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## **Trends in the Availability and Usage of Electrophysical Agents in Physiotherapy practices from 1990 to 2010: A review**

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### **Abstract**

**Background:** The use of electrophysical agents has a historically important role in physiotherapy practice. There are anecdotal reports that the availability and usage of electrotherapy modalities is declining, which may have implications for physiotherapy practice. The aim of the literature review was to provide scientific evidence on electrotherapy usage in the last twenty years by identifying trends in availability, use and non-use of electrotherapeutic modalities in physiotherapy practice during 1990s and 2000s.

**Methods:** Review of empirical studies published in the English language from 1990 to 2010 and identified through searching online bibliographic databases, which included Medline / OvidSP, PubMed Central, CINAHL/EBSCOhost, ScienceDirect, Scopus, ISI Web of Science and Google Scholar.

**Findings:** In the last twenty years, ultrasound availability and usage show increasing trends in several countries. The availability and use of pulsed shortwave diathermy

(PSWD) and laser have shown steady trends. Transcutaneous electrical nerve stimulation (TENS), interferential and biofeedback availability and usage have shown increasing trends in the UK and decreasing trends in Australia and the Republic of Ireland. Trends of continuous shortwave diathermy (CSWD) availability and use are declining irrespective of the country of the study. The availability and usage of microwave diathermy (MWD) and H-wave show steeply declining trends while there is a sharp rise in their non-availability over the last several years.

**Conclusions:** The availability and use of electrophysical agents have greatly changed in the last twenty years. Declining trends in the availability and usage along with rising trend of non-availability of electrotherapy modalities may have implications for electrotherapy education, training and the practice in the coming years.

**Keywords:** electrotherapy, physical therapy, physiotherapy, survey, therapeutic diathermy, therapeutic ultrasound, thermal modality.

## INTRODUCTION

Electrotherapy is the main module of physiotherapy practice.<sup>1,2</sup> It is provided using different electrophysical agents (EPAs) such as therapeutic ultrasound, shortwave diathermy (used in pulsed (PSWD) and continuous (CSWD) modes), microwave diathermy (MWD), interferential, transcutaneous electrical nerve stimulation (TENS), biofeedback, laser, and H-wave.<sup>3-4</sup>

The use of electrical energy for therapeutic purpose goes back as far as the 18<sup>th</sup> century.<sup>5</sup> Electrotherapy has been used for treating different medical conditions<sup>6</sup>. For example, use of diathermy for treating various gynaecological conditions<sup>7</sup> such as the use of microwave diathermy before conception and during early pregnancy.<sup>8</sup> In addition, shortwave diathermy has been used as early as in 1940 for treating nasal sinus infections.<sup>9</sup> In addition, a number of other electrotherapy modalities have been introduced and used since late 1980s and early 1990.<sup>10</sup> However, some of electrotherapy modalities most commonly used in the past are becoming less popular<sup>2</sup> while other electrotherapy modalities have become popular. For example, PSWD, used since its' development in the 1940s<sup>11</sup> became popular,<sup>12</sup> but more recently has started declining.<sup>13</sup> In addition, interferential, despite not being very new, also became popular among physiotherapists in the 1980s and thereafter.<sup>14, 15</sup> Moreover, some electrotherapy modalities most commonly used in the past have become less popular.<sup>2</sup> For example, CSWD used widely since the 1930s started declining in the 1950s<sup>13</sup> and by 2007 is rarely

used.<sup>11, 13, 16</sup> MWD used frequently before the 1970s<sup>17</sup> became rarely used in recent years in Australia<sup>16, 18</sup> while since 2007 it is not available and therefore not used in the UK.<sup>16</sup> Conversely, very recently ultrasound, TENS, and interferential enjoyed the status of the most commonly available and used electrotherapy modalities.<sup>1, 16, 18</sup> In addition, either using or not using a particular EPA has become a challenge in physiotherapy practice for a number of reasons, such as physiotherapists' use of evidence based practice, emphasis on physical exercise and manual therapies as well as a lack of evidence in clinical effectiveness of electrotherapy modalities.<sup>2, 19, 20</sup> Hence, there may be implications for teaching and training of electrotherapy in the physiotherapy discipline.<sup>19, 21, 22</sup> For example, there has been exclusion of MWD from a very recent text book on electrotherapy.<sup>20</sup> It is therefore important to assess scientific evidence as to the degree to which electrotherapy modalities are available and used, available but not used and not-available in physiotherapy practices. There is however no systematic study to inform the trends in the usage of electrotherapeutic modalities. Therefore there is a need to fill this gap in the literature and update the body of knowledge on the usage of electrotherapy modalities.

### ***Aims and objectives***

The aim of this systematic literature review was to provide a scientific evidence on trends in the availability and usage of nine different types of electrotherapeutic modalities i.e. ultrasound, PSWD, CSWD, MWD, interferential, TENS, biofeedback, laser and H-wave in physiotherapy practices in the last twenty years from 1990 to 2010.

## **METHODS**

### ***Definition of Physiotherapy practice***

In this review, the term physiotherapy practice was defined as 'any physiotherapy department or clinic in the public or private healthcare sector'.

### ***Electrophysical agents studied***

Electrophysical agents included in this review were therapeutic ultrasound, radiofrequency electromagnetic radiation (pulsed shortwave diathermy (PSWD), continuous shortwave diathermy (CSWD), microwave diathermy (MWD), interferential, transcutaneous electrical nerve stimulation (TENS), biofeedback, laser and H-wave.

### ***Inclusion criteria***

Inclusion criteria were empirical primary research studies in the English language published between January 1990 and June 2010. Study designs included were cross sectional surveys and audits of electrotherapy equipment, availability, use and non-use in physiotherapy departments and clinics. The outcomes investigated included the availability and usage of any or all of the nine electrotherapy modalities mentioned above.

### ***Exclusion criteria***

Discursive, hypothetical and review articles and studies in languages other than English.

### ***Databases searched***

Literature searches were conducted through several online bibliographic databases i.e. Medline / OvidSP, PubMed Central, CINAHL/EBSCOhost, ScienceDirect, Scopus, ISI Web of Science and Google Scholar.

### ***Keywords used***

The keywords used for literature searches were: electrotherapy, equipment, survey, electrophysical agents, physiotherapy, electrotherapeutic, devices, use, usage, availability, therapeutic, diathermy, microwave and shortwave. These keywords were searched using two Boolean search operators i.e. 'AND' and 'OR' through the above mentioned bibliographic databases. The process of the literature search is explained below.

### ***Search strategy, article shortlisting and data abstraction***

A team of two researchers (the authors) were involved in the literature review process. Using the above mentioned keywords and databases, SGSS conducted literature searches, shortlisted and reviewed the relevant articles and abstracted the data. AF supervised the process of the literature review and checked the abstracted data, which involved referring back to the original article(s) if required. Abstracted data was accepted with the consensus of both researchers (the authors).

The process of identification of relevant articles included reading the title, followed by review of the abstract and creation of a shortlist of relevant articles for full review. The process of selecting the research, shown in Figure 1 led to identification of 23 studies. Full text was obtained for these studies (n=23), which were reviewed and the data was abstracted for the publication year, location of the study, aims and objectives,

study design, data collection tool, sample size, response rate and the key findings with respect to the availability, use, non-use and non-availability of the nine electrotherapy modalities as shown in Table 1. This table also provides the reviewers' / authors' (our) comments / remarks on the studies included in this review. In a study by Pope et al.,<sup>23</sup> the authors only reported the total number of physiotherapists who had access to different electrotherapy modalities but they did not report the absolute number revealing the overall availability of devices for each modality surveyed in their study.

The present authors (reviewers) therefore determined the availability of electrotherapy modalities by the number of physiotherapists who had access to equipment of each modality divided with the total respondents in the study by Pope et al.<sup>23</sup> In addition, for studies that only reported equipment availability, we determined non-availability of equipment using the following formula.

Non-availability of equipment (%) = (total respondents who reported equipment availability / total respondents in the study) × 100.

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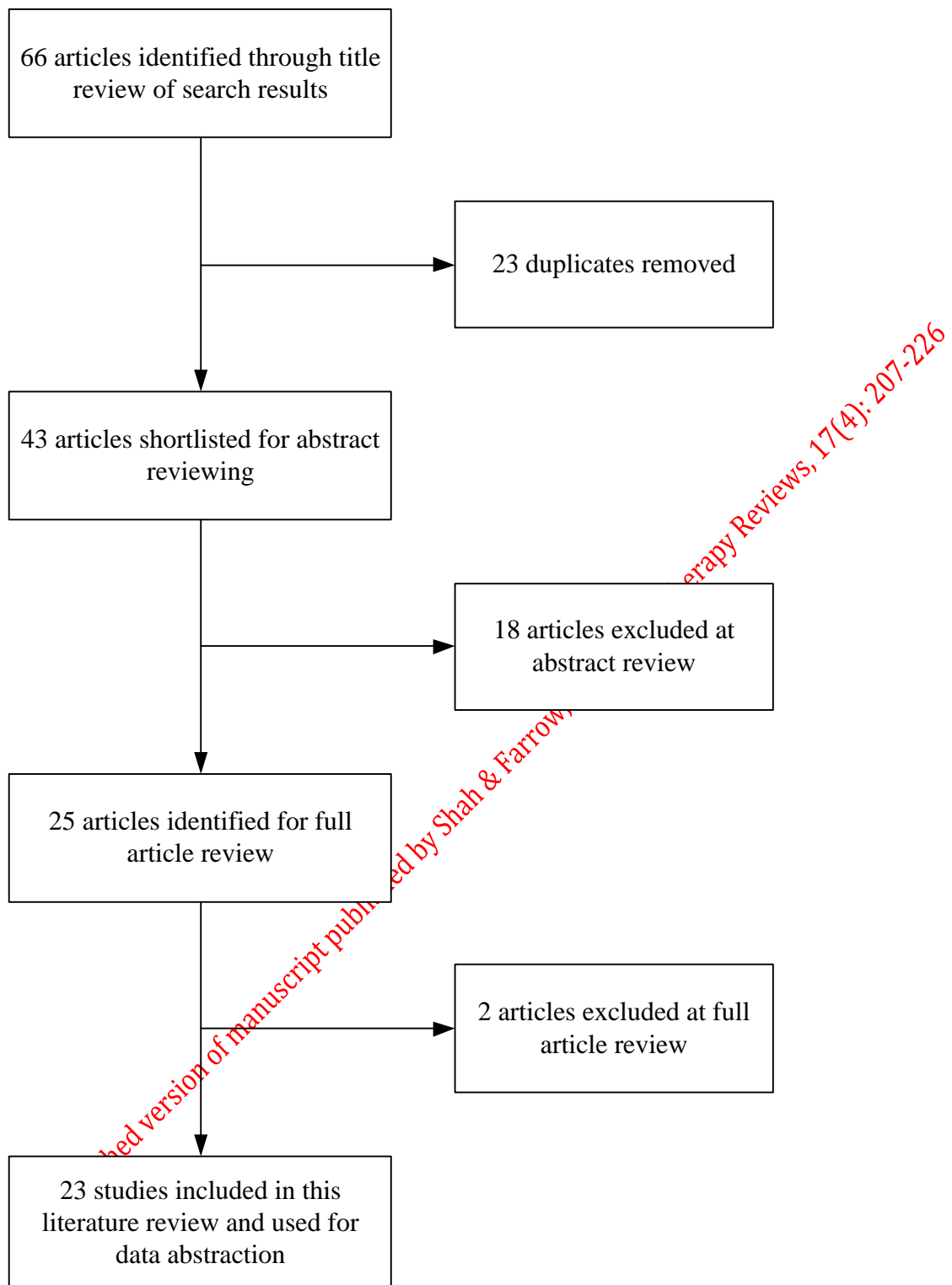


Figure 1 Flow chart of studies included and excluded in this literature review

Table 1 Data extracted from reviewed studies on the availability and usage of electrophysical agents in physiotherapy practices

Authors (year)	Location	Aims/objectives	Participants; Sample size= N	Design; (Response rate)	Findings	Reviewers' comments
Lindsay et al. 1990 <sup>24</sup>	Brisbane, Australia	Survey of ownership, frequency of use and factors affecting the pattern of use of electrotherapeutic modalities	Private physiotherapy practices; N =105	Questionnaire survey; (70%)	Physiotherapists aged <31 years more likely to use TENS than those ≥31 years (p <0.05). US owned by 100%; PSWD 20%, CSWD 66%; laser 17%, interferential 85%; TENS 92%; biofeedback 24% and MWD 33% of clinics. Frequency of use for those owning equipment: US 93%, PSWD 68%, CSWD 68%, laser 58%, interferential 90%, TENS 21%, biofeedback 18% and MWD 79%. Main reasons for use were 'effectiveness and portability' for TENS and 'effectiveness' for CSWD. Major reasons for non-use were cost and safety for CSWD and cost for PSWD. For MWD, the main reasons for frequent use were 'effectiveness'	Issues of safety, whether for the physiotherapist, the patient or both were not clear. No report on the number of devices available in each practice. This small study included only private clinics in Brisbane and findings cannot therefore be generalized, but suggested a regional trend of electrotherapy.

