ADAPTATIONS TO SPRINTING AND JUMPING AFTER TRAINING WITH A RESISTANCE HARNESS IN TRACK ATHLETES

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This study examined the effect of a harness resisting leg movement on sprinting and jumping performance. Split times for 10, 20, 36.58 and 50 meters, kinematics of hip and knee angles during sprinting, forces of maximum countermovement jumps and dual-energy X-ray absorptiometry (DEXA) were measured prior and following five-weeks of training with the resistance device. Results showed significant improvement in 10 m sprint times and knee extension during sprinting following five-weeks training ($p<.05$). No significant changes in jump or DEXA parameters were seen. Findings of the current study indicate that the SpeedMaker device may improve the acceleration phase of sprinting and stimulate a larger range of motion at the knee joint. Future studies with the device should include longer training periods, greater sample sizes and a measurement of resistance.

KEY WORDS: Stretch-shortening cycle, Range of Motion, Kinematics, Chronic

INTRODUCTION: Mechanical resistive devices are used among athletes to improve muscle response and activation. The stretch-shortening cycle indicates that muscular force will be increased if the muscle is stretched immediately prior to contraction. This concept has been demonstrated in both concentric and eccentric muscular contractions (Komi, 1984).

Coaches often incorporate the stretch shortening cycle throughout an athlete's training program. Resistance bands are widely used as mechanical aids that amplify the effects of the stretch-shortening cycle. Acute effects of elastic-cord towing bands improved the acceleration phase up to 20 meter(m) sprints by increasing stride length and distance of center of mass from the foot and trunk in trained athletes (Clark et al., 2009; Corn & Knudson, 2003). Lockie et al. (2003) also found that resistance training increases flexion at the hip, inferring increased stride length and thereby improving sprinting performance and increased hip muscle activity.

Improved speed of muscle contraction has been linked to hypertrophy when the muscle has been trained appropriately (Young & Bilby, 1993). Visser et al. (1985) validated Dual-energy X-ray absorptiometry (DEXA) as a non-invasive technique to determine muscle mass.

Although athletes may sprint up to 50 m in previous research incorporating resistance devices, positive training effects have only been consistent in the acceleration phase of sprinting, limiting improvements to distances less than 20 m (Harrison & Bourke, 2009).

Similar to resistance devices, countermovement jumps (CMJ) can elicit a stretch-shortening cycle stimulus prior to sprinting, improving maximum velocity during 100 m sprints in elite athletes (Kale et al., 2009). An improvement in initial sprint acceleration has also been found after performing CMJ (Hrysomallis, 2012). Therefore, coaches have been encouraged to integrate CMJ jumps in addition to resistance bands to improve sprinting performance through a stretch-shortening cycle stimulus.

Research of resisted sprint lengths greater than 20 m have not shown consistent training effects in kinematics regarding range of motion and stride length (Harrison & Bourke, 2009); and thus require further research. Although improvements in performance with resistance devices have been shown in the past, the source of these improvements is unclear. The researchers of the current study chose to assess improvements using multiple techniques- sprint times, range of motion kinematics, and CMJ- to identify a primary source of improvement. The purpose of the current study was to examine the effect of five weeks of training with the SpeedMaker (Elite Athletic Products Inc.; San Diego, CA, USA) resistance device on hip and knee range of motion while sprinting. Furthermore, the researchers aimed to determine if athletes improved CMJ performance after training with the SpeedMaker device. Secondary purposes were to investigate improvements in sprint time and indicators of hypertrophy in the gluteal region. The researchers hypothesized that training with the SpeedMaker resistance harness will show indications of hypertrophy as well as increase range of motion in the hip and knee angles, thereby improving running and jumping performance.

METHODS: Six female college track & field athletes (Mean ± SD: age = 19.83 y ± 1.95; height = 169.33 cm ± 7.72; mass = 62.78 kg ± 6.32) were recruited and signed informed consent. Pre- and post- tests described below were performed by six female collegiate track & field athletes before and after five weeks of training. One athlete was unable to complete post-testing sprints and jumps due to an ankle injury but was included for all other post testing. Athletes served as their own control group and were instructed to wear the device during their training sessions on Mondays, Wednesdays and Fridays for five consecutive weeks.

