Shifting body perception: How amputation alters dream imagery

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Summary. Recent neuroscience advances emphasize the complex relationship between the physical body and dreams during sleep, as these two bodies share many neurological and physiological components. Understanding how significant bodily changes, like amputations, affect dream body perception opens a window to investigate the contribution of memory and somatosensory processing in dream formation. This sleep laboratory PSG study aimed to collect dream reports from amputees through REM awakenings and assess the subjective body perception in their dreams. We compared these results with dream content from two control populations experiencing temporary body perception changes: muscle soreness and electrical muscle stimulation (EMS). The dream reports indicate mixed body perception, both as an intact body and post-amputation, especially in recent amputees. In addition, more temporary changes in body perception, such as those from muscle soreness and EMS, are represented differently in dreams compared to the dreams of amputees. The research suggests recent amputees, who might be more involved in psychological coping with the novel change in body configuration, dream more about their own body, pre- or post-amputation. Amputees' dreams are less movement- and body-focused compared to the dreams of people with temporary body changes, likely reflecting adaptation to the new body schema over time. This study contributes to ongoing research into the relationship between the physical and dreamed body by further addressing the subjective dream experience of amputees.

Keywords: Amputation, dreaming, phantom limbs, dream body, continuity hypothesis

1. Introduction

Exploring the impact of physical experiences on dream content and bridging the gap between the physical and dreamed body has been investigated for decades. Recent advancements in neuroscience have further elaborated on the physiological basis of dreaming, emphasizing the intricate relationship between the physical body and the dreamed body during sleep (Erlacher & Schredl, 2008; Peters et al., 2023). In addition to this, the continuity hypothesis suggests that wake-life experiences directly influence subsequent dream experiences (Schredl, 2000). One part of this puzzle might be solved by examining how bodily alterations, such as amputations, may influence body perception in dreams and subsequent dream content. Amputation, the surgical removal of a limb or part of it, represents a significant physical and psychological transition for individuals, prompting an investigation into its potential effects on dream experiences.

The somatosensory and motor cortex of the human brain play crucial roles in processing sensory information and coordinating motor functions, respectively. Amputation induces profound alterations in the somatosensory and motor cortex, leading to the reorganization and remapping of cortical representations corresponding to the amputated limb (Borsook et al., 1998; Flor et al., 1995). This neural reorganization is accompanied by functional changes, including heightened cortical activity in regions adjacent to the amputation site and modifications in sensorimotor integration (Kikkert et al., 2018). Such neuroplastic changes show the brain's ability to adapt to peripheral changes and reconfigure its internal representation of the body. Given the close association between sensory experiences and dream imagery, alterations in somatosensory cortex activity post-amputation may affect dream content. Research on lucid dreaming motor practice has suggested the involvement of the supplementary motor cortex in dream motor content and its connection to the dreamed body (Peters et al., 2023). Additionally, a combined EEG-fMRI study revealed that dreamed hand movement elicits similar activation in the sensorimotor cortex as compared to real hand movement in lucid dreaming (Dresler et al., 2011).

The phenomenon of phantom limb sensations illustrates the complex relationship between the physical loss of a limb and the brain's enduring representation of it. Despite the limb's physical absence, the neural circuits associated with it often remain active, leading to vivid sensations as if the limb were still present. Nearly all individuals who experience limb amputation report some form of phantom limb sensation, which can range from mild tingling or warmth to more intense feelings of movement or even pain (Stankevicius et al., 2021). Despite the absence of the limb, amputees can experience their bodies either intact (31%), as it was before the amputation, as it is after the amputation (21%), or have a mixed body perception (37%) in dreams (Mulder et al., 2008). The inclusion of phantom limbs in dreams shows

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the brain's capacity to maintain and integrate representations of the body, even in the absence of sensory input from the missing limb. For instance, individuals may experience sensations such as movement, touch, or even pain in their phantom limb or incorporate memories of their pre-amputation limb into their dreams, reflecting the persistence of neural representations despite physical loss. A study of 3,234 unilateral limb amputees investigated this by examining the relationship between post-amputation pain, other related factors, and body perception in dreams. The study found that 22% of participants couldn't recall their body in dreams, 24% saw themselves as intact, less than 3% as impaired, and 35% had mixed representations. The results showed that lower-limb amputation and the presence of phantom limb pain and residual limb pain were associated with recalling an impaired body in dreams. Non-painful phantom phenomena had no effect (Bekrater-Bodmann et al., 2015). Another recent study examined dreamed phantom limbs in sarcoma patients who underwent limb amputation, focusing on body image perception, pain coping strategies, and dream content. The study assessed phantom limb phenomena, limb telescoping (the perceived shortening of a phantom limb due to cortical reorganization), and weekly dream diaries at two time points: within three weeks post-surgery (T0) and four to six months after (T1). All participants experienced phantom limb sensations, with 35% reporting limb telescoping shortly after surgery, decreasing to 25% after four to six months. Half of the subjects still dreamed of having their missing limbs at both T0 and T1 (Giordano et al., 2021).

