Annals of Psychophysiology

Ann. psychophysiol.
ISSN 2412-3188 (Online) | 2410-1354 (Print)

Original Article

Changes in muscle tension patterns predicting the start of nocturnal leg cramps: A pilot study

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Citation: Chaney JL, Sherman RA. Changes in muscle tension patterns predicting the start of nocturnal leg cramps: A pilot study. APP. 2023; 10(1): 08-11

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DOI: 10.29052/2412-3188.v10.i1.2022.08-11

Received 16/03/2023

Accepted 26/05/2023

Published 01/06/2023

Funding: The Behavioral Medicine Research and Training Foundation (Port Angeles, Washington, USA) purchased the recording devices and computer and then loaned to the investigators to use in the study.

Conflicts of Interests: The authors have declared that no competing interests exist.

Abstract

Background: Although it is assumed that nocturnal leg cramps (NLC) are based on actual muscle cramps, no articles show that nocturnal leg cramps are preceded by changes in surface electromyograms (SEMG), which might indicate that a natural muscle cramp is occurring. This exploratory pilot study was designed to identify patterns of calf muscle activity before the onset of subjects' awakenings with pain associated with nocturnal leg cramps (NLC) to establish a precursor relationship between changes in muscle tension and the start of NLCs.

Methodology: Participants' relative calf muscle activity patterns during nighttime sleep were recorded for the entire night using a wireless ambulatory device on one night when subjects awakened with a leg cramp and one when there was no awakening. When the six issues awakened with pain from a leg cramp in the calf being recorded, relative muscle tension patterns were analyzed from 30 minutes before to 30 minutes after the awakening. These patterns were compared with 60-minute recordings on days when four subjects did not awaken with pain.

Results: All six participants were women between the ages of 23 and 56 (mean of 48 with SD of 13) who met the criteria for and had histories of nocturnal leg cramps for between 4 and 15 years (mean of 10 with SD = 4). All six had significant increases in patterns of relative muscle tension not associated with patterns of movement for an average of 41 seconds (SD 11) before awakening with pain (mean increase of 217%, SD 157, rang 100% - 500% with spikes having a mean of 250% above baseline, mean 251, range 200 – 800%). Relative muscle tension remained nearly twice the original baseline for about 50 seconds after a painful awakening and did not return to pre-occurrence levels for up to 20 minutes.

Conclusion: As Muscle tension changed before subjects were awakened by pain, the change in tension is not a reaction to the pain. The signal did not contain movement artifacts, so the change reflects a precursor to the pain, and nocturnal leg cramps are likely caused by muscle tension. Further research using a calibrated device to record microvolts objectively is in progress to confirm these initial findings.

Keywords

Nocturnal Leg Cramps, NLC, SEMG, Muscle Tension, Cramps, Leg Pain.

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Introduction

An estimated 50%–60% of adult patients presenting to primary care frequently report nocturnal leg cramps[1]. Nocturnal leg cramps (NLCs) affect the lower limbs, typically impacting the calf, hamstring, or foot muscles at night[2,3] and often interrupt sleep[1]. The etiology of leg cramps is unclear[1,4]. While some cases are associated with myopathic, neurologic, and metabolic causes, most cases are idiopathic with no known cause[1].

While the description of nocturnal leg cramps always includes sudden, abrupt leg pain occurring during nighttime sleep[1,5], none of the literature shows that an actual muscle cramp is taking place[6]. No treatments of idiopathic nocturnal leg cramps are successful[1,7]. Quinine is the most studied pharmacological intervention but is unsafe due to dangerous risk factors[3].

Methodology

This pilot study measured raw surface electromyograms (SEMG) during nighttime sleep from one calf of six subjects experiencing NLCs. The project was approved by Saybrook University's Institutional Review Board (Pasadena, California, USA), and all subjects signed an explanatory consent form before participating in the study. Subjects were recruited by word of mouth from people living near the first author. The study gathered data for up to 3 consecutive nights to capture a night in which participants reported a painful awakening and a night to obtain baseline tension in which participants did not report a painful awakening. The recordings captured muscle activity 30 minutes prior to and up to 30 minutes after the subject reported a painful awakening. All six participants were Black women living in the United States of America between the ages of 23 and 56 (mean of 48 with SD of 13) who met the criteria for[5,6] and had histories of nocturnal leg cramps for between 4 and 15 years (mean of 10 with SD = 4) occurring at least 3 times per month. The criteria excluded individuals receiving pharmaceutical treatment for cramps or those diagnosed with restless leg syndrome (RLS), a different problem than NLCs[5].