For pre and post-tests, a generalized self-selected warm-up including sprints, plyometrics and dynamic stretching was performed for five minutes. Following the warm-up, participants sprinted three 45 m lengths at 80, 90, and 100% maximum respectively with two-minute rests between each sprint.

Three minutes after completion of the sprints, athletes performed three maximum CMJ on a force platform (OR6-2000 Advanced Mechanical Technology, INC. [AMTI], Watertown, MA, USA) where data were collected at 1000 Hz. The athletes used bilateral arm swing during each jump and rested for one minute between jumps. Jump flight time (FT), peak vertical ground reaction force during take-off (VGRF); peak rate of force development (RFD) were measured and calculated according to Haff et al. (2015) (Δforce/Δtime over 50 ms).

Reflective markers were then placed on the participant's left shoulder, hip and knee joints and mid shank. Participants performed two 50 m sprints for time. Seven Cortex Motion Analysis Corporation (Santa Rosa, CA, USA) cameras were used to record the markers in the sagittal plane for one full stride at 36.58 m (40 yards) to analyze hip and knee angles at maximum sprint stride (Corn & Knudson, 2003). Data from sprint trials were tracked and filtered using a low-pass 4th order Butterworth with a cutoff frequency of 6Hz using Cortex Motion Analysis software. Minimum and maximum hip and knee angles were used to calculate range of motion of hip and knee joints which were averaged across the two sprint trials per testing session. Microgate (Bolzano BZ, Italy) timing gates were placed at 10, 20, 36.58 and 50 meters to measure sprint times. Athletes were measured by DEXA for indicators of hypertophy through lean tissue mass and body fat percentage in the gynoid region.

Peak values of FT, VGRFpeak, and RFDpeak were averaged across the three jump trials. Pre and post- test data for DEXA, kinematics, sprint times and force plate data were analyzed through SPSS v.24 software using paired t-tests. Alpha level was set at $p<0.05$. Cohen's d effect sizes were also used to determine magnitude of differences. Interpretation of effect size was based on the scale for effect size classification of Hopkins (2000): < 0.04 = trivial, 0.041 to 0.249 = small, 0.25 to 0.549 = medium, 0.55 to 0.799 = large, and >0.8 = very large.

RESULTS: Sprint times for the 10 m split improved significantly after training (p = .043). All split times for 20, 36.58 and 50 m improved with large effect sizes (see Table 1).

Table 1
Mean ± SD times, p-values and effect sizes for sprint distances before and after training (N=5).

Distance	Pre Test (sec)	Post Test (sec)	P-Value	Effect Sizes
10 Meter*	1.96 ± .08	1.77 ± .19	0.043	1.09
20 Meter	3.41 ± .15	3.15 ± .23	0.078	1.15
36.58 Meter	5.52 ± .13	5.29 ± .29	0.107	0.91
50 Meter	7.36 ± .21	6.96 ± .36	0.078	1.15

*=statistical significance.

There were non-significant improvements in VGRF, and RFD over the five-week training study (see Table 2). FT decreased non-significantly with a large degree of variance between subjects.

Table 2
Mean ± SD, p-values and effect sizes for VGRFpeak, FT and RFDpeak from pre and post-testing (N=5).

Test	Pre Test	Post Test	P-Value	Effect Size
$VGRF_{peak}$ (N)	822.2 ± 175.6	975.0 ± .352.4	0.13	0.83
RFD_{peak}	6347.6 ± 2001.3	8899.0 ± 4670.6	0.34	0.76
FT (ms)	500.3 ± 99.1	479.8 ± 86.5	0.78	0.22

Mean maximum knee extension angles decreased significantly after five weeks of training with the resistance harness (p = 0.025), suggesting an increased range of motion (ROM) of the knee, although ROM of the knee was not significant (p = 0.193). Similar to the sprint time comparison after training, ROM of the knee between pre and post-testing may have been significant if N>5 due to a large effect size. There were no statistically significant differences between flexion/extension angles or ROM of the hip between pre and post-test (see Table 3).

