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The Effects of a Sled Push at Different Loads on 20 Metre Sprint Time in Well-Trained Soccer Players

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ABSTRACT

This study determined the effects of a single sled push at different loads on sprint performance in competitive male soccer players. Twenty male competitive outfield soccer players (age 19.6 ± 1.3 y, body mass 73.6 ± 8.2 kg) were split into experimental ($n=10$) and control groups. In the experimental group, 20m linear sprint time was measured immediately before and 5, 6 and 7 minutes after the sled push with either 50 or 100% body mass. The control group performed the 20m sprints only. A repeated measures ANOVA comparing control and experimental groups revealed no effects of time, group or time by group interaction for either experimental condition (all $P > 0.05$). The repeated measures ANOVA compared the experimental conditions revealed effects of time ($P = 0.034$) and group ($P = 0.002$), but not time by group ($P > 0.05$). The effects sizes demonstrated favourable within group effects on sprint time that were *small* to *moderate* (-0.26 to 0.71) and *trivial* to *small* (-0.31 to 0.09) for the 50% and 100% body mass condition, respectively. These findings demonstrate that a sled push has no significant effect on 20 m sprint time in competitive footballers. If coaches continue to prescribe a sled push before sprinting, a single 15 m push with 50% body mass could have positive benefits.

Keywords: Post-activation performance enhancement, post-activation potentiation, association football, conditioning activity

INTRODUCTION

Association football (i.e. soccer) in an intermittent sport that incorporates high-intensity exercise (e.g. sprinting, changes of direction) interspersed with periods of low-intensity (e.g. standing, walking, jogging) (24). Players will perform between 17-81 sprints per game, depending on their position, which typically accounts for ~11% of the distance covered (2,24,25,33). Moreover players in lower leagues/levels will perform less high-intensity activity (i.e. sprinting) (24), due to the slower nature of the game. Though sprinting only accounts for a small percentage of the distance covered (i.e. 11%), it is recognised that sprinting is a key element within a match (19,30). Indeed, sprinting is the most common action involved in scoring and assisting which can distinguish between game outcomes (19). Given the importance of sprint performance to soccer, it is important for practitioners to utilise training methods that will enhance sprint time in their athletes.

Resistance training is one of the most widely used methods to enhance sprinting performance (7). When performed longitudinally, resistance training can enhance sprint performance (14). For example, after 10 weeks of power-based resistance training, 40m sprint time was decreased by ~0.13s (14). Moreover, a meta-analysis concluded that resistance training induced increases in lower-body strength were significantly related to decreased sprint time ($r = -0.77$) (29). Whilst it is evident that

resistance exercise can enhance performance, these changes take a prolonged period of time (i.e. weeks). Interventions (e.g. potentiating exercises) that can enhance performance acutely (i.e. within minutes) may complement the benefits induced by longer-term training regimes.

Post-activation performance enhancement refers to an improvement in exercise performance evoked by prior muscle activity (e.g. conditioning activity) (6) and is underpinned by a both central and peripheral factors e.g. elevated pre-synaptic excitation, enhanced myosin heavy chain phosphorylation (6). Generally, studies have observed that a prior conditioning activity can enhance performance acutely, with optimal benefits occurring between 5 and 7 minutes after the initial activity (27). Indeed, in stronger individuals (i.e. squat > 1.75 times body mass) a single set of high-intensity exercise (>85% one repetition maximum; 1RM) prior to performance is more beneficial than multiple sets or moderate intensity exercise (27,31). This is potentially owing to enhanced fatigue resistance and greater peripheral alterations (e.g. myosin heavy chain phosphorylation) in these individuals (27). Whilst this provides important information for practitioners working with athletes, several practical considerations still exist. Firstly, using a percentage 1RM to prescribe the intensity of conditioning activity is time consuming and subject to day to day variation (17). Secondly, the conditioning activity should be biomechanically similar to the exercise task (4) and, therefore using gym-based activities for sprinting may not be either optimal or logistically possible for many practitioners. Consequently, it is essential to use field-based modalities to induce post-activation performance enhancement and ensuring these are prescribed optimally.

