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Review Article

# Trends in deqi research: a text mining and network analysis

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ABSTRACT

*Background:* Deqi is a term describing a special state of the human body, which is ready to cure itself through acupuncture stimulation and is believed to be a key factor in acupuncture treatment. However, knowledge about deqi remains subjective. Therefore, in this study, we aimed to determine the factors related to deqi generation based on present studies to promote the progression of deqi research.

*Methods:* A term frequency–inverse document frequency (Tf-idf) was used to extract key elements from the abstracts of 148 articles searched from Pubmed, and the network structure between key elements was analyzed.

*Results:* A total of 37 items were extracted from the abstracts. Each item was categorized into one of three groups (acupuncture-related sensation, interventions or organ/mechanism). Acupuncture-related sensation was studied by comparing the items in the interventions group with the organ/mechanism group. Key elements related to deqi generation included muscles from the organ/mechanism group and intensity, depth and pressure from the interventions group. Items that belonged to the acupuncture-related sensation group were divided into two clusters: one cluster consisted of pain, tingling, aching, soreness, heaviness, fullness and numbness; the other included warm, cold and dull.

*Conclusion:* We could find out that the trend of deqi was leaning towards the interventions group, which related to the generation of deqi; thus, authors concluded that the mechanism studies, which are aimed to investigate why deqi is generated or what kind of meanings it has, are needed for evolution of acupuncture theory and application of the brand new technologies and related devices.



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## 1. Introduction

Deqi is a term describing a special state of the human body during acupuncture stimulation. This state of obscurity means that acupuncture stimulation has been sufficiently delivered to the meridian system, and that the human body is ready to cure itself.[1] Deqi sensation, on the other hand, includes a number of sensations that could be felt by both patients and doctors during acupuncture stimulation and is considered a sign of the deqi phenomenon.[2] Deqi sensation could be classified as a subcategory of deqi; however, many researchers and clinicians confuse these two terms due to the misuse of the terms, which also causes confusion in building a strategy for research studies.

For decades, deqi has been considered as a key issue in acupuncture research because of the possibility of correlations with clinical efficacy,[3] mechanisms of acupuncture treatment[4] or developments of new techniques of acupuncture treatment. The majority of deqi studies have focused on deqi sensation instead of deqi itself[5] because of the absence of objective parameters to quantify the deqi phenomenon despite the importance of deqi research. The absence of deqi parameters is related to the absence of definition for deqi from literature dealing with modern biological interpretation of deqi.[6]

Deqi sensation has been studied according to several themes. The deqi sensation questionnaire has been developed as Massachusetts General Hospital acupuncture sensation scale (MASS),[7] Southampton needle sensation questionnaire (SNSQ)[8] and acupuncture sensation questionnaire (ASQ).[9] Some studies assessed the relation between deqi sensation and quality or quantity of acupuncture stimulation. For the quantity of stimulation, the deqi sensation scale was compared between different levels of stimulation,[10] needle insertion locations[11] or insertion depths.[12] For a qualitative approach, researchers used various stimulation devices such as electro-acupuncture (EA)[13,14] and laser acupuncture (LA).[15]

Others studies have investigated the origin of deqi sensation such as the nervous system[16] or connective tissue.[17] Recently, an fMRI imaging technique was used to uncover the brain areas related to evoking the deqi sensation.[18,19] White[20] and Xiong[3] focused on the relation between clinical efficacy and deqi sensation and concluded that deqi sensation is deeply associated with the clinical efficacy of acupuncture treatment. However, those researches which at the beginning stage showed only superficial data such as the location, which is related with deqi or potentials, need to be advanced to show us what is deqi and what is its value.

In this study, text mining and network analysis techniques have been applied to articles about deqi sensation to extract certain patterns and relations from the variety of hypotheses and conclusions about deqi sensation. This extraction led to further study and clarification of the concepts and mechanisms of Deqi sensation.

## 2. Methods

### 2.1. Articles

De-qi, Deqi, De Qi and acupuncture sensation were used as key words to search for articles related to de qi sensation on the Pubmed homepage (http://www.ncbi.nlm.nih.gov/pubmed). A total of 148 articles remained after excluding articles written in Chinese. Only abstracts were used, because full-text articles contained additional descriptions.

