Original Article

Intra and intersession reliability of the Run Rocket™ in recreationally trained participants

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ABSTRACT

Sprint performance plays an important role in the success of many sports including track and field and team-based sports. Resisted sprint equipment has shown to be an effective method to increase sprint velocity and acceleration. The aim of the study was to determine the intrasession and intersession (7 days) reliability of a commercially available resisted sprint machine in recreationally trained individuals for two resistance settings. Fourteen recreationally active participants partook in the study (male = 10, female = 4) over a 7-day period. Three maximal 15m sprints, at two resistance levels (R0 and R5), were undertaken in a randomised order (6 sprints in total at each trial). Intrasession (comparison of the first 3 sprints for each trial) and intersession (mean of the 3 sprints for both trials) correlation coefficient (ICC), coefficients of variation (%CV), average variability, SEM and minimal detectable difference were calculated for 5 and 15m for both resistance levels. Intrasession reliability was very large to nearly perfect across both distances and resistance levels (ICC range .79 - .98), %CV ranged between 2.4 - 5.8% with larger values seen during the first trial for three of the four indices. Intersession reliability was very large to nearly perfect across all variables (ICC range .87 - .97), %CV was small and ranged between 2.0 - 4.1%. Average variability was small for all measurements. The Run Rocket™ showed high intra and intersession reliability. The results show that this equipment could be reliably used within a sprint programme for recreationally trained individuals.
Keywords: Athletic training; Sports performance; Exercise training.

INTRODUCTION

Sprint performance plays a role in the success of track and team sport athletes (Paulson & Braun, 2011; West et al., 2013). In high level female soccer, between 10 - 20% of performance is spent in high intensity and very high intensity running (Upton, 2011). Whereas in elite rugby union (Super 12), 25% and 4% of the game is spent sprinting by backs and forwards respectively (Duthie, Pyne, Marsh & Hooper, 2006). Gabbett (2012) reported that contact and non-contact straight line sprints accounted for 15.8 and 35.2% of movement in National Rugby League (NRL) competition. However, not all sports demonstrated these high percentages. Elite basketball players have only been shown to spend 4.9% ± 1.2 of game time undertaking sprinting activities, whilst elite field hockey has reported figures of 1.5% ± 0.6 (Scanlan, Dascombe & Reaburn, 2011; Spencer et al., 2004). Despite these variations across some team sports, time for the 40-yard sprint has been shown to be an indicator of playing level in the National Football League (NFL). Athletes at the NFL Combine, who were subsequently drafted, displayed significantly quicker times over the 40-yard test across all three positional groups (skills players, big skill players and linemen) (Sierer, Battaglini, Mihalik, Shields & Tomasini, 2008). Similarly, sprint time has also been used to distinguish between regional and national level junior rugby league (Till et al., 2011).

Despite maximal velocity being important in certain sports, team sport athletes may need to focus upon acceleration. Team based athletes, in sports such as soccer, rugby, football, netball and basketball, may not reach peak velocity and the ability to perform repeated sprints is more important (Cronin & Hansen, 2006; Girard, Mendez-Villaneuva & Bishop, 2011). Athletes with higher repeated sprint abilities in team sports may demonstrate a better tolerance of workload and reduction in injury (Malone et al., 2019). Team sports may not provide opportunities for athletes to reach maximal velocity and the ability to generate speed from a standing start is important (Lockie et al., 2011). Morin and colleagues (2015) relate forward acceleration to the amount of net horizontal force and impulse produced and its return through ground reaction force impulse. Therefore, acceleration not peak velocity, maybe fundamental to success in field sports and a focus of conditioning programmes. Consequently, athletic performance in these sports can be achieved through the attainment of maximal velocity and efficient acceleration (Ebben, Davies & Clewien, 2008).

