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ABSTRACT

Prosthesis users often make a choice between a myoelectric or body-powered upper-limb prosthesis. The choice may be determined using factors such as cost, insurance limitations, function, sensory feedback, and cosmesis. An updated systematic review was conducted to determine differences between myoelectric and body-powered prostheses in the past 3 years (mid-2013 to 2016) since the previous review. An additional 43 unique publications were identified. Ultimately, three of the publications were included, adding evidence to two previously developed empirical evidence statements regarding the potential need for multiple control strategies to facilitate intuitive prosthetic control and the value of task training in improving function. However, there is still insufficient evidence to conclude that either the myoelectric or body-powered prosthesis provides an overall advantage. Although excluded from this literature review, research on hybrid prostheses such as the DEKA arm and on sensation and haptic feedback is emerging. There is still a need for more empirical evidence regarding functional differences in upper-limb prostheses. (J Prosthet Orthot. 2017;29:P17–P20)

KEY INDEXING TERMS: amputation, control strategy, prosthesis, rehabilitation, transhumeral, transradial

It is well documented that the number of people living with an amputation is increasing, with the most recent estimates from 2005 suggesting that 41,000 individuals in the United States are living with major upper-limb loss. A study examining US service members from 2001 to 2011 reported that 14% of amputations involved the upper limb. Literature reports of rejection rates of upper-limb prostheses vary from 0% to 50% due to factors such as lack of perceived functional gains, prosthetic weight, and socket discomfort among others. Prosthetic prescription currently depends to varying degrees on patient input, the experience of treating clinicians with available components, literature on component function, manufacturer’s claims, and reimbursement methods. The purpose of this updated systematic review was to determine if new evidence supporting the differences between myoelectric (MYO) and body-powered (BP) prostheses in the areas of functionality, control, and sensory feedback, cosmesis, and rejection has emerged since the previous review conducted in 2013.

METHODS

LITERATURE SEARCH

Similar to the previous literature review, a systematic search was conducted using 9 databases for publications of articles from 2014 to 2016. As in the initial review, the databases were searched using broad key words related to upper-limb prostheses: myoelectric, body-powered, externally powered, transradial, transhumeral, upper limb, prosthesis, and artificial limb.

ELIGIBILITY CRITERIA

Inclusion and exclusion criteria were established to select publications that were relevant to the review’s purpose statement, which was to compare MYO and BP prostheses to help guide evidence-based clinical decisions. Editorial, case study/series, observational research designs, or literature reviews published between 2014 and 2016 were included. Conference proceedings, white papers, theses, dissertations, progress reports, non-English articles, partial hand/finger articles, surgical articles, modeling articles, pediatric articles, and electromyography (EMG)-only articles were excluded from the review. In addition, articles describing prostheses not currently commercially available such as the DEKA arm, able-bodied—only studies, or publications describing sensation capabilities were excluded because they did not pertain to the review’s purpose statement.
ASSESSMENT OF METHODOLOGICAL QUALITY

The study design and methodological quality of those publications that met the inclusion and exclusion criteria were independently assessed by at least two of three reviewers according to the protocol developed by the American Academy of Orthotists and Prosthetists (AAOP) State-of-the-Science Evidence Report Guidelines.8 Reviewers discussed pertinent issues until consensus on study design and methodological quality was obtained for the included publications.

Each reviewer rated each study according to the AAOP Study Design Classification Scale that describes the type of study design. The State-of-the-Science Conference (SSC) Quality Assessment Form was used to rate the methodological quality of studies classified as experimental (E1–E5) or observational (O1–O6). The form identifies 18 potential threats to internal validity with the first 4 (E3–E5) or 5 (O1–O6) criteria not applicable for given classification and 8 potential threats to external validity.8 Threats were evaluated and tabulated.

