

ASSOCIATION OF VERTICAL JUMP DISPLACEMENT WITH MULTIPLE INDICES OF RATE OF FORCE DEVELOPMENT

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INTRODUCTION

Rate of force development (RFD) is often assumed to be positively associated with power-dependent performance. It may be calculated as the slope of the force-time curve (delta force for designated starting and ending points divided by the corresponding elapsed time). Paradoxically, RFD appears to be only modestly associated with vertical jump performance. Therefore, either our logic has been faulty, or we have sub-optimally represented RFD during jumping. In 1995, Vladimir Zatsiorsky proposed four indices of RFD including 1) starting gradient (S-gradient: 50% of peak force / elapsed time to reach it), 2) acceleration gradient (A-gradient: 50% peak force / elapsed time from that point to peak force), 3) index of explosive strength (IES: peak force / time to peak force, and 4) reactivity coefficient (RC: peak force / (time to peak force x body mass)). We propose to also calculate five slopes from the force-time curve to represent RFD including 1) full RFD to peak force, 2) early-stage RFD, and 3) late-stage RFD with the point of demarcation between early and late stages being either 1) 50% of the time to reach peak force (temporally based: t) or 2) 50% of delta force to peak (kinetically based: k).

PURPOSE

- To determine the association of vertical jump displacement with nine proposed iterations of RFD obtained during vertical jumping in biological men and women.

METHODS

Sixty young adults (31 men, 29 women) performed three CMVJs on two occasions. A nine-camera 3D motion capture system (240 Hz, Qualisys Inc., Sweden) and force platform (1200 Hz, AMTI, Watertown, MA, USA) were used to collect 3D marker position data and vertical ground reaction force (vGRF) data for the right side of the body, respectively. Full-, early- and late-stage RFD, as well as Zatsiorsky's four indices of RFD were computed from vGRF data using the first sign of a positive slope of the force-time curve as the anchor point for all measures of RFD. (See Figures 1 and 2.) Data were extracted from the highest jump displacement at each session. An average of the two sessions was used in calculating bivariate correlations (r) for association determination.