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					and 'ease of application' and safety was the main concern for non-use. The reasons for non-ownership were cost, unfamiliarity and questionable effects for laser and a lack of need for biofeedback.	
Baxter et al. 1999 <sup>25</sup>	Northern Ireland (UK)	To evaluate use of therapeutic laser	Physiotherapists; N =148	Postal Questionnaire Survey in 2 stages; (63%, n=116)	Therapeutic laser was used mainly for burns but also for rheumatoid arthritis, various types of ulcer and shingles. A lack of information especially about the parameters of optimal treatment with laser was reported.	No information presented on the number of devices per department. Research design and selection of the sample was not clear. This was a regional study and therefore not generalizable but suggested a regional trend of laser usage in clinical practice.
Taylor and Humphry 1991 <sup>26</sup>	USA	Use of electrophysical agent modalities	Physiotherapists (specialist on physical disabilities); N=997 (randomly selected)	Postal Questionnaire Survey; (63%, n=629)	Figures on availability of devices not reported. Hot and cold packs were most commonly used. Use of US was 86%, TENS 88% and neuromuscular electrical stimulation (NMES) 89%. Use of several times / week equal for NMES and US but lower for TENS. Non-use was highest for US (14%)	Limited scope of the study on use of EPAs because participants were from one specialist group of physiotherapists in physical disabilities practice. Not known whether this survey covered both public and private practices. No precise data given on overall

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					followed by TENS (13%) and NMES (11%). Non-use of any electrotherapy modality was reported by 23% of physiotherapists. Most common mode of receiving training for US, TENS and NMES was 'on job training'. No training was received by 11% for US, 9% for TENS and 7% for NMES.	availability of PSWD, CSWD, MWD, biofeedback, laser, or H-wave; thus, providing limited knowledge on EPAs as a whole.
McMeeken and Stillman 1993 <sup>27</sup>	Victoria, Australia	Use of therapeutic laser	Physiotherapists; N = 122	Questionnaire Survey; (31%, n=38)	The maximum number of laser equipment was 3 devices per practice. The value of using laser was questioned and a lack of information about laser use and effectiveness was reported.	Mainly addressed clinical efficacy of therapeutic laser; hence less relevant but did not inform on frequency of use. As a regional Australian study, it cannot be representative of Australia as a whole. Moreover, sampling strategy was not random as compiled with information from laser manufacturers / suppliers and other sources such as healthcare professionals.
Kitchen 1995 <sup>28</sup>	England (6	Use of PSWD,	Physiotherapists	Face to face	US, PSWD and CSWD devices were	Exploratory study with a small

	health regions)	CSWD, ultrasound and laser in clinical practice	(NHS and private); N = 10	interviews; (100%, n=10)	available to all participants (n=10) while laser equipment was available to 40% (n=4) of participants. Personal experience and availability were the two main reasons for selection of the modalities. Doubts about the efficacy of electrotherapy agents were also reported. The occurrence of a number of adverse reactions due to these modalities was reported.	sample (n=10) over six health regions; location of the health regions was not described. Mainly referred to use of CSWD, PSWD, US and laser for management of soft-tissue problems and the factors affecting the selection of the modality. Hence, this study has less value for assessing the availability and use / non-use of EPAs. The occurrence of adverse reactions was not clear whether patients or physiotherapists experienced them.
Lindsay et al. 1995 <sup>29</sup>	Alberta, Canada	To survey all private practitioners registered within the Province of Alberta regarding modality usage	Physiotherapists, N = all private practitioners registered within the Province of Alberta	Questionnaire Survey; (41%, n=208)	Electrotherapy was a common treatment mode. US, interferential and TENS were most frequently used. Frequent use of TENS was greater amongst older physiotherapists and clinic owners (p < 0.05). [Similar to 1990 results by same researchers carried out in	Reported availability of PSWD and CSWD equipment as 'high' but did not report exact number of devices per department. There was no report on the non-use of modalities. Moreover, this study covered only private physiotherapists in the region of

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					Australia <sup>24]</sup> Male physiotherapists use of biofeedback was greater than female physiotherapists' use of this modality (p < 0.05).	Alberta; hence, the findings could not be representative of physiotherapists in both public and private sectors across Canada.
Pope et al. 1995 <sup>23</sup>	England	To study ownership and use of electrotherapy equipment	Senior physiotherapists in 139 hospitals in 14 regional health Authorities (RHAs), random sampling	Questionnaire Survey; (84%, n=116 hospitals)	More than one reply from each hospital. Total replies = 213. The reported ownership was US by 212 respondents, PSWD 209, CSWD 196, laser 196, interferential 207, TENS 209, biofeedback 176, MWD 178 and H-wave 173 respondents. Use with ownership was US 100%, PSWD 97%, CSWD 65%, laser 93%, interferential 99%, TENS 99%, biofeedback 94% and MWD 64% and H-wave 97%. Non-use despite ownership was PSWD by 3%, CSWD 35%, laser 7%, interferential 0.5%, TENS 1%, biofeedback 6%, MWD 36% and H-wave 3%. Reasons for non-use despite ownership for US	No exact sample size of physiotherapists reported. Report of final response rate was not clear as to whether response was a hospital or a physiotherapist. Figures on ownership and use / non-use were not clearly reported. No explanation of unfamiliarity with some modalities given. Some of the hospitals provided more than one response.

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					were not reported. Most common reasons for not purchasing CSWD, laser, biofeedback, MWD and H-wave equipment were unfamiliarity with the modalities, lack of clinical evidence and high cost.	
Kitchen and Partridge 1996 <sup>30</sup>	England	Survey of availability and frequency of use US, SWD and laser for treating of soft tissue lesions (Part-1)	Physiotherapists, N = 111 (in 14 NHS outpatient departments, one each in 14 health services regions), stratified random sampling	Postal Questionnaire Survey; (89%, n=99). Responses analyzed = 98	Availability of equipment of US (pulsed and continuous) was 100%, PSWD 98%, CSWD 85% and laser 33%. Frequency of use more than once per week: pulsed US 76%, continuous US 56%, PSWD 76%, CSWD 16% and laser 32%. Overall, laser was used by 97% of (i.e. 32 out of 33) physiotherapists with access to it. Physiotherapists preferred the use of non-thermal modalities (PSWD) to thermal modalities (CSWD) in treating a variety of soft tissue lesions at the NHS outpatients departments.	A very high response rate was achieved but the participants were only those physiotherapists who used electrotherapy and not every physiotherapist working in a participating department; hence, the findings might be less representative. Moreover, the focus of this study was on the types of soft tissue lesions and not on the types of electrotherapy modalities.
Seymour and	Trent	Survey of	Physiotherapists	Postal	Of respondents, 92% were female,	No report on how many

Kerr 1996 <sup>31</sup>	region, England	community based physiotherapists	(community based in Trent RHA); N = 150	Questionnaire Survey; (65%, n=97)	54% were aged 31-40. The workload for 57% physiotherapists was 6-10 patients/day. Use of electrotherapy modalities by physiotherapists was 73% for US, 3% for PSWD, 30% for interferential and 44% for TENS. 97% of physiotherapists received in-service training, usually once each month.	participants had access to electrotherapy equipment and how many did not use the equipment despite availability. This was another example of a local study representing the area covered by a health authority in the north of England. Only public sector community physiotherapists were involved providing limited information of physiotherapists' practices within the wider geographical boundaries of the Trent RHA.
Kitchen and Partridge 1997 <sup>32</sup>	England	Study of use of US, SWD and laser for management of soft tissue lesions (Part-2)	Physiotherapists, N = 111 (in 14 NHS outpatient departments, one each in 14 health services regions) stratified random sampling	Postal Questionnaire Survey; (89%, n=99). Responses analyzed= 98	The pattern of availability and use of US, PSWD, CSWD and laser was the same as reported in the above mentioned study by Kitchen and Partridge (1996) <sup>31</sup> , which was part-1 of this study. In addition, this article reported a number of factors affecting selection of electrotherapy	This was Part II of Kitchen and Partridge (1996) study; hence, our comments are the same as those reported above for the said study.

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					<p>modalities for treating different types of soft tissue lesions. Description of these lesions and factors is out of the scope of this review; hence not reported here.</p>	
Robertson and Spurrirt 1998 <sup>33</sup>	Tasmania and Victoria, Australia	Study of the availability and use of electrophysical modalities	Physiotherapy facilities (general hospitals, private practices, community clinics and rehabilitation centres); N =206	Postal Questionnaire Survey; (78%, n = 160)	<p>Availability of EPA: US 96%, SWD 52% (which included 36% for CSWD and 38% for combined PSWD and CSWD), laser 12%, interferential 77%, TENS 86%, biofeedback 32%, and MWD 7% of facilities. Use of modalities was US 100%, combined PSWD and CSWD 70%, only CSWD 86%, laser 100%, interferential 66%, TENS 96% and MWD 75%. Frequency of use of 'at least daily' was 81% for US, 51% for combined PSWD and CSWD, 43% for CSWD, 70% for laser, 53% for interferential and 83% for MWD. Most common frequency of use of 'at least monthly' was for TENS in 50% of facilities.</p>	Study targeted facilities with placements for physiotherapy students but no clear sampling method was reported. This sampling strategy may bias reporting the availability / use of electrotherapy modalities compared to other facilities without placements. There was no report of the number of devices for each modality at each facility. Nevertheless, this study had a high response rate and most of the electrotherapy modalities were covered.