EMPIRICAL EVIDENCE STATEMENTS

Based on results from the publications included in the updated review, empirical evidence statements (EESs) that compared BP and MYO prostheses were either developed or had their strength reevaluated. Reviewers rated the level of confidence of each EES as “high,” “moderate,” “low,” or “insufficient,” based on the updated number of publications contributing to the statement, the methodological quality of those studies, and whether the contributing findings were confirmatory or conflicting as similarly outlined by others.9 Note that in addition to peer-reviewed studies, editorials and systematic reviews were also included to the moderate and low confidence level descriptions due to the lack of observational and experimental studies available in the literature on the topic.

RESULTS

LITERATURE SEARCH

The updated literature review yielded 43 unique articles. After screening the inclusion and exclusion criteria, 33 publications were excluded. Ten articles were reviewed and scored for content and quality and an additional 7 articles were then excluded. This resulted in three publications included in the qualitative synthesis10–12 (Table 1).

STUDY DEMOGRAPHICS

The reviewed studies were classified into 1 of 9 defined study designs as described by the AAOP Study Design Classification Scale.8 Two publications were classified as O3, cross-sectional studies, and one was classified as E5, a controlled before-and-after study. Sample sizes range from 2 to 22 prosthesis users with additional able-bodied subjects studied for comparison. In total, this updated systematic review included 31 subjects with amputation and 33 able-bodied controls.

OUTCOME MEASURES FOR ASSESSMENT OF UPPER LIMB

The following outcomes were measured in the included publications: the SHAP test, surveys,10 movement time, force control, box and blocks test, duration of hand opening,11 range of motion, absolute kinematic variability, kinematic repeatability (adjusted coefficient of multiple determination) for trunk motion, shoulder flexion/extension, shoulder abduction/adduction, and elbow flexion/extension.12

METHODOLOGICAL QUALITY ASSESSMENT

Two of the included studies had moderate and one had low internal validity. Threats to internal validity preventing attainment of high scores included a lack of blinding and lack of

Table 1. Characteristics of included studies

<table>
<thead>
<tr>
<th>Author (yr)</th>
<th>Study design</th>
<th>Prosthesis types</th>
<th>Sample size</th>
<th>Mean age</th>
<th>Outcome measures</th>
<th>Overall quality of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensinger et al.10 (2015)</td>
<td>E5</td>
<td>Body-powered</td>
<td>2 individuals with amputation, 5 able-bodied</td>
<td>29, 30</td>
<td>SHAP, survey</td>
<td>Low</td>
</tr>
<tr>
<td>de Boer et al.11 (2016)</td>
<td>O3</td>
<td>Myoelectric</td>
<td>22 individuals with amputation; 22 able-bodied</td>
<td>Controls matched on sex, age (±5 yrs)</td>
<td>Movement time, force control, box and blocks, hand opening duration</td>
<td>Moderate</td>
</tr>
<tr>
<td>Major et al.12 (2014)</td>
<td>O3</td>
<td>Myoelectric</td>
<td>7 individuals with amputation; 6 able-bodied</td>
<td>49, 35</td>
<td>ROM, absolute kinematic variability (SD), kinematic repeatability (adjusted coefficient of multiple determination) quantified for triplanar trunk motion, shoulder flx/ext, abduction/adduction, elbow flx/ext</td>
<td>Moderate</td>
</tr>
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</table>

Mean age is in yrs. ROM indicates range of motion; SD, standard deviation; flx, flexion; ext, extension.
DISCUSSION

EMPIRICAL EVIDENCE STATEMENTS

The previous systematic review of MYO and BP prostheses developed 11 EESs. The additional publications included in this review update added evidence to two of these EESs:

- “Intuitive prosthetic control may require use of multiple control strategies, such as BP, MYO, or hybrid, that require less visual attention and ability to make coordinated motions of two joints but should be evaluated for each individual upper-limb prosthesis user.”
- “Prosthetic rehabilitation plan addressing critical factors such as EMG site selection, controls and task training, and comfort by cohesive team will improve function and long-term success of electrically powered prosthesis users.”

