Original Research Article: Investigating the Etiology of Lower Limb Amputations in East Azarbaijan Hospitals

Mohammad Irajian [1] | Mehrdad Zamani Esfahlani [2,*]

[1] Assistant Professor of Orthopaedics, Tuberculosis and Lung Disease Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[2] Assistant Professor of Spine Surgery, Department of Orthopedics, School of Medicine, Tabriz University of Medical Sciences, Tabriz, Iran

Use yor device to scan and read the article online

Citation M. Irajian, M.Z. Esfahlani, **Investigating the Etiology of Lower Limb Amputations in East Azarbaijan Hospitals.** *Eurasian J. Sci. Technol.*, **2024**, *4*(1), 21-30.

https://doi.org/10.48309/ejst.2024.418589.1097

Article info:
Received: 2023-09-29
Accepted: 2023-10-30
ID: EJST-2309-1097
Checked for Plagiarism: Yes
Language Editor:
Dr. Fatimah Ramezani
Editor-in-Chef:
Dr. Yehya Kamal Al-Bayati

Keywords:
Etiology, Lower limb, Amputations.

ABSTRACT

Introduction: As we navigate the intricate terrain of lower limb amputation etiology, this article seeks to provide valuable insights for healthcare professionals, researchers, policymakers, and anyone interested in the complexities of this critical healthcare issue. By unraveling the multifaceted factors contributing to lower limb amputations, we aim to contribute to the development of more effective prevention strategies, improved treatment approaches, and enhanced support systems for individuals living with limb loss.
Materials and methods: This retrospective study was conducted at a single-center and involved patients referred to our orthopaedic department for lower extremity amputation (LEA) during the period spanning January 2007 to December 2019 in East Azarbaijan Hospitals. Data collected included the year of amputation, patient age, gender, level of amputation, and the underlying cause for the amputation.
Results: The study encompassed a total of 114 lower extremity amputations, with major amputations accounting for 60.5% of the cases. Notably, the incidence of major amputations exhibited an upward trajectory over the study period, with an annual increase of 0.6 amputations per year. Male patients were significantly more prone to LEA than their female counterparts.
Conclusion: Within the patient population of our orthopaedic institution, the etiology of lower extremity amputations demonstrates a multifaceted nature that sets it apart from trends observed in other surgical specialties. Notably, the incidence of major amputations has shown a consistent upward trend over recent years.

Introduction

Lower limb amputations represent a profound and life-altering consequence of various medical conditions, traumatic injuries, and systemic diseases [1]. The loss of a lower limb, whether partial or total, is a deeply impactful event that can significantly affect an individual's quality of life, independence, and mobility.

Corresponding Author: Mehrdad Zamani Esfahlani. M_zamani@yahoo.com

Understanding the multifaceted etiology behind lower limb amputations is essential for improving prevention strategies, optimizing treatment modalities, and enhancing rehabilitation efforts [2].

Lower limb amputations can result from a myriad of causes, spanning traumatic injuries, vascular diseases, diabetic complications, cancer, congenital anomalies, and infections. Each etiological factor carries its unique challenges and complexities, necessitating a comprehensive investigation into the root causes, risk factors, and evolving trends associated with lower limb amputations [3,4].

The prevalence of lower limb amputations, which refers to the removal of all or part of one or both of the lower extremities, is a significant health concern with global implications [5]. The prevalence rates can vary widely depending on factors such as geographic location, population demographics, healthcare infrastructure, and the underlying causes of amputations.

Understanding the prevalence of lower limb amputations is crucial for healthcare planning, resource allocation, and the development of effective prevention and treatment strategies [6].

Here are some key points about the prevalence of lower limb amputations:

Global Variability

The prevalence of lower limb amputations varies around the world. Higher-income countries with well-established healthcare systems generally report lower amputation rates due to better access to preventive care and advanced treatment options. In contrast, lower-income countries may have higher amputation rates due to limited access to healthcare, particularly in rural areas [7].

