Climate change and climatic variation impact on chronic oedemas: a systematic review

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Key words

Chronic oedema, climatic variation impact, climate change, international perspectives, literature review, lymphoedema, symptom variation and linkage, systematic review

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Abstract

Background: Chronic oedema is a significant problem worldwide and results in substantial burden to the health services, as well as major impact on individuals' quality of life. It is primarily managed through ongoing use of compression garments, bandaging and manual lymphatic drainage. Higher temperatures and increased humidity result in additional discomfort through physiological changes related to oedema and increased difficulty with compression garment use. This may result in reduced compliance with core treatment recommendations, increased swelling and poorly managed symptoms. Rising temperature due to climate change is well documented with scientists predicting a 1.5–2.5% increase in average temperature across the globe by 2050. It is anticipated this will present significant challenges for the ongoing management of chronic oedema and an increased risk of infection. **Aims of study:** The objective of this study was to systematically review the literature for evidence of the impact of climatic conditions on chronic oedema. **Methods:** The PRISMA protocol was followed; a search of MEDLINE (via Ovid), Scopus, CINAHL, Informit Health Database Collection, Cochrane reviews, Web of Science, Emcare (via Ovid), Green File and Google Scholar was conducted using the search terms climat* OR weather OR tropic* AND chronic oedema OR lymphoedema OR edema. Studies were included that examined the general population (adult and/or children) who have chronic limb oedema as a result of primary or secondary lymphoedema, lipoedema, elephantiasis, vascular insufficiency or trauma or any other condition resulting in chronic oedema. Literature that were not a primary study and studies published before 2000 were excluded. **Results:** A total of 3,536 studies were identified and screened. Five articles met the inclusion criteria. Articles fell into three broad categories of compression garment difficulties, physiological changes and seasonal filarial attacks. Despite the broad search terms relating to chronic oedema, all included articles related to lymphoedema. Populations included breast cancer-related lymphoedema (*n*= 3), lymphatic filariasis lymhoedema (*n*=1) and lower-limb lymphoedema (*n*=1). Research was conducted in temperate climate (Sydney, Australia and Japan), tropical climate (Townsville, Australia, and Ghana) and continental climate (Alberta, Canada). **Conclusions:** Studies showed a clear connection with warmer temperatures and symptoms of lymphoedema, however, there were very few studies in this area and none relating to other types of chronic oedema. While qualitative indications showed a clear correlation with warmer weather, their physiological measures did not clearly reflect the same. There is a distinct lack of both quantitative and qualitative evidence. Further research in this area is strongly recommended.

Chronic oedema is a broad term used to describe oedema which has been present for more than 3 months (National Lymphoedema Partnership, 2015). It is a significant problem worldwide and results in substantial burden on the health system. In the UK alone, it is estimated that six in every 1,000 people (National Lymphoedema Partnership, 2019) and up to 28.75 per 1,000 people aged 85 or older (Moffatt et al, 2017) have chronic oedema. Todd (2013) suggests that the prevalence is likely to be significantly higher than this as people do not always seek assistance for swollen limbs.

Chronic oedema results from an imbalance between capillary drainage and lymphatic filtration and is commonly seen with conditions, such as venous insufficiency, trauma, or radiation therapy (Peterson et al, 2017). Additional risk factors resulting in chronic oedema include skin impairments, infection, fluid leakage, ulceration, deep vein thrombosis, obesity, chronic heart failure and severe immobility (Lymphoedema Framework, 2006; Keeley, 2018). With many of these conditions impacting the function of the lymphatic system, the terms chronic oedema and lymphoedema are sometimes used interchangeably (National Lymphoedema Partnership, 2015; Piller et al, 2017; Keeley, 2018). True lymphoedema is the result of a damaged or malformed lymphatic system and is a type of chronic oedema.

There are substantial financial costs associated with management of chronic oedema. Community based management involves skin care, external pressure (bandaging or garments), exercise, and massage/manual lymphatic drainage. In addition, acute infections requiring hospital admission occur frequently. Furthermore, it has a major impact on quality of life with one study reporting 80% of patients taking time off work as a direct result of their oedema as well as experiencing emotional distress due to negative impact on social and physical function (Moffatt et al, 2003).

