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Effect of Resistance on 20 m Running Performance

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ABSTRACT

Introduction: Sprinting is crucial in the development and final results of many individual and team sports. According to recent findings on the mechanical determinants of sprint performance, resistance sprinting (RSS) may be a suitable method to improve sprint performance in the acceleration and maximum velocity phases. Methods: Sports science students (183.6 ± 5.1 cm; 85.8 ± 6.8 kg; 24.5 ± 0.9 yrs), primarily involved in team sports (football, basketball), performed two-day testing. The first testing included a maximal strength test using the isometric mid-tight pull (IMTP) and a lower extremity explosive strength test using the countermovement jump (CMJ) without arm movement. The second testing was completed 48 hours later and included unresisted sprint (URS) and resisted sprint (RSS) over 20 m with three different resistances (8 oz = 0.24 kg, 12 oz = 0.34 kg, 2 lb = 0.9 kg). Results: A significant correlation was found between CMJ and speed tests (URS, RSS 8 oz, RSS 12 oz). The same applied to the relationship between IMTP and speed tests, with only one difference being that IMTP correlated with RSS 2 lb (r = -0.58). However, observing the relationship between velocity decrease (V_{dec}) and performance parameters showed the highest correlation between V_{dec} 8 oz and URS 20 m (r = -0.572) and also between V_{dec} 12 oz and CMJ (r = -0.370). At V_{dec} 2 lb, of all the performance parameters, IMTP (r = -0.260) was the only one which correlated. Conclusion: The study 's results demonstrate a relationship between CMJ and IMTP with unresisted sprint. Also, between maximal strength test, IMTP and heavy resisted sprint.

Keywords: sprint; sprint performance; resisted sprint training; velocity decrease; horizontal force

INTRODUCTION

Improving sprint performance is an important goal in many individual and team sports. Various training methods improve sprinting performance, including maximal sprint speed and resistance sprint training. Various resistance training exercises provide mechanical overload and require the generation of higher horizontal ground reaction forces, increasing the impulse towards the ground (Alcaraz et al., 2018).

When designing optimal training programs, it is necessary to understand the factors of acceleration and maximum sprint speed. Most coaches are trying to increase force production, strength-speed abilities, and reactive power in the vertical direction of movement (Seitz et al., 2014). Force the acceleration phase to the maximum speed; the force ratio decreases linearly. Horizontal force production may be a more vital determinant of sprint performance than vertical forces, especially during acceleration (Morin et al., 2012; Los Arcos et al., 2015). Resistance sprint training can provide suitable conditions for effective development.

Athletes currently use four methods to create horizontal resistance. These methods include aerodynamic (parachutes), motorized (1080 Sprint; 1080 Motion, Austin, TX), pulley (Exergenie, Thousand Oaks, CA) and sliding (sleds). The most common method for creating horizontal resistance is the sleds. However, this method presents an additional resistive force from sliding (friction force) (Cross et al., 2018).

The effect of 10 weeks of sled resistance training with a 50% decrease in velocity (V_{dec}) demonstrated an improvement in 30 m sprint performance and enhancements in force, maximal velocity and maximal horizontal power. For individual variability, V_{dec} is due to loading, a better method of determining sled load than body mass (Morin et al., 2022). This assertion is supported by Stavridis et al. (2023), who examined the effect of two sled resistance training programs with V_{dec} 50%, 10% BM and unresisted sprint (URS). After six weeks, the 50% V_{dec} group improved their performance in the 30 m sprint and showed significantly increased force, maximal horizontal power and higher stride frequency compared to the other groups.

The research part of this study investigated the correlation of the selected tests with the speed parameters, monitored the decrement in velocity at the chosen resistance, and compared this decrement in velocity with the performance parameters.

METHOD

Participants

Ten male sports science students volunteered to participate in this study (183.6 ± 5.1 cm; 85.8 ± 6.8 kg; 24.5 ± 0.9 yrs). All participants in this research had previous experience in speed and strength training and were active at the recreational level, predominantly in team sports (football, basketball). Based on prior knowledge, the participants could perform the exercises using the required technique, which, together with optimal health, formed suitable inclusion criteria for the research. Exclusion criteria included post-operative conditions, current injuries restricting movement and inability to perform the required physical activity. Attendants of this research were informed of the risks associated with testing and signed an informed consent form voluntarily agreeing to participate in the study, which was conducted in accordance with the Declaration of Helsinki.