### 2.2. Text mining and network analysis

#### 2.2.1. Tf-idf

Term frequency–inverse document frequency (tf-idf) is an index representing the significance of each term in a document set.[21] Term frequency, tf(t,d)), is the number of occurrences of term $t$ in document $d$. A higher term frequency indicates a higher relevance. Document frequency df(t) refers to the number of documents that contain the term $t$, indicating how rare the term is in the document set. A lower document frequency implies that the document is more informative because rare terms are more important than frequent terms in the document set. Thus, inverse document frequency (idf), defined as $\log(N/\mathrm{df}(t))$ arithmetically is proportional to the informativeness of $t$.

$T$ = set of terms, $D$ = set of documents, $t \in T$, $d \in D$, $N = n(D)$
$\mathrm{tf}(t,d)$ = #(term $t$ appearing in document $d$)
$\mathrm{df}(t)$ = #(document contains term $t$), $\mathrm{idf}(t) = \log(N/\mathrm{df}(t))$
$\text{tf-idf} = \mathrm{Tf}(t,d) * \mathrm{idf}(t)$

#### 2.2.2. Network construction

We wanted to observe how sensation is represented with stimulation and source. Therefore, network analysis based on tf-idf was conducted. Here, we used conditional tf-idf($a|b$), which is defined as the tf-idf score of term $a$ in documents containing term $b$.[22]

For each sensation, we included a vector calculated from conditional tf-idf for each stimulation.

$\text{tf-idf}(a|b)$,

where $a \in$ 'sensation', $a \in$ 'stimulation'.

Sensation is represented by a vector space of stimulation. Furthermore, a network is constructed with sensation represented as the nodes, and Euclidean distances of the vector are represented as weighted links. The same progress was conducted with 'source', not 'stimulation'.

#### 2.2.3. Clustering

From constructed networks, modules are defined by clustering. The clustering is performed with machine learning software Weka (Waikato Environment for Knowledge Analysis) version 3.6.13 (The University of Waikato, New Zealand) and the EM (Expectation Maximization) clustering algorithm.[23]

## 3. Results

### 3.1. *Items extracted from deqi articles and their classification*

A total of 37 items were extracted as a result of text mining (Fig. 1, Table 1). Extracted items were categorized into three groups in accordance with the characters and property of the items. The characters and properties were combined, and three groups remained. Ten items (aching, dull, heavy, tingling, soreness, fullness, warm, numbness, pain and cold) were assigned to the acupuncture-related sensation[24] group, which consisted of items representing the sensations related with acupuncture stimulation. Thirteen items (rotation, laser, intensity, deep, thermal, pressure, manipulation, electro-acupuncture (EA), temperature, heat, moxibustion, depth and electrical) were included in the interventions group, which consisted of items representing the condition or interventions for stimulation on the acupuncture points. Fifteen items (cognitive, cortical, cortex, sympathetic, limbic, hypothalamus, muscle, sensory, cerebellum, autonomic nerve system,[25] nerve, gyrus, tinnitus and heart) were categorized in the organ/mechanism group, which consisted of items representing the organs or biological mechanisms that can be related to generating deqi sensation. Every 37 of the items were included into one of the three groups.

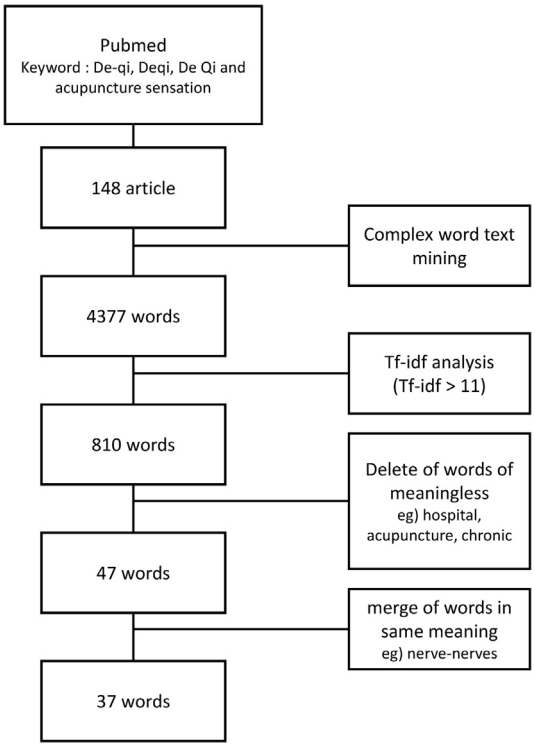


**Fig. 1** – Flow chart of item extraction.
The articles were searched with the keywords described in the method containing a total of 4377 words. 37 items were extracted from 4377 words by tf-idf analysis, with deletion of meaningless word or unrelated words and merging of same or similar words.

