`Major Lower Limb Amputations in the Marshall Islands: Incidence, Prosthetic Prescription, and Prosthetic Use after 6-18 Months.

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Abstract:

The Republic of the Marshall Islands has been recognised anecdotally to have high rates of major lower limb amputations secondary to diabetes. During 2001, a prosthetics service was introduced as part of the rehabilitation service at Majuro Hospital.

Study Aims:

1. To determine the incidence of major lower limb amputations over a one year period from 2002 to 2003.

2. To evaluate the proportion of patients suitable for prosthetic fitting.

3. Determine survival rates and usage of prostheses six to eighteen months after prosthetic fitting.

Method: *Amputation rates were established through review of the surgical logs at the two hospitals in the Marshall Islands. Prosthetic fitting rates were determined using records from Majuro hospital rehabilitation service. Follow up interviews were conducted with fifteen surviving patients who received prostheses during the study period, to investigate prosthetic use.*

Results: *The incidence of major lower limb amputation was found to be 79.5 per 100,000 population, with all forty-five amputations being associated with diabetes. Just over a third of these patients were discharged from rehabilitation with a prosthesis. Fifteen of the patients were followed up post discharge. All of the thirteen with transtibial amputations were found to be using their prosthesis at least some of the day. The two patients with transfemoral amputations had ceased to walk with their prosthesis.*

Conclusion: *This study identified a very high rate of lower limb amputation in the Marshall Islands by world standards. Prosthetic fitting rates and follow up results were comparable to those reported by others, and indicate that small, geographically isolated island nations such as the Marshall Islands are able to provide a successful prosthetics and rehabilitation service locally. (PHD, 2005 Vol 12 No 1 Pages 59 - 66)*

Introduction

The Republic of the Marshall Islands (RMI) is a nation of 29 coral atolls in the Pacific with a population of approximately 60,000 people. Health services are provided by two hospitals (one in the nation's capital, Majuro atoll, and one on the smaller island of Ebeye) and a network of small dispensaries staffed by individual health assistants on the outer islands. Majuro Hospital Rehabilitation Service (MHRS) is the country's only multi-disciplinary rehabilitation service, and provides services to inpatients and outpatients.

Non Insulin Dependent Diabetes Mellitus (NIDDM) is widely accepted to be the leading health problem facing the Marshallese people[1] and is also a major cause of lower limb amputation worldwide[2]. Studies investigating rates of lower limb amputations around the world have found incidences ranging from 2.8 (Madrid, Spain) to 43.9 (Navajo, USA) per 100,000 population, with up to 50% of these being related to diabetes[2]. Prior to this study, amputation rates in the Marshall Islands were believed to be high by world standards, but had never been formally investigated.

A prosthetics service was introduced at the MHRS in October 2001. A Marshallese citizen completed a six-month diploma in prosthetic technology in Brazil, and began providing a prosthetics service with the support of the Rehabilitation Service Manager (an occupational therapist) and a physiotherapist. Two to three patients per month began receiving prostheses and were successfully able to walk on discharge from the service, but little was known about their continued use of the prosthesis post discharge.

Not all patients who have amputations are suitable for fitting with a prosthesis. Age, level of amputation, motivation, cognitive function and presence of co-morbidities have all been found to influence whether a patient will be successful[3,4,5]. At MHRS, suitability for prosthetic fitting is determined through collaboration between the therapy staff, the patient and the treating surgeon. After amputation, all patients who are under consideration for prosthetic fitting are asked to participate in a general conditioning program at the MHRS. During this time the condition of the stump is monitored, crutches and/or wheelchair mobility is practiced and a general exercise program is commenced to help the patient to

prepare for mobility with a prosthesis. Progress and motivation during this phase of rehabilitation is also taken into account in making a final decision regarding fitting of a prosthesis. Patients are discharged from hospital as soon as the wound is sufficiently healed, and the process of prosthetic preparation, fitting and rehabilitation is continued as an outpatient service. Transtibial prosthesis are manufactured using exoskeletal resin designs (mainly due to cost and local availability of materials), with endoskeletal technology being used for transfemoral prostheses. A period of rehabilitation follows prosthetic fitting, during which patients are trained to put on and remove the prosthesis, bear weight on it, and learn to walk initially on flat ground and later on stairs, ramps and uneven ground. The patient is discharged when he or she is able to walk safely and confidently (with a gait aid if necessary), and there are no issues with the fit of the prosthesis.