In order to maximise acceleration and peak velocity, numerous training methods have been employed (Paulson & Braun, 2011). Practices such as sprint training (uphill, downhill and treadmill), plyometrics and weight training have all been used in an attempt to increase running velocity or acceleration in a variety of sports (Johnson et al., 2013; Lockie et al., 2012; Lockie et al., 2014). Resisted sprint training is a popular method of training and involves towing a sled or other equipment, such as a parachute. These devices are principally used to provide an external overload in an attempt to enhance physical output and efficiency (Petrakos et al., 2015). Quantifying load using a sled is problematic due to the friction force between the sled and surface (Cross et al., 2016). However, a number of authors have determined the friction and effective loading when using a sled which may overcome this problem and provide a practical solution (Andre, Fry, Bradford & Buhr, 2013; Cross, Brughelli, Samozino, Brown & Morin, 2017). Despite this difficulty, studies in professional and semi-professional rugby union athletes have shown significant increases in sprint performance following 6 weeks of resisted sprint training (Harrison & Bourke, 2009; West, 2013). Similar results for females have been reported by Makaruk et al. (2013) who showed significant decreases in 20m sprint time following a nine-week resisted sprint programme where the load used in the program decreased mean velocity by 10%. However, times for the sprints were measured using a stopwatch with no reported reliability. A recent study by Pantoja, Carvalho, Ribas and Peyré-Tartaruga (2018) highlighted the effect of sled towing (20, 30 and 40% of body mass) on sprint time, power and the force-velocity relationship using international, national and regional level athletes. With the greatest load, the end of the acceleration phase

was significantly greater compared to all other loads (ES = 2.22 - 3.25; p < .001). These results show that a heavier load may be required to provide sufficient stimulus for sprint development for a higher level of athlete. However, a group of semi-professional female handball players showed trivial and moderate effect sizes in 10m and 30m sprint times following a 10-week resisted sled programme using a load equating to 12.4 ± 0.2% body mass (Luteberget, Raastad, Setnnes & Spencer, 2015). Using a similar load (12.6% body mass), de Hoyo et al. (2016) reported an almost certain increase in countermovement jump and a likely decrease in sprint time (30 - 50m) in a group of U-19 elite soccer players. A more recent study by Monte and colleagues showed that towing with a load of 20% body mass maximised peak power production in male trained sprinters (100m personal best 10.91 ± 0.14) (Monte, Nardello & Zamparo, 2017). An assisted sprint training study by Upton (2011) showed this type of training method to be superior to resisted sprint training for shorter sprint distance (up to 13.7m) in female collegiate soccer players (Collegiate Division IA). Despite these conflicting results, resisted sprint training remains a popular choice of training for strength-trained or team-sport individuals (Petrakos et al., 2016).

The Run Rocket™ is a commercially available resisted sprint machine providing 30 levels of adjustable resistance. A mechanically braked flywheel, with a nylon cord, is attached via a harness to the athlete. This external resistance may necessitate an increase in horizontal ground reaction force to overcome the inertia of the flywheel, resulting in a higher muscular force. Adding this to a conditioning programme may provide enough stimulus to increase the horizontal ground reaction force overtime and subsequent sprint performance (Kawamori, Newton, Hori & Nosaka, 2014). In contrast to sleds, the Run Rocket™ has no friction considerations and can be used on any surface. To the knowledge of the authors, no intrasession or intersession reliability data exists on the Run Rocket™. The reliability of any equipment is necessary prior to any research or clinical application and reflects the degree of correlation and agreement between measures (Koo & Li, 2016). As a potential method to provide stimulus to those engaging in sprinting activities, reliability of this equipment is required.

The purpose of this study was to report the intrasession and intersession reliability of the Run Rocket™ at 5 and 15m at two different resistance levels (R0 and R5).

MATERIAL AND METHODS

Participants
Following institutional ethical approval and both written and verbal explanation of the procedures, 14 participants (10 male and 4 female) gave written informed consent to take part in the study (age 21.6 ± 2.1 y; body mass 73.4 ± 11.9 kg; stretch stature 174.5 ± 9.5 cm). Participants were recruited via an announcement on an undergraduate sports programme virtual learning environment for this observational study. Inclusion criteria were (1) healthy; (2) injury free; (3) engaged in recreational activities for at least 6 months. Exclusion criteria included (1) any injury that could be exacerbated during sprint performance; (2) less than 6 months of recreational activity. Participants had not undertaken any form of resisted sprint training or were undergoing any specific sprint training. During the testing, participants engaged in their normal physical activity, but refrained from any strenuous activity 24 hr prior to testing and maintained their normal diet. All testing was conducted according to the ethical principles stated in the Declaration of Helsinki (2013).