Chronic oedema is primarily managed through ongoing use of compression garments, bandaging and manual lymphatic drainage; however higher temperatures and increased humidity result in additional discomfort and lead to reduced compliance with these treatment recommendations (Al Onazi et al, 2020; Dai et al, 2020). This is likely to result in increased swelling and poorly controlled symptoms, increasing the risk of disease progression (Piller, 2015). Likewise, analysis of cellulitis, a common complication of chronic oedema, shows a marked increase of hospital admissions in summer months compared to the cooler winter months (Peterson et al, 2017; Hsu et al, 2019; Manning et al, 2019). Similarly, a study of the effect of seasonal variations in climate and upper-limb measures in a healthy population produced statistically significant increases in arm size in spring compared to summer and winter (Matthews et al, 2021). It was suggested that the varying temperatures and humidity levels were responsible for this finding. Understanding the impact of climatic variations on the chronic oedema population is critical to ensuring best management techniques and effectiveness of interventions.

The environment has been directly linked with prevalence of podoconiosis and lymphatic filariasis. Podoconiosis is a condition whereby exposure over time to red clay soils in specific volcanic regions results in lower-limb lymphoedema (Chandler et al, 2020; Deribe et al, 2020; Gislam et al, 2020). It is typically seen in highland regions of Africa, Central America and India and is linked to walking barefoot and having poor foot hygiene (Korevaar and Visser, 2012). The specific soil type means this condition is directly related to the environment.

Lymphatic filariasis is a parasitic infection spread by mosquitos infected with worm larvae (Lourens and Ferrell, 2019). The worm larvae cause blockages in lymphatic vessels and can result in lymphoedema. Environmental factors including temperature, humidity, water parameters, aquatic plants, and land utilization influence mosquito populations and subsequent prevalence rates (Pratiwi et al, 2018). The influence of climate on the prevalence of podoconiosis and lymphatic filariases has been widely published. However, the impact of climate on presentation of chronic oedema-related to these diseases has received very little attention.

Scientists predict a 1.5–2.5% increase in average temperatures across the globe by 2050 (U.S. Global Change Research Program, 2017). This climate change presents a challenge for human health and wellbeing, particularly in areas of already warm to hot climates. Increased temperatures contribute to more heart attacks, strokes, accidents, and heat exhaustion as well as increased human stress and reduced work capacity (Costello et al, 2009; Hughes and McMichael, 2011; McMichael et al, 2012; Kjellstrom et al, 2017). Understanding the resultant physiological changes and the impact on chronic oedema will enable proactive planning of treatment and risk management strategies to improve health outcomes.

This study systematically reviewed the literature for evidence about the impact of climatic variations on chronic oedema. The outcomes provide direction for further research to understand and mitigate environmental and climatic influences on chronic oedema.

Methods

This review used the working definition of chronic oedema as described by the National Lymphoedema Partnership (2015) on the International Lymphoedema Framework "chronic oedema is a term used to describe a group of conditions characterised by the presence of swelling within tissues of the body, caused by the accumulation of excess fluid within the interstitial space of the affected area".

Protocol and registration

The systematic review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO), registration ID: 163160 and published on July 5, 2020.

Eligibility criteria

Studies were included that examined the general population (adult and/or children) who have chronic limb oedema as a result of primary or secondary lymphoedema, lipoedema, elephantiasis, vascular insufficiency or trauma-related oedema. Studies were included if the study discussed how clinical presentation of the disease was influenced by climatic variations. Both qualitative and quantitative studies were included with no study design or language limits imposed on the search. Articles in languages other than English were included if they could be easily translated using Google Translate.

Exclusion criteria included articles that were not primary studies and studies published before 2000. The timeframe limit was deemed important to ensure current, relevant articles were included, as well as more accurate prevalence data.

