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The O.K.C. Above-Knee Running System

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For many years, above-knee amputees have been trying to run step over step rather than using the hop and skip running gait typified by Terry Fox in his run across Canada. This type of locomotion is still biomechanically defined as walking since it still contains a double support phase when both feet are touching the ground simultaneously. True running has no period of double support.

One reason that above-knee amputees have had to run in this manner is that the lower shank does not accelerate forward fast enough for true running due to inertia. While the thigh segment quickly flexes about the hip, the foot tends to stay in place, causing the knee to flex beyond a desirable position and resulting in what is commonly referred to as "excessive heel rise." This excessive heel rise causes a delay in getting the foot-shank complex to move into extension which complicates the amputee's basic problem of not having active control of the knee. It seems that the harder the amputee tries to flex his hip, the worse the heel rise becomes.

The O.K.C. system strives to solve these problems. It consists of a cable-housing arrangement (similar to that on a below-elbow prosthesis) that travels behind the hip joint and anterior to the knee axis (Figure 1). The proximal end of the cable is attached to a belt similar to a Silesian bandage by a short piece of elastic webbing and Dacron tape which is adjustable via a 4-bar buckle. The distal end of the cable is fixed to the proximal anterior shank section of the prosthesis.

When the hip joint starts to flex, just at the moment of "running toe off," tension in the cable causes a dynamic extension moment at the knee. In other words, power is being transferred to the knee joint directly from the action of hip flexion. When the thigh is fully flexed, the tension in the system is at its maximum. This turns out to be very desirable biomechanically, since the knee needs to be fully extended at heel strike. The O.K.C. system therefore supplies a dynamic force to the shank, much as the quadriceps does in the normal human leg during running (Figure 2).

It has been our experience that it is easier to start using this system on children running on grass and advance to adults later for two reasons. First, children are not afraid to try to run, especially when the practitioner tells them they are now capable of it. Second, due to lower stresses in the system, the prosthetist can use conventional upper extremity cable and housing components that are readily available rather than specially made cable and hardware which are needed for adults. It has been noted that some children are able to remove the cable after a few months, (much as training wheels on a bicycle) and still do a fair job of running step over step. They gain confidence from the system and use it to fine tune their running capabilities. However, it has been our experience that when truly fast running is required as in competitive events, the patient prefers the O.K.C. System. Parents report that their children like to keep the system in place at all times since it gives them a natural dynamic quadriceps effect. However, some adults prefer to remove the O.K.C. System for normal locomotion.

For adult running, we have found that special aircraft grade cable and terminal ends are required due to the increased stresses in the system. It has also been discovered that monofilament fishing line (300–500lb. test line)

