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Research Article

Predicting Walking Ability and Prosthetic Candidacy Following Lower Extremity Amputation; An Updated Systematic Review and Treatment Pathway

Scott Love[1]*, Carolyn Dias-Karch[1], Bianca Saragusti[1], Rebekah Langreck[1], Kayla Aponte[1], Rebecca Miro[2] and M Jason Highsmith[3]

[1]University of St. Augustine for Health Sciences, Doctor of Physical Therapy Program, St. Augustine FL

[2]University of South Florida, Morsani College of Medicine, School of Physical Therapy and Rehabilitation Sciences, Tampa, FL

[3]University of South Florida, Morsani College of Medicine, School of Physical Therapy and Rehabilitation Sciences, Tampa, FL. And U.S. Army Reserves. 319th Minimal Care Detachment. SP Corps. Pinellas Park, FL

***Corresponding Author:** Scott Love, University of St. Augustine for Health Sciences, Doctor of Physical Therapy Program, St. Augustine FL.

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Abstract

Background: There is not a clear compilation of existing literature that determines walking ability and prosthetic candidacy following lower extremity amputation (LEA). There is no multi-disciplinary instrument or patient centric decision-making protocol accepted that can predict walking ability and prosthetic candidacy nor support a treatment pathway. It is important to determine these factors to better assist clinicians in determining a patient's MFCL K-level to assist with the delivery of proper prosthetic componentry. Medicare Functional Classification Level (MFCL) K-level is a 0 to 4-point scale of functional level for those with limb loss. The purpose of this systematic literature review is to further develop evidence-based LEA patient centric treatment pathways that determine prosthetic candidacy decisions for LEAs. This evidence will assist the healthcare team in the decision-making process. In a similar systematic review (SR), Kahle., et al. reported into 2016 on the prediction of walking ability following lower limb amputation (LLA).

Methods: This search strategy was designed and similarly implemented from the previous Kahle SR based on predicting walking ability. An electronic literature search was executed from 8/1/2007 to 12/31/2015 using MEDLINE, EMBASE, CINAHL, and Cochrane.

Results: After electronic search and a thorough review and elimination of articles, a total of 104 quality studies were identified. Of these, 78 were systematically reviewed in two previous reviews and eliminated. Twenty-six remained for full evaluation. These updated study conclusions are drawn from a total sample (n) of 46,651 subjects. The size of this updated study has increased the original Kahle., et al. report by including 300% more subjects for a combined total of 61,858 subjects in the two SRs.

Conclusion: In the two combined SRs, cause of amputation (etiology), physical fitness, pre-amputation living status, amputation level, age, physical fitness, cognitive/mood disturbances, social support and comorbidities are included as moderate to strongly supported predictive factors of walking ability and prosthetic candidacy. These factors should be strongly considered in a detailed history and physical examination by the rehabilitation team and documented in the patient healthcare record.

Keywords: Amputee; K-Level; Prosthesis; Rehabilitation; Functional Level; Prosthetic Candidacy; Treatment Pathway

Introduction

Currently, there is no known multi-disciplinary physical rehabilitation instrument or patient centric decision-making protocol that can predict walking ability and prosthetic candidacy nor support a treatment pathway. In previous literature the prediction of walking ability has been reported [1]. However, these studies provide limited information, and some is not relevant today due to advancements in rehabilitation and prosthetic technology. Nor do they offer a clinical treatment pathway regarding the prediction of walking ability and prosthetic candidacy following lower LEA. Given the fact that the number of amputees living in the USA are predicted to increase two-fold to 3.6 million by the year 2050 [2]. An evidence-based rehabilitation treatment pathway is needed to streamline care for correct, initial, definitive prosthetic prescrip-

tion for LEA patients. This would benefit the physical therapy and prosthetic professions as well as the amputee who may eventually become a prosthetic user [3].

In a systematic review (SR), Kahle., *et al*. reported on the prediction of walking ability following lower limb amputation (LLA). Conclusions of that SR were that etiology, physical fitness, pre-amputation living status, amputation level, age, physical fitness, and co morbidities are included as moderate-to-strongly supported predictive factors of prosthetic candidacy. The Love SR has a higher mean age of 59.08y, as compared to the Kahle SR mean age of 57.03y. Most notably, this SR had one study by Cooper., *et al*., with a large N of 29543 with age range listed as 50y to 90y. Cooper., *et al*. studies took place in skilled nursing homes which would direct you to believe these subjects may be at the older end of the age range. Also, in the vanVelzen., *et al*. study, 2570 subjects were listed as mostly elderly. From these two studies, one could concur that the Love SR was studied with a much older subject selection than the Kahle SR. Further study of predictive factors in the elderly LEA population is needed to determine potential walking ability in more detail. Modifiable factors, such as smoking and obesity, can be targeted to optimize results after lower extremity amputation (LEA). Establishing accepted CPGs would be the end goal of this review. Before prosthetic prescription all attributes of walking potential should be considered. Not walking in the LEA population can lead to delirious effects in the major body systems and advance to a rapid decline in overall health.

In previous literature, the prediction of walking ability has been reported [4]. However, these studies provide limited information, and some is not relevant today due to advancements in rehabilitation and prosthetic technology. Nor do they offer a clinical treatment pathway regarding the prediction of walking ability and prosthetic candidacy following lower LEA. The quality of physical medicine research has improved in the last decade. Kahle., *et al.*'s SR included literature published through December 2015. The purpose of this study is to conduct a systematic review (SR) of additional existing literature to examine characteristics of persons with amputation which predict walking ability and prosthetic candidacy following LEA. The importance of this project is to further develop evidence-based clinical practice guidelines, and patient centric treatment pathways LEAs to receive an initial prosthesis that matches their functional abilities. This review is an updated addition of similar methods from past systematic reviews that assists in establishing a broad and current base of evidence examining walking ability in LEA patients.

Methods

The same search strategy employed by Kahle., *et al*. was repeated for this systematic review an electronic literature search was executed from 8/1/2007 to 12/31/2015 using MEDLINE, EMBASE, CINAHL, and Cochrane, and using the following keywords in the title or abstract.

Search 1

Walking candidacy* OR ambulatory candidacy* Meta-Analysis Articles

This was the widest search; an initial starting point yielded no applicable results. The search was expanded and specifically defined to yield appropriate articles.

Search 2

Title/Abstract/Keywords

Amput* OR limb loss AND ambulat* OR walk OR mobil* OR function* OR capacity OR strength OR stabile OR stabili* OR hospitiliz* OR outcome* OR quality OR prosthe* AND Title/Abstract/Keywords Preferred Language* OR Sex* OR Race* OR Ethnicity* OR DOB* OR Height* OR Weight* OR BP* OR BMI* OR Smoking (tobacco)* OR Medication* OR Drug* OR Lab-test* OR Clinical Decision Support* OR Clinical Quality Measures* OR Patient Specific Education Resources*.

Manuscripts were selected or eliminated based on the following criteria

Inclusion criteria

- Adult subjects with unilateral or bilateral lower limb amputation;
- Published after 8/1/2007
- Examined the relationship between predictive variables recorded prior to amputee rehabilitation and measures of walking ability following rehabilitation.
- Studies using health outcomes with a mobility component, such as the Functional Independence Measure
- English language
- Observational, retrospective studies if predictor variables were available.
- Randomized clinical trials.

Exclusion criteria

- Previously identified and discussed by Kahle., et al.
- Non-adult
- Prosthetic device or réhabilitation interventions studies
- Animal studies

- Case reports and series
- Letters, editorials, conference proceedings
- Manuscripts from developing nations.

