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Case Study in Benghazi Rehabilitation Center: Causes of Amputation and Used Artificial Limbs

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الملخص: تُعدّ الصحة جانبًا بالغ الأهمية في حياة الإنسان، إذ تؤثر في قدراته الجسدية وحالته النفسية والعاطفية، وتمكّنه من عيش حياة متكاملة والسعي لتحقيق طموحاته. ويُحدث فقدان أحد الأطراف تأثيرًا كبيرًا في حياة الفرد، حيث يحدّ من قدراته البدنية، ويؤثر في حركته، وقد يسبب الاكتئاب نتيجة فقدان الاستقلالية وزيادة الاعتماد على الآخرين في أداء المهام اليومية الأساسية. ومن هنا تبرز الحاجة إلى تعويض الطرف المفقود، إذ يساعد الطرف الصناعي الأفراد على استعادة قدر من السيطرة على حياتهم، ويعزّز قدرتهم على الحركة والإمكانات الجسدية، مما ينعكس إيجابًا على حياتهم العملية وثقتهم بأنفسهم من خلال استعادة جزء من استقلاليتهم. يهدف هذا العمل إلى إبراز أهمية الأطراف الصناعية، واستعراض التقنيات المستخدمة في Benghazi Rehabilitation Center ، وذلك لتحديد موقع ليبيا مقارنةً بدول العالم الأخرى في مجال الأطراف الصناعية .كما تهدف الورقة إلى نشر الوعي بأسباب البتر في مدينة بنغازي وسبل الوقاية منه قدر الإمكان .وقد أُجري تحليل إحصائي استنادًا إلى سجلات المركز لمراجعة الأسباب الرئيسة لحالات البتر، وتبيّن أن أكثر من نصف الحالات كانت ناتجة عن مرض السكري.

الكلمات المفتاحية: إعادة التأهيل؛ مبتور الأطراف؛ البتر؛ الأطراف الاصطناعية؛ الطرف الاصطناعي؛ الطرف الاصطناعي؛ اصطناعي .

Abstract: Health is a very important aspect of anyone's life, influencing their physical capabilities and emotional and mental state and help them live a fulfilling live and pursue their dreams. Losing a limp has a significant impact on a person's life, reducing physical ability, affects mobility and causes depression as they lose their independence and become more reliant on others for basic daily tasks. And so, comes the need to replace the lost limb. An artificial limb helps people regain some control over their life; it enhances mobility and physical capabilities hence improves their work life and confidence as they regain some independence. This work is to address the importance of artificial limbs and to overview the technology used in the Benghazi rehabilitation center to know where Libya stands compared to the other world regarding prosthetics. The paper is also aimed to spread awareness on the causes of amputation in Benghazi and how to prevent it if possible, a statistic is made using the records of the center to review the main cause of amputation, it prevailed that more than half of cases were due to diabetes.

Keywords: Rehabilitation; amputee; amputation; prosthetic; artificial limb; prosthetic limb; artificial.

I. INTRODUCTION

Prosthetic limbs are artificial devices used to replace a limb, usually after amputation or congenital condition, in order to restore function and quality of life. Prosthetics have developed from simple cosmetic devices to mechanical devices and further into myoelectric systems that integrate body electrical signals to coordinate movement, and advanced bionic systems integrating electronics, neural interfaces, and sensors to regain motor skills (Meier & Melton, 2014; Robertsson *et al.*, 2011). Prosthetic limbs are classified either by the location of the amputation, the functionality of the prosthetic, or the activity level of the amputee, 2021; (Segura *et al*., 2024).

A. Classification by Amputation Level:

Trans-humeral prosthetics are arms for amputation above the elbow, trans-radial prosthetics are arms for amputation below the elbow, transfemoral are legs for amputation above the knee, and transtibial prosthetics are legs below the knee (Kirilova *et al.*, 2021; Segura *et al.*, 2024).

B. Classification by Functionality of Prosthetic:

Passive prosthetics are purely cosmetic and may have minimal function, such as limited passive gripping of light objects (Walicka *et al.*, 2021).