Information sources

Literature search strategies were developed using medical subject headings (MeSH) and text words related to chronic oedema and climate. The following databases were searched: MEDLINE (via Ovid), Scopus, CINAHL, Informit Health Database Collection, Cochrane reviews, Web of Science, Emcare (via Ovid) and Green File. The electronic database search was supplemented by searching for research through other sources including Google Scholar and the author's personal file collections.

Additionally, PROSPERO was searched for relevant ongoing or recently completed systematic reviews. To ensure literature saturation, reference lists of included studies or relevant reviews identified through the search were scanned. The original search was completed on June 12, 2020. It was repeated on January 31, 2021 to ensure all recent relevant data was included.

Search

The search strategy was developed in MEDLINE and adapted to the syntax and subject headings of the other databases. The search strategy for MEDLINE (Ovid interface) and Epub is shown in *Table 1*.

Table 1. MEDLINE (Ovid) search strategy.

1	(climate change or microclimate or climatic or climate or season* or subtropic* or desert or cold weather or cold climate or monsoon or humid or humidity or weather or season* or wet season).mp.
2	((dry or hot or heat or tropic* or environment or geograph*) adj3 (climate or temperat*)).mp.
3	exp Climate/ or exp Climate Change/ or Meteorological Concepts/
4	1 or 2 or 3
5	(lymphedema or lymphoedema or chronic oedema or chronic edema or podoconiosis or elephantiasis or lymphatic or filariasis or cellulitis or lipoedema or lipedema or lipohyperdystrophy or endocrine dysfunction or vascular insufficiency).mp.
6	lymphedema/ or breast cancer lymphedema/ or elephantiasis/ or elephantiasis, filarial/ or non-filarial lymphedema/
7	edema/ or edema, cardiac/
8	Cellulitis/
9	Lipedema/
10	or/5–9
11	4 and 10
12	(mice or rats or monkey or resus).mp.
13	11 not 12

Study selection

All initial literature search results were uploaded to Covidence (*https://www.covidence.org/home*), an internet-based software program that facilitates collaboration among reviewers during the study selection process. Eligibility was completed independently by two reviewers (SW and BW). Initially, title and abstract screening was completed and where agreement between assessors occurred, full text articles were read applying the inclusion and exclusion criteria above. Data extraction and critical appraisal for each included study was completed. At each step of screening, full text reading, data extraction and critical appraisal, disagreements were discussed between SW and BW. When consensus could not be agreed in discussion, a third reviewer (NP) was involved. Reasons for excluding studies were recorded.

Data extraction process

A data extraction form was developed in Covidence, piloted on random included studies and refined accordingly. Two review authors (SW and BW) then independently extracted data. When a study reported data on multiple clinical conditions, data were extracted for chronic oedema only.

Data items

Information extracted from each article included:

- General information (title, abstract, year of publication, country in which the study was conducted, other notes i.e. funding source)
- Characteristics of the study (aim of study, study design, dates of data collection, population description, clinical diagnoses, comorbidities, side effects during study, inclusion/exclusion criteria, method of recruitment, total number of participants, reasons for dropping out of study)
- Outcomes (prevalence of disease, geographical location, notes on climatic conditions, impact of climate on presentation, quality of life)
- Limitations (limitations and recommendations from the study, potential conflict of interest for authors).

Risk of bias in individual studies

Assessment of bias for each study used the Crowe Critical Appraisal Tool (CCAT) (Crowe and Sheppard, 2011). This was recreated in Covidence. CCAT covers the preliminaries, introduction, design, sampling, data collection, ethical matters, results and discussion. A judgement as to the possible risk of bias on each of the domains was made and scored from 1–5. Scores were then added for a total overall score with the higher score reflecting higher degree of quality of the study. For each domain in the tool, the authors commented on the procedures undertaken for each study. If there was insufficient detail reported in the study, the risk of bias was deemed to be "unclear". Judgements were made independently by SW and BW.