Vascular Diseases

Peripheral artery disease (PAD) and complications related to diabetes, such as diabetic foot ulcers, are among the leading causes of lower limb amputations globally. The prevalence of these conditions has been on the rise, particularly in regions with a high prevalence of type 2 diabetes [8,9].

Traumatic Injuries

Traumatic injuries, including accidents, workplace injuries, and military combat injuries, can lead to lower limb amputations. The prevalence of traumatic amputations may vary depending on factors such as the frequency of accidents and the availability of emergency medical services [8].

Cancer

In some cases, lower limb amputations are performed as part of cancer treatment, such as the tumors removal in bone or soft tissue. The prevalence of cancer-related amputations can vary based on the incidence of cancer types that affect the lower limbs [8,10].

Age and Gender

The prevalence of lower limb amputations tends to increase with age. Older individuals are more susceptible to conditions like PAD and diabetes, which are risk factors for amputations. Gender can also play a role, as some studies have shown a higher prevalence of amputations in men compared to women [8].

Prevention Efforts

Public health initiatives and preventive measures, such as early diabetes management, smoking cessation programs, and improved vascular care, can help reduce the prevalence of lower limb amputations. Education and awareness campaigns about the importance of foot care and early detection of vascular issues are also essential components of prevention efforts [11].

Rehabilitation and Prosthetics

Advances in prosthetic technology and rehabilitation services have improved the quality of life for individuals living with lower limb amputations. These advancements can positively impact the prevalence by enabling better mobility and functionality among amputees [11].

This article embarks on a journey of exploration into the multifaceted etiology of lower limb amputations, aiming to shed light on the intricate interplay of factors contributing to this life-altering outcome. We delve into the key etiological categories, examining the role of traumatic injuries, vascular diseases, diabetes, cancer, congenital anomalies, and infections in the context of lower limb amputations [12,13] (Figure 1).

Moreover, this article explores the evolving trends in lower limb amputation etiology, considering how changes in healthcare practices, advancements in medical technology, and shifting demographics influence the landscape of amputation causes [14]. It also investigates the impact of disparities in healthcare access and socioeconomic factors on the prevalence of lower limb amputations in different regions [15,16].

In addition to dissect the etiological factors, we will also touch upon the psychological and emotional aspects of lower limb amputations, acknowledging the challenges faced by individuals who undergo such life-altering procedures and the importance of comprehensive care and rehabilitation in their journey towards recovery and adaptation [17,18].

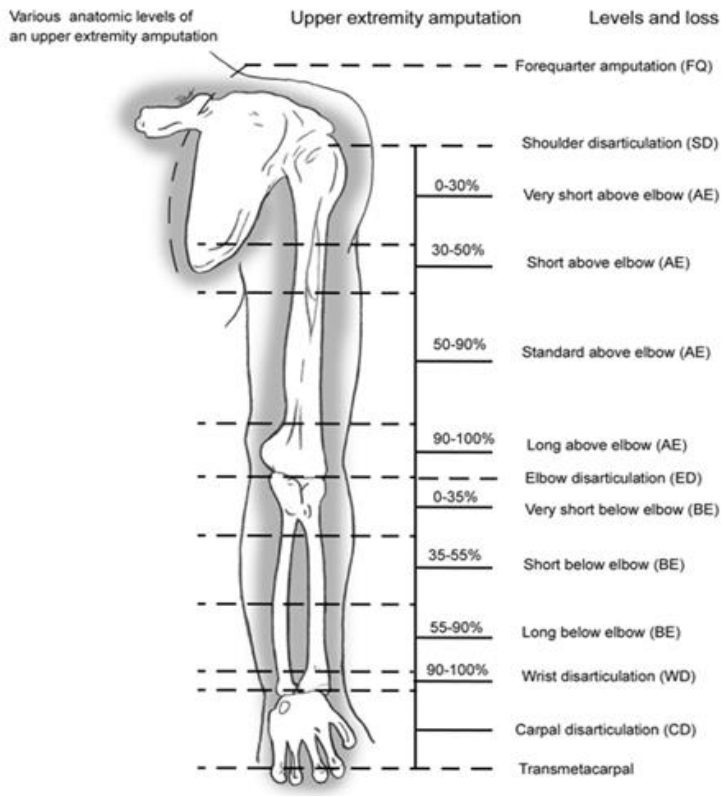

Figure 1 Level of lower limb amputation

As we navigate the intricate terrain of lower limb amputation etiology, this article seeks to provide valuable insights for healthcare professionals, researchers, policymakers, and