Test design

The purpose of this research was to determine the correlation of the tests performed with speed parameters (URS; RSS 8 oz; RSS 12 oz; RSS 2 lb) and to compare the performance parameters of IMTP, CMJ and unresisted sprint with the V_{dec}. A one-step protocol was implemented to measure maximal strength, lower limb explosive power, and acceleration velocity test without and with resistance. The test protocol consisted of two days. One day before the start of the first testing session, participants completed a familiarisation session, which consisted of an explanation of the exercises and a collection of anthropometric parameters. Participants were also instructed not to perform speed-strength exercises for 24 hours before testing. The first day of testing included a maximal strength test using the isometric mid-tight pull (IMTP) and a plyometric test, the countermovement jump (CMJ) without arm movement. With an interval of 48 hours, we performed a second testing session, which included sprints over 20 m unresisted and resisted sprint (URS; RSS 8 oz; RSS 12 oz; RSS 2 lb).

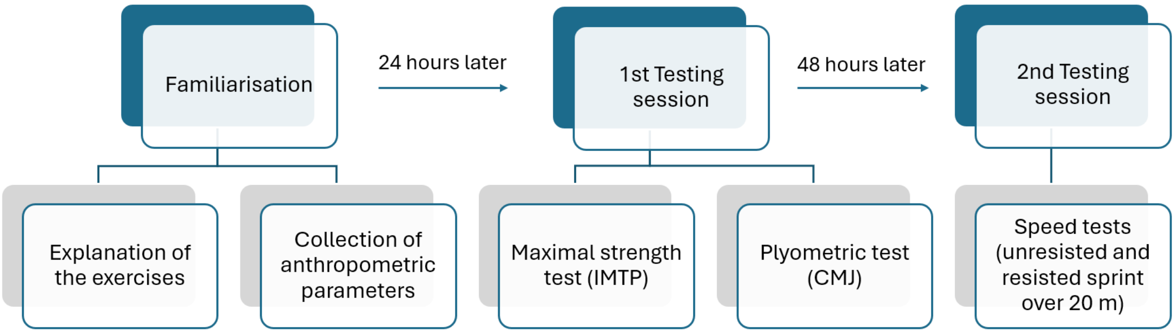

Figure 1. Overview of the research design

Procedures

The testing of maximal strength and explosive power of the lower limbs was realized in the gym, and speed tests were performed in the sports hall. Before each test, a 15-minute familiar standardized warm-up was completed, which included myofascial release, dynamic stretching, and a specific warm-up for the movement activity. In the IMTP exercise, subjects attempted to produce a maximal pull for 5 seconds in response to a verbal signal, with a rest interval of 2 minutes between trials. Comfort et al. (2019), in their study, described the methodological considerations and recommendations for IMTP that we followed. We restricted arm work to minimize upper body movement and focused more on the power generated by the lower extremities during CMJ exercise so that the subjects had their arms at their hips. Participants were instructed to perform the countermovement as quickly as possible and then jump vertically as high as possible, returning to a standing position after landing. The rest interval between each trial was one minute. Participants had three trials each for both tests. Dynamometer (Tindeq Progressor 300®, Trondheim, NO) was used to measure IMTP, and CMJ was monitored using My Jump 2 (My Jump Lab®, Carlos

Balsalobre, Madrid, Spain). In their article, Vieira et al. (2023) described the My Jump 2 mobile app as a valid and reliable tool for monitoring vertical jumps, presenting scores similar to those on force plates.

The speed test battery consisted of eight sprints, at the beginning without resistance and later on with gradually increasing resistance. On each attempt, the participants stood on a marked line from which they started from a two-point staggered stance. The marked line was one meter in front of the starting gate. The resistance trials required the strap to be stretched before the start to ensure no "bouncing" of the rope. Data collection and performance of subjects were measured during each sprint using timed photocells (Brower Timing Systems®, Salt Lake City, UT). Five pairs of photocells were used, with the help of which the time was recorded at 5, 10, 15 and 20 meters from the starting gate. The height of each photocell was set to one meter from the ground. Three load protocols were prescribed (8 oz = 0.24 kg; 12 oz = 0.34 kg; 2 lb = 0.9 kg), created using a resistive device (EXER-GENIE®, Thousand Oaks, CA). Imperial units are used in the studies because this device expresses resistance using these units (ounces, pounds).Participants had two attempts for each type of sprint (URS; RSS 8 oz; RSS 12 oz; RSS 2 lb). The best trial for each sprint type was selected for analysis.

