



RESEARCH ARTICLE

EFFECTIVENESS OF PHYSIOTHERAPEUTIC EXERCISES IN PRE PROSTHETIC AND PROSTHETIC PHASE IN LOWER LIMB AMPUTEE PATIENTS: SYSTEMATIC REVIEW

¹Irving López Gutiérrez, ²Luis Iván Verdín Uscanga, ³Raúl Hernández Castañeda and ⁴Diana Laura Morales Benítez

¹Bachelor 's Degree in Physical Therapy, School of Health Sciences, Universidad del Valle de México Campus Veracruz, Mexico; ²Bachelor 's Degree in Physical Therapy, School of Health Sciences, Universidad del Valle de México Campus Veracruz, Mexico; ³TTE. ATM. Hospital Militar, Centro de Rehabilitación Infantil del Hospital Militar, Ciudad de México; ⁴ Bachelor 's Degree in Physical Therapy, Universidad del Valle de México

ARTICLE INFO

Article History:

Received 15th May, 2022
Received in revised form
14th June, 2022
Accepted 17th July, 2022
Published online 30th August, 2022

Keywords:

Exercise, Physiotherapy, Lower Limb, amputation, Prosthetic Phase, Pre-Prosthetic Phase.

ABSTRACT

Background and objectives: Amputation is defined as an irreversible surgical act where total or partial removal of a body limb is done through one or more bones. It is said that the most frequent reasons are traumatic, oncologic and vascular. When people suffer from this type of process, they lose physical capacity which generates a decrease in their ability to ambulate and perform daily activities. The physiotherapeutic process in lower limb amputations is aimed at the recovery and functional retraining of ambulation to generate the greatest possible independence. This study aims to perform a systematic review of the literature to determine the effectiveness of rehabilitation exercises in the pre-prosthetic and prosthetic phases in lower limb amputee patients. **Material and methods:** A systematic review of published articles with a clinical trial study was carried out. where the information sources obtained were identified and quantified from digital databases such as: Elsevier, Google academic, Pubmed, PeDRO and Scielo; subsequently they were disfavored according to the selection criteria and qualitative information that was extracted from each of them. **Results:** Articles were obtained through systematic searching in the five database platforms. There were about 2,736 results, of which 8 of these articles met the established selection criteria. The results and conclusions of the included articles showed the positive effectiveness of physiotherapeutic exercises as part of the treatment in amputee patients. **Conclusions:** It was shown that integrating the rehabilitation area, and establishing a physiotherapeutic exercise program in the pre-prosthetic and prosthetic stages, has a positive effect on the experimental group.

INTRODUCTION

Amputation, also known as the loss or removal of a body part, is an irreversible surgical act, where the total or partial extirpation of a limb of the body is performed through one or more bones. These can occur for various reasons, leading to an amputated patient. The incidence of amputation varies from country to country, but the age and sex distribution is very similar. The highest prevalence is in the 40-59 and 60-79 age groups, 2/3 of amputations occur in patients over 60 years old, and it is higher in men than in women. The sex rate is 1 to 5 between women and men, due to the fact that there are higher-risk activities that men perform. On the other hand, the frequency of secondary amputations to a tumor is very similar in both genders and there is no difference in the incidence in right or left limbs, it is also mentioned that congenital deformities of the extremities are of similar recurrence for both sexes. The loss of the lower extremities has been associated with muscle atrophy ranging from 40% to 60% in the severed muscle groups, as well as up to 30% in the intact hip stabilizers near the amputation. Patients with lower extremity amputation often show structural changes in proximal muscle groups, including bone-free lean body mass in the lower thigh and an

increase in thigh fat percentage, which has been linked to poorer gait among healthy older adults, while atrophy of the hip stabilizing muscles has been shown to promote greater ambulation asymmetry among transfemoral amputee patients. With all this mentioned, we can realize that the maintenance of lower extremity strength is paramount for amputee patients. Ambulation is of great importance for social mobility and for independence in activities of everyday life. This is of major relevance because people who suffer a lower limb amputation, whether unilateral or bilateral, transfemoral or transtibial, often have gait disturbances even though the rehabilitation program has been completed. There are multiple reasons to perform an amputation, but it is mentioned that the most frequent causes are traumatic, oncologic, and vascular or endocrine. Traumatic amputation is indicated whenever the usefulness of a limb has been irreparably affected; this may be the case of injuries caused by electrocution, frostbite, crushing. Oncological amputation occurs in the case of bone tumors and soft tissue sarcomas of the extremities. Finally, amputation due to peripheral vascular diseases, which is manifested by the lack of circulation and

