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Low Back Pain in People With Lower Limb Amputation

A Cross-Sectional Study

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Study Design. A cross-sectional study based on an online questionnaire.

Objective. The aim was to investigate the prevalence and intensity of low back pain (LBP) in people with lower limb amputation (LLA) and to analyze the association factors that can influence the genesis of LBP.

Summary of Background Data. It is still unclear whether LBP is more prevalent in the amputated population than in its non-amputated counterpart. Given the multifactorial nature of LBP, it is necessary to explore possible factors that can influence its presence and intensity, to build a solid background to define a better rehabilitation pathway for the management of these people.

Methods. The online questionnaire included six sections. informed consent of the study, demographic information, comorbid conditions, history of LLA, history of LBP, and acceptance of the amputation.

Results. Between March and June 2021, 239 participants [mean age (SD). 49.2 (11.5); female 11%] completed the survey (response rate: 32%). From the results of this study, LBP in LLA showed a prevalence of 82% postamputation and 70% in the last year. A logistic regression with a backward method showed that participants who had problems in the not affected leg presented 1.58 (95% confidence interval: 0.70; 2.45) times higher odds to have LBP after the amputation.

Conclusion. This study shows that the prevalence of LBP in lower limb amputees appears to be higher than in the general population, with similar levels of pain intensity and frequency. The highest percentage of people with a sedentary lifestyle not practicing any kind of sports emphasizes the importance of educating this population on the importance of physical activity. New strategies to invest in the education of this population in terms of physical activity are needed.

Key words: low back pain, amputees, musculoskeletal pain, rehabilitation, LBP prevalence, physical therapy modalities

Level of Evidence: 4

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There are 4.1 million people with different levels of participation restrictions[1] in Italy, of which 1.2 million are related to dysfunctions of different motor domain.[2] Among them, about 200,000 have sequelae of lower limb amputation (LLA) due to different reasons: 80% are old adults who underwent amputations as a consequence of diabetes or vascular problems,[3] 10% are middle-aged adults, and 10% are young people, victims of road accidents and other types of traumatic events in addition to congenital malformations and tumors.[4] The level of amputation depends on its cause and on the possibility to ease the use of functional prosthesis.[5] The most frequent amputation levels occur below (transtibial 47%) and above the knee (transfemoral 31%). Other amputations involve other levels: shoulder disarticulation (1.5%), transhumeral (4%), elbow joint (0.5%), transradial (8%), hand amputation (2%), hip disarticulation and hemipelvectomy (2%), knee disarticulation (1%), and ankle disarticulation (3%).[4] Regardless of the cause of the amputation and the affected part of the body, an amputation impacts amputees' health-related quality of life (HRQoL). It represents a challenge at different levels, since not only does amputation impact amputees' physical activity, it also impacts their psychological, social, and economic spheres, with burdensome consequences on the national health system.[6]

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An amputation may lead to several burdensome secondary disabilities, such as different musculoskeletal diseases, affecting amputees' HRQoL and the return to before amputation activities.[7] In particular, low back pain (LBP) is one of the most frequent secondary disabilities involving the amputees.[8,9] Its onset depends on several physical, personal and amputee-specific factors.[10] Specifically, the physical factors are gait patterns,[11] reduced strength and endurance of the spinal muscles,[12] the discrepancy in leg length,[13] and increased anterior pelvic tilt.[14] Personal factors are age, sex, body mass index, work status, and the presence of comorbidities such as diabetes, depression, osteoarthritis, heart disease.[15] Finally, the specific factors of the amputee are the years of use of the prosthesis, the level of amputation, the pain of the not amputated limb and the presence of phantom pain or residual pain of the stump.

