Evidence Note

Differences in Myoelectric and Body-Powered Upper Limb Prostheses

Key Points

- **Research comparing upper limb prostheses is limited.**
- **Body-powered prostheses have demonstrated advantages in durability, training time, user feedback and frequency of adjustment and maintenance.**
- **Myoelectric prostheses have been shown to provide a cosmetic advantage, are more accepted for light intensity work, and may positively affect phantom limb pain when used actively.**
- **Body-powered prosthetic control can be improved by optimizing harness and cabling systems.**
- **Myoelectric prostheses can be improved with more intuitive control methods.**

Clinical Problem

The choice of a myoelectric (MYO) or body-powered (BP) upper limb prosthesis (Figure 1) can be determined using various factors including control, function, feedback, cosmesis and rejection. Upper limb prosthetic rejection rates may be as high as 50% [1]. A systematic review was conducted to determine differences between MYO and BP upper limb prostheses to inform clinical practice regarding these devices.

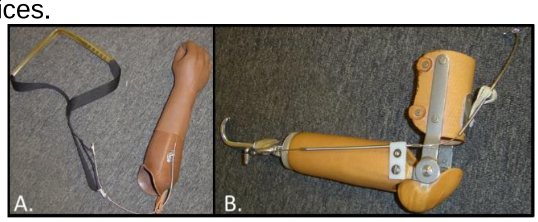

Figure 1. Body-powered prosthesis

Description of Systematic Review

A systematic review, based on guidelines developed by the American Academy of Orthotists and Prosthetists, was conducted to determine differences between MYO and BP upper limb prostheses to inform clinical practice regarding prescription of these devices and training of users. The following databases were searched: Pubmed, CINAHL, RECAL Legacy, Cochrane Database of Systematic Reviews, Cochran Clinical Trials Registry, EMBASE, PMC-NIH Research Publication Database, Web of Science and Google Scholar. The following article types were considered and reviewed: published between 1993-2013, editorial, case study/series, observational research designs, experimental research designs and literature reviews.

Scope of Review

The database search identified 462 unique publications. Ultimately, 31 of them were included in the qualitative synthesis. Eleven empirical evidence statements were developed based on findings reported in the literature. This evidence note will cover selected key points.

Summary of the Evidence

There is limited research directly comparing upper limb prostheses. The majority (19 of 31) of the studies reviewed were observational in design. Consequences of such high representation from observational studies include a lack of control in how devices are selected, as well as if, when and how they are trained and what their outcomes are under controlled conditions acutely and chronically. Six expert opinions were also included due to the lack of experimental studies. Common issues that reduced the internal validity of the reviewed studies included a lack of randomization, control group, blinding, poor reporting of fatigue, accommodation and training as well as a lack of effect size reporting. Compared with internal validity, the external validity in the included studies was greater; however, there were still areas that could be improved. Criteria noted as lacking in external validity included improving descriptions of the sample, selected outcome measures, the intervention as well as including a literary context for discussion and conclusions.


Figure 2. Myoelectric prosthesis

Collectively, studies disagree as to whether BP or MYO (Figure 2) prostheses are ultimately superior to one another functionally. For instance, users indicate BP prostheses are better suited for working conditions that include light sitting work or combined sitting/standing work but could include exceedingly heavy work [2, 3]. In contrast, MYO prostheses tend to be used for only light work [3, 4]. In specific tasks, MYO prostheses incorporating a hand reportedly offer the ability to handle larger-diameter objects and the ability to grasp small objects [3].Studies of varying quality and design suggest that depending on functional needs, control scheme familiarity and user preference, either BP with a conventional hook or MYO prostheses are advantageous compared to each other or other alternative [2, 3, 5-7]. In the observational work by Kejlaa [4], it is reported that BP prostheses may be used for a larger range and a typically more demanding level of work than myoelectric and passive alternatives.

BP prostheses presently have a key role among users who may be involved with heavy work in unforgiving environments or among users who are generally more functionally minded and have less regard for cosmesis [2, 3, 8]. However, there is still room for functional improvement of BP systems. Biddiss et al. [8] report that consumer design priorities for BP prosthesis users include improved comfort, reduced mass, and further functional enhancements. Specifically in regard to function, users express desire for improved wrist movement and control, improvements in overall maneuverability, coordination, and sensory feedback. While BP systems currently prevail in the area of sensory feedback, users express interest in further improvements here. Finally, increased grasp force is also of interest for BP system users [8]. It should be pointed out that no studies met inclusion on the subject of voluntary closing, which may offer some solution to the issue of deficient grip force. While there are certain functional benefits associated with BP prosthetic use, improvements are still necessary to maximize user's functionality and quality of life.

