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# Therapies for children with cerebral palsy

## A Web of Science-based literature analysis

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### Abstract

**OBJECTIVE:** To identify global research trends in three therapies for children with cerebral palsy.

**DATA RETRIEVAL:** We performed a bibliometric analysis of studies on therapies for children with cerebral palsy from 2002 to 2011 retrieved from Web of Science.

**SELECTION CRITERIA:** Inclusion criteria: (a) peer-reviewed published articles on botulinum toxin, constraint-induced movement therapy, or acupuncture for children with cerebral palsy indexed in Web of Science; (b) original research articles, reviews, meeting abstracts, proceedings papers, book chapters, editorial material, and news items; and (c) publication between 2002 and 2011. Exclusion criteria: (a) articles that required manual searching or telephone access; (b) documents that were not published in the public domain; and (c) a number of corrected papers from the total number of articles.

**MAIN OUTCOME MEASURES:** (1) Number of publications on the three therapies; (2) annual publication output, distribution by journals, distribution by institution, and top-cited articles on botulinum toxin; (3) annual publication output, distribution by journal, distribution by institution, and top-cited articles on constraint-induced movement therapy; (4) annual publication, distribution by journal, distribution by institution, and top-cited articles on acupuncture.

**RESULTS:** This analysis, based on Web of Science articles, identified several research trends in studies published over the past 10 years of three therapies for children with cerebral palsy. More articles on botulinum toxin for treating children with cerebral palsy were published than the articles regarding constraint-induced movement therapy or acupuncture. The numbers of publications increased over the 10-year study period. Most papers appeared in journals with a focus on neurology, such as *Developmental Medicine and Child Neurology* and *Journal of Child Neurology*. Research institutes publishing on botulinum toxin treatments for this population are mostly in the Netherlands, the United States of America, and Australia; those publishing on constraint-induced movement therapy are mostly in Australia and the United States of America; and those publishing on acupuncture are mostly in China, Sweden and the United States of America.

**CONCLUSION:** Analysis of literature and research trends indicated that there was no one specific therapy to cure cerebral palsy. Further studies are still necessary.

### Key Words

constraint-induced movement therapy; botulinum toxin; acupuncture; cerebral palsy; nerve injury; infant; children; brain; Web of Science; bibliometric; neural regeneration

### Research Highlights

We performed a bibliometric analysis of published studies on three common therapies to treat children with cerebral palsy from 2002 to 2011 retrieved from Web of Science. The three therapies were botulinum toxin, constraint-induced movement therapy, and acupuncture.

### Abbreviation

CIMT, constraint-induced movement therapy

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## INTRODUCTION

Cerebral palsy is a range of motor impairment and non-progressive posture syndromes<sup>[1]</sup>. It is attributed to non-progressive disturbances during brain development in fetuses or infants. Cerebral palsy is frequently accompanied by impaired cognition, communication and sensory perception, epilepsy, and behavioral abnormalities, or a combination of these features<sup>[2-3]</sup>. Cerebral palsy is a common cause of disability in childhood. The target of treatment is to achieve the best functional motor, language and intellectual status for children with cerebral palsy, and improve their ability to live and integrate into society<sup>[4]</sup>. We need comprehensive application of various treatment methods and techniques<sup>[5-6]</sup>. Management options include physiotherapy, occupational and speech therapy, orthotics, device-assisted modalities, pharmacological intervention, and orthopedic and neurosurgical procedures<sup>[1]</sup>. By searching Web of Science, we found three commonly used therapies: botulinum toxin, constraint-induced movement therapy (CIMT), and acupuncture. Botulinum toxin is commonly used to reduce spasticity and dystonia, and to improve range of movement and function in children with cerebral palsy. CIMT is an emerging approach for children with hemiplegic cerebral palsy that aims to increase spontaneous use of affected upper limbs and limit the effects of learned non-use. Acupuncture is commonly used in Asia and is said to stimulate the cerebral cortex and peripheral nerves, inducing reduced muscle tension to return to normal<sup>[7-8]</sup>. In this study, we analyzed research trends in these three therapies for children with cerebral palsy based on a bibliometric analysis of publications in Web of Science from 2002 to 2011.