Table 3
Mean ± SD, p-values and effect sizes for joint angles and ROM of the knee and hip before and after training (N=5).

Test	Joint Angle/Range of Motion (Deg)					
	Knee Ext[a]	**Knee Flex**	**Knee ROM**	**Hip Ext[b]**	**Hip Flex**	**Hip ROM**
Pre-Test	23.4 ± 4.7	129.4 ± 6.7	106.0 ± 9.4	-12.5 ± 14.5	30.6 ± 9.4	43.1 ± 20.1
Post-Test	18.0 ± 5.9	129.9 ± 7.3	112.0 ± 10.3	-15.9 ± 3.1	28.8 ± 3.6	44.7 ± 6.1
P-Value	0.025	0.902	0.193	0.563	0.701	0.834
Effect-Size	0.93	0.08	0.62	0.34	0.26	0.12

[a]=statistical significance
[b]=negative values in the hip joint refer to hyperextension past zero degrees.

DEXA scans measured whole body lean tissue mass in kilograms (kg) and percent body fat of the gynoid region. Lean tissue mass (p=0.30) and percent body fat in the gynoid region (p=0.21) decreased non-significantly between pre and post-tests.

DISCUSSION:
The most significant finding of the present study was the improvement in 10 m sprint times, supporting past research that resistance devices incorporated with sprint training improve acceleration (Clark et al., 2009; Corn & Knudson, 2003; Lockie et al. 2003). Split times for greater sprint lengths decreased non-significantly with a large effect size (see Table 1). Non-significant improvement of other sprint split times may be the result of a general training adaptation and should be controlled in future studies. However, the athlete's training did not differ throughout the study and was consistent from conditioning that occurred prior to data collection. Therefore, adaptations are not likely influential of increased 10 m acceleration. Knee extension also improved significantly, although full range of motion at the knee joint did not improve. This extension increase with the absence of increased flexion may have been the result of increased hamstring activation, which would have limited knee ROM, supporting the present results. However, electromyography (EMG) was not used in the present study so the researchers cannot verify increased hamstring activation.
Hip angles did not differ between pre and post-tests, contradictory to past studies that hip angles cause increased stride length, improving sprinting performance (Lockie et al., 2003). DEXA served as a measurement to indicate signs of muscle hypertrophy due to increases in lean body mass. A decrease in gynoid regional body fat was also suspected because the SpeedMaker harness targets hip flexor and extensor muscles. However, results from the DEXA showed no significant changes, inferring improvements in sprinting performance were apparent despite anatomical change. Decreased sprint times were present without improved

kinematics or anatomical changes, suggesting another source of performance improvement by the resistant device.
A limitation of the current study is the variance in track and field events between participants. Athletes with jumping field events may have had greater improvements in CMJ if technique primarily focused on jumping, as is seen with the high variability in the jump data. However, VGRF, RFD, and FT did not change significantly, and a large degree of variance was seen for all. Participants served as their own control for this study and should not be considered a confounding variable. The results from CMJ data were not consistent with past research, although resisted CMJ were not analysed in the present study; a difference from past research (Harrison & Bourke., 2009; Kale et al., 2009).
A measurement of the level of resistance was not provided by the manufacturers and was thus not accounted for in the current study, which is in contrast to prior research (Clark et al., 2009). This should be determined for future studies to maintain internal and external validity.

CONCLUSION: The minimal increase in knee ROM after the training study might occur with a larger sample size; and could be of interest to coaches seeking to improve sprint technique. The lack of change in CMJ parameters suggest that there is no advantage in training with the SpeedMaker device for jumping activities although horizontal jumping parameters could be measured for future studies. The SpeedMaker device did not improve lean tissue or regional fat concentrations following five weeks of training; therefore, the researchers of the present study do not recommended the use of the device to alter tissue makeup to that end.

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