Additionally, changes in motor cortex activity following amputation may influence the kinesthetic aspects of dreams, such as movement and action. It is noted that adaptation to the loss of a limb can manifest in indirect ways outside of own-body perception in dreams, for instance, by seeing oneself surrounded by amputees (Brugger, 2008). In a single case study, an amputee with REM behavior disorder showed stump movement congruent to dream content. The person also reported the disappearance of the unpleasant sensations and the recovery of the anatomical and functional integrity of the amputated limb, including motor awareness, while dreaming(Vetrugno et al., 2008). In another small study on dream body perception, six amputees were awakened during REM sleep and asked to report their dreams. Of these, three patients were able to provide detailed accounts. Remarkably, all reported that their amputated limbs were intact and fully functional within their dreams, and they did not experience phantom limb sensations during these dream episodes. This suppression of phantom limb experiences during sleep contrasts with their waking reality, where such sensations often result from a conflict between a preexisting body schema and the sensory information about the missing limb. Instead, the dreams favored an image of an intact body, suggesting a different mode of body perception operating during sleep (Alessandria et al., 2011).

The extent and nature of cortical changes following amputation remain an area of active scientific investigation and debate, which has significant implications for understanding dream body perception. On one side, research by Flor et al. shows significant cortical remapping, where neighboring brain regions take over areas previously linked to the amputated limb (Flor et al., 1995). This remapping demonstrates the brain's ability to adapt to sensory loss and has been proposed as a factor in altered body perception during both waking and dreaming states. On the other side, Makin et al. argue that cortical representations of the amputated limb can remain relatively stable even decades after amputation (Makin & Bensmaia, 2017). This stability may explain the persistent phantom limb sensations and the frequent depiction of intact limbs in dreams. Clarifying these perspectives on cortical remapping and stability is essential for understanding how physical changes like amputation shape dream body perception. If remapping alters the body schema, it might influence shifts in dream body imagery over time, while on the other hand, the stability of cortical representations could explain the persistence of pre-amputation imagery or vivid phantom limb sensations.

In conclusion, exploring how amputation influences dream content is crucial in understanding the interaction between physical experiences and dream perception. Amputation can trigger significant changes in the brain's somatosensory and motor cortex, altering dream content by affecting body perception, memory, and the presence of phantom limb sensations. The current study aims to investigate the body perception in dreams experienced by participants who underwent an amputation using qualitative analysis of dream reports, polysomnography (PSG) recordings and systematic REM awakenings. Additionally, dream content in individuals with limb amputation will be compared to two unique control groups: one experiencing muscle soreness and the other undergoing temporary electrical muscle stimulation (EMS). These groups provide a valuable comparison because they differ from amputees in several ways: they involve only temporary changes in body perception and lack the deep psychological adjustment associated with permanent limb loss. This allows us to investigate whether the enduring nature and psychological impact of amputation uniquely shape dream content or if similar patterns emerge from more transient changes in bodily sensation. By analyzing these differences, we can gain clearer insights into how both the duration and psychological weight of body alterations influence the dreaming experience. This investigation will expand on the few previous studies on body perception following significant body schema changes in dreams.

2. Methods

2.1. Participants

Ten participants were recruited in Switzerland via national trainers from PluSport athletics and alpine skiing, orthopedic shops in Bern and the region, private contacts, and physiotherapists from the SUVA Bellikon rehabilitation clinic. All participants have one or more amputations of the lower extremities and are active in sports. A total of ten participants (n_{female} = 1) took part in the study, with an average age of 47.5 ± 13.6 years. All participants ranged in age from 26 to 67 years, with an average of 14.4 years of amputation. The time of amputation varied between 29 and 3 years ago. Participation in the study was voluntary, and participants were not financially compensated. All participants were informed in writing about the process and the time required and signed a written consent form before taking part in the study. Pseudonymous codes were used to store the participant's data from the first meeting onward, ensuring optimal data safety. The study was approved by the ethics committee of the philosophical Faculty of Human Sciences at the University of Bern. In order to "blind" the participants, they participated in the study under the pretense of comparing the emotions in dreams of amputee athletes with the emotions of other athletes. Shortly before going to bed, they were shown a ten-minute PowerPoint presentation with photos of emotional athletes from various sports. The next morning after the intervention, each participant was informed by the researcher about the actual study goal (written and verbal), and any additional questions were clarified.

2.2. Intervention Process

The participants spent a night in the sleep laboratory at the ISPW at the University of Bern. They slept less than six hours the night before the intervention in order to increase sleep pressure during the experimental night. On the day of the intervention, the participants came to the ISPW at the University of Bern at around 21:15. The researcher showed them the laboratory, and the participants then prepared for sleep, and the electrodes for polysomnography (PSG) were attached. After the PSG signals were set up, participants watched the 10-minute PowerPoint presentation on emotions in athletes and went to sleep at 11:00 p.m. They were informed that REM awakenings would occur in the second half of the night, starting at 3:00 a.m. until a final awakening at 7:00 a.m.

2.3. Polysomnography and Data Collection

To perform REM awakening, PSG was applied according to the 10-20 system (Klem et al., 1999) with electrodes for EEG, ECG, EOG, and submental EMG using the SleepWorks™ software program from XLTEK™. The sleep data were scored manually using the criteria of American Academy of Sleep Medicine (Iber, 2007). Following REM onset and ten stable REM epochs, the participant was awakened, and their verbal dream report was recorded by asking the following questions: [Name] are you awake?" and "What was the last thing that went through your mind?" If a participant was able to give a dream report, the researcher asked further detailed questions regarding the body perception. The participant was then allowed to go back to sleep. Starting from the second REM awakening onwards, a wait of 20 stable REM sleep epochs was implemented before waking the participant, with the aim of extending the duration of the subsequent dream report.

2.4. Evaluation of the Dream Reports

The verbal dream reports were transcribed using Schredl's Dream transcription manual (Schredl, 2018). The reports were analyzed and evaluated using the dream manual, which was tailor-made for this study and has labels for evaluating body perception in dreams The translated version of the original German manual can be found in the supplementary materials. An example of one of these labels is the answer to the question, "Does the participant report an intact body perception, yes or no?" (Bekrater-Bodmann et al., 2015; Erlacher & Schredl, 2004).

