RESISTANCE TRAINING AND ENDURANCE PERFORMANCE

"Strength or power measured in non-rowing circumstances often seems to have little value when applied to rowing performance."
Fredrick Hagerman, Rowing physiologist

"Many top road riders do not do weight training, particularly the European professionals. However, this does not mean weight training is not useful."
Harvey Newton, Strength training coach to American cyclists

" I firmly believe in resistance training with heavy weights. So long as I taper sufficiently before a race, I feel they improve my performance."
Marianne Kriel, 1996 Olympic swimming medalist

Elite and recreational endurance athletes undertake resistance training believing it will improve performance. But training for endurance and training for maximal strength and power represent completely different and opposite forms of activity. Endurance training consists of many thousands of submaximal muscle contractions performed at low to moderate workloads, while training for strength and power involves relatively few contractions at maximal or near maximal force. From a physiological standpoint, it seems unlikely that muscle would be able to adapt to two seemingly incompatible training stimuli when they are undertaken simultaneously. Surprisingly, few good scientific studies have been conducted using well-trained athletes to determine if the improvements in muscular strength gained from resistance training result in enhanced endurance performance.

Swimming is one sport where the majority of competitors practice some form of resistance training. Although most competitive swimming distances might not be considered true endurance events, elite swimmers perform huge volumes of over-distance training. To determine whether adding resistance training to pool training might improve sprint-swim performance, Tanaka, et al. (1993) studied 24 experienced swimmers during 14 weeks of their competitive season. The swimmers were divided into two groups of 12 swimmers and matched for stroke specialties and performance. The two groups performed all swim training sessions together for the duration of the season, but in addition to the pool training, one group performed resistance training three days a week, on alternate days for eight weeks. The resistance training program was intended to simulate the muscles employed in front crawl swimming and utilized weight lifting machines as well as free weights. Swimmers performed three sets of 8-12 repetitions of the following exercises: lat pull downs, elbow extensions, bent arm flys, dips and chin ups. In order to maximize the resistance training effect, weights were progressively increased over the duration of the training period. Then both groups tapered for approximately two weeks prior to their major competition. The most important finding: resistance training did not improve sprint swim performance, despite the fact that those swimmers who combined resistance and swim training increased their strength by 25-35%. The extra strength gained from the resistance training program did not result in improved stroke mechanics. Their conclusion: "the lack of positive transfer between dry-land strength gains and swimming propulsive force may be due to the specificity of training."

In rowing, supplementary resistance training programs are still advocated by most coaches. In the early 1970's it was common to employ a program of high-resistance, low repetition training during the pre-season period, followed by a gradual transition to lower-resistance, high repetition endurance work nearer the competitive season. But during the past decade emphasis has shifted to a greater volume of local muscle endurance work during the pre-season, with using more exercises that simulate the rowing action as the competitive period approaches. Bell, Petersen, Quinney and Wenger (1993) studied 18 varsity oarsman who undertook three different resistance training programs during their winter training. In addition to their normal rowing, one group performed 18-22 high-velocity, low-resistance repetitions, while another group did low-velocity, high-resistance repetitions (6-8 reps). All exercises were rowing-specific and performed on variable-resistance hydraulic equipment four times a week for five weeks. A third group did no resistance training. After training, the high-velocity, low-resistance repetition group performed better in high-velocity movements, while the low-resistance, high-resistance group did better at low velocity actions. But when tested on a row ergometer, there was no difference between any group for peak power output or peak lactate levels. The conclusion: training effects were specific to the resistance training mode and did not transfer to the more complex action of rowing. Resistance training programs may actually restrict the volume of beneficial, sports specific training that can be achieved because of increased levels of fatigue.