The effects of an acute bout of squat exercise on sprint times are generally positive (3,36). For example, squatting with between 30 and 70% 1RM had a significant improvement on 40m sprint performance in strength trained men (36). However, as Crewther et al.(15) and Yetter and Moir(36) acknowledge, biomechanical similarity between the conditioning activity and performance are a key consideration. As such, there may be better lower-body exercises to prescribe to ensure dynamic correspondence for sprint performance (e.g. sled pushing). Seitz et al.(28) reported a 0.95 to 1.80% reduction in 20 m sprint time 4 to 8 minutes, respectively, after a single sled push with 75% body mass in rugby league players. However, when the sled push was performed with 125% body mass, sprint time was impaired at

all time points (28). Indeed, previous research has shown that using moderate loads (~50% body mass) during resisted sprint training results in greater improvements in sprint performance than lower or higher loads (26). Moreover, an important limitation, which Seitz and colleagues (28) acknowledge, is the absence of a control group. Thus, it is unknown if performance was enhanced due to the sled push, or due to the consecutive sprints. Therefore, the aim of this study was to investigate the effects of a sled push performed at 50 and 100% of body mass on sprint performance in well-trained collegiate football players. Given the lack of comparable reports, we propose the null hypothesis (i.e. no difference between conditions) for this study.

METHODS

Participants

Twenty male competitive outfield soccer players (age 19.6 ± 1.3 y, mass 73.6 ± 8.2 kg, stature 1.81 ± 0.7 m) were randomly split into two groups; experimental ($n = 10$) and control ($n = 10$) (See table 1). All participants were recruited from the host institutions sports academy. All participants regularly performed resistance (>1 year) and soccer (3 times per week) training and were asymptomatic of illness and injury. Participants completed a pre-participation screening questionnaire and informed consent prior to testing. Ethical approval was attained from the host institutions ethics committee and undertaken in accordance with the Declaration of Helsinki.

Study Design

Using a repeated-measures, between-groups design, participants attended the strength and conditioning laboratory on two occasions separated by one week. On both occasions' participants performed a standardised warm up (3 incremental runs and lower-body stretching) before sprinting and performing the sled push. On the first trial, the experimental group performed a 20 m, unresisted sprint before (60s) and 5, 6 and 7 minutes after a sled push at either 50 or 100% body mass. The second trial was identical to the first, but participants performed the sled push with the opposing condition. The order of the sled push was randomised between participants. For both trials a control group performed maximal unresisted sprints at the same times points as the experimental group but did not perform the sled push. Whilst the experimental

group was performing the sled push, the control group remained standing (~30 s).

Procedures

Anthropometric Assessment

Stature was measured before the warm up on the first visit using a stadiometer (Seca height measure, Birmingham, UK). Before the warm up of each visit, participants body mass was assessed using digital scales (SECA model 813, Birmingham, UK) and measured to the nearest 0.1kg. Participants were required to take off their footwear (plastic studded football boots) and stand on the scales with their weight distributed evenly across both feet. Clothing items such as shorts and t-shirts were worn during the weighing. This body mass was used to set the load for the sled push.

Sprint Time

Participants performed a maximal sprint effort which started in a static (i.e., preventing a pre-emptive backwards movement) standing position with their stance staggered (this was self-selected but standardised for all sprints). This was performed on a flat, artificial turf over 20 m. For each effort participants were instructed to maximally sprint through the timing gates. At baseline, participants performed three maximal unresisted 20 m sprints with 2 minutes rest between attempts. The lowest value (i.e., best performance) was used for analysis (28). After the sled push, participants complete a single maximal unresisted maximal unresisted sprint at 5-, 6- and 7-minutes post. Sprint time was recorded using timing gates set a 0 and 20 m (Brower Timing Systems, Utah, USA). These timing gates can provide reliable (coefficient of variation of 1%) assessments of sprint time (34).

Conditioning Activity

A single sled push stimulus was performed at either 50% or 100% body mass over a 15-metre distance. Plates were loaded manually on to a scrum sled (1.13m high, 0.65m wide; Scrum Sled, Perform Better, UK). The sled push was performed the same surface, and the athletes were instructed to 'explode', and 'push the ground away'. These cues were selected, as an external focus of attention can aid sprint time (5). Hand-height was individually standardised across trials. The athletes were instructed to push with a forward lean to optimise the striking angle of the foot (22). Participants regularly

performed sled pushes as part of their resistance training regimes, thus no familiarisation trials were provided.