Two authors independently assessed selected papers for content, quality, and critical appraisal. Like the original Kahle., *et al.* SR, a standardized checklist was used to abstract each report's methods, population, outcome measures and predictive factors[1]. Additionally, the UK National Service Framework for Long-term Conditions was used to assess the quality of each study as it allows assessment of quality in non-randomized cohort studies [5]. The reports and data extracted were verified by 2 independent authors who agreed upon a final scoring and data extraction. The International Classification of Functioning, Disability and Health (ICF) was used to present the predictive factors identified from these studies. Following study, evaluation and data extraction, factors predictive of walking ability and prosthetic candidacy following LEA were aggregated and their narratives were compared with the findings of the original Kahle., *et al.* SR. Meta-analysis was not possible, as the studies of similar outcome measures did not observe the same homogeneous patient characteristics; mainly amputation level, etiology and mean ages, were heterogeneous among these studies [1,4].

Results

Number of Identified Studies

A total of 2874 studies were identified through electronic search. Of these, 2770 were eliminated leaving a total of 104. Of these 104 articles, 78 were previously studied by Sansam and Kahle leaving a total of 26 for full evaluation (Figure 1).

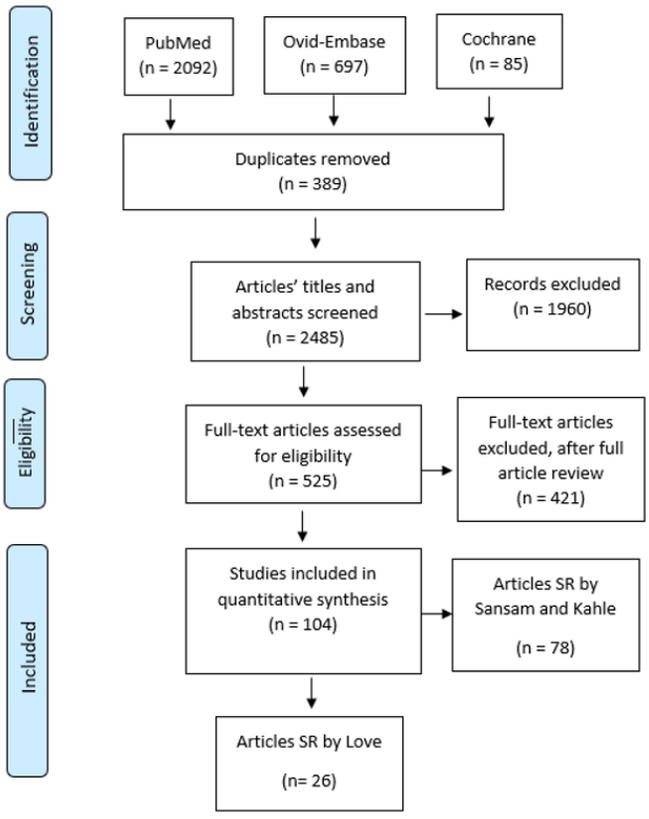

Figure 1: Prisma Flow Diagram.

Description of sample

The Love SR identified 45,651 subjects in 26 medium-but-mostly-high quality articles. Although height and weight were reported in six articles, they only involved 241 subjects out of the 45651 subjects. This represented only .005% of the sample and cannot be considered a powerful predictive characteristic.

Conversely, the Kahle SR. included a total of 12,410 subjects that were systematically reviewed with studies in 21 high and medium quality articles [4].

The Kahle SR reported three sub-groups of subjects: an experimental group of subjects with LEA, a control group of subjects with LEA and a control group of healthy subjects who were not amputees. Several of the studies included in the Kahle SR, had incomplete and inconsistent reporting of demographic and etiology data, which limited the ability to fully report the data. Of those studies sufficiently reporting this information, LEA etiology had the following distribution: 37% PVD, 27% trauma, 17% diabetic, 12% cancer, 6% infection and 2% congenital. Within the experimental group of LEAs, the subjects described had a mean age of 57.3y with a range of 48.1y to 69.8y. Within the described control group of subjects with LEA, the reported etiology was typically peripheral vascular disease (PVD) with comorbid diabetes mellitus (DM). Their mean age was 61.8y with a range of 46.0y to 67.7y. The smaller group of non-amputees, healthy control subjects described had a mean age of 49.0y with a range of 26.1y to 61.7y.

In the Love SR, because of the data in the articles reviewed, there were only two sub-groups: an experimental group of LEAs and a control group of LEAs. The control group was minuscule, amounting to 106 subjects or .002% of the N. Therefore, the control group will not be considered in the Love SR. In reviewing age and etiology of amputation data of those studies sufficiently reporting this information, LEA etiology had the following distribution: 58% PVD, 23% trauma, 8% diabetic, 7% cancer, 3% infection and 1% congenital. Within the Love SRs experimental group of LEAs, the subjects described had a mean age of 58.08y with a range of 25y to 81y. By comparison, the Kahle SR reported an age range of 48.1y to 69.8y in their study.

Three larger studies helped comprise most of the samples for the Love SR. Cooper., *et al*. included 29,543 subjects with an age range of 50y-90y. Cooper., *et al*. study took place in skilled nursing homes which would direct you to believe that these subjects may be in the older end of the age range. Sinha., *et al*. included 3,321 subjects but did not report an age range. However, Sinha., *et al*. did note an attrition rate of 43.5 and revealed that the study concerned the frail elderly. Finally, vanVelzen., *et al.* reported 2,579 subjects whose ages were listed as mostly elderly.

Inclusion of Cooper., *et al* and vanVelzen., *et al.* produces a SR with a sample size greater than the Kahle SR. Also, when analyzing amputation etiology, the Love SR had a combined percentage of PVD and diabetes subjects at 66%. The Kahle SR had a combined percentage 54% with similar subjects. A summary of the studies included in this systematic review and their characteristics is included in table 1.

First Author	Population	Total n	Walking Ability Measures	Results	Quality
Amtman 2015	Trauma 604, PVD 487,	1091	Physical function, depression, fatigue, sleep dist, satisfaction w social role, pain interference	LEAs report decreased physical function, pain interference, and satisfaction with social roles than the norm. Dysvascular LEAs reported decreased physical function and satisfaction with social roles than traumatic LEAs. Health indicator profiles provide clinically meaningful information of self-reported health status in LEAs.	High
Arneja 2015	NR	50	FIM, Length of stay	LEAs on chronic dialysis had significantly LOS and lower FIM scores compared with the non-ESRD group. Current practices need to be adjusted to accommodate the complex rehabilitation of ESRD LEAs.	High
Demet 2003	Trauma, PVD, Other	539	Nottingham HRQL	Men better than woman in HRQL, young age better HRQL, Older age shows less mobility, Vascular LEAs have greater physical disability	High
Durmus 2015	Traumatic	104	Depression, Satisfaction, Pain, Sleep disturbance, anxiety	Anxiety (state, trait or phobic), disturbed sleep, other psychiatric symptoms in LEAs undergoing lengthy prosthetic rehabilitation do differ from healthy controls. The presence and severity of phantom pain are unrelated to general psychiatric symptomology. Time since amputation, daily length of use and prosthesis satisfaction is negatively correlated with psychiatric symptoms.	High
Henry 20013	CH, DM, Renal	364	Additional amps, CV proc, Long LOS, Survival	Resource utilization high for amputees. Results similar across socio-economic levels. Higher social economic level pts may still have poor outcomes.	High
Hermodsson 1998	Vascular	112	MCFL after 6 months	The importance of this is that all amputees, whether fitted or not, should be rehabilitated and followed regularly for the remainder of their lives to ensure that their level of functioning is maintained as far as possible.	High
Hobara 2013	Not noted	25	Stair assessment index	The results of this study suggest that unilateral transfemoral amputees, both age and time could affect stair climbing.	High
Kalbaugh 2006	PVD	434	Prosthetic use, survival, maintenance of amb and ind living	BMI failed to correlate to outcome, although survival, ambulation, and independence were all lower in underweight individuals	High
Kingsbury 2014	Trauma	14	Gait, temporal spatial data, GRF on prosthetic and non-prosthetic leg	Preserving residual limb length improves loading at terminal stance.	High
Langlois 2014	6 trauma, CA 7 control	15	Ramp and slope ascent and descent	Quad strength and limb length increase ability on ramps and slopes	High
Lim 2006	Vascular and DM	87	Use of prosthesis	Young age more likely to receive prosthesis, longer rehab pts more likely to receive prosthesis, smoking significant comorbidity	High
Melchiorre 1996	12 trauma12 vasc	24	FIM Score	Trauma had less stump pain and co-morbidities. No significant difference in FIM	High

