PAP EFFECT OF RESISTANCE AND OVERSPEED RUNNING ON KINEMATICS AND SPRINT PERFORMANCE

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The purpose of this study was to examine if there is a post activation potentiation (PAP) effect of resistance and overspeed sprinting upon kinematics and performance of regular 20m sprints. Fifteen female team handball players performed three training protocols: seven normal 20m sprints, or seven sprints alternating between normal and either resistance or overspeed sprints in a session. The main finding was that only resistance runs had a PAP effect on the first normal 20m sprint. However, this was only the case after one resistance run. Using several resistance runs did not have any positive effect upon the normal runs, but causes probably fatigue as shown in the increased contact times and decreased vertical stiffness, step length and rate. Overspeed running did not cause any changes to the normal runs.

KEY WORDS: Warmup, Post activation potentiation, step length, step frequency

INTRODUCTION: Resistance and overspeed running is often used as training methods to enhance the sprint performance in athletics, soccer and other sports. These two training methods are based upon the principles of overload by force or velocity (van den Tillaar, 2004). Most of the studies that used these training methods to enhance sprint performance have used it over a several week training period (e.g. Majdell & Alexander, 1991; Clark et al., 2010; Rumpf et al. 2015). However, in training resistance runs are also used to have an acute effect upon regular sprints. The mechanism that is associated with this is called Post-Activation Potentiation (PAP) (Ebben, 2006; Bergmann, et al., 2013). PAP is defined as the muscles' ability to develop force is dependent on what has happened earlier within the muscle and improvements in performance that follow a submaximal or a maximal contraction (Baudry & Duchateau, 2007). These improvements are attributed to neuromuscular changes like higher sensitivity of actin and myosin molecules to Ca2+ availability (Shorten, 1987), increased synchronization of motor units firing, reduced peripheral inhibition from Golgi tendon organs, and enhanced reciprocal inhibition of antagonist muscles (Baker, 2001; 2003; Ebben et al., 2000; Ebben & Watts, 1998). The maximal effect of this phenomenon occurs for approximately 5–12 minutes only (Bishop, 2003).
Thus, this suggests that by including resisted sprints in a warm-up protocol normal sprint performance afterwards could be enhanced. In addition, athletes who warm up with resisted sprints usually anecdotally have a subjective perception that they can run faster in a normal sprint due to now experiencing less weight. In overspeed runs it is also suggested that it results in neuromuscular changes that could enhance the normal sprint performance (Majdell & Alexander, 1991). However, to the best of our knowledge no study has investigated the acute effect of resistance or overspeed sprinting upon regular 20 m sprints, which distance is very important for many sports like athletics and team sports (Hrysomallis, 2012).
Therefore, the purpose of this study was to examine if resistance or overspeed runs could initiate PAP, and change kinematics and thereby increase performance on normal 20 m sprints. It was hypothesized that both resistance and overspeed sprints will improve short-term running kinematics and 20m sprint performance caused by increased neuromuscular activity in the legs due to post activation potentiation.

METHODS: A counterbalanced crossover study was conducted to examine the PAP effects of resistance and overspeed runs upon normal 20m sprints. The subjects performed three test sessions on which they performed one of the three training protocols: 1) seven normal 20m sprints, 2) seven sprints alternating between normal and resistance runs or 3) seven sprints alternating between normal and overspeed runs. The overspeed and resistance runs were done using a towing system (Kristensen et al., 2006). Between every sprint approximately 5-6 minutes rest was used to avoid fatigue and the get the best PAP effect (Bishop, 2003). The 20 m times were measured with two pairs of wireless photocells (Brower Timing Systems, Draper, USA) with the subjects started from a standing split start 0.3 m behind the first pair of photocells. The kinematics were measured by an infra-red mat of 20 m, laser gun and an accelerometer attached to the back of the pelvis. These sensors were all synchronised by the Musclelab 6000 system (Ergotest Technology AS, Langesund, Norway), which made it possible to measure and analyse contact and flight time, step length and frequency and vertical stiffness (Morin et al., 2005) for each step during the 20m sprints. Kinematics from step 2 to step 13 were averaged and used for further analyses.