Statistical Analysis

Data were checked for normality and equal variances by the Shapiro-Wilk and Levene statistics, respectively, and these assumptions were repeatedly found to be satisfied ($P > 0.05$). Separate two-way repeated measures ANOVAs (time by group) were employed to determine changes in sprint time over time between the control and experimental groups. When sphericity was violated, the Greenhouse-Geisser correction was used. Between- [(50% body mass mean change–100% body mass mean change)/pooled standard deviation of the change score] and within-group (difference between means/pooled standard deviation) effect sizes (ES; Cohen's d) (12,16) and 90% confidence intervals (CI) were calculated to determine the magnitude of the changes between conditions. Thresholds for the magnitude of the observed change for each variable were qualified as trivial (< 0.20), small (0.20 to 0.59), moderate (0.60 to 1.19), large (1.20 to 1.99), and very large (> 2.00) (20). Alpha was set at 0.05.

RESULTS

Sprint times are detailed in figures 1 and 2 for the 50 and 100% body mass sled push conditions, respectively. The interaction effect was not significant ($F_{(2.5, 18)} = 2.2, P = 0.112$) for the 50% body mass condition (vs control). Changes approached significance for time ($F_{(2.5, 18)} = 3.0, P = 0.051$) and condition ($F_{(1, 18)} = 4.1, P = 0.056$). The within-group effect sizes for the 50% body mass condition displayed small to moderate differences to baseline at 5 to 7 minutes (Table 1).

A two-way repeated measures ANOVA found no effect of time ($F_{(2.8, 18)} = 2.3, P = 0.095$), group ($F_{(1, 18)} = 0.003, P = 0.954$), or time by group ($F_{(2.8, 18)} = 3.1, P = 0.507$) for the 100% body mass condition. Within-group effect sizes at 5 and 6 minutes were trivial and small at 7 minutes.

A two-way repeated measures ANOVA, comparing changes in sprint time between the two experimental conditions revealed a main effect for group ($F_{(1, 9)} = 18.4, P = 0.002$) and time ($F_{(3, 9)} = 3.3, P = 0.034$). The time by group effect was not significant ($F_{(3, 9)} = 1.5, P = 0.249$). Between-group effect sizes were small at 6 minutes, suggesting the 50% body weight

condition resulted in an improved in sprint time than the 100% condition.

DISCUSSION

This study sought to determine the effect of a single sled push at 50 or 100% body mass, on 20 m sprint time. We report that 20 m sprint time was not significantly different to baseline after a sled push at both 50 and 100% of body mass when compared to the control group. These data indicate that if practitioners want to enhance sprint time acutely in competitive footballers, a sled push is not suitable. Importantly, this study found that there were no negative effects of the sled, especially for 50% of body mass condition.

At all-time points after the sled push, sprint time was not significantly different from baseline in both conditions. These data are similar to studies reporting no difference and impaired sprint time in sprint time after a heavy squats (up to 10 minutes post) (3,23) or sled pushing (up to 12 minutes post) (28). For example, after a sled push at 125% body mass, Seitz et al. (28) reported impairments in sprint time at 15s to 12 minutes. The sled push is a suitable strategy for speed development, particularly when aiming to improve the ability to exert force during horizontal locomotion (11). However, sled pushing may alter the sprinting gait cycle by removal of the arm action that synchronizes and counterbalances the leg action occurring at the hip (21). Moreover, the 100% body mass condition, may have negatively impacted the specificity and transfer to maximal sprinting by inducing longer ground contact times (i.e. fatigue) (32).

Table 1. Effect sizes ± 90% confidence intervals within- (50 and 100%) and between (50 vs 100%) the two experimental groups. Text in italics denotes the qualitative interpretation of the effect sizes. Between-group effect sizes are between the two experimental conditions only.

