

Article

Predictors of Phantom Limb Pain, Psychological Factors and Chronic Musculoskeletal Pain Following Traumatic Lower-Limb Amputation: The Impact of Delayed Rehabilitation Services

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Abstract

Background: Phantom limb pain, poor sleep, musculoskeletal pain, and psychological distress are common in patients following traumatic lower-limb amputations. Nevertheless, there is still a lack of research on the connections between these variables and rehabilitation service accessibility. Evidence on phantom limb pain and related rehabilitation factors remains limited in conflict-affected settings, where access to timely prosthetic and rehabilitation services may be substantially disrupted. **Objective:** The study aimed to determine the prevalence of phantom limb pain and chronic musculoskeletal pain, and to assess their correlation with sleep quality, depression, anxiety and access to rehabilitation services in individuals with traumatic lower-limb amputation. **Methods:** Between August 2025 and April 2026, 491 patients with unilateral traumatic lower-limb amputations who were receiving outpatient rehabilitation services participated in the study. The Pittsburgh Sleep Quality Index was used to measure sleep quality, while the Hospital Anxiety and Depression Scale was used to measure anxiety and depression. In addition, participants reported delays in physiotherapy and prosthetic fitting, phantom limb pain, and chronic musculoskeletal pain. Mann–Whitney U tests were used for group comparisons, while multiple regression analysis and Spearman correlations were used to assess the relationships. **Results:** Phantom limb pain was reported by 78.8% of participants, while 46.2% experienced chronic musculoskeletal pain. Among patients who had not received a prosthesis, the mean delay to prosthetic provision was 472.9 days, while the median delay was 502 days. Poorer sleep quality ($\beta = 0.480$, $p < 0.001$) and longer delays to prosthetic fitting ($\beta = 0.184$, $p = 0.002$) were independently associated with greater phantom limb pain intensity. Participants with chronic musculoskeletal pain and those who had not received a prosthesis experienced poorer sleep quality, greater depression and anxiety, and more severe phantom pain than participants without musculoskeletal pain and those who had received a prosthesis. **Conclusions:** Phantom limb and chronic musculoskeletal pain are highly prevalent after lower-limb amputation. Delayed prosthetic fitting and sleep disturbances are associated with greater phantom pain.

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1. Introduction

Lower-limb amputation is a life-altering condition with numerous social, psychological, and physical repercussions [1]. Patients who have lost a limb are known to deal with a variety of issues and problems. Phantom limb pain (PLP), which is described as painful feelings felt in the missing limb, is one of the most often reported consequences after amputation [2]. It has been estimated to affect 61% of those who have lost a limb [3]. Prosthetic use, everyday functioning, and overall rehabilitation results can all be severely hampered by phantom pain [4]. Despite the high prevalence of phantom pain post lower-limb amputation, the exact mechanisms underlying its development remain insufficiently documented [2]. Examining the relationships between various factors such as sleep disturbances, psychological factors, rehabilitation access, and pain outcomes may help us better understand the mechanisms creating phantom limb pain following amputation.

In addition to phantom pain, people with lower-limb amputations often experience secondary musculoskeletal disorders. It has been reported that low back pain is prevalent among patients with lower-limb amputation, affecting approximately 62%, while contralateral limb pain has been found in 43% of this population [3]. Thus, lower-limb amputation is associated with secondary musculoskeletal pain, particularly neck pain, low back, knee and hip pain, as a result of asymmetrical loading, altered biomechanics, and compensatory movement during prosthetic usage [5]. Moreover, this secondary musculoskeletal pain can extend beyond physical limitations, as this pain is well-known to negatively affect sleep and psychological status, increasing the risk of poor sleep quality, depression and anxiety [6].

Psychological discomfort is an important aspect of the post-amputation experience that goes beyond physical problems. People who have lost limbs have frequently been shown to have high levels of anxiety and depression [7]. Psychological problems are highly prevalent among patients with amputation. The prevalence of depression among amputees was 40.7%, while anxiety existed in 66.7% [8]. These psychological problems can negatively affect quality of life and adherence to rehabilitation and functional recovery [8].