To examine the acute PAP effect of resistance and overspeed runs upon normal sprints a one-way ANOVA for each protocol was used upon the sprint times and the different kinematic variables. The level of significance was set at $p<0.05$ and all data are expressed as mean ± SD. Statistical analysis was performed using SPSS 22.0 for windows (SPSS, inc., Chicago, IL). Effect size (ES) was evaluated with Cohen's d between sprints.

RESULTS: When sprinting with resistance or overspeed the 20m times were respectively 6.5% slower and 7% faster than the normal sprints. During the resistance sprints the step length, flight time and vertical stiffness was lower and contact time was longer than the normal sprints, while for the overspeed runs the step length, vertical stiffness increased and the contact times decreased except with the first normal run (Fig. 1 and 2).

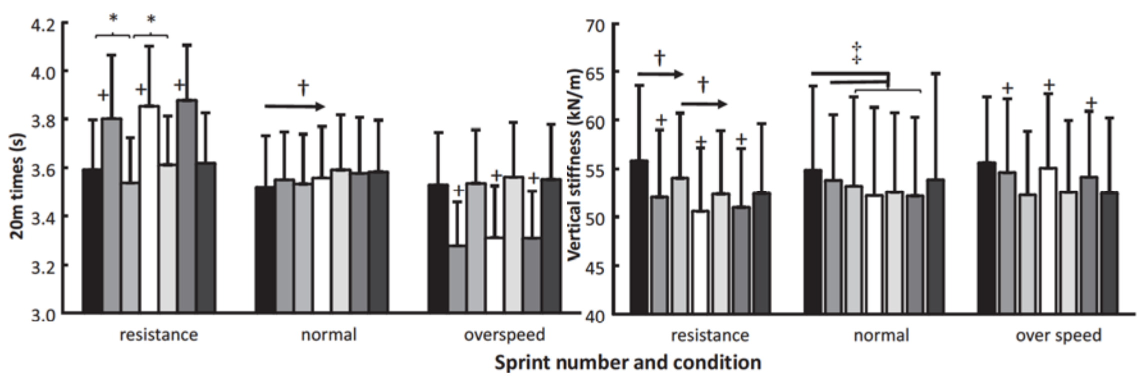

Figure 1. Sprint time and mean vertical oscillation per sprint run (± SD) for the resistance, normal and overspeed protocol. * indicates a significant change between these two sprints. † indicates a significant change between this sprint and all right from the sign. ‡ indicates a significant change between sprint 1 and 2 with sprint 3 to 6. + indicates a significant difference with the normal runs

Sprint times were significantly affected during the resistance and normal sprint protocol; in the resistance protocol the subjects ran faster in the second normal 20m sprint (1.7%, ES: 0.85), while they ran significantly slower again in the third normal sprint after the second resistance run (ES: 1.3). In the normal sprint protocol, the subjects ran significantly slower after the third sprint (Fig. 1). In the resistance protocol the vertical stiffness (from normal run 1 to 2 and from 2 to 3), step length (from run 2 with 4) and step rate (from run 1 with 3) decreased during the normal runs, while the contact times increased significantly from normal run 1 to 2 and from 2 to 3 (Fig. 2). In the normal sprint protocol step rate (from 1 to 3, 2 to 4 and 3 to 6) and vertical stiffness (run 1 and 2 with runs 3, 4, 5, and 6) decreases significantly, while contact time (from 1 and 2 with 3) and flight time (run 3 with run 7) increased. During the overspeed protocol, no significant changes in sprint time and kinematics in the normal runs were found (Fig. 1 and 2).