tissue death due to vascular insufficiency or diabetes mellitus. When talking about amputation levels, these vary depending on the limb which is involved and the extension level of the injury (Table 1). On the medical side, it has been most useful to divide the rehabilitation program for amputee patients into 4 phases: the pre-surgical phase, the surgical phase, the pre-prosthetic treatment and the prosthetic treatment. If the patient comes to the physiotherapy area after amputation surgery, the focus of rehabilitation treatment should be on the pre-prosthetic and prosthetic phases. The pre-prosthetic treatment is of great importance since the patient should be taught the proper bandaging of the residual limb in order to give the correct shape and obtain an adequate residual limb. In the same way, the prosthetic part is necessary because it is where activities such as putting on and taking off the prosthesis correctly, intensifying exercises, correcting posture, and re-educating gait, among many others, are carried out. When individuals suffer the loss of a part of a lower extremity, they experience both physical and psychological changes, leading to a loss of physical capacity, resulting in a decrease in their ability to ambulate and in their everyday life activities. The main objective of the physiotherapeutic process in lower limb segment amputations is the recovery and functional reeducation of gait in order to be able to perform daily life activities as independently as possible. Within these rehabilitation protocols, strength, balance, functional tasks, transfers and gait training exercises are included. These are usually accompanied by other techniques, such as proprioceptive neuromuscular facilitation.

MATERIALS AND METHODS

A systematic review of publications with the clinical trial design was carried out to identify and analyze the information obtained from various scientific articles on the efficacy of pre-prosthetic and prosthetic exercises in the rehabilitation of lower extremity amputees or lower limb amputated patients. From November 2021 to April 2022, a strategic search was carried out in bibliographic databases on 5 platforms: Elsevier, Google academic, Pubmed, PEDro and Scielo. The keywords used for the strategic search of the research in both Spanish and English, such as exercise, physiotherapy, lower limb, amputation, prosthetic phase, and pre-prosthetic phase, these words were enclosed in quotation marks to delimit and make the search for information more specific and likewise Boolean operators were used as connectors, in the same way, these were put in quotation marks to delimit and make the search for information more specific, which were connected by applying the Boolean operators “and”, “not” and “or”. Inclusion and exclusion criteria were established for the selection of articles, which are detailed below:

Inclusion criteria: studies published from 2003-2022, randomized clinical trials and research studies, lower limb amputated patients, older than 15 years, whose implementation of physiotherapeutic exercises is focused on the pre-prosthetic or prosthetic phase. Exclusion criteria: studies published before 2003, studies based on systematic reviews, patients who are upper limb amputees, patients younger than 15 years old, and studies that don't present the implementation of physiotherapeutic exercises (Diagram 1). The quality of the articles was evaluated using the CASPe and McMaster guides. It was carried out by peers, including authors I.L.G and L.I.V.U. Finally, once the selected articles were obtained, the information contained in them was analyzed and the qualitative results of the observations and conclusions were extracted.

The entire selection procedure for published articles is shown graphically utilizing a research selection diagram. (Diagram 1)

RESULTS

A search for information was carried out on different platforms of digital tools, the title and description of these were reviewed and 2.736 scientific articles were found, of which 40 were selected for analysis, based on the selection characteristics, which included inclusion and exclusion criteria. Finally, 8 publications met the established criteria and were included in the study. In the selected articles there was a predominance of male amputees, which gave us an example of the prevalence of lower limb amputations in male patients as previously mentioned. In the analysis of the age of the patients, there was a wide range of variety, ranging from 15 to 65 years of age, with an average of 40 years. The etiology or causes of amputations presented in the articles are ordered in such a way that the most common was a traumatic origin, followed by diabetes, vascular disease and the last one by tumor origin (Graph 1). Regarding the level of amputation, the majority of patients in the selected studies consisted of participants with amputation at the transtibial level, followed by individuals with transfemoral amputation. With regards to the pre-prosthetic and prosthetic phases, two articles were found fully focused on the pre-prosthetic phase and two on the prosthetic phase, while the other four talked about the intervention of exercises in both phases or prosthetic periods respectively. Most of the studies were comparative or experimental. Six of these studies were presented, in two groups: one experimental and one control, with the purpose of being able to analyze, compare or verify the results that were presented later or after the exercise intervention in both study groups.