Measures
Sprint time was recorded using infrared timing gates placed at 0, 5 and 15 m (Brower TC Speed Trap II, Utah, USA). A previous study had reported high reliability of this equipment (ICC 10 m – 0.91, CV – 2.3%; 20 m – 0.91, CV – 2.9%) (Shalfawi, Enoksen, Tønnessen & Ingebrigsten, 2012).

Procedures
On two occasions, separated by 7 days, participants undertook 3 maximal 15m sprints at 2 resistance levels (total of 6 sprints at each trial). The order of the sprints was randomised using an online random sequence generator. Three familiarisation sprints with the harness attached were performed following the warmup at each trial.

The participants completed the standardised FIFA 11+ 3 part, 20-minute warm up comprising of jogging, strength, plyometrics, balance and running exercises (Dvorak, Junge & Grimm, 2005). The final section of the warmup included 3 sets of 20 m sprints (1 x 50%, 1 x 75%, 1 x 90% of maximum). Three 15m familiarity sprints were also completed (1 x no harness, 1 x resistance zero, 1 x resistance 5). After the warmup, each participant undertook 6 maximal 15m sprints, 3 at resistance level zero (R0) and 3 at resistance level 5 (R5), in a randomised order.

Participants placed their front foot 5 cm behind the first set of gates and used the same front foot for each trial. A two-point standing position was used at the start and participants started their sprints on their own volition. A shoulder harness supplied by the manufacturer was worn by the participants and attached to the Run Rocket™. The cord of the Run Rocket™ was attached approximately midway between the medial borders of the scapulae by way of a D-ring and a waist buckle was used to secure the harness (Figure 1). The resistance of the Run Rocket™ was adjusted using the manual adjuster knob; this was conducted blind to the participant and lead researcher. Full recovery took place between sprints (> 6 min). All testing took place on an indoor basketball court.

Figure 1. Run Rocket™ harness attachment.

Analysis
Dependent variables were displayed as mean ± standard deviation. Reliability was calculated using predesigned spreadsheets with all data log transformed to estimate similar errors across the range of values (Hopkins, 2015). Intraclass correlation coefficients and associated 90% confidence intervals were used to estimate test-retest reliability. Coefficient of variation (CV) was also calculated as the typical error expressed

as a percentage of the mean (%CV). The %CV was interpreted as small if less than 10% (Bradshaw, Hume, Calton & Aisbett, 2010). In addition, average variability was interpreted by combining ICC and %CV and analysed as small when ICC > .67 and CV < 10%, moderate when ICC < .67 and CV > 10% and large when ICC < .67 and CV > 10% (Bridgeman, McGuigan, Gill & Duslon, 2016). Standard error of measurement (SEM) was estimated using the formula $SEM = SD\sqrt{1 - ICC}$ and the minimal detectable difference (MDD) was calculated using the formula $MDD = SEM \times 1.96 \times \sqrt{2}$ (Weir, 2005). The scale of magnitude for effect statistics used were rated as trivial (< .1), small (.1 - .29), moderate (.3 - .49), large (.5 - .69), very large (.7 - .89) or nearly perfect (.9 - .99) (Hopkins, 2002).

RESULTS

The Run Rocket™ showed high intrasession reliability for both resistances (R0 and R5) over each distance (5 and 10 m). The descriptive data for the two intrasession trials and the intersession reliability are displayed in Table 1.

Table 1. Intrasession and intersession reliability.

	ICC (CI 90%)	%CV	Average variability	SEM (s)	MDD (s)
Trial 1					
R0 5m	.79 (.57 - .91)	4.2%	small	.12	0.25
R0 15m	.92 (.84 - .97)	3.6%	small	.26	0.26
R5 5m	.91 (.81 - .96)	5.8%	small	.21	0.29
R5 15m	.95 (.90 - .98)	5.6%	small	.52	1.11
Trial 2					
R0 5m	.92 (.84 - .97)	4.6%	small	.09	0.33
R0 15m	.97 (.93 - .99)	2.4%	small	.15	0.73
R5 5m	.97 (.94 - .99)	2.9%	small	.11	0.57
R5 15m	.98 (.97 - .99)	2.5%	small	.26	1.45
Intersession					
R0 5m	.87 (.67 - .95)	3.6%	small	.09	0.24
R0 15m	.97 (.94 - .99)	2.0%	small	.09	0.41
R5 5m	.96 (.89 - .98)	3.7%	small	.10	0.31
R5 15m	.97 (.92 - .99)	4.1%	small	.40	0.73

Abbreviations: ICC, interclass correlation coefficient; %CV, percentage coefficient of variation; CI, confidence intervals; SEM, standard error of measurement; MDD, minimal detectable difference; R, resistance level.