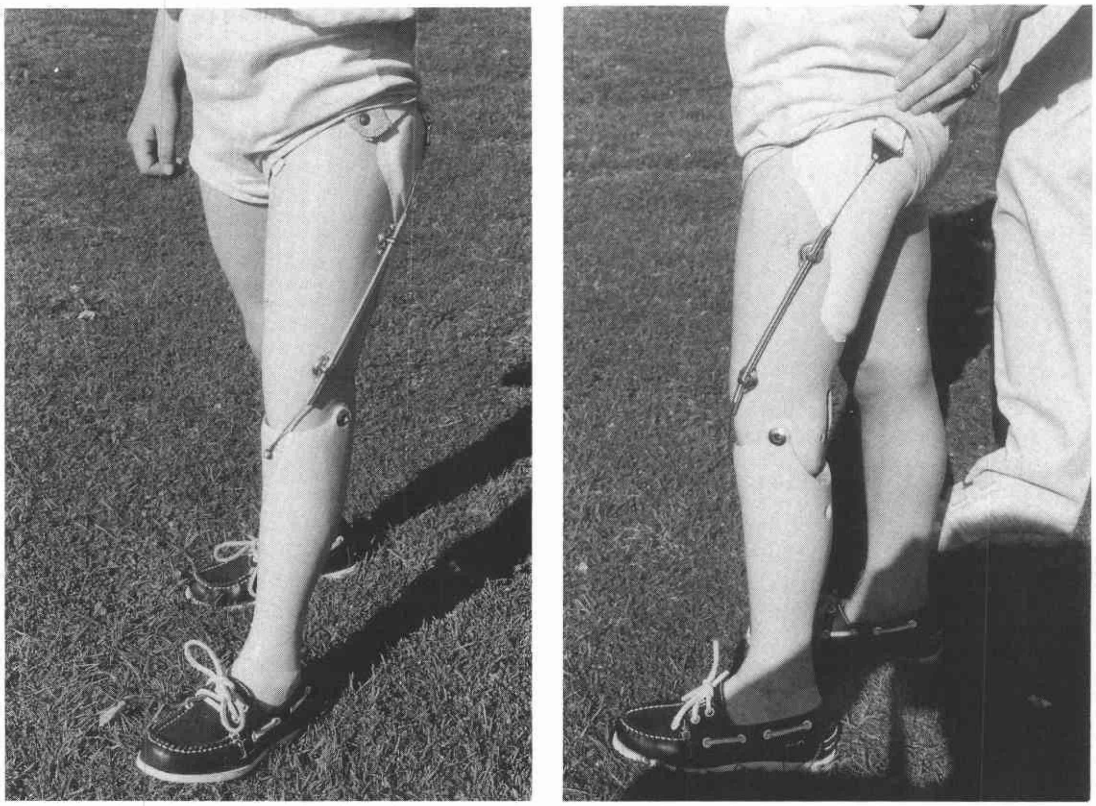

Figure 1. Lateral views of prosthesis showing path and attachment points of the OKC running cable.

works quite nicely as the coefficient of friction between the cable and housing is reduced. A plastic housing such as polypropylene tubing (commonly used in air conditioner drains) works best with this monofilament.

An extension aid of surgical tubing or elastic webbing augments the O.K.C. System and provides another method of fine tuning the system. Some competitive runners also like to use a flexion limiter with the system. This consists of a ¾'' thick piece of PE-LITE® at the back of the knee joint which does not allow the knee to flex completely. This flexion limiter acts as a compressive stop which tends to bounce the knee into extension and swings out of the way during normal walking. A variety of other methods of limiting flexion can be used.

To our knowledge, the first above-knee amputee to ever run step over step on an above-knee prosthesis was in March, 1982 utilizing an O.K.C. System. Since that day, many adults who enjoy competitive running or just sports in general have been fit. The shortest residual limb fit successfully with the O.K.C. System was on a 17 year old above-knee male with a 2⅞'' femur. The longest have been knee disarticulation amputees.

It is easier to implement this system if the patient is using an exoskeletal prosthesis, since the cable and housing have a natural surface to ride and sit on. However, we have placed several on endoskeletal systems with a little creative rigging (Figure 4). It is also possible to laminate a track directly into the thigh portion of the prosthesis which eliminates the need for housing. However, this sometimes causes excessive breakage unless a section of housing is extended distally to reduce the bending radius distally about the knee.

Sitting can be a problem unless the cable or monofilament is placed in such a way as to allow the cable and housing to move posterior to the knee during sitting. This prevents the creation of a knee extension moment, which

