

Natalie Thomas, MSOP and Wendy Beattie, CPO, FAAOP; Eastern Michigan University; nthoma20@emich.edu

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VO_{2Max} Testing as a Predictor of Prosthetic Function

Clinical Question: Can VO_{2Max} testing determine whether prosthetic use is advisable for an individual dysvascular lower limb amputee given his/her current functional capacity?

Background: The physiological impact of limb loss and the physiological condition of lower limb amputees effects prosthetic candidacy. Successful ambulation with a prosthesis requires that the amputee be able to meet above average energy expenditure demands. This critically assessed topic will investigate research on the degree of physical fitness required for successful prosthetic use. Potential for positive prosthetic outcome is traditionally determined by use of the Amputee Mobility Predictor (AMP), a multi-step test involving physical activities, as stated by Gailey et al. Outcomes of the AMP focus almost exclusively on the musculoskeletal system and do not directly measure the physiological health of the patient. Maximal oxygen consumption (VO_{2max}) is the criterion method used to describe and stratify levels of cardiorespiratory fitness and associated physiological risk factors. Would the inclusion of testing the physiological fitness of lower limb amputees via maximal oxygen consumption in addition to the functional information obtained by the AMP provide valuable information regarding potential outcomes of prosthetic use?

Search Strategy:

Databases Searched: Google Scholar

Search Terms: “Lower Limb Amputee”, “Maximum Oxygen Uptake”, Rehabilitation, Elderly, Prosthetics, and Fitness (sequentially)

Inclusion/Exclusion Criteria: English language

Synthesis of Results: Fleury et al.’s systematic review on the factors affecting prosthetic rehabilitation of older vascular lower extremity amputees assessed 308 articles. Age alone was found to not be an absolute contraindication to gait retraining. An amputee’s pre-morbid function and mobility is extremely indicative of post-amputation rehabilitation, as many older adults might have been sedentary for long periods of time. Additionally, the ability to stand unsupported on the remaining limb is key in predicting successful prosthetic use. The number of comorbidities as well as the severity of these can affect the likelihood of prosthetic rehabilitation. The authors reported support for safe and successful ambulation using a prosthesis requires that a patient reach an intensity of 50% of VO_{2Max} or higher. Chin et al assessed the physical fitness of 17 transfemoral dysvascular amputee patients not previously fit with a prosthesis using a cycle ergometer. Percent VO_{2Max} was found to be a significant indicator of prosthetic success. They determined that 53.9% VO_{2Max} or higher was indicative of individuals who would be successful prosthetic users. Erjavec et al aimed to establish the exercise power level closest to the 6-minute walk test in people with lower limb amputation due to peripheral vascular disease (PVD). They concluded that people after transfemoral amputation who reach the level of 30 W or more in the exercise test with an arm ergometer are likely to be able to complete the 6-minute walk test using a prosthesis. This conclusion suggests that simple exercise testing can be useful for screening to determine prosthetic candidacy. Toda et al, examined the ambulatory outcome of 7 unilateral hip disarticulation amputees. They found a strong correlation between the % VO_{2Max} measured and ultimate success with ambulation.

Clinical Message: In conclusion, there is support for the premise that physiological testing can aid in the evaluation of individuals with lower limb amputations. This data has not been compared with the results from evaluation with the AmpPro, a standard evaluation tool which does not require ergometers or respiratory gas collection/evaluation systems. It would be deleterious to have oxygen consumption become a litmus test of sorts, as many individuals undergoing amputation have become deconditioned in the lead up to, and recovery from amputation. Instead, perhaps physiological testing would become an addition to the evaluation process of a new amputee and could lead to meaningful and deliberate physiological rehabilitation. If improvements to overall physical fitness were realized, this could be followed by prosthetic intervention, if desired and appropriate.