### 3.2. *Relationships between items in ARS and other groups*

A large-scale map of the relationship between all items was constructed to determine the direction or tendency of research. Pain had a major position in the network map with the largest number of connections (Fig. 2A). In the map without pain, there were a large number of networks between the ARS group and the interventions group, while the ARS group had the smallest connection with the organ/mechanism group (Fig. 2B).

Three items in the ARS group had a significant relationship (correlation (conditional tf-idf) over 0.5) with the items in the organ/mechanism group. Heavy and numbness had relationships with muscle. Pain was related to cognitive, cortical, sympathetic, limbic, sensory and autonomic systems (Fig. 3).

Table 1 – Frequency Information of Extracted 37 Items

| Term | tf | idf | tf/idf | Term | tf | idf | tf/idf |
|---|---|---|---|---|---|---|---|
| Pain | 235 | 67 | 91.98115 | Dull | 21 | 15 | 21.86925 |
| Rotation | 61 | 11 | 71.74157 | Tingling | 23 | 21 | 20.59109 |
| Laser | 45 | 7 | 61.75737 | Soreness | 19 | 14 | 20.35576 |
| Intensity | 77 | 39 | 48.23429 | Sympathetic | 15 | 8 | 19.71591 |
| Deep | 48 | 17 | 47.37768 | Limbic | 14 | 7 | 19.2134 |
| Moxibustion | 27 | 6 | 37.86198 | Thermal | 11 | 3 | 19.14399 |
| Electrical | 37 | 17 | 36.5203 | Heavy | 18 | 15 | 18.74507 |
| Manipulation | 46 | 27 | 36.16153 | Cognitive | 13 | 6 | 18.71133 |
| Sensory | 36 | 17 | 35.53326 | Gyrus | 14 | 8 | 18.40152 |
| Electro-acupuncture | 34 | 16 | 34.45437 | Aching | 17 | 14 | 18.21305 |
| Autonomic nerve system | 32 | 14 | 34.28339 | Temperature | 13 | 7 | 17.84102 |
| Nerve | 31 | 14 | 33.21203 | Numbness | 16 | 13 | 17.65665 |
| Tinnitus | 16 | 3 | 27.8458 | Cold | 12 | 6 | 17.27199 |
| Hypothalamus | 21 | 8 | 27.60227 | Fullness | 12 | 8 | 15.77273 |
| Heart | 25 | 13 | 27.58851 | Heat | 9 | 5 | 13.66663 |
| Cortex | 27 | 16 | 27.36083 | Cerebellum | 10 | 8 | 13.14394 |
| Depth | 24 | 12 | 27.31926 | Cortical | 8 | 5 | 12.14811 |
| Pressure | 25 | 15 | 26.03482 | Warm | 8 | 6 | 11.51466 |
| Muscle | 18 | 10 | 21.91471 | | | | |