Miller 2001	52%vascular, 48% other	435	ABC scale fear of falling. Houghton, MS-PEG, Frenchay index, hx of falls. autonomy, years since amp, pain, social support, perceived health	Evidence to support prognosis for prosthetic and non-prosthetic mobility is not available in current literature.: Falling and fear of falling are pervasive among amputees. Comprehensive and ongoing intervention and education should be considered. Research is required to assess the consequences of falling and fear of falling. Falling and fear of falling may provide clinicians with a good marker to monitor physiologic and psychological change as well as prosthetic use and usefulness.	High
Nadollek 2002	10 vasc. 12 DM	22	Quiet stance, hip Abd. strength, gait parameters	More weight on sound limb than prosthetic limb, hip abductor strength positively correlates with gait parameters.	High
Osmani 2011	Trauma (Blast or GSW)	101	rehabilitation duration, ambulation grade (3-point SU scale), time to prosthetic fitting	Traumatic limb amputation should be performed as distal as possible, any delays in prosthetic fitting must be avoided, shorter time to prosthetic fitting associated with shorter rehabilitation time, but level more important.	High
Pohjolainen 1991	NR	125	walking distance, wearing a prosthesis, walking time, outdoor walking, walking aid use, accommodation situation	Prognosis for ambulation following ambulatory function and prosthetic use is best in younger and working age groups. Use of prosthesis can be improved by proper prosthetic fitting immediately after active postoperative training, especially in elderly amputees. Accommodation situation does not appear to relate to any studied factors	High
Raya 2010	52 Trauma, 20 Disease/ other	72	6-minute walk test	Hip abduction strength is a strong predictor of 6-minute walk test score, ability to rise from chair, sit down in controlled fashion, and step over an obstacle.	High
Remes 2009	NR, but geriatric	119	Socio-demographic factors, comorbidities, preamputation medications, age, Gender, level, cognitive impairment, hx of vascular procedures	Amputees who received prosthesis were significantly younger, more frequently male, lived with a companion, had unilateral BKA, and had diabetes became ambulatory, more frequently than those who remained non-ambulatory. Women were older than men and discharged into institutional care alone more than men, and use more antihypertensive medication than men.	High
Sinha 2011	Vascular, traumatic, congenital, tumorous	3321	Gender, age, education, phantom limb pain, depression, etiology	Women reported worse QoL than men, age and education important predictors of QoL. QoL adversely affected by phantom and stump pain, depression, vascular etiology.	High
Taylor 2005	Vascular	553	Age, level, race, gender, presence of DM2, history of smoking, presence of ESRD, CAD (high-risk eagle criteria), dementia, nutritional deficiency, etiology of amputation, history of vascular intervention of LE, ambulatory status before amputation, independent living status prior to amputation.	Older, sicker patients have a limited capacity for functional rehabilitation and may be best served with a palliative AKA. Conversely, healthier amputees with BKA achieve higher functional status. Hx of smoking not a predictive factor. Although more research is needed, BKA in these instances should not be considered failure of therapy, but another treatment option capable of extending functionality and independent living.	High
Vogel 2014	NR	4965	ADL score (by comorbidity, age, and amputation level),	AKA and BKA Medicare-eligible nursing home residents were associated with similar initial declines in functional status. While neither functional trajectory returned to baseline at six months after the procedure, BKA had superior trajectories in this population compared to AKA. Functional status after amputation in nursing home residents is multifactorial beyond procedure type, and this analysis has demonstrated worse functional trajectories after intervention were associated with female gender, poor baseline cognitive performance and poor baseline ADL scores. Comorbid conditions including ESRD and CVA were associated with significantly inferior trajectories and these patients may benefit from an AKA as their trajectories are the worst. The findings of this analysis highlight the importance of considering pre-morbid conditions, cognitive status, and baseline ADL function prior to amputation in nursing home residents. This data may assist providers and patients about the trajectory and time course of changes in functional status after amputation and physicians the opportunity to make more patient-centered outcomes decisions.	Medium

Carpenter 2014	Geriatric	769	Self-report: Cognitive impairment, depression, fall in past 12 months, lives alone, takes at least 6 medications, uses a cane, abnormal vs. normal baseline function, borderline vs. normal baseline function, inability to cut toenails, drives a car, drives only during the day, married, fair/poor vs. excellent/good health rating, taking at least 3 medications, non-healing foot ulcer, leg injury, diabetes, prior stroke, irregular heart rhythm, urine incontinence, wears eyeglasses, sense of imbalance, previous near fall, previous fall injury, sense of imbalance, previous 6-month ED visit, requires community services, unable to arise after fall, previous indoor fall, chair stand, chair sit, raise feet while walking, turn 180 degrees, visual acuity <20/20, impaired hearing, near tandem stand.	No factor successfully predicted falls within 6 months, This SR demonstrates that previously described predictors generally lack sufficient accuracy to increase or decrease fall risk, validation in other settings is needed.	High
Cooper 2011	Geriatric	29543	Grip Strength, walking speed (short walking tests, chair rising (5xSTS), timed up and go, standing balance.	younger participants tended to have higher levels of physical capability as indicated by stronger grip strength, shorter chair rise times, faster walking and TUG speeds and lower odds of inability to balance for 5 seconds than older participants. Physical capabilities decline with age. Men tend to perform better than women with the exception of walking speed, which can be explained by differences in body size.	High

Table 1: Summary of Studies included in Literature Research.

Settings, study designs and independent variables

The predominant setting for the Love SR was skilled nursing centers. In Cooper., *et al*. this study had 29543 subjects. The setting of this study was listed as a research program. Upon review of the Love SR studies, data was taken from mostly skilled nursing facilities. Additionally, subjects were studied in varied organizations, including prosthetic rehabilitation programs, Veteran's Administration hospitals, university hospitals and community dwellings. In addition to these settings, data was also collected from hospital settings, army hospitals and university laboratories. Fifty three percent of the included studies were SRs. Thirty nine percent were retrospective and 8% were prospective studies. The predominant independent variable was LEA. Prosthetic fitting and rehabilitation was most listed as a treatment.

This is dissimilar to the Kahle SR., who found that the predominant setting for these studies was a rehabilitation center. Other settings included university medical centers, Veteran's Administration hospitals, private sector hospitals and skilled nursing facilities. In addition to these locations, data was also collected from military treatment facilities, trauma centers, private sector prosthetic practices and university laboratories. Fifty percent of the included studies were prospective, 38% were retrospective and 3% were SRs. The predominant independent variable was LEA. In the Love SR, prosthetic rehabilitation was commonly included as treatment [4].