Where total scores differed by more than six points discussion was held between the two reviewers to resolve the disagreements. Study quality was taken into consideration when analysing results using the NHMRC level of evidence rating (NHMRC, 2009). Poor quality is defined as a NHMRC level of evidence rating of IV or below (NHMRC, 2009) or a final CCAT quality assessment score of 50% or less (Crowe and Sheppard, 2011).

Summary measures

The clinical outcomes considered were diagnoses, prevalence, disease progression, changes in limb measurements including volume, size and extracellular fluid, subjective changes such as feeling heavy or swollen, compliance with treatment and management recommendations, and quality of life. Climatic connections considered were adverse weather events, seasonal variations, climate related to geographical location, topical conditions, such as temperature, humidity, rainfall, perceived temperature and adaptive comfort.

Synthesis of results

Articles in the final list were imported into NVIVO, which is a qualitative data analysis software. Narrative synthesis was chosen to analyse the data due to the mixed methods of the included studies, the variability in diagnoses considered and the broad research questions (Popay et al., 2006). The CCAT quality score and NHMRC level of evidence rating were incorporated into the analysis along with the target population, method of assessment, number of participants, links with climate and limitations. Preliminary synthesis included textual description and tabulation. Exploration of relationships between moderating variables was executed in Excel and NVIVO and presented descriptively. Quantitative data were analysed using Excel spreadsheets and comparative tabulation.

Risk of bias across studies

We assessed for the possibility of publication bias by considering recruitment methods for participants, ethical approval, and any sources of funding. We also considered participant numbers to support generalisability of results.

Results

Study selection

The database search (*n*=3,301) and a search of author's personal records (*n*=235) identified a total of 3,536 articles (*Figure 1*). After duplicates were removed, 2,489 titles and abstracts were screened against the inclusion criteria and full text screening was carried out on 195 articles. A total of 190 articles were excluded for the following reasons: no connection between chronic oedema and the environment (*n*=48); not a primary study/research (*n*=39); published before 2000 (*n*=30); the study was about mosquitoes or other animals (*n*=23); no connection with chronic oedema (*n*=20); the study looked only at prevalence and not how disease was influenced by the environment (*n*=17); not in English and unable to easily translate (*n*=9); or duplicate article (*n*=4). The remaining five studies met the inclusion criteria were included in the review.

Study characteristics

The included studies relate to three categories of primary diagnoses, being breast cancer related lymphoedema (*n*=3), lymphatic filariasis related lymphoedema (*n*=1) and lower-limb secondary lymphoedema (*n*= 1).

Methods of investigation varied between studies. Four studies utilised a survey or questionnaire as part of their assessment, one study used focus groups and two used repeated physiological assessments. Two studies explored compliance with wearing compression garments (Al Onazi et al, 2020; Dai et al, 2020), two investigated changes in limb size and volume as a result of the weather (Phillips, 2011; Czerniec et al, 2016), and one study investigated the extent to which seasonal variation influenced filarial attacks (Kwarteng et al, 2019).

Numbers of participants ranged from 25 (Phillips, 2011) to 170 (Dai et al, 2020), with a total of 437 included participants. All studies considered how the climate impacted presentation of the disease. For Phillips (2011), Czerniec et al (2016) and Kwarteng et al (2019), this was the primary focus of their study. The two remaining studies considered climate related impacts as secondary outcomes (Al Onazi et al, 2020; Dai et al, 2020). A summary of results is presented in *Table 2*.

Synthesis of results

Compliance wearing compression garments

Dai et al (2020) and Al Onazi et al. (2020) explored compliance with recommendations relating to use of compression garments. Although Al Onazi et al (2020) was based in Canada and focused on upper-limb lymphoedema and Dai et al (2020), based in Japan, looked at lower-limb lymphoedema, they had similar findings. Both studies reported a high rates of difficulty wearing compression garments during the summer: 77% of 170 respondents (Dai et al, 2020); and 48% of 48 participants (Al Onazi et al, 2020).