For each resistance and distance, reliability was very large to nearly perfect. R0 for trial 1 and 2 showed an ICC range between .79 - .97, with %CV 2.4 - 4.6%. At R5, ICC ranged between .91 - .98, with associated %CV range 2.5 - 5.8%.

DISCUSSION

The aim of this study was to analyse the intrasession and intersession reliability of the Run Rocket™ for short sprint distances (5 and 15m) at two mechanically braked resistance levels. The results showed that the Run Rocket™ displayed very large to nearly perfect reliability within a single session and between sessions for each level (R0 and R5) and over each distance (5 and 15m).

To our knowledge, this is the first study to test the intrasession and intersession reliability of this equipment in recreationally trained participants. Reliability as expressed by the %CV is unbiased for any sample size and is therefore appropriate for comparisons between the trials (Hopkins, 2000). Our study reported a %CV range between 2.4 - 5.8% for all the trials. These values were higher to those of Martinez-Valencia et al. (2015) who reported a %CV of 0.4% and 1.9% for horizontal velocity and ground reaction force respectively during sled towing at a range of additional loads (10%, 15% and 20% of body mass) in twenty-three experienced sprinters. Similar %CV were reported by Cross, Brughelli and Cronin (2014) in their study into the effects of vest loading on sprint kinetics and kinematics using university-level athletes. Peak velocity for the 9 kg and 18 kg vest showed %CV of 1.9% and 2.2% respectively. A later study by Cross et al. (2017) produced %CV between 3.0 to 4.3% when using a winch to pull a sled with a range of mass and velocities.

The ICC for both resistance levels and both distances were very large and nearly perfect which were similar to other resisted sprint studies (range .79 - .98). Pantoja et al. (2018) reported similar reliability values during sled towing with a group of international, national and regional sprint athletes (ICC = .87 - .94). Bachero-Mena and González-Badillo (2014) studied the effects of three different sled loads on acceleration in male, physically active participants (5%, 12.5% and 20% of body mass). The ICC for all running distances were greater than .9, except 0 - 10m (ICC .87). In another sled towing study, authors reported lower ICC values for their 10m sprint time (ICC range .56 - .74) for light and heavy load sleds amongst recreational and state level participants (Kawamori, Nosaka & Newton, 2013). A study using resisted sprint training with English League competitive ice hockey players yielded an ICC of .997 when performing a heavy 10s resisted sprint on icmatte (Matthews, Comfort & Crebin, 2010). Clarke et al. (2009) reported an ICC range between .761 and .997 for 4 different elastic cord resistances during their elastic overspeed study (range 2 - 4.69% of body weight). A wider range of ICC values were shown in an assisted sprint study on female collegiate soccer players. The repeated sprints, with assistance of 10, 20, 30 and 40% of body weight, showed ICC values of .48, .58, .81 and .83 respectively (Bartolini et al., 2011).

Our current study had some limitations. Firstly, the sample population used in our trial was taken from recreationally trained individuals and may not reflect the entire athletic population. It is recommended that future studies conduct reliability analysis for the cohort using the equipment. Secondly, an arbitrary number is assigned to the resistance on the Run Rocket™ and no actual load is given. Therefore, it is not clear what percentage of body mass these equate to or the effect that they have on velocity. However, this was not the purpose of the study and subsequent studies may wish to quantify the effect of the resistance on velocity in order to prescribe a training programme based on the decrease in maximal velocity.

CONCLUSION

Considering the importance of sprint performance across a wide range of sports, methods used to enhance both acceleration and peak velocity are key. A variety of methods have shown increases in sprint performance, primarily by increasing the net horizontal force and impulse by the addition of an external load. Results from towing sleds has demonstrated decreases in sprint time, but some issues surrounding the friction between the sled and surface make load selection problematic. The Run Rocket™ has the ability to provide very large or nearly perfect intrasession and intersession reliability across a range of resistance levels during short sprints. It could be considered as part of a training programme for those wishing to enhance their net horizontal force.

