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Review

Systematic Literature Review of Adverse Reproductive Outcomes Associated with Physiotherapists' Occupational Exposures to Non-ionising Radiation

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Abstract: Systematic Literature Review of Adverse Reproductive Outcomes Associated with Physiotherapists' Occupational Exposures to Non-ionising Radiation: Syed Ghulam Sarwar SHAH, *et al*. School of Health Sciences and Social Care, Brunel University London, UK—Objectives: To review empirical research on adverse health and pregnancy outcomes associated with physiotherapists' occupational exposure to radiofrequency electromagnetic fields (RF EMFs) from shortwave (SWD) and microwave (MWD) diathermy devices. **Methods:** A systematic review of peer reviewed literature published from 1990 to 2010 in the English language searched in eight online bibliographic databases: CINAHL, EBSCOhost, ISI Web of Knowledge, Medline, OSH UPDATE, PubMed Central, ScienceDirect, and Scopus. **Results:** Findings suggest that physiotherapists' occupational exposure to SWD was statistically significantly associated with delayed time to pregnancy (>6 months), still birth, altered gender ratio (low ratio of boys to girls), congenital malformations and low birth weight (<2,500 g) among physiotherapists' offspring. Physiotherapists' exposure to MWD was also found to be statistically significantly associated with spontaneous abortion. However, causal mechanisms for these statistical associations are unknown. The present systematic review has found these adverse reproductive outcomes and health effects associations with RF EMFs from therapeutic diathermy devices to be inconsistent. **Conclusions:** A number of studies did not find statistically significant results to replicate associations with such adverse outcomes, and therefore further research, preferably prospective studies of cohorts of physiotherapists, is warranted.
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Key words: Electrotherapy, Non-ionising radiation, Occupational exposure, Physical therapist, Therapeutic diathermy, Radiofrequency electromagnetic fields

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Physiotherapists, also known as physical therapists, administer radiofrequency (RF) electromagnetic energy (EME) for beneficial therapeutic effects to patients through shortwave (SWD) and microwave (MWD) diathermy devices. A recent study has shown that stray RF electromagnetic fields (EMFs) from the diathermy devices could be higher than the occupational exposure limits at currently designated safe distances i.e. 1 m from the devices[1]. Excessive exposure to RF EMFs could result in adverse pregnancy / reproductive outcomes[2–4] in some occupational groups such as physiotherapists[5]. Adverse pregnancy outcomes among physiotherapists have been the focus of research for a number of years. In 1983, a case control study by Kurppa *et al*.[6] reported associations between physiotherapists' occupational exposure to non-ionising radiation (NIR) from diathermy use and the occurrence of congenital malformations including oral clefts, defects to the central nervous system, cardiovascular system, and skeletal defects. However, Kurppa *et al*.[6] did not report odds ratios in support of their findings. A later study by Logue *et al* (1985)[7] reported a statistically significant risk of congenital malformations among offspring of male physiotherapists exposed to NIR from MWD and SWD usage. In 1987, McDonald *et al*.[8] reported the occurrence of spontaneous abortions, still births, congenital defects and low birth weights (≤2,500 g) among physiotherapists but the odds ratios of observed to expected outcomes, were not statistically significant. In addition, Hamburger *et al*. (1983)[9] reported a statistically significant association between heart disease and male physiotherapists' occupational exposure to NIR from SWD.

Researchers interested in physiotherapists' occupational health and safety have therefore raised concerns regarding the potential adverse effects among physiotherapists exposed to RF EMFs higher than the

permissible limits. These concerns became stronger as a result of the announcement from the International Agency for Research on Cancer (IARC) that EMFs should be classified as possible carcinogens to humans (Group 2B) in both the power frequency[10], and the radiofrequency range[11].

In addition, a considerable decline in the use of therapeutic diathermy in particular MWD and continuous SWD (CSWD) has been reported in several countries[12]. There are reports of cessation of MWD usage in physiotherapy departments in government sector hospitals in south-eastern and south-western England[13]. One of the reasons for the non-use or very low use of MWD and CSWD has been safety concerns of physiotherapists not only for patients but also for themselves[14–17].

A few literature reviews have reported the evidence of adverse health effects in particular pregnancy outcomes among physiotherapists associated with exposure to RF EMFs. For example, a review by Jauchem[18] reported that population-based studies present ambivalent results for effects of RF EMFs on birth defects, fertility, neuroblastoma in offspring, and levels of reproductive hormones. In addition, a number of other reviews have assessed adverse health effects associated with RF EMFs from a variety of sources[19–21]. However, there has been no systematic evaluation of published evidence with regard to the range of adverse health effects and pregnancy outcomes that may be associated with physiotherapists' occupational exposure to RF EMFs from therapeutic diathermy devices.