The Love SR found independence in activities of daily living (IADLS) to be supported by a single reference, whereas the Kahle SR found BMI, motivation; social support, smoking, and phantom limb were each supported by a single reference. The Love SR found Race and time to rehabilitation to be moderately supported by 2 references. The Kahle SR found the following predictive factors; IADLs, time to rehabilitation, race, and vascular intervention were moderately supported by 2 references. The Love SR found these predictive factors more strongly supported in a moderate level, smoking, gender and physical fitness. These studies were supported with 3 to 5 references. The Kahle SR found the following predictive factors were more strongly supported with a moderate level of evidence of 3-5 references. They were the ability to stand on one leg, cognition and mood disturbance, gender, pre-amputation living status and cause of amputation. Race, vascular intervention, and pre-amputation living status were newly identified in the

Kahle SR as well as the Love SR and not identified in the original Sansam., *et al*. article [1,4].

The Love SR found co-morbidities, stump factors and pain, cognition/mood disturbance, vascular intervention/disease, premorbid living status, BMI/height and weight, gender, amputation level, cause of amputation and age to be the most strongly supported predictive factors when considering walking ability and prosthetic candidacy. They were supported by 6 or more references. In the Kahle SR, the factors most strongly supported by 6 references or more when considering walking ability and prosthetic candidacy, were amputation level, physical fitness, age, and comorbidities. In the Love SR and the updated Kahle SR, amputation level, comorbidities and age were determined to be strongly supported predictive factors. There is increasing agreement that these identified predictive factors are important when contemplating walking ability and prosthetic candidacy with the LEA subject.

Discussion

The purpose of this study was to extend the body of knowledge, using the same search strategy of predicting walking ability, following LLA, originally completed in the Kahle SR, The Love SR identifies predictive factors of walking ability and prosthetic candidacy and updates the findings to include current literature. We hypothesized that most factors, previously identified as important or predictive in determining walking ability and prosthetic candidacy, would be reinforced and that, potentially, new factors would emerge as important in determining a LEA receiving a prosthesis. This hypothesis was confirmed because all but five of the previous predictive factors were reported in the updated articles, with 15 of the same predictive characteristics from the original Sansam article. The Love SR and the Kahle SR identified eight new predictive factors in these reviews that were not previously identified in the original Sansam., *et al*. review [4].

Predictive factors

This literature review reports results from 26 studies in the eight-year range, from 2007-2015. The Kahle SR initially reported results from 21 articles from the same time span. The Kahle SR was groundbreaking in reporting results past the original Sansam., *et al.* article. The Sansam., *et al*. original search included 57 years of literature consisting of 57 studies from 1950-2007. This updated study increases the size of the original Kahle SR report by including 212% more subjects, for a total of 67,179, between the Kahle SR and the Love SR. In terms of prosthetic studies, this is a considerably large study, relative to other systematic reviews, which tend to include much smaller samples. In a recent comprehensive SR of microprocessor knee-based conclusions on 625 subjects [4], the subjects became an LEA due to PVD, which is consistent with epidemiologic data [2]. Given the percent of PVD LEAs, the ages reported and the majority practice setting being a skilled nursing facility, the results of the Love SR would have high generalizability in today's rehabilitation climate, especially when considering older PVD, LEA patients who are residents in skilled nursing facilities.

Body mass index (BMI)

In the Love SR, eight authors reported demographics (i.e., height, weight, and BMI). In these reports, they found BMI did not strongly correlate with improved prosthetic walking ability or prosthetic candidacy. The Kahle SR only found a single author, in a high-quality study, Linberg., *et al.,* reporting demographics (i.e., height, weight, BMI) These factors did not improve times in the six-minute walk test (6MWT) [4].

Motivation

In the Love SR, out of the 26 authors, none measured motivation as a predictive factor for walking ability. While the Kahle SR reviewed one article by Hamamura., *et al.* in a high-quality study, they found significance in motivation as a predictive factor for successful prosthetic ambulation among geriatric subjects [4]. Since no studies in the Love SR reported measuring motivation, this SR cannot report motivation as a predictive factor for walking ability or prosthetic candidacy.

Social support

In two high quality articles, Henry., *et al*. and Miller., *et al*. reported no improvement with walking ability related to social support [7,8]. In a small, high-quality study (N = 119) Remes., *et al*., identified that greater levels of social support were associated with more hours of prosthetic walking. These subjects were mainly younger, male, and lived with a companion [6]. In the Kahle SR in a high-quality article by Webster., *et al*., supported improved social support as a factor for walking ability [4].

Smoking

In the Love SR, high-quality studies by Lim., *et al*., Pohjolainen., *et al*., and Taylor., *et al*., reported smoking as predictive factor for walking ability. However, all 3 studies related the outcomes with delayed healing with diabetes mellitus (DM) subjects [9-11]. In the 2016 Kahle SR, a high-quality article by Wong., *et al*. reported that smoking was associated with significantly poor outcomes in diabetic TTAs. Another high-quality study by Czerniecki., *et al*. reported smoking status had a likely relationship with a more proximal level amputation[4].

	Cause of amputation (Etiology)	Amputation Level	Stump factors and pain	Cognition/ Mood Disturbance	BMI -Height, weight	Physical Fitness	Motivation	Ability to Stand on 1 Leg (SLS)	IADLs	Age	Comorbidities	Gender (sex)	Social support	Time to rehabilitation	Smoking	Premorbid living status	Race	Vascular intervention/ disease
Amtman 2015	1		1	1		1				1								1
Arneja 2015	1	1								1		1						
Demet 2003	1				1					1		1						
Durmus 2015	1		1		1	1				1		1						
Henry 2013	1	1								1	1	1	1				1	1
Hermodsson 1998	1									1								
Hobara 2013	1	1			1					1		1						
Kalbaugh 2006	1				1					1						1		
Kingsbury 2014	1	1			1					1								
Langlois 2014	1				1	1				1								
Lim 2006	1	1								1	1							
Melchiorre 1996	1		1							1	1							1
Miller 2001	1		1			1				1			1					
Nadollek 2002	1				1	1				1								
Osmani 2011	1	1								1				1				
Pohjolainen 1991		1	1		1					1		1		1	1	1		1
Raya 2010	1									1								
Remes 2009	1			1						1	1	1	1			1		1
Sinha 2011	1	1	1	1						1		1						1
Taylor 2005	1	1		1						1		1			1	1	1	1
Vogel 2014		1		1						1	1	1				1		
Carpenter 2014	1			1		1			1	1						1		
Cooper 2011										1		1						
Johannessen 2010	1	1								1		1				1		
Losa 2014	1									1								
vanVelzen 2006	1					1				1	1							
Total	23	11	6	6	8	7	0	0	1	26	6	12	3	2	2	7	2	7

Table 2: Predictive Factors investigated in articles.

Stump factors and pain

In the Love SR, stump factors and pain were strongly supported with six high-quality articles. Overall pain rating scores for LEAs were significantly worse than normal for pain interference, indicating LEAs have greater pain that interferes with prosthetic walking and participation in normal social activities [12]. In a small, high-quality study with (N=24), Melchiorre., *et al*. reported traumatic amputees had less pain interference [14]. In a large, high-quality study (N=3321), quality of life (QoL) factors by Sinha., *et al*. reported women demonstrated decreased QoL overall than men. Age and education were important predictors of QoL. Finally, QoL was adversely, directly affected by phantom pain/sensation, stump pain, depression, and vascular etiology of LEA[13].