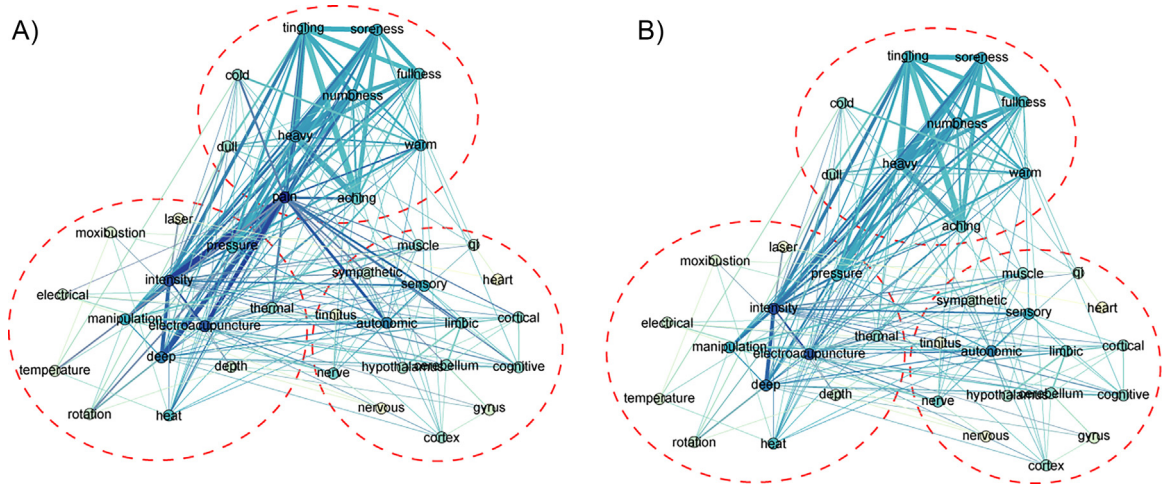


**Fig. 2** – Large-scale network map.
Items are placed into one of three groups (red dotted circles), and the strength of the connection (conditional tf-idf) is represented as the thickness of the line connecting each item. A: network map with the pain node. B: network map without the pain node.

Eight items in the ARS group had significant relationships with the items in the organ/mechanism group. Five of the items were related to one item in the organ/mechanism group. Aching and soreness were related to depth. Fullness and numbness were related to pressure. Warm was related to intensity. Three items were related to two or more items in the organ/mechanism group. Heavy was related to depth and pressure. Tingling was related to intensity, depth and pressure. Pain was related to intensity, depth and EA (Fig. 4).

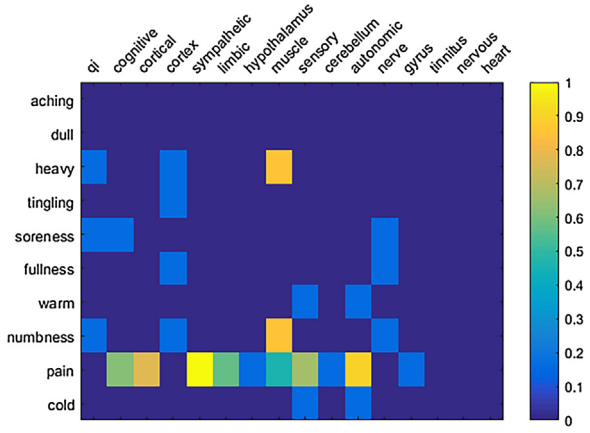


**Fig. 3** – Matrix of correlations between the ARS and the organ/mechanism groups.
Pain shows the broadest correlation with organ/mechanism group, while other sensations do not show correlation (conditional tf-idf) with the items in the organ/mechanism group except for the muscle. The muscle shows significantly high correlation with the sensation of heavy, numbness and pain. Correlation was indicated as a heat map colour in the right side.

### 3.3. *Relationship between items inside the ARS group*

The network map inside the ARS group shows two clusters. One is composed of seven items (pain, tingling, aching, soreness, heaviness, fullness and numbness), with each item tightly connected. The other network map is composed of three items (warm, cold and dull), with the connection between the items relatively weak (Fig. 5A).

Without pain (Fig. 5B), two cluster is divided more clearly and the worm became obvious as a core or the smaller network consisted with three items while the pain makes broad connection with every items in Fig. 5B.

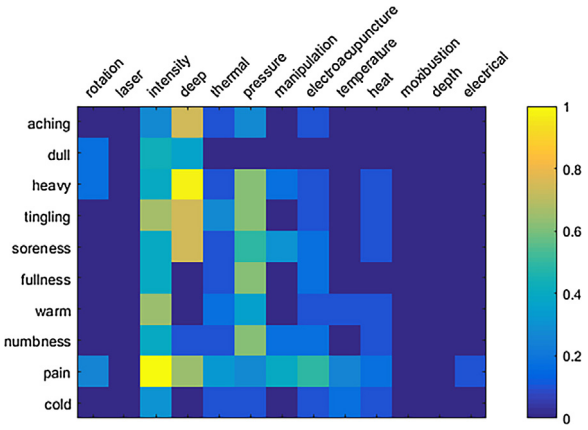


**Fig. 4** – Matrix of correlations between the ARS and the interventions groups.
Intensity, deep and pressure show the most significant correlation with the items in the ARS group. Correlation was indicated as a heat map colour in the right side.