Condition	Within-group effect size			Between-group effect size		
	5 mins	6 mins	7 mins	5 mins	6 mins	7 mins
50%	<i>Small</i> -0.26 ± 0.68	<i>Moderate</i> -0.71 ± 0.57	<i>Moderate</i> -0.62 ± 0.65	<i>Trivial</i> -0.19 ± 0.45	<i>Small</i> -0.41 ± 0.35	<i>Trivial</i> -0.23 ± 0.40
100%	<i>Trivial</i> 0.09 ± 0.64	<i>Trivial</i> -0.01 ± 0.74	<i>Small</i> -0.31 ± 0.72			

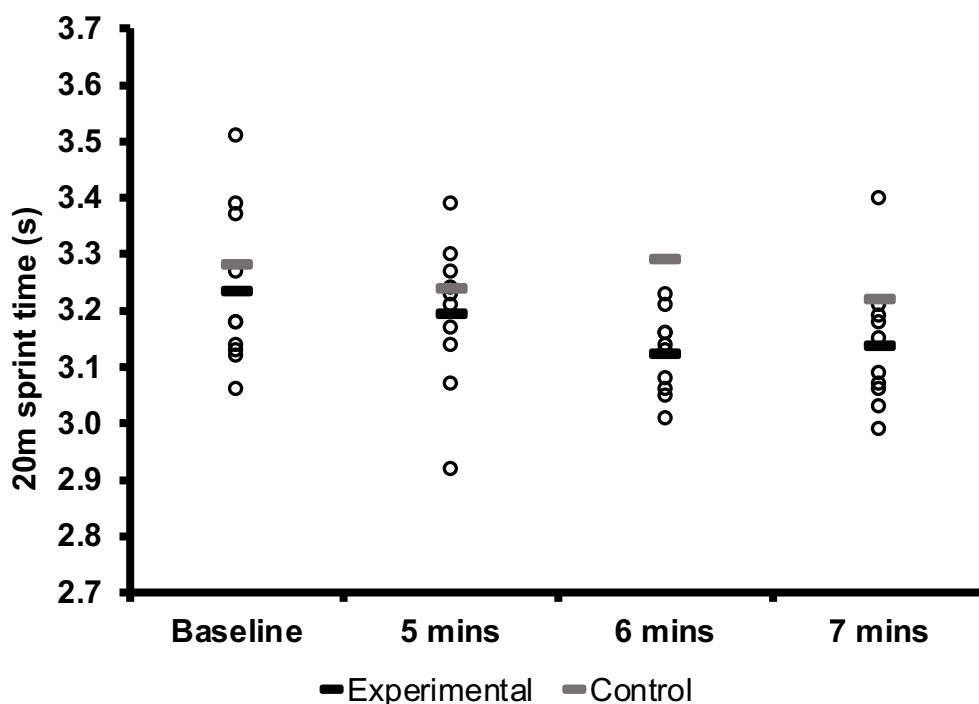


Figure 1. Sprint times (seconds) after the 50% body mass sled push. The rectangles denote the means for each group. The circles denote the individual values for the experimental group only.