Al Onazi et al (2020) was interested in understanding why participants did not comply with compression garment recommendations. Their study built on outcomes of a previous study (McNeely et al, 2016) where it was noted that many patients did not wear their compression

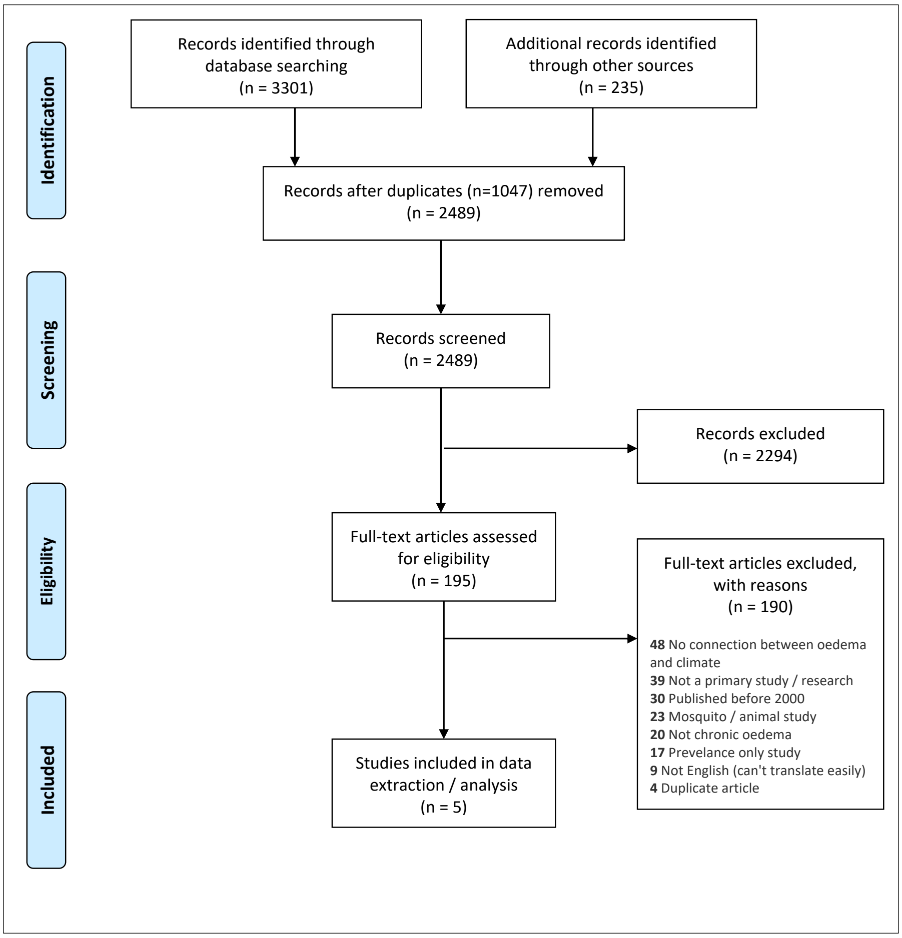

Figure 1. PRISMA flow diagram. Adapted from Moher et al (2009).

garments throughout the day. This follow-up study explored the barriers and facilitators to use of daytime compression. Participants were women with breast cancer-related lymphoedema who had participated in the study by McNeely et al (2016). They first completed surveys with participants, with results from the surveys assisting to form probing questions for the subsequent focus groups. Their key results, summarised in *Table 3*, showed that the main reasons for not continuously wearing their prescribed compression garments were: weather (wearing their sleeve less during summer season due to discomfort related to heat and humidity); social settings (not wearing the compression sleeve when attending specific social settings or hiding the sleeve when in public settings due to unwanted attention or questions); and interference with function (the sleeve interfered with their work or daily routine).

While Al Onazi et al (2020) explored all reasons for non-compliance regarding compression garments, Dai et al (2020) was specifically interested in the awareness and attitude regarding compression garment use during summer. Questionnaires were sent to patients randomly selected from the database of a single stocking sales company. Inclusion criteria were women with lower limb lymphoedema.