2.5. Exploratory Comparative Dream Content Analysis

To explore how different types of temporarily altered body experiences are reflected in dreams, we conducted a comparative dream content analysis across three distinct groups using unpublished datasets previously recorded for different projects within the same time period: Participants ($N = 8$, $N_{female} = 2$, $M_{age} = 24.5$, $SD_{age} = 2.01$) subjected to electrical muscle stimulation (EMS) of the flexor muscles of forearm during dreaming and those experiencing muscle soreness ($N = 12$, $N_{female} = 10$, $M_{age} = 22.5$, $SD_{age} = 1.08$) in the arms during dreaming. Participants in both groups were Sports students at the University of Bern, Switzerland. In the EMS group, participants received brief, perceptible electrical stimuli during REM sleep using the Rehamove 3 (Kubersky, 2018). For the muscle soreness group, participants underwent a strength training protocol designed to induce delayed onset muscle soreness (DOMS) before sleep. These two control conditions did not receive a cover story. The PSG setup and PSG analysis were identical to the current study. In the two control groups, systematic awakenings were performed during REM sleep to obtain dream reports, following the same protocol as used for the amputee group. To evaluate the dream reports from the three populations, the blind rater used a Dream Content Analysis (DCA) Manual, which contained scales on realism/bizarreness (Schredl, 2003b), number of dream characters, interaction, emotions (Schredl, 2018) and items taken from the Bodily Experiences in Dreams (BED) Questionnaire (Noreika et al., 2020).

The results of the DCA were compared for each population using a combination of the Chi^2 test for items with a binary response and an Kruskal-Wallis-test for items with a scaled response using Jamovi.

3. Results

3.1. Participants

Ten participants with amputations, comprising one woman and nine men, participated in the study, with a mean age of 47.5 ± 13.6 years. All participants were engaged in sports at a national or international level, with four participants involved in alpine skiing and others participating in wheelchair basketball (N=2), golf (N=1), cycling (N=1), floorball (N=1), triathlon, and shooting sports (N=1). Among the participants, six had amputations below the knee joint, while four had amputations above the knee joint, including two participants affected on both sides. On average, the participants had lived 33.1 years before their amputations and had spent 14.4 years with their amputations. Three participants underwent amputation later in life, at ages 60, 50, and 47, with only 3 years since their amputations at the time of measurement. In contrast, two participants experienced amputation earlier, after 19 and 15 years of life, and had lived 29- and 23-years post-amputation, respectively.

3.2. Evaluation of Dream Reports

A total of 28 dream reports were collected, transcribed, and evaluated. The overall dream recall rate for all REM awakenings was 93%, with an average dream report length of 66 ± 67 words. Eight dreams (26.7%) described amputation-related body perception, either directly in the initial dream report or through follow-up questions. In two dream reports, post-amputation body perception or body experience was explicitly described in the dream report:

> *"… We had to walk around the hole. And I had the prosthesis on because two or three looked at me for so long.*

They still do that a lot. I was still wearing shorts, and you can see the prosthesis…"

"… It was about a problem with the sports prosthesis…"

Two other dreams mention post-amputation body perception after follow-up questioning by the researcher:

"…There was so much stuff everywhere that I couldn't even use a wheelchair…"

"…We sat at the table. Yes, I had them on (the prostheses).…"

One dream indicated intact body perception upon further questioning:

Researcher: "Do you happen to know whether you had the prosthesis on? "

"No, that can't be possible. I didn't have that yet."

Three other dream reports mention some type of body perception, but it is unclear whether the dreamer experiences an intact or post-amputation body:

"… He (the dog) always sleeps on the bed in between the legs, so we laid down and went to sleep…"

In this dream, the participant mentions that the dog usually sleeps between the legs on the bed, but it is unclear whether the dog lies in between the two people's legs, or whether the participant is referring to their own legs, either pre- or post-amputation.

"… The last thing was something to do with shooting because I used to shoot competitively until about two years ago, and now I'm having trouble concentrating on the target since the phantom pain…"

The dreamer refers to their struggles with aiming for the target because of their phantom pain in waking life. However, whether they experienced this phantom pain and the post-amputation body in the dream remains unclear.

"… I know I was standing with my right foot on the foot of the person on the right. I noticed that I was standing on someone's foot and felt it and I didn't have any shoes on, I was barefoot…"

Finally, this dream includes details about the sensations of the right foot. The dreamer talks about standing with their right foot on top of someone else's foot. Interestingly, this participant had the left leg amputated above the knee. In conclusion, four dreams included post-amputation body perception in the dream, whereas only one presented intact body perception, pre-amputation. Three dreams were unclear about the type of body perception related to the amputation. The three participants with the shortest time post-amputation (Time Post) were responsible for most of the dreams with dream body perception related to the amputation (Table 1).

Table 1. Dream body perception.

Participant	Time Pre (years)	Time Post (years)	Dream Body Perception
3	60	3	Post-Amputation
4	20	13	Post-Amputation
5	15	23	Ambiguous
6	47	3	Post-Amputation
6	47	3	Ambiguous
7	50	3	Post-Amputation
7	50	3	Intact Body
9	17	17	Ambiguous

Note. The type of dream body perception of the participants reporting body perception related to the amputation in their dreams, as well as the time spent with an intact body (Time Pre) and the amputation (Time Post) are presented. Participant 1 and 2 did not report any body perception and participant 7 reported two types of body perception.