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					<p>Three most common reasons for using US, interferential and TENS were: known effects, ease of application and availability. Availability of alternative method and safety were two of the most common reasons for non-use.</p>	
Partridge and Kitchen 1999 <sup>34</sup>	England and Wales (UK)	<p>Phase-I: Adverse health of electrotherapy in patients)</p> <p>Phase-II: Adverse health in patients with neurological conditions</p>	<p>Physiotherapy departments in NHS hospitals; N = Phase-I = 200; Phase-II= 145</p>	<p>Postal Questionnaire Survey: (Phase I: 74%, n=148); Phase II: 80%, n=116)</p>	<p>Phase-I did not report availability or use of EPAs. Adverse health due to use of modalities reported for patients and not relevant here. Phase-II found 52% of physiotherapists working in neurology were in senior 1 grade. 70% did not use electrotherapy in neurological conditions. Use of electrotherapy during previous year was reported by 55% for US, 8% for SWD, 7% for laser. 14% for interferential and 58% for TENS. Remaining participants did not use these modalities.</p>	<p>Focus on health effects in patients; therefore, less relevant to this review. However, it provided some data on the use of EPAs. Use of SWD was reported but no details of PSWD and CSWD given. Study provided little information on electrotherapy modalities overall.</p>

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Cooney et al. 2000 <sup>35</sup>	Republic of Ireland	Study of availability and use of electrotherapy modalities in public and private physiotherapy practices	Physiotherapists; N = 120 (public = 40 and private =80)	Postal Questionnaire Survey; (Total =72%, n=86; public sector = 88%, n=35; private practitioners = 64%, n=51)	Availability of equipment was US 95%, PSWD 39%, CSWD 37%, laser 38%, interferential 98%, TENS 97%, biofeedback 3%, MWD 6% and H-wave 2%. Availability of PSWD, CSWD, laser, TENS, biofeedback and MWD equipment was higher in public sector practices while US, interferential and H-wave equipment was higher in private practices. US, Interferential and TENS were used by 100% of facilities. Frequency of use of '2-3 days/ week' was 90% for US, 53% for PSWD, 10% for CSWD, 59% for laser, 95% for interferential, 15% for TENS while MWD was used least. Non-use was higher in the public sector. Wishing to purchase equipment was reported by 8% for US, 18% for PSWD, 41% for laser and 11% for TENS. There was no desire to purchase MWD or H-wave due to	The sample size was small, particularly for public sector physiotherapists; thus, limiting the generalizability of findings. The reasons for selection or non-use of the surveyed modalities were not reported. None of the modalities was reported to have ceased to be used. However, the study provided better information on purchase of equipment although it was difficult to know the exact status of device ownership.
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					these being superseded by other modalities. Cost was the main consideration for not buying PSWD, CSWD and laser in private practices.	
Shields et al. 2001 <sup>36</sup>	Republic of Ireland	Survey of the availability, use, age, non-use and intention to purchase PSWD and CSWD	Physiotherapy facilities; N =240 (82 hospital departments and 158 private practices)	Postal Questionnaire Survey; (Total = 96%, n=231; hospital departments = 95%, n=78; private practices = 97%, n=153)	Availability of SWD: 65% in hospital departments (CSWD and PSWD in 54%) and 12% in private practices (CSWD in 5%, PSWD in 4%). Non-use despite availability was 12% of hospital departments and 33% of private clinics. The number of available devices was 1-3 devices/department; one device/department in 51% of hospital departments and 92% of private practices. SWD devices were <10 years old in 43% of hospital departments and 46% of private practices. Among 35% of hospital departments and 89% of private practices with no SWD devices, reasons for non-purchase included	A high response rate, which provides results that are the most representative and more generalizable. However, only SWD was covered. No details on safety issues (neither for patients nor for physiotherapists) were reported; however, the issue of evidence on clinical effectiveness of SWD (both PSWD and CSWD) was raised.

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					nature of the patients, lack of space, cost, lack of evidence for clinical efficacy and safety concerns. In hospitals, SWD servicing and quality control testing were carried out in 53% and 49% respectively, most commonly every six months by external contractors. In private clinics, servicing (58%) and quality control testing (50%) were carried out generally less than once a year by an external contractor.	
Shields et al. 2002 <sup>37</sup>	Republic of Ireland	Study of safety issues and clinical effectiveness of PSWD and CSWD	Senior physiotherapists; N= 116 (in 41 hospital departments)	Postal Questionnaire Survey; (75%, n =87), Responses analyzed = 83	Approximately 65% of participants were senior physiotherapists, with mean time since qualification of 12 years. Equipment availability was US 99%, PSWD 94%, CSWD 93%, laser 63%, interferential 100% and TENS 99%. 'Frequent or often' use was reported by 91% for US, 45% for PSWD, 21% for CSWD, 76% for laser, 73% for interferential and 58% for	Reported total response rate was 75% (n=87); however, only 83 responses were analyzed; hence, the effective response rate of this study was 72%. This reduced response rate was not reported. Reporting of electrotherapy equipment availability was given in percentages with no actual number of departments. It was

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				<p>TENS. Non-use despite availability was 12% for PSWD, 44% for CSWD, 12 % for laser and 1% for interferential. No respondent reported non-use for US and TENS. The mean period for using PSWD and CSWD was 10 (<math>\pm 6</math>) and 14 (<math>\pm 9</math>) years respectively. PSWD and CSWD were not used in 10% (n=9) of departments. The majority used capacitive method and air space drums during SWD. Measures for physiotherapists' safety included keeping a distance of 3m between SWD equipment and metallic objects, no use of other modalities within the same vicinity, a separate room for SWD treatment, notification of SWD use to other physiotherapists particularly pregnant colleagues and advice to therapists to leave the room during the treatment.</p>	<p>therefore difficult for reviewers to ascertain whether the total completed / returned surveys or the total analyzed surveys were included. No information on the frequency of use of electrotherapy by a physiotherapist per day or per week. The study largely addressed operator safety issues, and provided valuable discussion on safety issues and raised concerns regarding a lack of adherence to physiotherapists' safety guidelines.</p>
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					However, taking no measures for physiotherapists' safety was reported by 30% of respondents.	
Warden and McMeeken 2002 <sup>38</sup>	Victoria, Australia	To assess the availability, frequency of use and dose of ultrasound in treating sports injuries	Physiotherapists (in sports injuries); N = 355	Postal Questionnaire Survey; (48%, n=171)	There were 60% male respondents (n=102). Median experience (10 years) and workload of 15 patients / day. US devices were available to all respondents. The most common pattern of use was 'at least daily' (84%, n=143). Treatment with US = 25% of total patients; 4 patients / day (median figures). The main factors in deciding dose of US were training during graduate degree (83%) and experience (76%). Of respondents, 72% reported a lack of research evidence for US therapy.	The response rate was comparatively low and only sports physiotherapists were selected suggested a source of bias in favour of champions for providing US therapy for sports injury. Therefore, the findings cannot be representative of US usage in physiotherapy practice in Australia as a whole.
Chipchase and Trinkle 2003 <sup>39</sup>	Southern Australia	To determine the frequency and trends of use and effectiveness of US	Physiotherapists (special interest in musculoskeletal); N = 380 (public	Postal Questionnaire Survey; (55%, n=210)	Once/day and an average of 33% ( $\pm 2$ ) of treatments involved US therapy. The four most frequently used EPAs were US, interferential, CSWD and TENS. Healing of tissues	The response rate was moderate. The study involved both private and public sector physiotherapists but the breakdown was not reported.

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			and private)		and thermal effects were two main reasons for using US.	The frequency of use was calculated by the number of patients / week treated with US, not by the actual number of sessions of US therapy. This study involved only physiotherapists <i>interested</i> in musculoskeletal injuries. No details given about the number of respondents who were <i>actually</i> working in musculoskeletal physiotherapy. The findings may not be representative of all physiotherapists working in (Southern) Australia.
Al-Mandeel and Watson 2006 <sup>40</sup>	England (North)	Use of PSWD	Patient records; N = 1750 patient files in 8 hospitals	Audit; (response rate = Not applicable)	Total number of patients treated with PSWD = 192. Treatments with PSWD = mean 11% (range 8%-13%). Treatment time = mean 12 (range 5-20) minutes/session. Frequency of PSWD use: 1/week = 76%, 2x/week = 20%, 3x/week = 5%.	This clinical audit determined PSWD use through patients' case notes, finding only a small percent of patients treated with PSWD; no information as to whether PSWD equipment was available but not used or not

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						available. This audit provided valuable information on duration of PSWD treatment although information was incomplete in the majority of patient files.
Tabasam and Johnson 2006 <sup>41</sup>	England (North)	Use of interferential for pain management	Physiotherapists; N = all physiotherapists in 4 hospitals	Postal Questionnaire Survey, (Not stated)	Interferential use by 91% (n=57). Frequency of use: 63% (n=36), used for pain relief: 61% (n=35) of which 71% treated less than 25% of total clinic patients. Average treatment time with interferential was between 11 and 20 minutes.	This small regional study, involved physiotherapists from only 4 hospitals. Neither the actual sample size nor the response rate reported. It was the only study that focused on interferential use but only in pain management. The findings on interferential use very specific but did not represent overall pattern of use of this modality. No details about non-availability and non-use reported.
Shah et al. 2007 <sup>16</sup>	England (Southeast and Southwest)	The availability and use of electrotherapy equipment	NHS Physiotherapy departments (N=46), random	Postal Questionnaire Survey (100%)	Availability of equipment: US 100%, PSWD 93.5%, CSWD 30.4%, laser 50%, interferential 95.7%, TENS 82.6%, biofeedback 84.8%, MWD 0%	Response rate excellent but sample size moderate. Involved only NHS physiotherapy departments and clinics located

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	including London)				<p>and H-wave 6.5%.</p> <p>Use: US 80.4%, PSWD 69.6%, CSWD 8.7%, laser 37%, interferential 76.1%, TENS 60.9%, biofeedback 65.2%, MWD 0% and H-wave 2.2%.</p> <p>Non-use despite availability: US 0%, PSWD 15.2%, CSWD 89.1%, laser 52.2%, interferential 4.3%, TENS 17.4%, biofeedback 17.4%, MWD 0% and H-wave 93.5%.</p> <p>Available but no information about use: US 19.6%, PSWD 15.2%, CSWD 2.2%, laser 10.9%, interferential 19.6%, TENS 21.7%, biofeedback 17.4%, MWD 0% and H-wave 4.3%.</p> <p>None availability was US 0%, PSWD 6.5%, CSWD 69.6%, laser 50%, interferential 4.3%, TENS 17.4%, biofeedback 15.2%, MWD 100% and H-wave 93.5%.</p>	<p>in Southeast and Southwest England including London.</p> <p>Showed a regional trend.</p> <p>Findings might not be representative of the whole NHS.</p>
Wong et al. 2007 <sup>42</sup>	USA (Northeast	Use of therapeutic ultrasound	Physiotherapists (orthopaedic	Postal Questionnaire	60% of physiotherapists reported likely to use US for ≥25% of patients	Response rate was moderate and this study involved

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	and Mid-Atlantic regions)		specialists); N = 457	Survey;; (45.3%, n=207)	and 40% reported unlikely to use US for ≤10% of patients. 50% reported US as clinically important, 35% reported as not important and 15% would not use US.	physiotherapists from only one specialist group (i.e. orthopaedic specialists). Therefore, the findings cannot represent US usage by all physiotherapists in the survey regions in the USA. Moreover, the usage was reported only for pain, (soft) tissue inflammation, healing, swelling and scar remodelling. The clinical importance was also studied with respect to the conditions above, but there was no information about the overall effectiveness of US in physiotherapy practice. Therefore, findings cannot be generalized to overall physiotherapy practice.
Chipchase et al. 2009 <sup>18</sup>	Australia	Availability and usage of EPAS	Physiotherapists; N = 12893	Postal Questionnaire Survey; (27%,	Availability of equipment: US 90%, PSWD 11%, CSWD 12%, laser 32%, interferential 72%, TENS 82%,	Sampling of participants was limited to those physiotherapists who had consented to release of

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				n = 3538)	biofeedback 52% and MWD 2%. Daily use: US 37%, PSWD 1%, CSWD 2%, laser 5%, interferential 24%, biofeedback 8%, and MWD 0.2%. Non-use despite equipment availability: US 22%, PSWD 96%, CSWD 95%, laser 81%, interferential 24%, TENS 30%, biofeedback 58% and MWD 99%.	their contact details; the response rate was therefore very low. Thus, major limitations to the generalizability of findings applicable to Australia as a whole. The study did not cover all modalities, e.g. H-wave was not surveyed. No reasons were stated for non-use despite availability of equipment and no implications were discussed for widespread non-use of available equipment.
Scudds et al. 2009 <sup>43</sup>	UK and Hong Kong (HK)	Use and effectiveness of TENS compared to other EPAs in pain treatment	Physiotherapists; N =1200 (600 each from the UK and HK), random sampling	Postal Questionnaire Survey; (Overall 34.7%, n=416; UK =35%, n=211; HK =34%, n=205)	Usage of electrotherapy modalities for pain management was US 86%, SWD 50%, laser 48%, interferential 78% and TENS 98% in HK and US 72%, SWD 24%, laser 22%, interferential 64% and TENS 79% in the UK.	Sample was randomly selected but response rate was low. The generalizability of findings limited due to participants comprising <1% of the total registered physiotherapists in the UK and only 9% of those in Hong Kong. The data on the use of EPAs was presented only in graphical format: the reviewers'

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						determining the % of use by viewing the graph. No breakdown of SWD into separate use of PSWD and CSWD. Authors' emphasis was on differences rather than similarities between practices in the two countries. The study determined use of selected EPAs for only one medical issue i.e. pain.
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## FINDINGS

The types of electrotherapy modalities that were investigated in 23 studies included in this literature review are shown in Table 2.