AUTHOR CONTRIBUTIONS

Conceptualization, M.G. and E.S.; Methodology and Investigation, M.G., J.M., E.S. and K.R.; Data analysis, M.G.; Writing—original draft preparation, M.G.; writing—review and editing, M.G., J.M., E.S. and K.R.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

REFERENCES

Andre, M., Fry, A., Bradford, L., & Buhr, K. (2013). Determination of Friction and Pulling Forces During a Weighted Sled Pull. J Strength Cond Res, 27(5), 1175-1178. https://doi.org/10.1519/jsc.0b013e318269aaef

Bachero-Mena, B., & González-Badillo, J. (2014). Effects of Resisted Sprint Training on Acceleration With Three Different Loads Accounting for 5, 12.5, and 20% of Body Mass. J Strength Cond Res, 28(10), 2954-2960. https://doi.org/10.1519/jsc.0000000000000492

Bartolini, J., Brown, L., Coburn, J et al. (2011). Optimal Elastic Cord Assistance for Sprinting in Collegiate Women Soccer Players. J Strength Cond Res, 25(5), 1263-1270. https://doi.org/10.1519/jsc.0b013e318215f575

Bradshaw, E., Hume, P., Calton, M., & Aisbett, B. (2010). Reliability and variability of day-to-day vault training measures in artistic gymnastics. Sports Biomech, 9(2), 79-97. https://doi.org/10.1080/14763141.2010.488298

Bridgeman, L., McGuigan, M., Gill, N., & Dulson, D. (2016). Test-Retest Reliability of a Novel Isokinetic Squat Device With Strength-Trained Athletes. J Strength Cond Res, 30(11), 3261-3265. https://doi.org/10.1519/jsc.0000000000001410

Clark, D., Sabick, M., Pfeiffer, R., Kuhlman, S., Knigge, N. & Shea, K. (2009). Influence of Towing Force Magnitude on the Kinematics of Supramaximal Sprinting. J Strength Cond Res, 23(4),1162-1168. https://doi.org/10.1519/jsc.0b013e318194df84

Cronin, J. & Hansen, K. (2006). Resisted Sprint Training for the Acceleration Phase of Sprinting. Strength and Conditioning Journal, 28(4), 42-51. https://doi.org/10.1519/1533-4295(2006)028[0042:rstfta]2.0.co;2

Cross, M., Brughelli, M., & Cronin, J. (2014). Effects of Vest Loading on Sprint Kinetics and Kinematics. J Strength Cond Res, 28(7), 1867-1874. https://doi.org/10.1519/jsc.0000000000000354

Cross, M., Tinwala, F., Lenetsky, S., Samozino, P., Brughelli, M., & Morin, J. (2016). Determining friction and effective loading for sled sprinting. J Sports Sci, 35(22), 2198-2203. https://doi.org/10.1080/02640414.2016.1261178

Cross, M., Brughelli, M., Samozino, P., Brown, S., & Morin, J. (2017). Optimal Loading for Maximizing Power During Sled-Resisted Sprinting. Int J Sports Physiol Perform, 12(8), 1069-1077. https://doi.org/10.1123/ijspp.2016-0362

de Hoyo, M., Gonzalo-Skok, O., Sañudo, B., Carrascal, C., Plaza-Armas, J., Camacho-Candil, F., & Otero-Esquina, C. (2016). Comparative Effects of In-Season Full-Back Squat, Resisted Sprint

Training, and Plyometric Training on Explosive Performance in U-19 Elite Soccer Players. J Str Cond Res, 30(2), 368-377. https://doi.org/10.1519/jsc.0000000000001094

Duthie, G., Pyne, D., Marsh, D., & Hooper, S. (2006). Sprint Patterns in Rugby Union Players During Competition. J Strength Cond Res, 20(1), 208-214.

Dvorak, J., Junge, A., & Grimm, K. (2005). Football medicine manual. Zurich: F-MARC, 81-93.