Smith *et al*[16] reported that amputees complained that LBP is even more uncomfortable than phantom limb pain or residual stump pain. Nevertheless, LBP in amputees is a neglected field, with only a few studies[15] exploring its prevalence, risk factors and trends over time. Some studies reported that LBP affects 50% to 80% of the amputated population[9,17] but data are yet to be conclusive. In Italy, only a few studies have investigated secondary disabilities after LLA, such as LBP.[3,15] Furthermore, no national study has evaluated the prevalence of this secondary disability, in this population, on the national territory.[3]

To conclude, it is still unclear whether LBP is more prevalent in the amputated population than in its not amputated counterpart.[18] Given the multifactorial nature of LBP, it is necessary to explore the possible factors that can influence its presence and intensity to build a solid background to define a better rehabilitation pathway for the management of these people. For this reason, this study aims at investigating in a sample of Italian amputees the LBP prevalence at one-year time, at six months, in the last month and before the coronavirus disease-2019 (COVID-19) pandemic, together with its intensity and the association factors to its onset. The abovementioned time steps (eg, one year, six and one months) were investigated before the COVID-19 pandemic onset, in Italy (ie, 2019 and 2020). We hypothesized that the COVID-19 pandemic could have interfered with LBP development due to reduction in HRQoL and levels of physical activity as a consequence of the different limitations imposed during the lockdowns. In particular, these two are well-known factors associated to LBP development and intensity.[19]

METHODS

Design

A cross-sectional study was performed at the University of Genoa through an online questionnaire. The study had the following aims: (1) to investigate the prevalence and intensity of LBP in people with LLA and (2) to analyze the association factors that can influence the genesis of LBP. The questionnaire was developed according to the International Handbook of Survey Methodology[20] and the Declaration of Helsinki.[21] The ethical approval was obtained from the Ethics Committee for University Research (CERA: University Research Ethics Committee), University of Genoa (date of approval: February 18, 2021—CERA2021.37), and it is reported following the STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology).[22] The questionnaire was validated by a panel of experts belonging to different professional categories and by amputees (five physiotherapists, five bioengineers, and five people with LLA who met the eligibility criteria for this study) who assessed its content and face validity. The questionnaire included six sections: (1) informed consent of the study, (2) demographic information, (3) comorbid conditions, (4) history of LLA, (5) history of LBP, and (6) acceptance level of the amputation. In the first section of the questionnaire, all the participants were informed about the study and how their data would be stored and processed. In order to proceed with the questionnaire, the participants had to provide their informed consent at the beginning of the questionnaire. Furthermore, this section indicated how to contact the researchers and ask for support or information. The questionnaire could be interrupted at any time, and the consent could be withdrawn by closing the browser.

In the second section, participants filled in the questionnaire with their demographic information such as age, the gender they most identified with, current work or study status, socioeconomic status, education level, level and type of physical activity, and sleep quality. The third section focussed on the number of comorbidities (diabetes, arthritis, obesity, cardiovascular diseases, depression, neurological disease, none or "other" which the participants could freely fill in). Also, the level and years of amputation and whether the participants had undergone spinal surgery was asked. The fourth section investigated the history and characteristics of LLA, the type of prosthesis and the presence of phantom pain and residual stump pain. The fifth section focussed on the history, presence, duration, intensity of pain of LBP following the advice from Dionne *et al*[23] on back pain prevalence studies. The presence of an episode of back pain before the outbreak of the COVID-19 pandemic was also asked. Finally, in the last section of the questionnaire, the level of agreement with two sentences was investigated. The first sentence dealt with their levels of acceptance toward their situation (i.e., "I am optimistic about my future, and I am ready to face what will happen in my life") and the second with their level of awareness ("I am aware of my situation, and I have accepted my personal story"). The Italian version of the questionnaire was sent over and the English translated version is reported in supplemental file (Supplemental Digital Content 1, translated version of the questionnaire, http://links.lww.com/BRS/B905).

Participants

A sample of Italian participants with LLA living in Italy was recruited. People were considered eligible to participate in this study if they met the following criteria: unilateral lower

extremity amputation with different amputation levels (ie, transfemoral, transtibial, disarticulation of the hip, knee, or ankle), age over 18, amputation occurring no earlier than 12 months, a minimum of six months of use of the prosthesis since amputation. On the other hand, participants with a history of spinal surgery, bilateral lower extremity amputation, or other levels of amputation beyond those mentioned above were excluded. Finally, no limits were placed on the etiology of amputation.