A period of rehabilitation follows prosthetic fitting, during which patients are trained to put on and remove the prosthesis, bear weight on it, and learn to walk initially on flat ground and later on stairs, ramps and uneven ground

This study aimed to:

1. Determine the incidence of major lower limb amputations in the Marshall Islands between 1st April 2002 and 31st March 2003.
2. Identify the proportion of patients deemed suitable for prosthetic fitting during the first year of the service.
3. Investigate the survival rates, degree of prosthetic use and reasons for non-use by patients between six and eighteen months after prosthetic fitting.

Methods

Investigation of the incidence of amputations and prosthetic fitting rates

The prosthetics service was introduced in October 2001. The initial six months included some inconsistencies and delays in prosthetic fitting due to issues with acquisition of supplies, consistency of referrals and planning of the service. The twelve month period between 1st April 2002 and 31st March 2003 was therefore chosen for this investigation.

The surgical referral logs at both hospitals in the Marshall Islands were searched for occasions of major lower limb amputations during the study period. Major lower limb amputations were defined as hip disarticulation, transfemoral (above knee), knee disarticulation, transtibial (below knee) and Syme's amputations. Forty-five patients were identified who met these selection criteria.

Documentation of age, gender, site of amputation and pre-operative diagnosis was sought retrospectively from the surgical logbook. Where necessary, medical records and MHRS referral records were also used to confirm history of NIDDM and complete any gaps in the data.

"Prosthetic fitting" was defined as patients having been discharged from rehabilitation able to ambulate with a prosthetic device, with or without a gait aid. Patients who had been assessed and fitted with prostheses were identified retrospectively from MHRS records.

Follow up of Prosthetic Users

A follow up survey was conducted with the patients who met one of the following criteria:

a) Had an amputation during the study period and a prosthesis fitted within 2 months of the end of the study period (n=10), or

b) Had an amputation prior to the study period but received a prosthesis during the study period (n=13).

No interim prostheses are manufactured at Majuro Hospital, and there is a time lag of between two and four months between amputation and prosthetic fitting. Complications with wound healing or co-morbidities sometimes cause further delays. The additional two month period at the end of the study period was added to capture participants who had amputations during the study period and were fitted with prosthesis, whilst still allowing a minimum of six months between prosthetic fitting and follow up. The mean time between fitting and follow up was 13.5 months.

Due to the lack of a prosthetics service prior to 2001, several patients who had amputations months or years prior to 1st April 2002 had prostheses fitted during the study period. The sample for the follow up study included all patients who were fitted with prostheses during the study period, regardless of when they had their amputation.

All patients who met the selection criteria were contacted and invited to participate in the follow up study, to investigate the outcomes of rehabilitation 6 to 18 months after prosthetic fitting. Three of the 23 patients who received prostheses during the study period had died. Fifteen of the remaining twenty patients (75%) could be contacted and agreed to participate in the study. Participants were interviewed using a short questionnaire written for the purpose of the study. Interviews were done in Marshallese, face to face at the rehabilitation service for participants living in Majuro and by HF radio for those living in the outer islands.

Participants were classified according to:

• The **frequency** with which they used their prosthesis (daily, several times per week, less than once a week or never). "Several" times was defined as at least once a week but not every day.
• The **amount of time per day** they wore the prosthesis (less than four hours, four to eight hours, or more than eight hours per day).

