

The EXER-GENIE Speed TrainerTM for resisted sprint training: calibration, analysis of load-velocity relationships and comparison with sled modality.

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Speed | Force | Resistance | Power | Propulsion | Biomechanics

Headline

Resisted Sprint Training (RST) is an effective method to stimulate sprint acceleration mechanics and performance (e.g. 1-3). As for gym-based resistance training, it is imperative to establish the athlete's load-velocity profile to correctly individualize RST loads. The Speed Trainer EXER-GENIETM (STExe) is a cheap and practical pulley-based system, with interesting calibration and reliability results (4) but no data is available for high to very high resistances, nor the load-velocity relationships provided by the STExe, especially in comparison to sled modality standards.

Aim

Our aim was to further explore the use of the STExe by extending calibration and reliability testing to higher loads, presenting inter-device comparisons of resistive forces at different cable distances, and for different resistance-setting notches. We then aimed to analyse the load-velocity relationships with the STExe and propose a conversion method between the STExe and the sled pulling modality.

Methods

Calibration

The horizontal resistive force (Fhzt) delivered by the STExe was measured for three different devices (STExe 1 and STExe 2 were new, and STExe 3 had been used for one year by sprinters), and for four loads (in notches) corresponding to four different Fhzt values (light, medium, high and very high: 5oz, 12oz, 11lb and 2lb manufacturer settings, respectively). Fhzt was measured for the two cable output directions of STExe and for two cable distances (from 5 to 10 m and from 25 to 30 m) using a digital K-Pull dynamometer (500 Hz, Kinvent Biomécanique, Montpellier, France). Fhzt measurements were repeated six times per output direction, and per resistive force level for each STExe. The STExe were attached to a fixed point at hip height, and an experimenter pulled the K-Pull dynamometer horizontally, attached to the STExe cable, at a constant speed. All measurements were taken under the same experimental conditions.

Descriptive analyses are presented as mean \pm SD for each STExe, each notch, length, and for both output directions. The data were analysed using Cohen's d test to evaluate the effect sizes between the different conditions, and confidence intervals (CI) were calculated for each effect size.

Load-Velocity relationship and comparison with sled pulling

Sixteen participants (5 women and 11 men, age: 19.9 ± 2.9 years; body mass: 65.9 ± 9 kg; height: 174.3 ± 7.2 cm) were

given a verbal explanation of procedures before agreeing to take part in the study. Two of them had low sprint training experience, six had moderate experience, and eight had high experience. They all had previously practiced RST and were familiar with the use of the STExe. The protocol was conducted in accordance with the Helsinki Declaration. After complete warm-up including resisted sprints, participants performed a total of eight sprints until top speed, with 3-min recovery: three sprints pulling a sled loaded with 25, 50 and 75% of their body mass, then one unresisted sprint, and finally four sprints using the STExe, with resistance set at the fourth, seventh, ninth, and eleventh notches, which induced low, medium, high and very high Fhzt according to previous observations. All sprints were conducted on the same day on an official synthetic track, and subjects pulled the sled or STExe with a harness attached at the pelvis. Participants' running speed was continuously recorded with a 18-Hz GPS system (GPEXE, Exelio, Italy) allowing us to determine maximal running speed for each condition.

Linear load-velocity relationships were established for each subject in Excel for the sled and STExe conditions. The reliability of these linear relationships was verified using the determination coefficient (R^2).

Results

The first analysis presented shows Fhzt for various devices (two new ones and a third one used for a training year) and notches (average and standard deviation for 6 trials).

These Fhzt were then compared for the two possible outputs (pulling one side of the cable or the other side in the other direction), and at two cable lengths, short and long. Finally, for each athlete tested, based on matching the Figure 2 data, a perfectly linear relationship was found between their sled load and equivalent STExe load (i.e. loads leading to similar running velocity and %Vdec).

Discussion

For similar settings, resistive force measurements differed between the devices tested, especially the new ones compared to the older one, which is in line with Ghigiarelli's results (4). As expected, we observed differences between the four notches tested (Table 2), showing that turning just one notch causes a clear change in resistive force. We confirm here that the STExe allows setting the full range of resistive forces for sprinting, from almost nil to maximal (the load is so high with notches 15-20 and beyond that no athlete can overcome the

resistance), and that both pulling directions provide a very similar amount of resistance.