What about resistance training by cross-country skiers? Leena Paavolainen, Hakkinen, and Rusko (1991) studied the effects of dynamic resistance training on maximal isometric strength and aerobic power of 15 national class cross-country skiers during six weeks of their pre-season training period. Seven of the skiers supplemented their normal aerobic workouts with "explosive" strength sessions. These sessions consisted of plyometric jumping exercises and heavy resistance (80% of 1 RM) squats and contributed about a third of the total training load. The other eight skiers performed the same aerobic training, but during the last three weeks of the study added "endurance strength training" which comprised many repetitions of "specific" leg and arm exercises. Jumping height and time to reach maximal isometric force production improved significantly in the explosive strength trained group. There were no differences in these measures before or after the six week training period for the endurance trained group. But neither were there any differences in VO2max or measures of the aerobic and anaerobic "thresholds" between the two groups after the different training regimens. They concluded that "endurance athletes can undertake explosive strength training programs without a concomitant reduction in aerobic capacity." It's difficult to see, though, why an athlete would wish to follow this advice. The only effect of the explosive strength training was to improve jump height and time to reach maximal force production. Both these measures are unrelated to the demands of competitive cross-country skiing. In the first instance, cross-country skiers certainly do not need to be able to jump great heights during their event. Neither are they required to produce low numbers of maximal contractions. Cross-country races typically last from 15 to 120 minutes. The forces involved are quite low and the number of repetitions very high. The most important determinant of success in this sport is a skier's VO2max, and this did not improve with either strength training regimen!

Resistance training for endurance cyclists results in extra muscle bulk and added weight which can reduce their performance levels. James Home and co-workers at the University of Cape Town recently examined the effects of a six week progressive resistance training program on 40 km cycling performance. Seven endurance-trained cyclists who were riding approximately 200 km per week added three resistance training sessions to their normal cycling workouts. These sessions consisted of three sets of 6-8 maximal repetitions of leg press, quadriceps extensions and hamstring curls, all exercises which recruit muscles used in cycling. The resistance training program resulted in maximal substantial strength gains of about 25%. The strength gains, however, did not transfer into superior cycling performances. On the contrary, 40 km times slowed from 58.8 minutes to 61.9 minutes after resistance training. Additionally, cyclists complained of feeling "tired and heavy" while riding and were forced to reduce their weekly training distance by about 20% during the study. Although it's impossible to determine whether resistance training alone or the effect of resistance training resulting in tiredness which forced a reduction in endurance training volume caused the impaired performance, it's clear that there was no positive effect of undertaking the two different training modes concurrently.

We find strong evidence against a training program incorporating resistance training into well-trained endurance athletes' normal workouts to improve their endurance performance. There are, however, several scientific studies that report a beneficial effect of resistance training on both short and long-term endurance capacity. Hickson et al. (1988), a frequently cited investigation supporting the use of strength training to improve endurance, found that a three-times-a-week strength training program undertaken for 10 weeks did not change the VO2max of moderately-trained runners and cyclists. But a short-term (4-8 minutes) endurance test was improved by 12% for both running and cycling, while long-term endurance improved from 70 to 85 minutes for cycling.

Marcinik et al. (1991) showed that strength training had positive effects of endurance cycling capacity. Eighteen males performed 12 weeks of strength training three times a week. The strength training consisted of 8-12 repetitions of upper body exercise (bench press, push-ups, lat pull-downs, arm curls) and 15-20 repetitions on lower body exercises (knee extensions, hip flexion's, parallel squats) with a 30-second rest between exercises. The strength training program had no effect on the subjects VO2max. However, 1 RM for knee extension and hip flexion improved by 30% and 52% respectively. More important, cycle time to exhaustion at 75% of VO2max improved a massive 33% from 26.3 minutes before strength training to 35.1 minutes after training. The conclusion: "strength training improves cycle endurance performance independently of changes in VO2max... and that this improvement appears to be related to increase in leg strength."

Several reasons explain why some individuals improve their endurance capabilities with strength training while others don't. First, it appears that there is a minimal amount of muscle strength required for endurance events. This general principle applies to athletes of all abilities, but is especially important for those individuals who are new to a sport and therefore only moderately-trained in that discipline. These novice athletes will benefit from any increase in general fitness, be it an improvement in strength or endurance. This explains why the greater muscle power seen after short-term strength training programs increases endurance capacity in these individuals. In all likelihood, any training stimulus which overloads the working muscles would have improved their performance. The large improvements in muscle power seen after strength training merely compensate for their poor technique or efficiency of movement. This is especially true in sports such as swimming and rowing, where stroke mechanics and technical proficiency are perfected only after many years of training and hours on the water.

For highly-trained athletes who are already capable of generating high power outputs in their chosen discipline, further improvements in strength are a less important factor in enhanced endurance performance. At the highest level of competition, increases in strength and power are not as critical to successful performance as the development of correct technique. For these athletes, the concept of specificity rules! The bottom line is that modern training studies do not support the use of resistance training programs for improving the performances of highly-trained athletes.

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