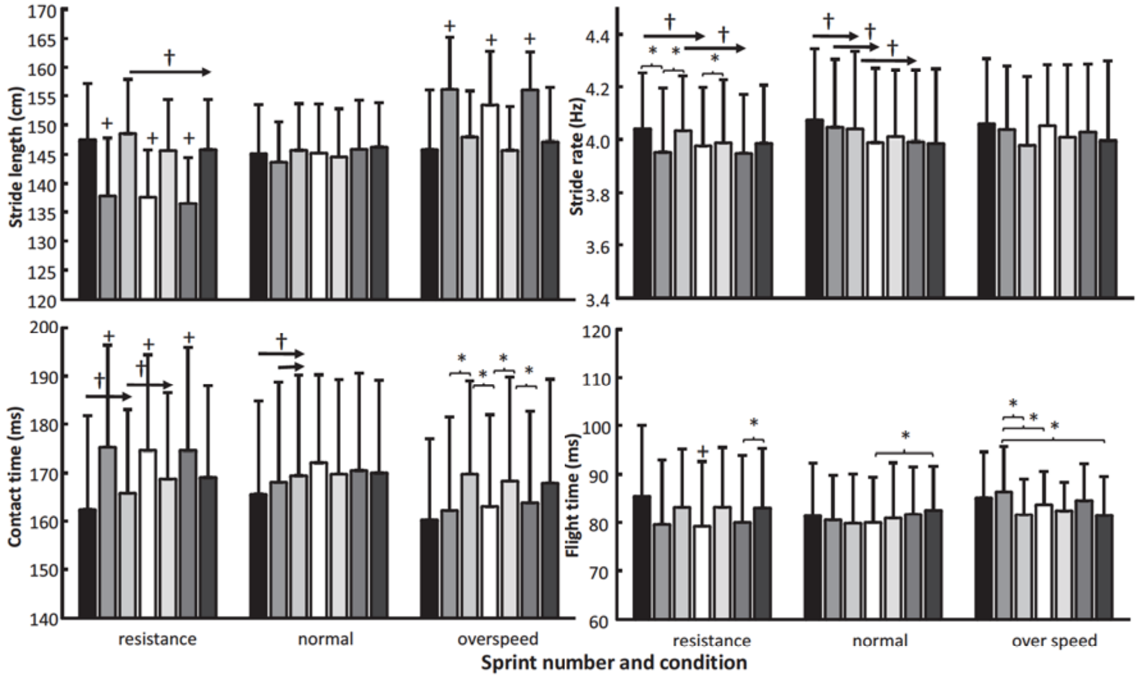

Figure 2. Average step length and frequency, contact and flight time (± SD) per sprint run for the resistance, normal and overspeed protocol. * indicates a significant change between these two sprints. † indicates a significant change between this sprint and all right from the sign. + indicates a significant difference with the normal runs

DISCUSSION: The main finding was that only resistance runs had a PAP effect on the first normal 20m sprint. However, this was only the case after one resistance run. Overspeed running did not cause any changes to the normal runs.

The kinematics and sprint times differences were comparable with a study of Kristensen et al (2006) who also used a similar towing device, but investigated the effect of resistance and overspeed training over a 6 weeks intervention. It is difficult to explain the PAP effect after one resistance run by the observed kinematics. A longer contact time in the second normal run was found that could result in more propulsive force produced during the step (Cronin et al., 2008; Morin et al., 2015). Since the total step time (flight + contact time) did not change significantly (p=0.14) it could increase the step length. However, the average step length (from 1.47 to 1.48 m, Fig. 2) did not significantly increase (p=0.53), which could be caused by the variability of the subjects in their steps.

From sprint four (normal protocol) and sprint five (third normal run) in resistance protocol, it seems that fatigue occurs as shown by slower sprint times (Fig. 1). This was mainly caused by the decreased vertical oscillation (Fig. 1) stride rate and increased contact times (Fig. 2). In addition, step length decrease from normal run two to four in the resistance protocol, which was in accordance to Kristensen et al. (2006) who found that after training with the resistance over a period of time result in shorter step lengths.