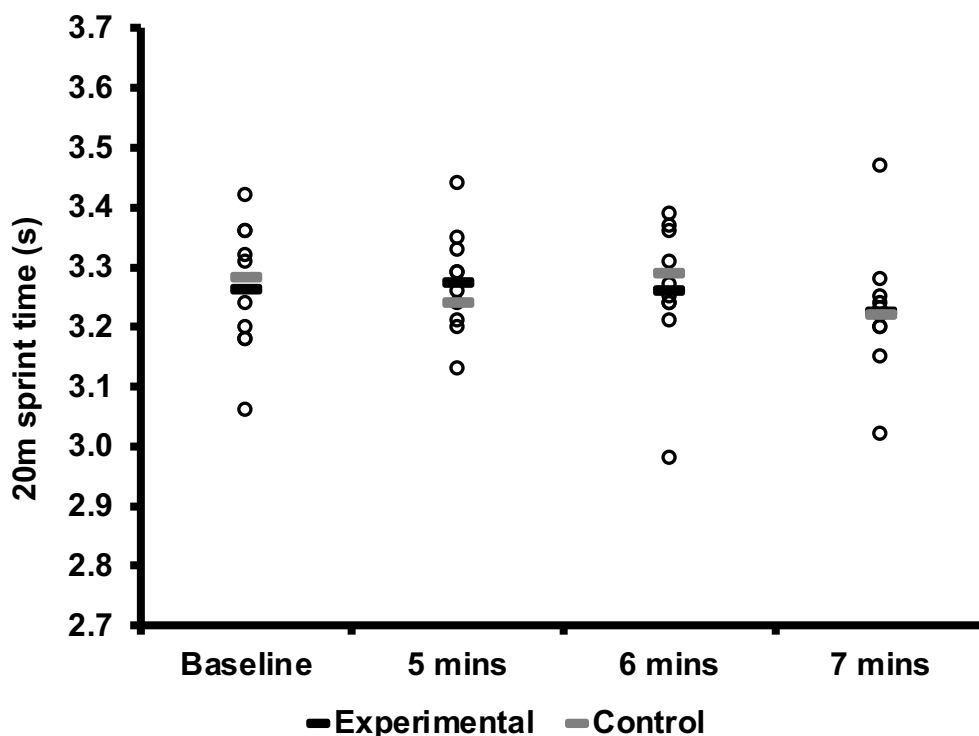


Figure 2. Sprint time (seconds) after the 100% body mass sled push. The rectangles denote the means for each group. The circles denote the individual values for the experimental group only.

The load condition included during sprint efforts might explain the different effect sizes after pushing a sled (18). According to the present results, the lighter load (i.e., 50% of body mass) resulted in a moderate improvement (indicative of post-activation performance enhancement/fitness) in 20 m sprint time, whereas the effects for the 100% body mass condition were lower. These findings are similar to work in rugby players analysing the potentiating effects of performing sled push exercise on 20 m sprint test (28). After pushing a sled with 75% of body mass, athletes presented better 0-20 m sprint times in 4, 8, and 12 minute intervals, while the opposite was observed after a 125% of body mass sled push (28). These results (28) suggest that the load underpins the potentiating effects in sprinting activities. In fact, pushing a sled with 50% of body mass represents a moderate load, resulting in 50% of velocity decrement (power training threshold), whereas 100% of body mass represents a heavy load, resulting in 80% of velocity decrement (strength-speed training threshold) (9,10). As such, the small differences, although non-significant, between loads are logical. Indeed, the sled push with 100% body mass may have generated greater neuromuscular fatigue than 50% body mass, thus limiting transfer of training effect during 20 m sprint. Moreover, the associated neuromuscular fatigue resulting from the heavy load and short rest interval

may not have allowed for sufficient restoration of adenosine triphosphate and phosphocreatine, the clearance of fatigue-inducing substrates, and the restoration of force production capacity, which negatively affected 20 m sprint (13). That said, pushing the sled with heavy load can be strenuous for the involved muscles which are needed for sprinting, thus resulting in detrimental performance.

In the present study, there was a potential improvement at 6 mins in 50% of body mass condition. This finding suggests that including a load which corresponds to the power training threshold (9,10) during sprint efforts can elicit an improvement in 20 m sprint time after an approximately six minute passive recovery period. This response corresponds to the post-activation performance enhancement which is a physiological phenomenon associated to the changes in muscle temperature, muscle/cellular water content, and muscle activation after a brief bout of high-intensity exercise (6). Regardless of the mechanisms, athletes may benefit of positive transfer resulting from the similarities between activities (sled pushing and sprinting) in terms of the muscle fibers involvement (8). Moreover, the sled push accentuates the biomechanics of the acceleration phase, promoting a lowered torso, hips, and positive shin angles (18). This position allows athletes to correctly simulate the triple extension

position; a key aspect during sprinting activities. Given that these effects were only approaching significance, we tentatively suggest that the sled push with 50% body mass could be used to elicit a moderate improvement in 20 m sprint time.

The current study required athletes to attend on to occasions and perform sprints at 5, 6 and 7 minutes each time. It is plausible that the findings at 6 and 7 minutes were affected by the sprints performed prior. However, it is unfeasible to separate these visits, given we have 2 conditions; this would result in 6 visits. Moreover, our approach has been adopted beforehand (28,35). Unfortunately, we did not collect data on the breakdown of sprint times within the 20 m distance. Thus, we do not know if shorter sprint time (e.g. 5 and 10 m) was affected by the conditioning activity. However, considering the average sprint distances (~21m) in soccer (1) the assessment of 20 m sprint performance may be of greater practical relevance.