Figure 2. Visual representation of IMTP testing

Figure 3. Visual representation of speed testing

Statistical Analysis

The results are presented using basic descriptive statistics, including the mean (mean), standard deviation (SD), minimum value (min) and maximum value (max). Because some variables do not show a normal distribution of the data, as confirmed by the Kolmogorov-Smirnov test ($p < 0.01$), the Spearman correlation coefficient was used to assess the magnitude of the relationships. Data were collected in Excel (Microsoft, USA), and statistical analysis was performed in RStudio 2023.09.1 (Posit Software, PBC) as IDE for language R version 4.3.2. The level of statistical significance was set at ≤ 0.05.

RESULTS

The results are described in Tables 1-3. Table 1 describes the mean, minimum and maximum values, and standard deviation (SD). Spearman correlation is presented in Tables 2 and 3.

Table 1. Descriptive statistics

Variable	Mean (SD)	Minimum	Maximum
URS 20 m (s)	3.054 (0.154)	2.87	3.30
RSS 8 oz 20 m (s)	3.520 (0.143)	3.34	3.68
RSS 12 oz 20 m (s)	3.879 (0.198)	3.57	4.17
RSS 2 lb 20 m (s)	4.293 (0.394)	3.84	5.03
V_{dec} 8 oz 20 m (%)	15.331 (2.649)	10.303	18.710
V_{dec} 12 oz 20 m (%)	27.036 (2.758)	23.077	31.935
V_{dec} 2 lb 20 m (%)	40.441 (8.431)	30.449	55.769
CMJ (cm)	48.380 (3.365)	44.200	54.500
IMTP (N)	1899.300 (338.231)	1412.000	2576.000

A strong negative correlation was found between CMJ and URS (r = -0.48), RSS 8 oz (r = -0.51) and RSS 12 oz (r = -0.55). Similarly, IMTP showed a negative correlation with URS (r = -0.55), RSS 8 oz (r = -0.51), RSS 12 oz (r = -0.47) and RSS 2 lb (r = -0.58). The results from CMJ exhibited a weak correlation with RSS 2 lb (r = -0.24). There is almost no correlation observed between V_{dec} 8 oz and CMJ (r = -0.036), but a strong relationship with URS 20 m (r = -0.572). The V_{dec} 12 oz showed no significant correlation with IMTP results (r = 0.090), compared to a moderate correlation demonstrated in the results of URS 20 m (r = -0.307) and CMJ (r = -0.370). The V_{dec} 2 lb relationship between CMJ (r = 0.176) and URS 20 m (r = 0.196) was negligible, and the relationship with IMTP (r = -0.260) showed a weak correlation.

Table 2. Correlation matrix (CMJ, IMTP)

	CMJ	IMTP
URS 20 m	r = -0.48, p = 0.156	r = -0.55, p = 0.097
RSS 8 oz 20 m	r = -0.51, p = 0.134	r = -0.51, p = 0.130
RSS 12 oz 20 m	r = -0.55, p = 0.097	r = -0.47, p = 0.174
RSS 2 lb 20 m	r = -0.24, p = 0.503	r = -0.58, p = 0.077
V_{dec} 8 oz 20 m	r = -0.04, p = 0.920	r = 0.12, p = 0.751
V_{dec} 12 oz 20 m	r = -0.37, p = 0.291	r = 0.09, p = 0.803
V_{dec} 2 lb 20 m	r = 0.18, p = 0.626	r = -0.26, p = 0.467

Table 3. Correlation matrix (V_{dec} 8 oz; V_{dec} 12 oz; V_{dec} 2 lb)

	V_{dec} 8 oz 20 m	V_{dec} 12 oz 20 m	V_{dec} 2 lb 20 m
CMJ	r = -0.036, p = 0.920	r = -0.370, p = 0.291	r = 0.176, p = 0.626
IMTP	r = 0.115, p = 0.751	r = 0.090, p = 0.802	r = -0.260, p = 0.467
URS 20 m	r = -0.572, p = 0.083	r = -0.307, p = 0.387	r = 0.196, p = 0.585

