Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

DYNAMOMETRIC ANALYSIS OF RESISTED SLED ON SPRINT RUN

Mário Nogueira[1], Nuno Viriato[2,3], Mário Vaz[2,3], João Carvalho[3] and Filipe Conceição[1,4]

Faculty of Sport, CIFI2D, University of Porto, Portugal[1,]
INEGI, Faculty of Engineering, University of Porto, Portugal[2]
Faculty of Engineering, University of Porto, Portugal[3]
Porto Biomechanics Laboratory (LABIOMEP), University of Porto, Portugal[4]

The main purpose of this work was to perform a dynamometric analysis of the step in resisted sprint with sled towing, using different connection points (vest and belt) as well as distinct velocities (90% and 92,5% of the maximum speed). A sample of 8 male sprinters participants was constituted. Each individual performed 2 trials of 30m for each test. The data of GRF were collected through a force plate (Bertec 4060-15) placed at 20m from the starting line. Results pointed out that the vest seems to be advantageous for the propulsive phase of the support whilst the belt for the breaking phase of the support.

KEY WORDS: Speed, Resisted race, Dynamometry, Sled

INTRODUCTION: The athlete performance during sprinting race depends on the combination of amplitude and step's frequency. However, these variables rely upon the athlete's capacity and technical ability to apply high magnitudes of force during the ground support, in very short time intervals.

The continuous search for the performance's optimization promoted the development of different means and special training methods, namely the resisted races which are widely used in the various individual and collective sports. Within these methods, the ones which stand out are the races with vests and belts connected to a sled.

The use of these methods seems to increase muscle overload of the athlete, thereby increasing the activity and the muscle recruitment (Faccioni, 1994), promoting an improvement in the Force/Velocity relationship (Plisk, 2000) by the athlete's superior ability to generate greater horizontal and/or vertical velocity (Zatsiorsky ,1995).

It is also known that these methods promote the development of the sprint's specific force and the step's frequency (Letzelter et al, 1995). They also facilitate a greater activity of the hip, knee and ankle extensor muscles (Faccioni, 1994). Even if they are largely used in sports, and notwithstanding the fact that there are several studies dedicated to the kinematic changes produced by its use (LeBlanc & Gervais, 2004; Spinks et al, 2007; Cronin et al, 2008; Alcaraz, 2008), the literature reveals a scarcity of studies centred in the ground reaction forces (GRF).

Through the comparative analysis of the GRF during ground support when sprint with a sled and normal race, the aims of this study were: i) to verify if the use of the resisted methods with sled towing modify the way that forces are applied on the ground; ii) to determine if there are changes in the GRF with the change of the connection point (vest or belt) in the athlete body: iii) to ascertain if the usage of the resisted methods with sled towing induces greater instability when compared to the normal race; iiii) to observe if there are changes in the GRF with the use of distinct loads (90% and 92.5% of the maximum speed).

METHODS: To carried out this study a sample of 8 young male sprinters (age=18±1.7years; mass=70±7.7kg; height=1.80±0.08m), who have no record of neural and/or skeletal muscles injuries, were constituted. The subjects gave a written informed consent to participate in the current study.

The data of GRF were collected through a force plate (*Bertec* 4060-15) connected to an A/D conversion plate (*Biopac MP100.2.0*), sampling at 1000Hz, placed at 20m from the starting line.

Each individual performed 2 trials of 30m for each test, i.e. normal race, resisted race with vest at 90% and at 92,5% of the maximum speed and resisted race with belt at 90% and at 92,5% of the maximum speed. The data collection was done with two individuals simultaneously, who shifted the activity and rest periods. The used load was determined according to the formula describe by Lockie et al (2003). Table 1 shows the reference values for losses of 10% and 7,5% of the individual maximum speed (the sled weight was considered – 3.6kg), depending on the load.

Table 1
Load (kg) required for the sled towing in maximum speed training according to individual body mass – adapted of Lockie et al. (2003)

Individual Body Mass (kg)		85	80	75	70	65	60	55
Maximum Velocity Percentage	**90%**	10.70	10.07	9.44	8.81	8.18	7.55	6.92
	92.5%	6.54	6.15	5.77	5.38	5.00	4.61	4.23

The GRF were analysed through routines developed in *Matlab* environment (The Matworks Inc., USA) considering an initial decomposition of the vertical, antero-posterior and medial-lateral components of the GRF, in areas (Fig.1), with the correspondent time intervals and impulses as described by Conceição (2004).