CONCLUSION

This study aimed to determine the effects of a sled push at 50 and 100% body mass on subsequent 20 m sprint time. Compared to the control condition, sprint time after a 50 and 100% body mass sled push were unaffected. However, the 50% body mass sled push did demonstrate a moderate effect that approached significance at 6 minutes post sled push. Importantly, there were no negative affects of the sled push on sprint time. Therefore, if athletes or coaches wish to use the sled push exercise as a conditioning activity prior to performing sprinting training, using a load corresponding to 50% body mass may be considered.

DISCLOSURE OF INTEREST

The authors report no conflict of interest.

REFERENCES

- Andrzejewski, M, Chmura, J, Pluta, B, and Konarski, JM. Sprinting activities and distance covered by top level Europa league soccer players. *Int J Sport Sci Coach* 10: 39–50, 2015.
- Bangsbo, J, Mohr, M, and Krstrup, P. Physical and metabolic demands of training and match-play in the elite football player. *J Sports Sci* 24: 665–674, 2006.
- Beato, M, Bigby, AEJ, De Keijzer, KL, Nakamura, FY, Coratella, G, and McErlain-Naylor, SA. Post-activation potentiation effect of eccentric overload and traditional weightlifting exercise on jumping and sprinting performance in male athletes. *PLoS One* 14: 1–13, 2019.
- Beato, M, McErlain-Naylor, SA, Halperin, I, and Iacono, A Dello. Current evidence and practical applications of flywheel eccentric overload exercises as postactivation potentiation protocols: A brief review. *Int J Sports Physiol Perform* 15: 154–161, 2020.
- Benz, A, Winkelman, N, Porter, J, and Nimphius, S. Coaching instructions and cues for enhancing sprint performance. *Strength Cond J* 38: 1–11, 2016.
- Blazevich, AJ and Babault, N. Post-activation potentiation versus post-activation performance enhancement in humans: historical perspective, underlying mechanisms, and current Issues. *Front Physiol* 10, 2019.
- Bolger, R, Lyons, M, Harrison, AJ, and Kenny, IC. Sprinting performance and resistance-based training interventions: A systematic review. *J Strength Cond Res* 29: 1146–1156, 2015.
- Bompa, T and Haff, GG. *Periodization: Theory and methodology of training*. 5th ed. Champaign, IL: Human Kinetics, 2017.
- Cahill, MJ, Cronin, JB, Oliver, JL, Clark, KP, Lloyd, RS, and Cross, MR. Resisted sled training for young athletes: When to push and pull. *Strength Cond J* 42: 91–99, 2020.
- Cahill, MJ, Oliver, JL, Cronin, JB, Clark, KP, Cross, MR, and Lloyd, RS. Sled-push load-velocity profiling and implications for sprint training prescription in young athletes. *J Strength Cond Res EPUB*, 2020.
- Cissik, J. *Strength and conditioning: A concise introduction*. London, UK: Routledge, 2011.
- Cohen, J. *Statistical power analysis for the behavioral science*. Hillsdale, NJ: Lawrence Earlbaum Associates, 1988.
- Cormie, P, McGuigan, MR, and Newton, RU. Developing Maximal Neuromuscular power: Part 1 - biological basis of maximal power production. *Sport Med* 41: 17–39, 2011.
- Cormie, P, McGuigan, MR, and Newton, RU. Adaptations in athletic performance after ballistic power versus strength training. *Med Sci Sports Exerc* 42: 1582–1598, 2010.
- Crewther, BT, Kilduff, LP, Cook, CJ, Middleton, MK, Bunce, PJ, and Yang, GZ. The acute potentiating effects of back squats on athlete performance. *J Strength Cond Res* 25: 3319–3325, 2011.
- Dankel, SJ, Mouser, JG, Mattocks, KT, Counts, BR, Jessee, MB, Buckner, SL, et al. The widespread misuse of effect sizes. *J Sci Med Sport* 20: 446–450, 2017.
- García-Ramos, A, Haff, GG, Pestaña-Melero, FL, Pérez-Castilla, A, Rojas, FJ, Balsalobre-Fernández, C, et al. Feasibility of the 2-point method for determining the 1-repetition maximum in the bench press exercise. *Int J Sports Physiol Perform* 13: 474–481, 2018.