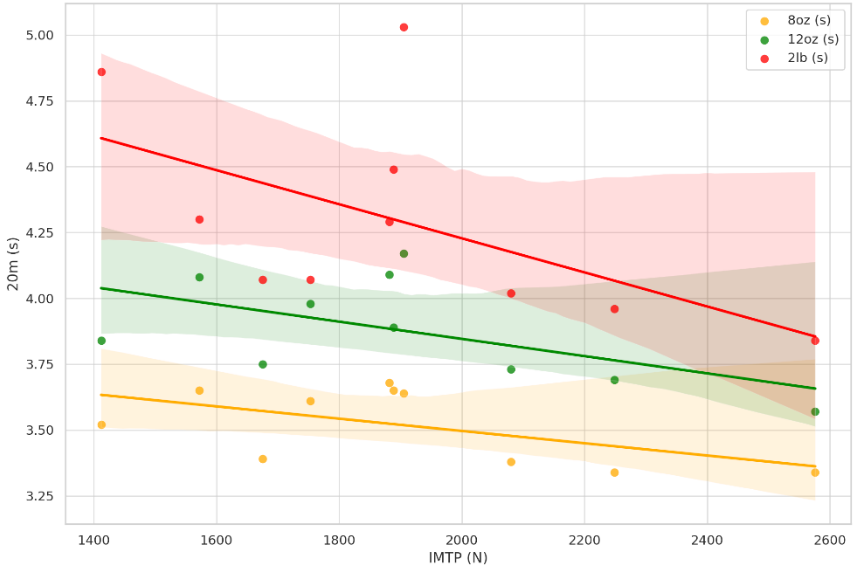

Figure 4. The relationship between IMTP and RSS 20 m

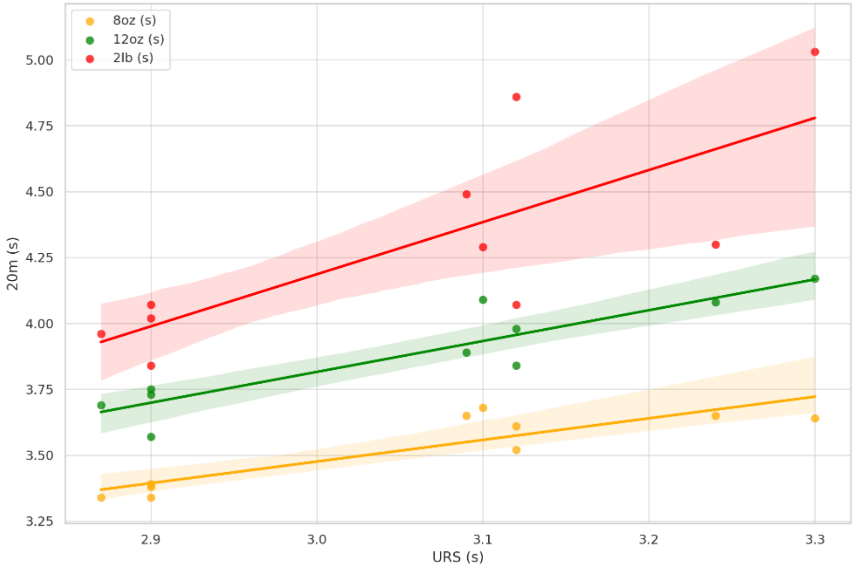

Figure 5. The relationship between URS and RSS 20 m

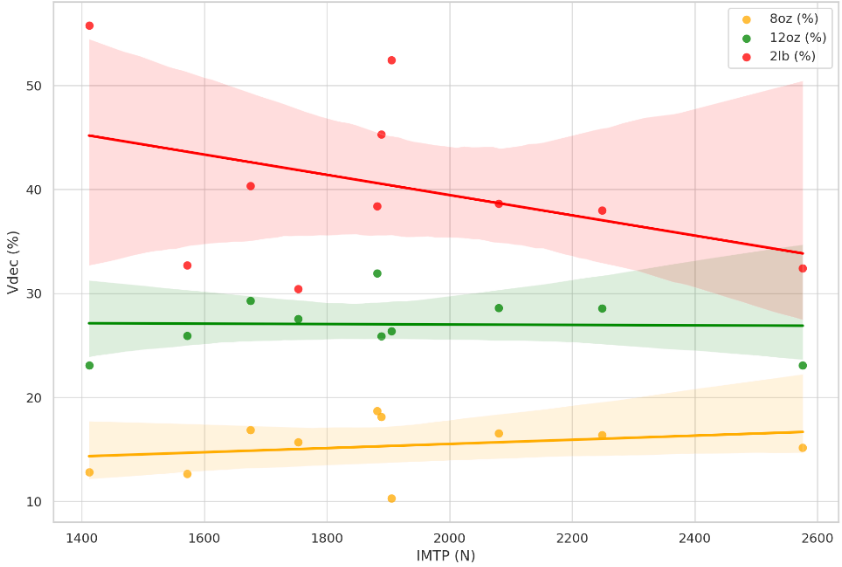

Figure 6. The relationship between IMTP and Vdec

DISCUSSION

This research included a relatively small homogeneous sample (n = 10), which may limit our findings. This study focused on the relationship between the countermovement jump and isometric mid-tight pull strength tests and velocity parameters at a distance of 20 meters. It brought interesting findings on the interactions between the strength and speed performance of athletes to the fore. For CMJ, we observed a strong negative correlation with URS values at a distance of 20 meters ($r = -0.48$, $p = 0.156$). Morris et al. (2022) support our findings where their analysis compared the relationship of CMJ with acceleration velocity ($r = -0.550$, $p < 0.036$), and a similar correlation suggests that higher CMJ values may be associated with better acceleration performance in sprinting.

Townsend et al. (2019) in their research found a correlation between IMTP and unresisted sprint over 20 m ($r = -0.693$, $p < 0.05$). For IMTP, we found a strong relationship with URS 20 m ($r = -0.55$, $p = 0.097$), findings that are supported by international publications. An even higher correlation was determined concerning RSS 2 lb ($r = -0.58$, $p = 0.077$). Owen et al. (2020), in their meta-analysis, confirm the relationship between strength tests and acceleration speed. Our findings are consistent with the results of this meta-analysis. In this section of the discussion, we focus on observing the relationships between our test variables (CMJ, IMTP and URS 20 m) and velocity decrease at resistances (Vdec 8 oz, Vdec 12 oz and Vdec 2 lb). The device on which we conducted the research provided an average decrease in velocity of up to 40% at 2 lb resistance. Lahti et al. (2020) suggest with their findings that heavy resistance sprint training can improve sprint performance. Adaptations can be maximised when velocity decreases by 50%. This assertion is supported by an earlier systematic review by Petrakos et al. (2016), who describe an improvement in initial acceleration for very heavy loads ($>V_{dec}$ 30%), where velocity is low and resistive forces are high. For lighter loads ($<V_{dec}$ 10%), there is an improvement at the maximum velocity phase, where velocity is high and resistive forces are lower. It is important to remember that heavy resistance sprint training will not work the same for every athlete, and each athlete's performance needs to be considered as well. This can be predicted to some extent by appropriate initial performance testing, including