LIMITATIONS

Additional studies might have been included; however, their generalizability to the study purpose and population was sufficiently unclear. For instance, publications including only able-bodied subjects using a simulator were excluded. This is because current literature does not demonstrate that the degree of impairment is comparable between simulated prosthetic use in able-bodies and actual prosthetic use among persons with amputation.

DEKA arm studies were also excluded. The DEKA arm has multiple different control strategies relevant to the study topic. However, the system is not representative of classic MYO systems and has heretofore only been available to a limited population. Further, it is not commercially available at this time.

CONCLUSIONS

Since the previous systematic review evaluating differences in MYO and BP upper-limb prostheses, new evidence has emerged, which strengthens evidence suggesting that intuitive prosthetic control may require the use of multiple control strategies for each individual upper-limb prosthesis user. Evidence has also since emerged indicating that prosthetic rehabilitation addressing critical factors will most likely improve function and long-term upper-limb prosthetic success. It seems that, at this time, there is inadequate evidence to support an overall advantage of BP upper-limb prosthetic control or MYO prosthetic control. Rather, individual patient attributes, goals, and functional needs reporting effect sizes. Strengths noted in internal validity were clearly outlining eligibility criteria and acclimation as well as the use of reliable outcome measures and the attainment of statistical significance.

Two of the included studies yielded moderate level external validity and one achieved high external validity. Threats to external validity included lack of documentation regarding clinical significance and generalizability of the sample. Strengths to external validity included clear sample and outcome descriptions and conclusions supported by study results (Table 2).

Ultimately, Sensinger et al.10 a controlled before-and-after trial (E5) had low overall quality, whereas de Boer et al.11 and Major et al.12 both cross-sectional studies (O3), demonstrated moderate overall study quality.

The publication by de Boer et al.11 studied intermanual transfer effects of experienced below-the-elbow MYO prosthesis users and concluded that intermanual transfer has relevance regarding training of persons with upper-limb amputation. This supports the previous EES suggesting that control scheme familiarity can make either BP or MYO prostheses more advantageous. This publication also supports the EES regarding a prosthetic rehabilitation plan that addresses critical factors including control and task training that will improve function and long-term success of electrically powered prosthesis users.

Major et al.12 concluded that training dedicated to optimization of compensatory dynamics may be necessary to improve the functionality of transradial prosthesis users. This adds evidence to both the previously mentioned EESs regarding control scheme familiarity and a prosthetic rehabilitation plan that factors in control and task training.

Table 2. Internal and external validity of included studies

<table>
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<tbody>
<tr>
<td></td>
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<td>1-4   5  6 7 8 9 10 11 12 13 14 15 16 17 18</td>
<td>Total</td>
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<tr>
<td>Sensinger et al.10 (2015)</td>
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A dot (●) signifies that the study included the respective criterion, whereas a blank space signifies that the criterion was not represented in the study. n/a indicates not applicable; Mod, moderate.

The updated systematic review added more evidence to two previous EESs that describe the potential need for multiple control strategies in an individualized prosthetic care pathway and the importance of a comprehensive rehabilitation plan to prosthetic success.

Sensinger et al.10 concluded that users performed better on the SHAP test when they could switch between voluntary opening and voluntary closing modes of their BP prostheses. This conclusion supports the EES that intuitive prosthetic control may require use of multiple control strategies and should be evaluated for each individual upper-limb prosthesis user.

The publication by de Boer et al.11 studied intermanual transfer effects of experienced below-the-elbow MYO prosthesis users and concluded that intermanual transfer has relevance regarding training of persons with upper-limb amputation. This supports the previous EES suggesting that control scheme familiarity can make either BP or MYO prostheses more advantageous. This publication also supports the EES regarding a prosthetic rehabilitation plan that addresses critical factors including control and task training that will improve function and long-term success of electrically powered prosthesis users.

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largely determine, which control strategy and prosthetic type is optimal for each patient with upper-limb amputation.

REFERENCES