Rassegna

Prosthesis rejection in individuals with limb amputation: a narrative review with respect to rehabilitation

Rifiuto della protesi in individui con amputazione di un arto: una revisione della letteratura con riferimento alla riabilitazione

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SUMMARY. Objective. To evaluate the refusal of the prosthesis in order to highlight elements in determining the acceptance/rejection of the prosthetic devices, and its role on rehabilitation program. **Methods.** A literature review through a search of the database Medline for studies published between October 2007 and May 2020 using the key words "prosthesis", "limb", and "accept"*. **Results.** Nine studies were included. Women appear to be more concerned about discomfort in using body-powered devices and about prosthesis cosmetic appearance. Level of limb amputation was considered relevant for prosthesis rejection only for the upper limb. Children fitted with prosthesis before two years old were less likely to abandon the prosthesis, preschool children have a lower drop-out prevalence compared to adults and school-age children. **Conclusions.** Understating the factors for rejections is crucial for more favorable health outcomes; multiple psychological factors should be considered during the rehabilitation process of individuals with limb amputation. Rehabilitation should consider psychosocial assistance for acceptance and perception of body representation and its discrepancy with the real body.

KEY WORDS: limb amputation, prosthesis, acceptance, rejection, psychological.

RIASSUNTO. Scopo. Valutazione del rifiuto della protesi con lo scopo di evidenziare gli elementi correlati all'accettazione/rifiuto dei dispositivi protesici e il suo ruolo nel programma di riabilitazione. **Metodo.** Una revisione della letteratura attraverso la ricerca del database Medline per studi pubblicati tra Ottobre 2007 e Maggio 2020 utilizzando le parole chiave "prosthesis", "limb", and "accept"*. **Risultati.** Sono stati inclusi nove studi. Le donne sembrano essere maggiormente focalizzate sul malessere nell'utilizzo di dispositivi meccanici e sull'estetica nei dispositivi cosmetici. Il livello di amputazione dell'arto è stato considerato rilevante per il rigetto della protesi solo per l'arto superiore. I bambini a cui è stata applicata una protesi prima dei due anni di età erano meno soggetti all'abbandono della protesi. I bambini in età prescolare hanno un tasso di drop-out inferiore se confrontato con adulti e bambini in età scolare. **Conclusioni.** Il riconoscimento di fattori associati al rigetto è cruciale per esiti di salute più favorevoli; durante il processo di riabilitazione di individui con amputazione di un arto, andrebbero considerati fattori psicologici multipli. La riabilitazione dovrebbe tenere in considerazione un'assistenza psicosociale per l'accettazione e la percezione della rappresentazione del corpo e la sua discrepanza con il corpo reale.

PAROLE CHIAVE: amputazione, protesi, accettazione, rifiuto, psicologico.

INTRODUCTION

Limb amputation is a traumatic physical and psychological event. Individuals have difficulty with the separation of the mental representation of the body and the anatomical limb, and the physical and psychological acceptance of the prosthetic limb.

According to the German phenomenology, it is accepted that the body can be described as a *body-object* (Koerper), i.e., the body we have, and as a *lived-body* (Leib), i.e., the body we are[1]. Comprehensive rehabilitation of the amputee should consider restoring the separation that the amputation triggers between the body-object and the body-lived, as it happens in cases of hand transplantation[2].

Along with the prosthesis, the person should accept an external mechanical element. The prosthesis helps to fix the disrupted body image, but it also irrevocably states what is no longer there (e.g., limb loss).

The loss of a body part strongly affects a person's interaction with and sense of belonging in their environment (from a phenomenological point of view, his *Da Sein*). An analogy can be noted with the myth of Samson[3], in which the loss of a part of self (his hair) leads to the loss of all skills.

The subject that experiences a limb amputation needs to resolve an underlying conflict, i.e., his survival is intimately linked to the limb amputation, but this makes him "another" from who he was before. This is the reason why the amputation occurrence is a traumatic event, as it represents an existential *continuum* interruption, as seen in other disorders[4,5].