Intervention time varied depending on the authors and their study objectives, ranging from weeks to months. The most common treatment duration was 8 weeks with a time session ranging from 30 minutes to 1 hour. The physiotherapeutic exercise programs of the analyzed scientific articles contain warm-up exercises, balance, stretching and strengthening of hip muscles such as flexors, extensors, abductors, and adductors to walking exercises on parallel bars, each one having its objectives and results according to the authors' research. These parameters are described in the table (Table 2).

DISCUSSION

Through data interpretation collected from the selected literature, there is a considerable improvement in parameters of balance, strength, endurance or resistance, while functional improvements in gait were found. All this with the help of physiotherapeutic intervention and its various rehabilitation exercise programs during the main stages of the prosthesis in lower limb amputated patients. On the other hand Nolan L, Ph.D. (2012). mentions that his results went beyond improving gait, but managed to make his patients in the experimental group run. In most of the studies, the exercise programs focused on strength training except for sethy, D., Snehlata K., E. & Sau, K. (2009). Whose main focus was balance training. The intervention time of the exercise programs was variable depending on the objectives proposed by the authors, being the shortest of 2 weeks established by Sahay, P. *et al* (2014). And the longest of 5 months of intervention according to the research of Moreno Lorenzo, *et al.* (2003).

Table 1

TYPE OF LOWER LIMB AMPUTATION	DESCRIPTION
Partial toes.	Removal of any part of one or more toes.
Disarticulation of the toes.	Disarticulation of the metatarsophalangeal joint.
Partial foot/radius resection.	Resection of toes and metatarsals 3, 4 and 5.
Transmetatarsal.	Amputation of the midsection of the metatarsals.
Syme's.	Disarticulation of the ankle with fixation of a heel pad to the distal end of the tibia. May include exeresis of the malleoli and distal tibial/peroneal attachments.
Long transtibial (below the knee).	More than 50% of tibial length.
Transtibial (below the knee).	Between 20% and 50% of tibial length.
Short transtibial (below the knee).	Less than 20% of tibial length.
Disarticulation of the knee.	Amputation of the knee joint; femur intact.
Long transfemoral (above the knee).	More than 60% of femur length.
Transfemoral (above the knee).	Between 35% and 60% of the length of the femur.
Short transfemoral (above the knee).	Less than 35% of femur length.
Hip disarticulation.	Amputation of the coxofemoral joint; pelvis intact.
Hemipelvectomy.	Resection of the lower half of the pelvis.
Hemicorporectomy	Amputation of both lower extremities and pelvis below the level of the L4 -L.

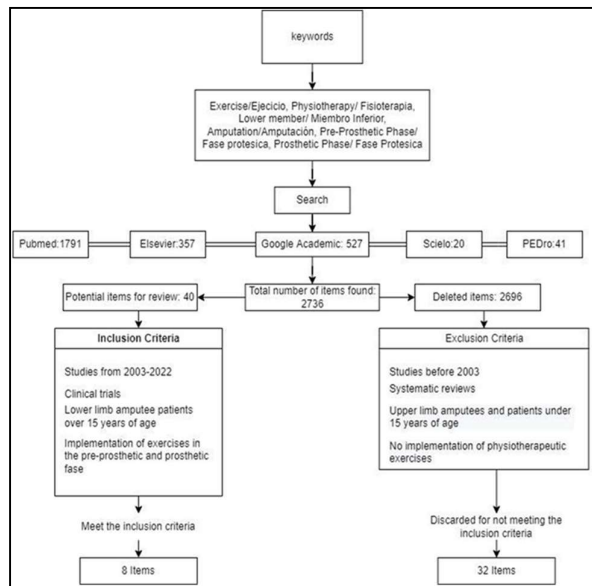
Source: Nahuinco, 2017.