Sleep disturbance is another significant problem among patients with lower-limb amputation. Studies regarding sleep disturbance in patients with lower-limb amputation remains limited. In a study including 35 amputees and 35 controls, it was reported that 82.9% of amputees experienced sleep disturbances, and these disturbances were significantly associated with anxiety and depression [9]. Previous research found that sleep problems and anxiety are important considerations in post-amputation rehabilitation, and care while longer prosthesis use, greater daily prosthesis use, and higher prosthesis satisfaction are linked with fewer psychiatric symptoms [10].

Although phantom pain, depression, anxiety and sleep disturbance are widely recognized consequences of amputation, the burden of lower-limb amputation extends beyond these problems to include secondary musculoskeletal pain. Due to changes in biomechanics, imbalance, compensatory movements, and constant use of prosthetic limbs, people suffering from amputations commonly experience musculoskeletal pain, with low back pain emerging as the most frequent one [3], affecting approximately 82% of patients following amputation [11]. These problems have been found to contribute to sleep disturbances, anxiety, depression, and increased pain severity [12].

In Gaza, where the frequency of traumatic amputations has significantly increased recently as a result of armed violence, this issue is especially pertinent. Living in such

circumstances frequently presents a number of obstacles to recovery, such as restricted access to physiotherapy services, postponed prosthesis fitting, and limited medical resources. Therefore, delays in prosthetic fitting and limited prosthesis use may exacerbate anxiety, sleep disturbance, and impaired psychological adaptation, ultimately hindering rehabilitation and functional recovery after amputation [10].

Recent studies have examined the functional and psychosocial correlates of PLP in individuals with lower-limb loss [13]. However, evidence remains limited among individuals living in conflict-affected settings, where traumatic amputations and disruptions in access to prosthetic and rehabilitation services may create a distinct clinical context. The present study addresses this gap by examining PLP and related factors among individuals with traumatic lower-limb amputation in the Gaza Strip.

Therefore, the current study sought to investigate phantom pain, sleep quality, depression, anxiety, chronic musculoskeletal pain, and access to rehabilitation services including physiotherapy, prosthetic services, and mental health support services for patients with lower-limb amputation. Additionally, this study looked for independent factors of phantom limb pain, such as poor sleep, anxiety, depression, and delays in receiving rehabilitation treatments. We hypothesized that poorer sleep quality, higher levels of anxiety and depression, the presence of chronic musculoskeletal pain, and longer delays in prosthesis provision would be independently associated with greater phantom limb pain intensity in individuals with traumatic lower-limb amputation.

2. Methods

2.1. Study Design and Setting

This study is a cross-sectional observational study. The study was conducted in the outpatient rehabilitation facilities of government hospitals, which provide amputees with physiotherapy and rehabilitation services. People who visited the rehabilitation clinics for follow-up care or physiotherapy assessment were recruited as participants over the study period (August 2025–April 2026). Trained physiotherapists and orthopedic surgeons with expertise in musculoskeletal and amputation rehabilitation performed the data collection.

2.2. Ethical Considerations

The Palestinian Health research council (The Helsinki Committee) granted ethical permission for this study in August 2025 (permission No. PHRC/HC/1241/25). All participants were made aware of the study's objectives, the fact that participation was entirely voluntary, and their freedom to discontinue participation at any moment without losing access to rehabilitation treatments. Prior to their participation, all participants provided written informed consent. All acquired data was securely saved and used exclusively for research purposes in compliance with ethical norms and the Declaration of Helsinki's principles, and participant confidentiality.

2.3. Participants

The study included 491 people who had had their lower-limbs amputated. All eligible patients who visited the rehabilitation clinics during the study period were invited to participate in the recruitment process. They were all adults 18 years of age or older who had undergone unilateral lower-limb amputation (above-knee or below-knee amputation). Those who had amputations due to solely traumatic injuries were included. The exclusion criteria were participants with neurological problems, patients in the immediate postoperative phase after amputation surgery, and those who had reported a history of mental health issues or sleep difficulties before amputation, as well as those who were taking medication for depression, anxiety, or sleep disturbances prior to the amputation.