## DATA SOURCES AND METHODOLOGY

### Data retrieval

This study used bibliometric analyses to quantitatively and qualitatively investigate research trends in studies of therapies for children with cerebral palsy. We searched Web of Science, a database of research publications and citations, selected and evaluated by the Institute for Scientific Information in Philadelphia, PA, USA. We found three common therapies: botulinum toxin, CIMT, and acupuncture. We then searched using the key words "cerebral palsy" and "child or infant", along with either "botulinum toxin", "constraint-induced movement therapy", or "acupuncture" to find articles on the use of

botulinum toxin, CIMT, or acupuncture, respectively, to treat children with cerebral palsy. We limited the period of publication from 2002 to 2011 and compiled a bibliography of all articles related to these therapies. We downloaded the data on August 4, 2012.

### Inclusion criteria

Inclusion criteria were as follows: (1) published peer-reviewed articles on any of the three therapies, including original research articles, reviews, meeting abstracts, proceedings papers, book chapters, editorial material, and news items, which were indexed in Web of Science; (2) year of publication 2002–2011; and (3) citation database was Science Citation Index Expanded.

### Exclusion criteria

We excluded articles that required manual searching or telephone access, documents that were not published in the public domain, and several corrected papers. Outcomes for all articles referring to the three therapies for treating children with cerebral palsy were assessed using the following criteria: (1) number of publications on the three therapies; (2) annual publication output on botulinum toxin; (3) distribution by journal on botulinum toxin; (4) distribution by institution on botulinum toxin; (5) most-cited articles from 2002 to 2011 on botulinum toxin; (6) annual publication output on CIMT; (7) distribution by journal on CIMT; (8) distribution by institution on CIMT; (9) most-cited articles from 2002 to 2011 on CIMT; (10) annual publication output on acupuncture; (11) distribution by journal on acupuncture; (12) distribution by institution on acupuncture; and (13) most-cited articles from 2002 to 2011 on acupuncture.

## RESULTS

**Search results for three therapies used to treat children with cerebral palsy from 2002 to 2011** (Table 1) As shown in Table 1, there were 480 articles on the use of botulinum toxin to treat children with cerebral palsy, which is much more than those on the use of CIMT and acupuncture.

Table 1 Number of publications on three therapies for treating children with cerebral palsy from 2002 to 2011

Query formulation	No. of publications
ts="cerebral palsy" and ts=(child* or infant*) and ts="botulinum toxin"	480
ts="cerebral palsy" and ts=(child* or infant*) and ts=constraint-induced movement therapy	84
ts="cerebral palsy" and ts=(child* or infant*)	35

**Annual publication output relating to the use of botulinum toxin to treat children with cerebral palsy in Web of Science from 2002 to 2011 (Figure 1)**

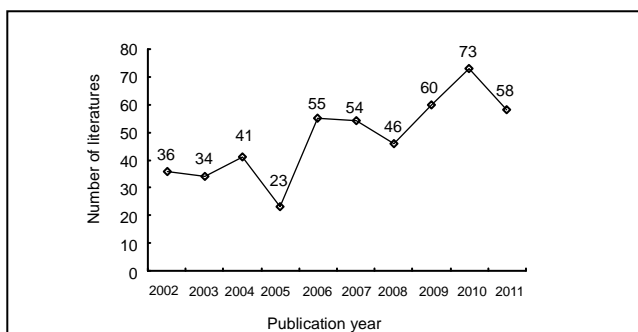


Figure 1 Annual number of publications on botulinum toxin for treating children with cerebral palsy in Web of Science from 2002 to 2011.

A total of 480 publications on botulinum toxin for treating children with cerebral palsy were retrieved from Web of Science from 2002 to 2011. The number of relevant publications increased over the 10-year study period; 36 papers were published and included in Web of Science in 2002, but the number of published papers had increased to 73 in 2010. However, the numbers of papers published heavily decreased in 2005, 2008 and 2011.

