STRENGTH TRAINING IN EXPLOSIVE-TYPE SPORTS: SPRINTING

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Introduction

Various forms of strength training are now used worldwide to improve run sprinting ability. There are several physiological rationales concerning why strength training might improve sprinting ability. The metabolic systems that adapt due to the performance of strength training are the predominant metabolic systems utilized in sprinting. It has been estimated that sprinting for three seconds derives approximately 32%, 55%, 10%, and 3% of the needed energy from intramuscular adenosine triphosphate, intramuscular phosphocreatine, anaerobic glycolysis, and aerobic metabolism, respectively (Spensor et al. 2005). While sprinting for 200 meters and 400 meters derives approximately 71% and 57% of the needed energy from anaerobic sources (Spensor and Gastin 2001).

Physiological factors related to anaerobic energy production have been shown to increase with both types of training. Both strength and sprint type training have shown increases, decreases and no change in creatine kinase activity (Costill et al. 1979, Komi et al 1982, Parra et al. 2000, Tesh and Alkner 2002). Similarly weight training (Tesh and Alkner 2002, MacDougall et al. 1977) and sprint type (Dawson et al. 1998; Ross and Leveritt 2001) training have resulted in significant increases as well as no change in intramuscular adenosine triphosphate and phosphocreatine concentrations. However, there may not be a necessity of increased intramuscular phosphagen concentrations for improvements in short sprint ability. A sprint-training program has been shown to significantly decrease 40 m sprint time and repeat sprint ability (total time for six 40 m sprints separated by 24 seconds) by approximately 2% with no significant change in intramuscular phosphocreatine concentration (Dawson et al. 1998). Increases in the activity of glycolytic enzymes and intramuscular glycogen have also been shown with both types of training. For example, activity of glycogen phosphorylase, phosphofructokinase (PFK) and lactate dehydrogenase (LDH) have been shown due to weight training (Costill et al. 1979; Tesh and Alkner 2002) and sprint training (Abernathy et al. 1990; Rodas et al. 2000; Ross and Leveritt 2001; MacDougall et al. 1998). While both increases and no change in intramuscular glycogen have been shown due to weight (Tesh and Alkner 2002) and sprint type training (Baurgomaster et al. 2006; Ross and Leveritt 2001). Although changes in anaerobic enzymatic activity, intramuscular phosphagens and intramuscular glycogen are inconsistent with training, both types of training have shown increases. This inconsistency in terms of adaptations may in part be dependent upon many factors, such as type of training, rest periods between training bouts, rest periods within a training session, and length of training session. For example, short sprint repetitions (less than 10 seconds) and a combination of short and long sprint (greater than 10 seconds) repetitions result in no change in intramuscular glycogen, however long sprint repetitions (greater than 10 seconds) do result in an increase in intramuscular glycogen (Ross and Leveritt 2001).

It has been demonstrated that maximal running speeds are more related to greater ground reaction forces during foot strike than to more rapid leg movements during sprinting (Weyand et al. 2000). Due to the relationship between force development and power (power = force x distance divided by time) increases in maximal strength as well as rate of force development could increase sprint ability by increasing, ground reaction forces during foot strike. Many types of weight training can increase maximal force capabilities. Concerning ground reaction forces it has been reported that a significant correlation exists between maximal force during the first 100 ms of a loaded jumping action and sprint time at 2.5 (r = 0.73) and 10 m (r = 0.80) (Young, McLean and Ardagna 1995). Strength training where rapid force development is attempted during training can increase rate of force development in the first 100 to 200 milliseconds of a muscular contraction (Behm and Sale 1993; Hakkinen, Komi and Tesch 1981). Thus the ability to exert more force during each foot contact of a sprint either due to higher maximal strength levels or increased rate of force development would increase maximal sprinting ability. Even small changes in rate of force development could significantly affect sprinting ability. A decrease of 0.005 s in ground contact time per foot strike over 20 foot strikes would result in a decrease in sprint time of 0.1 s.