No PAP effect of the overspeed runs on the times and kinematics of normal runs were found, which was surprising since earlier training studies (Majdell & Alexander, 1991, Kristensen et al., 2006) found positive effect after a training period, which was mainly caused by a shorter step time. That no PAP effect of the overspeed runs was found was probably because the subjects were not familiar with this type of training. In handball resistance runs are used in training by holding subjects for a 5-10m distance, while this was their first time with overspeed runs. Thus, in future studies it would be interesting to investigate the acute effect of overspeed runs on normal runs after a training period with overspeed runs. Since, no changes in sprint times and kinematics were found in the normal runs during the overspeed protocol, this could also indicate that fatigue did not occur during this protocol.

Some limitations of the study were that no force plate and EMG measurements were performed to investigate if there were changes in the propulsive forces (Morin et al., 2015) or muscle activation, which could explain the PAP effect (Baker, 2001; 2003; Ebben, 2006).

CONCLUSION: This study shows that resistance running caused a positive acute effect in the normal 20m sprint performance (1.7%) after the use of one resistance run in handball players. However, this effect is there only for one run. Using several resistance runs did not have any positive effect upon the normal runs, but causes fatigue as shown in the increased contact times and decreased vertical stiffness, step length and rate. Future studies should be performed in which EMG and kinetics are included to gain more information about the acute effects of resistance and overspeed runs upon normal runs. The gained information can help researchers, coaches and athletes in their understanding about these training methods and if they should include these types of practice to their regular training and how much they should train to get the best output of it.

REFERENCES:

Baker, D. (2001). A series of studies on the training of high intensity muscle power in rugby league football players. *Journal of Strength and Conditioning Research,* 15, 198-209.

Baker, D. (2003). Acute effect of alternating heavy and light resistances on power output during upper-body complex power training. *Journal of Strength and Conditioning Research,* 17, 493-497.

Baudry, S. & Duchateau, J. (2007). Postactivation Potentiation in a human muscle: effect on the reate of torque development of tetanic and voluntary isometric contraction. *J Appl Pysiol*, 103, 1318–1325.

Bergmann, J., Kramer, A. & Gruber, M. (2013). Repetitive hops induce postactivation potentiation in triceps surae as well as an increase in the jump height of subsequent maximal drop jumps. *PLoS One.*

Bishop, D. (2003). Warm-up I: Potential mechanisms and the effects of passive warm-up on exercise performance. *Sports Medicine,* 33, 439-454.

Clark, K. Stearne, D. Walts, C. & Miller, A. (2010). The longitudinal effects of resisted sprint training using weighted vests. *Journal of Strength and Conditioning Research,* 24, 3287-3295.

Ebben, W. & Watts, P. (1998) A review of combined weight training and plyometric training modes. *Journal of Strength & Conditioning Research*, 12, 18-27.

Ebben, W. (2006) A brief review of concurrent activation potentiation: theoretical and practical constructs. Journal of Strength & Conditioning Research, 20, 985-991.

Hrysomallis, C. (2012). The Effectiveness of Resisted Movement Training on Sprinting and Jumping Performance. *Journal of Strength & Conditioning Research*, 26, 299-306.

Kristensen, GO, van den Tillaar, R. & Ettema, G. (2006) Velocity specificity in early phase sprint training. *Journal of Strength and Conditioning Research,* 20, 833-837.

Majdell, R. & Alexander, M. (1991). The effect of overspeed training on kinematic variables in sprinting. *Journal of Human Movement Studies*, 21, 19-39.

Morin J. Dalleau, G., Kyröläinen, H. Jeannin, T. & Belli, A. (2005). A simple method for measuring stiffness during running. Journal of Applied Biomechanics, 21, 167-180.

Morin, J., et al., (2015). Acceleration capability in elite sprinters and ground impulse: push more, brake less. *Journal of Biomechanics*, 48, 3149-3154.

Rumpf, M. et al. (2015). The effect of resisted sprint training on maximum sprint kinetics and kinematics in youth. *European Journal of Sport Science*, 15, 374-381.

Shorten, M. (1987) Muscle elasticity and human performance. Medicine, Sport & Science, 25, 1-18.

van den Tillaar, R. (2004). Effect of different training programs on the velocity of overarm throwing: a brief review. *Journal of Strength and Conditioning Research,* 18, 388-396.