Setting

The questionnaire was implemented online via Microsoft Forms and sent from March 22 to June 21, 2021. The target population was found via social media outlets, orthopedic clinics, and amputee trade associations such as the paralympic and sports associations. In particular, participants were contacted by their association or individually by the investigators via personal emails or direct messages on social media platforms. A database was created on Microsoft Excel to create a list of people, associations, companies, and public administrations to recruit and ask for collaboration. Authors contacted companies and trade associations through telephone or e-mail to collaborate to disseminate the questionnaire. After two weeks, a reminder was sent to increase the participants' responsiveness. At the end of the data collection period, the possibility to fill in the questionnaire was suspended. Subsequently, a final Excel sheet was extracted with the synthesis of all the participants' data to be able to analyze the answers collected.

Bias

To reduce any possible selection bias, the questionnaire was submitted to various entities, such as sports associations, social associations, orthopedic clinics, and health workshops (ie, Italian places where people receive customized orthopedic treatments and rehabilitation solutions). Recruiting people from sport associations could have influenced the sample, resulting in representing a more physically active cohort. However, the majority of our sample were not active people who were not practising any sports. Moreover, online surveys represent themselves a barrier as they cannot reach people who are less keen on using technologies.

Statistical Methods and Analysis

Descriptive analysis was conducted to understand the characteristics of the sample. Continuous variables were reported as mean ± SD, while categorical variables were reported as absolute and percentage frequencies. All incomplete questionnaires were excluded for the analysis of the results.

A descriptive explanatory analysis was performed. Specifically, a logistic regression with a backward method was performed to assess the individual association of each variable on the prevalence of back pain following LLA. The variables considered were: gender (categorical variable: male/female/other), educational level (categorical variable: Middle School/High School/Bachelor of Science/Master of Science), sport level (categorical variable: no sport/amateur/elite athlete), hours of sleep (categorical variable: <4 h/between 4 and 6 h/between 6 and 8 h/more than 8 h), comorbidities (categorical variable: none/one/more than one/three), smoking status (dichotomous variable: yes/no), amputation level (categorical variable: transtibial/transfemoral/hip disarticulation/knee disarticulation/ankle disarticulation) musculoskeletal problems in the not amputated limb (dichotomous variable: yes/no), type of prosthesis (categorical variable: passive/active/other), frequency of use of the prosthesis (categorical variable: <4 h/about 8 h/more than 12 h), years of use of the prosthesis (categorical variable: between 6 mo and 1 y/ between 1 and 2 y/ between 2 and 3 y/ more than 3 y), back pain before the amputation (dichotomous variable: yes/no) and acceptance of the amputation (dichotomous variable: yes/no). The selection of the variables in the final model was informed by previous literature on LBP and amputees and statistical selection. Specifically, the final model included the variables: musculoskeletal problems in the not amputated limb, type of prosthesis and frequency of prosthesis use. Gender, educational level, sporting level, hours of sleep, comorbidities, smoking status, amputation level, years of use of the prosthesis, back pain before the amputation and acceptance of the amputation were deleted from the final model since the *P*-value of the association was > 0.2. The linearity of the continuous variables for the logit of the dependent variable was evaluated using the Box-Tidwell procedure. A Bonferroni correction was applied using all 20 terms of the model, obtaining acceptance of statistical significance when $P < 0.01$. On the basis of this evaluation, all continuous independent variables were linearly related to the logit of the dependent variable. There was no standardised residual assessment in the case list. Odds ratio and 95% confidence interval were estimated for each reference category.