18. Haff, G and Triplett, NT. *Essentials of Strength and Conditioning*. 4th ed. Champaign, IL: Human Kinetics, 2015.
19. Haugen, TA, Tønnessen, E, Hisdal, J, and Seiler, S. The role and development of sprinting speed in soccer. *Int J Sports Physiol Perform* 9: 432–441, 2014.
20. Hopkins, WG, Marshall, SW, Batterham, AM, and Hanin, J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc* 41: 3–12, 2009.
21. MacAdam, P, Cronin, JB, Uthoff, AM, Johnston, M, and Knicker, AJ. Role of Arm Mechanics during Sprint Running: A Review of the Literature and Practical Applications. *Strength Cond J* 40: 14–23, 2018.
22. Majumdar, A and Robergs, R. The science of speed: Determinants of performance in the 100 m sprint. *Int J Sport Sci Coach* 6: 479–493, 2011.
23. McBride, JM, Nimphius, S, and Erickson, T. The acute effects of heavy-load squats and loaded countermovement jumps on sprint performance. *J Strength Cond Res* 19: 893–897, 2005.
24. Mohr, M, Krstrup, P, and Bangsbo, J. Match performance of high-standard soccer players with special reference to development of fatigue. *J Sports Sci* 21: 519–528, 2003.
25. Rampinini, E, Coutts, AJ, Castagna, C, Sassi, R, and Impellizzeri, FM. Variation in top level soccer match performance. *Int J Sports Med* 28: 1018–1024, 2007.
26. Rodríguez-Rosell, D, Sáez de Villarreal, E, Mora-Custodio, R, Asián-Clemente, JA, Bachero-Mena, B, Loturco, I, et al. Effects of Different Loading Conditions During Resisted Sprint Training on Sprint Performance. *J Strength Cond Res Publish Ah*, 2020.
27. Seitz, LB and Haff, GG. Factors modulating post-activation potentiation of jump, sprint, throw, and upper-body ballistic performances: A systematic review with meta-analysis. *Sport Med* 46: 231–240, 2016.
28. Seitz, LB, Mina, MA, and Haff, GG. A sled push stimulus potentiates subsequent 20-m sprint performance. *J Sci Med Sport* 20: 781–785, 2017.
29. Seitz, LB, Reyes, A, Tran, TT, de Villarreal, ES, and Haff, GG. Increases in lower-body strength transfer positively to sprint performance: A systematic review with meta-analysis. *Sport Med* 44: 1693–1702, 2014.
30. Styles, WJ, Matthews, MJ, and Comfort, P. Effects of strength training on squat and sprint performance in soccer players. *J Strength Cond Res* 30: 1534–1539, 2016.
31. Suchomel, TJ, Nimphius, S, and Stone, MH. The importance of muscular strength in athletic performance. *Sport Med* 46: 1419–1449, 2016.
32. van den Tillaar, R and Gamble, P. Comparison of step-by-step kinematics of resisted, assisted and unloaded 20-m sprint runs. *Sport Biomech* 18: 539–552, 2019.
33. Vigne, G, Gaudino, C, Rogowski, I, Alloatti, G, and Hautier, C. Activity profile in elite Italian soccer team. *Int J Sports Med* 31: 304–310, 2010.
34. Waldron, M, Worsfold, P, Twist, C, and Lamb, K. Concurrent validity and test–retest reliability of a global positioning system (gps) and timing gates to assess sprint performance variables. *J Sports Sci* 29: 1613–1619, 2011.
35. Winwood, PW, Posthumus, LR, Cronin, JB, and Keogh, JWL. The acute potentiating effects of heavy sled pulls on sprint performance. *J Strength Cond Res* 30: 1248–1254, 2016.
36. Yetter, M and Moir, GL. The acute effects of heavy back and front squats on speed during forty meter sprint trials. *J Strength Cond Res* 22: 159–165, 2008.