Additionally, those with pre-existing chronic illnesses like chronic musculoskeletal pain, diabetes mellitus or hypertension were excluded. Also, patients requiring stump revision surgery because of active residual limb problems such as symptomatic neuromas, painful exostoses, and severe scar-related complications were excluded from the study.

Of the total individuals screened, 727 were assessed. In total, 236 participants were excluded: 74 were candidates for stump revision surgery, 46 had chronic musculoskeletal pain/diabetes mellitus-related amputations, 56 reported sleep problems prior to amputation, 33 had symptoms of anxiety or depression before amputation, and 27 declined to participate. Consequently, 491 participants were included in the final analysis.

2.4. Data Collection Procedures

The period of data collection was August 2025–April 2026. An orthopedic doctor and physiotherapists with expertise in the clinical care of patients with lower-limb amputations conducted the evaluation and data collection. The staff were given instructions on how to administer the study questionnaires and evaluation procedures in a standardized manner before the study started. Participants who met the eligibility requirements and were present at the rehabilitation clinics during this time were invited to take part. Following informed consent, participants completed validated questionnaires and a clinical interview as part of a structured evaluation to record their demographics, information about amputations, the presence of phantom pain, and the timing of their access to rehabilitation services.

2.5. Instruments

The Pittsburgh Sleep Quality Index (PSQI), an established tool for assessing subjective sleep quality during the previous month, was used to assess sleep quality. In total, 19 self-rated items make up the PSQI, which jointly evaluates several aspects of sleep, such as subjective sleep quality, sleep latency, duration, sleep efficiency, sleep disruptions, use of sleep medications, and daytime dysfunction. A global score between 0 and 21 is produced by combining these elements, with larger scores denoting worse sleep quality. A global PSQI score of more than five was used to categorize people as having poor sleep quality [14].

The Hospital Anxiety and Depression Scale (HADS), which is frequently used to measure symptoms of anxiety and depression, was employed to assess depression and anxiety. The fourteen items on the test are split into two subscales that assess anxiety and depression symptoms independently. Subscale scores range from 0 to 21, with each item being rated on a four-point scale [15].

Phantom limb pain was assessed in two stages. Participants were first asked whether they had experienced phantom limb pain following amputation (Yes/No). Those reporting phantom limb pain were subsequently asked to rate their average phantom limb pain intensity using the 11-point Numeric Pain Rating Scale (NPRS), where 0 indicates “no pain” and 10 indicates “the worst pain imaginable.” The NPRS is a valid and reliable instrument for assessing pain intensity in clinical and research settings. It has been found that the NPRS is highly responsive to changes in pain intensity and gives valid and reliable pain assessments across different populations [16].

During the clinical interview, phantom pain was also evaluated. Phantom limb pain, which is described as unpleasant sensations felt in the missing limb after amputation [2], was asked to be reported by the participants. Furthermore, the existence of persistent and chronic musculoskeletal pain was evaluated, which was defined as primary pain that had persisted for more than 3 months [17]. Based on the patient’s self-report during the clinical evaluation, the existence of each pain condition was noted.

The timing of accessing rehabilitation services including prosthetic fitting, accessing mental health services and the start of physiotherapy after amputation was examined in order to assess access to rehabilitation services and note the duration of delay in receiving these rehabilitation services. The participants were asked if they had encountered any delays in receiving a prosthetic rehabilitation or physiotherapy services. According to conventional clinical practice standards, delayed access to rehabilitation was described as starting rehabilitation after the early postoperative rehabilitation period.