anyone interested in the complexities of thiscritical healthcare issue. By unraveling the multifaceted factors contributing to lower limb amputations, we aim to contribute to the development of more effective prevention strategies, improved treatment approaches, and enhanced support systems for individuals living with limb loss.

Materials and methods

Study Design

This study employs a retrospective observational design to investigate the etiology of lower limb amputations in East Azarbaijan Hospitals (Imam Rwza Hospital, Shohada Hospital, and Shahriai Hospital) over a defined period (2007-2019). It seeks to identify and analyze the causes and associated factors contributing to lower limb amputations in this region.

Inclusion Criteria

(1) Patients of all age groups who underwent lower limb amputation in East Azarbaijan Hospitals (Imam Rwza Hospital, Shohada Hospital, and Shahriai Hospital).

(2) Patients with complete medical records, including demographic information, clinical history, and details of the amputation procedure.

(3) Patients with amputations resulting from various etiological factors, including but not limited to vascular diseases, diabetes-related complications, traumatic injuries, cancer, congenital anomalies, and infections.

Exclusion Criteria

(1) Patients with incomplete or missing medical records.

(2) Patients with lower limb amputations due to non-medical reasons (e.g., elective amputations for cosmetic purposes).

(3) Patients with amputations due to rare or extremely uncommon causes that do not represent typical etiological factors in the region.

Sampling

Convenience sampling will be used to select a representative sample of patients who meet the inclusion criteria from the records of East Azarbaijan Hospitals. Given the retrospective nature of the study, all eligible patients within the defined time frame will be included.

Sample Size Calculation

To ensure a robust sample size, we will aim to include data from at least 114 patients who meet the inclusion criteria. This sample size will provide adequate statistical power to analyze the various etiological factors contributing to lower limb amputations.

Study Protocol

Data Collection: Comprehensive data will be collected from medical records, including patient demographics, medical history, diagnostic reports, and surgical details.

Categorization: Patients will be categorized into study groups based on the primary etiological factor leading to their lower limb amputation.

Data Analysis: Statistical analysis will be performed to identify trends, risk factors, and associations within each study group. Descriptive statistics and inferential tests (e.g., chi-square and t-tests) will be used as appropriate.

Ethical Approval

Ethical approval will be obtained from the Institutional Review Board or Ethics Committee of the respective hospitals, ensuring patient confidentiality and data protection.

Statistical Analysis

(1) The statistical analysis will involve the following:

(2) Descriptive statistics: Mean, standard deviation, median, and percentages.

(3) Inferential statistics: Chi-square tests, t-tests, or non-parametric equivalents, as applicable, to assess associations and differences between study groups.

(4) Multivariate analysis, such as logistic regression, to identify independent risk factors.

(5) Significance level set at $p < 0.05$.

Results

Between 2007 and 2019, a total of 114 lower extremity amputations (LEA) were performed on 106 patients within our study cohort. Among these amputations, the majority, constituting 60.5% (n = 69), were classified as major, while the remaining 39.5% (n = 45) were categorized as minor amputations. The gender distribution revealed that 61.4% (n = 70) of the patients were male, while 38.6% (n = 44) were female.

Notably, a statistically significant difference emerged, with a higher prevalence of LEA observed among men compared to women ($p = 0.015$). Furthermore, an age-based distinction was evident, with men undergoing amputation at a significantly younger age compared to women (men: 54.8 ± 2.8 years, women: 64.9 ± 3.2 years, $p = 0.021$).