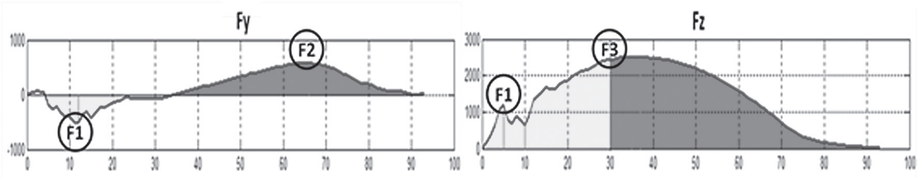

Figure 1: Example of an output of the data concerning the antero-posterior (Fy) and vertical (Fz) components of the GRF. (Breaking phase – yellow zone; Propulsive phase – red zone (darker); F1 – breaking peak; F2 and F3 – Propulsive peak).

It was also considered the maximum and minimum strength values and the time in which they occurred. Descriptive statistical methods were used to calculate average and standard deviation. Through the cross-correlation it was compared the different sort of races.

RESULTS AND DISCUSSION: It was verified an increase of the contact time (Ct) in the velocity race with sled towing, compared to the normal race. Ct_{normal}=107.3±8.04ms; $Ct_{V90\%}$=114.5±5.50ms;$Ct_{B90\%}$=114.6±6.11ms. Similar results were obtained in other studies (Saraslanidis, 2000, Sheppard, 2004), since resisted methods promote changes in the muscle activity pattern, thereby modifying the force application during the stretch shortening cycle of muscles that contribute to the displacement (Letzelter et al, 1995). It was also observed that the resisted methods use, enhance the increase of the propulsive forces (Pf) and the decrease of the breaking forces (Bt), compared to the normal race (Table 2).

Table 2
Average angles and Breaking (Bf) and Propulsion (Pf) average forces (N) in the touchdown (α) and take-off (β) instant during the support phase, in the tests performed

	Normal	V90%	B90%	V92,5%	B92,5%		Normal	V90%	B90%	V92,5%	B92,5%
α°	-83.57 ±1.72	-83.79 ±2.23	-85.79 ±2.06	-83.43 ±1.92	-84.14 ±1.70	Bf (N)	75.71 ±29.67	47.43 ±16.45	66.43 ±21.49	64.86 ±8.36	72.07 ±18.83
β°	77.86 ±1.68	79.07 ±1.69	78.71 ±3.04	78.14 ±1.38	77.79 ±1.98	Pf (N)	91.43 ±19.43	126.71 ±28.32	102.21 ±11.19	106.71 ±26.23	101.64 ±22.36

However, though these facts are visible when both vest and belt are used, they were even more evident with the vest usage. The use of B90% seems to promote a greater body trunk forward leaning, leading the athlete to execute the support in a farther point of the vertical projection of his centre of mass, producing greater Bf when compared to the use of V90%.

Therefore, this result suggests that V90% seems to be more advantageous if the workout objective is to apply greater force in the support phase.
In the vertical component of the GRF (Table 3), the average values for the performed tests don't differ substantially among themselves, thus verifying a slight decrease of the values in the propulsion and breaking phases, with the use of loads.

Table 3
Average values for the GRF (N), in the performed tests, in the vertical (Z) and antero-posterior (Y) component

	Normal		Vest 90%		Belt 90%		Vest 92,5%		Belt 92,5%	
	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y
Breaking Peak	±1008.7	-784.86	±970.79	-676.00	±925.07	-596.21	1037.36	-674.29	1197.71	-672.00
	±205.12	±212.47	±254.82	±250.66	±262.13	±259.67	±221.50	±173.76	±531.58	±267.55
Propulsive Peak	2615.86	493.86	2515.21	535.71	2434.71	505.29	2511.36	452.36	2554.07	507.79
	±392.82	±65.40	±390.04	±44.12	±306.71	±50.90	±373.84	±193.10	±372.97	±26.44

In the antero-posterior component of GRF (Table 3), the use of loads caused a decrease of the breaking phase, in which the belt presented an inferior decrease compared to the vest. Concerning the propulsive phase, it was observed an increase of the force values, especially with the use of V90%. This result confirmed that the use of loads with the vest is more effective for the force application in the propulsive phase.
When the loads are used, the higher production of force in the propulsive phase of support is associated to the increase of the concentric phase time of support, and to a decrease of eccentric phase time (Table 4).

Table 4
Average values of eccentric (EccT) and concentric times (ConT) during the support, in the performed tests (ms)

	Normal	Vest 90%	Belt 90%	Vest 92,5%	Belt 92,5%
EccT	41.14	32.14	39.36	39.29	40.56
	±9.58	±8.27	±7.51	±6.64	±6.56
ConT	66.14	82.36	75.29	74.93	72.00
	±6.07	±10.99	±6.83	±9.33	±9.13

The data obtained by the correlation between resisted methods and the normal race showed high correlation (r=0,99). However there are differences in the way that force is applied – as it can be seen through a more careful analysis of the figures resulting from the tests comparison (Fig.2).