Moreover, limb amputation is a trauma because the correspondence between the mental self and the real self is disrupted. In addition, there is also a strong influence on the encounter with another person who brings its representation with him. Notably, James[6] stated: «Whenever two people meet, there are really six people present. There is each man as he sees himself, each man as the other person sees him, and each man as he really is». The common feature of the three representations, in the case of the amputee, is the missing limb; on one hand, this is the recurrence of the trauma, on the other hand, it is something that cannot be mentally filled by the prosthesis.

Demographic characteristics of limb amputation

In the United States, an estimated 185,000 persons undergo an amputation of the upper or lower limb each year[7]. The development of conservative methods, the advent of antibiotic therapies, the use of bone and skin plastic reconstructive surgery, and the progress of vascular interventions have reduced the incidence of amputations of the lower limb by almost 50%[8-10]. The major cause of lower limb amputation in high-income countries is still linked to peripheral vascular disease. Within these groups, the common causes are arteriosclerosis, diabetes mellitus, and Burger disease, which usually affect the elderly and may lead to amputation.

Limb amputations occurring secondary to vascular disease accounts for most cases (54%) with over two-thirds presenting as a comorbid diagnosis of diabetes. Lower limb amputation risk increased up to 15-fold in people with diabetes[8]. 45% of the cases of limb loss result from trauma. Limb loss resulting from the cancer accounts for less than 2% of cases[7].

In Italy, among the amputation rate for the traumatic events (31.2% of the total, GBD[11]), the three most frequent causes are falls (12.8%), crushing accidents by mechanical forces (4.2%), and road accidents (3.8%; GBD[11]). Individuals who are subjected to amputation due to pathology are usually over 60 years of age (in Italy: 65.4 years old), while traumatic amputations generally involve younger and more active subjects.

Approximately 42% of persons living with limb loss are 65 years or older; 65% are men[7]. Sixty-five percent of these persons underwent an amputation to the lower extremity, and more than 50% of these amputations were major (i.e., excluding toes). In contrast, of the total number living with the loss of an upper limb, only 8% were categorized as major (i.e., excluding fingers).

Congenital malformations are the cause of a small percentage of amputations (i.e., <3% of limb losses). Congenital limb deficiency can affect 6-7 out of every 10000 newborns and can be distinguished in congenital (chromosomal abnormalities, genetic syndromes, pharmacological, infectious, toxic, and physical) or acquired (paralytic limbs, severe pseudarthrosis, shortening of the upper limbs, non-functional ankylosis)[12-15].

Prostheses are prescribed to improve the functional and aesthetic aspects concerning the type of malformation (e.g., amelia, peromelia, phocomelia, and ectromelia), the extent and the severity of limb loss. Only a small part of amputations is caused by tumors (around 3-4%) and acute infections.

The limb amputation is generally followed by a long period of prosthetic rehabilitation to reintegrate the subject to daily living and social activities. A key element to consider in this multistep process is the prosthesis acceptance by the subject.

The present study aimed to evaluate the literature relating to the refusal of the prosthesis in order to highlight elements in determining the acceptance/rejection of the prosthetic devices.

MATERIALS AND METHODS

This review began with a search of Medline through the PubMed database (National Library of Medicine, Washington, DC) for English language articles published between 1st October 2007 and 15th May 2020 using the key words *prosthesis*, *limb*, and *accept**.

The following keywords were used: (a) "prosthesis" AND "limb" AND "accept", (b) "prosthesis" AND "lower limb" AND "accept", (c) "prosthesis" AND "upper limb" AND "accept", (d) "prosthesis" AND "congenital limb deficiency" AND "accept", (e) "prosthesis" AND "traumatic limb amputation" AND "accept".

We performed a comprehensive literature search from 1st October 2007 up to and including May 2020. We excluded all papers published before 2007 because there were already two previous systematic reviews published in 2007[16,17].