The primary factors precipitating LEAs within our study population were diverse. Tumors accounted for the largest proportion at 28.9%, followed closely by implant-associated complications, contributing to 25.4% of cases. Angiopathies represented 21.1% of the cases, while malformations and infections each constituted 9.6%. A smaller percentage, 5.3%, fell under the category of "other" causes. Notably, implant-related complications and the majority of tumors invariably led to major amputations.

Specifically, implant-associated complications significantly increased the likelihood of a transfemoral amputation or hip exarticulation, while tumors were strongly associated with amputations occurring around the knee joint. In contrast, malformations, angiopathies, and infections were more likely to result in minor amputations (Figure 2).

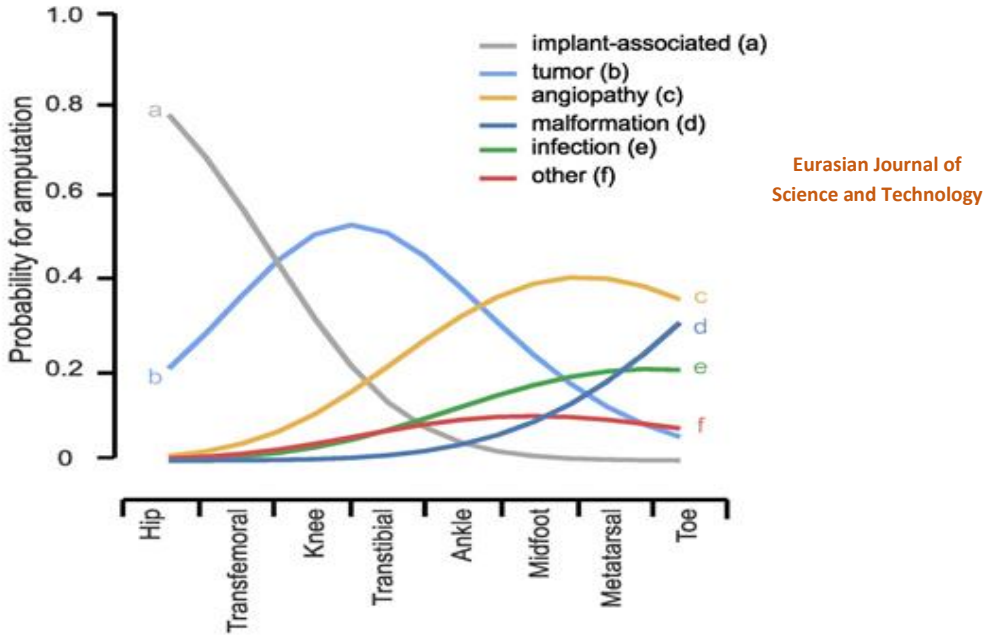

Figure 2 Multivariate logistic regression analysis for the amputation level

Our analysis also unveiled a significant impact of age on the probability of undergoing a major amputation. Increasing age emerged as a significant risk factor, particularly for major amputations involving transfemoral amputation or hip exarticulation (Figure 3).

Examining the temporal trend from 2007 to 2019, a notable pattern emerged. We observed a statistically significant increase in the number of major amputations during this period, with an average of 0.6 new major amputations occurring annually. In contrast, the number of minor amputations remained relatively constant over the same timeframe, with an average of 0.04 new minor amputations per year (Figure 4). These findings underscore the evolving landscape of lower extremity amputations within the study duration.