**Distribution of output by journal for publications on use of botulinum toxin to treat children with cerebral palsy in Web of Science from 2002 to 2011 (Figure 2)**

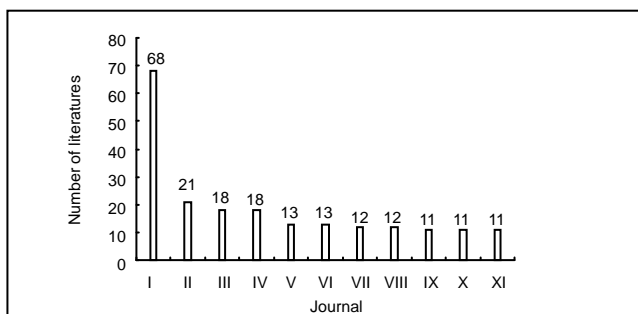


Figure 2 Top 11 journals were selected based on the number of publications on botulinum toxin for treating children with cerebral palsy between 2002 and 2011.

I: *Developmental Medicine and Child Neurology*; II: *Journal of Child Neurology*; III: *American Journal of Physical Medicine Rehabilitation*; IV: *Archives of Physical Medicine and Rehabilitation*; V: *Clinical Rehabilitation*; VI: *Gait Posture*; VII: *Pediatric Neurology*; VIII: *Revista de Neurologia*; IX: *European Journal of Neurology*; X: *European Journal of Paediatric Neurology*; XI: *Journal of Rehabilitation Medicine*.

*Developmental Medicine and Child Neurology* published 68 papers, followed by *Journal of Child Neurology*, *American Journal of Physical Medicine Rehabilitation*, and *Archives of Physical Medicine and Rehabilitation*, which published 21, 18 and 18 papers, respectively (Figure 2).

**Distribution of output by institution for publications on use of botulinum toxin to treat children with cerebral palsy in Web of Science from 2002 to 2011 (Figure 3)**

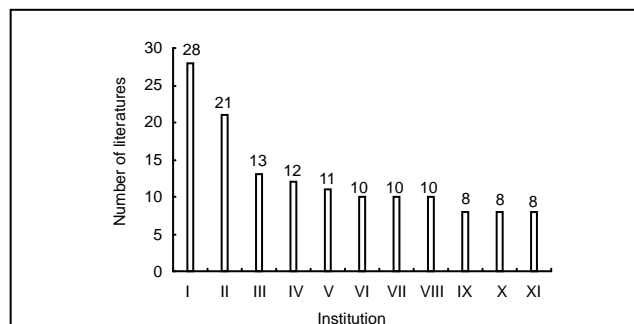


Figure 3 The top 11 institutions for publications on botulinum toxin for treating children with cerebral palsy from 2002 to 2011.

I: Murdoch Childrens Research Institute, Australia; II: University of Munich, Germany; III: Radboud University Nijmegen, Netherlands; IV: The University of Melbourne, Australia; V: Yonsei University, Korea; VI: Catholic University of Leuven, USA; VII: Shriners Hosp For Children, USA; VIII: VU University Amsterdam, Netherlands; IX: Sint Maartensklin, Netherlands; X: The University of Auckland, New Zealand; XI: University of Washington, USA.

A total of 480 articles were analyzed by institution. The Murdoch Children’s Research Institute in Australia and the University of Munich in Germany were the most prolific research institutes (Figure 3). Four of the top 11 research institutes publishing in this field were in the Netherlands, three were in the United States of America.

**Highly cited papers on the use of botulinum toxin to treat children with cerebral palsy in Web of Science from 2002 to 2011 (Table 2)**

A total of 480 papers on the use of botulinum toxin to treat children with cerebral palsy were cited in Web of Science from 2002 to 2011. “Cerebral palsy”, published in 2004 by the journal *Lancet*<sup>[1]</sup>, was cited 118 times, which was more times than any other paper. Of the nine most-cited papers, two were published in *Developmental Medicine and Child Neurology*, two were published in *Journal of Bone and Joint Surgery-British Volume*; of these nine most-cited papers, five were published in 2004, two in 2003.