Of the 170 women who responded to the survey, 130 (76.5%) reported problems wearing compression garments during summer. As shown in *Table 3*, patients also reported issues with clothing comfort, skin issues and fashion. It is noted that the questionnaire specifically asked about these issues and there was no opportunity for any additional responses from participants. It is, therefore, difficult to know if there were additional reasons why participants experienced difficulty in summer.

Both studies reported the impact of heat on fashion as a significant issue. Participants indicated in cooler months they are happy to wear their garment, however, in warmer months when less clothing is worn, they are more self-conscious wearing a sleeve. In winter people can cover their garment under long-sleeved clothing, whereas in summer their limbs are more exposed.

Physiological changes

Czerniec et al (2016) and Phillips (2011) both focused on physiological measures of lymphoedema. These studies

Table 2. Summary of results.

Study	Aim	Population	Method	Climate links	Limitations	NHMRC	CCAT Score
Al Onazi et al, 2020 Canada	The objective of this study was to explore the barriers and facilitators to use of daytime compression among women with breast cancer related lymphedema	Women with breast cancer related lymphoedema, mean age = 65. 23 participants in focus groups 48 questionnaires	Focus groups. Questionnaires	Twenty-three participants (48%) reported that their ability to wear the sleeve was affected by weather, with 21 (44%) reporting wearing their sleeve less during summer season due to discomfort related to heat and humidity	The study involved a convenience sample of women who previously took part in the LYNC trial. Thus, participants in this research may have been more motivated and better informed due to their prior involvement in a randomized controlled trial and may not be a representative sample of women with BCRL	III-3	95%
Czerniec, 2016 Australia	The primary aim of this study was to determine the extent to which extracellular fluid, arm volume, and self-reported s welling fluctuated in women diagnosed with BCRL lymphedema compared to women without BCRL. Secondary aims were to determine if aspects of the weather, namely heat, humidity, and barometric pressure, influenced BCRL	Women with breast cancer related lymphedema, mean age 62.5 years 26 participants	Self-reported arm swelling Measures of arm volume, and extracellular fluid with bioimpedance Measured on 9 occasions over 6 months	Neither humidity nor barometric pressure affected lymphedema Temperature had a low correlation with extra-cellular fluid, and self-reported swelling Temperature was the only aspect of the weather found to have an, albeit low, impact on lymphedema	Small sample size. Not all women completed all nine measurement sessions Measures of extracellular fluid and arm volume commenced at the wrist. Fluctuations distally in the hand would have been undetected Participant weight was not recorded at each measurement session. Weight lost or gained over the course of this study may have impacted arm measures Sydney, Australia has a temperate climate. The results of this study may therefore not be applicable to women living in climates that have greater range and extremes of temperature	III-2	85%

Table 2. Summary of results (Conitnued).

Study	Aim	Population	Method	Climate links	Limitations	NHMRC	CCAT Score
Dai, 2020 Japan	To clarify the awareness and the attitude of patients with leg lymphoedema with respect to their use of compression stockings	Patients with ISL stage II leg lymphoedema. 170 participants.	Survey	76.5% experienced problems while wearing compression stockings during summer. Clothing comfort issues, such as the sensation of heat and perspiration; skin issues, such as itchiness, redness, and inflammation; and fashion concerns	Survey recipients were randomly selected from a database from one stocking sales company, therefore there is a possibility that patient characteristics were biased	III-3	80%
Kwarteng, 2019 Ghana	To determine the seasonal variation of acute filarial attacks in some selected Lymphatic Filariasis (wucheria bancrofti) endemic communities in Ghana	Lymphedema patients with lymphatic filariasis. 142 participants	Structured questionnaires	97 (68.3%) of the study participants experience attacks during the wet season and 36 (25.4%) reported the incidence of filarial attacks during both seasons (wet and dry) Compelling evidence that incidence of filarial attack associates strongly with rainy season compared to dry season	None stated	III-3	85%
Phillips, 2011 Australia	To investigate the relationship between seasonal variation in climate and upper limb size, volume, fluid distribution and diagnosis	Women with breast cancer related lymphoedema aged 39 – 82 years Median age = 57 25 participants	Survey	No relationship was identified between seasonal variation in climate and upper limb size, volume or fluid distribution in women following BC treatment Participants reported feeling heaviness in their arm or hand in spring (56%) compared to summer or winter (48% on both occasions) Participants reported more swelling in their arm or hand in spring and summer (48% and 52% respectively) compared to winter (28%)	Small sample size limits statistically significant results Unable to control confounding factors prior to measurements	III-2	90%

Table 3. Participants reporting problems wearing compression garments during summer.