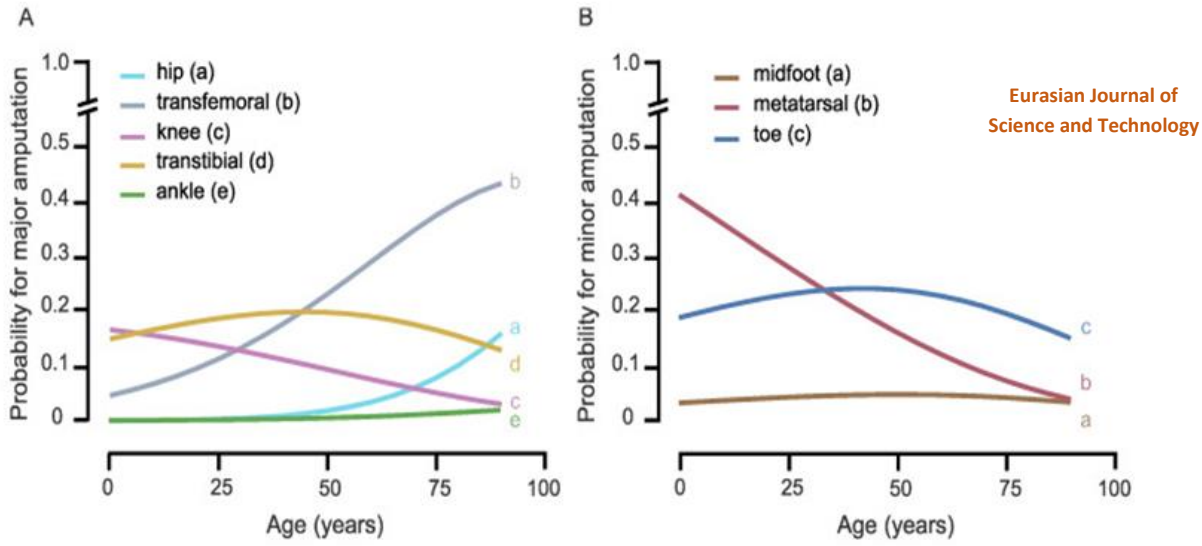

Figure 3 Multivariate logistic regression analysis for the level of amputation

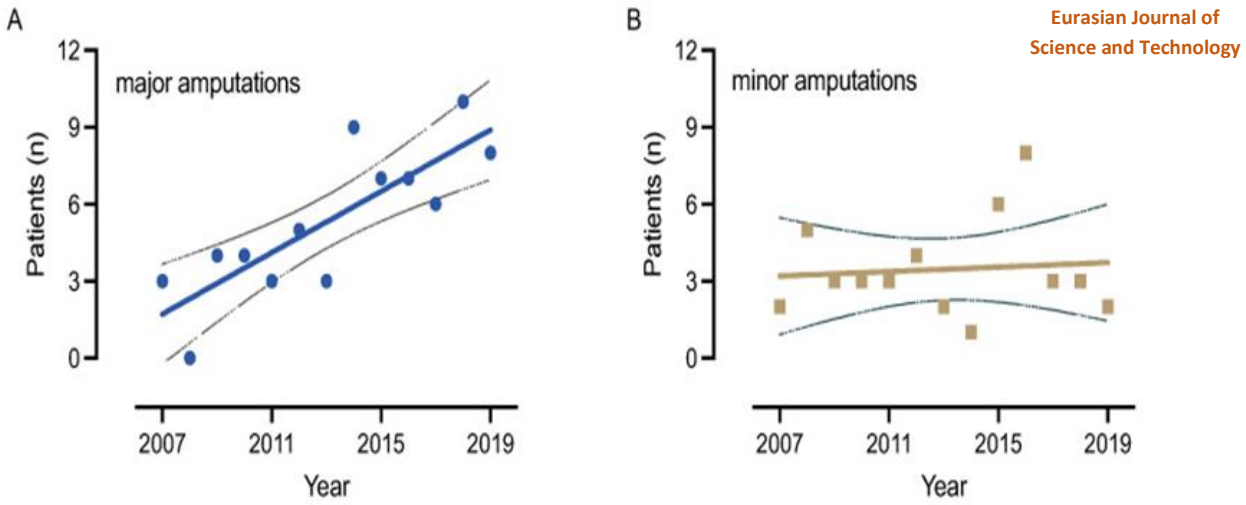

Figure 4 Linear regression analysis for major (A) and minor (B) amputations over time

Discussion

In this retrospective analysis conducted at a single-center, our investigation revealed a multifactorial etiology for lower extremity amputations (LEA) within our orthopaedic patient cohort, distinguishing it from trends observed in other surgical specialties. The most prevalent diagnoses leading to LEA among our patients were primarily tumors and implant-related complications, in contrast to the predominant global etiology of peripheral artery disease (PAD) and diabetes mellitus (DM)-related amputations. Importantly, the type and level of amputation were found to be significantly influenced by factors such as age, sex, and diagnosis. Furthermore, our analysis of temporal trends demonstrated a consistent increase in major amputations, while minor amputation rates remained relatively stable during the study period [17].