Furthermore, through a 4-point Likert scale, the level of amputees' agreement was investigated with the two sentences, reported in the last section of the questionnaire. Participants who partially or completely agreed with a statement (scores 2–3) were considered to agree with the statement. The consensus with each statement was investigated. In the absence of a standard threshold, we defined a $\geq 70\%$ agreement with a statement as consensus.[24]

RESULTS

The questionnaires were delivered to 683 participants. Received responses were N = 239 participants (response rate: 32%). A total of 444 questionnaires, oppositely, were seen and then ignored, forgotten, or never seen at all. Out of the filled questionnaires received, 78 were excluded because participants met one of the exclusion criteria for this study. Finally, 161 questionnaires were examined and included in

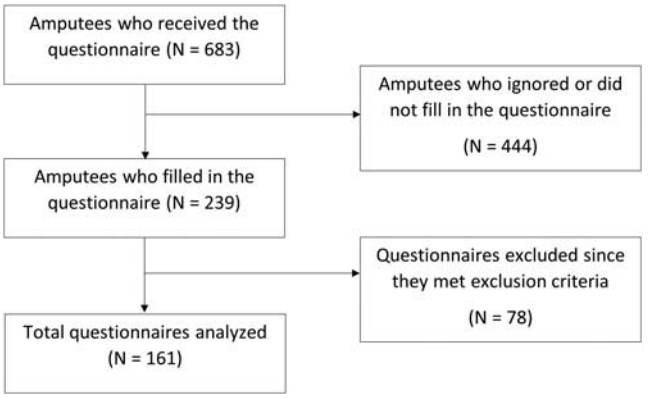

FIGURE 1. Questionnaires' flow chart.

the study (Fig. 1). Participant characteristics are reported in Table 1.

The characteristics of the amputated population are shown in Table 2.

The prevalence of LBP is described in Figures 1 and 2. Data regarding back pain about the level of pain, frequency and prevalence are shown in Table 3.

As for the participants' agreement with the sentences reported in the last section of the questionnaire, to the sentence "I am optimistic about my future, and I am ready to overcome what life puts in front of me" (level of optimism) N = 147 (91%) agreed with this sentence. As far as the second sentence is concerned "I am aware of my situation, and I have accepted my personal history" (level of self-acceptance), N = 146 (91%) of the participants agreed with it. Therefore, an agreement was found for both sentences.

Moreover, the binomial logistic regression was performed to ascertain the association of the independent variables gender, education level, sport level, hours of sleep, comorbidity, smoking status, level of amputation, musculoskeletal problems in the not amputated limb, type of prosthesis, frequency of the use of prosthesis, years using prothesis, LBP before amputation and acceptance toward amputation on having LBP after amputation (dependent variable). After the backward elimination method, only the variable "musculoskeletal problems in the not amputated limb," "type of prosthesis," and "frequency of the use of prothesis" had a significance level $P < 0.2$. Among the abovementioned variables, only the variable "musculoskeletal problems in the not amputated limb" was significant. Participants who had musculoskeletal problems in the not amputated limb presented 1.58 (95% confidence interval: 0.70; 2.45) times higher odds to have LBP after amputation (Table 4).

TABLE 1. Descriptive Statistics

	N = 161; N (%)
Age, mean (SD)	49.2 (11.5)
Gender	
Male	144 (89.4)
Female	17 (10.6)
Level of education	
Primary education	69 (42.9)
Secondary education	77 (47.8)
Bachelor of Science (BSc)	8 (5.0)
Master of Science (MSc)	7 (4.3)
Occupation	
Unemployed	23 (14.3)
Student	5 (3.1)
Worker	94 (58.4)
Retired	39 (24.2)
Average annual income in €	
< 15,000 euro	54 (33.5)
Between 15,001 and 28,000	71 (44.1)
Between 28,001 and 50,000	28 (17.4)
Between 50,001 and 75,000	6 (3.7)
More than 75,000	2 (1.3)
If practise sport	
No	95 (59.0)
Yes	66 (41.0)
Sport level	
No sport	95 (59.0)
Amateur	29 (18.0)
Elite athlete	37 (23.0)
Number of sports practised	
No sport	96 (59.6)
One sport	59 (36.7)
More than one sport	6 (3.7)
Average hours of sleep	
Less than 4 hours	10 (6.2)
Between 4 and 6 hours	52 (32.3)
Between 6 and 8 hours	91 (56.5)
More than 8 hours	8 (5.0)
Presence and number of comorbidities	
None	116 (72.1)
One	43 (26.7)
More than one	1 (0.6)
More than three	1 (0.6)
Smoke	
No	104 (64.6)
Yes	57 (35.4)

SD indicates Standard Deviation.