The extracted data revealed that 12 (52.2%) studies were published during the 1990s and 11 (47.8%) studies were published in the 2000s. All of these studies were conducted in English speaking countries: Australia (n=6), Canada (n=1), England (n=8), England and Wales (UK) (n=1), Hong-Kong and UK (n=1), Northern Ireland (UK) (n=1), Republic of Ireland (n=3), and the USA (n=2). The identification of studies conducted in only English speaking countries was probably due to selection of language as English. This literature review revealed that most of these studies were conducted within a regional context such as a study by Lindsay et al.<sup>24</sup> conducted in Brisbane, Australia; a study by Lindsay et al.<sup>29</sup> in the province of Alberta, Canada; a study by Seymour and Kerr<sup>31</sup> in the Trent region, England; a study by Tabasam and Johnson<sup>41</sup> in North England and a study by Wong et al.<sup>42</sup> in the Northeast and mid-Atlantic regions of the USA.

This literature review found that the 'cross sectional survey' design with a postal questionnaire was the method most used. However, Kitchen<sup>28</sup> used face-to-face interviews for their survey and Al-Mandeel and Watson,<sup>40</sup> who conducted an audit, reviewed patients' case files/records to extract the data on the use of electrotherapy. In the reviewed studies, research participants were physiotherapists; however, physiotherapy departments through their representatives were also recruited as participants in some studies.<sup>24, 33, 34, 36</sup> Most of the studies involved physiotherapists working in the public sector while a few studies<sup>24, 29</sup> involved only private practitioners. Physiotherapists working in both private and public sectors were involved in some studies.<sup>28, 33, 35, 36, 39</sup> In addition, this review revealed that some studies involved specialized physiotherapists for particular clinical conditions. For example, a study by Taylor and Humphry<sup>26</sup> involved physiotherapists specialized in physical disabilities; Seymour and Kerr<sup>31</sup> involved only community physiotherapists; Warden and McMeeken<sup>38</sup> involved physiotherapists interested in sports injuries; Shields et al.<sup>37</sup> involved only senior physiotherapists; Chipchase and Trinkle<sup>39</sup> included physiotherapists interested in the musculoskeletal field and Wong et al.<sup>42</sup> involved physiotherapists specialized in orthopaedics. Moreover, a few studies investigated the use of electrotherapy in treating particular medical conditions. For example, the use of EPAs in the management of pain was studied by Tabasam and Johnson<sup>41</sup> and Scudds et al.<sup>43</sup>

In the reviewed studies, the sample sizes varied from 10 participants<sup>28</sup> to a maximum of 12,893 participants.<sup>18</sup> However, a few studies did not provide the exact sample size. For example, Wong et al.<sup>42</sup> did not provide any information on their sample size while Lindsay et al.<sup>29</sup> reported their sample size as 'all private practitioners registered in Alberta, Canada' and did not provide the exact number of the private practitioners. The response rate also varied widely in the reviewed studies from 27%<sup>18</sup> to the highest response rate at 99.3%.<sup>36</sup>

The findings of this literature review showed that some studies investigated only one electrotherapy modality such as therapeutic ultrasound studied by Warden and McMeekan,<sup>38</sup> Chipchase and Trinkle<sup>39</sup> and Wong et al.,<sup>42</sup> PSWD by Al-Mandeel and Watson,<sup>40</sup> interferential by Tabasam and Johnson<sup>41</sup> and laser by Baxter et al.<sup>25</sup> and McMeekan and Stillman.<sup>27</sup> Shields et al.<sup>36, 37</sup> studied two shortwave modalities i.e. PSWD and CSWD. The remaining studies investigated more than two electrotherapy modalities. Only three studies i.e. Pope et al.,<sup>23</sup> Cooney et al.,<sup>35</sup> and Shah et al.<sup>16</sup> studied several modalities including US, PSWD, CSWD, MWD, TENS, interferential, biofeedback, laser and H-wave (Table 2).

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Table 2 Types of electrotherapy modalities investigated in the reviewed studies

<i>Study / Reference</i>	<i>Year</i>	<i>Country / Location</i>	<i>US*</i>	<i>PSWD</i>	<i>CSWD</i>	<i>Laser</i>	<i>IFT*</i>	<i>TENS</i>	<i>BFD*</i>	<i>MWD</i>	<i>H-wave</i>
Lindsay et al. <sup>24</sup>	1990	Australia (Brisbane)	✓	✓	✓	✓	✓	✓	✓	✓	
Baxter et al. <sup>25</sup>	1991	Northern Ireland				✓					
Taylor and Humphry <sup>26</sup>	1991	USA	✓				✓	✓			
McMeeken and Stillman <sup>27</sup>	1993	Australia (Victoria)				✓					
Kitchen <sup>28</sup>	1995	England	✓	✓	✓	✓					
Lindsay et al. <sup>29</sup>	1995	Canada (Alberta)	✓	✓	✓		✓	✓	✓		
Pope et al. <sup>23</sup>	1995	England	✓	✓	✓	✓	✓	✓	✓	✓	✓
Kitchen and Partridge <sup>30</sup>	1996	England	✓	✓	✓	✓					
Seymour and Kerr <sup>31</sup>	1996	England (Trent region)	✓	✓				✓			
Kitchen and Partridge <sup>32</sup>	1997	England	✓	✓	✓						
Robertson and Spurrirt <sup>33</sup>	1998	Australia	✓	✓	✓	✓	✓	✓	✓	✓	
Partridge and Kitchen <sup>34</sup>	1999	England and Wales	✓	✓		✓	✓	✓			
Cooney et al. <sup>35</sup>	2000	Republic of Ireland	✓	✓	✓	✓	✓	✓	✓	✓	✓
Shields et al. <sup>36</sup>	2001	Republic of Ireland		✓	✓						
Shields et al. <sup>37</sup>	2002	Republic of Ireland		✓	✓						
Warden and McMeeken <sup>38</sup>	2002	Australia (Victoria)	✓								
Chipchase and Trinkle <sup>39</sup>	2003	Australia (South)	✓								
Al-Mandeel and Watson <sup>40</sup>	2006	England		✓							
Tabasam and Johnson <sup>41</sup>	2006	England (North)					✓				
Shah et al. <sup>16</sup>	2007	England (South)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wong et al. <sup>42</sup>	2007	USA (Northeast/Mid-Atlantic regions)	✓								
Chipchase et al. <sup>18</sup>	2009	Australia	✓	✓	✓	✓	✓	✓	✓	✓	
Scudds et al. <sup>43</sup>	2009	Hong Kong and UK	✓	✓	✓	✓	✓	✓			

\*US = ultrasound, IFT =interferential, BFD= Biofeedback

The findings of our literature review regarding the trends in the availability and non-availability as well as use and non-use despite availability of nine electrotherapy modalities are presented, in the order of high to low number of studies that investigated these modalities, in the following sub-sections.

### ***Ultrasound (US)***

Ultrasound was the most commonly studied modality in the reviewed literature. This modality was reported in 17 out of 23 studies (73.9%) included in this review.

Four studies<sup>26, 38, 39, 42</sup> investigated only ultrasound and 13 other studies investigated ultrasound along with other modalities (Table 2). However, not all the studies reported statistics on the variables 'availability', 'use', 'non-use despite availability' and 'non-availability' of this electrotherapy modality. For example, Taylor and Humphry<sup>26</sup> and Syemour and Kerr<sup>31</sup> did not report data on the availability and non-availability whereas Kitchen<sup>28</sup> did not report data on 'use' and 'non-use despite availability'. In addition, Scudds et al.<sup>43</sup> did not report statistics on all these four variables and provided data on use of only ultrasound in comparison to other EPAs for pain management. Moreover, Pope et al.<sup>23</sup> reported the number of physiotherapists (n=212) who had access to ultrasound equipment; therefore we determined by the calculation method explained in the last paragraph of the methods section that the availability of ultrasound was 99.5% in their study. Data on the availability and use of ultrasound extracted from the reviewed studies showed that the availability of this modality was very high between 1990 and 2009; however, the availability of ultrasound started to decline more recently (Figure 2).

The use of ultrasound was high i.e. between 70% and 100% but fitting of a linear trend line showed a declining trend in the use of this modality, especially from 2003 to 2009. Non-use despite availability of this modality was low but it showed an increasing trend. Similarly, non-availability of this modality was very low from 1990 but it rose to 10% in 2009 (Figure 2).