Our study population predominantly comprised male patients, a finding consistent with various prior studies that have identified male sex as a significant risk factor for amputations, both in diabetic and non-diabetic populations [8]. Notably, our investigation also revealed that males tended to undergo amputation at a significantly younger age than females, a pattern consistent with findings from population-based studies. This age and sex discrepancy might be attributed to several factors, including demographic differences such as a higher average age among women and lifestyle-related predispositions to comorbidities such as DM and PAD [12].

The average age at the time of amputation within our study cohort was approximately 58.7 years, which stands in contrast to some prior studies reporting higher mean ages by 10 to 15 years [14]. This disparity can be explained by the fact that these earlier studies primarily analyzed patient populations with a higher prevalence of comorbidities like DM and PAD, which are typically associated with older age groups [19]. In our orthopaedic patient population, a notable proportion presented with musculoskeletal tumors, a condition that can affect individuals of various age groups, including children and adolescents. Furthermore, malformations, often leading to amputations during early infancy, contributed to the diversity of age groups in our study. Thus, it becomes evident that amputations within the orthopaedic context are not exclusive to older patients [20].

Nonetheless, increasing age was identified as a significant risk factor for major amputations, particularly transfemoral amputations and hip exarticulations, a trend in alignment with prior research findings. Currently, amputation is typically not the primary treatment option for musculoskeletal tumors. Instead, most tumor-associated amputations in our cohort were necessitated by relapses or complications arising from failed extremity-preserving techniques, thereby increasing the probability of amputation with advancing age. A similar pattern was observed in cases of implant-related amputations, where the majority of procedures constituted salvage interventions following multiple prior revision surgeries. Consequently, the probability of amputation tends to rise with age, especially in the context of implant-associated complications [21].

Interestingly, our study uncovered a contrasting trend compared to many European and Western countries, where major amputation rates have seen a decline. This divergence may be attributed to the predominant etiological factors associated with amputations in those regions, namely PAD and DM [22]. The implementation of effective therapies for these conditions, including advancements in angiology, improved recanalization techniques for PAD, enhanced DM prevention programs, and specialized diabetic foot care, has contributed to a reduction in amputation rates, particularly in PAD/DM-related cases. However, despite these strides, the goal set in the St. Vincent's Declaration of 1989 to reduce DM-associated amputations by half within five years has yet to be realized [23]. A recent publication by Kröger *et al.* highlighted changes in amputation indications in Germany between 2005 and 2014, revealing an overall increase of 3.5% in amputations when excluded. This implies that musculoskeletal disorders play a significant role in the landscape of amputations. Furthermore, the study emphasized that major amputation rates have

not decreased for patients with tumors and other musculoskeletal disorders, underscoring the influence of these conditions on the prevalence of major amputations [24,25].

In the United States, Kalbaugh *et al.* observed shifts in amputation indications between 2006 and 2016, with a notable increase in infections as a contributing factor, rising from 8% to 24%. Within our population, the surge in major amputations corresponded to a rise in implant-related complications. Given the consistently high numbers of primary total joint replacements in Germany, coupled with an aging population, an increased demand for revision surgeries is anticipated [26].

Conclusion

Within the patient population of our orthopaedic institution, the etiology of lower extremity amputations demonstrates a multifaceted nature that sets it apart from trends observed in other surgical specialties. Notably, the incidence of major amputations has shown a consistent upward trend over recent years. The type and level of amputation were found to be significantly influenced by patient age and gender, in addition to the underlying diagnosis. These findings underscore the unique landscape of lower extremity amputations within the orthopaedic context, emphasizing the multifactorial nature of the condition and the need for tailored approaches to its management.