Rehabilitation-related variables were defined using the date of amputation as the reference point. Delay to physiotherapy initiation was defined as the number of days between amputation and the commencement of physiotherapy rehabilitation. This variable was analyzed as a continuous measure, with higher values indicating longer delays in accessing rehabilitation services. Among patients who had received a prosthesis, delay to prosthesis fitting was defined as the number of days between limb amputation and the first definitive prosthetic fitting and was analyzed as a continuous variable. Participants who had not received a prosthesis at any time from amputation until the date of study assessment were classified as prosthesis not fitted, which was treated as a categorical variable indicating the absence of prosthetic fitting rather than a duration of delay. Delay to prosthesis provision was entered into the regression model as a continuous variable and was expressed as the number of days from amputation to prosthesis fitting.

3. Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 26. The distribution of the variables was assessed using normality tests and histograms visual inspection. Most variables were not normally distributed; thus, non-parametric tests were applied. Descriptive statistics are presented as mean $\pm$ standard deviation and median with interquartile range (IQR). Categorical variables are expressed as frequencies and percentages. Spearman's rank correlation coefficient was used to examine the associations between the study outcomes. Comparisons of sleep quality, depression, anxiety and phantom pain between participants with and without chronic musculoskeletal pain and between those who had received a prosthesis and those who had not were performed by Mann–Whitney U test. A p -value of <0.05 was considered statistically significant. A regression analysis was performed to identify potential predictors of phantom pain. Only those variables that showed a significant association with phantom pain were included in the model.

Variables that were identified in the preliminary analyses were evaluated for inclusion in the multivariable regression model. Variables that did not show a significant association with phantom limb pain intensity were not included in the final regression model.

4. Results

The demographic characteristics of the participants are shown in Table 1. The study included 491 patients, of whom 79.0% were male. Most of them had completed secondary school (64.2%). Around two-thirds of them reported having no stable monthly income (67.8%). Above-knee amputation was the predominant amputation level (79.8%). In total, 41.5% of the sample had received a prosthesis at the time of evaluation; among these patients, temporary prostheses were more common (57.8%). Also, phantom pain was highly prevalent, affecting 78.8% of participants.

Table 1. Demographic and clinical characteristics of the participants with lower-limb amputation.

Variable	Category	Frequency	Percent
Gender	Male	388	79.0%
	Female	103	21.0%
Marital status	Single	161	32.8%
	Married	330	67.2%
Level of education	Graduate level	114	23.2%
	Secondary school	315	64.2%
	Diploma	57	11.6%
	None	5	1.0%
Smoking	No	124	25.3%
	Yes	367	74.7%
Alcohol	No	466	94.9%
	Yes	25	5.1%
Income status	No income	333	67.8%
	Monthly income	158	32.2%
Monthly income range	300–600 USD	123	77.8%
	600–1200 USD	35	22.2%
Did you receive a prosthesis?	Yes	204	41.5%
	No	287	58.5%
Level of amputation	Above Knee	392	79.8%
	Below Knee	99	20.2%
Type of prosthesis	Permanent	86	42.2%
	Temporary	118	57.8%
Phantom pain	Yes	387	78.8%
	No	104	21.2%
Received mental health support services	Yes	37	7.53%
	No	454	92.46%

As presented in Table 2, 46.2% of the sample reported having chronic musculoskeletal pain. LBP was the most common complaint, either occurring alone (45.4%) or in combination with other musculoskeletal pain, while isolated neck pain was reported by 26.9%. Low back pain combined with neck pain represented an additional 14.5% of cases.

Table 2. Prevalence and distribution of chronic musculoskeletal pain among participants with lower-limb amputation.