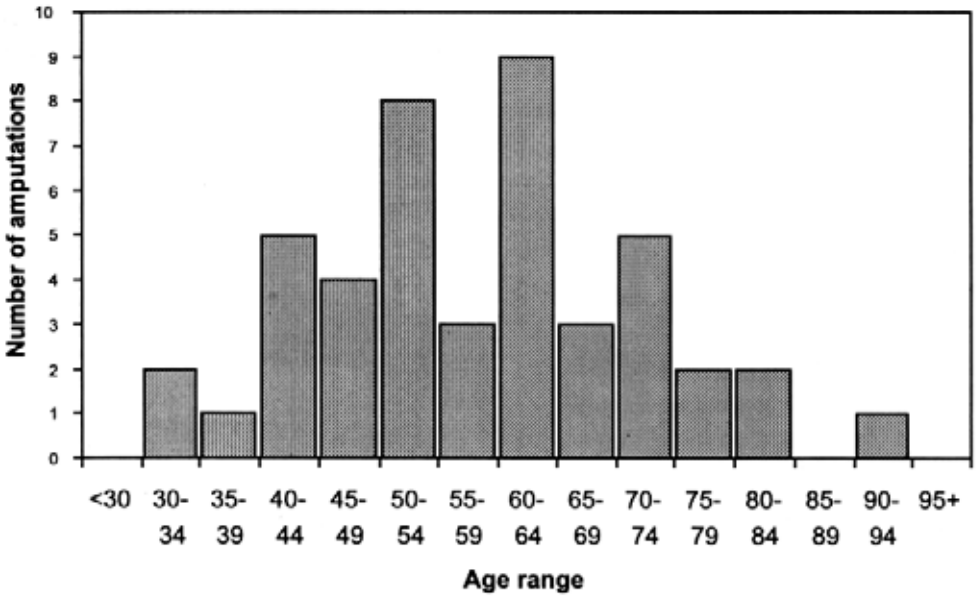
Incidence of major lower limb amputations

Forty-five amputations were conducted in the Marshall Islands between 1st April 2002 and 31st March 2003.

Table 1: Patients who had amputations between 1st April 2002 and 31st March 2003.

	Male (n=32)	Female (n=13)	Total Sample (n=45)
Mean Age	59.8	52.8	57.8
Age Range	31 - 94	32 - 70	31 - 94
Side of Amputation			
Left	12	8	20
Right	18	5	23
Unknown	2	0	2
Site of Amputation			
Transfemoral	9	1	10
Transtibial	23	12	35

Figure 1: Number of amputations by age range



Forty amputations were conducted at Majuro Hospital and five at Ebeye Hospital. Table 1 shows the demographic data and amputation level for this patient group. Figure 1 provides a breakdown of numbers of amputations by five-year age range. All forty-five amputations were non-traumatic, and all were related to some kind of infection secondary to, or co-existing with, NIDDM. Using the projected population for 2002 of 56,639 based on the 1999 census data[6], the incidence of amputation in the Marshall Islands during this period was calculated to be 79.5 per 100,000 population.

In 2000, the Global Amputee Study Group investigated amputation rates in ten countries around the world, and standardised all amputation rates to a European population[2]. As close to half of the Marshallese population is under sixteen years of age and the incidence of amputation is known to increase with age, the incidence identified in this study was also standardised to a European population for the purpose of comparison with the Global Study Group results. The population used was the European population (2001) published on the website of the United Nations Population Division[7]. The most recent population data with a breakdown within five-year age ranges for the Marshall Islands is from the 1999 census, and is therefore expected to be an underestimate of the population in 2002. However, standardisation within these limitations leads to an incidence of 428 per 100,000.

These results may also be skewed by the inclusion of one outlier in the 90 to 94 age bracket (given that there were estimated to be only nine people in total in the Marshall Islands in this age bracket in 1999). However, even with this outlier eliminated, the adjusted incidence is 370 per 100,000, more than eight times higher than the highest incidence found in any of the ten locations studied by the Global Amputee Study Group.

Table 2: Prosthetic fitting of patients who had amputations during the study period

	Male	Female	Total	% of total amputees (n = 45)
suitable for fitting	**18**	**5**	**23**	**51.1%**
Total fitted by 30/12/03	17	0	17	
Fitted by 30/5/03 (included in follow up survey)	*10*	*0*	*10*	
Fitted by 30/12/03 (not included in follow up survey)	*7*	*0*	*7*	
Assessed as suitable but not successfully fitted with prosthesis	1	5	6	
ssessed as unsuitable for prosthetic fitting/ nassessed*	**14**	**8**	**22**	**48.9%**

** Includes the 5 patients from Ebeye who were not referred to Majuro Hospital Rehabilitation Centre. Following discussions with the surgeon at the time of data collection, two of these may be prosthetic candidates and will be reviewed.*

Patients fitted with lower limb prostheses

Of the forty-five patients who had amputations in the RMI during the study period, twenty-three (51.1%) were referred to MHRS and assessed as being appropriate for prosthetic fitting. Not all of these twenty three patients completed rehabilitation during the study period, and therefore only part of this sample was included in the follow up survey. This data is summarised in Table 2.