3.3. Comparison of Dream Content Analysis across Three Populations

The dream content analysis (DCA) compared the dream content of our amputation population with two other altered body experience populations. The three populations together consisted of 81 dream reports, including 28 amputation dream reports, 35 dreams in the muscle soreness control population, and 18 in the EMS control population. On average, the amputation group reported 2.8 dreams per participant, the muscle soreness group 2.75 and the EMS group 1.3 dreams. The DCA was split into a general DCA and a body-related DCA. The scores were corrected for the number of dreams per population and represent the total number of positively scored items divided by the total number of dreams in that population. In Table 2, the results of the general DCA are presented, including the subjects: Bizarreness, Emotion, the Number of Dream Characters, Verbal Interaction, and Aggression.

The dreams in the soreness population were more often negatively charged (22.9%) in comparison to the amputation (10.7%) and EMS (9.3%) populations. The amputation dreams contained fewer dream characters per dream (0.64) in comparison to the muscle soreness (2.09) and EMS group (1.61).

The Kruskal-Wallis test revealed several items with statistically significant differences across populations. The average number of dream characters per dream was higher in the muscle soreness ($H(2)==16.4$, $p=<.001$) and EMS ($H(2)==6.54$, $p=0.011$) populations compared to the ampu-

Table 2. Dream content analysis findings.

Population	Soreness	Amputation	EMS
n	35	28	18
Bizarreness	47.9%	45.5%	50.0%
Positive Emotion	7.6%	8.3%	0.0%
Negative Emotion	22.9%	10.7%	9.3%
Characters	2.09***	0.64	1.61*
Verbal Interaction	34.3%	35.7%	27.8%
Verbal Aggression Out	5.7%	3.6%	5.6%
Verbal Aggression In	2.9%	3.6%	5.6%
Physical Aggression Out	0.0%	0.0%	0.0%
Physical Aggression In	2.9%	0.0%	0.0%

Note. The numbers, except for the item: 'Characters', represent the percentage of dreams that include the specific content within each population. For Bizarreness, Positive Emotion, and Negative Emotion, the numbers are corrected as they were scored on a scale 0-4. The numbers for the item 'Characters' represent the average number of characters per dream for each population. The results of a Kruskar-Wallis test are presented: $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 3. Percentages of body-related dream content for each population.

Population	Soreness	Amputation	EMS
n	35	28	18
Body Interactions	2.9%	0.0%	0.0%
Sport Active	8.6%	7.1%	5.6%
Sport Passive	17.1%	14.3%	16.7%
Legs	37.1%*	10.7%	16.7%
Arms	20.0%	10.7%	22.2%
Activity	31.4%	25.0%	11.1%
Injury	2.9%	10.7%	22.2%*
Verbs Movement	0.69*	0.18	0.33

Note. All items, except for 'Verbs Movement,' represent the percentage of dreams that include the specific content within each population. 'Verbs Movement' shows the total number of movement-related verbs divided by the total number of dreams in that population. The results of a Chi-squared test are presented with: *p < .05, **p < .01, ***p < .001.

tation population. Negative Emotion was more prevalent in the soreness population compared to the EMS condition, but this difference was only close to significance (H(2)=3.42, p=0.065).

In Table 3, the results for the body-related DCA are presented. In the body-related dream content analysis, notable differences emerged among the three populations. The soreness group reported body interactions in 2.9% of their dreams, while neither the amputation nor the EMS groups had any occurrences of body interactions. Regarding sport-related content, the soreness group had the highest percentage of dreams involving active sports activities at 8.6%, compared to 7.1% in the amputation group and 5.6% in the EMS group. Passive sports activities were most frequently reported in the soreness group (17.1%), followed by the EMS group (16.7%) and the amputation group (14.3%).

Dreams featuring references to legs were predominant in the soreness group, occurring in 37.1% of reports, significantly higher than the amputation group (10.7%) and the EMS group (16.7%). Conversely, the EMS group had the highest percentage of arm-related content in their dreams (22.2%), compared to 10.7% in the amputation group and 20.0% in the soreness group. Finally, movement-related verbs were more commonly found in the soreness group (0.69 per dream) compared to the amputation (0.18 per dream) and EMS groups (0.33 per dream).

A chi-squared test revealed that for the category 'Legs', there was a statistically significant difference between the muscle soreness and the amputation population (χ^2=5.73, p=0.017). Furthermore, a statistically significant difference was found for the category 'Injury' between the muscle soreness and EMS group (χ^2=5.22, p=0.022). The Kruskal-Wallis test revealed that the number of movement-related verbs was higher in the soreness population, compared to the amputation population (H(2)=6.37, p=0.012).

4. Discussion

The findings from this study offer valuable insights into the relationship between amputation, dream content, and body perception among individuals engaged in sports at elite levels. Despite the stable cortical adjustments post-amputation, our results reveal a mix of expressions of body perceptions in dreams among participants. Our participants were not informed about the true objective of the study, which was to investigate body perception in dreams. Instead, they were told that the study focused on emotions in dreams. This cover story allowed us to observe body perception in dreams as it naturally occurs, without priming the participants to consciously focus on their bodies. It is possible that individuals who undergo amputation, an experience that can have significant psychological implications, might have heightened body perception in their dreams, whether related to their intact or post-amputation state, as their daily experiences and concerns might be more centered around their bodies.