DISCUSSION

After the data analysis, LBP after amputation is a common phenomenon in lower limb amputees, in Italy, with a prevalence of 82% postamputation, 70% in the last year, 67% in the last six months and 51% in the last month. In the light of the above, amputees seem to have more frequent LBP than the general population,[25] whose lifetime prevalence of nonspecific LBP is estimated to be

TABLE 2. Amputation Type, Cause, Prosthesis, and Pain

	N = 161; N (%)
Upper limb amputation	
No	154 (95.7)
Yes	7 (4.3)
Lower limb amputation	
Right	69 (42.9)
Left	92 (57.1)
LLA level	
Transtibial	64 (39.8)
Hip disarticulation	3 (1.9)
Knee disarticulation	12 (7.5)
Ankle disarticulation	1 (0.6)
Transfemoral	81 (50.2)
etiology of amputation	
Malformation/neonatal disorder	4 (2.5)
Tumor	9 (5.6)
Traumatic	135 (83.9)
Vascular disease	9 (5.6)
Infection	4 (2.4)
Pain in nonamputated limb	
No	59 (36.7)
Yes	102 (63.3)
Pain in amputated limb	
No	55 (34.2)
Yes	106 (65.8)
Prothesis's type	
Passive	79 (49.1)
Active	76 (47.2)
Other	6 (3.7)
Prothesis's time	
Between six months and one year	4 (2.5)
Between one year and two years	15 (9.3)
Between two and three years	10 (6.2)
More than three years	132 (82.0)
Frequency of use of prostheses	
Less than four hours	9 (5.6)
About eight hours	26 (16.2)
More than 12 hours	126 (78.2)

LLA indicates lower limb amputation.

between 60% and 70%, with a one-year prevalence between 15% and 45% and a four-week prevalence of 31%. Our results are in line with the ones reported by Devan *et al*[26] and Sivapuratharasu *et al*[27] who reported a prevalence of LBP after amputation of about 63%, ranging from 48% to 77%.

One of the possible explanations behind the higher prevalence of LBP in amputees compared with the general population revolves around the different adaptation and changes in load and load capacity that amputees need to face after amputation.[14] Perkins *et al*[28] concluded that in people with LLAs, the increased susceptibility to LBP could be partly due to changes in the muscular and surrounded tissues as a result of the amputation in addition to a local load mismatch with an altered gait pattern. Moreover, Gailey *et al*[29] investigated whether leg length differences may contribute to LBP in this population. Movement during walking, single stance support, and walking with the prosthesis were analyzed, finding a correlation between the difference in length of the limbs and LBP. Additionally, amputees who adopt a same-length prosthesis as the healthy limb have significantly fewer pain symptoms than those with length asymmetries between the not amputated limb and the prosthetic limb. Postural asymmetries can arise from these leg length difference.[13] Morgenroth *et al*[30] disagree with this finding, showing no statistically significant correlation between pain and LBP genesis due to leg length differences. Another presumed risk factor for LBP onset is the possible movement alterations of the lumbosacral spine.[11] According to the authors, it is possible that in this population, there is an increase in local load, leading to a lack of balance, due to greater axial rotations of the lumbar spine,[30] more rigid trunk-pelvic coordination strategies[31] and an apparent tendency toward inversion in the patterns of trunk-pelvic movement in the sagittal and transverse planes.[32] In conclusion, in the systematic review by Sivapuratharasu *et al*[27] the authors concluded that it is difficult to draw firm conclusions behind the higher prevalence of LBP in amputees due to the complexity of this phenomenon and the interweaving of different causes.