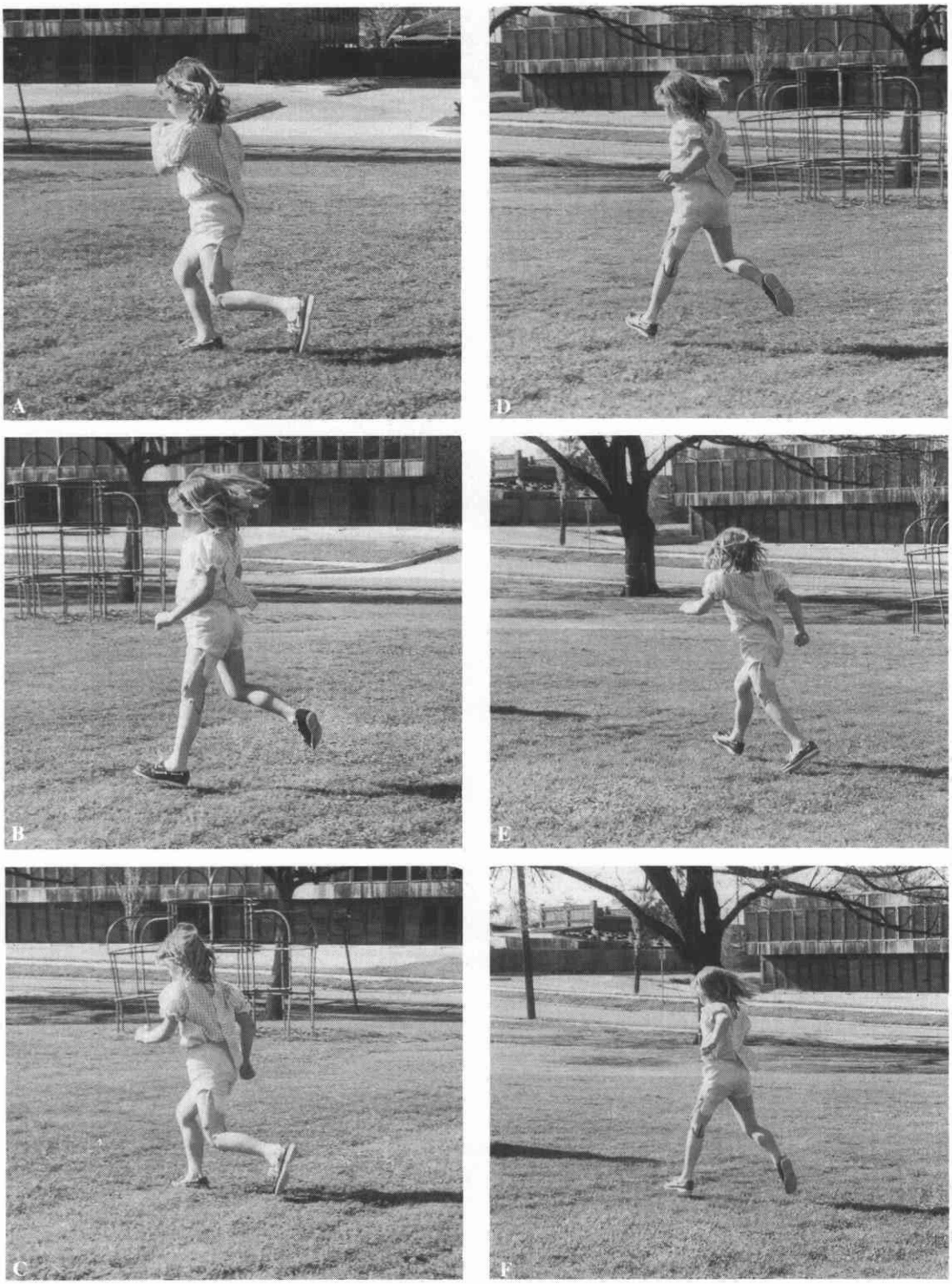

Figure 2. Running sequence showing action of the cable system.