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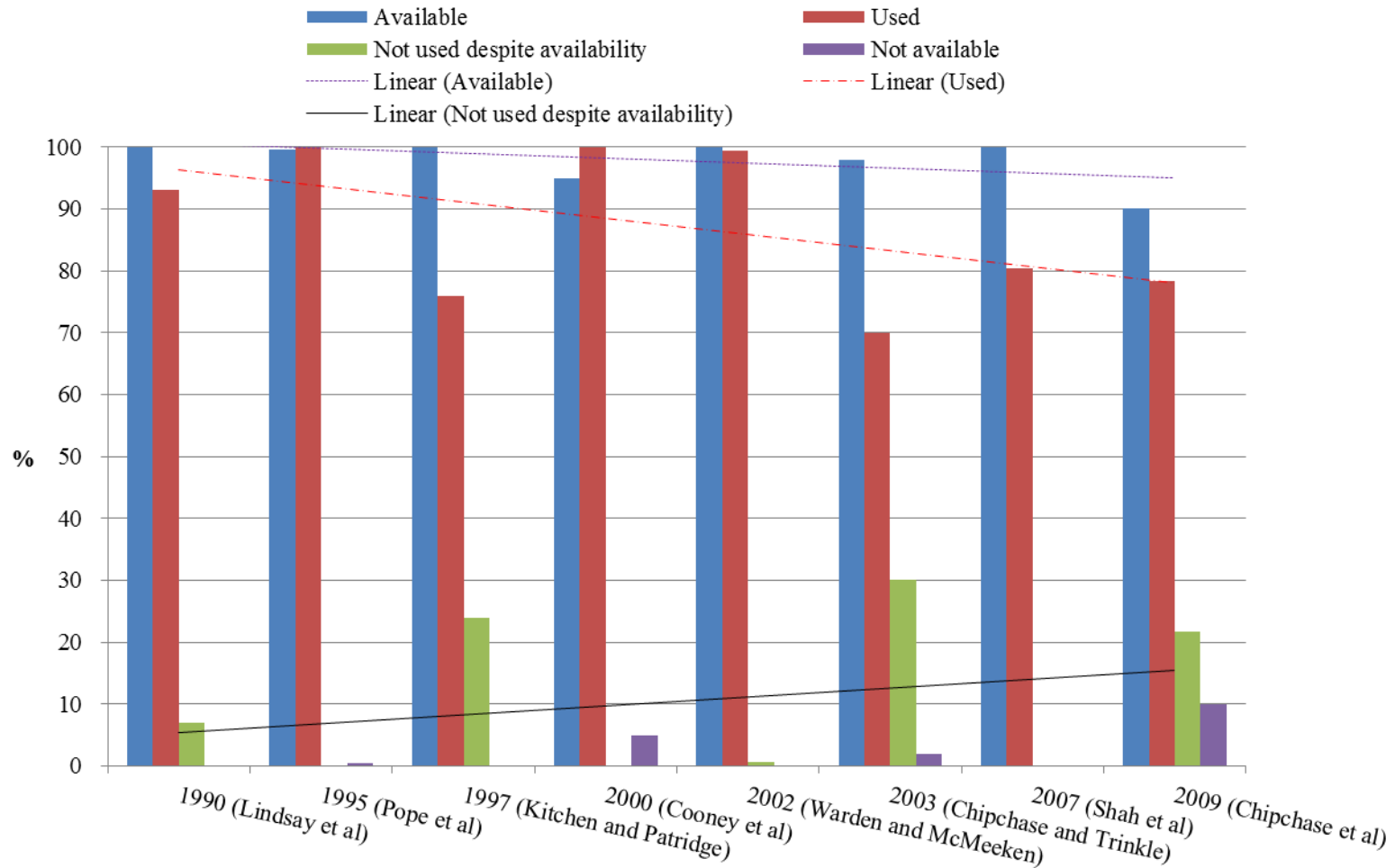


Figure 2 Availability, use, non-use and non-availability of ultrasound (1990 to 2009)

### ***Pulsed shortwave diathermy (PSWD)***

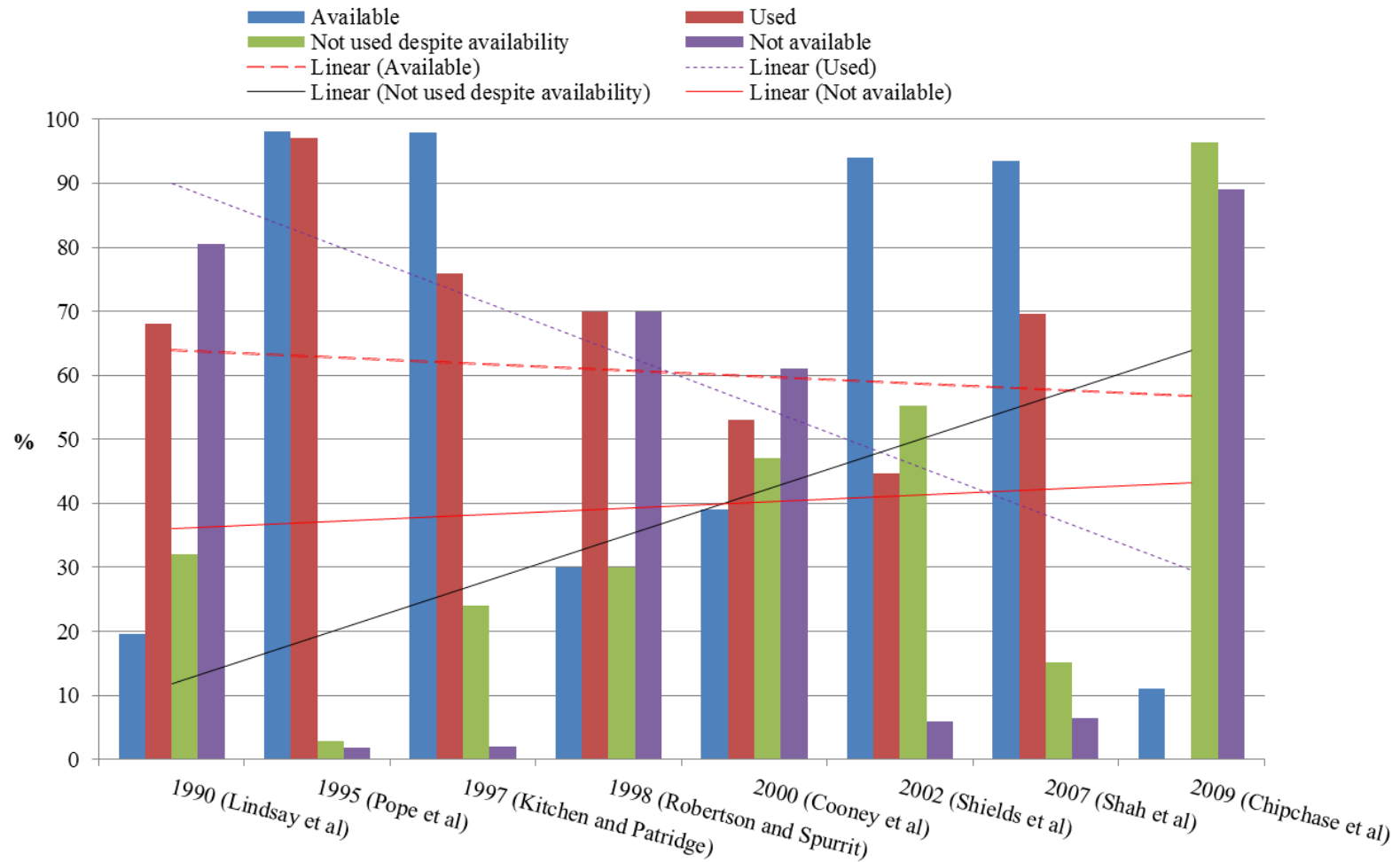
Pulsed shortwave diathermy (PSWD) was also one of the most commonly studied electrotherapy modalities in the reviewed literature. This modality was investigated in 16 out of 23 studies (69.6%) included in this literature review. Study of only PSWD was conducted by Al-Mandeel and Watson<sup>40</sup>, two studies by Shields et al.<sup>36, 37</sup> investigated the PSWD modality along with continuous shortwave diathermy (CSWD) while in the remaining studies (n=13) PSWD was studied in conjunction with other modalities (Table 2). A few of these studies did not report data on all or some of the four variables i.e. 'availability', 'use', 'non-use despite availability' and 'non-availability' for this modality. For example, study by Lindsay<sup>29</sup> and Syemour and Kerr<sup>31</sup> did not report on the four variables above while Kitchen<sup>28</sup> reported data only on the availability of this modality. Scudds et al.<sup>43</sup> reported data on the use but for combined shortwave diathermy (SWD); hence, it was not possible to extract data for only PSWD from their study. In addition, Pope et al.<sup>23</sup> reported only the number of physiotherapists (n=209) having access to PSWD equipment. We therefore, calculated that the availability of PSWD was 98.1% in the study by Pope et al.<sup>23</sup>

Data on the availability and use of PSWD extracted from the reviewed studies (presented in Figure 3) revealed that the availability of this modality was highly variable with highest (>90%) availability during 1995, 1997 and 2002 while the lowest availability (11%) was reported in 2009. The highest (97%) use of PSWD was reported in 1995 by Pope et al.<sup>23</sup>; however, the use of this modality started declining afterwards. In 2002, the use of PSWD was 45%<sup>37</sup> and in 2009, the use of this modality was less than 1% reported by Chipchase et al.<sup>18</sup> Fitting of linear trend lines across the abstracted data on the availability and use of PSWD revealed considerable declining trends in the availability and use of this modality (Figure 3).

The non-use despite availability of PSWD varied from 3% in 1995,<sup>23</sup> 55% in 2002<sup>37</sup> to 96% in 2009.<sup>18</sup> The non-availability of this modality was fluctuating. In 1990, it was 81%,<sup>24</sup> in 1995 it was 2%,<sup>17, 23</sup> in 2006 the percentage increased to 6%<sup>37</sup> and in 2009 it was 89%.<sup>18</sup> Linear trend lines fitted across the non-use despite availability and the non-availability data for this modality showed a rising trend for both of these parameters of PSWD (Figure 3).



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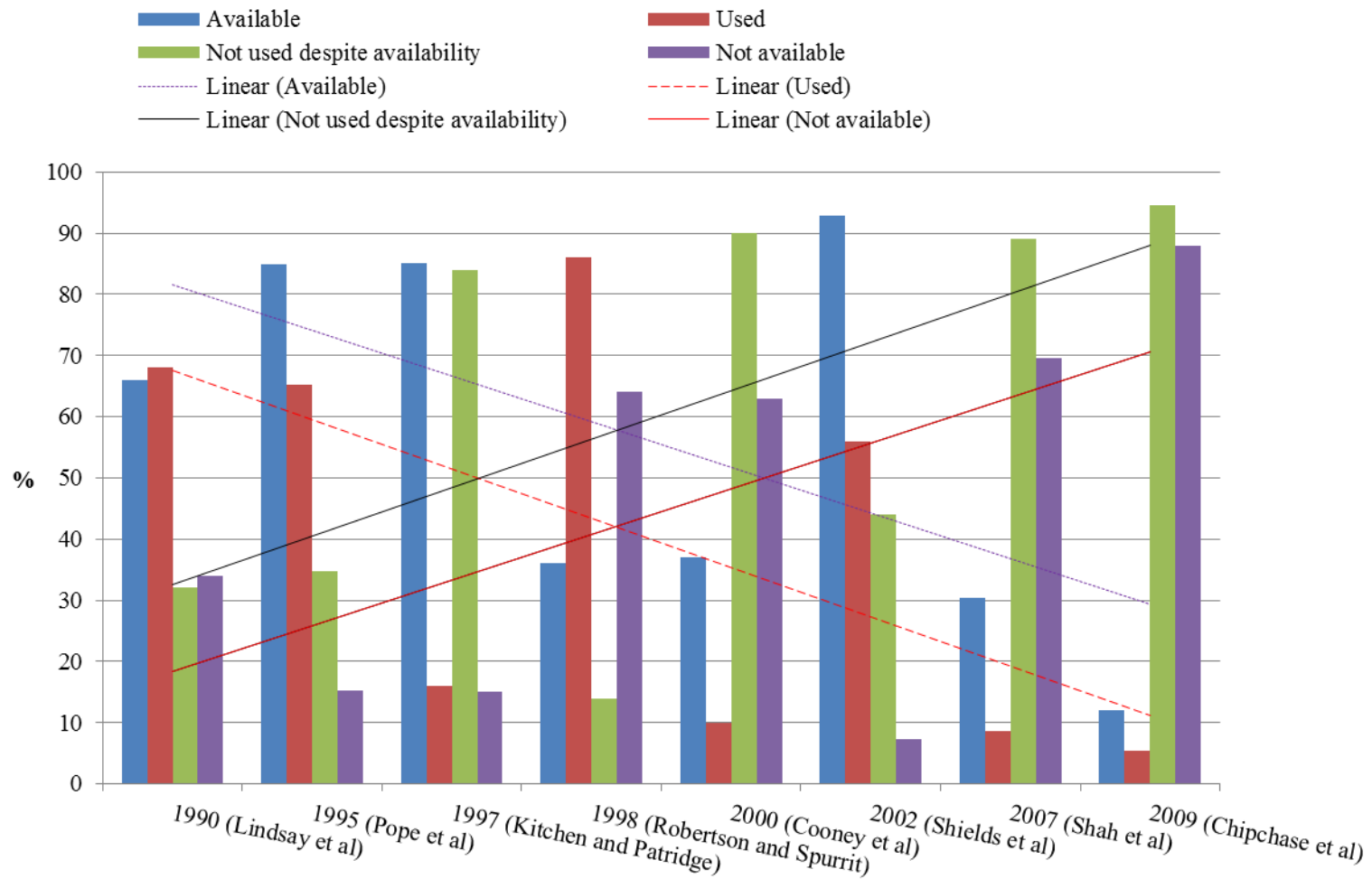
pre-pub. Figure 3 Availability, use, non-use and non-availability of PSWD (1990 to 2009)