MYO prostheses with hand terminal devices reportedly improve cosmesis compared to BP prostheses with hook terminal devices [2, 3]. Other studies show that users concerned with cosmesis prefer a myoelectric prosthesis [9]. Myoelectric prosthesis users also reportedly have improved psychosocial and social adaption compared to body-powered users [9], likely due to aesthetic design of myoelectric prostheses. From a cosmetic perspective, BP prostheses include harness suspension systems with cable controls that can be visible through and damaging to the user's clothing in addition to irritating the axilla [3]. The combination of these factors may influence prosthetic choice for users concerned with cosmesis.

Moderate evidence indicates that in order to improve intuitive prosthetic control, multiple control strategies may need to be implemented. Intuitive control strategies should require less visual attention, allow for coordinated motions of two joints and should be evaluated for each individual prosthesis user. According to experts, MYO control offers little proprioceptive feedback or information to the user regarding joint position, speed of movement and grip force [2, 7]. Conversely, when someone has already accepted a MYO prosthesis as their primary system, they tend to report improved sensory feedback, including proprioception, in connection with the prosthesis [10]. Davilli et al. [11] describe early technological designs integrating tactile and thermal feedback for MYO prosthesis users. Pattern recognition control systems that allow multiple movements have the potential to provide more reliable MYO prostheses via self-recalibration, improved maintenance and increasing functional use time and wear [12].

Both BP and MYO prosthesis users prioritize wrist movement, improved control mechanism that require less visual attention and the ability to make coordinated motions of two joints [13]. There is a lack of agreement between professionals and prosthesis users regarding matters of importance [14] suggesting that experts attempting to improve upper extremity prosthetic control need to better match innovation and design to user's preferences. It is also possible that systems designed for controlling normal human anatomy and physiology may be inadequate in subtle ways. For instance, Smits et al. [15] report that the typical triphasic EMG contraction pattern seen during upper limb movement in the normal arm, while present when the transhumeral amputee's arm is moved, is modified. If contemporary control and interface systems are exclusively designed around unimpaired signaling, then unsatisfactory control and function may result. The limited evidence suggests that upper limb prosthesis improvement may require an individualized control strategy and training plan. It is important to note that over 260 articles were excluded due to their focus on development of specific control algorithms or EMG processing but did not test these with actual prosthetic devices or prosthesis users. Translational research in this area is lacking.

Economic Implications

When healthcare costs are a factor, the fact that BP systems require less training and that they are more durable than alternatives also has appeal to assure enhanced functionality with potentially less healthcare financial resources. Blough et al. [16] projected costs over the lifespan of veterans who lost their upper extremity(ies) in service during the Vietnam War compared with veterans and service members from Operations Enduring Freedom and Iraqi Freedom (OEF/OIF). They reported that upper extremity prosthetic costs over the lifespan for Vietnam veterans with unilateral UE loss who owned and used 1.0±0.8 devices at a time were $131,900. Conversely, veterans from OEF/OIF who had unilateral UE limb loss used 1.8±1.7 devices at a time and had projected lifetime costs of $823,239 for prosthetic care. These prosthetic projections are helpful but predicated on multiple assumptions and do not clarify the specific devices utilized. More recently, Resnik et al. reported externally powered upper limb prostheses range in cost from $25,000 to $75,000 which is substantially higher than BP prostheses ranging from $4,000 to $10,000 [17]. Insurance reimbursement has also changed considerably in that time. Nevertheless, while these UE prosthetic costs demonstrate [10, 16, 17] that MYO are more expensive and require more training [3], a detailed healthcare economic analysis of upper limb prosthetic costs related to both device provision and training is presently needed to clarify financial differences and the associated cumulative financial impact on the user.

Future Research

Outside of surveys, there is little evidence addressing the functional capabilities of prostheses users, and fewer studies making a direct comparison of prostheses in a controlled setting. A few standardized tests to directly evaluate prostheses function were found in multiple studies. Currently evidence is insufficient to conclude that either the current generation of a MYO or a BP prosthesis provides a significant general advantage. Selection of a prosthesis should be made based on a patient's individual needs with regard to domains where differences have been identified. A patient's personal preferences, prosthetic experience and functional needs are all important factors to consider. This work demonstrates that there is a lack of empirical evidence regarding functional differences in upper extremity prostheses. Future research should address this lack of evidence.

Acknowledgements

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Suggested Citation

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