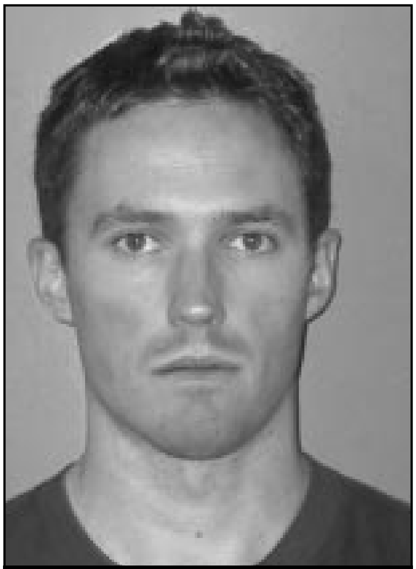
The Development of LEG POWER



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Leg power is an important physiological quality for many sports (Wilson et al. 1993). In fact, the ability to produce high levels of leg power is a determining factor for superior performance in several sports, including the sprint events in track and field, long track speed skating, and track cycling.

Before a coach or exercise physiologist can begin to prescribe exercise regimes to develop leg power, it is important that the coach possess a basic working knowledge of the terminology and definitions associated with this important physiological quality. Unfortunately for "math-a-phobics," the concept of power must be explained in mathematical terms. Explaining the concept of power in mathematical terms can help the coach to understand the different physiological qualities that must be addressed to develop leg power.

In mathematical terms, power can be defined by the following equation:

Power = Force x Velocity

While this equation may elicit fear and anguish in those who suffered through high school physics, the "take-home" message can be easily grasped: power incorporates a force component and a velocity component. To further illustrate this point, let's consider a term developed in European sport science that is sometimes used interchangeably with the term *power* to describe movements that require considerable force and velocity for its execution. The term is *speed-strength*. Speed-strength may be a much more descriptive term to describe power, as speed and strength are qualities that are familiar to almost every coach. Movements that require power or speed-strength are characterized by a relatively high speed of execution as well as by a relatively forceful muscle contraction (that is, they require strength and speed).

At this point, the concept of power or speed-strength should begin to make sense, even to the mathematically challenged. Nevertheless, let's consider a practical example to solidify an understanding of power that involves comparing the physiological demands of three different athletic movements. The following three examples will illustrate the differences between movements that require strength, speed, and finally power (i.e. speed and strength).

The 1 repetition maximum (1 RM, i.e. the maximal amount of weight that can be lifted correctly for one repetition) in the dead lift is characterized by the production of a great amount of muscle force. For those who are not familiar with the dead lift, it involves lifting a weight off the ground to a standing position. For all of us, performing to our individual maximum by lifting the heaviest possible weight in the dead lift requires considerable force and effort. If one were to attempt this movement, it would also become obvious that to execute this maximum lift with a great amount of speed would be nearly impossible as the load is simply too heavy. The 1 RM dead lift would be an example of a movement requiring a large amount of force or strength.

The overhead smash in badminton, on the other hand, is not characterized by requiring a great amount of strength. Contrary to the 1 RM dead lift, the smash in badminton is characterized by a very high speed of movement. In the badminton smash, it is not so much the strength of the movement that elicits an effective smash, but the speed of movement. Therefore, the badminton smash is a movement characterized by requiring a high speed of movement and in this case, strength contributes to a much lesser degree.

The shot put event in track and field requires a relatively equal contribution from both the strength component and the speed component. In the shot put, it is the speed with which force can be developed that becomes important for successful execution of the movement.

To summarize, performing a 1 RM in the dead lift requires a high amount of strength; the overhead smash in badminton requires high speed; and the shot put requires considerable strength **and** speed. Of the three examples given, the shot put is the athletic movement that displays the greatest power output.

The concept of power should now be clear. From this basic understanding of power, it is now possible to discuss methods to develop this important physiological quality.

How Do We Train Power?