Significant correlations between maximal force development in a concentric squat (r = 0.74, Bret et al. 2002), one repetition maximal squat ability (r = 0.89, Meckel et al. 1995), and maximal concentric and eccentric knee extension and flexion at velocities ranging from 30 to 230 deg/s (r = 0.55-0.99, Alexander 1989) and 100 m time have been demonstrated. Although none significant correlations to isometric strength of the knee extensors, hip extensors and flexors to time during the first 15 meters and last 15 meters in a 30 m sprint have also been shown (Kukolj et al. 1999). Thus it might be hypothesized that increases in dynamic strength could result in increases in maximal sprint ability.

Although there are physiological rationales for why strength training could increase maximal sprinting ability transfer or carryover of strength gains to sprinting ability is not a one-to-one relationship. Transfer of an increase in a physiological adaptation due to ancillary training to the task being trained for can be defined as performance gain divided by gain in a physiological adaptation. For example, after eight weeks of strength training one repetition squat ability increased 20.9% while 40 m sprint time decreased 2.3% (Wilson, Murphy and Walshe 1996) showing a transfer of approximately 11%. While after six months of nonlinear periodized weight training one repetition maximal leg press ability demonstrated a significant improvement of 31.9% and 40 yard (36.7 m) sprint time decreased 6.36% showing a transfer of 19.9% (Marx et al. 2001). Although strength transfer to sprint ability is not a one-to-one relationship some transfer does occur indicating strength training can increase sprint ability.

Weight Training

Short-duration weight training programs have been shown to improve maximal sprint ability. An eight week program consisting of only the bench press and squat decreased 40 m sprint time by 2.3% in a group of males who had been weight training for at least one year and could perform a half squat with at least a minimum their own body mass (Wilson, Murphy and Walshe 1996). A nine-week training program emphasizing the lower body significantly improved acceleration during the first 10 meters of a 100 m sprint in a group of physical education students with no prior strength training experience (Delecluse et al. 1995). While a total body nonlinear periodized program performed for six months decreased 40-yard (36.7 m) sprint time by 6.36% in a group of college-age females with no prior strength training experience (Marx et al. 2001). However, not all programs have shown significant changes in sprint ability. Nine week training programs emphasizing the lower body and emphasizing either high force or high power during training showed no significant change in 30 m sprint time (Harris et al. 2000) in a group of American football players. A 10 week program consisting of only heavy squats showed no significant change in 30 m sprint time in a group of individuals with at least one year of weight training experience and capable performing a half squat with a minimum of their own body weight (Wilson et al. 1993). Collectively this information could be interpreted to conclude that short-term weight training programs result in increased sprint ability only in individuals with little or no prior weight training experience and that perhaps a program with the goal of increasing sprint ability should be a total body program.

Plyometric Training

Plyometric training might be hypothesized to increase sprint ability because drop jump ability (short stretch-shortening cycle) has been shown to have significant correlations to 30 m (r = -0.79) and 100 m (r = - 0.75) sprint times (Hennessy and Kilty 2001). While distance during a five step bound plyometric test (long stretch-shortening cycle) has shown a significant correlation to 300 m (r = -0.54) sprint time (Hennessy and Kilty 2001). This hypothesis is supported by studies showing improved sprint ability with plyometric training. Over nine weeks of unloaded plyometric training with 10 types of plyometric drills 100 m sprint time significantly decreased from 12.51 to 12.30 s or 1.7% in a group of physical education students with no prior weight training experience (Delecluse et al. 1995). Similarly a six-week plyometric program consisting of four to five horizontal and vertical plyometric drills significantly decreased 50 m sprint time by 1.5% and 2.1% in a group of none athletic adult males and a group of athletic (basketball players) adult males, respectively (Wagner and Kocak 1997). However, performance of unloaded drop jumps for 10 weeks in a group of individuals with at least one year of weight training experience and capable performing a half squat with a minimum of their own body weight showed a none significant change in 30 m sprint time (Wilson et al. 1993). While four weeks of unloaded horizontal and vertical jump plyometric training resulted in no significant change in 20 m sprint time in physical education students (Herrero et al. 2006). Similar to weight training studies short-term plyometric training can result in increased sprint ability, however not all studies show a significant improvement.