ORCID

Mohammad Irajian
https://orcid.org/0000-0001-6599-2600

References

[1] Fylstra B.L., England D.L., Stevens P.M., Campbell J.H., Wurdeman S.R., Creating Adjusted Scores Targeting mobiLity Empowerment (CASTLE 1): determination of normative mobility scores after lower limb amputation for each year of adulthood, *Disability and Rehabilitation*, 2023, 1 [Crossref], [Google Scholar], [Publisher]

[2]Lee L.S., Hitzig S.L., Mayo A., Devlin M., Dilkas S., MacKay C., Factors influencing physical activity among individuals with lower limb amputations: a qualitative study, *Disability and Rehabilitation*, 2023, **45**:1461 [Crossref], [Google Scholar], [Publisher]

[3]England D.L., Miller T.A., Stevens P.M., Campbell J.H., Wurdeman S.R., Mobility Analysis of AmpuTees (MAAT 7): normative mobility values for lower limb prosthesis users of varying age, etiology, and amputation level, *American Journal of Physical Medicine & Rehabilitation*, 2022, **101**:850 [Crossref], [Google Scholar], [Publisher]

[4]Aghamohamadi D., Gol M.K., An investigation into the effects of magnesium sulfate on the complications of succinylcholine administration in nulliparous women undergoing elective cesarean section: A double-blind clinical trial, *International Journal of Women's Health and Reproduction Sciences*, 2019, **7**:520 [Crossref], [Google Scholar], [Publisher]

[5]Grudziak J., Etiology of major limb amputations at a tertiary care centre in Malawi, *Malawi Medical Journal*, 2019, **31**:244 [Crossref], [Google Scholar], [Publisher]

[6]Eidmann A., Kamawal Y., Luedemann M., Raab P., Rudert M., Stratos I., Demographics and Etiology for Lower Extremity Amputations—Experiences of an University Orthopaedic Center in Germany, *Medicina*, 2023, **59**:200 [Crossref], [Google Scholar], [Publisher]

[7]Ferrer C., Cannizzaro G.A., Borlizzi A., Caruso C., Giudice R., Acute ischemia of the upper and lower limbs: tailoring the treatment to the underlying etiology, in *Seminars in Vascular Surgery.* [Crossref], [Google Scholar], [Publisher]

[8]Diao S., Kassé A., Diouf J., Sané J., Thiam B., Diallo M., Sy M., Major limb amputations: etiological and clinical profile in a hospital in Sub-Saharan Africa, *Open Journal of Orthopedics*, 2021, **11**:40 [Crossref], [Google Scholar], [Publisher]

[9]Khanbabaei Gol M., Aghamohammadi D., Effect of intravenous infusion of magnesium sulfate on opioid use and hemodynamic status

after hysterectomy: double-blind clinical trial, *The Iranian Journal of Obstetrics, Gynecology and Infertility*, 2019, **22**:32 [Crossref], [Google Scholar], [Publisher]

[10] Khanbabayi Gol M., Eidy M., Zamani Esfahlani M., Frequency ratio of carpal tunnel syndrome in women with breast cancer treated with lymphedema in Tabriz medical education centers; 2018-2019, *The Iranian Journal of Obstetrics, Gynecology and Infertility*, 2020, **22**:62 [Crossref], [Google Scholar], [Publisher]

[11] Ettema S., Kal E., Houdijk H., General estimates of the energy cost of walking in people with different levels and causes of lower-limb amputation: a systematic review and meta-analysis, *Prosthetics and orthotics international*, 2021, **45**:417 [Crossref], [Google Scholar], [Publisher]

[12] Biagioni R.B., Louzada A.C.S., Biagioni L.C., da Silva M.F.A., Teivelis M.P., Wolosker N., Cross-Sectional Analysis of 180,595 Lower Limb Amputations in the State of Sao Paulo Over 12 Years, *World journal of surgery*, 2022, **46**:2498 [Crossref], [Google Scholar], [Publisher]

[13] Shahidi N., Mahdavi F., Gol M.K., Comparison of emotional intelligence, body image, and quality of life between rhinoplasty candidates and control group, *Journal of Education and Health Promotion*, 2020, **9** [Crossref], [Google Scholar], [Publisher]