**Annual publication output relating to CIMT for treating children with cerebral palsy in Web of Science from 2002 to 2011 (Figure 4)**

A total of 84 publications on the use of CIMT to treat children with cerebral palsy were retrieved from Web of Science from 2002 to 2011. The number of relevant publications increased over the 10-year study period.

Table 2 The top nine cited papers on botulinum toxin for treating children with cerebral palsy from 2002 to 2011

Title	Author	Journal	Publication year	Total citation	Average per year
Cerebral palsy <sup>[1]</sup>	Koman LA, et al.	Lancet	2004	118	13.11
A double-blind placebo-controlled trial of botulinum toxin B for sialorrhea in Parkinson's disease <sup>[9]</sup>	Ondo WG, et al.	Neurology	2004	79	8.78
Botulinum-A toxin injection into the detrusor: a safe alternative in the treatment of children with myelomeningocele with detrusor hyperreflexia <sup>[10]</sup>	Riccabona M, et al.	Journal of Urology	2004	76	8.44
Botulinum toxin treatment of spasticity in diplegic cerebral palsy: a randomized, double-blind, placebo-controlled, dose-ranging study <sup>[11]</sup>	Baker R, et al.	Developmental Medicine and Child Neurology	2002	70	6.36
Musculoskeletal aspects of cerebral palsy <sup>[12]</sup>	Graham HK, et al.	Journal of Bone and Joint Surgery-British Volume	2003	62	6.20
Measures of muscle and joint performance in the lower limb of children with cerebral palsy <sup>[13]</sup>	Fosang AL, et al.	Developmental Medicine and Child Neurology	2003	60	6.00
Sagittal gait patterns in spastic diplegia <sup>[14]</sup>	Rodda JM, et al.	Journal of Bone and Joint Surgery-British Volume	2004	54	6.00
Botulinum toxin type A injections: adverse events reported to the US Food and Drug Administration in therapeutic and cosmetic cases <sup>[15]</sup>	Cote TR, et al.	Journal of The American Academy of Dermatology	2005	53	6.62
Effect of botulinum toxin in the treatment of drooling: a controlled clinical trial <sup>[16]</sup>	Jongerius PH, et al.	Pediatrics	2004	53	5.89

Two papers were published and included in Web of Science in 2002, but the number of published papers increased to 20 in 2011. However, numbers of papers published slightly decreased in 2004, 2008 and 2010.

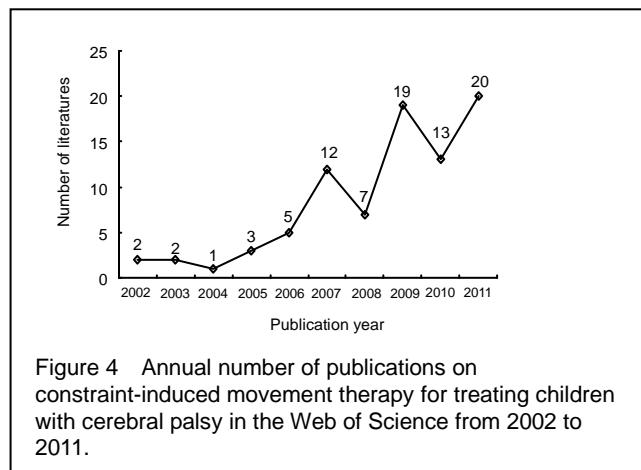


Figure 4 Annual number of publications on constraint-induced movement therapy for treating children with cerebral palsy in the Web of Science from 2002 to 2011.

**Distribution of output by journal for publications on use of CIMT to treat children with cerebral palsy in Web of Science from 2002 to 2011 (Figure 5)**

As shown in Figure 5, *Developmental Medicine and Child Neurology* published 13 papers, followed by *Physical Therapy*, which published five papers.