No data was specifically collected to determine the reasons why 48.9% of the patients were either not referred to rehabilitation, or referred but considered unsuitable for prosthetic fitting. However, the group that were assessed as suitable were on average approximately ten years younger (mean age 55.5 for men; 45.5 for women; 53.2 years total) than those not referred for prosthetic fitting (mean age 65.4 for men; 55.4 for women; 62.5 years total). Hospital staff reported other reasons to include co-morbidities, history of previous amputations and lack of motivation.

Six of the patients who had major amputations during the study period and were deemed suitable for a prosthesis during the study period had not received one by the end of 2003. The most common reason for this was failure to follow-up with the rehabilitation program (n=5). One patient did not receive a prosthesis due to further medical complications. Four out of the five patients who failed to complete the Rehabilitation were female (refer to Table 3).

Prosthetic use after 6-18 months

A total of 26 patients were accepted for prosthetic fitting during the study period. Of these, 23 (88.5%) completed rehabilitation and were discharged with a prosthesis. This included ten of the patients who had amputations during the study period, and thirteen who had amputations in previous years (seven within the previous twelve months; three between one and two years before; two between two and three years previously; and one had been an amputee for more than three years). Three patients who were deemed appropriate and accepted for prosthetic fitting did not complete rehabilitation. Of these, two were female (one transfemoral and one

Table 4: Patients fitted with prostheses between 1st April 2002 and 31st March 2003

	Male (n=18)	Female (n=5)	Total (n=23)
Mean age	53.4	51.2	52.9
Age Range	42 - 72	45 - 60	42 - 72
Amputation Type			
Transfemoral	5	0	5
Transtibial	13	5	18
Side of Amputation			
Left	7	2	9
Right	11	3	14

Table 3: Reasons for lack of fitting in suitable patients

	Male	Female	Total
Non compliant with rehabilitation program	1	4	5
Medical complications	0	1	1
Total	**1**	**5**	**6**

transtibial amputation) and one was male (transfemoral amputation). Table 4 shows the characteristics of participants who were fitted with prostheses during the study period.

Table 5: Characteristics of the follow up sample

	Interviewed	Died	Lost to follow up	TOTAL
Total	15 (65%)	3 (13%)	5 (22%)	23
Male	13	1	4	18
Female	2	2	1	5
Amputation Type				
Transfemoral	2	1	2	5
Transtibial	13	2	3	18
Mean age (years)	58.5	54.3	47.7	

The twenty-three patients who received prostheses during the study period met the criteria for inclusion in the follow up sample. At the time of follow up, three patients had died and five could not be contacted. The remaining fifteen agreed to participate in the study. Demographic characteristics of the follow up sample are summarised in Table 5.

Thirteen of the fifteen patients interviewed (86.6%) stated that they were still using their prosthesis. These thirteen all had transtibial amputations, whereas the two patients who were no longer using them both had transfemoral amputations. The reasons given for lack of use of the prosthesis were problems with the fit of the prosthesis in one case, and problems with the condition of the stump in the other. The latter patient was living in an outer island and had been unable to return to Majuro for review.

Eleven of the thirteen patients using their prosthesis wore it every day, the other two reported that they used it several times per week. Five of the respondents report that they wore their prosthesis at least nine hours per day, four reported that they wore it between 4 and 8 hours per day, and four wore it less than 4 hours per day. None of the respondents reported needing help donning or doffing their prosthesis.

Respondents were asked whether they use a gait aid with their prosthesis. Six required no gait aid (46% of patients successfully using prostheses) and seven used a gait aid at least some of the time (one used a single point stick, two used walking frames and four used either one or two axillary crutches).

All of the patients successfully using prostheses reported that they could walk without assistance from another person inside their home. Six reported that they never needed assistance, whilst two reported that they sometimes need to have someone walk beside them, and five reported needing physical assistance in challenging areas such as stairs or rocky ground.

Table 6: Response to the follow up survey

	Gender		Amputation Type		Total Sample (n=15)
	Male (n=13)	Female (n=2)	Transtibial (n=13)	Transfemoral (n=2)	
Mean Age (years)	58.8	56	59.4	52.5	58.5
Living Location					
Urban area	9	2	10	1	11 (73%)
Outer Island	4	0	3	1	4 (27%)
Days worn per week					
Every day	10	1	11	0	11 (74%)
Several days per week	1	1	2	0	2 (13%)
Not at all	2	0	0	2	2 (13%)
Hours worn per day					
Not wearing	2	0	0	2	2 (13%)
Less than 4	3	1	4	0	4 (27%)
4-8	4	0	4	0	4 (27%)
9 or more	4	1	5	0	5 (33%)
Gait aid used (by prosthetic users)					
Yes	6*	1*	7*	-	7* (54%)
No	5	1	6	-	6 (46%)

**Gait aids included: Single point stick (n=1) Walking frame (n=2) and either one or two axillary crutches (n=4)*

Five patients reported that they are able to do all normal daily activities independently using the prosthesis. The other eight reported some limitations, but were still able to be independent around their local area. One participant reported that he was still able to ride his bicycle using the prosthesis, and two reported that they have returned to driving a car. Results of the follow up survey are summarised in Table 6.