Body-powered prosthetics rely on the amputee's own movements via straps, cables, and harnesses; mechanical knee joints are an example (Meier & Melton, 2014).

Myoelectric prosthetics use electrical signals from the user's muscles to power motors and produce movement (Olaya-Mira *et al.*, 2025).

Hybrid prosthetics combine elements from different categories to provide both simple body-powered and complex externally powered functions (Olaya-Mira *et al.*, 2025).

C. Classification by Activity Level (K-levels):

Indicates a person's likelihood for prosthetic use:

K0: No potential for walking or safe transfer with a prosthetic.

K1: Limited household ambulation on level surfaces (Andrews *et al.*, 2017).

K2: Limited community ambulation with low-level barriers.

K3: Community ambulator, walks at various speeds and crosses most environmental barriers.

K4: High-activity adult or athlete exceeding normal ambulation (Andrews *et al.*, 2017).

II. LITERATURE REVIEWS

Losing a limb significantly affects mobility, daily activities, and independence. About 63.6% of amputees report difficulties with hygiene, bathing, and dressing (Al-Eqabi *et al.*, 2024). Psychological impacts include impaired social life and professional limitations, reported by 64% and 68% of patients, respectively (Hamed, 2016; El Sahly & Cusick, 2016).

In Libya, diabetes is the leading cause of lower limb amputation, accounting for 68.6% of cases between 2010 and 2019, rising from 61.1% in 2010 to 71.4% in 2019 (Walicka *et al.*, 2021). Benghazi Rehabilitation and Handicap Center were the only functioning physical rehabilitation center after the 2011 revolution, providing free services to inpatients and outpatients, mostly male patients, with limited female staff in administrative roles (Hamed, 2016; El Sahly & Cusick, 2016).
Assessment of prosthetic adaptation uses gait analysis, mobility evaluation, physical assessment, and self-report questionnaires (Olaya-Mira *et al.*, 2025)

III. METHODOLOGY

This study is a descriptive cross-sectional approach to investigate the type of prosthetics, causes of limb amputation, and the distribution of the center's patients. Data was collected using multiple tools, first, structured interviews, with key staff members, they were directly interviewed and questioned on the procedure of making prosthetics and their quality. Secondly, direct observation on site, visits were conducted to the rehabilitation center while taking notes about what prosthetics are available. Thirdly, achieved records review, patients' electronic medical records were accessed to get relevant data, specifically (reason of amputation) leaving out personal information to adhere to confidentiality and ethical standards. Some of the medical records were lost in the process of transforming the handwritten archive to an electronic one, it was only transformed into electronic version in the past two years by the center (walicka *et al.*, 2021).

Regarding data analysis, a simple statistic was made on the collected data to compute the frequency and percentage of different causes of amputation in the Benghazi rehabilitation and handicap center to identify the most frequent cause.

IV. OBSERVATIONS AND STATISTICS OF THE BENGHAZI REHABILITATION AND HANDICAB CENTER

A Prosthetics provided in the center The center provides both upper limbs and lower limbs. In general, upper and lower limbs address Different functional needs, upper limps tend to be more focused on restoring motor skills and grabbing function, while lower limbs are focused on weight bearing and providing stability, balance, and mobility. From the study in the center, it was clear that lower limb prosthetics were of high quality and functionality, the center provides monocentric mechanical knee joint for transfemoral amputees.

The joint has load-dependent brakes mechanism, when the weight is placed on the heel the brakes activate providing stability and protection for the duration of stance phase. The knee also has automatic release mechanism as the brakes deactivate when the weight shifts to the forefoot, allowing for easy initiation of the swing phase (Meier & Melton, 2014). The mechanical knee also has mechanical extension assistance which is generally a spring system that helps the lower leg straighten during the swing phase of walking and it also reduces stumbling and reduces user effort.

Regarding upper limb prosthetics they are only cosmetic with no grasping mechanism, and during this study there were no upper prosthetics available because of the high cost of the materials used to imitate normal skin (Segura *et al.*, 2024)، And there aren't always tons use of them. The center has a lot of work to do to catch up with current technology of prosthetic upper limb.