Our participants show significant variability in the time spent pre- and post-amputation, averaging 33.1 years pre-amputation and 14.4 years post-amputation. Previous research has already emphasized this demographic detail, which is likely crucial for understanding body perception in dreams among amputees (Mulder et al., 2008). For example, our dataset includes participants who underwent amputation later in life with only a few years post-amputation, as well as those who have lived longer with an amputation than without it. The duration of time spent pre- versus post-amputation might thus influence dream content, relying on memories and the plasticity of the somatosensory cortex. Shorter pre-amputation periods in combination with longer post-amputation periods may lead to different dream representations compared to those with longer and shorter periods, respectively. Our study, however, shows that four out of five dreams that included body perception related to amputation came from participants who had undergone amputation within the past three years. This suggests that the memory of the traumatic body alteration at the time of occurrence might significantly affect dream content, shaping dream body perception to reflect both pre- and post-amputation states. These findings align with the notion that recent and significant physical changes, especially those with strong emotional and psychological impacts, are more likely to be integrated into dream narratives. Furthermore, the frequency and vividness of body-related dreams might be influenced by the ongoing process of adaptation and coping, as recent amputees continuously navigate their new physical realities during waking life. Furthermore, individuals with older amputations may be less likely to report specific details about their body in dream narratives, reflecting a reduced psychological salience of the amputation over time as they integrate their altered body into their sense of self and daily life. Interestingly, this pattern may differ for individuals with congenital differences, who have never experienced an intact limb and, therefore, lack a pre-loss body memory. Despite this, the phenomenon of aplasic phantoms—sensations of absent limbs in individuals with congenital differences—suggests the presence of neural structures formed before birth that could underpin both phantom sensations and dream representations. These structures may be reinforced by observing movements in others or other environmental factors (Brugger et al., 2000).

Amputation induces cortical adjustments, however, the altered patterns of sensory processing vary among individual plasticity levels, potentially influencing the dream experience differently. The time elapsed post-amputation was suggested to have no relation with dream body perception; however, the older participants are, the more likely they are to dream about an intact body (Mulder et al., 2008). Phantom pain, commonly experienced by more recent amputees, can affect sleep quality and subsequently influence dream experiences. The presence of phantom pain reduces the likelihood of dreaming with an intact body schema, as the brain's persistent pain signals reinforce the awareness of limb loss, carrying over into the dreaming state (Alessandria et al., 2011). Although this study did not directly examine phantom pain, participants in this study reported frequent nighttime phantom pain episodes. These ongoing sensations might contribute to a reduced probability of intact body perception within their dreams, as they may integrate these painful, phantom limb sensations into dream content. This suggests that persistent phantom pain likely plays a critical role in shaping dream experiences for amputees, maintaining the body's altered state even in dreams, but it warrants further exploration.

Another factor contributing to reduced intact body perception in dreams among amputees could be the daily observation of movement behaviors in non-amputees. This phenomenon is grounded in the neural processes activated during observation. Studies have shown that observing movement sequences can activate brain areas similar to those engaged during actual movement execution. These areas include the premotor cortex and the posterior parietal cortex, which are crucial for planning and coordinating movement (Rizzolatti & Craighero, 2004). The premotor cortex plays a significant role in the preparation and initiation of movements. When an individual observes another person performing a movement, mirror neurons in the premotor cortex are activated, mirroring the observed action as if the observer were performing the movement themselves (Rizzolatti et al., 2006).

Similarly, the posterior parietal cortex is involved in integrating sensory information to guide movements. It helps in understanding the spatial aspects of observed movements and in planning similar actions (Fogassi et al., 2005). When amputees observe non-amputees, their posterior parietal cortex may be activated in a way that emphasizes the differences between their own physical capabilities and those of intact-bodied individuals. This neural mirroring effect suggests that the continuous observation of intact-body movements could reinforce the neural representation of an intact body, yet paradoxically, it may also heighten the awareness of the amputee's current physical state. This duality could contribute to the complex perception of an intact body in dreams. The brain's plasticity allows it to adapt to new realities, and the daily reinforcement of movement behavior through observation could influence how amputees perceive their own bodies, both while awake and in the dream state (Ramachandran & Altschuler, 2009).

In addition to explicit references to body perception related to amputation, some participants in our study reported dreams that indirectly conveyed their altered bodily experiences. For instance, phrases like "I couldn't use my wheelchair" suggest a form of logical thinking where the dreamer experienced their body as post-amputation, even without directly mentioning an intact or amputated body. These dreams illustrate the nuanced ways in which individuals with amputations perceive and integrate their physical realities into their dream narratives. Such indirect representations in dreams highlight the adaptive and cognitive processes involved in how individuals with amputations construct their dream experiences. Rather than explicitly depicting physical attributes, these dreams often reflect underlying psychological and emotional responses to their altered body states. This aligns with previous research suggesting that dreams serve as a reflection of waking life experiences and internal cognitive processes (Revonsuo, 2000).

This DCA aimed to investigate how altered body experiences shape dream content by comparing individuals with a permanent physical change—amputees—with two control groups experiencing temporary bodily changes: muscle soreness and EMS during sleep. This design allowed us to explore whether the permanence and psychological impact of amputation influenced dream content differently from temporary, sensation-based alterations. In addition to assessing general and body-specific dream content, we examined how each type of bodily experience influenced dream themes, emotions, and perceptions of the body. The amputation group, unlike the control groups, faced not only a lasting physical change but also the significant psychological impact of adapting to limb loss, potentially altering their sense of body and self in unique ways. By comparing this group with those experiencing only temporary and solely sensation-based changes, we aimed to clarify whether the psychological and cortical adjustments to amputation creates distinct patterns in dream content, such as the persistence of the missing limb or altered body schema, which might not appear as strongly in the control groups. This approach might provide a better understanding of how both physical and psychological dimensions of body alteration shape the subconscious experience of the dream state.