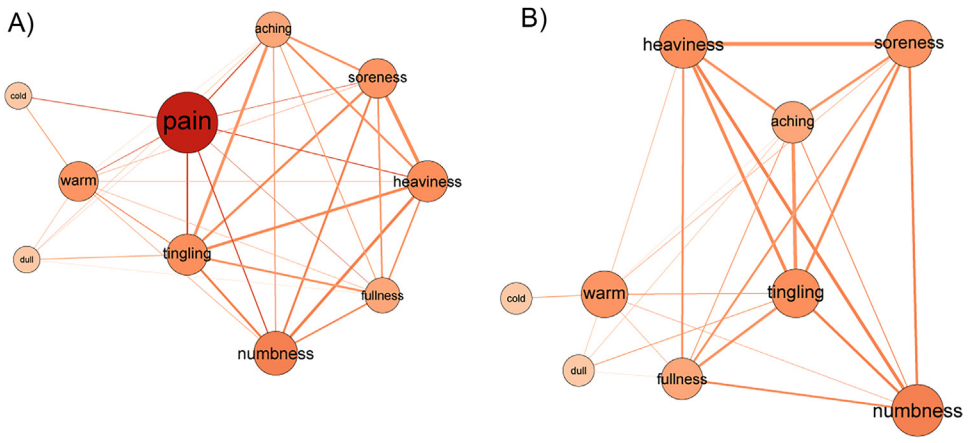


**Fig. 5** – Network inside the ARS group.
The number of items found is expressed as the size of a circle and the depth of colour. The strength of the network is expressed as the thickness of the lines that are connecting items. A: network map with the pain node. B: network map without the pain node.

## 4. Discussion

Deqi was first described in the 'Yellow Emperor's Internal Medicine'[1] as the pathophysiological reaction of the human body, which occurs when acupuncture stimulation is adequate. The passage of more than a thousand years narrowed the meaning of deqi in the Qing dynasty as sensations represented by four sensations (soreness, numbness, fullness/distention and heaviness) related to acupuncture stimulation.[26] Despite a change in meaning, the relationship between deqi and the efficacy of acupuncture treatment has been assessed, and many acupuncture studies have kept deqi as an important parameter.[27] However, factors related to understanding deqi, such as the mechanism, related organs, biological parameters or even the relationship with efficacy, remain unclear. Researchers shall set the direction of deqi research to the real substance of deqi to obtain data that can be used in the clinic. Thus, we have tried to use this research trend of deqi in this study.

Text-based data can be extracted and structured easily, quickly and objectively from a large amount of documents by using text mining and related techniques.[28] In this study, the text mining method was applied to determine the points that needed reinforcement and the factors related to deqi generation from the trend of research. Until now, most deqi studies have been performed sporadically by individual researchers without a strategy or a roadmap, and we considered that absence as a challenge to advance the acupuncture theory. We expect that the results of this study could help researchers to set their own direction for studying deqi independently from existing results.

We found two directions of study that existed when we set the ARS group, which is one of the main subjects of this study, as the core of items in the large-scale network map (Fig. 2). One was interventions to maximize or lead out deqi, and the other was organs or mechanisms related to deqi; those two groups can be considered as a lower category of ARS. Prior to the explanation of the current direction of deqi research, pain was addressed in many studies, similar to focusing on a hub in the network map (Fig. 2A). Pain was used in both ARS and symptoms of the disease, and it was very difficult to distinguish between these factors using only text mining. Thus, we analyzed another network map without pain (Fig. 2B) to more distinctly observe the total network. The direction of deqi research is deflected to sensation itself or to intervention studies. The underlying cause of the deflection may be interpreted with two reasons briefly; first, the lack of measurable definition of deqi may cause the bias of researchers who have only limited time and resources; and this lack of definition obstructs new protocol to contact to the mechanism of deqi while deqi can be measured only with questionnaires,[8,9,29] which limited research subjects to humans. The limitation of deqi research can be overcome with the development of non-invasive techniques that can examine the human body, such as fMRI,[19,30] HRV[31] and EEG,[32] and the focus of deqi research should shift to the mechanism or real substance of deqi. For example, we could find out the location[18,19] and their function in the brain where is related with deqi followed by the evolution of fMRI technology. In addition, we could be closer to the mechanism of acupuncture treatment and real body of meridian system if we could what happens when the deqi is generated.