Ebben, W., Davies, J., & Clewien, R. (2008). Effect of the Degree of Hill Slope on Acute Downhill Running Velocity and Acceleration. J Strength Cond Res, 22(3), 898-902. https://doi.org/10.1519/jsc.0b013e31816a4149

Gabbett, T. (2012). Sprinting Patterns of National Rugby League Competition. J Strength Cond Res, 26(1), 121-130. https://doi.org/10.1519/jsc.0b013e31821e4c60

Girard, O., Mendez-Villanueva, A., & Bishop, D. (2011). Repeated-Sprint Ability – Part I. Sports Med, 41(8), 673-694. https://doi.org/10.2165/11590550-000000000-00000

Harrison, A., & Bourke, G. (2009). The Effect of Resisted Sprint Training on Speed and Strength Performance in Male Rugby Players. J Strength Cond Res, 23(1), 275-283. https://doi.org/10.1519/jsc.0b013e318196b81f

Hopkins, W.G. (2000). Measures of Reliability in Sports Medicine and Science. Sports Med, 30, 1-15. https://doi.org/10.2165/00007256-200030010-00001

Hopkins, W. (2002). A New View of Statistics. Sportsciorg. Available at: http://www.sportsci.org/resource/stats/effectmag.html

Hopkins, W., G. (2015). Spreadsheets for analysis of variability and reliability. Sportscience, 19, 36-42.

Johnson, A., Eastman, C., Feland, J., Mitchell, U., Mortensen, B., & Eggett, D. (2013). Effect of High-Speed Treadmill Training With a Body Weight Support System in a Sport Acceleration Program With Female Soccer Players. J Strength Cond Res, 27(6), 1496-1502. https://doi.org/10.1519/jsc.0b013e31826cac04

Kawamori, N., Nosaka, K., & Newton, R. (2013). Relationships Between Ground Reaction Impulse and Sprint Acceleration Performance in Team Sport Athletes. J Strength Cond Res, 27(3), 568-573. https://doi.org/10.1519/jsc.0b013e318257805a

Kawamori, N., Newton, R., Hori, N., & Nosaka, K. (2014). Effects of Weighted Sled Towing With Heavy Versus Light Load on Sprint Acceleration Ability. J Strength Cond Res, 28(10), 2738-2745. https://doi.org/10.1519/jsc.0b013e3182915ed4

Koo, T., & Li, M. (2016). A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. J Chiropr Med, 15(2), 155-163. https://doi.org/10.1016/j.jcm.2016.02.012

Lockie, R., Murphy, A., Knight, T., & Janse de Jonge, X. (2011). Factors That Differentiate Acceleration Ability in Field Sport Athletes. J Strength Cond Res, 25(10), 2704-2714. https://doi.org/10.1519/jsc.0b013e31820d9f17

Lockie, R., Murphy, A., Schultz, A., Knight, T., & Janse de Jonge, X. (2012). The Effects of Different Speed Training Protocols on Sprint Acceleration Kinematics and Muscle Strength and Power in Field Sport Athletes. J Strength Cond Res, 26(6), 1539-1550. https://doi.org/10.1519/jsc.0b013e318234e8a0

Lockie, R., Murphy, A., Callaghan, S., & Jeffriess, M. (2014). Effects of Sprint and Plyometrics Training on Field Sport Acceleration Technique. J Strength Cond Res, 28(7), 1790-1801. https://doi.org/10.1519/jsc.0000000000000297

Makaruk, B., Sozański, H., Makaruk, H., & Sacewicz, T. (2013). The Effects of Resisted Sprint Training on Speed Performance in Women. Human Movement, 14(2), 116-122. https://doi.org/10.2478/humo-2013-0013

Malone, S., Hughes, B., Doran, D., Collins, K., & Gabbett, T. (2019). Can the workload–injury relationship be moderated by improved strength, speed and repeated-sprint qualities?. J Sci Med Sport, 22(1), 29-34. https://doi.org/10.1016/j.jsams.2018.01.010

Martínez-Valencia, M., Romero-Arenas, S., Elvira, J., González-Ravé, J., Navarro-Valdivielso, F., & Alcaraz, P. (2015). Effects of Sled Towing on Peak Force, the Rate of Force Development and Sprint Performance During the Acceleration Phase. J Hum Kinet, 46(1), 139-148. https://doi.org/10.1515/hukin-2015-0042