**Distribution of output by institution for publications on use of CIMT to treat children with cerebral palsy in Web of Science from 2002 to 2011 (Figure 6)**

A total of 84 articles were analyzed by institution. Columbia University in the United States of America, Emory University in the United States of America, the

University of Queensland in Australia and Howard Florey Institute in Australia were the most prolific research institutes (Figure 6). Of the top 11 research institutes publishing in this field, five are in Australia, three are in the United States of America.

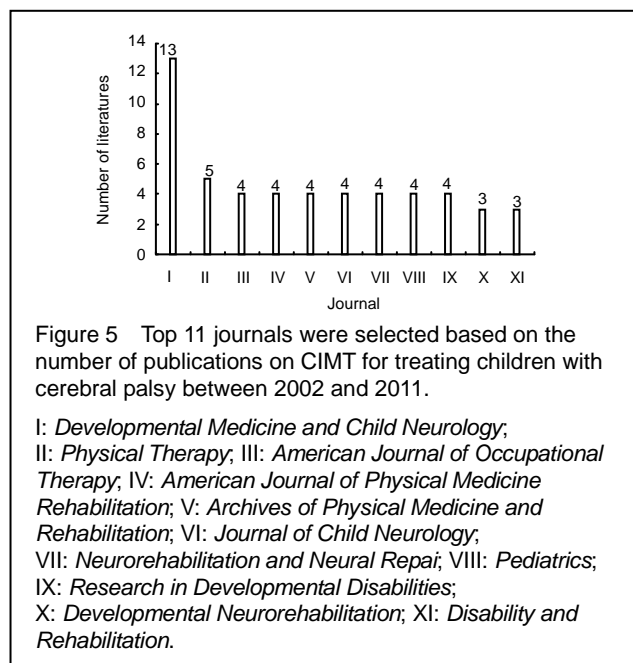


Figure 5 Top 11 journals were selected based on the number of publications on CIMT for treating children with cerebral palsy between 2002 and 2011.

I: *Developmental Medicine and Child Neurology*; II: *Physical Therapy*; III: *American Journal of Occupational Therapy*; IV: *American Journal of Physical Medicine and Rehabilitation*; V: *Archives of Physical Medicine and Rehabilitation*; VI: *Journal of Child Neurology*; VII: *Neurorehabilitation and Neural Repair*; VIII: *Pediatrics*; IX: *Research in Developmental Disabilities*; X: *Developmental Neurorehabilitation*; XI: *Disability and Rehabilitation*.

**Highly cited papers on the use of CIMT to treat children with cerebral palsy in Web of Science from 2002 to 2011 (Table 3)**

A total of 84 papers on the use of CIMT to treat children with cerebral palsy were cited in Web of Science from 2002 to 2011.

Table 3 The top 10 cited papers on constraint-induced movement therapy for treating children with cerebral palsy from 2002 to 2011