In the Kahle SR, only the Van Eijk., *et al*. medium quality article reported that the presence of phantom pain was significant for decreased walking ability [4].

Independence in activities of daily living

In the Kahle SR, activities of daily living were studied. In a medium-quality article, using the preoperative Barthel Index (BI) as a measure of a LEAs ability to perform basic activities of daily living (ADL), van Eijk., *et al*. reported on ADLs as a predictive factor. The BI in this article reported as an evaluation of functional status at baseline. Preoperative BI was estimated, based on history taking and was significantly associated with increased prosthetic use [4]. BI was also a significant indicator for TUG test completion. Conversely, Wong., *et al*. in a high-quality study, found no correlation between IADLS and outcomes with TTAs. "This is inconsistent with the previous report of dependency for self-care prior to amputation is an independent negative predictor of walking ability up to 18 years after surgery" [4].

Time to rehabilitation

In the Love SR, only two articles used time to rehabilitation as a predictive factor for walking ability. Osmani., *et al*., in a high-quality study, reported that any delays in prosthetic fitting must be avoided; shorter time to prosthetic fitting is associated with shorter rehabilitation time. The Osmani., *et al*., study had an N=101, all young, trauma LEAs [16]. In another high-quality study, Pohjolainen., *et al*. concluded that the use of a prosthesis can be improved by proper prosthetic fitting immediately after active postoperative training. Due to the subjects studied being in a skilled nursing facility, they were most likely already in physical rehabilitation [10].

In the Kahle SR, it was reported that Stineman., *et al*. demonstrated in two different high-quality studies, that patients who had early physical rehabilitation made higher motor gains than those individuals who had later rehabilitation. Also, subjects who received acute postoperative inpatient rehabilitation compared to those with no inpatient rehabilitation, had an increased likelihood of 1-year survival after home discharge. Prosthetic limb candidacy and prescription did not differ significantly between groups [4].

Race

The Love SR reported, in two high-quality studies, that race had no significant impact on walking ability and prosthetic candidacy. In two high-quality studies from the Kahle SR, race was not a significant predictive factor in affecting the functional outcomes of LEAs or being a predictive factor of walking ability [4].

Vascular intervention

In the Love SR, vascular interventions were discussed in 7 high-quality articles. Amntman., *et al*. reported, in a high-quality study, that dysvascular LEAs reported decreased physical function and satisfaction with social roles than traumatic LEAs [12]. Also, Sinha., *et al*. in a high-quality study, suggests QoL is adversely affected by phantom limb and stump pain, depression and vascular etiology [13].

The Kahle SR, in a high-quality study, Suckow., *et al*. reported that it is possible to identify patients undergoing lower extremity bypass (LEB) who have the best chance to achieve good functional outcomes, even if a major amputation is ultimately required. These functional outcomes can be directly determined by patient health characteristics. These findings can assist with patient education for all therapists and surgical decision making for physicians who treat subjects who are poor candidates for lower limb bypass. Wong., *et al*. found indicators of poor vascularity, such as absence of popliteal pulse. Low Ankle Brachial Index measurements were significantly associated with poor clinical outcomes [4].

Ability to stand on one leg

There were no articles reviewed in the Love SR that studied ability to stand on one leg, as a predictive factor for walking ability and prosthetic candidacy. In the Love SR, most subjects studied were older and residents of skilled nursing facilities. Therefore, the ability to stand on one leg may not have been an appropriate testing measure for the population.

In the Kahle SR, a medium-quality study, by Grameaux., *et al*. identified the one leg balance test as appropriate for evaluation in the time directly following amputation so a prognosis can be established for success in prosthetic ambulation. "Hamamura., *et al*. in a high-quality study, identified the patient's ability to stand on one leg, the non-amputated limb, as one of the most valuable factors contributing to successful prosthetic ambulation in geriatric amputees, reporting significance in successful prosthetic walkers" [4]. van Eijk., *et al*. in medium-quality article, reported that one-leg

balance standing time was significantly, positively associated with prosthetic ambulation and prosthetic use [4].

Depression/Mood cognition

In one of the few studies that had a control group, a small but high-quality study by Durmus., *et al*. reported results among 51 amputees and 53 non-amputees. Durmus., *et al*. studied symptoms of anxiety among the two groups. Using a reliable and valid anxiety measure instrument, the amputee group had a higher score of state anxiety, trait anxiety and disturbances in their sleep, as compared to the control group. In the amputee group, no difference was measured in psychiatric symptoms between amputees who complained of phantom pain and those who did not experience phantom pain. There were significant increases in state anxiety when there was an increase in time since amputation, decrease in duration of prosthesis use, duration of daily prosthesis use, and satisfaction with prosthesis [15].

In a high-quality study by Taylor., *et al*. a strong statement about dementia was presented. Patients with LEA, with poor ambulation ability, over age 70, diagnosed with dementia, end-stage renal disease and advanced coronary artery disease and demonstrated poor functional levels should be considered bedridden. These subjects would be best served with a palliative above knee amputation. In this study of 627 amputees, most of the subjects were not prosthetic users, were TFAs over 60y or had a non-ambulatory household status. One could determine from the study's patient setting that the preponderance of the subjects had poor functional levels at the beginning of the study. Prosthetic use and daily ambulation are routinely witnessed in healthy patients over 70y, while researching this information [11].

The Kahle SR noted that Webster., *et al*. reported, in a study of high-quality, management of depression and promotion of social support may have a positive effect on prosthetic use. O'Neill., *et al*. in a report of medium quality, concluded that LEA subjects with cognitive deficits may need augmented rehabilitation or not be considered for prosthetic candidacy and use an alternative method for mobility rehabilitation. Stineman., *et al*. reported, in a high-quality study, that activities of daily living (ADLs) and mobility (physical functioning) displayed increases in motor FIM scores that were achieved at discharge from physical rehabilitation. Lower extremity amputees with psychosis achieved lower motor FIM scores, but no direct correlation between psychosis and prosthetic candidacy was reported [4].

Gender

Two high-quality studies in the Love SR reported men have increased strength compared to females. This could lead to a higher rate of prosthetic walking [6,17]. In a very large, high-quality study by Cooper., *et al*. they note a variety of differences between male and females. This study was done from data recorded from males and females between 50y and 90y. Their results show there are age and gender differences in physical capability, assessed at age 50y and above. While levels of physical capability decline with age, in most tests, males perform better than females. Evidence revealed gender difference in grip strength with females decreasing faster than males when increasing in age. Also, there is a wide gender difference in walking speed with increasing age. Cooper., *et al*. states "This data is some of the first to be presented which demonstrate the nature of age and gender differences in objective measures of physical capability across a large, representative sample of older people" [17]. Conversely, eight other high-quality studies found no correlation between gender, walking ability and prosthetic candidacy.

In the Kahle SR four high-quality studies found no association between gender and walking ability following LEAs. Gender is not a predictive determinant [4].

Pre-amputation living status

As in the Kahle SR, the Love SR also reported collected data on living status. Several related factors reported were pre-amputation, marital status, and independence levels. However, none of them reported correlations on pre-amputation living status being a predictive characteristic of walking ability and prosthetic candidacy for the LEA [4].

Cause of amputation

Most studies in the Love SR listed the cause of amputation as an area to be studied to predict walking ability and prosthetic candidacy. Some authors reported cause of amputation as a factor; however, there was no strong correlation using cause of amputation as a predictive factor of walking ability and prosthetic candidacy. Amtmann., *et al*. in a high-quality study, reported LEAs, due to dysvascular and traumatic amputation, significantly differed on physical function and satisfaction with social roles when relevant clinical characteristics were studied [12].