	Al Onazi et al (2020)	Dai et al (2020)
Clothing discomfort		
Heat	44%	70%
Perspiration	-	54%
Social settings		
Fashion concerns	50%	38%
Unwanted attention	27%	-
Skin problems		
Inflammation	-	14%
Itch	-	38%
Redness	-	23%
Work/daily routine	29%	-

considered included participants with or at risk of developing secondary upper-limb lymphoedema post breast cancer. Both completed repeated measures with participants over a fixed period of time, however, with varying methodology and outcomes. Phillips (2011), who was based in Townsville, took measurements three times over the year at key seasonal changes — November (spring), February (summer) and June (winter). Czerniec et al (2016) on the other hand, based in Sydney, implemented a rolling recruitment over a 3-year period. All women were measured over a 6-month period according to the following schedule: once per week for 4 weeks and then once per month for a further 5 months, for a total of nine measures over a 6-month period. They also included a control group of women without lymphoedema.

Before completing any physical measurements, Czerniec et al (2016) asked patients to report their perceived level of arm swelling using a visual analogue scale and complete a short survey. They then completed physical measures including arm volume and extra-cellular fluid (ECF). Daily weather data on the day of measurement as well as the two days prior was recorded and used in data analysis. Overall, they found little variation in measures over a 6-month period, except for self-report which fluctuated markedly. There was no correlation between lymphoedema and humidity nor barometric pressure. The only aspect of the weather that was found to have an, albeit low, impact on lymphedema was temperature. There was a low correlation with ECF and self-reported swelling, and little correlation with arm volume. No aspect of the weather was found to have any effect on the ECF, arm volume or self-reported swelling of women without lymphoedema.

Phillips (2011) also asked participants to complete a survey prior to taking physical measurements, as well as report their perceived level of swelling over the previous 3 months. Additionally, she measured overall body size to ensure any changes in physical measures were a result of lymphoedema and not weight gain. Physical measures included limb size, limb volume and ECF (fluid distribution). Overall, she found no relationship between seasonal variation in climate and upper-limb size, volume or fluid distribution. A non-significant trend was reported for both participants with lymphoedema and those at risk of developing lymphoedema to have larger measures in spring, suggesting that there is a natural tendency to retain extra fluid when temperatures begin to rise.

It is worth noting that participants in both studies reported feeling heaviness in their arm or hand more often in spring and summer, despite the physiological measures not reflecting statistically significant changes.

Seasonal impact on lymphatic filariasis induced lymphoedema

Kwarteng et al (2019) assessed the occurrence of filarial attacks in a population diagnosed with lymphoedema due to lymphatic filariasis. They acknowledged that filarial attacks are believed to be caused by several factors including the release of an endosymbiont, release of antigens after death of adult worms, bacterial and fungal infections in already compromised lymphatic vessels and infective bites from mosquitos (Kwarteng et al, 2019). While it is well documented that mosquito vector density increases during rainfall, the extent to which the increased numbers of mosquitos correlate with acute filarial attacks was unknown and formed the basis for this study.

A total of 142 patients with leg lymphoedema completed structured questionnaires regarding the incidence and frequency of filarial attacks over the previous year. Results showed that 94% of participants experienced filarial attacks during the previous year. Sixty-eight percent reported having filarial attacks during the wet season with 25% reporting attacks during both wet and dry seasons. While the reasons for the high number of overall acute filarial attacks was not clear, there was a definite association between season of attacks and frequency of attacks.