Title	Author	Journal	Publication year	Total citation	Average per year
Efficacy of constraint-induced movement therapy for children with cerebral palsy with asymmetric motor impairment <sup>[17]</sup>	Taub E, et al.	<i>Pediatrics</i>	2004	123	13.67
Effects of constraint-induced movement therapy in young children with hemiplegic cerebral palsy: an adapted model <sup>[18]</sup>	Eliasson AC, et al.	<i>Developmental Medicine and Child Neurology</i>	2005	92	11.50
Efficacy of a child-friendly form of constraint-induced movement therapy in hemiplegic cerebral palsy: a randomized control trial <sup>[19]</sup>	Charles JR, et al.	<i>Developmental Medicine and Child Neurology</i>	2006	83	11.86
Plasticity in the developing brain: implications for rehabilitation <sup>[20]</sup>	Johnston MV.	<i>Developmental Disabilities Research Reviews</i>	2009	67	16.75
Forced use treatment of childhood hemiparesis <sup>[21]</sup>	Willis JK, et al.	<i>Pediatrics</i>	2002	56	5.09
Methods of constraint-induced movement therapy for children with hemiplegic cerebral palsy: development of a child-friendly intervention for improving upper-extremity function <sup>[22]</sup>	Gordon AA, et al.	<i>Archives of Physical Medicine and Rehabilitation</i>	2005	49	6.12
Efficacy of a hand-arm bimanual intensive therapy (HABIT) in children with hemiplegic cerebral palsy: a randomized control trial <sup>[23]</sup>	Gordon AM, et al.	<i>Developmental Medicine and Child Neurology</i>	2007	47	7.83
Constraint-induced movement therapy in the treatment of the upper limb in children with hemiplegic cerebral palsy: a Cochrane systematic review <sup>[24]</sup>	Hoare B, et al.	<i>Clinical Rehabilitation</i>	2007	39	6.50
Modified constraint-induced movement therapy for young children with hemiplegic cerebral palsy: a pilot study <sup>[25]</sup>	Naylor CE, et al.	<i>Developmental Medicine and Child Neurology</i>	2005	39	4.88
Development of hand-arm bimanual intensive training (HABIT) for improving bimanual coordination in children with hemiplegic cerebral palsy <sup>[26]</sup>	Charles J, et al.	<i>Developmental Medicine and Child Neurology</i>	2006	38	5.43

“Efficacy of constraint-induced movement therapy for children with cerebral palsy with asymmetric motor impairment”, published in 2004 by the journal *Pediatrics*<sup>[17]</sup>, was cited 123 times—more times than any other paper on this topic. Of the 10 most-cited papers, five were published in *Developmental Medicine and Child Neurology*, two in *Pediatrics*; of these 10 most-cited papers, three were published in 2005, two each in 2006 and 2007.

treat children with cerebral palsy were retrieved from Web of Science from 2002 to 2011. The number of relevant publications changed irregularly over the 10-year study period; 10 papers were published and included in Web of Science in 2008, seven papers in 2009, and fewer than five papers in each of the other years.

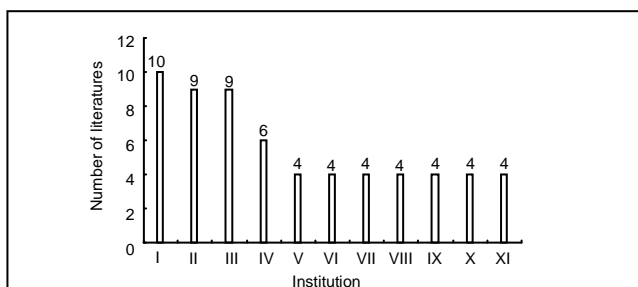


Figure 6 The top 11 institutions for publications on CIMT for treating children with cerebral palsy from 2002 to 2011.

I: Columbia University, USA; II: Emory University, USA; III: University of Queensland, Australia; IV: Howard Florey Institute, Australia; V: Austin Research Institute, Australia; VI: Karolinska Institute, Swedish; VII: Murdoch Childrens Research Institute, Australia; VIII: The University of Alabama System, USA; IX: University of Children's Hospital, Germany; X: Federal University of Minas Gerais, Brazil; XI: The University of Melbourne, Australia.

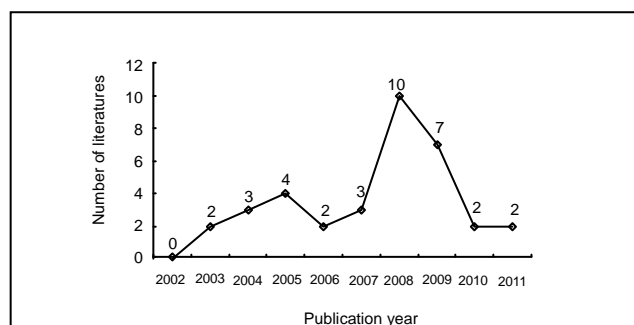


Figure 7 Annual number of publications on acupuncture for treating children with cerebral palsy in the Web of Science from 2002 to 2011.