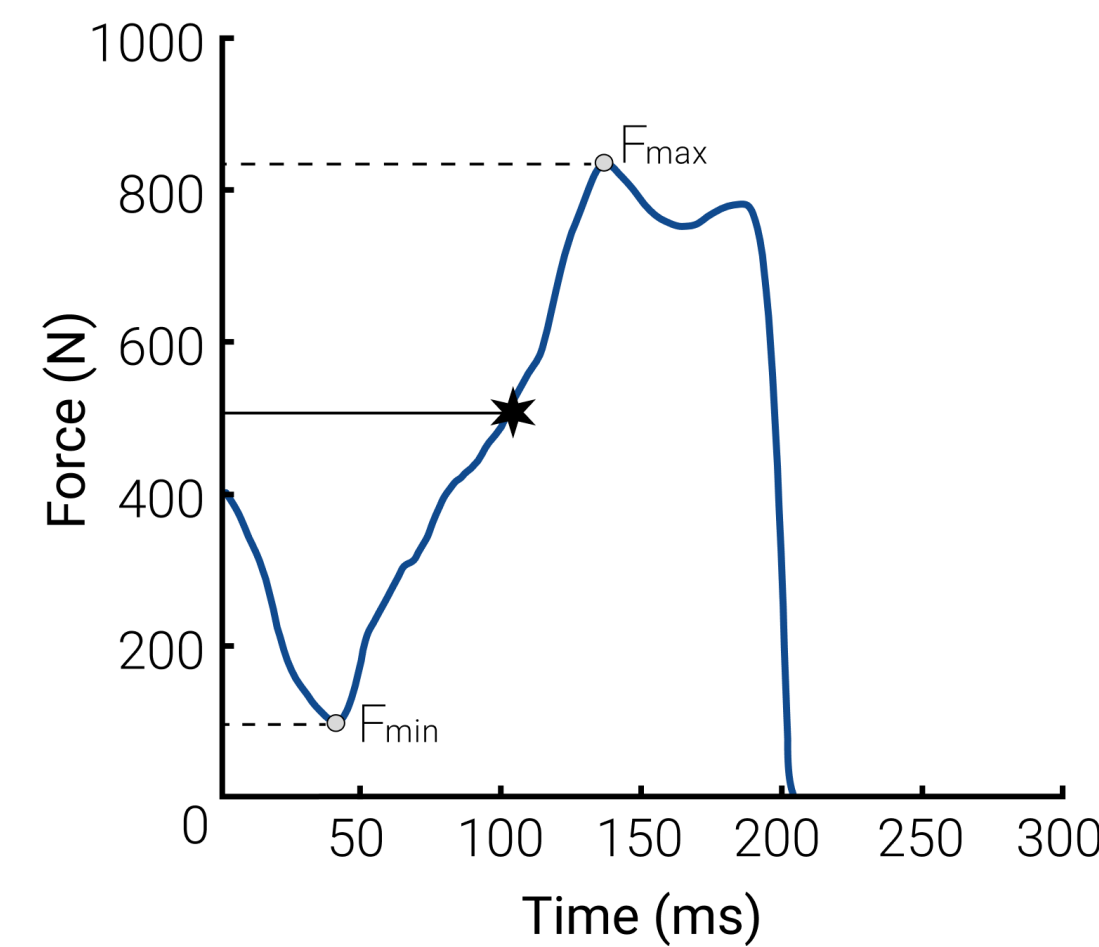


Fig. 1. Zatsiorsky's start- and acceleration gradients were based on 50% of peak force.