Table 2

Title and autor	Amputation level	Prosthetic phas	Number of patients	Study objectives	intervention time	Exercises program	Results
"Effect of balance exercise on balance control in unilateral lower limb amputees. (Sethy, 2009)	-Trans femora l amput ation: 15 patient s -Trans tibial amput ation: 15 patient s	Prosthetic	Total=30 Experimentalgroup=15 Controlgroup=15M	To analyze and compare the effect of balance training on balance control in transtibial and transfemoral amputees.	4 weeks -Five times per week 30 min a day	Experimentalgroup: -Phyaction balance exercises: mediolateral andanteroposterior balance exercises and conventional training Conventionalgroup: -Conventional training and parallel bars.	There was a significant improvement in the experimental group. Balance control improved in unilateral lower extremity amputees.
"Short-term effect of physiotherapy rehabilitation on functional performance in lower limb amputees functional performance of	Experi mental group: 21 Tra nsti bial s	Pre-Prost hetic Prostheti c	Total=58 HExperi mental group= 29M	Toassessthe efficacy of a short, intensive physiotherapy program versus usual care consisting of supervised gait.	Intensive individual and standardized training with a duration of 1 hr.	Experimental group: -Strengthening of lower extremities. -Coordination. -Correctedgaitand obstacle Control group: -Supervised gait.	The experimental group significantly outperformed the control group in the 2-minute walk test. A short, intensive physiotherapy program improves gait speed.
Lower limb amputees." (RAU, 2007)	8 Tra nsf em oral s Contro l group: 22 tran stib ial s 7 tran s mo rals		Control group=29 M				
"Efficac of proprioceptive neuromuscular facilitation techniques versus traditional prosthetic training to improve ambulatory function in transtibial amputees." (Sahay, 2013)	Transti bial amputa tion	Pre-Prost hetic Prostheti c	Total=30 -19 males 11 females Experimental group(FNP)=15 Control group=15	To evaluate the efficacy of neuromuscular facilitation techniques vs. traditional prosthetic training to improve gait in transtibial amputees.	10 sessions for 2 weeks, 30 minutes a day.	Pre-prosthetic phase: Strengthening of lower limbs -Resistance training Prosthetic Phase: -Muscle strengthening-Weight bearing and weight shifting -Balance exercises-Parallel bar gait training Resistance, approach, slow inversion and rhythmic stabilization)	Proprioceptive neuro muscular facilitation (PNF) exercises were shown to be more effective in improving stride width, stride length and motor skills index. These improvements were present in the experimental group but not in the control group.