Variable	Category	Frequency	Valid Percent
Presence of Chronic Musculoskeletal Pain	No	264	53.8%
	Yes	227	46.2%
	Total	491	100%
Type of Musculoskeletal Pain /Chronic Pain	Low back + Hip + Knee pain	1	0.4%
	Low back pain	103	45.6%
	Low back pain + Elbow pain	1	0.4%
	Low back pain + Hip pain	5	2.2%
	Low back pain + Knee pain	3	1.3%
	Low back pain + Neck + Shoulder + Elbow	3	1.3%
	Low back pain + Neck + Shoulder pain	2	0.9%
	Low back pain + Neck pain	33	14.5%
	Low back pain + Shoulder pain	7	3.1%
	Neck pain	61	27.0%

Neck pain + Elbow pain	1	0.4%
Neck pain + Shoulder + Elbow pain	1	0.4%
Neck pain + Shoulder pain	5	2.2%
Total	226	100%

Table 3 presents the distribution of quality of sleep, depression, and anxiety. Poor sleep quality was observed in 49.9% of the participants. Most participants had depression scores within the normal range (60.1%). Similarly, anxiety scores were normal in 56.0% of participants.

Table 3. The distribution of sleep quality, depression, and anxiety scores among patients with lower-limb amputation.

Variable	Category	Frequency	Percent
Sleep	0–5 (normal sleep)	246	50.1%
	>5 (sleep disturbance)	245	49.9%
Depression	0–7 (normal)	295	60.1%
	8–10 (mild)	195	39.7%
	11–14 (moderate)	1	0.2%
Anxiety	0–7 (normal)	275	56.0%
	8–10 (mild)	210	42.8%
	11–14 (moderate)	6	1.2%

The descriptive and clinical statistics for continuous variables are shown in Table 4. Participants had a mean age of 34.5 ± 12.1 years. Considerable delays in rehabilitation services were observed among our sample. The median delay to initiation of physiotherapy sessions was 32 days (IQR = 48.8), while the median delay to prosthetic fitting was 89 days (IQR = 66) among those who already received a prosthesis and 502 days (since the day of amputation) (IQR = 246) among those who had not yet been fitted with prosthesis.

Table 4. Descriptive statistics of demographic characteristics, clinical characteristics, and delay in rehabilitation services among patients with lower-limb amputation.

Variable	Mean	SD	Median	IQR	95% CI
Age (years)	34.52	12.06	33	13	32.86–36.19
Sleep	5.46	2.31	5	3	5.46–5.14
Depression	5.63	1.89	5	2	5.37–5.89
Anxiety	5.52	1.76	5	1	5.28–5.76
Chronic pain Intensity	5.9	1.4	6	2	5.71–6.1
Physiotherapy delay (days)	35.22	30.03	32	48.75	31.07–39.36
Delay to prosthesis (days)_Fitted	109.78	63.01	89	66	101.08–118.48
Delay to prosthesis (days)_Not Fitted	472.9	167.85	502	246	453.46–492.46
Phantom pain intensity	3.19	2.62	3	4.6	2.83–3.55

Note. Standard deviation (SD), interquartile range (IQR), confidence interval (CI).

The correlation matrix found several relevant associations, as expressed in Table 5. Sleep quality was associated with greater phantom pain intensity ($r = 0.611$, $p < 0.001$) and greater musculoskeletal pain ($r = 0.585$, $p < 0.001$). Sleep quality was also associated with greater depression ($r = 0.320$, $p < 0.001$) and anxiety symptoms ($r = 0.192$, $p < 0.001$). Furthermore, higher phantom pain intensity was associated with longer delay to prosthetic fitting ($r = 0.164$, $p < 0.001$), chronic musculoskeletal pain ($r = 0.266$, $p < 0.001$), higher depression levels ($r = 0.228$, $p < 0.001$), and higher anxiety ($r = 0.153$, $p = 0.001$).

Table 5. Spearman correlations between prosthetic delay, physiotherapy delay, sleep quality, musculoskeletal pain intensity, depression, anxiety, and phantom pain intensity.

Variable	1	2	3	4	5	6	7
1. Delay to prosthesis	—						
2. Delay to physiotherapy	−0.08	—					
3. PSQI	−0.01	0.02	—				
4. Maximum MSK pain intensity	0.02	0.13	0.59 **	—			
5. Depression	0.11 *	−0.01	0.32 **	0.11	—		
6. Anxiety	0.09 *	−0.05	0.19 **	0.02	0.62 **	—	
7. Phantom pain intensity	0.16 **	−0.05	0.61 **	0.27 **	0.23 **	0.15 **	—

Note. Values are Spearman's rank correlation coefficients (ρ). PSQI = Pittsburgh Sleep Quality Index; MSK = musculoskeletal. * $p < 0.05$. ** $p < 0.01$.