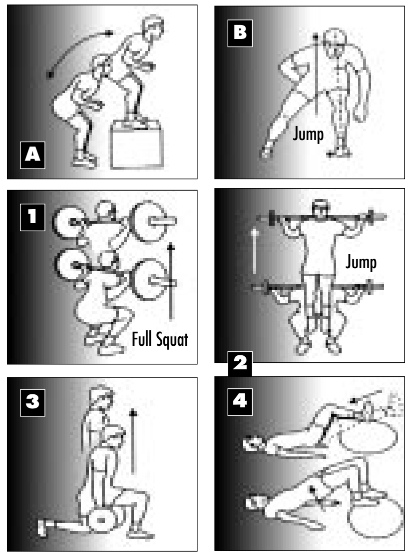
When designing a resistance training program aimed at improving power and speed, many different variables come into play. For example, the number of exercises, number of sets and repetitions, amount of load or resistance used, rest periods (both within and between sessions), the speed of movement, the exercises themselves, and how they are sequenced with the rest of the training program must all be considered.

The first, and probably most important, consideration is what movements you will have your athletes perform. This comes back to specificity, one of the basic principles of training. In order for improvements in power and speed to be transferred from land to the sporting environment, the exercises must mimic the sporting movements as close as possible. Taking a speed skater for example, doing a single leg movement (that is, lateral single leg box jumps) would be more specific to skating than doing a movement with both legs (for example, back squats). It is essential that you choose specific exercises at this time because the adaptations that accompany this type of training are primarily neural. These neural adaptations, however, will only be of benefit if the movement used during training closely resembles the movement during performance.

The next variable of concern is how much load to use during the resistance training program. Traditionally, it has been suggested that very heavy loads (that is, >90 per cent of 1 RM) be used to improve maximal power (Baechle 1994). More recently, however, it has been speculated that for improvements in maximal power, one should be training at the load that actually allows for

Sample Programs

Sample Program 1

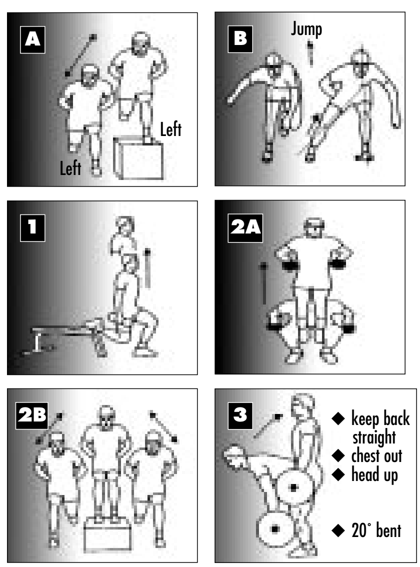


Exercise Description	*Sets*	*Reps*	*Tempo* E	P	C	*Rest (sec.)*
Warm-up & jumps						
A) Double Leg Box Jumps	2	6	2	1	ex	60
B) Single Leg Skaters Hops	2	6/leg	1	0	ex	60

	Sets	*Reps*	*Tempo* E	P	C	*Rest (sec.)*
Resistance Exercises						
1) Back Squats	2-4	6	2	1	ex	180
2) Jump Squats	2-4	8	1	0	ex	180

	Sets	*Reps*	*Tempo* E	P	C	*Rest (sec.)*
Resistance Exercises						
3) Single Leg Squats	2-4	6/leg	1	0	ex	180
4) Physioball Hamstring Curl	2-4	8	2	1	1	120

Sample Program 2



	Sets	*Reps*	*Tempo* E	P	C	*Rest (sec.)*
Warm-up & Jumps						
A) Lateral Single Leg Box Jumps	2	6/leg	2	1	ex	60
B) Skater Stride Imitation Jumps	2	6/leg	1	0	ex	60

	Sets	*Reps*	*Tempo* E	P	C	*Rest (sec.)*
Resistance Exercises						
1) Bulgarian Single Leg Speed Squats	2-4	15"/leg	1	0	ex	220
2A) Dumbell Jump Squats	2-4	8	1	0	ex	SS