Correlation analysis between items belonging to the ARS group and the other two groups was performed to determine the influence of each item on the ARS. Within the organ/mechanism group, heavy, numbness and pain were correlated. Heavy and numbness were only correlated with muscle. Pain was correlated with cognitive, cortical, sympathetic, limbic, sensory and autonomic systems, and the pattern of correlation was different from the pattern of correlation for heavy and numbness. The pattern of pain was unclear, which indicates that pain had two meanings, as was previously mentioned. Thus, only muscle can be identified as an organ related to deqi sensation, while the others remained as candidates. We observed a wide variety of patterns in the correlation matrix with the interventions group. Intensity, depth and pressure were the major elements of stimulation related to ARS. Intensity correlated with every item in the ARS group regardless of significance. The skin may not be the

source of deqi sensation because ARS was related to depth and pressure, which aims to transport acupuncture stimulation to a deeper place such as the muscle or subcutaneous tissue. Briefly, we could conclude that the origin of deqi is potentially located in a deeper place in the body according to the results of correlation analysis.

Controlling pain is the most prevalent goal of acupuncture.[33] Thus, the word pain has been used as a symptom of disease in most acupuncture studies. However, pain is also used as a term of sensation during acupuncture stimulation in deqi research, and these two meanings of pain are inseparable with the text mining method. We decided not to add an additional process despite the fact that we could manually separate these two meanings because additional processes could indicate the subjective bias of the researcher. We analyzed both maps with or without pain and were able to draw detailed conclusions (Fig. 5A and B).

Items in the ARS group were separated into two clusters following the results of network analysis regardless of the existence of pain. The larger cluster had a tight network between each item inside the group, for example, pain, tingling, aching, soreness, heaviness, fullness and numbness. The smaller cluster had a loose network, which may be caused by low frequency of items in this group, between each item inside the cluster, although the use of the items in the article was similar to the items in the other cluster. The network between the two clusters was limited, and most of the networks between the two clusters were connected through warm when we removed the pain node. Cold connected only with warm. Dull connected most with tingling; however, it was sorted to the smaller cluster because the network strength was weak for warm and cold. The items in the small cluster were used relatively less frequently. Further study is required to clarify the relation with other items.

Aching and tingling were two major division in the Southampton needle sensation questionnaire.[8] Aching, dull, uncomfortable, heavy, pressure, bruised and stinging were grouped as the aching deqi and tingling, warm, spreading, fading, numb, twinge and throbbing were grouped as the tingling deqi in the SNSQ. However, there was no tendency to separate the items contained in the SNSQ. We concluded that the separation of deqi into aching and tingling in the SNSQ should be considered in subsequent studies while we consider the use of the SNSQ in the study of acupuncture.

In this study, we evaluated deqi studies performed in 2015 by using text mining and network analysis methods. As a result of this study, we could quantitatively observe that the trend in deqi research has focused on intervention studies; intensity, depth and pressure were related to deqi sensation; only the muscle was related to deqi generation. The research trend of deqi weighting to the intervention for generating deqi may be the proof of the potential relationship between deqi and efficacy of acupuncture treatment. The trend also shows us about the lack of knowledge about deqi and meridian system itself from the lack of the study about the mechanism study of deqi.

From the results of the study, the authors recommend the necessity of mechanism study underlying the deqi phenomenon to define deqi itself and, moreover, for the advance of acupuncture theory and understanding of human body. We also expect an implication or fusion of modern technology to the acupuncture theory to be possible as a result of mechanism study of deqi in the future. Despite the result indicating an understanding about deqi and meridian system and directing the way to research, we should be cautious when we use these data, because text mining only shows the trend of study results, although most researchers publish only positive data. Thus, we suggest readers to accept this positive data and to pursue more progressive studies about deqi.