### ***Continuous shortwave diathermy (CSWD)***

Continuous shortwave diathermy was another commonly studied electrotherapy modalities in the reviewed literature. CSWD was not studied as a single modality in any of the studies included in this review. However, CSWD was studied in conjunction with other modalities (Table 2). This modality was investigated in 14 out of the 23 studies (60.9%). This indicated that the number of studies of CSWD was lower than the number of studies that investigated ultrasound and PSWD (Table 2). It is also important to point out that a few studies did not provide data on the 'availability', 'use', 'non-use despite availability' and 'non-availability' of this modality. For example, a study by Lindsay<sup>29</sup> did not report extractable data on all of the above four variables with respect to CSWD. Kitchen<sup>28</sup> did not report data on 'use' and 'non-use' of CSWD despite equipment availability. Scudds et al.<sup>43</sup> reported data on the use of combined shortwave diathermy; therefore, extraction of data for only CSWD was not possible from their study. As mentioned earlier, Pope et al.<sup>23</sup> reported only the number of physiotherapists (n=196) having access to CSWD equipment. As mentioned earlier, we therefore calculated the availability of CSWD as 85% in the study by Pope et al.<sup>23</sup>

Data on the availability and use of CSWD extracted from the reviewed studies (shown in Figure 4) revealed that the availability of this modality was very high i.e. about 85% during 1995<sup>23</sup> and 93% in 2002<sup>37</sup> while the lowest availability (12%) was reported in 2009.<sup>18</sup> The use of CSWD fluctuated considerably between 1990 and 2009. The highest use (86%) of CSWD was reported in 1998 by Robertson and Spurrirt,<sup>33</sup> which declined to 56% in 2002<sup>37</sup> and reached the lowest level (5%) in 2009.<sup>18</sup> Fitting of linear trend lines across the data on the availability and use of CSWD revealed considerable declining trends in both the availability and the use of this modality.

'Non-use despite availability' of this modality varied from 14% in 1998<sup>33</sup> to 44% in 2002<sup>37</sup> to 95% in 2009.<sup>18</sup> 'Non-availability' of CSWD was lowest (7%) in 2002<sup>37</sup> but it increased to 88% in 2009.<sup>18</sup> Linear trend lines fitted across the 'non-use despite availability' and the 'non-availability' data for CSWD showed a rising trend for both these parameters for this modality (Figure 4).

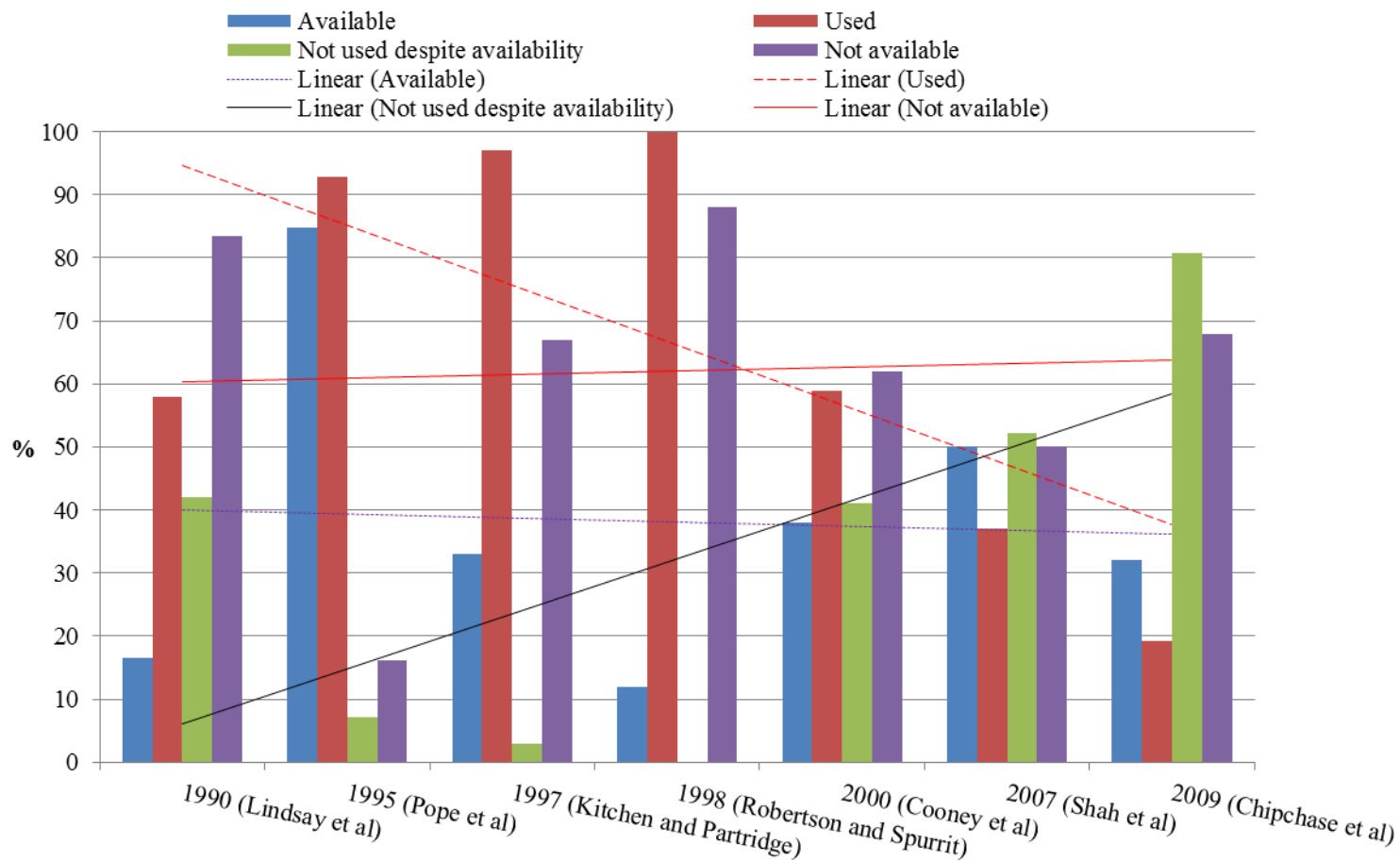


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Figure 4 Availability, use, non-use and non-availability of CSWD (1990 to 2009)

## **Laser**

Therapeutic laser was also one of the most commonly studied modalities in the reviewed literature. This modality was investigated in 13 out of 23 studies (56.5%) included in this literature review. Two studies<sup>25, 27</sup> investigated only laser while the remaining 11 studies investigated laser along with other electrotherapy modalities (Table 2). Nevertheless, the data for laser on all or some of the four variables (i.e. 'availability', 'use', 'non-use despite availability' and 'non-availability') were not provided in some of these studies. For example, studies by Baxter et al.<sup>25</sup> and McMeeken and Stillman<sup>27</sup> did not report extractable data on the above four variables with respect to laser. A study by Kitchen<sup>28</sup> reported data only on the availability of this modality but did not report data on the other three variables. Partridge and Kitchen<sup>34</sup> reported data on the 'use' and 'non-use' of laser but they did not report data on the 'availability' and 'non-availability'. As reported earlier regarding the study by Pope et al.,<sup>23</sup> we determined the availability of laser to be 84.8%. Data on the 'availability', 'use', 'non-use despite availability' and 'non-availability' of laser extracted from the reviewed studies (shown in Figure 5) indicated that the availability of this modality was highest (92%) in 1995.<sup>23</sup> However, it declined in the subsequent years. Therefore, the availability of this modality showed an overall declining trend (Figure 5).

The use of laser increased from 58% in 1990<sup>24</sup> to 100% in 1998.<sup>33</sup> However, its use decreased to 59% in 2000<sup>35</sup> and reached the lowest level of 19% in 2009.<sup>18</sup> Therefore, the use of laser overall showed a steady increasing trend from 1990 to 2000; however, data showed a slightly declining trend for laser use after 2000 (Figure 5). 'Non-use of laser despite availability' of equipment was 42% in 1990<sup>24</sup> but declined to 0% in 1998.<sup>33</sup> However, it increased to 41% in 2000<sup>35</sup>, almost doubling to 81% in 2009.<sup>18</sup> Consequently, the data for the 'non-use despite laser equipment availability' showed an increasing trend (Figure 5). The non-availability of laser fluctuated in the last twenty years; however, the data extracted from the reviewed studies revealed overall a slowly rising trend in the 'non-availability' of this modality (Figure 5).



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Figure 5 Availability, use, non-use and non-availability of laser (1990 to 2009)

## ***Interferential***

This literature review revealed that interferential modality was also one of the commonly studied electrotherapy modalities. This modality was investigated in 12 out of 23 studies (52.2%) included in this review (Table 2). A study by Tabasam and Johnson<sup>41</sup> studied only this modality while the remaining ten studies studied interferential along with other modalities (Table 2). It is important to point out that Tabasam and Johnson<sup>41</sup> studied treatment with interferential by auditing / reviewing patients' case files and they did not report statistics on the 'availability', 'use', 'non-use' and 'non-availability' of equipment with respect to this modality in physiotherapy departments. In addition, Taylor and Humphry<sup>26</sup> and Seymour and Kerr<sup>31</sup> reported data on the 'use' and 'non-use' of interferential but they did not report data on the overall 'availability' and 'non-availability' of this modality. Two further studies<sup>29, 34</sup> also did not report extractable data with respect to this modality. Pope et al.<sup>23</sup> reported the total number of physiotherapists (n=207) having access to interferential equipment and from this figure we determined the equipment availability of this modality to be 97% in the study by Pope et al.<sup>23</sup>

Data on the 'availability', 'use', 'non-use' and 'non-availability' of interferential extracted from the reviewed studies (presented in Figure 6) showed a slightly declining trend of the availability and use of interferential modality. Although the use of this modality increased from 90% in 1990 to 100% in 2000, it declined by about 25% in 2009 compared to 2000 (Figure 6). The lowest use of this modality was 66% in 1998.<sup>33</sup> The 'non-use' of interferential was highest (about 35%) in 1998<sup>33</sup> while the 'non-use' of this modality was reported zero by Cooney et al. in 2000<sup>35</sup> and Shan et al.<sup>16</sup> However, the 'non-use' of interferential again increased to 24% in 2009.<sup>18</sup> Similarly, the 'non-availability' of interferential equipment was 15% in 1990<sup>24</sup>, and decreased to 2% in 2000<sup>35</sup> but it increased again and reached 28% in 2009.<sup>18</sup> Therefore, the 'non-availability' of interferential equipment revealed an overall increasing trend (Figure 6).