Participants' patterns of relative calf muscle activity during nighttime sleep were recorded using a wireless ambulatory Cricket device (Somaxis, INC., California, USA) which had the advantage of not having wires running from sensors on the calf to a recording device. The investigators feared wires would interfere with the subjects' normal movements. The device was not calibrated sufficiently, so only the percent change in the signal could be used when subjects' recordings were compared. The device's motion sensor was not sensitive enough to detect movement artifacts indicative of a spam starting so changes in the raw signal typical of movements[8] were used to estimate when movement artifacts were recorded. When subjects awakened with pain from a leg cramp in the calf being recorded, relative muscle tension patterns were analyzed from 30 minutes before to 30 minutes after the awakening. These patterns were compared with 60-minute recordings on days when four subjects did not awaken with pain.

Result

For the four subjects recorded on nights without leg cramps, the 60-minute segments showed typical, movement artifact-free baseline instabilities8 ranging from 15 to 100% with few spikes in the recording (Table 1). During the night when the subjects were awakened by pain in their calves, all six showed similarly stable, 30-minute, pre-awakening baselines free of movement artifacts with few spikes. In the average of 41

ISSN 2412-3188 (Online) | 2410-1354 (Print)

seconds (SD = 11, range of 25 – 50 seconds) just before awakening with pain, all six had large increases in patterns of relative muscle tension not associated with patterns of movement (mean increase of 217%, SD 157, range 100% - 500% with spikes having a mean of 250% above baseline, mean 251, range 200 – 800%). Relative muscle tension remained nearly twice the original baseline for about 50 seconds after a painful awakening and did not return to pre-occurrence levels for up to 20 minutes. See Table 1 for details of the individual results.

Table 1: Summary of Recordings

Subject #	NIGHT WITHOUT NLC: 1-hour recordings on the night without awakening with pain		NIGHT WITH Nocturnal Leg Cramps (NLC): 1-hour recordings on the night when awakened with nocturnal leg pain (30 minutes before and after the awakening)					
	Stability of raw EMG for 1 hour	Spikes of one second or less in baseline	Stability of raw EMG for 25 minutes before pre-awakening increase	Spikes of one second or less in baseline	Percent increase from pre-awakening baseline to just before wakening	Stability of raw EMG just before awakening	# Seconds between start of change in baseline and awakening report	# Seconds to return to baseline
1	Poor recording		Stable within 10%	2 spikes 20 % above BL	150% increase above BL	Unstable with 3 spikes 200% above baseline	50	60
2	Slightly unstable within 15%	5 spikes 100 % above BL	Stable within 5%	2 spikes 20% above BL	500% increase above BL	Very unstable with 2 spikes 500% above BL and 1 spike 100% above BL	40	70
3	Slightly unstable within 10%	7 spikes 100% above BL	Stable within 10%	No spikes	300% increase above BL	Very unstable with 2 spikes 800% above BL	30	Did not return to BL
4	Unstable BL with changes within 50%	5 spikes within 100% above BL	Slightly unstable with changes within 20%	5 spikes within 50% of BL	100% increase above BL	Very unstable with 3 spikes 200% above BL	50	50
5	Highly unstable with changes of 100%	Frequent spikes 150% above BL	Stable within 10%	No spikes	150% increase above BL	Very unstable with 2 spikes 200% above BL	25	20
6	Poor recording		Stable within 5%	No spikes	100% increase above BL	Unstable with 3 spikes 200% above BL	50	Did not return to BL

Discussion

Even given the device limitations, the data demonstrated increased muscle tension significantly above baseline for all six subjects who reported awakening with painful cramping.

Although it is assumed that the pain from nocturnal leg "cramps" (NLC) are a result of muscle activity preceded by changes in surface electromyograms (SEMG) as is found for typical cramps[8], the authors were unsuccessful in finding any studies demonstrating this predictive relationship. Theories about complex underlying mechanisms abound, but facts are few and far between. The lack of published studies is very odd as NLCs are one of the most common pain syndromes, and muscle tension recordings from major muscles have been made by rehabilitation physicians evaluating pain syndromes since the late 1940s[9]. The lack of such published studies indicates that there must have been attempts to perform them but that the results were never published or are buried in older books. This study is the first to indicate that such a predictive relationship.

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A seventh subject who had leg pain due to tumors in her feet was recorded. She showed no significant changes in muscle tension during the night's recording.

Conclusion

As Muscle tension changed before subjects were awakened by pain, the change in tension is not a reaction to the pain. The signal did not contain movement artifacts, so the change reflects a precursor to the pain, and nocturnal leg cramps are likely caused by muscle tension. Further research using a calibrated device to objectively record microvolts is in progress to confirm these initial findings.

Acknowledgment

Drs. Jerry R Devore and Sam Kohlenberg assisted with different aspects of the methodology.

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