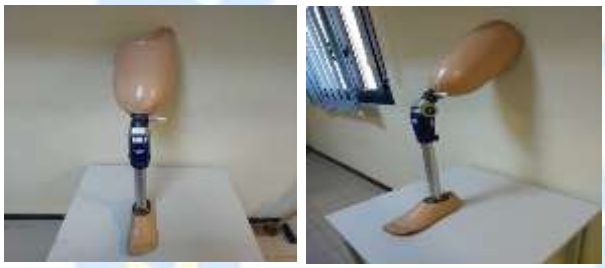

Fig. 1: Transfemoral prosthetic leg with mechanical knee joint.

Fig. 2: Transtibial prosthetic leg.

A. Causes of amputation in the Benghazi rehabilitation and handicap center:

We obtained data from the years 2021, 2022, 2024, and 2025. 2023 data was lost while in handwriting before being digitized. All personal information has been neglected and focused mainly on the cause of amputation. Based on the data the cause of amputation is divided into 7 causes:

1) war and weapons related injury: which includes injuries due to the war itself and after, and it includes stepping on mines and receiving gunshots (Although some of gun related injuries are from fights or a stray bullet). The total number of amputee's who received prosthetics was 185 patients.

2) Diabetes: This disease is the most prominent cause of amputation, neuropathy and poor circulation could lead to foot ulcers, these ulcers can become infected and if not treated properly it could lead to amputation. There have been many studies focused on the early detection of diabetic foot to avoid amputation. The number of prosthetics provided for diabetic foot amputees was 313 in 4 years (Walicka *et al.*, 2021).

3) Car accidents: Libya is known for its dangerous driving; in 2024 it was classified as one of the highest traffic fatalities globally with a rate of 73 fatalities in 100,000 people which is significantly higher than the standard average rate of 20 fatalities of 100,000 people. The number of prosthetics provided for the casualty of car accidents is 96 in four years. (Libya Review, 2024).

4) Cancer: If a tumor grows in a limp such as osteosarcoma, it can damage surrounding tissue or if the tumor is too big or invasive sometimes it's impossible to remove it without sacrificing the limb. the number of prosthetics provided for tumor patients is 6 in four years (Kirilova *et al.*, 2021).

5) Congenital defect: A congenital defect could result in the absence of limb which is known as Amelia. Amelia is a rare congenital defect condition characterized by complete absence of a limb or more. The number of prosthetics provided for individuals with this case is 14 prosthetics (Khanal *et al.*, 2022).

6) Electricity: Exposure to high voltage can cause severe injuries including potential for amputation. Only one prosthetic was provided for this cause.

7) Work injury: there were two cases of work injuries in the centers achieve. Unknown causes: two prosthetics in 2021 were provided to patients with unknown causes of amputation. They were not written in the handwritten Archive.

B. Demonstration of statistics taken from center:

The statistics are from data collected from the center archives and some data from the red cross.

Table I: Number of cases alongside cause of amputation:

Cause of amputation	2021	2022	2024	2025	Total Number
War & guns injuries	107	34	28	16	185
Work injury	1			1	2
Congenital malformation	11	2	1		14
Car accident	40	24	21	11	96
Cancer	4	1		1	6
Diabetes	130	68	72	43	313
Electricity	1				1
Unknown	2				2

The table exhibits the causes of amputation of cases assessed in the Benghazi center alongside the number of cases; the following graphs are graphic representations of the previous table.

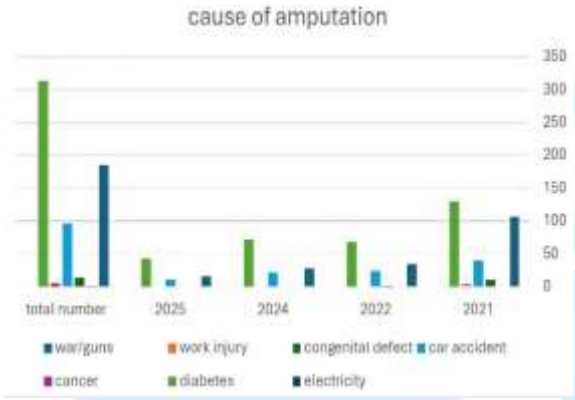

Fig.3: Graph showing causes of amputation per year.