Emotional content was more varied across the groups. The muscle soreness population exhibited the highest incidence of negative emotions (22.9%) compared to the amputation and EMS groups (10.7% and 9.3%, respectively). The difference between the soreness and amputation group was insignificant, while the difference between the soreness and EMS population was very close to significance ($H(2)==3.42$, $p=0.065$), This finding could be explained by the discomfort and fatigue associated with muscle soreness, as pain and physical strain often translate into increased negative affect during sleep and dream content (Levin & Nielsen, 2007).

Dream characters were markedly fewer in the amputation group (0.64 characters per dream) compared to the 2.09 characters on average in the muscle soreness group ($H(2)==16.7$, $p=<.001$), and the 1.61 in the EMS group ($H(2)==6.54$, $p=0.011$). This might reflect a more self-centered or solitary dream experience in the amputation population, where the body itself may be the focal point, overshadowing interactions with others. This aligns with the idea that dreams often reflect waking self-perception, especially in individuals who have undergone significant bodily changes and are more involved with their own daily physical experiences (Solms, 1997). More likely, the higher number of characters in dreams reported by the soreness and EMS groups can be attributed to their active social lives as sports students, in contrast to the amputees, who were not students and may have had less social interaction.

Dreams in the muscle soreness group exhibited a higher prevalence of movement-related verbs, compared to the amputation group ($H(2)==6.37$, $p=0.012$) and the EMS group. However, the latter did not reach statistical significance. The EMS group, while also experiencing a form of physical stimulation, may not exhibit the same level of movement-related verb prevalence because the EMS is less physically engaging than muscle soreness and does not involve the same level of physical activity or exertion. Thus, the increased prevalence of movement-related verbs in the muscle soreness group might be a reflection of their recent physical exertion and the corresponding impact on their dream content. (Schredl, 2003a).

Even though the muscle soreness was induced in the non-dominant arm, the soreness group reported a significant amount of leg-related dream content. This amount was statistically more than the dreams of the amputation population (χ^2=5.73, p=0.017), but not the EMS population (χ^2=2.36, p=0.124). The EMS and amputation population did not differ significantly (χ^2=0.342, p=0.559). This could be explained by the broader impact of physical training or soreness on bodily awareness. Soreness in one part of the body, even when localized, may heighten general body perception, leading to an increased focus on other body parts, such as the legs, in dreams. This aligns with the theory that physical discomfort can trigger a more generalized bodily awareness during sleep, where other areas, like the legs, may become focal points despite the localized soreness. A notable distinction between the muscle soreness group and the amputation group is that the amputations exclusively involved the lower extremities. This could potentially limit the likelihood of dreaming about the legs. Conversely, the significant alteration in body schema related to the lower extremities might intensify dreams about this area, as such a profound change could be a highly emotionally salient experience.

Interestingly, the EMS group reported the highest frequency of injury-related content (22.2%), a finding that may be linked to the direct stimulation of muscles, which might be perceived as discomfort or strain during sleep. The significant discrepancy in injury-related dream content between the soreness and EMS groups could be attributed to the differing nature of these bodily sensations (χ^2=5.22, p=0.022). Soreness, particularly delayed onset muscle soreness (DOMS), is often a familiar and expected outcome of physical exertion, and athletes may perceive it as part of a normal recovery process. This familiar sensation may not trigger the same level of distress or discomfort in dreams, thus leading to fewer representations of injury. In contrast, EMS provides an unfamiliar, external stimulation during sleep, which may be perceived as more intrusive or unnatural. This might result in a heightened perception of vulnerability or discomfort, manifesting as injury-related dream content. The unfamiliar nature of the EMS stimulus could provoke an anxiety response in dreams, potentially leading to more injury-themed narratives.

Given that both the muscle soreness and EMS groups were composed of sports students, similar to the amputee group who are also athletes, their high engagement with body awareness and movement likely minimizes the differences in body- and movement-related dream content. While temporary alterations like EMS and muscle soreness seem to evoke more immediate physical concerns (e.g., injury, leg movement), the amputation group demonstrates a more subtle engagement with the body.

Individuals who have experienced limb loss may have heightened body and movement-related dream content immediately following the amputation, as the body undergoes significant adjustment. Over time, however, as individuals acclimate to their new bodily state, the focus on movement and injury in dreams may diminish. This gradual return to a “normal” dream experience could signify psychological and physical adaptation to the new body configuration. As people become more comfortable and integrated with their altered body image, the intense focus on body perception and movement in dreams may taper off, reflecting their increased familiarity with their condition.

Variations in the credibility of the cover story about emotions in dreams may have impacted participants differently, potentially influencing their dream experiences. Additionally, the necessity of the cover story itself warrants reconsideration. The central research question—whether individuals dream of an amputated body or an intact body—focuses directly on body perception in dreams. Thus, it might have been more effective to be transparent with participants about the study’s aims. By informing them that the study was examining how their dream bodies manifest, we could have encouraged them to pay closer attention to their experienced dream body. Another point of attention is the fact that only the experimental group received the cover story. This distinction is essential as the cover story may have contributed to the finding of fewer dream characters reported by amputees. A potential explanation is that the cover story might have directed participants’ attention inward, prompting greater self-reflection on their emotions and their dream content. This increased self-focus could have reduced the salience of external dream elements, such as other characters, which may have contributed to this finding.