A practically important result of this calibration is the difference in the requested Fhzt when the cable is pulled over 5 to 10 m (early sprint acceleration) compared to 25 to 30 m (late sprint acceleration). Another aspect that was not addressed in our study comes from users feedback and published data (5) showing a difference between a “cold” and a “hot” device after repeated use that generates significant heat due to friction dissipation. These points should be considered when setting the resistance load individually, and we recommend using the sprint running velocity as a reference, in order to estimate the zone of the load- and thus force-velocity spectrum stimulated (6, 7).

The load-velocity relationships (Figure 1) obtained with the STExe were highly linear ($R^2 > 0.95$) for all subjects, in both the sled (in line with previous studies 6, 7) and the STExe (confirming it is possible to build resisted sprint load-velocity

with this device). The different relationships are due to different units to express resistance between the two modalities. Interestingly, as shown in Figure 2 and 3, when plotted together using running velocity as the common factor for correspondence, these load-Vdec relationships between STExe and sled showed a perfect fit ($R^2 = 1$) for all subjects, yet with different slopes likely due to the individual load-velocity profile variability (Figure 4).

As for gym-based resistance training, it is crucial to individualize RST based on the desired decrement in maximal velocity (and thus the corresponding zone of the force-velocity spectrum (8), whether using a sled mass or a notch on the STExe. For the latter, it is very interesting that high and very high resistive forces do not require to get and manipulate heavy loads (just turn notches on the 3-kg pulley device) and do not generate the same “jolts” during sprint trials, due to inertia of a heavy sled.

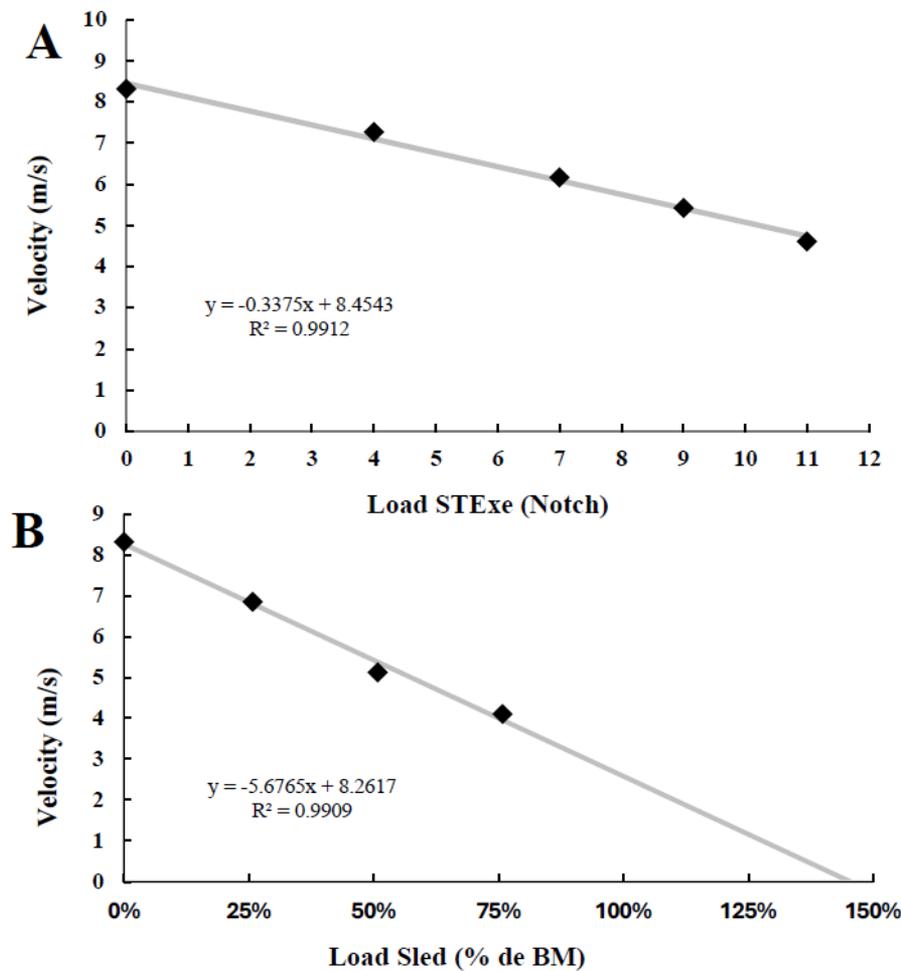


Fig. 1. Typical example of the linear load-velocity relationship between for **A:** load in notches of a Speed Trainer Exer-Genie (STExe), and for **B:** load as a percentage of body mass with a sled for the same participant.

Table 1. Comparison of horizontal resistance force measurements between the three Speed Trainer EXER-GENIE (STExe) devices for over a cable distance of 25 to 30m across four notches (4, 7, 9, and 11th).