Matthews, M., Comfort, P., & Crebin, R. (2010). Complex Training in Ice Hockey: The Effects of a Heavy Resisted Sprint on Subsequent Ice-Hockey Sprint Performance. J Strength Cond Res, 24(11), 2883-2887. https://doi.org/10.1519/jsc.0b013e3181e7253c

Monte, A., Nardello, F., & Zamparo, P. (2017). Sled Towing: The Optimal Overload for Peak Power Production. Int J Sports Physiol Perform, 12(8), 1052-1058. https://doi.org/10.1123/ijspp.2016-0602

Morin, J., Slawinski, J., Dorel, S. et al. (2015). Acceleration capability in elite sprinters and ground impulse: Push more, brake less?. J Biomech, 48(12), 3149-3154. https://doi.org/10.1016/j.jbiomech.2015.07.009

Pantoja, P., Carvalho, A., Ribas, L. & Peyré-Tartaruga, L. (2018). Effect of weighted sled towing on sprinting effectiveness, power and force-velocity relationship. PLOS ONE, 13(10), p.e0204473. https://doi.org/10.1371/journal.pone.0204473

Paulson, S., & Braun, W. (2011). The Influence of Parachute-Resisted Sprinting on Running Mechanics in Collegiate Track Athletes. J Strength Cond Res, 25(6), 1680-1685. https://doi.org/10.1519/jsc.0b013e3181dba3f5

Petrakos, G., Morin, J., & Egan, B. (2016). Resisted Sled Sprint Training to Improve Sprint Performance: A Systematic Review. Sports Med, 46(3), 381-400. https://doi.org/10.1007/s40279-015-0422-8

Scanlan, A., Dascombe, B., & Reaburn, P. (2011). A comparison of the activity demands of elite and sub-elite Australian men's basketball competition. J Sports Sci, 29(11), 1153-1160. https://doi.org/10.1080/02640414.2011.582509

Shalfawi, S., Enoksen, E., Tønnessen, E., & Ingebrigtsen, J. (2012). Assessing the test-retest reliability of the portable Brower Speed Trap II testing system. Kinesiology, 11(1), 24-30.

Sierer, S., Battaglini, C., Mihalik, J., Shields, E., & Tomasini, N. (2008). The National Football League Combine: Performance Differences Between Drafted and Nondrafted Players Entering the 2004 and 2005 Drafts. J Strength Cond Res, 22(1), 6-12. https://doi.org/10.1519/jsc.0b013e31815ef90c

Spencer, M., Lawrence, S., Rechichi, C., Bishop, D., Dawson, B., & Goodman, C. (2004). Time–motion analysis of elite field hockey, with special reference to repeated-sprint activity. J Sports Sci, 22(9), 843-850. https://doi.org/10.1080/02640410410001716715

Till, K., Cobley, S., O'Hara, J., Brightmore, A., Cooke, C., & Chapman, C. (2011). Using anthropometric and performance characteristics to predict selection in junior UK Rugby League players. J Sci Med Sport, 14(3), 264-269. https://doi.org/10.1016/j.jsams.2011.01.006

Tønnessen, E., Shalfawi, S., Haugen, T., & Enoksen, E. (2011). The Effect of 40-m Repeated Sprint Training on Maximum Sprinting Speed, Repeated Sprint Speed Endurance, Vertical Jump, and Aerobic Capacity in Young Elite Male Soccer Players. J Strength Cond Res, 25(9), 2364-2370. https://doi.org/10.1519/jsc.0b013e3182023a65

Upton, D. (2011). The Effect of Assisted and Resisted Sprint Training on Acceleration and Velocity in Division IA Female Soccer Athletes. J Strength Cond Res, 25(10), 2645-2652. https://doi.org/10.1519/jsc.0b013e318201be16

Weir, J. (2005). Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. J Strength Cond Res, 19(1), 231-240.

West, D., Cunningham, D., Bracken, R. et al. (2013). Effects of Resisted Sprint Training on Acceleration in Professional Rugby Union Players. J Strength Cond Res, 27(4), 1014-1018. https://doi.org/10.1519/jsc.0b013e3182606cff