Risk of bias across studies

There is potential bias from Dai et al (2020) whose participants were recruited from existing clients of a stocking company. Additionally, they gathered information from a questionnaire with set questions relating to the impact of the weather, which may have influenced results by excluding other potential aspects that were unreported. Phillips (2011), Czerniec et al (2016) and Al Onazi et al (2020) all worked with participants on repeated occasions. The frequent contact and access to lymphoedema measures may have resulted in improved self-efficacy for participants to comply with treatment recommendations and therefore display lower fluctuations in results. Kwarteng relied on patient self-report of symptoms and time of year.

All studies appear to be independent, with no researcher receiving specific funding to complete the study. All studies indicated appropriate relevant ethical approval. Small numbers of participants for Phillips (2011), Czerniec et al (2016) and Al Onazi et al (2020) limit generalisability of data.

Discussion

Summary of evidence

This systematic review found very few studies considering the impact of climate on chronic oedema. With just two studies considering the impact of climate on compression garment use, two studies looking at the subjective experience and physiological impact of climate and one study assessing the seasonal influence of filarial attacks, the overall evidence is not sufficiently robust to determine the comparative effect of climatic variations. Future research should consider larger participant recruitment to provide greater statistical significance of results, as well as a broader geographical selection leading to higher generalisability.

The evidence regarding the physiological impact of lymphoedema is inconclusive with results varying across studies. Future research, utilising similar methodology and outcome measures, will build on the foundation that has been laid and provide greater clarity and direction for better patient outcomes.

The evidence available suggests that there is a definite influence on the qualitative experience for people with chronic oedema including feelings of increased swelling and heaviness as well as difficulties wearing compression garments. Interestingly, this did not clearly correlate with the physiological measurements. It is a clear indication that future studies need to have a mixed methods approach and include both qualitative and quantitative data to fully understand the patient experience.

Strengths and limitations

This appears to be the first systematic review and synthesis to explore the evidence around the impact of the climate on symptoms of chronic oedema. Because of the limited number of studies in this area, the scope was kept very broad with the specific inclusion and exclusion criteria further refined as the review processed. While this approach ensured inclusion of all aspects of research linking chronic oedema with climate, it also resulted in mixed studies, using mixed methodologies and with varying target audience.

Two studies considered compression garments, however, one looked at women with lower-limb lymphoedema while the other looked at women with upper-limb lymphoedema. Two studies considered physiological impacts of the weather however they were both unable to counter all confounding factors, and utilised varying methods of measurement, making results not directly comparable.

Studies were generally of a high quality, perhaps reflecting the use of qualitative reporting guidelines. Notwithstanding the use of the CCAT and NHMRC level of evidence, quality appraisal retains a degree of subjectivity, and although all articles were independently critically appraised and scored by SW and BW, it is possible that other researchers may have appraised the quality of the studies in a different way.

Conclusions

Chronic limb oedema is recognised as a major clinical problem worldwide and is predicted to further increase in the coming years (Guest et al, 2015; Moffatt et al, 2019; Wound Care People, 2019). When addressed early and managed well, its impact can be minimised. Climate change has been shown to have several direct and indirect influences on human health. In particular, we are seeing an increase in adverse weather events and an increase in average temperatures (Hughes and McMichael, 2011). With climate and health being intrinsically linked (McMichael et al, 2008) it is not possible to consider the issue of chronic limb oedema management without also considering the influence of the climate.

Despite significantly different climatic conditions across the globe, a single recommended treatment strategy prevails. Understanding the impact of climatic changes on chronic oedema will enable review of treatment approaches to potentially eliminate old and never proven concepts from the field. This will challenge the current management techniques currently being used globally, including use of compression garments, bandaging and manual lymphatic drainage.

Results from this systematic review confirm that compliance with current treatment recommendations is challenging in warm to hot temperatures, however, the extent of the impact on people with chronic limb oedema remains inconclusive. Increased knowledge relating to the impact of climatic variations is critical to ensuring best management techniques and effectiveness of interventions. It is therefore, imperative to better understand how chronic oedema is managed in these conditions and for evidence-based recommendations to enable relevant and high-quality health management. Further research in this area is vital.

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