Titles and abstracts of studies retrieved were screened by two authors (DP and SD) and checked for agreement. Full-texts of studies judged by abstract and title to be relevant were read and independently evaluated for the stated eligibility criteria. Reference lists of potentially relevant original studies were handsearched.

Papers written in different languages than English, letters to the editor, reviews, case reports, and unpublished articles were excluded. Articles were checked for disagreement via discussion between the authors. The initial search yielded 707 studies. Six hundred eighty studies that did not fulfill the eligibility criteria were excluded.

Records were excluded because of the following criteria: Two records were written in other languages than English, 108 were about prosthetic features or properties, 17 focused on psychological aspects, 69 were about osteointegration or implants, 21 were about endoprosthesis, 51 concerned mechanisms of movement and kinematics, 64 were about reconstruction/limb salvation after neoplasy, injuries or other causes, 224 were focused on vascu-

lar prosthesis and surgery techniques, 3 concerned rubber foot/hand, 2 articles were about phantom limb, 1 was about intermanual transfer, 17 involved neural interfaces and neural mechanisms, 7 referred to vascular complications, 2 concerned fitting time, 1 referred to people with sirenomielia, 4 concerned people with congenital deficiencies, 13 were assessments of scale/tests, 8 concerned the validity of satisfaction scales, 9 were about movements dis-/ability and functional outcome, 6 referred to arthroplasty studies, 2 were about wound problems and prosthetic infections, 12 were about rehabilitation, 25 referred to amputation surgery, 1 was about hand transplantation, 1 was about vascular diseases, 1 was about dental material, 1 about antivenom study, 5 referred to animal prosthesis and surgery and 3 were not found. Fourteen records were excluded since they were published before the 1st of October 2007. Four records were excluded because they were secondary studies (e.g., reviews[16-19]).

The final analysis was based on nine original studies.

RESULTS

Table 1 depicts the findings of nine original studies included in the review. Although study designs were heterogeneous, employing different methods, samples, and prostheses, the prevalence of abandoned prostheses ranged from 24%[20] to 70%[21].

Across studies, there was an agreement about factors related to the abandonment of prostheses. Women were more likely to abandon a prosthesis than men[21-24]. Notably, Resnik et al.[21], in a study of 776 veterans, reported that 76.5% of women abandoned the prosthesis compared to 52.3% men. The most common reasons in women concerned body-powered devices. This was mainly due to the discomfort for their use. The end design of body-powered devices was particularly important, especially for women[21]. Women were also more likely to use cosmetic than functional devices compared to men[21,23,24]. It was also reported that body perception was a crucial influence for prosthesis acceptance[23,25-27].

Upper and lower limb prostheses seemed to have the same rate of rejection, even if the prosthesis had a more aesthetic meaning among those with upper limb amputation[23].

The level of amputation was not considered relevant for abandonment of prostheses[26]. For the upper limb, the level of amputation (i.e., proximal and distal) was reportedly associated with prosthesis rejection in Biddiss and Chau[22].

Children were observed in three studies[20,22,28]. Children that began wearing the prosthesis before two years old were less likely to abandon the prosthesis[28]. Studies reported that in preschool children, the prevalence of drop-out was less compared to adults[20,22]. Interestingly, sex was not considered as a factor explaining prosthesis abandonment in Toda et al.[28]. Only one study[20] found that the level of amputation influenced the acceptance rate. In fact, above elbow amputees had a longer wearing time than children with below-elbow amputations[22], and the rate of rejection was higher in school-age compared to preschool children.

DISCUSSION

Based on the literature data, several elements should be addressed. In our study, the prevalence of prosthesis abandonment ranged from 24%[20] to 70%[21], and it is in line with previous data[16,17] that found average rejection rates for body-powered and electric prostheses were 45% and 35% respectively in paediatric population and 26% and 23% respectively in adult population.

The amputee's rehabilitation begins with an initial fundamental question: "How can I focus on something that no longer exists?" In this respect, we are dealing with an ambivalence that "hooks", since rehabilitation is focused on strengthening the rest of the body to get it used to manage a missing part. The limb will not return; it will only be possible to restore a body function, a "function", which will be different from that intended as physiological.

