STANCE PHASE CHARACTERISTICS OF ABOVE-KNEE PROSTHESES

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Abstract

The design of mechanisms claimed to afford improved function to the amputee while the prosthesis is weight-bearing has generally been carried out in an intuitive fashion. This paper reports the findings of a preliminary investigation into the objective assessment of various types of devices with a view to ascertaining whether or not the amputee is able to use the theoretical advantage they offer him.

During the stance phase of gait, the prosthesis is required to be stable from heel contact until the time of initiation of knee flexion preparatory to swing through. The voluntary use of hip extensors and flexors together with body contact eg. ischial seat, will in some way meet these requirements. By measuring this anterior-posterior hip moment as the amputee performs various activities; walking, climbing stairs and ramps, stepping over objects etc., the influence of a knee mechanism can be evaluated.

The anterior-posterior hip moment was calculated on the basis of the force actions as measured by an instrumented pylon in the shank of the prostheses, and the limb configuration defined by the segment lengths and the knee angle. All the instrumentation was therefore incorporated in the prosthesis, allowing the amputee a greater degree of freedom than would be possible with a force platform technique.

Knee Stability

In a normal individual, the Joints between the various limb segments are stabilized by muscle and ligament action. After an above-knee amputation, control of the artificial knee is transferred to the patient's hip musculature. A degree of stability can however be provided in the design of the prosthesis. The methods for achieving this may be grouped into three main divisions.

(1) Alignment of the knee axis with respect to the hip and ankle.

(2) The development of a resisting moment at the knee.

(3) The use of polycentric knee mechanisms. These are designed to provide a mechanical advantage to the amputee and hence reduce the hip moment required to either flex or extend the knee.

Apparatus

To calculate the force actions transmitted at the junction between limb segments, it is necessary to measure the externally applied forces and the configuration of the limb. This is frequently accomplished by the use of force plates and photography. Since complete specification of the ground-to-foot force is necessary, a single step six component force platform is required. It was decided to incorporate force and displacement measurement into the prosthesis. This allows more than one stride to be investigated and obviates the tedious reduction of film data.

The dynamometer is of similar form to that used by Cunningham and Brown (1952) but modified to be compatible with a number of different prostheses. It is capable of measuring all the components of the resultant force applied to it.

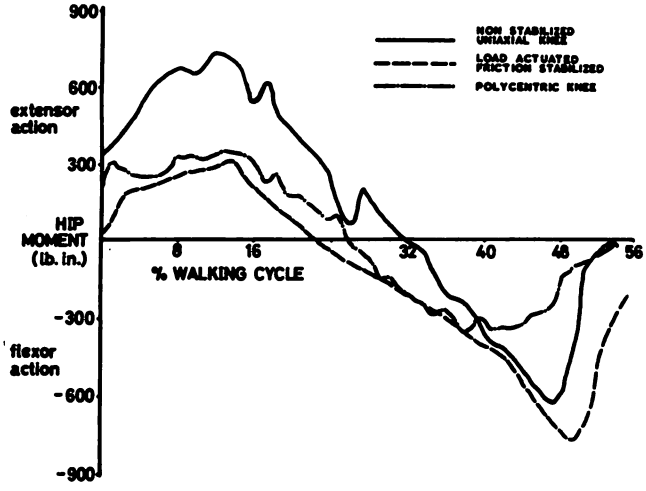
The dynamometer is connected between the foot and knee unit. Therefore, the force actions transmitted at the proximal and distal joints of the prosthesis can be completely defined. To calculate the bending moment about the hip joint, it is necessary to define the position of the dynamometer relative to this. Continuous measurements were therefore made of the angle of knee flexion, using a precision variable resistor.

The anterior-posterior moment at the hip joint was calculated from this data

for a variety of activities. The results were plotted against percentage of the gait cycle to allow comparison even though the cadence may vary from test to test.

Results

The composite diagram illustrates the variation with time of the a-p hip moment exerted by an amputee when using three different types of knee, in level walking.



It can be seen that the friction stabilized knee is an advantage in the early part of the stance phase, but requires a higher hip moment to flex the knee prior to swing through. The polycentric type of knee clearly provides assistance in all parts of the stance phase.

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