The multivariable regression analysis of the factors associated with phantom pain is presented in Table 6. The analysis explained 26.6% of the variance in phantom pain intensity (adjusted $R^2 = 0.249$). Sleep quality and delay to prosthetic fitting were significantly associated with phantom pain. Poor sleep quality was significantly associated with phantom pain ($\beta = 0.480$, $p < 0.001$) and longer delays to prosthetic fitting were also observed as a potential risk factor ($\beta = 0.184$, $p = 0.002$). Gender, amputation level, and socioeconomic factors were not significantly associated with phantom limb pain intensity in the preliminary analyses and were therefore not included in the final regression model.

Table 6. Multiple linear regression predicting phantom pain intensity.

Predictor	B	SE B	β	t	p
Constant	−1.72	1.05	—	−1.64	0.102
Delay to prosthesis	0.003	0.001	0.18	3.11	0.002
Sleep quality	0.77	0.12	0.48	6.50	< 0.001
Maximum MSK pain intensity	−0.03	0.15	−0.01	−0.20	0.843
Depression	−0.09	0.12	−0.06	−0.76	0.451
Anxiety	0.06	0.11	0.04	0.52	0.603

Note. B = unstandardized regression coefficient; SE B = standard error of the unstandardized regression coefficient; β = standardized regression coefficient; t = t statistic. MSK = musculoskeletal.

Comparison of sleep, anxiety, depression, and phantom pain intensity between patients with lower-limb amputation with and without chronic musculoskeletal Pain and those who received prosthesis and those who did not receive

Compared to patients without chronic musculoskeletal pain, those with lower-limb amputation with chronic musculoskeletal pain had [17] significantly poorer sleep quality ($p < 0.001$), higher anxiety ($p < 0.001$) and depression symptoms ($p < 0.001$), as well as higher phantom pain intensity ($p < 0.001$). Similarly, patients who had not received a prosthesis demonstrated significantly poorer sleep quality ($p = 0.009$), higher depression ($p < 0.001$) and anxiety symptoms ($p < 0.001$), and greater phantom pain intensity ($p = 0.002$) compared with those who had received a prosthesis.

5. Discussion

The results of this study demonstrate the frequency and complexity of phantom limb pain, one of the most enduring and incapacitating effects after lower-limb amputation. In total, 78.8% of the people in our sample with traumatic lower-limb amputations reported having phantom limb pain, which is in line with recent publications showing a prevalence rate of 71.73% [18]. This high frequency highlights the substantial pain burden experi-

enced by the post-amputation population, especially in those with traumatic etiologies. The increased rates of phantom pain seen in this study can be explained by the fact that traumatic amputations frequently result in more extensive nerve injury and tissue damage than disease-related or vascular amputations [19]. This result is particularly important in the Gaza Strip, where traumatic lower-limb amputations occur within a conflict-affected setting and individuals may face substantial barriers to continuous pain management, rehabilitation, and prosthetic care.

Peripheral, spinal, and central nervous system pathways are known to contribute to phantom limb discomfort [20]. Unusual nociceptive signals are produced by peripheral nerve damage and the development of neuromas. Central sensitization intensifies these signals in the spinal cord, maintaining discomfort [21]. Phantom limb pain is frequently resistant to traditional analgesics because of the intricate interactions between these processes, as well as its relationship with psychological status [8].