In the case of limb amputation, there is also one more element: the prosthesis. The latter is an element of material devitalization, which replaces a "dead" part of itself.

The most desirable outcome is the development of feelings of acceptance towards the prosthesis in such a way that it helps to restore the self-image. However, this path is not as easy as one might imagine. The prosthesis represents something devitalized, built, made with specific materials that do not resemble the missing limb, but which has the critical task of replacing it.

Earlier, the objective of rehabilitation has been focused on the functional restoration of the limb. Recently, the aesthetic integration of the limb, aimed at restoring self-integration in order to resume a role in the world, increased its importance[29].

Another element linked to the mourning is the fact that, when the prosthesis is removed, the absence of the body part occurs again: "There is no longer a body part, I am intact with the prosthesis; without it, I am incomplete". On a psychological level, it is the revocation of the trauma that recurs in the violence of reality without the subject being able to stem it through defensive psychological mechanisms: the "body part" of me no longer exists.

These elements should be considered for access and adherence to rehabilitation treatment pathways. Indeed, not surprisingly, it is reported in many cases, the refusal of the prosthesis leading to the return of the person to the "missing" state.

Prosthesis acceptance is a crucial element for better rehabilitation outcomes. Functional use of prostheses could help to improve the quality of their life, also reducing the self-stigma when they keep some working ability.

The embodiment (i.e., the consciousness that one has of his body) is intimately linked to body awareness and operates at different complexity levels, more or less explicit. This qualifies the embodiment process as one of the most complex to be treated in the study of the mind[30].

Recently, it has been proposed that the embodiment has a dual nature: *perceptual*, the object is incorporated in the body image of the subject (e.g., the illusion of the rubber hand, where the object was seen to correspond to the mental image we have of our hand) and *motor*, the object is incorporated in the subject's body scheme (e.g., in the case of using tools, the object becomes a body extension)[30].

In line with the previous reviews[16,17] and within this theoretical framework, the rates of rejection exhibit a wide range of variance, possibly due to the heterogeneous samples involved and the methodological differences between studies. While prostheses design also ranged widely, there was a

Table 1. Primary studies included in the review.

Reference	Study design	Population	Variables studied	Objective	Results
Resnik et al.[21]	Cross-sectional survey	21 women (63.5±14.1 yr) 755 men (54.5±9.6 yr) with unilateral UL amputation.	Gender, types of device, terminal device used, suspension methods, frequency, and hours of use. Satisfaction scales (i.e. TAPES OPUS CSD).	To compare prosthetic use and outcomes of female and male with UL amputation.	76.5% of women and 52.3% of men reported prosthesis abandonment. Reasons for body-powered refusal devices were: poor fit/discomfort (87.5% women, 73.5% men) Reasons for abandoning a myoelectric device were: heaviness/fatigue for women (83.3%) and low fit/discomfort for men (69.8%). Women rated satisfaction with prosthesis/terminal device movement more favorably compared to men. Women used cosmetic devices as their primary prosthesis more often.
Resnik et al.[24]	Case series (Structured surveys and semi-guided interviews)	3 women (28.3±4.04 yr) with trans-radial amputation.	The functionality of DEKA Arm, appearance-conspicuousness, weight, satisfaction with her personal prostheses, her self-concept and lifestyle needs.	Key factors and tradeoffs that shape women's attitudes towards the DEKA Arm.	Advanced UL prosthetic technologies (i.e., DEKA Arm) were accepted by women if appropriately gendered in appearance and designed with women's priorities.
Toda et al.[28]	Medical records and face-to-face interviews	37 children (21 females, 16 males, 3.2±4.1 yr) with unilateral below-elbow limb deficiency.	Fitting age, continuous usage, level of amputation situation for usage, gender, affected side.	To investigate the state of powered prosthesis usage and identify a ratio of rejection among children.	The age of non-users was significantly older compared with users at the time of their first fitting. 7/8 children found the prosthesis unnecessary. All the 8 children who stopped using their prosthesis were fitted after 2 yr old. The rate of discontinuation was 32% and was higher compared with those fitted before 2 yr old. 15/29 children were using a powered prosthesis at home and at school but came to use it only at home because they could not obtain cooperation from the school or they suffered from careless and hurtful comments.
Hoffman[27]	Ethnographic study	4 women (42.8±16.5 yr) 4 men (41±13.7 yr).	Prosthetic training, compensatory skills enduring pain and prosthetics.	To assess the relationship between the biological and socio-cultural disability in lower limb amputees.	During physical rehabilitation of lower limb amputees, body normalcy is re-constructed. The mere use of prosthesis is insufficient since it stigmatizes the body as absent a limb. To avoid such stigmatization, the health professionals teach compensatory and discursive skills that enable the incorporation of the prosthesis in body techniques.