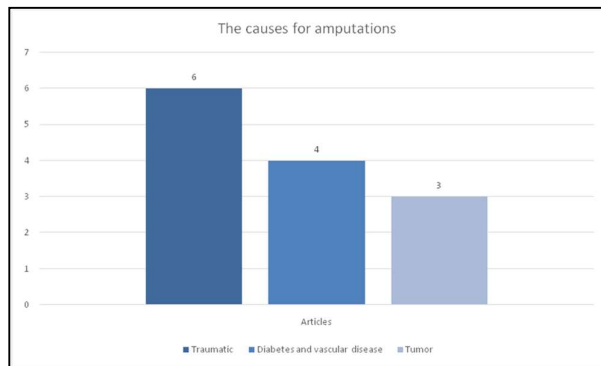
Continue

<p>"The effect of a home exercise intervention in people with lower limb amputations." (Godlwana, 2019)</p>	<p>Amputation below the knee</p>	<p>Pre-Prosthetic</p>	<p>Total=154-54 Females -100 Males Experimental group=77 Control group=77</p>	<p>To compare whether a home education and exercise program is more effective than usual treatment in improving function and mobility.</p>	<p>3 months</p>	<ul style="list-style-type: none"> • Bed exercises to prevent edema and deformity of the residual limb. • Stretching exercises • Strengthening exercises • Balance and mobility rehabilitation • Prevention of contractures. 	<p>There was an improvement in function, mobility and quality of life in the first 3 months after amputation.</p>
<p>"Muscle strengthening with isokinetic exercises <i>In above-knee amputees in pre-prosthetic period, a study of 10 cases.</i>" (Gallegos, 2004)</p>	<p>Amputation below the knee</p>	<p>Pre-Prosthetic</p>	<p>Total= 10M</p>	<p>To design a strengthening program with the use of isokinetic exercises for above-knee amputees in the pre-prosthetic phase and to evaluate the strength of specific muscles at the beginning and at the end of the program.</p>	<p>2 months -3 times a week</p>	<p>-Warm-up exercises with cycloergo meter -Isokinetic exercises to strengthen hip muscles: • flexors • extensors • adductors • abductors</p>	<p>There was an improvement in the arches of mobility and a significant increase in the degree of strength of the hip muscles.</p>
<p>"A single-blind crossover trial of hip abductor strength. Training to improve Timed Up & Go Performance in patients with unilateral transfemoral amputation." (Pauley, 2014)</p>	<p>Transfemoral amputation</p>	<p>Pre-Prosthetic</p>	<p>Total=17 M Experimental group= 9 Control group=8</p>	<p>To evaluate hip abductor muscle strength training in transfemoral amputation.</p>	<p>Total of 8 weeks 2 times a week 25- 30 minutes sessions</p>	<p>Experimental treatment: -Warm-up with stationary ergometer bicycle. -Strengthening exercise with hip abductor machine. Control treatment: -Supervised arm ergometry.</p>	<p>After 8 weeks of treatment, there was an improvement in the performance of the Timed Up & Go and 2-minute walk tests, as well as an improvement in balance and abductor strength. These positive results were presented in the experimental group.</p>
<p>"A training program to improve hip strength in lower limb amputees" (Nolan, 2012)</p>	<p>Transfemoral amputation - Bilateral amputation</p>	<p>Prosthetic</p>	<p>Total=1611 males 6females Experimental group= 8 Control group=</p>	<p>To research/investigate the effect of a hip strength training program to determine whether after the program patients are able to run</p>	<p>8 weeks</p>	<ul style="list-style-type: none"> • Crunches and push-ups • Physiotherapy • Walking • Nordic walking • Swimming • Boxing • Aerobic exercises 	<p>In the training group there was an increase in hip strength and oxygen consumption was minimized, while in the control group hip strength decreased. Six patients were able to run.</p>
<p>"Prosthetic and functional treatment lower limb amputees" (Moreno, 2003)</p>	<p>Transfemoral amputation</p>	<p>Pre-Prosthetic</p>	<p>Total=50 M</p>	<p>To know and follow up prosthetic treatment protocol for lower limb amputees.</p>	<p>5 months</p>	<p>Pre-prosthetic phase: -Respiratory physiotherapy -Active free and resisted kinesitherapy according to tolerance -Muscle balance exercises -Proprioception -Muscle tonification Prosthetic phase: -Support and counter support exercises. -Exercises of latero medial and Anteroposterior load</p>	<p>It was shown that the success of a lower limb fitting depends on factors such as age, level of amputation and etiology.</p>
						<p>transfers in a static and swinging way. -Walking in and out of the parallel bars. -Handling of walking sticks -Walking on unstable ground, up and down stairs</p>	



Source: own authorship

Diagram 1



Graph 1

Clinical trials included 2 groups, one experimental and the other control. We demonstrated by means of clinical experimentation the effectiveness that presents in a comparative manner. According to the systematic review by Cabrerizo, G. L. carried out in 2015, positive results were found in the study, as they mention that they showed that physiotherapeutic work helped improve gait parameters, strength, balance, coordination and proprioception compared to supervised gait alone. On the other hand, in 2018, Ülger, Ö., Tezel Y.S. & Seher Erol, C. refer in their results that the different types of treatment studied and mentioned in their review had positive effects on the functional status of the patients in the study groups. In the comparative bibliography, information, no more than 10 years old was sought due to the fact that it was based on more updated physiotherapeutic exercises compared to previous reviews. Together with the inclusion and exclusion criteria; likewise, positive results were found both in comparison and in obtaining results from experimental studies of the authors included in the present study, for affirming their hypotheses, where the impact of physiotherapy included as part of the treatment was mentioned, in lower limb amputee patients was mentioned.

CONCLUSION

Through this systematic review, we concluded that the application of physiotherapeutic exercise in the different stages of prosthesis had a beneficial effect on all patients, fulfilling the

proposed objectives and evidencing the results of the different articles presented. The evidence reviewed in our study shows the importance of early rehabilitation exercises for lower limb amputees beginning in the pre-prosthetic phase, because this therapy focuses on the molding and toning of the residual limb, as well as its strengthening in preparation for the next phase, which is aimed at training with the prosthesis and whose objective is the functional re-education of gait for the greatest possible independence. This study is open to new research approaches or with different characteristics, such as intervention from another area to help this type of people. It is possible that studies with exercise intervention for a longer period of time than those presented in the selected studies may show greater benefits. There may also be differences depending on the age range studied. Finally, the systematic review of the literature carried out confirms the effectiveness of physiotherapy exercises demonstrates that the techniques employed provide benefits that are reflected in the functional recovery of lower limb prosthetic amputees.