Force analysis : STE 1 vs. STE 2 vs. STE 3				
	STExe 1 (N)	STExe 2 (N)	STExe 1 - 2 ΔN (95% CI)	ES Cohens'd (95% CI)
Notch 4	6.36 ± 1.12	14.65 ± 1.25	-8.72 (-10.35 ; -7.09)	-7.02 (-10.19 ; -3.86)
Notch 7	15.51 ± 0.72	29.11 ± 1.09	-13.49 (-14.77 ; -12.21)	-15.1 (-21.52 ; -8.68)
Notch 9	33.29 ± 3.17	49.67 ± 3.3	-16.3 (-20.72 ; -11.87)	-5.05 (-7.46 ; -2.63)
Notch 11	53.24 ± 4.75	56.48 ± 1.92	-3.07 (-7.87 ; 1.73)	-0.86 (-2.1 ; 0.38)
	STExe 2 (N)	STExe 3 (N)	STExe 2 - 3 ΔN (95% CI)	ES Cohens'd (95% CI)
Notch 4	14.65 ± 1.25	5.6 ± 0.76	8.97 (7.52 ; 10.41)	8.97 (5.04 ; 12.91)
Notch 7	29.11 ± 1.09	18.19 ± 1.05	10.9 (9.44 ; 12.37)	10.27 (5.82 ; 14.72)
Notch 9	49.67 ± 3.3	45.33 ± 2.62	4.33 (0.5 ; 8.17)	1.45 (0.18 ; 2.72)
Notch 11	56.48 ± 1.92	93.99 ± 5.53	-46.92 (-52.39 ; -41.46)	-8.69 (-12.51 ; -4.87)
	STExe 1 (N)	STExe 3 (N)	STExe 1 - 3 ΔN (95% CI)	ES Cohens'd (95% CI)
Notch 4	6.36 ± 1.12	5.6 ± 0.76	0.76 (-0.47 ; 2)	0.79 (-0.38 ; 1.97)
Notch 7	15.51 ± 0.72	18.19 ± 1.05	-2.67 (-3.83 ; -1.52)	-2.98 (-4.62 ; -1.33)
Notch 9	33.29 ± 3.17	45.33 ± 2.62	-12.63 (-16.65 ; -8.61)	-4.18 (-6.29 ; -2.07)
Notch 11	53.24 ± 4.75	93.99 ± 5.53	-41.29 (-48.03 ; -34.55)	-7.9 (-11.26 ; -4.54)

Note: DN = Mean differences (newton). 95% CI = 95% confidence interval. ES = Effect Size.

Table 2. Comparison of horizontal resistance force measurements between output 1 and output 2 (i.e. two possible pulling directions) of the cable (25 to 30 m) for four notches of three Speed Trainer EXER-GENIE (STExe) devices

Force analysis : Output 1 vs. Output 2					
	Notch	Output 1 (N)	Output 2 (N)	ΔN (95% IC)	ES Cohens'd (95% IC)
STExe 1	4	6.36 ± 1.12	6.58 ± 0.6	-0.23 (-1.39 ; 0.93)	-0.25 (-1.39 ; 0.88)
	7	15.51 ± 0.72	15.4 ± 0.76	0.11 (-0.84 ; 1.06)	0.15 (-0.98 ; 1.29)
	9	33.29 ± 3.17	32.43 ± 2.9	0.3 (-3.88 ; 4.48)	0.29 (-0.91 ; 1.48)
	11	53.24 ± 4.75	55.27 ± 2.12	-2.03 (-6.77 ; 2.7)	-0.55 (-1.7 ; 0.6)
STExe 2	4	14.65 ± 1.25	14.54 ± 0.74	0.11 (-1.39 ; 1.61)	0.11 (-1.14 ; 1.35)
	7	29.11 ± 1.09	29.16 ± 0.94	-4.9 (-6.3 ; -3.5)	-0.05 (-1.23 ; 1.14)
	9	49.67 ± 3.3	51.46 ± 7.22	-1.8 (-9.01 ; 5.42)	-0.32 (-1.46 ; 0.82)
	11	56.48 ± 1.92	51.83 ± 2.65	5.69 (2.57 ; 8.81)	1.98 (0.53 ; 3.43)
STExe 3	4	5.6 ± 0.76	5.15 ± 0.71	0.44 (-0.51 ; 1.39)	0.6 (-0.56 ; 1.76)
	7	18.19 ± 1.05	18.38 ± 0.51	-0.2 (-1.25 ; 0.86)	-0.24 (-1.38 ; 0.9)
	9	45.33 ± 2.62	40.98 ± 2.91	12.16 (8.35 ; 15.97)	1.58 (0.22 ; 2.94)
	11	93.99 ± 5.53	101.11 ± 5.19	-7.12 (-14.02 ; -0.22)	-1.33 (-2.58 ; -0.08)

Note: DN = Mean differences (newton). 95% CI = 95% confidence interval. ES = Effect Size.