	Sets	*Reps*	*Tempo* E	P	C	*Rest (sec.)*
Resistance Exercises						
2B) Single Leg Up and Over Jumps	2-4	6/leg	1	0	ex	220
3) Romanian Dead Lift	2-4	8	2	0	1	180

Explanation of symbols and program variables

** ***Tempo*** ***E*** = is the time in seconds to complete the eccentric range of the movement
P = is the time in seconds for a pause during the transition between eccentric and concentric movement
C = is the time in seconds to complete the concentric range of the movement
Note: "ex" in the concentric phase represents "explode"

***** Rest*** ***SS*** = superset (that is, there is no rest between the two exercises)

Exercise diagrams courtesy of Physigraphe maximal power to be realized. Some research suggests that this will occur at approximately 30 per cent of maximal isometric force (Wilson et al. 1993). When choosing the load for your athletes to train at, you again should think about specificity and what you are actually trying to improve upon. If the sport involves a great deal of inertia, then you may want to train at heavier loads(i.e. bias the training towards the strength side of the power formula). This would be true for the start in speed skating, for example, where the athlete has to generate large amounts of force to get his or her body moving from a static position. However, if the movement you are training for involves lower forces developed at faster speeds, you will probably want to use lighter loads and ensure the lifting and lowering speeds are similar to performance conditions. Taking strides during a sprint for the puck in ice hockey would be an example where forces are not as high (relative to starting from a standstill), but the time for force generation is considerably shortened. Realistically, both of these conditions will probably occur at some point during performance. It is then up to the coach to prescribe loads that specifically mimic the forces and speed of movement that occur during competition.

Regardless of the load used during this type of training, it is inherent that the intensity of the work will be very high. This must be considered when prescribing rest periods. Because intense efforts tax the nervous system and short-term energy systems a great deal, it is necessary to take relatively long rest breaks between sets. Three to five minute static rest breaks should be adequate to ensure that a high quality of effort is attained in each set. The neuromuscular fatigue that results from this type of training is quite substantial as well. Therefore, a large amount of recovery between training sessions of this type is required. Training of this nature should probably only occur once or twice a week at maximum to allow for adaptations and proper recovery.

The number of sets, reps, and exercises that should be used is affected by a number of variables such as training history, training phase, and the volume and intensity of the rest of the training program. Therefore, it is difficult to give exact numbers in these cases. However, the intensity will be very high and the volume will be relatively low when compared with other types of resistance training. Generally speaking, 1 to 3 sets of 2 to 8 repetitions, and 2 to 4 exercises should allow for adequate improvements in speed and power.

Where this type of training fits in with the rest of a training program is very important as well. In most cases, you will want your athletes relatively fresh and rested to ensure that they are doing quality work. If the athlete's nervous system is not rested, they will not be able to train at the desired intensity and the results will not be as positive. Again, it is up to the coach to find a time in the weekly plan when their athletes will be able to do this type of work properly without adversely affecting subsequent training sessions.

As mentioned earlier, the movements or exercises used to develop speed and power are very important. The chart on page 24 outlines a couple of sample training programs for the ice athlete, complete with suggested exercises, lifting tempos, and rest periods.

Considerations Prior to Beginning a Program Designed to Develop Power

Firstly, it is crucial that all strength training be carried out under the supervision of a qualified professional. Adherence to proper lifting technique and loading parameters is essential to ensure that the proper physiological adaptations occur and to minimize the risk of injury.

Furthermore, due to the high physiological demands of training power, it is recommended that only experienced athletes perform this type of training. A general guideline that can be followed to ensure safety is that all athletes performing high intensity strength training should have a minimum of two years of strength training experience.

In conclusion, this article has provided a brief overview of the components of power, a framework for the loading parameters needed to train this quality, and a sample program aimed at improving leg power. Remember, power is a very important physiological quality in the development of the high performance athlete, but using these training methods can pose a risk to the inexperienced athlete or coach. Good luck with your training, and always consult a professional if you have questions or doubts about implementing a program designed to improve power.

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