ	Triple jump	22	1.82	72.6
HJ	High jump	24	1.89	81.9
TC	Track cycling	25	1.83	86.0
GY	Gymnastics	19	1.78	78.5
KA	Karate	30	1.75	89.3

RESULTS AND DISCUSSION

The strength and power characteristics indicated qualitative and statistically significant differences between athletes (Figure 1). In every case the fit to an athletes' own model was significantly better than the fit to any of the others.

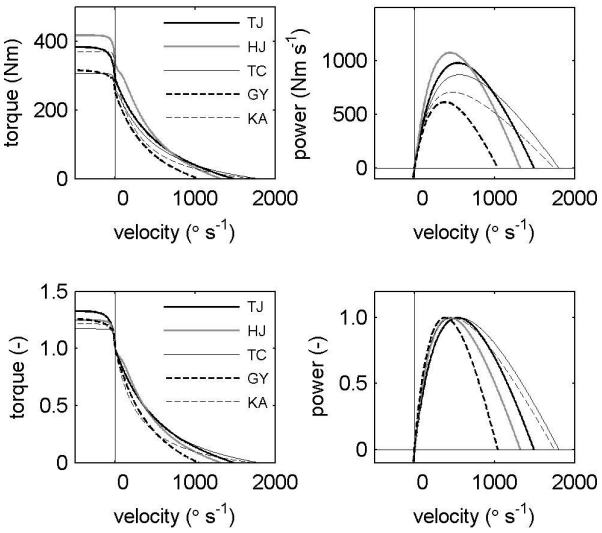

Figure 1: Knee extension results for the five elite athletes: (a) maximum voluntary torque–velocity; (b) normalised torque–velocity; (c) power–velocity; and (d) normalised (to the peak value) power–velocity.

A number of sport-specific demands which are reflected in both the absolute and normalised results can be identified: (i) HJ, TJ and GY requires eccentric extensor strength for landing (high T_{ecc}/T_o); (ii) TC requires concentric speed and strength and is one of few sports that actively focuses on knee flexion (high $\square_{max}$, $\square_c/\square_{max}$ and $\square(P_{max})$); (iii) GY does not require high absolute strength or speed (low $\square_{max}$, P_{max}, $\square(P_{max})$); and (iv) KA requires speed rather than pure strength and kicking is a predominately unloaded action (high $\square_{max}$). It would be of interest to assess to what degree the specificity of these strength and power curves are genetic and trained. Such a differentiation is not possible from the present results but would provide useful further work.

CONCLUSIONS

The strength and power characteristics for elite athletes from different sports show significant differences that generally reflect the sport-specific demands.

REFERENCES

1. Izquierdo M, et al. *Eur J Appl Physiol.* **87**:264-271, 2002.
2. Baker D, et al., *Eur J Appl Physiol.* **104**:350-355, 1994.
3. Yeadon MR, et al., *J Biomech.* **39**:476-482. 2006.

Table 2. Key parameters describing the strength model for the five elite athletes.

Subject	Knee Extension					Knee Flexion					Hip Extension					Hip Flexion				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
TJ	**1.28**	0.46	25.3	0.98	9.3	1.25	0.42	24.6	0.84	8.8	1.25	*0.50*	*18.2*	1.08	*6.8*	1.20	0.30	*18.0*	0.36	5.9
HJ	1.24	0.32	23.1	**1.08**	7.8	*1.10*	**0.24**	*18.0*	*0.36*	*5.6*	1.17	**0.16**	32.1	0.62	8.7	1.39	0.34	**23.4**	0.68	**7.8**
TC	*1.17*	0.24	**31.5**	0.87	**9.8**	**1.28**	*0.50*	**36.0**	**1.24**	**13.3**	*1.12*	0.40	34.0	**1.78**	**12**	**1.40**	0.45	*18.0*	0.39	6.4
GY	**1.28**	*0.50*	*18.1*	*0.62*	*6.6*	1.26	0.37	*18.0*	0.37	6.3	**1.37**	*0.50*	19.1	*0.50*	7.0	*1.15*	**0.16**	*18.0*	*0.22*	*4.8*
KA	1.22	**0.16**	30.5	0.71	8.3	1.23	0.33	30.1	0.61	10.1	1.36	**0.16**	**36.0**	1.02	9.8	1.18	*0.50*	20.6	**0.72**	7.6

1. T_{ecc}/T_o (-) ratio of maximum voluntary eccentric to maximum voluntary isometric torque; 2. $\square_c/\square_{max}$ (-) curvature of the concentric hyperbola, range from 0.15 (high) to 0.5 (low); 3. $\square_{max}$ (rad s^{-1}) maximum angular velocity; 4. P_{max} (kW) maximum power; 5. $\square(P_{max})$ (rad s^{-1}) angular velocity at maximum power.