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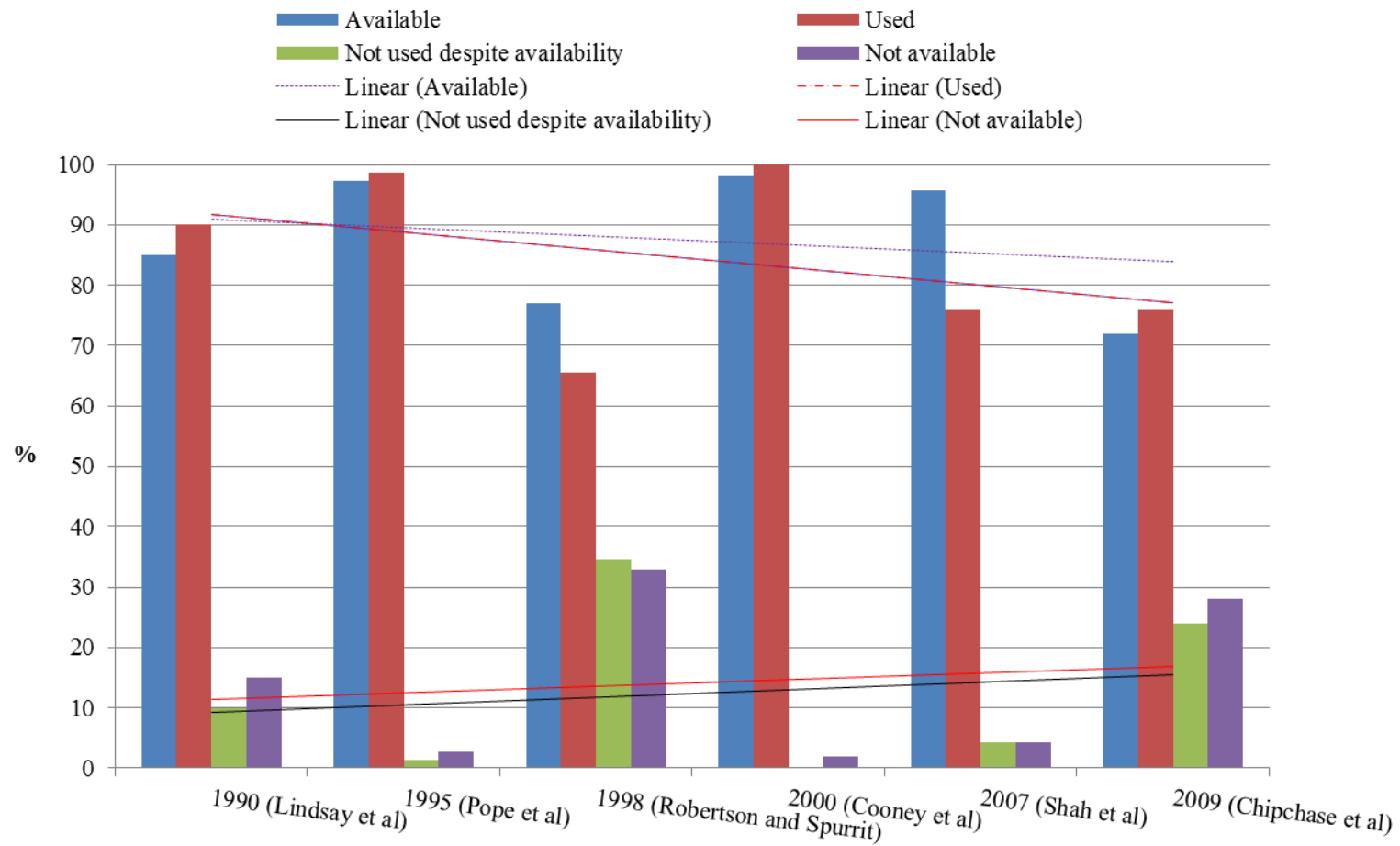


Figure 6 Availability, use, non-use and non-availability of interferential (1990 to 2009)

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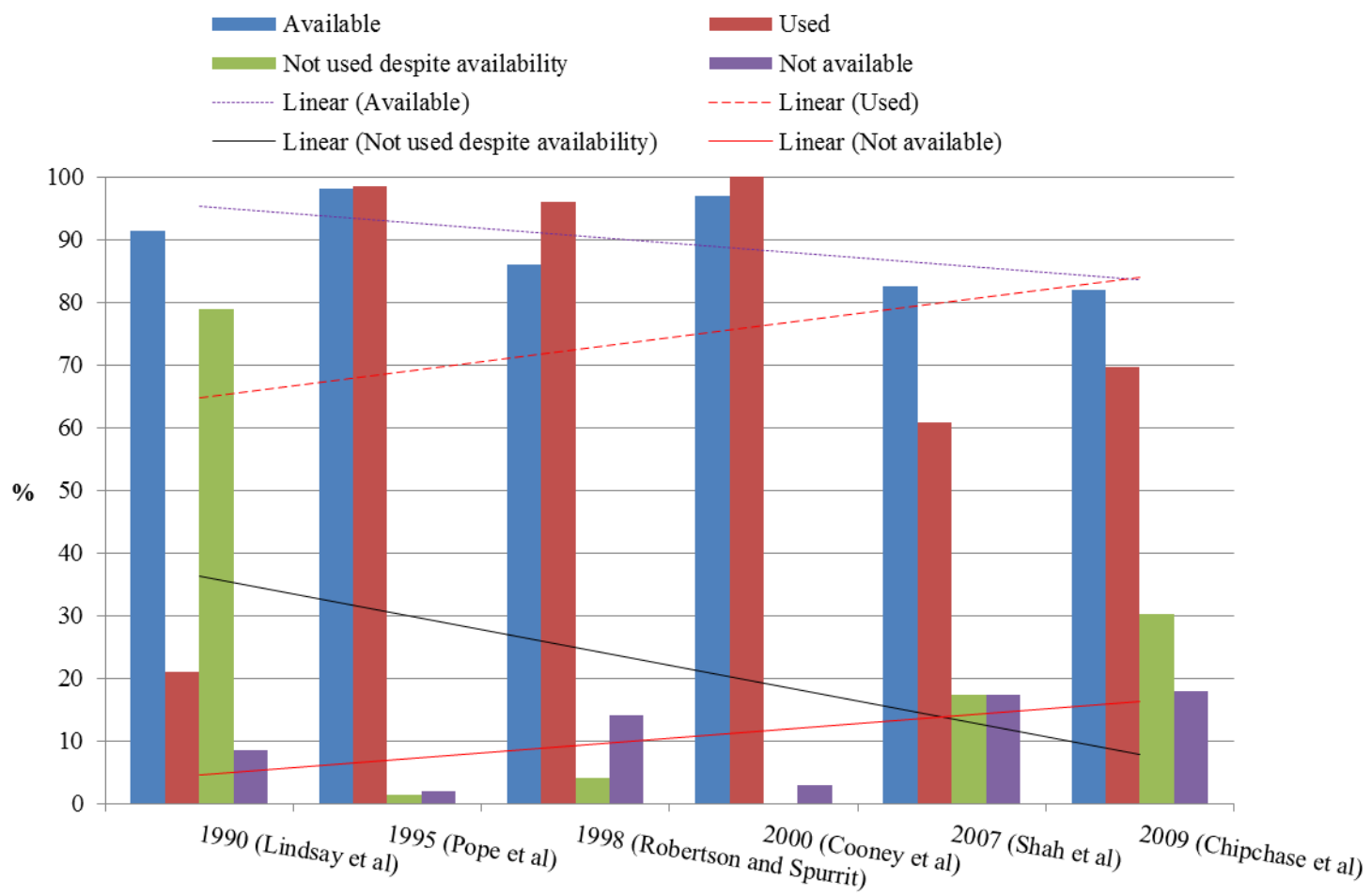
### ***Transcutaneous electrical nerve stimulation (TENS)***

Transcutaneous electrical nerve stimulation was one of the commonly studied electrotherapy modalities in the reviewed literature. This modality was studied in 11 out of 23 studies (47.8%) included in this review (Table 2). Taylor and Humphry<sup>26</sup> studied only TENS while the other ten studies investigated TENS along with other modalities (Table 2). Three studies<sup>26, 31, 34</sup> reported data on the 'use' and 'non-use' of TENS but they did not report data on the overall 'availability' and 'non-availability' of this modality. A study by Lindsay et al.<sup>29</sup> did not report extractable data with respect to this modality. As mentioned earlier, we determined the availability of this modality as 98.1% in the study by Pope et al.<sup>23</sup> The statistics on the 'availability', 'use', 'non-use' and 'non-availability' of TENS extracted from the reviewed studies revealed that the availability of TENS equipment presented a slightly declining trend (Figure 7).

The use of this modality showed an increasing trend from 1990 to 2000; however, the use of this modality decreased by about 30% in 2009 compared to 2000 (Figure 7). In addition, there was a declining trend in the 'non-use despite availability' of TENS; thus, the 'non-availability' of equipment of this modality suggested overall a slightly increasing trend.

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Figure 7 Availability, use, non-use and non-availability of TENS (1990 to 2009)

## Biofeedback

This literature review showed that the biofeedback modality was one of the less commonly studied electrotherapy modalities in the reviewed studies (Table 2). Biofeedback was investigated in seven out of 23 studies (30.4%) included in this review (Table 2). In these seven studies, biofeedback was investigated in association with other modalities (Table 2.2). Lindsay et al.<sup>29</sup> did not report extractable data with respect to this modality. Two studies<sup>33, 35</sup> did not report data on the 'availability' and 'non-availability' of biofeedback equipment; however, they presented data on the 'use' and 'non-use' of this modality. In addition, Pope et al.<sup>23</sup> also did not report data with respect to the overall availability of this modality. Therefore, the availability of this modality was determined by us as 83% in the study by Pope et al.<sup>23</sup> Data on the 'availability', 'use', 'non-use' and 'non-availability' of interferential extracted from the reviewed studies are presented in Table 3.

Table 3 Availability, use, non-use and non-availability of Biofeedback (1990-2009)

Year (Study)	Available (%)	Used (%)	Not used despite availability (%)	Not available (%)
1990 (Lindsay et al) <sup>24</sup>	24	18	83	77
1995 (Pope et al) <sup>23</sup>	83	94	6	17
1998 (Robertson and Spurrit) <sup>33</sup>	32	NA	NA	68
2000 (Cooney et al) <sup>35</sup>	3	NA	NA	97
2007 (Shah et al) <sup>16</sup>	84.8	65.2	17.4	15.2
2009 (Chipchase et al) <sup>18</sup>	52	43	58	48

The extracted data (Table 3) showed that the availability of biofeedback fluctuated between 1990 and 2009. In 1995, Pope et al.<sup>23</sup> reported availability of biofeedback as 83% which declined to the lowest level of 3% in 2000 as reported by Cooney et al.<sup>35</sup> However, the availability of this modality increased in the later years to 85% reported by Shah et al.<sup>16</sup> and it declined once again to 52% in 2009 as reported by Chipchase et al.<sup>18</sup> The use of this modality was lowest (18%) in 1990<sup>24</sup> and highest (94%) in 1995.<sup>23</sup> However, the use of this modality decreased and reached about 43% in 2009.<sup>18</sup> The 'non-use' of biofeedback was highest (83%) in 1990<sup>24</sup> and lowest (2.2%) in 2007.<sup>16</sup> However, it increased to 58% in 2009.<sup>18</sup> The 'non-availability' of biofeedback equipment was highest (97%) in 2000<sup>35</sup> but it declined to the lowest of 15.2% in 2007.<sup>16</sup> Overall, the 'availability' and 'non-availability' of this modality fluctuated in the reviewed studies.