REFERENCES

Vázquez-Vela, E. (2015). Los amputados, un reto para el estado. *Academia Nacional de Medicina*: 2-9.

Pauley, T., Devlin, M. & Madan-Sharma, P. (2014). Un ensayo cruzado simple ciego de la fuerza del abductor de la cadera. *J Rehabil Med*, 1-7.

Ñahuincopa Pariona, G. (2017). Tratamiento Fisioterapéutico En Amputados Debajo De Rodilla Del Miembro Inferior. *Universidad Inca Garcilaso De La Vega*, 11-34.

Samitier, C.B., Guirao, L., Pleguezuelos, E., Pérez-Mesquida, M.E., Reverón, G. & Costea, M. (2010). Valoración de la movilidad en pacientes con amputación de miembro inferior. *REHABILITACIÓN (Madr)*, 45(1):61-66 <http://doi:10.1016/j.rh.2010.09.006>

Taberner-Rodríguez, J. (2011) Intervención fisioterápica en un paciente amputado con muñon transfemoral corto y reduccion para la marcha. *UNIVERSIDAD DE ZARAGOZA*, 6.

Govantes-Bacallao, Y. Julio Alba Gelabert, C. & Aries Cantalapedra, A. (2016). Protocolo de actuación en la rehabilitación de pacientes. *Revista Cubana De Medicina Fisica Y Rehabilitacion*, (1): 33-43.

Ramos, R. L. & Baryolo Cardoso, A.D. (2005). Rehabilitacion Del Amputado De Miembro Inferior. *Medicina De Rehabilitacion Cubana*, 41.

Esquenazi, A. (2014). Rehabilitation after amputation. *J am Podiatr Meed Assoc*, 13-22.

Sahay, P., Santosh, K., Shahnawaz, A., Lenka, P. & Ratnesh, K. (2014). Efficacy of proprioceptive neuromuscular facilitation techniques versus traditional prosthetic training for improving ambulatory function in transtibial amputees. *Hong Kong Physiotherapy Journal*, 28-34. <http://dx.doi.org/10.1016/j.hkpj.2013.02.002>

Nolan, L. (2012). A training programme to improve hip strength in persons with lower limb amput. *J Rehabil Med*, 1-8.

Sethy, D., Snehlata K., E. & Sau, K. (2009). Effect of balance exercise on balance control in unilateral lower limb amputee. *The Indian Journal of Occupational Therapy*, 1-6.

Cabrerizo, G. L., (2015). Fisioterapia post protetizacion en amputados de miembro inferior. *UNIVERSIDAD DE VALLADOLID*, 1-44.

Ülger, Ö., Tezel Y. S. & Seher Erol, C. (2018). A systematic literature review of physiotherapy and rehabilitation

- approaches to lower-limb amputation. *Physiotherapy Theory and Practice An International Journal of Physical Therapy*,4-12.
- Rau, B. (2007). Short-term effect of physiotherapy rehabilitation on functional performance of lower limb amputees . *Informa Health Care*, 1-13. <http://DOI:10.1080/03093640600994615>
- Godlwana, L., Stewart, A. & Musenge, E. (2019). El efecto de una intervención en el hogar en personas con amputaciones de miembros inferiores: un ensayo clínico controlado. *Rehabilitación Clínica Sage* ,1-12.<https://doi.org/10.1177/0269215519880295>
- Gallegos, M. D., Flores Vasconcelos, O., Guadarrama Becerril, J.I., Chávez Arias, D.D., Diez García, M.P. & García Vázquez, G. (2004). Fortalecimiento muscular con ejercicios isocinéticos en pacientes amputados por arriba de rodilla en periodo preprotésico, estudio de 10 casos. *Revista Mexicana De Medicina Física Y Rehabilitación* ,1-7.
- Moreno Lorenzo, C., Fernández Fernández, M.J., Iglesias Alonso, A., García Marcos, J.F. & Guisado Barrilao, R. (2003). Tratamiento protésico y funcional en amputados de miembro inferior . *Revista Iberoamericana De Kinesiología*,1-15.