Maximal Power Training

Maximal power training refers to performing exercises with added resistance so that maximal power in the movement is developed. Training for a 10 week period using weighted squat jumps with added resistance of approximately 30% maximal isometric force significantly decreased 30 m sprint time from 4.54 to 4.49 s or 1.1% which approached significance ($p < 0.1$) in a group of males who had been weight training for at least one year and could perform a half squat with at least a minimum their own body mass (Wilson et al. 1993). In the same study no significant change in 30 m sprint time was shown by groups performing weight training (only squats) and plyometric training (only depth jumps). Use of maximal power training may however be most beneficial when used in combination with weight training. A nine-week weight training program or maximal power program emphasizing the lower body showed no significant change in 30 m sprint time (Harris et al. 2000) in a group of American football players with prior weight training experience. However, in the same study a group performing a combination of both weight training and power training showed a significant decrease in 30 m sprint time from 4.42 to 4.36 s or 1.4%.

Resisted Towing

Towing of weighted devices, such as sleds is perhaps the most common resisted towing technique, however parachutes have also been used for this purpose. Resisted towing does alter sprint speed and running mechanics. Female sprinters towing 2.5 kg and 10 kg had decreased sprint times of 8% and 22%, respectively over 30 m (Letzelter, Sauerwein and Burger 1995). Running mechanics were also altered with a decrease in stride length, increased upper body lean, increased stance phase duration and increased thigh angle at both the beginning and the end of the stance phase demonstrated at both towing resistances. Similarly athletes towing sleds with resistance equivalent to 12.6% and 32.2% of body mass for 15 meters showed decreases in stride length of 10% and 24%, respectively (Lockie, Murphy and Spinks 2003). This study also showed other changes in running mechanics with stride length decreased, duration of the stance phase increased, trunk flexion increased, and hip range of motion increased with both towing resistances.

Resisted towing training of physical education students over eight weeks did not significantly change average (7.62 to 7.67 m/s) 50 m velocity while unresisted sprint training significantly increased (7.48 to 7.62 m/s) 50 m velocity (Zafeiridis et al. 2005). However, resisted towing did significantly increase average velocity in a 50 m sprint from 0 to 10 m, 0 to 20 m and significantly increased stride rate. While unresisted sprint training increased average running velocity from 20 to 40 m, 20 to 50 m, 40 to 50 m and increased stride length maximum running speed. Although resisted towing did not significantly change 50 m velocity it did significantly change some aspects of sprint performance positively. Likewise although unresisted training did alter 50 m velocity it did not significantly change velocity during the first 20 m of the 50 m sprint. Thus it could be hypothesized that a combination of both types of training would result in the most beneficial effects.

The Need for Combination Training

Although the use of only one type of training (only weight training, maximal power training, plyometric training) or one training exercise from one training type (only one type of plyometric training exercise) in a training study can be used to answer whether or not training affects a specific variable related to training (sprint speed) coaches and athletes typically do not perform only one type of training or one training exercise from one training type within a total training program. Several times within the studies discussed above it was indicated that some combination of training types might produce the most beneficial results in terms of sprint speed.

The need for a combination of several training types in order to maximally increase sprint speed is indicated by the typical practices of coaches and athletes. For example, a training program consisting of foot speed, agility, total body resistance training and unresisted sprint training has been shown to decrease 40 yard (36.7 m) sprint time in high school field hockey players 6.06 to 5.83 s or 1.39%, high school American football players 5.20 to 4.98 s or 4.0% and high school American football players 5.91 to 5.23 s or 11.5% (data courtesy of J. Graham).

One limitation of studies to date examining the effect of training on sprint speed is the use of untrained or moderately trained individuals. When athletes have been studied they have been athletes that need sprint speed as one characteristic necessary for success in their sport, but they are not sprint specialists. Therefore research training athletes who are sprint specialists is needed. Future research concerning sprint speed and various training methods should focus not only on addressing physiological outcomes of one type of training, but also the effect of training type combinations on sprint speed because combining two or more training types appears to have the most beneficial effect on sprint speed. Studies also should focus on the effect of training on sprints of various lengths and the effect on different intervals within a sprint (0 to 10 m, 10 to 20 m within a 50 m sprint) of different training types.

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