HYBRID AND ALTERNATIVE PROSTHETIC DESIGNS FOR SPORTS AND RECREATION
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The pursuit of sports and recreation activities continues to expand in both able bodied and physically challenged populations. Persons with a hand absence(s) may in certain instances have more leisure time than their two handed peers allowing them to participate more frequently in activities like golf, tennis and water sports.

Many individuals with a physical challenge, such as a hand absence, wish to perform their leisure time or sports activities competitively. These individuals require prosthetic technology that allows them to achieve those goals. The type of prosthesis that they utilize for their ADL, work environment and domestic life most likely will not provide the level of technology required for participation in high performance sports and recreation activities.

Sophisticated, externally powered prostheses, although highly functional, are not necessarily the logical choice for these activities. In fact the application of this type of prosthetic technology to rigorous sports and recreation can prove detrimental to the life and function of these prostheses. Similarly, most basic body powered prostheses, although simple, rugged and dependable most likely do not provide the level of function required to perform at optimal levels in sports and recreation activities.

The bio-mechanical complexity and physical demands that many sports and recreation activities place upon an upper limb prostheses are significant. Engineering difficulties arise in the ability of a standard prosthesis to transfer kinetic energy and duplicate the degrees of motion and freedom that exist in natural human anatomy. Two dimensional prosthetic joints simply cannot provide for the smooth transfer of energy that is required for high performance, bi-manual power and control. A clear illustration of these bio-mechanical demands exists in the simple swing of a baseball bat. The transfer of energy from the torso through the arms into the bat requires multiple movements within all the upper extremity joints as well as forearm pronation and supination. The action that is commonly referred to as “wrist break” is actually a complex series of motions involving many degrees of freedom within the forearm and wrist. No standard prosthetic forearm or mechanical wrist system provides the range of motion and degrees of freedom required to duplicate the dynamic “wrist break” required to swing a bat bilaterally with power and control. Attempting to swing a bat with a prosthesis that has limited degrees of freedom typically results in either damage to the prosthetic components and or damage to the tissues of the residual limb.

Solutions to these prosthetic dilemmas exist but they represent a departure from traditional prosthetic technology design in both function and appearance.

The word “hybrid” as currently used in prosthetics refers to a prosthesis constructed with multiple components that represent combinations of both traditional body powered and externally powered technology. Hybrid prostheses as well as unique alternative designs can provide viable solutions in achieving performance in sports and recreation if the prosthetic user is willing to sacrifice certain cosmetic elements in exchange for function and competitive high performance.

The basic myo-electric forearm can be easily modified to receive a more traditionally designed body powered component or custom recreational and sports terminal device equipped with a standard one half inch diameter threaded mounting stud. Both Texas Assistive Devices® and Otto Bock® produce myo to body power converters or couplers.
Three companies manufacture activity-specific terminal devices for sports and recreation. Texas Assistive Devices®, Hosmer Dorrance® and TRS Inc®. TRS Inc. manufactures the broadest array of sports and recreation adapters but these products are complimented by those additional and or alternative products produced by Texas Assistive Devices® and Hosmer®. The variety of sports and recreation adapters has blossomed over the last ten years. Activities from archery to wind surfing are now accessible using either specialized prosthetic accessories or by modifying sports equipment to function for a person with a hand absence.

Proper prosthetic alignment is an important consideration in specific sports to ensure that safety and success are achieved. In sports such as weight lifting or archery, the socket-to-arm alignment and wrist-angle-to-prosthesis centerline are critical in achieving performance. Pre-flexion in a trans-radial prosthesis can be counter productive and inhibit an athlete from handling the heavy loads generated in activities like the “bench press”. Similarly pre-flexion makes it difficult to handle the loads and torque generated while drawing a bow to shoot an arrow. A neutrally aligned prosthesis allows for more direct axial load onto the residual limb improving stability without inducing torque that could impact control and accuracy.

The key emphasis in the development of most prosthetic sports accessories has been to encourage bi-manual function and capability rather than to emphasize uni-lateral performance. Bi-manual involvement and performance are valuable to the athlete from a therapeutic perspective, especially over a lifetime of activity.

Radical departures from conventional designs clearly illustrate this attempt to increase bi-manual performance. The arrival and acceptance of the shorty sports prosthesis and its application for both trans-radial and trans-humeral athletes points the way to future developments that can incorporate unique materials and components designed to achieve specific bio-mechanical and energy assistive properties for persons with an upper limb absence. The profession has seen these departures in lower extremity prostheses especially in the realm of custom sprinting and running legs. In upper extremity we are only scratching the surface as to what may be possible.

The shorty sports arm typically utilizes a roll-on silicone type suspension to help eliminate harnessing thereby improving range of motion. It may contain carbon fiber reinforcing for improved strength coupled with weight reduction or it may be constructed of co-polymers for water sports applications. The shorty’s primary goal however is to eliminate unnecessary joints, mass and weight. The prosthesis is designed to terminate as closely as possible to the end of the residual limb. The interior lock system of the roll-on liner may dictate some additional length.

Either a friction or disconnect style wrist is attached. On the trans-humeral athlete the prosthesis’s length without a terminal device should attempt to duplicate the length of the normal humerus. For the short trans-radial athlete, depending upon the activity, the “wrist component” should be positioned not longer than mid-forearm. The prosthesis may also be slightly pre-flexed for particular activities like swimming to enhance ease of use and performance.

Designed in this way the shorty sports arm provides more direct control over the sports accessory and improved proprioception for the user. During an activity like swimming the resistance of a swimming accessory like the TRS Freestyle® swim device creates high torque and stress loads on the residual limb. The shorty prosthesis helps minimize these forces by bringing the loads closer to the end of the residual limb.

Eliminating the prosthetic elbow joint and forearm for the trans-humeral athlete in an activity like golf is proving to be very productive. The entire lower end of the prosthesis is replaced by a long, energy-storing polymer coupling that terminates in a golf grip attachment component.
Several different golf adapters are applicable to his concept including the TRS Golf Grip® and Golf Pro® technologies. The flexible coupling provides numerous degrees of freedom duplicating the necessary movements required to swing a golf club bi-manually with power and control. The shorty sports arm with its silicone suspension and light weight allows for a normal range of unrestricted, gross motor movement throughout the arms and torso. This frees kinetic energy to be transferred through to the club when striking the ball. The end result is improved bi-manual performance, ie. longer drives and a swing that exhibits better control with less effort and more proprioceptive response.

In summary, the design and construction of a hybrid or custom sports arm requires that the prosthetist and athlete communicate closely to determine the capabilities and needs involved. The environmental conditions, stresses and loads that the prosthesis will encounter must be defined. Materials and suspension design will vary depending upon the primary application. An activity-specific prosthesis needs to be constructed to enable the user to duplicate the biomechanical elements required by the sport or recreation. Prosthetic alignment can play a valuable role in achieving performance in specific sports activities like weight lifting and archery.

In certain cases an externally powered arm can be modified to perform sports and recreation activities with the addition of a body powered wrist coupler accessory. The prosthetic sports arm may in fact be built for a single activity like golf and incorporate more radical design elements that sacrifice appearance for function and performance, such as the shorty sports arm. Placing the sports accessory as close to the end of the residual limb as possible can typically enhance performance and control of the activity. A wide range of prosthetic sports and recreation accessories exist to help the athlete be functionally bi-manual and competitive with two handed peers. Future prosthetic designs for the upper limb may incorporate technological innovations that have been successful in lower extremity sports prostheses.

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