## 5. Conclusion

As a result of this study aiming to evaluate the trend in deqi research and the related factors to generate deqi, we obtained the following conclusions and future plans. First, the present study placed too much emphasis on interventions related to deqi, and future studies should focus more on mechanisms. Second, muscle, intensity, depth and pressure were related to the generation of deqi. More studies about neuronal mechanisms are recommended to learn more about the generation and usage of deqi. Lastly, there is now a chance to advance the methodology of deqi research and to investigate the mechanism of acupuncture treatment by taking advantage of the progress of related technology.

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## References

1. Veith I. *The yellow emperor's classic of internal medicine*. University of California Press; 2015.
2. Park H, Park J, Lee H, Lee H. Does Deqi (needle sensation) exist? *Am J Chin Med* 2002;30:45–50.
3. Xiong J, Liu F, Zhang M-M, Wang W, Huang GY. De-qi, not psychological factors, determines the therapeutic efficacy of acupuncture treatment for primary dysmenorrhea. *Chin J Integr Med* 2012;18:7–15.
4. Zhu S-P, Luo L, Zhang L, Shen S-X, Ren X-X, Guo M-W, et al. Acupuncture de-qi: from characterization to underlying mechanism. *Evid-Based Complement Alternat Med* 2013; 2013.
5. Park J-E, Ryu Y-H, Liu Y, Jung HJ, Kim AR, Jung SY, et al. A literature review of de qi in clinical studies. *Acupunct Med* 2013, acupmed-2012-010279.
6. Yuan H-W, Ma L-X, Qi D-D, Zhang P, Li C-H, Zhu J. The historical development of deqi concept from classics of traditional Chinese medicine to modern research: exploitation of the connotation of deqi in Chinese medicine. *Evide-Based Complement Alternat Med* 2013;2013.
7. Kong J, Gollub R, Huang T, Polich G, Napadow V, Hui K, et al. Acupuncture de qi, from qualitative history to quantitative measurement. *J Alternat Complement Med* 2007;13:1059–70, http://dx.doi.org/10.1089/acm.2007.0524.
8. White P, Bishop F, Hardy H, Abdollahian S, White A, Park J, et al. Southampton needle sensation questionnaire: development and validation of a measure to gauge acupuncture needle sensation. *J Alternat Complement Med* 2008;14:373–9, http://dx.doi.org/10.1089/acm.2007.0714.