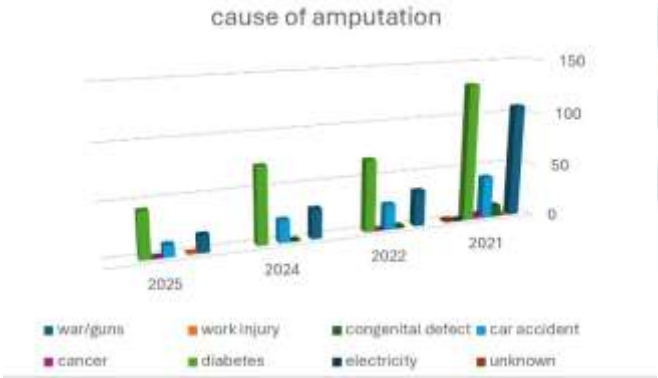

Fig.4: Graph showing causes of amputation per year.

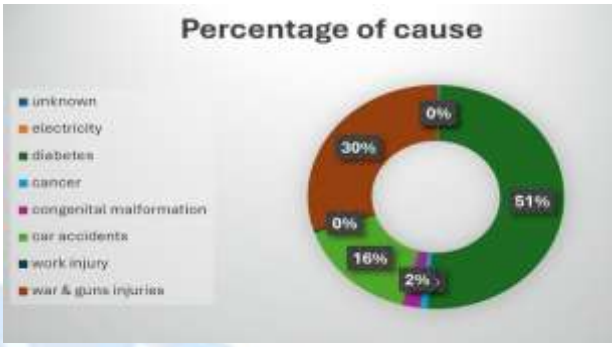

Fig.5: Causes of amputation by percentage pf total number of cases.

Parentages lower than 0.5% are written as 0% in the previous Pie chart, it demonstrates that diabetes is cause of more than half of the cases.

CONCLUSION

After the visit to the Benghazi rehabilitation and handicap center and conducting a study, it was clear that the main cause of amputation in Benghazi, Libya and surrounding towns is diabetes by 50.6% from the overall amputees who were provided prosthetics by the center. And is due to the high population suffering from diabetes. The second main cause of amputation by 30% was war and guns and vast majority of them are from 2021 and before, which indicates an increase in safety in the recent years. The third cause of amputation was car accidents adding up to 15.5% of total amputees (Walicka *et al.*, 2021; Libya Review, 2024).

The lower limb amputees are significantly more than upper limb amputees with a percentage of 97.5% of total amputees which numbers was counted by the red cross in the last two years. The number of prosthetics provided in the center decreased in 2025 by about 40% compared to 2024 and 2022 mainly because the center suffered from lack of equipment's especially upper limb prosthetics. Regarding the prosthetics provided in the center, upper limps provided are only cosmetic wit conclusion (Meier & Melton, 2014; Segura *et al.*, 2024). After the visit to the Benghazi rehabilitation and handicap center and conducting a study, it was clear that the main cause of amputation in Benghazi, Libya and surrounding towns is diabetes by 50.6% from the overall amputees who were provided prosthetics by the center. And is due to the high population suffering from

diabetes. The second main cause of amputation by 30% was war and guns and vast majority of them are from 2021 and before, which indicates an increase in safety in the recent years. The third cause of amputation was car accidents adding up to 15.5% of total amputees. The lower limb amputees are significantly more than upper limb amputees with a percentage of 97.5% of total amputees which numbers was counted by the red cross in the last two years.

The number of prosthetics provided in the center decreased in 2025 by about 40% compared to 2024 and 2022 mainly because the center suffered from lack of equipment's especially upper limb prosthetics. Regarding the prosthetics provided in the center, upper limps provided are only cosmetic with no grasping functionality. And lately even those cosmetic hands are often not available, which is very insufficient and needs urgent enhancement. Unlike the lower limbs which provide level 1 and level 2 of mobility and are very sufficient for regaining stance and walking function for amputees. h no grasping functionality. And lately even those cosmetic hands are often not available, which is very insufficient and needs urgent enhancement. Unlike the lower limbs which provide level 1 and level 2 of mobility and are very sufficient for regaining stance and walking function for amputees.