In another high-quality study, Lim., *et al*. report that patients undergoing major LEA are generally older, with a high prevalence of comorbidities. Despite a low immediate mortality, the overall long-term results of LEAs of PVD and diabetic nature remain dismal [9]. A high-quality study, by Remes., *et al*. tracked the health progression of 119 LEAs with an etiology of PVD, from admission through one year of physical rehabilitation in a skilled nursing facility. Most LEA patients did not return home in one year after their

first LEA. Comorbid conditions, particularly influencing functional capacity, hindered ambulation with a prosthesis [6].

The strongest case was made by Arneja., *et al*. using high-quality study with a retrospective cohort study with an N = 50; who studied a group of end stage renal dialysis (ESRD) LEAs. They also studied an equal numbered control group of LEA non-renal dysfunction subjects. Arneja., *et al*. states "Patients with lower limb amputations on chronic dialysis had significantly longer length of stay and lower Functional Independence Measure (FIM) scores compared with the non-ESRD group. It is suggested that current practices need to be adjusted to accommodate the complex rehabilitation needs of the ESRD patient population"[18]. While this study may be valid for the ESRD LEA subjects, it does not have carry over to the higher percentage of LEAs with multiple etiologies for amputation [19].

In the Kahle SR, Hamamura., *et al*. reported, in a high-quality study regarding cause of amputation, there was no significant difference between the two groups of successful and unsuccessful ambulators. In a high-quality study, Wezenberg., *et al*. reported the presence of an amputation because of vascular deficiency was significantly associated with a lower VO2peak. While traumatic amputation was not significantly associated with a difference in VO2peak compared with controls. Having LEA due to vascular dysfunction was associated with a 26.4% decrease in VO2peak compared with having a traumatic amputation. In a second article, Wezenberg., *et al*. also found traumatic amputees walked at the same VO2 as able-bodied controls but did so at a lower walking speed [4].

Vascular amputees walked at an even slower speed with a substantially higher VO2. Both amputee groups chose a walking speed that was lower than the most economic walking speed. Consideration of peak aerobic capacity is an important factor when attempting to improve walking ability in amputees [4]. Kahle., *et al*. also reported an association between the cause of amputation and walking potential in five studies, with subjects undergoing an amputation due to vascular disease achieved a poorer outcome than those due to trauma and other non-vascular causes [4].

Amputation level

In the Love SR, the effects of amputation level as a predictive factor for walking ability and prosthetic candidacy was a topic reviewed in most studies. Demet., *et al*. reported, in a high-quality study, that LEAs should be followed by a physical rehabilitation process, especially when the subject could be a prosthetic candidate. The objective of this study was to assess factors related to health-related quality of life (HRQL) in subjects with LEA. Correlations were sought between the six categories of distress: age, sex, cause and level of amputation and rehabilitation discharge location. HRQL measures showed impairments in the categories of physical disability, pain, and energy level. In this study, while controlling for sex and age, young age at the time of amputation, traumatic origin LEA and amputation level were independently associated with better HRQL [20].

Taylor., *et al*. performed a high-quality, retrospective study of 553 amputees. Amputation surgery was performed from 1998-2003. This study showed age as a very important factor to determine walking ability and prosthetic candidacy. Statistically significant preoperative factors independently associated with not wearing a prosthesis in order of greatest to least risk were non-ambulatory before amputation, above knee amputation, age >60 years, homebound but ambulatory status, and coronary artery disease. Statistically significant preoperative factors, independently associated with death in decreasing order of influence, included: age ≥70 years, age 60y to 69y and the presence of coronary artery disease. Statistically significant preoperative factors independently associated with failure of ambulation, in decreasing order of influence included: age ≥70 years, age 60y to 69y, bilateral amputation, and unilateral level of amputation. Statistically significant preoperative factors, independently associated with failure to maintain independent living status in decreasing order of influence, included: age ≥70 years, age 60 to 69, level of amputation, homebound ambulatory status [11].

In a medium-quality study by Vogel., *et al*. article the effects of amputation among frail elderly nursing home subjects were studied. Elderly nursing home residents undergoing TTA or TFA failed to return to their functional baseline within 6 months. Among frail elderly nursing home subjects, higher amputation level, stroke, and poor baseline cognitive scores were associated with inferior functional status following LEA [21].

The Artwert., *et al*. study, a high-quality article, reported functional use of a prosthesis in TTAs is directly related to residual-limb quality in general. A tibial length of 12-15 cm from the knee joint line correlated with a better functional outcome than shorter tibial lengths. The surgeon must give strong thought to the residual limb length to ensure a more likely improved functional outcome after TTA [4].

Suckow., *et al*. in a high-quality article, reported TTAs and TFAs were equally likely to ambulate independently or with assistance at hospital discharge, with significant difference between the two levels. Patients who underwent a minor amputation were more likely to ambulate with or without assistance but less so than patients who did not have an amputation after lower limb bypass. Linberg., *et al*. in a high-quality article, reported a significant differ-

ence in the 6MWT. Walking distance, between bilateral TTAs and unilateral TFAs participants, were measured, with bilateral TTAs walking further. Chin., *et al*. reported, in a medium-quality study, solely on the hip disarticulation amputee (HDA) where older HDAs in good physical condition and with a low prevalence of comorbidities could successfully walk with a prosthesis in a community setting [4].

Czerniecki., *et al*. reported the rates of success were similar: 35%, 31%, and 33% of transmetatarsal (TM), transtibial (TTA) and transfemoral (TFA) amputees, respectively, achieved mobility success when seen in a comprehensive inpatient rehab unit [3]. Fortington., *et al*. in a high-quality study, reported decreased walking performance by people with a TFA versus TTA. In a walking performance test 1-year post-amputation, TFAs showed a lower 5-m walk test and fewer steps taken per day. One year after discharge from physical rehabilitation, people with TFA or TTA increased the number of steps taken per day from 570 steps at discharge to 1314 steps after 1-year discharge and were able to maintain this level in the second year [4].

A high-quality study by Grameaux., *et al*. did not find a statistically significant worse result in bio-energetic efficiency after TFA but did find a reduction in walking speed. Only, when age was considered in a multiple regression model, was the impact of the level of amputation statistically significant. Hamamura et al. reported, in a high-quality study, no significant difference between the successful and unsuccessful ambulator groups, when considering amputation level. Stineman., *et al*. reported, in a high-quality study, that TTAs measured increased levels of activities of daily living (ADLs), mobility scores and increases in motor FIM scores at physical rehabilitation discharge. TFA was associated with lower motor FIM gains, but no direct correlation between amputation level and prosthetic candidacy was reported [4].

Van Eijk., *et al*. in medium-quality article, reported low amputation level versus a high amputation level was significantly positive for increased prosthetic use. Further, they found amputation level as a predictor for ability to complete the TUG test. Webster., *et al*. in a high-quality article, reported TFAs were significantly less likely to achieve prosthetic fitting success at 1 yr. A high-quality study by Wezenberg., *et al*. reported the level of amputation was not associated with VO2peak [4].

Physical fitness

The Love SR shows the importance of physical fitness in 5 high-quality articles. Langlois., *et al*. suggested, in a high-quality study, that the activity level of persons with LEA depends upon their physical condition, the fit and quality of their prosthetic components and how well they use their prosthesis. The 6-minute walk test score was shown to be a good predictor of physical capacities to negotiate slopes and ramps. While negotiating ramps, success was correlated to residual-limb strength and length. Results show that walking strategies adopted by persons with LEAs to negotiate ramp locomotion mainly depends on their muscular capacities and endurance. Therefore, muscular strengthening and endurance should be a priority during physical rehabilitation [22].