As for this study, the result of the logistic regression highlighted that experiencing musculoskeletal problems in the not amputated limb was associated with 1.58 times greater risk of developing LBP after amputation. A qualitative study by Devan and colleagues investigated amputees' perception of LBP, focusing on the perceived reasons behind this disease. In particular, amputees reported not amputated limb pain to be one of the reasons behind LBP.[19] Hence, our evidence confirms quantitatively what amputees perceive about their condition.

However, LBP is a complex phenomenon and other reasons behind its genesis on amputees were already highlighted elsewhere. In particular, the presence of residual pain in the stump, the presence of a phantom limb and having more than two ongoing comorbidities seem to be positively associated with the development of LBP.[26] Moreover, the examined sample appears to be a population with an average age of 50 years, mainly represented by sedentary people that are working and that do not practice sport. This factor could have affected the higher prevalence of LBP, as people who practise sports regularly appear to have a lower rate of LBP in most of the population.[33] All guidelines on LBP management recommend staying active because movement can reduce

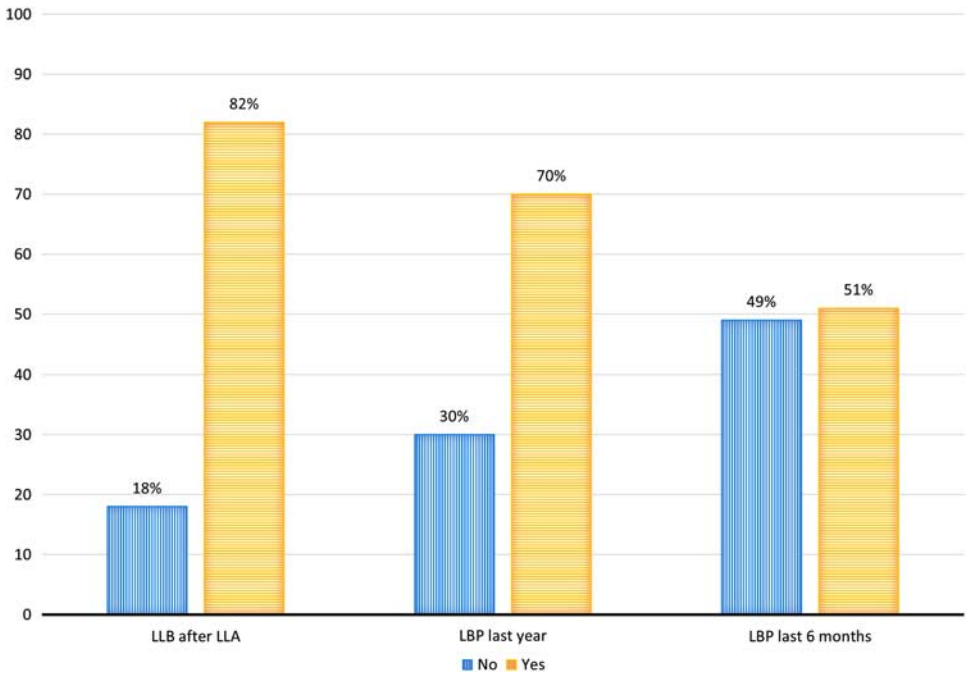

FIGURE 2. Prevalence of low back pain (LBP) in lower limb amputation (LLA). full color online

TABLE 3. LBP Distribution

	N = 161; N (%)
LBP before LLA	
No	98 (60.9)
Yes	63 (39.1)
LBP post-LLA	
No	29 (18.0)
Yes	132 (82.0)
LBP last month	
No	79 (49.1)
Yes	82 (50.9)
LBP last six months	
No	52 (32.3)
Yes	109 (67.7)
LBP last year	
No	49 (30.4)
Yes	112 (69.6)
LBP before COVID-19 (2019)	
No	56 (34.8)
Yes	105 (65.2)
Frequency LBP post-LLA	
No	29 (18.0)
Occasional	89 (55.3)
Frequent (more than one episode per week)	24 (14.9)
Persistent (nearly every day)	19 (11.8)
Pain intensity, mean (DS)	4.9 (2.9)

COVID-19 indicates coronavirus disease-2019; LBP, low back pain; LLA, lower limb amputation.

pain and improve the return to normal activities.[33] In addition, being physically active help people with amputation cope with their LBP and manage their disease.[19] As for the gender differences, the biopsychosocial approach to pain attributes gender differences in pain due to biological, psychological, and sociocultural factors.[34] In this study, due to the low sample number of women N = 17 versus the high number of men recruited N = 144, it was probably not possible to observe and draw similar conclusions.