## ***Microwave diathermy (MWD)***

Microwave diathermy was also a less commonly studied electrotherapy modality in the reviewed literature. This modality was investigated in only six (26.1%) out of 23 studies included in this review. MWD was not studied as a single modality in any of the 23 studies included in this review but was studied along with other electrotherapy modalities (Table 2). As reported earlier, we calculated the availability of MWD as 83.6% in the study by Pope et al.<sup>23</sup> In addition, Cooney et al.<sup>35</sup> reported use of MWD as the 'least used' but did not report any statistics on the 'non-use despite availability' of MWD equipment. A later study by Shah et al.<sup>16</sup> conducted in southeast and southwest of England showed that MWD was not available and not used in the NHS physiotherapy departments included in their survey. Table 4 presents the statistics on the 'availability', 'use', 'non-use' and 'non-availability' of MWD extracted from the reviewed studies.

The findings showed that the availability of this modality was highest (84%) in 1995<sup>23</sup> and decreased considerably to 6% in 2000<sup>35</sup>, falling to the lowest level (2%) in 2009.<sup>18</sup> The 'use' of MWD was between 64% and 79% from 1990 to 1998; however, it declined to very low use from 2000 to none in 2007. Similarly, the 'non-availability' of MWD was higher ranging from 67% in 1990<sup>24</sup> to 93% in 1998<sup>33</sup> and 100% in 2007.<sup>16</sup> However the lowest 'non-use' of MWD (21%) despite equipment availability was reported by Pope et al. in 1995.<sup>23</sup> The greater difference in the 'non-availability' of MWD might be due to the differences in the location of studies. For example, the Pope et al. study<sup>23</sup> was conducted in England while other studies on MWD were conducted in Australia<sup>18, 24, 33</sup> and in the Republic of Ireland<sup>35</sup> as shown in Table 2. The data on MWD presented in Table 4 revealed that the overall availability and use of this modality showed a declining trend while the 'non-use' and 'non-availability' presented an increasing trend in the reviewed studies.

Table 4 Availability, use, non-use and non-availability of MWD (1990-2009)

Year (Study)	Available (%)	Used (%)	Not used despite availability (%)	Not available (%)
1990 (Lindsay et al) <sup>24</sup>	33	79	21	67
1995 (Pope et al) <sup>23</sup>	84	64	36	16
1998 (Robertson and Spurr) <sup>33</sup>	7	75	25	93
2000 (Cooney et al) <sup>35</sup>	6	Least used	Not reported	94
2007 (Shah et al) <sup>16</sup>	0	0	0	100
2009 (Chipchase et al) <sup>18</sup>	2	0.6	99	98

## **H-wave**

H-wave was the least studied modality in the reviewed literature. It was investigated in only 13% i.e. three of the 23 studies included in this review (Table 2). Data extracted from these studies on the 'availability', 'use', 'non-use despite availability' and 'non-availability' of equipment is presented in Table 5.

The findings showed that the availability and use of H-wave was highest in 1995.<sup>23</sup> However its lowest availability was 2% in 2000<sup>35</sup> and the lowest use was 34% in 2007.<sup>16</sup> There were no data on the 'use' and 'non-use despite availability' of this modality reported in the study by Cooney et al.<sup>35</sup> The highest non-availability of this modality was 98% in 2000<sup>35</sup> but it declined to 93.5% in 2007.<sup>16</sup> Overall, the reviewed literature showed that the availability of H-wave was at the verge of disappearing and its non-availability in physiotherapy departments was becoming widespread from 2000 onwards.

Table 5 Availability, use, non-use and non-availability of H-wave (1995-2007)

Year (Study)	Available (%)	Used (%)	Not used despite availability (%)	Not available (%)
1995 (Pope et al) <sup>23</sup>	82	97	3	18
2000 (Cooney et al) <sup>35</sup>	2	Not reported	Not reported	98
2007 (Shah et al) <sup>16</sup>	6.5	33.8	0	93.5

## **DISCUSSION**

This literature review comprised a review of 23 studies. Our detailed comments on each of the studies included in this literature review are given in Table 1. Overall, we found that most of the studies were conducted on a regional level with a small sample size; hence, the findings of these studies have limited generalizability. In addition, reporting of the data in these studies varied; therefore, it was difficult to extract the required data on the same parameters from all of the studies.

Our findings of the present literature review show overall patterns in the availability and usage of nine electrotherapy modalities as follows. Therapeutic ultrasound was the most available (90% to 100%) and used (70% to 100%) since 1990. The reasons for widespread use of ultrasound could be the ease of application and portability.<sup>24</sup> However, ultrasound non-use despite availability has increased recently, especially

in Australia (22%)<sup>18</sup> and there are calls for trials to study clinical effectiveness of ultrasound.<sup>39, 42, 44</sup>

Our findings show that PSWD availability and usage is high in the UK and the Republic of Ireland but low in Australia. The non-use of PSWD despite equipment availability is low in England compared to the Republic of Ireland and Australia. Overall, the non-use of PSWD despite availability of equipment has greatly increased in the recent years, especially in Australia (96%)<sup>18</sup> where it is mostly non-available (89%)<sup>18</sup>. CSWD shows a declining trend in availability and use while its non-availability and non-use despite equipment ownership shows rising trends, which might be due to safety concerns.<sup>44-46</sup>

For laser, availability is slightly decreasing, and use shows a substantial declining trend while its non-availability and non-use despite availability shows increasing trends. Interferential shows a steady but declining trend in availability and use; however, its non-availability and non-use despite equipment ownership show slightly rising trends, especially in Australia. Also, there is demand for more research on clinical effectiveness of interferential.<sup>35</sup> Trends for TENS show a low decline in availability and non-use despite ownership; however, its use and non-availability show moderately increasing trends. The non-use of this modality is higher in Australia compared to the UK. In addition, further research on the clinical effectiveness of TENS has been suggested.<sup>43, 45, 46</sup> Biofeedback is highly available and used in England compared to in Australia and the Republic of Ireland where this modality was mostly non-available during the review period. The non-use of this modality is the highest in Australia.

Our review has revealed that MWD availability and use show a very steep decline from 1990 to 2009 while its non-availability and non-use despite equipment ownership was the highest of all electrotherapy modalities included in this review. In addition, we found greater differences in the degree of 'non-availability' of MWD in the reviewed studies, which might be due to the differences in the location of studies. For example, the Pope et al. study<sup>23</sup> was conducted in England while other studies on MWD were conducted in Australia<sup>18, 24, 33</sup> and in the Republic of Ireland<sup>35</sup> as shown in Table 2. It is also imperative to note that only one study i.e. Shah et al.<sup>16</sup> reported 100% non-availability hence non-use of this modality in England. The main reasons for widespread non-use of MWD may be safety concerns for patients<sup>34</sup> and physiotherapists<sup>44-46</sup> and supersession of this modality.<sup>35</sup>

Trends in the availability and the use of H-wave showed a great decline while its non-availability was found steeply increasing during the last two decades.

The main reasons for widespread non-use of this modality might be due to its supersession.<sup>35</sup>

In summary, our findings suggest that electrotherapy modalities studied in this review can be divided in four categories. The first category includes the most commonly available and used modalities that are ultrasound, interferential, TENS and biofeedback. The second category comprises frequently available and used modalities that include PSWD and laser. The third category consists of CSWD, which is a rarely used modality. The fourth (last) category contains MWD and H-wave, which are very rarely used electrotherapy modalities and they are at the verge of disappearance from physiotherapy practice.

This literature review has also revealed that there have been differences in the availability and usage of electrophysical agents in physiotherapy practices in the last twenty years. These differences varied between electrotherapy modalities, between countries, between public and private physiotherapy practices, and between the years of the studies. Differences in the use and availability of EPAs might be determined by differences in these countries in terms of electrotherapy education and training,<sup>43</sup> and the nature of clinical practices.<sup>35, 43</sup> In addition, use of electrotherapy is determined by several factors such as the equipment availability,<sup>30, 44</sup> reputation of being safe, such as for ultrasound and TENS,<sup>24, 47, 48</sup> physiotherapists' experience and belief about effects of the modality,<sup>49</sup> the clinical effectiveness<sup>50</sup> the type of medical condition<sup>30, 49</sup> and the nature of physiotherapy practices.<sup>16, 24, 27</sup> Overall, the emerging trend for electrotherapy revealed in this review is that the use of these EPAs is declining and their non-availability is rising, which may be due to several reasons (Table 6). The most common reasons for non-use of EPAs include lack of evidence for clinical effectiveness, non-availability of equipment, safety concerns, and lack of knowledge / familiarity with and training in using these electrotherapy modalities.

In addition, the non-use and non-availability of these modalities might have implications for their purchasers, users (clinicians and patients) as well as manufacturers and suppliers. Non-use despite equipment availability for some of these modalities is a waste of resources for the purchasers of this costly equipment.<sup>16</sup>

Table 6 Reasons for non-use of electrophysical agents in physiotherapy practices

Reasons for non-use	References
Non-availability of equipment	17, 30, 44
Safety concerns / fear of safety	11, 24, 33, 47
Lack of evidence for clinical effectiveness	11, 27, 28, 33, 35-37, 43, 50-52
Physiotherapist's choice	23,15
Lack of knowledge / training and unfamiliarity with the modality	23, 35, 52, 53
Lack of research and information on EPAs	25, 27
Nature of the clinical condition being treated	30
Supersession of modality e.g. MWD and H-wave	35
Level of ease of / difficulty in application	24
Area / nature of practice i.e. private vs. public sector use, and busy vs. less busy practice	50, 54
Cost of the equipment, especially for private practices	23, 35, 50

The non-use might lead to non-purchase of the latest models, which might affect the medical device industry. Non-availability and non-use despite availability might also have an impact on patients who might require use of particular EPAs. For example, use of electrotherapy might be useful for some patients but they might not be provided or treated with the required EPA for a variety of reasons including lack of scientific evidence of effectiveness. Such cases have been suggested as denying a potential benefit for the patient.<sup>2</sup>

Other implications of non-use and non-availability include impact on physiotherapy teaching, training and practice, such as removal of MWD in some text books on evidence based electrotherapy practice<sup>20</sup> and subsequent effect on undergraduate curriculum and practical training for EPA.<sup>21, 33, 51</sup> This shift away from electrotherapy would probably change the nature of physiotherapy practice with less electrotherapy and more non-electrotherapeutic treatments in the future. However, accepting or abandoning any EPA without systematic research and scientific evidence cannot be supported. Most commonly, it has been noticed that a lack of clinical effectiveness has been suggested to be the main reason for not using some of these electrotherapy modalities. However, this attitude towards EPAs has been challenged by some practitioners from within the physiotherapist community. For example, Watson<sup>2</sup> is of the view that there is difference between lack of evidence and evidence of lack and he has suggested that physiotherapists might adopt alternative treatment approaches and use their own experiences and expert opinions when there is no published evidence regarding EPAs.

Any future research therefore should systematically investigate the issue of lack of clinical effectiveness of electrophysical agents used in physiotherapy practice and suggest recommendations for teaching and training for effective and safe use of EPAs to future physiotherapists.

## CONCLUSION

Of the nine electrophysical agents studied in this review, ultrasound is the most commonly available and used modality across the countries studied during the last twenty years. There is also a high availability and use of interferential, TENS and biofeedback in different countries. PSWD is commonly used in England and the Republic of Ireland compared to Australia; however, its non-use despite equipment availability is higher in Australia and the Republic of Ireland compared to England. The availability and non-availability of laser is moderate but its use is declining while non-use despite equipment availability is rising. CSWD is a less commonly available and used modality across the countries and its non-availability and use despite device availability is increasing. MWD and H-wave are the least available modalities and their use is steeply declining while their non-availability is the highest of all EPAs included in this review.

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