[14] Stewart C.C., Berhaneselase E., Morshed S., The Burden of Patients With Lower Limb Amputations in a Community Safety-Net Hospital, *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*, 2022, **30**:e59 [Google Scholar], [Publisher]

[15] Utiyama D.M.O., Alfieri F.M., dos Santos A.C.A., Ribeiro C.P.C., Sales V.C., Battistella L.R., Effects of an Inpatient Physical Rehabilitation Program Designed for Persons with Amputations of Traumatic or Vascular Etiologies, *JPO: Journal of Prosthetics and Orthotics*, 2022, **34**:152 [Google Scholar], [Publisher]

[16] Jiang S., Zhang, Y., Alsaikhan, F., Jalil, A.T., Gol, M.K.,Tarighatnia, A., A meta-analysis review of the effect of Zn-doped synthetic polymer materials on bone regeneration, *Journal of Drug Delivery Science and Technology*, 2022, 103792 [Crossref], [Google Scholar], [Publisher]

[17] Hunter S.W., Motala A., Cronin A.E., Bartha R., Viana R., Payne M.W., Cortical activation during imagined walking for people with lower limb loss: a pilot study, *Frontiers in Human Neuroscience*, 2023, **17** [Crossref], [Google Scholar], [Publisher]

[18] Gol M.K., Payami S., Lotfi A., Study of the Effect of Ear Acupressure on Stress and Serum Cortisol Level Before Rhinoplasty Surgery: A Randomized Clinical Trial, *Crescent Journal of Medical & Biological Sciences*, 2020, **7** [Google Scholar], [Publisher]

[19] McDonald C.L., Westcott-McCoy S., Weaver M.R., Haagsma J., Kartin D., Global prevalence of traumatic non-fatal limb amputation, *Prosthetics and orthotics international*, 2021, 0309364620972258 [Crossref], [Google Scholar], [Publisher]

[20] Miller M.J., Blankenship J.M., Kline P.W., Melanson E.L., Christiansen C.L., Patterns of sitting, standing, and stepping after lower limb amputation, *Physical therapy*, 2021, **101**:pzaa212 [Crossref], [Google Scholar], [Publisher]

[21] Miller M.J., Cook P.F., Magnusson D.M., Morris M.A., Blatchford P.J., Schenkman M.L., Christiansen C.L., Self-efficacy and social support are associated with disability for ambulatory prosthesis users after lower-limb amputation, *PM&R*, 2021, **13**:453 [Crossref], [Google Scholar], [Publisher]

[22] Krueger M.D., Mortality After Nontraumatic Major Lower-Limb Amputations in Medicare Patients at a Large Metropolitan Prosthetic Facility, *JPO: Journal of Prosthetics and Orthotics*, 2023, **35**:250 [Google Scholar], [Publisher]

[23] Resnik L., Borgia M., Heinemann A.W., Clark M.A., Prosthesis satisfaction in a national sample of Veterans with upper limb amputation, *Prosthetics and orthotics international*, 2020, **44**:81 [Crossref], [Google Scholar], [Publisher]

[24] Gaunaurd I.A., Morgan S.J., Balkman G.S., Kristal A., Rosen R.E., Haynes J.S., Gailey R.S., Hafner B.J., Modifying the five-time sit-to-stand test to allow use of the upper limbs: Assessing initial evidence of construct validity among lower limb prosthesis users, *PloS one*, 2023, **18**:e0279543 [Crossref], [Google Scholar], [Publisher]

[25] McLarney M., Pezzin L.E., McGinley E.L., Prosser L., Dillingham T.R., The prevalence of lower limb loss in children and associated costs of prosthetic devices: A national study of commercial insurance claims, *Prosthetics and orthotics international*, 2021, 0309364620968645 [Crossref], [Google Scholar], [Publisher]

[26] JA M.P., Martínez M., Factors related to success in the prosthetic fitting of lower limb amputees from vascular etiology, *Rehabilitacion*, 2022, S0048 [Crossref], [Google Scholar], [Publisher]