**Annual publication output relating to the use of acupuncture to treat children with cerebral palsy in Web of Science from 2002 to 2011** (Figure 7)

A total of 35 publications on the use of acupuncture to

**Distribution of output by journal for publications on the use of acupuncture to treat children with cerebral palsy in Web of Science from 2002 to 2011** (Figure 8) *Developmental Medicine and Child Neurology* and *Journal of Child Neurology* each published four papers, three papers were in *Journal of Alternative and Complementary Medicine*, and two papers each were in *European Journal of Paediatric Neurology*, *Neural Regeneration Research* (Figure 8).

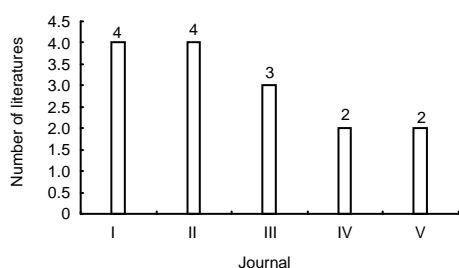


Figure 8 Top five journals were selected based on the number of publications on acupuncture for treating children with cerebral palsy between 2002 and 2011.

I: *Developmental Medicine and Child Neurology*;  
 II: *Journal of Child Neurology*;  
 III: *Journal of Alternative and Complementary Medicine*;  
 IV: *European Journal of Paediatric Neurology*;  
 V: *Neural Regeneration Research*.

### Distribution of output by institution for publications on the use of acupuncture to treat children with cerebral palsy in Web of Science from 2002 to 2011

A total of 35 articles were analyzed by institution. The University of Hong Kong in China and Capital Medical University in China were the most prolific research institutes (Figure 9). They published five and three papers, respectively. And there was another prolific research institute in China that is Chinese People's Liberation Army General Hospital. Of the other five top research institutes publishing in this field, two were in Sweden, another two were in the United States of America, and one institute was in Canada.

### Highly cited papers on the use of acupuncture to treat children with cerebral palsy in Web of Science from 2002 to 2011 (Table 4)

A total of 35 papers on the use of acupuncture to treat children with cerebral palsy were cited in Web of Science from 2002 to 2011. "Complementary and alternative medicine use in families of children with cerebral palsy", published in 2003 by *Developmental Medicine and Child Neurology*<sup>[27]</sup>, was cited 35 times—more times than any other paper on this topic. Of the 10 most-cited papers, two were published in *Developmental Medicine and Child Neurology*.

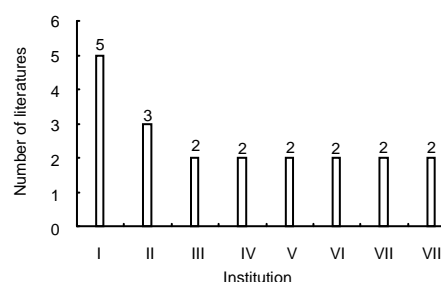


Figure 9 The top eight institutions for publications on acupuncture for treating children with cerebral palsy from 2002 to 2011.

I: University of Hong Kong, China; II: Capital Medical University, China; III: Chinese People's Liberation Army General Hospital, China; IV: Örnköldsviks Hospital, Sweden; V: University of Alberta, Canada; VI: University of Arizona, USA; VII: University of California System, USA; VIII: University of Gothenburg, Sweden.

Table 4 The top 10 cited papers on acupuncture for treating children with cerebral palsy from 2002 to 2011