Table 3. Comparison of horizontal resistance force measurements between two cable distances (5 to 10m and 25 to 30m) for output 1 across four notches of three Speed Trainer EXER-GENIE (STExe) devices

Force analysis : 5 to 10m vs. 25 to 30m					
	Notch	5 to 10m (N)	25 to 30m (N)	ΔN (95% IC)	ES Cohens'd (95% IC)
STExe 1	4	9.08 ± 1.7	6.36 ± 1.12	2.72 (0.87 ; 4.58)	1.89 (0.53 ; 3.25)
	7	28.05 ± 2.07	15.51 ± 0.72	12.54 (10.55 ; 14.53)	8.1 (4.67 ; 11.53)
	9	47.52 ± 5.79	33.29 ± 3.17	15.07 (8.84 ; 21.31)	2.96 (1.25 ; 4.67)
	11	79.3 ± 2.28	53.24 ± 4.75	26.06 (21.26 ; 30.86)	6.99 (3.97 ; 10)
STExe 2	4	21.07 ± 1.37	14.65 ± 1.25	6.42 (4.51 ; 8.33)	4.9 (2.42 ; 7.38)
	7	47.73 ± 7.75	29.11 ± 1.09	16.02 (8.79 ; 23.26)	3.2 (1.41 ; 4.99)
	9	73.25 ± 5.94	49.67 ± 3.3	23.58 (17.4 ; 29.76)	4.91 (2.64 ; 7.17)
	11	81.76 ± 2.1	56.48 ± 1.92	24.51 (21.77 ; 27.26)	12.5 (7.14 ; 17.86)
STExe 3	4	12.24 ± 0.5	5.6 ± 0.76	6.65 (5.82 ; 7.48)	10.3 (6.03 ; 14.58)
	7	38.18 ± 1.31	18.19 ± 1.05	19.99 (18.47 ; 21.52)	16.84 (10.01 ; 23.67)
	9	90.41 ± 7.46	45.33 ± 2.62	45.07 (37.88 ; 52.26)	8.06 (4.64 ; 11.48)
	11	181.67 ± 9.95	93.82 ± 6.17	83.45 (70.33 ; 96.57)	10.97 (5.73 ; 16.2)

Note: DN = Mean differences (newton). 95% CI = 95% confidence interval. ES = Effect Size.