Discussion

The incidence of major lower limb amputation identified in this study is extremely high compared to reports from other countries. The highest incidence found by the

Global Amputee Study Group (adjusted to a standard European population) was 43.9 per 100,000 in the mostly native American population of Navajo, USA[2] – the unadjusted incidence of 79.5 per 100,000 in the RMI during the study period is almost double this figure. After standardisation to a European population the incidence rises even more dramatically. Some limitations in the calculation of these incidence rates are discussed below.

All of the amputations reported in the Marshall Islands were related to, or at least co-existing with, NIDDM. Diabetes is known to have a high impact on amputations around the world, although the degree of this impact varies from place to place. Studies in the USA and Europe have identified relative risks of non-traumatic lower extremity amputation for diabetics between 11 and 40 times that of patients without diabetes[8,9,10,11]. The Global Amputee Study Group found that percentages of amputations related to diabetes in their study populations ranged from 20% (England) to over 80% (Navajo).

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Almost three times as many men than women had amputations during the study period. Although this difference appears surprising, the proportion of 71% males in this amputee population is not dissimilar to that found by others[2,3,4]. The average age of this sample, at 57.8 years, is younger than that found by other authors in samples of vascular amputees [4,5,12,13]. The youngest patients in the Marshall Islands sample were 31 and 30 for men and women respectively, which highlights the young age at which Marshall Islanders are being affected by NIDDM.

Proportion of patients suitable for prosthetic fitting

About half (51.1%) of the patients who had amputations in the Marshall Islands were considered appropriate for fitting of prostheses. Not all of those completed the lengthy rehabilitation process required to successfully use a prosthesis, with approximately 37% of patients who had amputations during the study period being fitted with prosthesis by 6 months after its conclusion. Many studies reported in the literature have looked at prothetic fitting rates, but the majority have utilised populations referred for rehabilitation. This clearly introduces bias towards patients who are more likely to be prosthetic candidates, and success rates of up to 80% reported in such studies are not comparable to this population[12,13]. In contrast, Dade et al (2001) examined all patients over 65 who had a lower extremity amputation in a region of Minnesota for vascular disease between 1974 and 1995[5]. They found that 36% of this sample were successfully fitted with prostheses, a similar rate to that found in the Marshall Islands.

It is interesting to note that women were over represented in the group that failed to complete rehabilitation in this study, to the extent that none of the women who had amputations during the study period were successfully fitted with a prosthesis. The reasons for this require further investigation, but could be related to differences in value placed on walking for women versus men, differing levels of motivation, or aesthetic appearance of a prosthesis. Reports from other studies have not provided a breakdown of successful prosthetic fitting by gender, so we do not know whether this finding is unique to the Marshall Islands.

Prosthetic use and survival six to eighteen months post discharge from rehabilitation

The majority of patients followed up who were fitted with a prosthesis were still using it after six to eighteen months. However there was a distinct difference between patients with transfemoral amputations and those with transtibial amputations. The thirteen participants with transtibial amputations who were followed up were successfully walking with their prosthesis, but the two participants with transfemoral amputations had both ceased to use it. Decreased success rates for transfemoral prostheses have also been found in other places. De Luccia et al (1992)[4] followed up 105 patients with unilateral amputations over five years in Brazil. At three years, 77.4% of transtibial and 58% of the patients with transfemoral amputations were alive and using their prosthesis at least some of the time. Pohjoleinen et al (1990)[3] studied a group of amputees one year post operatively in Helsinki, and found 50% of patients with transfemoral amputations compared with 79% of transtibial amputations used their prosthesis all day. Furthermore, 73% of patients who were unsuccessful with prostheses had transfemoral amputations. Reasons for this were suggested to be the retention of proprioception and reduced energy requirements for ambulation following transtibial amputation, resulting in earlier and better mobility when the knee joint is preserved.