sprint force-velocity profiling (F-V profile). Morin and Samozino (2016) describe the F-V profile as a relationship between strength (force) and speed (velocity) to assess an athlete's ability during ballistic exercises (jumps, sprints). Through this profiling, we can identify whether an athlete is deficient in force or velocity during a given movement, independent of their power capabilities. With this profiling, we can make athlete's training programs more specific, using detailed, objective information.

In this research, sprints were performed with light a load (8 oz = V_{dec} 10–15%), moderate (12 oz = V_{dec} 25–30%) and heavy load (2 lb = V_{dec} 40–50%). We found a strong relationship between V_{dec} 8 oz and URS 20 m (r = -0.572, p = 0.083), which may indicate that this resistance was not sufficient to produce a required decrease in velocity and to create the necessary stimulus to improve sprint performance in the acceleration phase. When comparing URS 20 m and V_{dec} 2 lb (r = 0.196, p = 0.585), this relationship is minimal, which may predict sufficient load for a more efficient development of sprint performance in the acceleration phase, compared to unresisted sprint as reported by other foreign publications. This load created a relatively strong correlation with maximal strength exercise, IMTP (r = -0.260, p = 0.467). Stronger and more explosive athletes will require heavier loads to perform sprints at the required intensity to create the necessary adaptations.

However, it is necessary to point out that our study has its limitations and therefore, future research with a larger sample and more diverse parameters is needed for a more accurate and comprehensive understanding of these relationships.

CONCLUSION

The study aims to compare the relationships between the strength tests, IMTP and CMJ, with unresisted sprint, resisted sprint and velocity decrements at different resistances. Both strength tests correlated with URS 20 m, CMJ (r = -0.48, p = 0.156) and IMTP (r = -0.55, p = 0.097). The isometric mid-tight pull test showed a high correlation in sprinting with each load and a decrement in velocity with a heavy load. The results of this study demonstrate the relationship between measures of strength and speed that are important to athletes. Consideration should be given to implementing the IMTP test into a test battery to assess athlete performance. Also, these results contribute to the growing awareness and association between strength tests, speed parameters and velocity decrements in the context of athletic performance. Emphasis on the individual characteristics of athletes and their responses to given tests may help to understand this complex issue better.

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