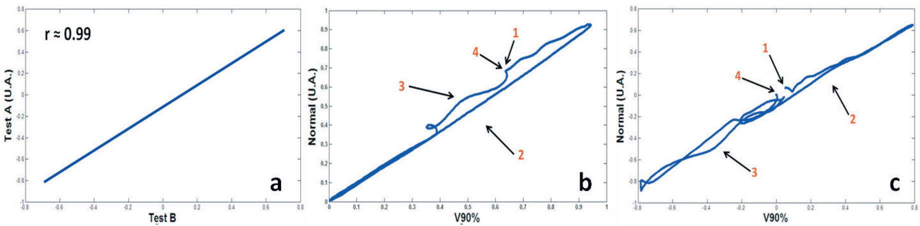

Figure 2: Example of comparison between the normal race and race with vest. (a) - image expected for r ≈ 0,99; comparison between normal race and vest to 90% in the vertical component (b) and in the antero-posterior component (c); [1 - Initial contact with the ground; 2-total support higher forces; 3-exit stage; 4-end of contact with the ground].

Through the comparison between the normal race and the tests with resisted methods we verified that there are differences in the initial and final phases of support, even though they

are similar in the instant of the foot's full contact to the ground. These differences were found in (Fig.2b) and in (Fig.2c). The differences found with the usage of belt show smaller magnitude when compared to the ones found with the vest usage.
The use of resisted methods with belt seems to benefit the anticipation of the maximum peak of force application in the support phase. On the other hand, the use of the vest delays the maximum peak of force application. For that reason, the belt seems to cause an anticipation of the ground contact, so as to correct a possible body trunk forward leaning of the athlete. This occurs because the belt is attached next to the athlete's centre of mass. The use of the vest seems to promote greater stability and may be associated with a more vertical trunk, minimizing the breaking force and maximizing the propulsive force, as we can observe in the touchdown (α) and take-off (β) angles (Table 2).

CONCLUSION: There are differences in the way that GRF forces are applied when the resisted methods are used, especially in the initial and final phases of the support. The connection point at the waist provokes greater instability than the vest, compared to the normal race.
The vest use seems to benefit the propulsive phase of movement, while the belt is more advantageous in the breaking phase. The alterations found with the use of inferior loads (92.5% of the maximum speed) present the same tendency that the superior loads, being these ones of less magnitude.

REFERENCES:

Alcaraz, P. E., Palao, J. M., Elvira, J. L., & Linthorne, N. (2008). Effects of three types of resisted sprint training devices on the kinematics of sprinting at maximum velocity. Journal of Strength Conditioning Research, 22(3), 890-897.

Conceição, F. (2004). Estudo biomecânico do salto em comprimento: modelação, simulação e optimização da chamada. Unpublished Ph.D. Thesis. Faculty of Sport. Porto, University of Porto.

Cronin, J., Hansen, K., Kawamori, N., & Mcnair, P. (2008). Effects of weighted vests and sled towing on sprint kinematics. Sports Biomechanics, 7(2), 160-172.

Faccioni, A. (1994a). Assisted and resisted methods for speed development (part I) - Resisted speed methods. *Modern Athlete & Coach,* 32(2), 3-6.

Faccioni, A. (1994b). Assisted and resisted methods for speed development (part II) - Resisted speed methods. *Modern Athlete and Coach*, 32(3), 8-12.

LeBlanc, J. S., & Gervais, P. L. (2004). Kinematics of assisted and resisted sprinting as compared to normal free sprinting in trained athletes. Proceedings of the *22th International Symposium on Biomechanics in Sport*, Ottawa, Canada 536. http://ualberta.ca/~jsl/pdfISBS04:Paper.pdf.

Letzelter, M., Sauerwein, G., & Burger, R. (1995). Resistance runs in speed development. Modern Athlete and Coach, 33(4), 7-12.

Lockie, R. G., Murphy, A. J., & Spinks, C. D. (2003). Effects of resisted sled towing on sprint kinematics in field-sport athltes. *Journal of Strength and Conditioning Research,* 17(4), 760-767.

Saraslanidis, P. (2000). Training for the improvement of maximum speed: flat running or resistance training? *New Studies in Athletics*, 15(3), 45-51.

Sheppard, J. (2004). The use of resisted and assisted training methods for speed development: coaching considerations. *Modern Athlete & Coach*, 42, 9-13.

Spinks, C. D., Murphy, A. J., Spinks, W. L., & Lockie, R. G. (2007). The efects of resisted sprint training on aceleration performance and kinematics in soccer, rugby union, and australian football players. *Journal of Strength & Conditioning Research*, 21(1), 77-85.

Zatsiorsky, V. (1995). Science and practice of strength training. Human Kinetics Publishers. Champaign, Illinois.