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(Continued) - Table 1. Primary studies included in the review.

Reference	Study design	Population	Variables studied	Objective	Results
Akarsu et al.[26]	Cross-sectional study	15 (31.9±8.4 yr) bilateral, 15 (27.3±6.6 yr) unilateral lower limb amputee individuals.	Unilateral vs. bilateral amputation, SF-36, SAT-PRO, ABIS, HS, 6MWT, 10MWT.	To compare the quality of life and functional gait of individuals with bilateral and unilateral lower limb amputations.	The frequency of prosthesis usage positively correlated with SF-36 subscores (except for pain). No correlations were found with ABIS (HS scores 6MWT and 10MWT measurements were significantly higher in individuals with unilateral lower limb amputation group.
Sousa et al.[23]	Qualitative interviewing	4 women, 10 men not engaged in sport. 1 woman and 6 men engaged in sport. Men: 29.9±6.8 yr, women: 28±2.94 yr.	Gender, type of amputation; prosthesis, aesthetics dimension.	To investigate how to two subsets of individuals with amputations perceive themselves and perceive how others view them.	Sports engagement positively influences how amputees perceive their body. The main barrier was the disability-related perception of amputation from other individuals.
Messinger[25]	Case studies	2 men, 20-35 yr.	Level of autonomy, the way that the program structure suited their personalities.	To investigate how injury context plays a role in the rehabilitation of military individuals who suffered a UL amputation as a result of blast trauma.	Rehabilitation should focus on the subjective experiences and feelings of individual patients.
Egermann et al.[20]	Retrospective study	41 children (3.9±1.1 yr) with unilateral congenital UL transverse deficiency and traumatic UL amputation.	Age, type of device-level of amputation, time of daily use, susceptibility to breakdown.	To evaluate the acceptance of myoelectric prostheses in preschool children and to investigate factors related to the use of UE prostheses.	76% successfully used the prosthetic device. Above elbow, amputees had a higher wearing time than children with below elbow amputations. Children who had a body-powered active device prior to myoelectric prosthesis shown a tendency of higher wearing time compared to individuals with a passive device. Repair times were positively related to daily wearing time. 24% of the subjects rejected the myoelectric device.
Biddiss and Chau[22]	Questionnaire	59 prosthesis rejecters 132 prosthesis wearers with congenital or acquired UL absence.64 children 11±5 yr, 127 adults 42±15 yr.	Level of limb absence, the origin of limb absence, length of residua, bilateral limb absence, gender, age, information services, healthcare services, fitting-time frame, involvement in prosthesis selection, prosthesis use and prosthesis satisfaction.	To develop a model for prediction of UL prosthesis use or rejection.	Satisfaction with healthcare and prostheses, high perceived need for prostheses, was strongly correlated with prosthesis acceptance. Low and high-level limb amputation were related to prosthesis rejection.High rates of rejection (>40%) were prevalent between 4-

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Reference	Study design	Population	Variables studied	Objective	Results
					10 and 19-35 yr. Low rates (<20%) were higher for children <4 yr, and adults between 36-50 years or >60 yr. Females showed higher rates of prosthesis rejection than males, mostly those with acquired limb absence. Individuals with congenital bilateral limb absence were less likely to use a prosthesis than those with congenital unilateral limb absence. Fitting at >2 yr for children with congenital limb absence or more than 0.5 yr from amputation was related to higher probability rejection.