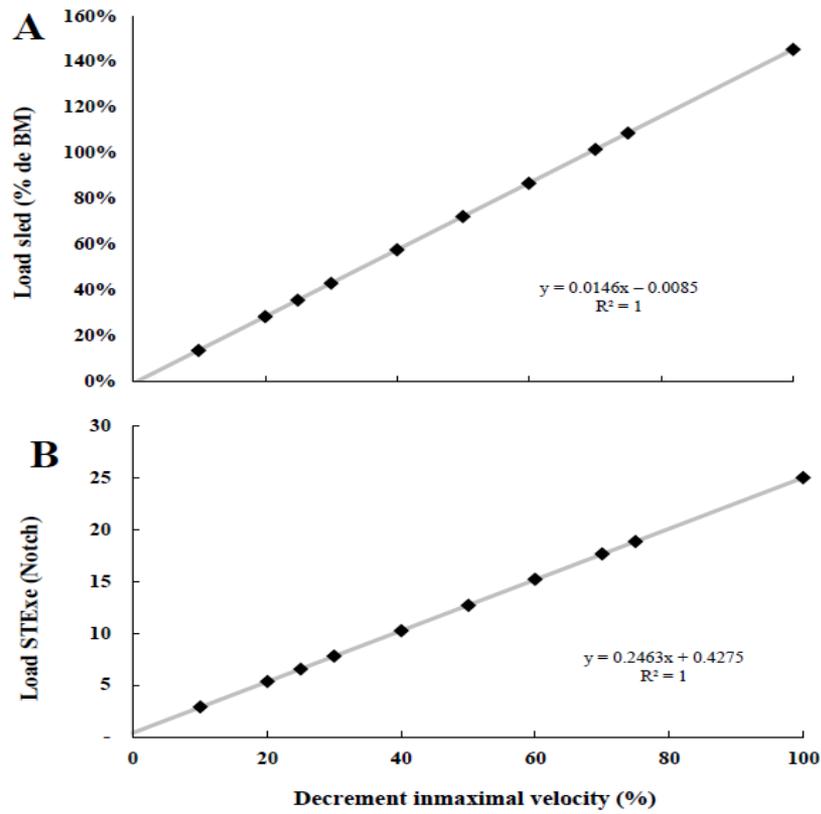


Fig. 2. Typical example of the linear relationship between load and %Vdec (velocity decrement from maximal velocity) for A: load as a percentage of body mass with a sled, and for B: load in notches with a Speed Trainer EXER-GENIE (STExe), as a function of maximum velocity decrement for the same participant.

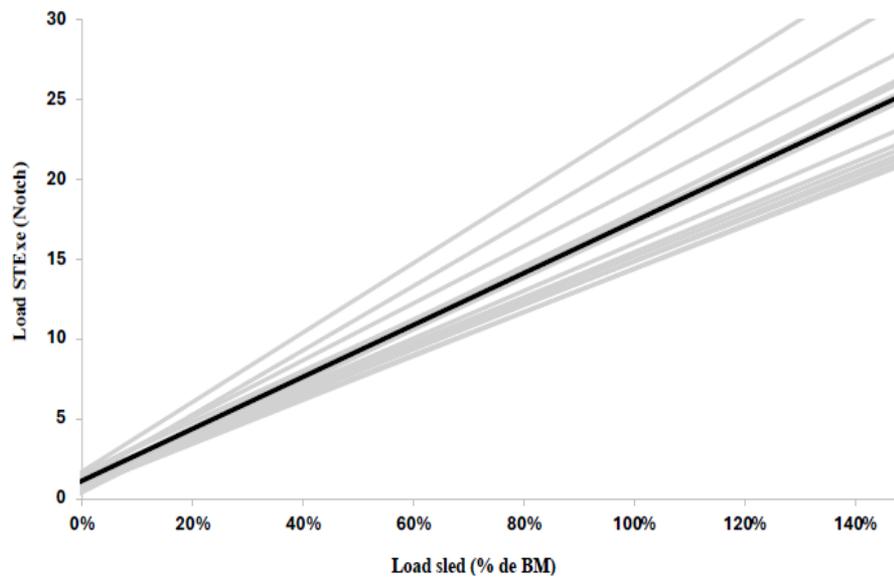


Fig. 3. Individual (in gray) and average linear relationship for all participants (in black) between the load in notches of a Speed Trainer EXER-GENIE (STExe) and the load as a percentage of body mass of a sled.

Limitations

Some inevitable limitations inherent to the STExe device have been discussed earlier (heat, difference between devices, effect of the cable length) but should be thought within the context of the clear practicality, low cost, and wide range of loads delivered. The following limitations apply to our protocol:

- The calibration force measurements were taken manually, requiring an experimenter to pull the STExe at a constant speed. Speed variations were controlled as much as possible but could have slightly affected the Fhzt measurements.
- Only six measurements were performed for each category, which is insufficient for optimal statistical power and intraclass correlation coefficients to accurately quantify reliability.
- Only three devices were tested (two new and one regularly used for a year) which does not allow us to extend conclusions to other STExe devices. Consequently, it is recommended that individual load-velocity relationships and RST programming should be done with any new device without comparison to other ones.

Practical applications

- The STExe is perfectly suitable for sprinting with RST and generates a very smooth type of resistance compared to sleds especially for high resistive forces.
- The major advantage of the STExe is that it can be used on any type of surface or field, court, athletic track, or even ice, and is very easy to transport and set (small package of only ~3 kg) compared to the equivalent sled for the same load spectrum (i.e. minimal to maximal loads for any athlete).
- The only way to generate accurate and actionable data for RST programming is to perform with each STExe a calibration to quantify the resistive forces, and/or an individual load-velocity spectrum for each athlete.
- That being said, as for the friction coefficient of a sled (9), a force sensor-based calibration is not strictly necessary: knowing the athlete's load-velocity profile is sufficient to individualize training provided the STExe device and running conditions (speed measurement, ground surface type, shoes etc) are equal.
- Exactly as for sled modality, knowing the resistance level (STExe notches) and maximal sprint speed for four sprints (one unresisted, three resisted) is sufficient to establish a reliable and interpretable linear relationship.
- A direct conversion between sled and STExe conditions is possible for a given device and individual, but a generalized STExe-Sled conversion that would apply to any athlete-device is currently not possible.

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