Regarding the pain intensity and frequency, it seems to be generally moderate (5/10) with an occasional frequency. Previous evidence on normative data reported that the intensity of pain as perceived by people with LBP, in general population,[35] was NRS = 5.54 ± 1.96. Hence, the examined population in this study seem to experience a similar pain intensity compared with not amputees.

Regarding the psychological variables of acceptance of personal history and optimism for the future, most of the participants showed a positive vision, which perhaps contributed not to developing a condition of poor HRQoL. Self-acceptance is an important part of the individual capable of counteracting depression and contributing to better management of LBP. It can be an important preventive factor for LBP in people with LLA.[36] Good levels of acceptance and a positive attitude toward the future are linked to a lower perception of pain and a higher level of HRQoL in several conditions.[37] On the other hand, behavioral and social maladaptive adjustments in a chronic health condition with disabilities can compromise an individual's coping strategies, thus increasing the risk of developing LBP and intensity.[18] Mazzone *et al*[37] showed that among individuals with amputations, those with

TABLE 4. Low Back Pain After Lower Limb Amputation

	Odds Ratio	*P*	95% CI per OR	
			Minimum	Maximum
Problems in the nonamputated leg	1.578	<0.001*	0.7036	2.452
Type of prothesis	0.6233	0.128	−0.1784	1.425
Frequency of the use of prothesis	−0.5576	0.139	−1.296	0.1807

**Statistically significant.*
CI indicates confidence interval; LBP, low back pain; LLA, lower limb amputation; OR, odds ratio.

recurrent LBP reported lower HRQoL compared with those without LBP. However, our study did not adopt specific outcome measures to provide the scientific literature with an accurate multimodal assessment of psychological variables related to pain among amputees (eg, catastrophising, depression and anxiety).[38] Future studies should explore those variables through a multimodal assessment of the psychological well-being status of this population with specific rating scales and programs.

Different limitations of this study need to be discussed and addressed. First, this is a cross-sectional study, unable to identify a cause-effect relationship between the above-mentioned factors and LBP, but only an association between them. Second, there was a low response rate of the questionnaires (32%). Comparing to other surveys present in the literature, the study by Devan *et al*[26] and Ephraim *et al*[7] had a response rate of about 43% and 71%, respectively. Despite numerous attempts to increase the response rate and adherence to the study, using various reminders, the low response rate may have biased our results. Third, people with a pessimistic view of their condition may have not filled in the survey. This could explain why a 91% agreement was found for the two sentences that related to the levels of acceptance and optimism about their situation. Finally, online surveys represent themselves a barrier as they cannot reach people who are less keen on using technologies.

CONCLUSIONS

The main results of this study show that the prevalence of LBP in lower limb amputees appears to be higher than in the general population, with similar levels of pain and frequency of episodes. Furthermore, having a musculoskeletal problem in the not amputated limb is associated with LBP in the amputated population. The highest percentage of people with a sedentary lifestyle not practising any kind of sports brings to the forefront the importance of educating this population on the importance of physical activity both as a preventive and curative factor. Therefore, health-policy makers should find new strategies to invest in the education of this population in terms of physical activity, fostering the connections with sport and patients' associations.

➢ Key Points

- ❑ The prevalence of LBP in lower limb amputees appears to be higher than in the general population.
- ❑ Having a musculoskeletal problem in the non-amputated limb is significantly associated with LBP.
- ❑ Long-term interventions, based on exercise and education, are needed to reduce the incidence, prevalence, and secondary impacts of LBP in amputees.

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