RECOMMENDATIONS

- Diabetes is the main reason for amputation especially in lower limbs; hence, more research should be conducted on how to diagnose diabetic foot earlier so amputation would be avoided, or conducting studies to evaluate the reason a high percentage of Libyan's population suffers from diabetes in the first place (Walicka *et al*., 2021).
- The upper limbs provided by the center (when available) are only cosmetic, and so we encourage more studies on artificial hands to replicate grasping and basic functions of the hand because currently Libya is very behind. so, we encourage the search for a quick solution, whether it’s mechanical, myoelectric, or bionic as long as it is easy to use and affordable to cover the shortage (Segura *et al.*, 2024). Also, we encourage the study of delay to why myoelectric and bionic hands have yet not spread in Libya.
- As for prosthetic lower limbs in the center, there is room for improvement but it's not urgent as in the state of upper limbs (Meier & Melton, 2014).

REFERENCES

Al-Eqabi, Q. A. K., Niazy, S. M., & Radhi, M. M. (2024). Amputation-related factors influencing activities of daily living among amputees. *Iranian Journal of War and Public Health*, 16(2), 123–129.

Andrews, K. L., Nanos, K., & Hoskin, T. (2017). Determining K-levels following transtibial amputation. *International Journal of Physical Medicine & Rehabilitation*, 5(398), 1–2.

El Sahly, R. M., & Cusick, A. (2016). Rehabilitation services in Benghazi, Libya: An organizational case study. *World Family Medicine Journal / Middle East Journal of Family Medicine*, 14(11), 1–8.

Hamed, R. M. A. (2016). *Rehabilitation services in post-revolutionary Benghazi, Libya, from the perspective of disability workers: A case study of the Benghazi Rehabilitation and Handicap Centre*. (Doctoral dissertation, University of Wollongong).

Khanal, S., Pachya, U., Thapaliya, S., Magar, S. R., Panthi, B., & Khatri, A. (2022). Congenital limb deficiency: A case report. JNMA: *Journal of the Nepal Medical Association*, 60(249), 485–488.

Kirilova, M., Klein, A., Lindner, L. H., Nachbichler, S., Knösel, T., Birkenmaier, C., … Dürr, H. R. (2021). Amputation for extremity sarcoma: Indications and outcomes. *Cancers*, 13(20), 5125. https://doi.org/10.3390/cancers13205125.

Libya Review. (2024, June 11). *Libya records highest traffic fatality rate worldwide*. Retrieved from https://libyareview.com/45043/libya-records-highest-traffic-fatality-rate-worldwide/.

Meier, R. H., 3rd, & Melton, D. (2014). Ideal functional outcomes for amputation levels. *Physical Medicine and Rehabilitation Clinics of North America*, 25(1), 199–212.

Olaya-Mira, N., Gómez-Hernández, L. M., Viloria-Barragán, C., & Soto-Cardona, I. C. (2025). Methods to assess lower limb prosthetic adaptation: A systematic review. *Journal of Neuro-Engineering and Rehabilitation*, 22(1), 100.

Robertsson, O., Mendenhall, S., Paxton, E. W., Inacio, M. C., & Graves, S. (2011). Challenges in prosthesis classification. *The Journal of Bone and Joint Surgery*, 93(Supplement_3), 72–75.

Segura, D., Romero, E., Abarca, V. E., & Elias, D. A. (2024). Upper limb prostheses by the level of amputation: A systematic review. *Prosthesis*, 6(2), 277–300.

Walicka, M., Raczyńska, M., Marcinkowska, K., Lisicka, I., Czaicki, A., Wierzba, W., & Franek, E. (2021). Amputations of lower limb in subjects with diabetes mellitus: Reasons and 30-day mortality. *Journal of Diabetes Research*, 2021, 8866126. https://doi.org/10.1155/2021/8866126.