Transparency about the study’s aims in the amputation group might have provided clearer insights without compromising the study’s objectives, as participants’ neurological and psychological frameworks—such as the somatosensory representation of their bodies, previous experiences, and memories—would still predominantly determine their dream content. By being open with the participants, we could have potentially obtained more accurate and insightful data on how amputees perceive their bodies in dreams. Furthermore, the order of REM awakenings could have influenced dream content, as participants became familiar with detailed questions about dream content and body perception after the initial awakening. However, by using a cover story, we gained insight into the natural frequency of body perception in amputees’ dreams, enabling us to see whether amputees are prone to dream more about their bodies following such an impactful body alteration.

The study’s small sample size of 10 participants limits the generalizability of the findings. However, for our dream content analysis, we gathered data from three separate trials across different populations, lending substantial statistical power to our study. Nonetheless, further research with larger sample sizes remains essential. Future research into the dream experiences of amputees should involve a larger participant cohort and standardization of questions about body perception to enhance objectivity in evaluation. Also, to test the hypothesis that amputees, specifically recent amputees, have more body perception in dreams in comparison to non-amputees, a structured comparison should be made using a control group.

Despite these challenges, the data provided insights into how amputees’ somatosensory representation, memories, and past experiences shape their dream body perception. Moving forward, future research could benefit from refining methodologies to capture dream experiences more accurately among amputees, perhaps through longitudinal studies or employing advanced neuroimaging techniques. This would enable deeper investigation into the mechanisms underlying body representation in dreams and their implications for understanding brain plasticity and somatosensory processing in this unique population.

5. Conclusions

In conclusion, this study examined the content of dreams among amputees, with a particular focus on how they perceive their bodies within these dreams. The findings revealed a diverse array of experiences. Some participants made explicit references to their body perception related to amputation, while others referred to it more indirectly. Notably, while one dream referenced the intact body pre-amputation, the majority acknowledged the post-amputation body. Interestingly, most of the dreams involving amputation-related body perception occurred in individuals who had recently undergone amputation. This could suggest that the recent experience of bodily alteration may significantly influence dream content, as these individuals are likely still psychologically adjusting to their new body configuration. In contrast, individuals with older amputations appeared to have a lesser degree of amputation-related body perception in their dreams. This might indicate that over time, the psychological processing of body alteration may reduce dream body perception as the alteration becomes a more integrated and less salient aspect of their life. By comparing the dream content to other populations experiencing changes in body perception, we aimed to determine how different temporary physical experiences during waking life influence dream content, particularly in relation to body perception. Amputation represents a more long-term change in body perception, which results in distinct dream representations compared to the more temporary changes induced by muscle soreness and EMS. Overall, this study contributes to the growing body of literature on dream research and the bridge between the physical and dream body by looking at people who undergo significant body transformations, reflecting changes in cortical organization, memories, and body perception in dreams.

Conflicts of Interest

The authors declare no conflict of interest.

AI Statement

ChatGPT by OpenAI was used to improve the clarity and flow of the writing. All final edits and content were reviewed and approved by the author(s) to ensure accuracy and originality.

References

Alessandria, M., Vetrugno, R., Cortelli, P., & Montagna, P. (2011). Normal body scheme and absent phantom limb experience in amputees while dreaming. Consciousness and Cognition, 20(4), 1831–1834. https://doi.org/10.1016/j.concog.2011.06.013

Bekrater-Bodmann, R., Schredl, M., Diers, M., Reinhard, I., Foell, J., Trojan, J., Fuchs, X., & Flor, H. (2015). Post-Amputation Pain Is Associated with the Recall of an Impaired Body Representation in Dreams—Results from a Nation-Wide Survey on Limb Amputees. PLOS ONE, 10(3), e0119552. https://doi.org/10.1371/journal.pone.0119552

Borsook, D., Becerra, L., Fishman, S., Edwards, A., Jennings, C. L., Stojanovic, M., Papinicolas, L., Ramachandran, V. S., Gonzalez, R. G., & Breiter, H. (1998). Acute plasticity in the human somatosensory cortex following amputation. NeuroReport, 9(6), 1013.

Brugger, P. (2008). The phantom limb in dreams. Consciousness and Cognition, 17(4), 1272–1278. https://doi.org/10.1016/j.concog.2008.01.005

Brugger, P., Kollias, S. S., Müri, R. M., Crelier, G., Hepp-Reymond, M.-C., & Regard, M. (2000). Beyond re-membering: Phantom sensations of congenitally absent limbs. Proceedings of the National Academy of Sciences, 97(11), 6167–6172. https://doi.org/10.1073/pnas.100510697

Dresler, M., Koch, S. P., Wehrle, R., Spoormaker, V. I., Holsboer, F., Steiger, A., Sämann, P. G., Obrig, H., & Czisch, M. (2011). Dreamed Movement Elicits Activation in the Sensorimotor Cortex. Current Biology, 21(21), 1833–1837. https://doi.org/10.1016/j.cub.2011.09.029

Erlacher, D., & Schredl, M. (2004). Dreams reflecting waking sport activities: A comparison of sport and psychology students. International Journal of Sport Psychology, 35(4), 301–308.