A high-quality study by Nadollek., *et al*. while studying gait asymmetry in LEA, determined that muscle strength of all hip musculature showed increased results in decreasing gait asymmetry and unloading the sound side in weight bearing stance and ambulation. The correlations between overall bilateral hip muscle strength, during weight distribution and gait ground reaction forces, illustrate the importance of strengthening these muscles both pre-operatively and post-operatively [23].

A high-quality, large study of N=1091, by Amtmann., *et al*. reported that health indicator profiles are clinically meaningful and are used effectively to examine multiple, self-reported health amongst LEAs. The results of this study suggest the LEAs report overall decrease physical functioning, satisfaction with social roles and pain interference, when compared to the population at large. Persons with LEA due to vascular disease report worse physical functioning and satisfaction with social roles than traumatic LEAs. Therefore, the results of this study, because of the large number of subjects, should strengthen the conclusions that physical function is an important predictor of walking ability and prosthetic candidacy [12].

Finally, a small study N=48, but high in research quality by van-Velzen., *et al*. studied the influence of physical capacity on regaining walking ability and the development of walking ability following LEA surgery. From these studies, there is strong evidence that shows deterioration of two aspects of physical capacity (muscle strength and balance) and of two aspects of walking ability (walking velocity and symmetry) after LEA. Strong evidence was found for a relation between balance and walking ability. In physical rehabilitation, increasing functional ability and walking ability following LEA should be encouraged since several parameters of functional ability have been shown to be decreased after amputation, although their relation to regaining walking ability and maintaining walking ability remains unclear [12,19,22,23].

In reviewing the SR by Kahle., *et al*., he found the following: Raya., *et al*. in a high-quality article, reported hip strength and balance were significant factors impacting six-minute walk scores in individuals with LLA. The six-minute walk test can identify impair-

ments of the musculoskeletal system that can affect ambulation ability, such as weakness in the muscles that support ambulation [4]. Chin., *et al.,* in a high-quality study, reported, when older hip disarticulation amputees (HDAs) are in good physical condition, they are successfully able to walk with a prosthesis in a community setting. Hamamura., *et al*. found, in a high-quality article, the successful ambulatory group had a significantly higher VO2max, compared with the failure group [4]. Guanard., *et al*. in high-quality article, reported rehabilitation factors, such as lower extremity strength, static and dynamic balance and ability to displace the center of mass (CoM), over the base of support, were all significant in relation to perform high-level mobility activities [4].

Age

In the Love SR, a large, cross sectional, high-quality study by Cooper., *et al*. found comparisons between lower functional levels and higher mortality rates are consistently found among the aging population, even though women have a longer mean life expectancy as compared to men, despite having lower functional levels and greater levels of self-reported functional limitations than men. In addition to gender differences, age-related changes in functional levels are well reported with consistent evidence of declining physical functional levels with increasing age [17].

In a high-quality study by Demet., *et al*. multiple factors including age as it related to health-related quality of life (HRQL) revealed that LEAs should be followed by a physical rehabilitation program, especially when the subject could be a prosthetic candidate. Correlations sought between the six categories of distress, age, sex, cause and level of amputation and rehabilitation discharge location. HRQL measurements showed impairments in the categories of physical disability, pain, and energy level. In this study, while controlling for sex and age, young age at the time of amputation and traumatic origin, younger LEAs were independently associated with better HRQL [20].

Pohjolainen., *et al*. in a high-quality study reported a decrease in walking ability as the LEA ages. Functional ability and accommodation situation were studied by examining and surveying 125 LEAs after one postoperative year. They studied multiple independent variables. An unfavorable correlation was found between increasing age and the following aspects of physical function, walking distance, walking time, time walking outdoors, increased need for assistive devices when walking and prosthesis wearing time [10]. In a high-quality review by Remes., *et al*. they reported that increasing age and comorbidities as a strong factor when determining walking ability and receiving a prosthesis [6]. In a large, high-quality study of Quality of life (QoL) factors by Sinha., *et al*., women reported worse QoL overall, than men; age and education were important predictors of QoL. Finally, QoL was adversely affected by phantom pain/sensation, stump pain, depression, vascular etiology of LEA [13].

In a high-quality study Taylor., *et al*. revealed age as well as amputation level as an important predictive factor for walking ability and prosthetic candidacy. Taylor., *et al*. performed retrospective study of 553 amputees. Amputation surgery was performed from 1998-2003. This study showed age as a very important factor to determine walking ability and prosthetic candidacy. Statistically significant preoperative factors, independently associated with not wearing a prosthesis, in order of greatest to least risk, were: non-ambulatory before amputation, above knee amputation, age >60 years, homebound but ambulatory status and coronary artery disease. Statistically significant preoperative factors independently associated with death in decreasing order of influence included: age ≥70 years, age 60 to 69, and the presence of coronary artery disease. Statistically significant preoperative factors, independently associated with failure of ambulation, in decreasing order of influence, included: age ≥70 years, age 60 to 69, bilateral amputation, and unilateral level of amputation. Statistically significant preoperative factors, independently associated with failure to maintain independent living status, in decreasing order of influence, included: age ≥70 years, age 60 to 69, level of amputation, homebound ambulatory status [11].

In the Kahle updated SR, they studied the following research studies. A high-quality report by Erjavec., *et al*. age was a key determining predictive factor, in combination with the results of the exercise stress test, a six-minute walk test at admission, the FIM at admission and gender successfully discriminated between patients who were fit with a prosthesis and those who were not. Grameaux., *et al*. in a high-quality study, found a statistically significant worse result in bio-energetic efficiency related to age, when considered with amputation level [4].

Hamamura., *et al*. reported, in a high-quality study, that no significant difference existed between the successful and unsuccessful ambulation groups when considering age. Webster., *et al*. in a high-quality article, reported increased age was directly associated with significantly less prosthetic ambulation time [4].

Stineman., *et al*. reported ADL function and mobility (physical functioning) using gains in motor Functional Independent Measurement (FIM) scores, achieved by rehabilitation discharge. Advanced age was associated with lower motor FIM gains, but no direct correlation between age and prosthetic candidacy was reported [4]. Wong., *et al*., in a high-quality article, reported age was not a significant predictive factor in affecting the outcome in LEAs.

van Eijk., *et al*., in medium- quality article, reported age was not significantly associated with prosthetic use [4].

Co-morbidities

In the Love SR, a high-quality article by Melchiorre., *et al*. reviewed a small N=24 (12 vascular LEA and 12 traumatic LEA) sample of LEAs and used FIM and commodity scales to measure outcome. This study compared the FIM scores of vascular and traumatic unilateral LEAs at admission, then again at discharge from a rehabilitation facility. The FIM scores that were used were the amputation FIM sub-scores and then total FIM scores. Comorbidity indexes were developed to measure the stump condition and co-morbidities seen in both LEA groups. The vascular LEAs were significantly older and had significantly increased stump comorbidities. Among both LEA groups, there was no significant difference in length of stay, medical comorbidity score, amputation level and total FIM scores between the two LEA groups, both at admission and discharge. Medical comorbidity scores were a good predictor of discharge FIM scores for traumatic LEAs. It was noted that stump comorbidity predicted discharge FIM scores for vascular LEAs, though not as well. They concluded that inpatient traumatic LEAs may be younger than vascular LEAs. However, traumatic LEAs may not necessarily show increased health scores or show better functional outcomes than vascular amputees. These outcomes conclude that co-morbid conditions and how they affect walking outcomes is not necessarily clear [14].