Title	Author	Journal	Publication year	Total citation	Average per year
Complementary and alternative medicine use in families of children with cerebral palsy <sup>[27]</sup>	Hurvitz EA, et al.	<i>Developmental Medicine and Child Neurology</i>	2003	35	3.50
The use of complementary and alternative medicine in children with chronic medical conditions <sup>[28]</sup>	Samdup DZ, et al.	<i>American Journal of Physical Medicine &amp; Rehabilitation</i>	2006	20	2.86
Complementary and alternative therapies for cerebral palsy <sup>[29]</sup>	Liptak GS.	<i>Mental Retardation and Developmental Disabilities Research Reviews</i>	2005	19	2.38
Randomised control trial of tongue acupuncture versus sham acupuncture in improving functional outcome in cerebral palsy <sup>[30]</sup>	Sun JG, et al.	<i>Journal of Neurology Neurosurgery and Psychiatry</i>	2004	17	1.89
Use of complementary and alternative medical therapies in a pediatric neurology clinic <sup>[31]</sup>	Soo I, et al.	<i>Canadian Journal of Neurological Sciences</i>	2005	14	1.75
Parental perceptions of the therapeutic effect from osteopathic manipulation or acupuncture in children with spastic cerebral palsy <sup>[32]</sup>	Duncan B, et al.	<i>Clinical Pediatrics</i>	2004	9	1.00
Effect of acupuncture on the brain in children with spastic cerebral palsy using functional neuroimaging (fMRI) <sup>[33]</sup>	Wu Y, et al.	<i>Journal of Child Neurology</i>	2008	8	1.60
Randomized controlled trial of acupuncture versus sham acupuncture in autism spectrum disorder <sup>[34]</sup>	Wong VC, et al.	<i>Journal of Alternative and Complementary Medicine</i>	2010	7	2.33
'Electro-acupuncture in a child with mild spastic hemiplegic cerebral palsy <sup>[35]</sup>	Svedberg L, et al.	<i>Developmental Medicine and Child Neurology</i>	2003	7	0.70
Effects of music on anxiety and pain in children with cerebral palsy receiving acupuncture: a randomized controlled trial <sup>[36]</sup>	Yu H, et al.	<i>International Journal of Nursing Studies</i>	2009	5	1.25

## DISCUSSION

Bibliometric analysis, based on Web of Science publications, identified several research trends over the past 10 years in studies of botulinum toxin, CIMT and acupuncture as treatments for children with cerebral palsy. Many more articles have been published on the use of botulinum toxin to treat these children than on the use of CIMT or acupuncture. Although the number of publications increased over the 10-year study period, the increase was irregular. Most papers appeared in journals with a focus on neurology, such as *Developmental Medicine and Child Neurology*, *Journal of Child Neurology*. Research institutes publishing on the use of botulinum toxin to treat children with cerebral palsy are mostly in the Netherlands, the United States of America, and Australia; those publishing on the use of CIMT to treat these children are mostly in Australia and the United States of America; and those publishing on the use of acupuncture to treat them are mostly in China, Sweden and the United States of America. So far, there is no one specific therapy that can cure cerebral palsy effectively alone. There are more than 10 types of treatments for cerebral palsy. Doctors are inclined to use comprehensive applications of two or three treatments<sup>[37-38]</sup>. Botulinum toxin is commonly used to reduce spasticity and dystonia in children with cerebral palsy. CIMT is emerging as a treatment approach for children with hemiplegic cerebral palsy. Acupuncture, developed as a school of its own, has made progress in terms of basic research and clinical applications. Because of the complex pathogenesis of cerebral palsy and the wide variation in associated brain damage, clinical treatment of cerebral palsy is difficult<sup>[39-40]</sup>. Single treatments rarely achieve the desired therapeutic effect; comprehensive approaches are necessary, possibly with a regimen of various integrated treatments<sup>[41-43]</sup>. We should pay attention to the relevance and effectiveness of treatment methods and options.

**Author contributions:** Yaping Mu wrote the manuscript. Yaping Mu, Na Li, Lijun Guan, Chunnan Wang, and Shuyun Shang retrieved the references, extracted the data, and conceived and designed the study. Yan Wang contributed to the review, conception and design, paper revision, and study instruction.

**Conflicts of interest:** None declared.

**Author statements:** The manuscript is original, has not been submitted to or is not under consideration by another publication, has not been previously published in any language or any form, including electronic, and contains no disclosure of confidential information or authorship/ patent application disputations.

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