Given that the amputations in this study were all diabetes related, the advanced stage of the disease that likely led to a transfemoral amputation must also be taken into account, and the likelihood that these patients may also be in generally poorer health at the time of their amputation. The sample size in this study was too small to draw definitive conclusions, however

these results support the need to carefully evaluate patients with transfemoral amputations, including both physical abilities and motivation, before manufacturing a prosthesis.

The success rates of prosthetic fitting must also be considered in the context of the experience of the staff providing the prosthetics service. This data has been drawn from the first full year of prosthetic service provision in the Marshall Islands, with the most qualified prosthetics staff member being a prosthetic technologist trained within a six-month course, working in isolation from other prosthetic professionals. Although a university qualified Occupational Therapist and (for part of the time) Physiotherapist made up the rehabilitation team, this is a major contrast to most other prosthetic services that have published data from their programs. In most Western countries, a multi-disciplinary team of health professionals (presumably with university qualifications) provides a coordinated amputee rehabilitation program. This limited experience may also be a factor in the decreased success rates for the provision of transfemoral prostheses, which are clearly more complex to fit and manufacture than transtibial devices. An improvement in success with this population could therefore be expected with more experience and further training of the local staff.

patients living in outer islands did not appear to be doing any worse with their prostheses than those in urban areas.

The geographic isolation of communities within the Marshall Islands may also be a factor influencing rates of prosthetic fitting. Some of the patients return home to small communities on isolated coral atolls, often hundreds of kilometres from Majuro. These patients are not easily able to return to Majuro Hospital Rehabilitation Service for advice or adjustments if they have difficulty after discharge from rehabilitation. However, patients living in outer islands did not appear to be doing any worse with their prostheses than those in urban areas. Those with transtibial prostheses were all using them to some extent, with one even reporting that he is using it to ride his bicycle around his island!

The death rate of 13% at the time of follow up comes as no surprise, as other authors have also recorded high death rates within two years for patients who have amputations related to diabetes[12,14,15]. No data was available on survival rates for patients amputated during the study period who were not fitted with prostheses, however it would be expected that survival would be lower for this group. Those referred for rehabilitation would have been patients in better general health and therefore considered better candidates for successful prosthetic fitting.

Study Limitations

The incidence of amputation in this study was calculated utilising only one year of data, and it is possible that there was an atypical peak in amputation rates over this period. Further investigation is needed over a longer period to confirm these findings. The most recent population figures available are from the 1999 census of population, and the denominator used in calculating the incidence was a population estimate based on projections from 1999. This figure may not be an accurate reflection of the current population.

The follow up study was particularly limited by a small sample size, which makes it difficult to draw definitive conclusions or generalise to a wider population. Further to this issue, five of the twenty-three patients were lost to follow up, partially because of the difficulty of locating people in areas that have no telephones or street addresses, and in villages in remote outer islands.

This study included only patients who had amputations and received prostheses in the Marshall Islands, a small pacific island nation with a unique culture, and a variety of internal and external issues that affect provision of health services. Caution must therefore be taken in generalising these results to other regions. However, the Marshall Islands also share many things in common with its Pacific neighbours, including high rates of NIDDM, geographical isolation and a dispersed population. Many of these findings may therefore be useful in the development and evaluation of services in other pacific nations.

Conclusion

The incidence of major lower limb amputations in the Marshall Islands identified in this study is extremely high compared to other locations reported around the world. All amputations recorded in this study were related to NIDDM, some in people as young as thirty years of age, emphasising the huge impact that diabetes is having on this Pacific population.

This research obtained data from the first year of provision of prosthetic services within MHRS. Although the service is still in its infancy and prosthetics staff have limited training and experience, the results of prosthetic fitting in participants with transtibial amputations are comparable to those found in vascular amputee populations elsewhere. Outcomes for participants with transfemoral amputations were less favorable, and these require further investigation with a larger sample to draw significant conclusions.

Given the high rates of NIDDM throughout the Pacific,

the need for prosthetic services appears to be essential. It is thought that only a handful of Pacific countries currently have this service available locally. Results of this study indicate that with government support and suitable training of staff, local prosthetic services can have successful outcomes. Finding effective ways to provide ongoing education and professional development for rehabilitation clinicians working in these isolated nations remains an ongoing challenge.

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