In addition to peripheral and central sensitization, several other mechanisms have been proposed to contribute to phantom limb pain. Residual limb pain and symptomatic neuromas may provide persistent nociceptive input that maintains central sensitization and amplifies phantom pain [22]. Furthermore, contemporary models propose that disrupted sensorimotor processing may contribute to the persistence of phantom limb pain. Sensorimotor incongruence, arising from a mismatch between motor intention, sensory feedback, and the cortical representation of the missing limb, has been proposed as one potential mechanism, while the stochastic entanglement hypothesis suggests that impaired sensorimotor circuitry may become functionally linked with pain-related neural activity [23,24]. These mechanisms were not evaluated in the present study and, therefore, cannot explain the observed associations directly, but they represent important biological contributors that should be considered when interpreting our findings and in future research.

The significant correlation between sleep disturbances and phantom limb pain is a key finding of the current study. Sleep quality was associated with phantom pain. Nearly half of the individuals reported having sleep difficulties, highlighting its high prevalence among individuals following lower-limb amputation. Sleep is essential for preserving the homeostasis of the central nervous system, controlling inflammatory reactions, and promoting neuroplasticity [25]. Sleep disturbances can increase central sensitization, disrupt descending inhibitory pain pathways, and raise pro-inflammatory cytokines including interleukin-6 and tumor necrosis factor- α , all of which intensify pain perception [26]. Additionally, sleep disturbance may promote maladaptive plasticity that maintains phantom limb sensations by impeding adaptive brain restructuring after amputation [27]. Because these mechanisms were not examined in the present study, they should be regarded as biologically plausible explanations rather than direct evidence from our findings.

This study found a significant correlation between symptoms of anxiety and depression with phantom limb pain, which is consistent with earlier research relating psychological factors to pain severity [27]. Poor psychological status may negatively affect rehabilitation outcomes by reducing treatment adherence and motivation, thus delaying functional recovery [28].

Although anxiety and depression were correlated with PLP, they were not independently associated with PLP after adjustment for other variables, including sleep quality. This may suggest that sleep disturbance represents a potential pathway linking psychological distress and pain [29]; however, mediation cannot be inferred because no formal mediation analysis was performed. These findings support integrated rehabilitation approaches addressing both sleep and psychological health. This can be supported by previous evidence that recognized poor sleep as a significant mediator between pain and depression, and poor sleep leads to an increase in of the symptoms of depression [30].

This research highlights the significance of integrated approaches that address both sleep and mental health in the rehabilitation process by suggesting that sleep quality may be a key mechanism connecting psychological distress to phantom limb pain.

These associations can be particularly relevant in the present population, in which patients with traumatic lower-limb amputation live within a conflict-affected environment characterized by ongoing stress and disruptions in healthcare and rehabilitation access. Although these contextual exposures were not directly measured, they can shape the interaction between psychological problems, sleep disturbance, and PLP. Within the present analytical framework, PLP intensity was the dependent outcome, whereas chronic musculoskeletal pain was examined as an associated explanatory variable. In total, 46% of participants reported having chronic musculoskeletal pain, which is indicative of the secondary effects of limb loss and changed biomechanics. Low back pain in people with lower-limb amputation showed a prevalence of 82% [11]. People who have lost a lower-limb frequently develop compensatory walking patterns and rely more on their remaining joints and muscles, which can result in overuse and physical discomfort [31]. Previous results suggest that LBP after lower-limb amputation is influenced by various physical and psychosocial factors, such as poor sleep quality, prosthesis use, and adaptation to amputation. Thus, rehabilitation strategies should address not only pain but also sleep quality, and psychological adjustment. Phantom limb pain also seems to be influenced by access to rehabilitation services, especially prompt prosthesis fitting. The relationship with delayed prosthetic fitting may be especially relevant in the Gaza Strip, where disruptions in healthcare delivery and limited access to rehabilitation resources can prolong the pathway from amputation to prosthetic fitting. Delays in prosthetic provision were found to be associated with phantom limb pain in the current investigation, indicating that extended periods of time without prosthetic use may be a factor in the development of phantom limb pain. Our results are supported by previous evidence that included 51 patients with leg amputation and found that timing to prosthetic fitting was associated with psychiatric symptoms and sleep quality in individuals with lower-limb amputation [10]. These results highlight the necessity for healthcare systems to guarantee prompt access to prosthetic and physiotherapy services because postponed rehabilitation may worsen pain and functional impairments.