References:

1. Chin, T., Kuroda, R., Akisue, T., Iguchi, T., & Kurosaka, M. (2012). Energy consumption during prosthetic walking and physical fitness in older hip disarticulation amputees. *Journal of Rehabilitation Research and Development*, 49(8), 1255-1260.
2. Erjavec, T., Vidmar, G., & Burger, H. (2014). Exercise testing as a screening measure for ability to walk with a prosthesis after transfemoral amputation due to peripheral vascular disease. *Disability and Rehabilitation*, 36(14), 1148-1155.
3. Fleury, A. M., Salih, S. A., & Peel, N. M. (2013). Rehabilitation of the older vascular amputee: A review of the literature. *Geriatrics and Gerontology International*, 13, 263-273.
4. Gailey, R. S., Roach, K. E., Applegate, E. B., Cho, B., Cunniffe, B., Licht, S., . . . Nash, M. S. (2002). The amputee mobility predictor: An instrument to assess determinants of the lower-limb amputee's ability to ambulate. *Archives of Physical Medicine and Rehabilitation*, 18(5), 613-627. <http://dx.doi.org/10.1053/apmr.2002.32309>
5. Toda, M., Chin, T., Maeda, N., Kitagawa, A., & Kohno, H. (2015). The threshold of physical fitness in terms of maximal oxygen uptake as a predictive factor for achieving prosthetic walking in elderly with unilateral transferal amputation or hip disarticulation. *Sports and Exercise Medicine*, 1(4), 126-132. <http://dx.doi.org/10.17140/SEMOJ-1-120>
6. Waters, R. L., & Mulroy, S. (1997). The energy expenditure of normal and pathological gait. *Gait and Posture*, 9(3), 207-231. [http://dx.doi.org/10.1016/S0966-6362\(99\)00009-0](http://dx.doi.org/10.1016/S0966-6362(99)00009-0).

Evidence Table

	Chin, 2012¹	Erjavec, 2014²	Fleury, 2013³	Toda, 2015⁵
Population	<i>17 dysvascular TF amputees</i>	<i>101 consecutively recruited participants after transfemoral amputation due to PVD</i>	<i>Dysvascular, lower limb amputees, over 65 years old.</i>	<i>7 consecutive HD amputees at a rehab facility, over 60, never worn a prosthesis previously</i>
Study Design	<i>Retrospective</i>	<i>Prospective exploratory cohort study</i>	<i>Literature Review</i>	<i>Prospective, consecutive</i>
Intervention	<i>Fit and trained subjects with TF prostheses</i>	<i>Rehabilitation program and fitness testing with hand wheel ergometer</i>	<i>Prosthetic fitting</i>	<i>Fit and trained all subjects with HD prostheses</i>
Comparison	<i>Successful or unsuccessful prosthetic users at the end of rehab</i>	<i>Comparing the mean differences in oxygen uptake between the hand wheel ergometer exercise test and the 6MWT with respect to the maximum exercise power</i>	<i>Successful or unsuccessful prosthetic users, determined by various methods,</i>	<i>Successful or unsuccessful prosthetic users at the end of rehab</i>
Methodology	<i>Fitness assessed via %VO2 max during one legged cycle ergometer</i>	<i>Establish at which exercise-power level is the vascular response, as by the oxygen uptake during exercise testing using a hand-wheel ergometer, closest to the response during the 6MWT in people after lower-limb amputation due to PVD.</i>	<i>Review the literature on factors affecting prosthetic rehabilitation of older vascular lower extremity amputees.</i>	<i>Energy expenditure during ambulation assessed at CWS</i>

Outcomes	<i>Ability to walk with or without a cane for 100 meters</i>	<i>VO2 during 6 MWT</i>	<i>Various, including hours of use, distance able to ambulate, prosthetic prescription, etc.</i>	<i>Continued use of prosthesis for ambulation</i>
Key Findings	<i>50%VO2 max is minimum level of physical fitness for successful TF use in subjects with dysvascular amputation</i>	<i>30 W is the maximum exercise power threshold necessary for the ability to successfully walk with a prosthesis after transfemoral amputation</i>	<i>Further research on the factors affecting prosthetic rehabilitation of lower extremity amputees is needed to formulate the most appropriate assessment tool to identify patients who will undergo successful prosthetic ambulation.</i>	<i>60%VO2 max is necessary for successful HD use in individuals over 60</i>
Study Limitations	<i>Small sample size</i>	<i>Small sample size</i>	<i>Lack of a single assessment tool, or outcome measure</i>	<i>Small sample size</i>