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Aspects of Muscle Compensatory Processes and Physical Activity in the Survivors of Polio

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With the increasing understanding of the factors causing new symptoms in polio survivors comes an increasing awareness of the benefits and risks of physical exercise and training. Some training studies have been reported lately in the literature that can be of help in recommending appropriate training regimes. An important aspect is that different muscles in different persons can be very differently affected by polio: some may be atrophied to the point where no exercise or training is possible; some may be moderately weak but in an unstable state showing progressive weakness and a risk for overuse; others may be moderately weak but stable to where some training might be of value; and in some muscles, compensation by reinnervation has resulted in "nearly normal" or "normal" muscle function, but there might be risk for disuse. It is, thus, important to individualize the training advice, not only among individuals but also for different muscle groups of a particular individual.

In practice, this is a great challenge to the physiotherapist, and other professionals who design the training programs, and requires a detailed analysis of the muscle function both with clinical testing and laboratory investigation using dynamometer measurements and electromyography. Our experience is that by having detailed information, the polio survivor has a better opportunity to adopt a daily physical activity pattern that provides the appropriate amount and type of exercise but without overuse and fatigue.

DOES TOO MUCH DAILY PHYSICAL ACTIVITY AND EXERCISE TRAINING CAUSE ACUTE AND/OR PERSISTENT DAMAGE OF POLIO-AFFECTED MUSCLES? To answer this question, detailed knowledge about the compensatory processes in the polio-affected muscles is necessary. Compensation occurs through reinnervation by adjacent nerve fibers to muscle fibers (muscle cells), which have lost their innervation by the death of nerve cells in the acute polio phase as well as later on. The polio-affected muscles otherwise would have atrophied. This compensatory mechanism seems to be very powerful: a nerve cell can reinnervate 4-5 times the normal number of muscle fibers and, in extreme cases, even more than 10 times. The other compensatory mechanism is hypertrophy of the muscle fibers, most likely caused by extreme use of the weak muscle that is still strong enough to be used in daily activities. Even to rise from a chair or walk on a flat surface may give a near maximal load and by that be a stimulus for increase in size of muscle fibers, but not in number, just as in very heavy resistance training. Muscle fibers may then reach a size double or three times the normal size. Thus, whereas physical activity does not seem to be a prerequisite for reinnervation, it is for the increase of muscle fiber size.

IS THERE A DANGER IN HAVING LARGE MOTOR UNITS (THAT IS, TOO MANY MUSCLE FIBERS INNERVATED FROM THE SAME NERVE CELL) AND TOO LARGE MUSCLE FIBERS? Our recent follow-up studies over eight years (Grimby et al, 1998) indicate that very large motor units, more than 20 times normal, with around 10 times the normal number of muscle fibers, may have problems. Either they may lose some of their muscle fibers and thin out due to defective neuromuscular connections, or they may just die easier. We have no systematic information available whether physical activity and overuse could bring about such a loss of muscle fibers or nerve cells. A defective neuromuscular transmission can be identified in some motor units, but we have not found in our studies an indication that this is a major factor for muscle weakness. Whether it can contribute to muscle fatigue is still under debate. The other compensatory mechanism — hypertrophy (increase in size) of muscle fibers — has a positive effect on the maintenance of strength, but it could be a negative for endurance, as capillarization and the aerobic metabolic system of the muscle cell (mitochondria) do not increase in response to the increase in size. Indeed, such large muscle fibers may be less resistant to overuse.

We know, in fact, very little about the risk of overuse causing persistent muscle damage. What we know now is the risk for long-lasting fatigue after too strenuous exercise in polio-

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affected muscles. They need a longer recovery period than "normal" muscles, which must be taken into account when designing training programs and adjusting daily activities. In training studies, we have the experience that with long enough rest periods, which could be days or weeks after a too strenuous bout of exercise (Agre et al, 1998), full recovery will occur. Thus, there is a risk for overuse but, with proper attention to the fatiguing symptoms, the function will recover after the exertion. The risk occurs when the polio survivor does not rest enough, and his/her muscles remain in a constant condition of overload, with its negative effects on function. Although this is not easy to prove scientifically and experimental studies would be unethical, we must rely on a successive collection of data to understand the balance between the pros and cons of physical activity. My personal view is that an approach of trial and error under professional monitoring will yield in practical terms what is a beneficial level of physical activity and what could be deleterious for a specific individual.