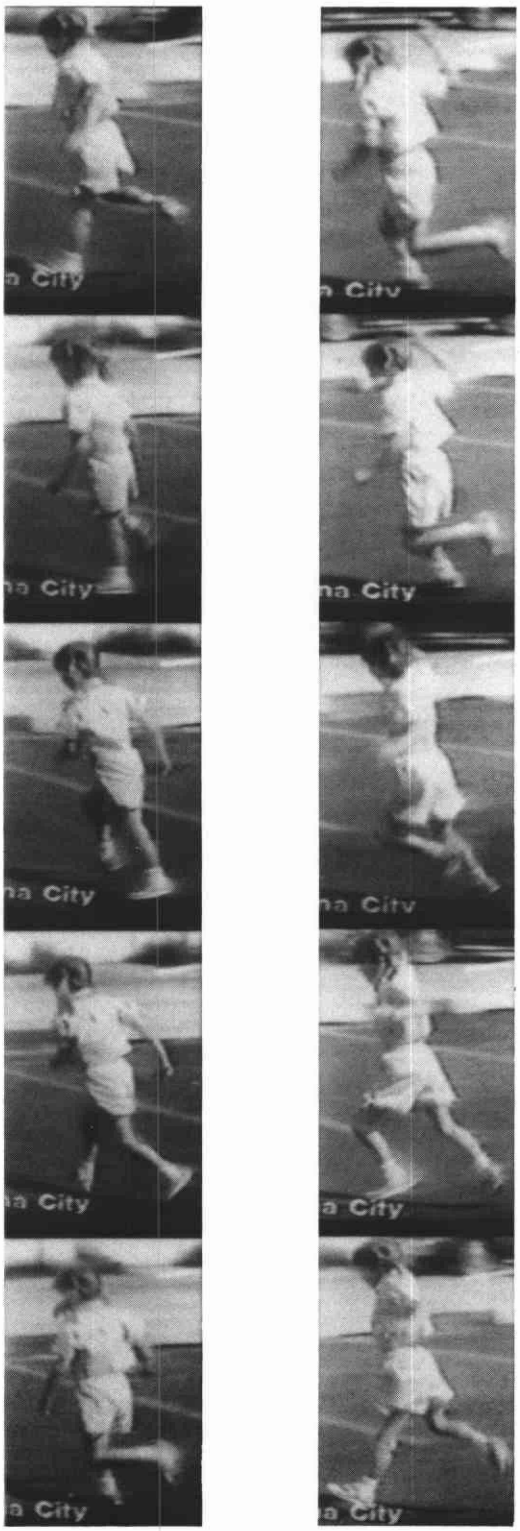

Figure 3 (left). Series of photographs taken from video screen.

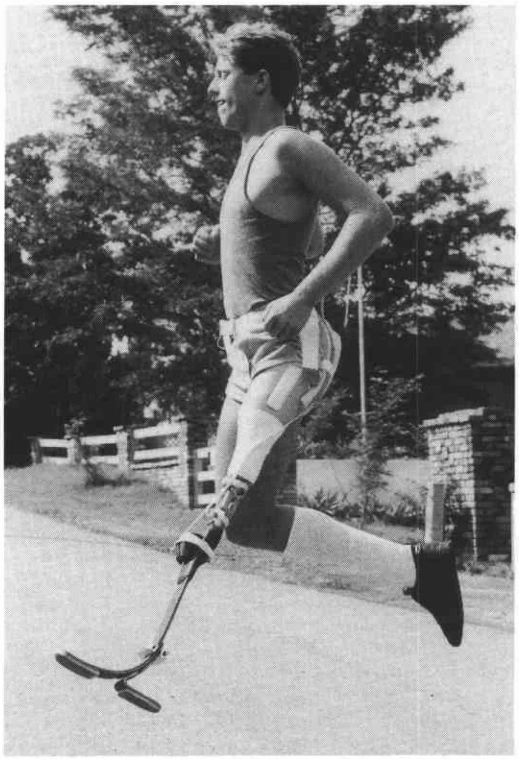

Figure 4. OKC running cable on an endoskeletal prosthesis. Aircraft cable and terminal ends were used in fabrication.

could be bothersome during sitting.

Last, we have found it most helpful that the heel portion of the prosthetic foot be soft enough to provide very easy planer-flexion so as to lessen the tendency for the knee to be forced into flexion by the ground reaction force at heel strike.

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