However, direct evidence examining the relationship between the timing of prosthetic fitting and PLP remains scarce, and the available evidence is limited. Therefore, the present findings should be considered preliminary and interpreted cautiously. Moreover, the cross-sectional design does not establish the temporal direction of this association. Reverse causation is possible, whereby individuals with more severe PLP may experience greater difficulties with prosthetic fitting or participation in rehabilitation, potentially contributing to longer delays. A bidirectional relationship between PLP and delayed prosthetic fitting also cannot be excluded. Although this association was statistically significant, its magnitude was modest, suggesting that delay to prosthetic fitting may represent only one of several factors associated with PLP intensity. The conflict-related context in which this study was conducted should also be considered when interpreting these findings. Individuals with traumatic amputations living in humanitarian settings may experience psychological trauma, repeated exposure to stressful events, disrupted healthcare systems, and prolonged delays in accessing rehabilitation and prosthetic services.

These contextual factors may independently influence pain perception, psychological well-being, and rehabilitation outcomes, while also contributing to delayed prosthetic fitting. Because these factors were not directly measured in the present study, their contribution cannot be quantified and should be explored in future prospective investigations. This study has several limitations that should be considered when interpreting the findings. The cross-sectional design precludes establishing temporal or causal relation-

ships between phantom limb pain and the examined rehabilitation, prosthetic, psychological, and sleep-related variables. Consequently, the observed associations should not be interpreted as evidence of causation. Furthermore, because all variables were collected during a single assessment, the temporal sequence between exposure and outcome cannot be determined, and bidirectional relationships are possible. For example, poor sleep quality may contribute to greater phantom limb pain, while more severe phantom limb pain may also adversely affect sleep quality. Prospective longitudinal studies are needed to clarify the direction and causality of these relationships. The cross-sectional design precludes determining the temporal direction of this modest association between delays in prosthetic fitting and PLP, and reverse causation cannot be excluded. Prospective studies are needed to clarify this relationship.

Although the study examined delays in physiotherapy and prosthetic fitting, other potentially important factors were not assessed, including residual limb pain, prosthesis quality, level of social support, post-traumatic stress disorder, detailed characteristics of the traumatic injury and sensorimotor disturbances. Because these variables are recognized contributors to phantom limb pain, residual confounding cannot be excluded. Also, participants were recruited from conflict-affected settings with limited healthcare resources, which may reduce the generalizability of the findings to populations living in more stable environments with earlier access to rehabilitation and prosthetic care. An additional limitation of this study is that time since amputation and the onset of phantom limb pain were not collected. These variables may influence the severity and characteristics of phantom limb pain and could provide important insight into its clinical course.

6. Conclusions

78.8% of people with traumatic lower-limb amputations reported having phantom pain. Depression, anxiety, delayed prosthesis fitting, chronic musculoskeletal pain, and poor sleep quality were all significantly correlated with phantom pain intensity. The significance of early prosthetic rehabilitation and sleep management is highlighted by the fact that among these parameters, sleep disturbance and longer delays to prosthesis fitting were independently associated with higher phantom pain severity. In total, 46.2% of participants reported having chronic musculoskeletal pain, which was primarily chronic low back pain and was linked to considerably poorer outcomes for sleep, anxiety, depression, and phantom pain. Future research needs to determine whether early prosthesis provision and integrated therapy that addresses psychological discomfort, musculoskeletal pain, and sleep can lessen the intensity of phantom pain and enhance long-term results. Prospective and interventional research is required to determine causative pathways and direct individualized rehabilitation techniques.

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Disability Language/Terminology Positionality Statement: The authors primarily use person-first language, including terms such as “individuals with lower-limb amputation” and “patients with lower-limb amputation”, reflecting the clinical and rehabilitation context of this study and the terminology commonly used in prosthetic and rehabilitation practice. The authors acknowledge that preferences regarding disability-related terminology may vary among individuals and communities.

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