9. Kim Y, Park J, Lee H, Bang H, Park HJ. Content validity of an acupuncture sensation questionnaire. *J Alternat Complement Med* 2008;14:957–63, http://dx.doi.org/10.1089/acm.2007.0565.
10. Loyeung BYK, Cobbin DM. Investigating the effects of three needling parameters (manipulation, retention time, and insertion site) on needling sensation and pain profiles: a study of eight deep needling interventions. *Evid-Based Complement Alternat Med* 2013;2013:12, http://dx.doi.org/10.1155/2013/136763.
11. Fang J, Krings T, Weidemann J, Meister IG, Thron A. Functional MRI in healthy subjects during acupuncture: different effects of needle rotation in real and false acupoints. *Neuroradiology* 2004;46:359–62.
12. Choi Y-J, Lee J-E, Moon W-K, Cho SH. Does the effect of acupuncture depend on needling sensation and manipulation? *Complement Ther Med* 2013;21: 207–14.
13. Kong J, Ma L, Gollub RL, Wei J, Yang X, Li D, et al. A pilot study of functional magnetic resonance imaging of the brain during manual and electroacupuncture stimulation of acupuncture point (LI-4 Hegu) in normal subjects reveals differential brain activation between methods. *J Alternat Complement Med* 2002;8:411–9.
14. Zhou K, Fang J, Wang X, Wang Y, Hong Y, Liu J, et al. Characterization of De Qi with electroacupuncture at acupoints with different properties. *J Alternat Complement Med* 2011;17:1007–13.
15. Litscher G. Yes, there is deqi sensation in laser acupuncture. *Evid-Based Complement Alternat Med* 2013;2013.
16. Leung AY, Park J, Schulteis G, Duann JR, Yaksh T. The electrophysiology of de qi sensations. *J Alternat Complement Med* 2006;12:743–50.
17. Langevin HM, Churchill DL, Fox JR, Badger GJ, Garra BS, Krag MH. Biomechanical response to acupuncture needling in humans. *J Appl Physiol* 2001;91:2471–8.
18. Sun J, Zhu Y, Yang Y, Jin L, von Deneen KM, Qin W, et al. What is the de-qi-related pattern of BOLD responses? A review of acupuncture studies in fMRI. *Evid-Based Complement Alternat Med* 2013;2013.
19. MacPherson H, Asghar A. Acupuncture needle sensations associated with De Qi: a classification based on experts' ratings. *J Alternat Complement Med* 2006;12:633–7.
20. White P, Prescott P, Lewith G. Does needling sensation (de qi) affect treatment outcome in pain? Analysis of data from a larger single-blind, randomised controlled trial. *Acupunct Med* 2010;28:120–5.
21. Joachims T. *A probabilistic analysis of the Rocchio algorithm with TFIDF for text categorization: DTIC document*; 1996.
22. Lee T, Jung W-M, Lee I-S, Lee Y-S, Lee H, Park H-J, et al. Data mining of acupoint characteristics from the classical medical text: DongUiBoGam of Korean Medicine. *Evid-Based Complement Alternat Med* 2014;2014.
23. Sharma N, Bajpai A, Litoriya MR. Comparison the various clustering algorithms of weka tools. *Int J Emerg Technol Adv Eng* 2012;4.
24. Arendt-Nielsen L, Svensson P. Referred muscle pain: basic and clinical findings. *Clin J Pain* 2001;17:11–9.
25. Shi Y, Zhang S, Li Q, Liu Z, Guo S, Yang J, et al. A study of the brain functional network of Deqi via acupuncturing stimulation at BL40 by rs-fMRI. *Complement Ther Med* 2016;25:71–7, http://dx.doi.org/10.1016/j.ctim.2016.01.004.
26. Yuan H-W, Ma L-X, Qi D-D, Zhang P, Li C-H, Zhu J. The historical development of Deqi concept from classics of traditional Chinese medicine to modern research: exploitation of the connotation of Deqi in Chinese medicine. *Evid-Based Complement Alternat Med* 2013;2013:639302, http://dx.doi.org/10.1155/2013/639302.
27. Zhou W, Benharash P. Significance of "Deqi" response in acupuncture treatment: myth or reality. *J Acupunct Merid Stud* 2014;7:186–9, http://dx.doi.org/10.1016/j.jams.2014.02.008.
28. Abbe A, Grouin C, Zweigenbaum P, Falissard B. Text mining applications in psychiatry: a systematic literature review. *Int J Methods Psychiatr Res* 2016;25:86–100, http://dx.doi.org/10.1002/mpr.1481.
29. Kou W, Gareus I, Bell JD, Goebel MU, Spahn G, Pacheco-López G, et al. Quantification of DeQi sensation by visual analog scales in healthy humans after immunostimulating acupuncture treatment. *Am J Chin Med* 2007;35:753–65, http://dx.doi.org/10.1142/S0192415X07005247%M 17963316.
30. Lee I-S, Jung W-M, Lee Y-S, Wallraven C, Chae Y. Brain responses to acupuncture stimulation in the prosthetic hand of an amputee patient. *Acupunct Med* 2015;33:420–4.
31. Li Q-Q, Shi G-X, Fu X-X, Han L-L, Liu L-Y, Liu C-Z, et al. Effects of Deqi on autonomic balance in adult tinnitus patients: study design of a randomized controlled trial. *Evid-Based Complement Alternat Med* 2013;2013:756012, http://dx.doi.org/10.1155/2013/756012.
32. Hori E, Takamoto K, Urakawa S, Ono T, Nishijo H. Effects of acupuncture on the brain hemodynamics. *Auton Neurosci* 2010;157:74–80, http://dx.doi.org/10.1016/j.autneu.2010.06.007.
33. Han J-S, Ho Y-S. Global trends and performances of acupuncture research. *Neurosci Biobehav Rev* 2011;35:680–7, http://dx.doi.org/10.1016/j.neubiorev.2010.08.006.