Vogel., *et al*. reviewed a medium-quality study on LEAs in the elderly. However, there was a very high N=4965, which is a large sample for LEA research. Their research was based on the impact of amputation level and comorbidities on functional status of nursing home resident LEAs. They concluded that the TFA and TTA population, among Medicare-eligible nursing home residents, showed initial declines in functional status in both TFAs and TTAs. Neither functional trajectory returned to baseline at 6 months' post amputation. TTAs had superior functional trajectories in this population compared with TFAs. Functional status, after amputation in nursing home residents, is multi-factorial as to surgery procedure type. This study demonstrated decreased functional trajectories after interventions were associated with poor baseline cognitive performance and poor baseline ADL scores. Also, co-morbid conditions, including ESRD and history of stroke, were associated with significantly decreased functional trajectories. Vogel., *et al*. states "these patients may benefit from an AK amputation because their trajectories are the worst. The findings of this analysis highlight the importance of considering pre-morbid conditions, cognitive status, and baseline ADL function before amputation in nursing home residents" [21].

This data may assist healthcare professionals, prosthetists and patients regarding the functional trajectory and the amount of time for changes in functional status to occur after amputation. This also may assist physicians in the opportunity to make more patient-centered outcome decisions during pre-amputation and post-amputation, to assist with follow up care [21].

In the Kahle SR, they reported the following. In a high-quality study by Chin., *et al*. they reported when there is low comorbidity prevalence; older LEAs were successfully able to walk with a prosthesis in a community setting. Hamamura., *et al*. reported in a high-quality article that LEAs with less comorbidities have a positive effect. Webster., *et al*. in a high- quality article, reported history of dialysis was associated with significantly less prosthetic ambulation [4]. Wong., *et al*. in a high-quality article, reported amputation due to diabetes, high Total White Count (TWC), Erythrocyte Sedimentation Rate (ESR), C-Reactive Protein (CRP), Urea, Creatinine (Cr), Neutrophils, absence of pulses, low Ankle Brachial Index (ABI) and Toe Brachial Index (TBI) were significantly associated with poor clinical outcomes in LEAs. van Eijk., *et al*. in medium-quality article, reported multiple comorbidities was not significantly associated with prosthetic use [4].

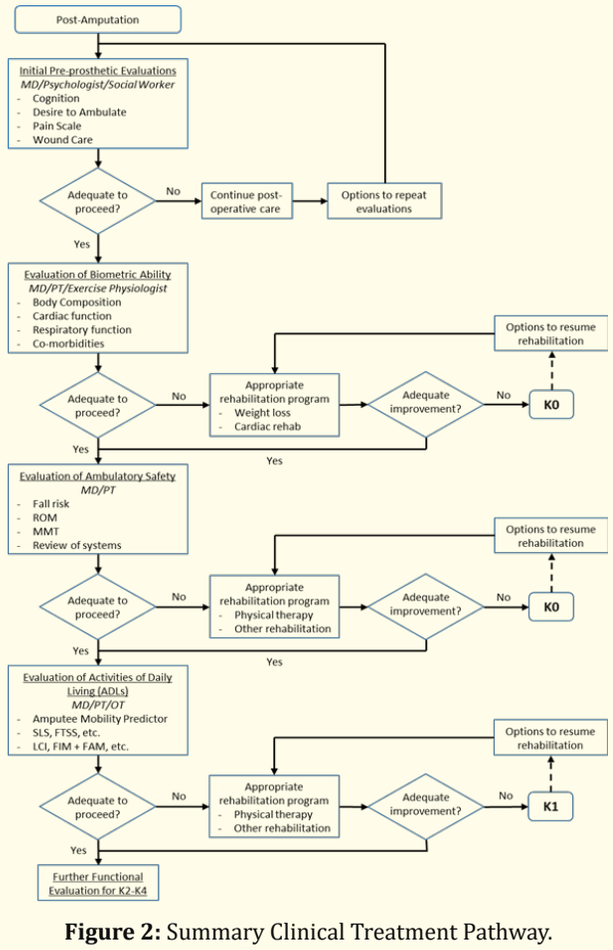

Figure 2: Summary Clinical Treatment Pathway.

Understanding the goal of defining walking ability and prosthetic candidacy and the potential for patients not to receive treatment based on subjective opinion, a clinical treatment pathway has been designed, based on this established literature. (Figure 2) This treatment pathway considers current predictive factors and reintroduction into evaluation should the patient reach a previously defined terminal MFCL K-Level.

Conclusion

In the Love SR of 26 mostly high-quality articles, motivation, smoking, ability to stand on one leg, IADLs, race, and time to rehabilitation were predictive factors with minimum support for walking ability and prosthetic candidacy. Moderately supported factors included; gender, physical fitness and social support. The most strongly supported factors were amputation level, age, comorbidities, cognition/mood disturbance and cause of amputation.

The Love SR and the Kahle SR had multiple shared predictive factors among the minimally and moderately supported articles, those being, motivation, smoking, physical fitness and ability to stand on one leg. In the Kahle SR, the most strongly supported predictive factors were amputation level, age, physical fitness and co-morbidities. The Love SR and the Kahle SR shared strongly supported predictive factors of amputation level, age and comorbidities.

Difference among predictive factors among studies

Predictive factors that had a disparity between studies were cognition, mood/disorder and cause of amputation. The Love SR showed these factors as strongly supported. The Kahle SR showed them as moderately supported predictive factors. The small disparity between these factors can be easily explained when the populations of the two studies are examined. The Love SR has a higher mean age of 59.08y, as compared to Kahle SR mean age of 57.03y. Most notably, the Love SR had the Cooper., *et al*. study with a large N of 29543, it was completed in skilled nursing facilities. Also, the vanVelzen., *et al*. study, 2570 subjects were listed as mostly elderly. From these two studies, one could concur that the Love SR studied a much older subject selection than the Kahle SR. Therefore, in the Love SR factors such as cognition and mood disorder are more common.

Also, the Love SR has a higher rate of LEAs with a combined etiology of PVD and diabetic LEAs at 66% as compared to Kahle SR at 54%. This would cause researchers to look at cause of amputation and their potential outcomes more closely.

Importance of the study

The predictive factors from the current Love SR are mostly supported in the earlier Kahle SR and should be strongly considered in a complete history and physical examination by physical therapists, prosthetists and all other members of the healthcare team who would be assisting in determining prosthetic candidacy and MFCL (K-Level) for the LEA. This information must not only be used with recent LEAs, but also long-term LEAs who might not have received correct prosthetic candidacy originally. Predictive factor data is consistent with information available in the complete patient health care records. This would assist the decision of prosthetic candidacy and MFCL K-Level determination prior to fitting the initial, definitive prosthesis for any trained healthcare professional. Additionally, these factors seem to have importance later, after physical therapy rehabilitation, when assisting the healthcare team in determining the appropriate prosthetic prescription upgrade due to increases in functional level potential for the LEA.

When assisting the LEA, over-prescription of the prosthesis, is preferred to under-prescribing. Because the cost of a less active patient, including potential falls and decreased work environment and social roles, who are limited by technologies and therapies which could otherwise improve their health and function, far outweighs the actual cost difference of a lower level prosthesis. This clinical treatment pathway is designed to encourage over-prescription to assist all LEAs overcome the delirious effects of amputation.

Disclosures

Contents of the manuscript represent the opinions of the authors and not necessarily those of the Department of Defense, Department of the Army, or the Department of Veterans Affairs or any academic or healthcare institution. Authors declare no conflict of interests.

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