Legend: TAPES= Trinity Amputation and Prosthetic Experience Scale (TAPES) satisfaction scale; OPUS CSD= Orthotics and Prosthetics User's Survey (OPUS) Client satisfaction with devices (CSD) scale; SF-36= Short Form 36- health survey version 2 for assessing the quality of life (QoL); SAT-PRO= Satisfaction with Prosthesis Questionnaire; ABIS= Amputee Body Image Scale; HS= Houghton Scale; 6MWT= six-minute walk test; 10MWT= 10-meter walk test; CHAID= Chi-squared Automatic Interaction Detection; CART= Classification and Regression Tree; C5.0 algorithms= Rule Quest Research, Australia.
Note: Only variables related to the research question are reported in the table.

slight trend toward prioritizing function over cosmetic designs.

The qualitative studies highlighted the importance users placed on presenting a "normal" appearance and "not standing out". Cultural variations due, in part, to differential health resources should be considered before choosing a prosthesis. Age and gender should be considered when prescribing a prosthesis. Indeed, women and young adults were more likely to reject a prosthesis compared to other populations. This may be due to the acceptance and perception of body representation. This could also explain the greater use of cosmetic devices in this population compared to the body-powered prosthesis. Notably, the type of prosthesis was not considered a factor for abandonment in men, while in women the cosmetic prosthesis was less rejected.

Notably, the review by Ritchie et al.[18] concluded that patients have been most dissatisfied with their ability to use the prostheses for food preparation and consumption. The type of prosthesis was not considered a factor for abandonment in men, while in women, the cosmetic prosthesis was less rejected for the reasons explained above.

The most critical age group is considered late childhood and early adolescence because in these age groups there is a great threat to emerging sexual identity. In a previous review, Biddiss and Chau[16] found that significantly lower rates of rejection for devices were observed in adult populations than in the pediatric population while the average incidence of non-wear was similar for pediatric (16%) and adult (20%) populations. By contrast, Biddiss and Chau[22] and Egermann et al.[20] reported that in preschool children, the prevalence of drop-out was less compared to adults. As far as children are concerned, they identify the "self" through their body, and this happens in the first year of age. Moreover, overall growth and development of motor skills proceed in an orderly sequence and the age at which infants and children attain motor milestones varies. Thus, children are able to "adapt" their body (even without a limb) to the skills required.

Interestingly, a systematic review[19] has concluded that an acceptance rate for a congenital unilateral upper extremity amputee is higher if the prosthesis is delivered at less than two years because it is part of the "self" identification and of the developing of the motor skills. In children[19] the prosthesis will need to accommodate growth and development and withstand the rigors of use during play since limbs grow longitudinally faster than circumferentially. Children outgrow their prostheses quickly. This could explain the higher rate of rejection in this population. A young child may start to refuse to wear the prosthesis because of discomfort.

For all these reasons, the rehabilitation process should have an efficacious program of exercises to ameliorate the effective usability of the prosthesis and include psychological support. Moreover, alongside the motor and functional outcomes, psychological support at the beginning and at the end of the rehabilitation program should be suggested.

CONCLUSIONS

The study highlights that understanding the factors for rejections are crucial for better health outcomes. In particular, prosthesis rejection is very high, as it ranges between 24 to 70% of cases. Women seem particularly susceptible to the cosmetic role of the prosthesis compared to men. Moreover, women present a higher rate of prosthesis rejection compared to men. The level of amputation is relevant only for the upper limb prosthesis rejection. Youth and adults have more propensity to abandon the prosthesis compared to the children <2 yrs old and elderly. The amputation level plays a role in particular for the acquired amputation. Overall, the body-object concept is more influential than the lived-body concept on prosthesis rejections. Therefore, rehabilitation should consider psychosocial assistance for acceptance and perception of body representation.

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