THE LITERATURE NOW DOCUMENTS A NUMBER OF TRAINING STUDIES. Of prime importance is separating resistance from endurance training programs. A person with weak muscles may use them close to their maximum only for a short period of time, e.g., climbing stairs. Thus, there will be no time for adaptation to endurance. By reducing the intensity, such as walking slower and taking short breaks for other types of activity, both resistance and endurance training at an appropriate level may be achieved. Another way is to choose a medium where the load can be more individualized between muscle groups as in pool training. In a study with a control group at our polio clinic, increased general endurance and less pain in daily life was demonstrated in the group with pool training compared to the group that received advice about their physical activity. There was no deterioration of function after the pool training (Willèn et al, 1999).

Other training studies indicate the possibility of improving the general endurance of polio persons by using individual training programs, as on a bicycle ergometer, or group training on the floor with combined endurance and submaximal resistance training with music (Ernstoff et al, 1996). In general, it would be of value to encourage endurance types of programs with proper intensity and the possibility of individualizing the load as in pool training, giving proper time for rest between the exercises.

The role of resistance training for polio muscles is more controversial. However, short-term resistance training at high or maximal intensity has been demonstrated to give an increase of muscle strength in moderately affected muscles, measuring more than 3 on the manual muscle testing scale (Einarsson, 1991). Such an increase in strength seems to be maintained, probably by adaptation of the physical activity level in daily life, and could be beneficial and allow a broader type of exercises with relatively less effort. Such a program did not result in any negative effects or evidence of muscle damage when properly supervised. Also low intensity strength training can improve muscle performance and reduce the experience of fatigue. There was no change in serum creatine kinase after a 12-week muscle-strengthening program, which would have indicated muscle damage (Agre et al, 1997).

TO LEARN THE APPROPRIATE LEVEL OF PHYSICAL ACTIVITY TO AVOID UNNECESSARY OVERLOAD ON THE ONE HAND AND DISUSE ON THE OTHER IS IMPORTANT FOR MAINTAINING OPTIMAL PHYSICAL FUNCTION IN POLIO-AFFECTED MUSCLES. As important is to avoid pain, it being both a limiting factor for physical performance and an indication of overload that could be on muscles as well as joints and other tissue structures. The experience of pain is evidently closely related to physical activity. Individuals who spontaneously chose a walking speed close to their maximum speed were more prone to experience pain in their daily life (Willèn et al, 1998). The results of that study indicated also that those who were less affected by muscle weakness experienced more pain than individuals with weaker muscles, and they might, thus, have a pattern of daily activity that was too strenuous. Advice and adaptation of the daily physical activity to avoid pain is an important feature in the post-polio management. ■

REFERENCES

Agre, J.C., Rodriguez, A.A., & Franke, T.M. (1998). Subjective recovery time after exhausting muscular activity in postpolio and control subjects. *American Journal of Physical Medicine & Rehabilitation,* 77, 140-144.

Agre, J.C., Rodriquez, A.A., & Todd, F.M. (1997). Strength, endurance and work capacity after muscle strengthening exercise in postpolio subjects. *Archives of Physical Medicine & Rehabilitation,* 78, 681-686.

Einarssson, G. (1991). Muscle conditioning in late poliomyelitis. *Archives of Physical Medicine & Rehabilitation,* 72, 11-14.

Ernstoff, B., Wetterqvist, H., Kvist, H., & Grimby, G. (1996). The effects of endurance training on individuals with post-poliomyelitis. *Archives of Physical Medicine & Rehabilitation,* 77, 843-848.

Grimby, G., St. Ålberg, E., Sandberg, A., & Stibrant Sunnerhagen, K. (1998). An 8-year longitudinal study of muscle strength, muscle fiber size, and dynamic electromyogram in individuals with late polio. *Muscle Nerve,* 21, 1428-1437.

Willèn, C., & Grimby, G. (1998). Pain, physical activity, and disability in individuals with late effects of polio. *Archives of Physical Medicine & Rehabilitation,* 79, 915-919.

Willèn, C., Stibrant Sunnerhagen, K., & Grimby, G. (1999). *Dynamic exercise in water in individuals with late polio.* Manuscript submitted for publication.

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