Erlacher, D., & Schredl, M. (2008). Do REM (lucid) dreamed and executed actions share the same neural substrate? International Journal of Dream Research, 1(1). https://doi.org/10.11588/ijodr.2008.1.20

Flor, H., Elbert, T., Knecht, S., Wienbruch, C., Pantev, C., Birbaumers, N., Larbig, W., & Taub, E. (1995). Phantom-limb pain as a perceptual correlate of cortical reorganization following arm amputation. Nature, 375(6531), 482–484. https://doi.org/10.1038/375482a0

Fogassi, L., Ferrari, P. F., Gesierich, B., Rozzi, S., Chersi, F., & Rizzolatti, G. (2005). Parietal lobe: From action organization to intention understanding. Science (New York, N.Y.), 308(5722), 662–667. https://doi.org/10.1126/science.1106138

Giordano, A., Boffano, M., Piana, R., Mutani, R., & Cicolin, A. (2021). Body Schema Self-Awareness and Related Dream Content Modifications in Amputees Due to Cancer. Brain Sciences, 11(12), Article 12. https://doi.org/10.3390/brainsci11121625

Iber, C. (2007). The AASM Manual for the Scoring of Sleep and Associated Events: Rules. Terminology and Technical Specification. https://ci.nii.ac.jp/naid/10024500923/en/

Kikkert, S., Johansen-Berg, H., Tracey, I., & Makin, T. R. (2018). Reaffirming the link between chronic phantom limb pain and maintained missing hand representation. Cortex; a Journal Devoted to the Study of the Nervous System and Behavior, 106, 174–184. https://doi.org/10.1016/j.cortex.2018.05.013

Klem, G. H., Lüders, H. O., Jasper, H. H., & Elger, C. (1999). The ten-twenty electrode system of the International Federation. The International Federation of Clinical Neurophysiology. Electroencephalography and Clinical Neurophysiology. Supplement, 52, 3–6.

Kubersky, B. (2018, April 23). ScienceMode, Rehamove 3 Description and Protocol. https://hasomed.de/wp-content/uploads/2020/05/RehaMove3_ScienceMode_Description_and_Protocol_20180421.pdf

Levin, R., & Nielsen, T. A. (2007). Disturbed dreaming, posttraumatic stress disorder, and affect distress: A review and neurocognitive model. Psychological Bulletin, 133(3), 482–528. https://doi.org/10.1037/0033-2909.133.3.482

Makin, T. R., & Bensmaia, S. J. (2017). Stability of Sensory Topographies in Adult Cortex. Trends in Cognitive Sciences, 21(3), 195–204. https://doi.org/10.1016/j.tics.2017.01.002

Mulder, T., Hochstenbach, J., Dijkstra, P. U., & Geertzen, J. H. B. (2008). Born to adapt, but not in your dreams. Consciousness and Cognition, 17(4), 1266–1271. https://doi.org/10.1016/j.concog.2007.04.001

Noreika, V., Windt, J. M., Kern, M., Valli, K., Salonen, T., Parkkola, R., Revonsuo, A., Karim, A. A., Ball, T., & Lenggenhager, B. (2020). Modulating dream experience: Noninvasive brain stimulation over the sensorimotor cortex reduces dream movement. Scientific Reports, 10(1), 6735. https://doi.org/10.1038/s41598-020-63479-6

Peters, E., Golembiewski, S., Erlacher, D., & Dresler, M. (2023). Extending mental practice to sleep: Enhancing motor skills through lucid dreaming. Medical Hypotheses, 174, 111066. https://doi.org/10.1016/j.mehy.2023.111066

Ramachandran, V. S., & Altschuler, E. L. (2009). The use of visual feedback, in particular mirror visual feedback, in restoring brain function. Brain, 132(7), 1693–1710. https://doi.org/10.1093/brain/awp135

Revonsuo, A. (2000). The reinterpretation of dreams: An evolutionary hypothesis of the function of dreaming. Behavioral and Brain Sciences, 23(6), 877–901. Cambridge Core. https://doi.org/10.1017/S0140525X00004015

Rizzolatti, G., & Craighero, L. (2004). THE MIRROR-NEURON SYSTEM. Annual Review of Neuroscience, 27(1), 169–192. https://doi.org/10.1146/annurev.neuro.27.070203.144230

Rizzolatti, G., Fogassi, L., & Gallese, V. (2006). Mirrors In The Mind. Scientific American, 295(5), 54–61. https://doi.org/10.1038/scientificamerican1106-54

Schredl, M. (2000). Continuity between waking life and dreaming: Are all waking activities reflected equally often in dreams? Perceptual and Motor Skills, 90(3), 844–846.

Schredl, M. (2003a). Continuity between waking and dreaming: A proposal for a mathematical model. Sleep and Hypnosis, 5(1), 38–52.

Schredl, M. (2003b). The Problem of Dream Content Analysis Validity as Shown by a Bizarreness Scale.

Schredl, M. (2018). Researching Dreams: The Fundamentals. Springer International Publishing. https://doi.org/10.1007/978-3-319-95453-0

Solms, M. (1997). The neuropsychology of dreams: A clinico-anatomical study (pp. xviii, 292). Lawrence Erlbaum Associates Publishers.

Stankevicius, A., Wallwork, S. B., Summers, S. J., Hordacre, B., & Stanton, T. R. (2021). Prevalence and incidence of phantom limb pain, phantom limb sensations and telescoping in amputees: A systematic rapid review. European Journal of Pain (London, England), 25(1), 23–38. https://doi.org/10.1002/ejp.1657

Vetrugno, R., Arnulf, I., & Montagna, P. (2008). Disappearance of “phantom limb” and amputated arm usage during dreaming in REM sleep behaviour disorder. Journal of Neurology, Neurosurgery & Psychiatry, 79(4), 481–483. https://doi.org/10.1136/jnnp.2007.129783

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