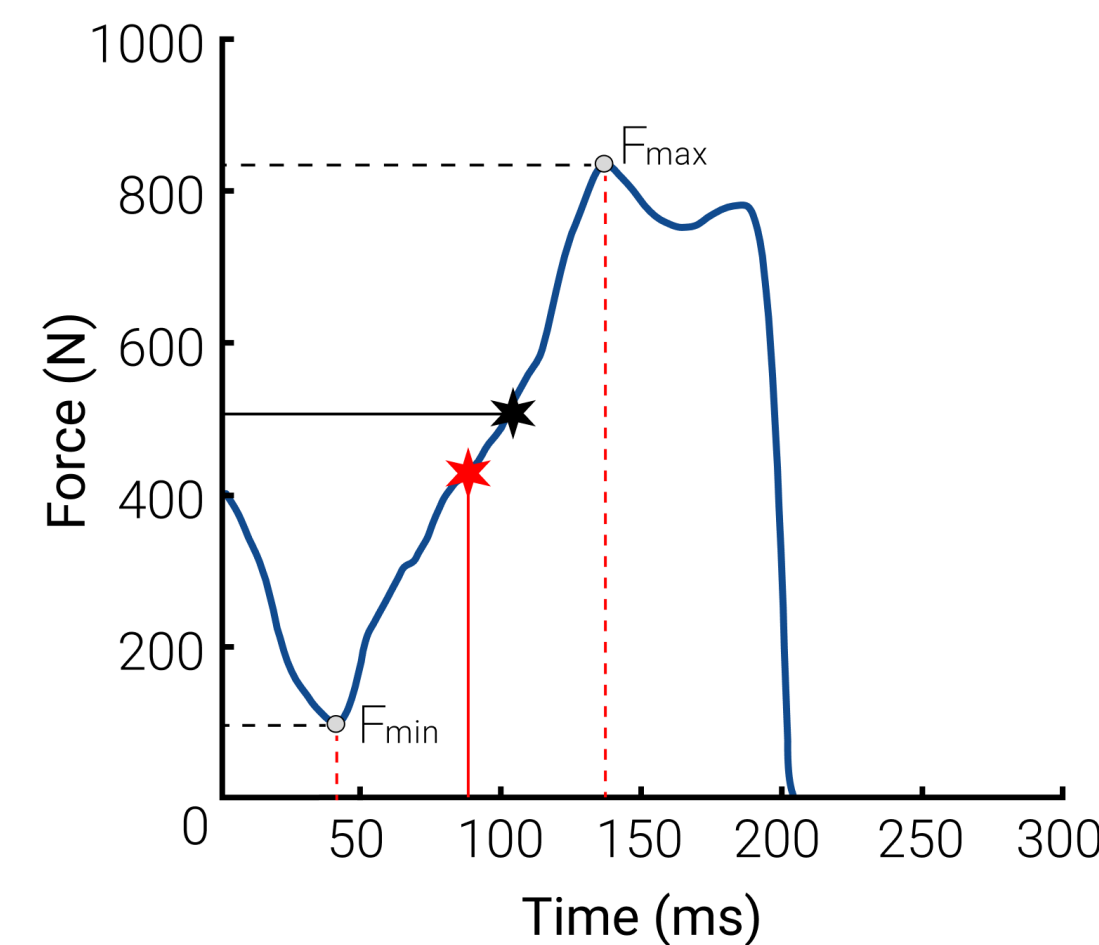


Fig. 2. Early- and late-stage slope-calculated RFDs were based on 50% of the elapsed time to peak force (t) and 50% of delta force to peak (k), respectively.

RESULTS

See Table 1.

Table 1. Descriptives and associations (r) of counter-movement vertical jump (CMVJ) displacement with nine indices of RFD. Early- and late-stage RFD variables were based on either temporal (t) or kinetic (k) considerations. The anchor point for RFD calculations was the first sign of a positive slope (beginning of eccentric phase) of the force-time curve.

Variables				CMVJ	CMVJ	CMVJ
	All Subjects n=60 Mean (Std Dev)	Men n=31 Mean (Std Dev)	Women n=29 Mean (Std Dev)	All Subjects r	Biological Men r	Biological Women r
CMVJ (m)	0.55 (0.14)	0.59 (0.15)	0.51 (0.12)	---	---	---
S-gradient ($N \cdot s^{-1}$)	2603.63 (1007.61)	2890.07 (1118.66)	2286.49 (769.43)	0.12	0.10	-0.10
A-gradient ($N \cdot s^{-1}$)	2199.85 (1704.77)	2653.26 (2158.83)	1697.85 (753.17)	0.26*	0.26	-0.05
IES ($N \cdot s^{-1}$)	2290.12 (1226.85)	2728.86 (1468.34)	1804.38 (609.94)	0.25	0.24	-0.11
RC ($N \cdot s^{-1} \cdot kg$)	31.61 (16.01)	33.83 (19.94)	29.14 (9.86)	0.18	0.20	0.01
Full RFD ($N \cdot s^{-1}$)	1791.45 (942.69)	2104.51 (1073.01)	1444.83 (626.59)	0.19	0.17	-0.09
Early-stage RFD $_t$ ($N \cdot s^{-1}$)	1563.10 (856.65)	1836.70 (981.05)	1260.19 (570.89)	0.04	-0.04	-0.16
Early-stage RFD $_k$ ($N \cdot s^{-1}$)	1665.15 (883.56)	1969.24 (985.66)	1328.48 (611.43)	0.07	0.03	-0.19
Late-stage RFD $_t$ ($N \cdot s^{-1}$)	2022.46 (1391.18)	2376.08 (1675.12)	1630.96 (858.57)	0.23	0.24	-0.02
Late-stage RFD $_k$ ($N \cdot s^{-1}$)	2225.91 (1693.49)	2702.87 (2130.44)	1697.85 (753.17)	0.28*	0.28	-0.05

* $p \leq 0.05$

CONCLUSIONS

- Associations of CMVJ displacement with nine indices of RFD were negligible-to-low regardless of biological sex.

PRACTICAL APPLICATIONS

- RFD during CMVJs as measured herein appears to have little association with jump performance.
- Although RC is a normalized expression of IES, normalizing the remaining RFD indices for body mass might alter these findings.
- Using unilateral force output herein was a study limitation.