The objective of this study was to review empirical peer reviewed research, published over the last two decades i.e. from 1990 to 2010, on adverse health effects and pregnancy outcomes among physiotherapists occupationally exposed to stray RF EMFs from SWD and MWD devices used for electrotherapy in physiotherapy departments.

Methods

In undertaking systematic literature reviews, it is critical to focus upon the research question(s) in order to identify the most relevant literature[22]. Formulating clear and answerable review questions is facilitated by the PICO framework[23], which focuses on four key elements i.e. the patient or population or problem being addressed, the intervention or exposure being considered, comparison intervention or exposure when relevant, and the outcome of intervention or exposure[24, 25]. Originally the PICO was developed for clinical studies[24, 26]; however, it is now being used in other fields[27, 28]. For non-intervention studies, researchers have suggested that the intervention component of the PICO should be replaced with the exposure component because the former is a planned procedure while the exposure is an unintentional occurrence[22]; for example physiotherapists' unintended exposure to RF EMFs from therapeutic diathermy devices.

We therefore used the PICO framework for our literature review as follows: Population=Physiotherapists, Intervention/Exposure=unintended exposure to RF EMFs from therapeutic diathermy devices, Comparison=control groups not exposed to RF EMFs (where applicable) and Outcomes=adverse health and pregnancy outcomes.

The inclusion criteria were primary human studies reporting any adverse health effect or pregnancy outcome among physiotherapists occupationally exposed to RF EMFs from SWD and/or MWD devices published in the English language from January 1990 to June 2010. The exclusion criteria included discursive, hypothetical / theoretical and review articles, cross sectional studies, papers presented at conferences and articles published in languages other than English. Eight online bibliographic databases searched were CINAHL, EBSCOhost, ISI Web of Knowledge, Medline, OSH UPDATE, PubMed Central, ScienceDirect, and Scopus.

Literature searches were conducted using a set of keywords suitable for the PICO framework as follows. For the population element, we used keywords: physiotherapists and physical therapists. Keywords used for the exposure element were: occupational exposure, radiofrequency radiation, EMF exposure, electromagnetic field exposure, radiofrequency radiation exposure, radiofrequency electromagnetic fields, radiofrequency electromagnetic radiation, shortwave diathermy, microwave diathermy, physical therapy, radiation, radio waves, occupational health, electromagnetic radiation exposure, physiotherapy, and electrotherapy. For the outcome(s) element, key words used were: reproductive outcomes, pregnancy outcomes, adverse outcomes, birth weight, abortion, spontaneous abortion, congenital malformation, gender ratio, hyperthermia, outcome measures, and health risk.

The literature review process, as illustrated in Fig. 1, led to identification of 10 studies that reported health effects or pregnancy outcomes among physiotherapists who were exposed to RF EMFs. Full text of these studies (n=10) were obtained and reviewed. The reviewed studies were appraised for assessing the strength of evidence using the CASP (Critical Appraisal Skills Programme) approach (http://www.casp-uk.net). Methodological issues and weakness of evidence in two studies i.e. Israel *et al.*[29] and Vangelova *et al.*[30] precluded their inclusion in the final synthesis. The data extracted from the remaining eight articles using the PICO (i.e. Population,

Intervention/Exposure, Comparison and Outcome) framework is presented in Table 1. The abstracted data included the publication year and study location, design/method of study, population (subjects), exposure (to RF EMFs / type of diathermy device), comparison (control group) and the key outcomes (findings) of the research. Table 1 shows extracted data from the reviewed articles and reviewers' (our) comments on each study along with the level of evidence.

Results

Searching the above mentioned databases, eight relevant studies (Table 1) were identified that were published between 1990 and 2001. These studies were mainly conducted in Western Europe, and in particular in Scandinavian countries. Seven out of eight studies were published in the 1990s while the remaining one study was published in 2000s. The majority of studies (n=7, 87.5%) focused on pregnancy outcomes associated with physiotherapists' occupational exposure to RF EMFs and one study (12.5%) investigated other health issues such as effects on physiotherapists' immune system (Table 1). Most commonly, a case control study design was used and participants were female physiotherapists. The sample size and the number of cases and controls varied between studies (Table 1).

In these studies, exposure to RF EMFs was mainly from SWD; however, a few studies investigated RF EMF exposure from MWD devices (Tables 1 and 2). Most of the reviewed studies reported a range of adverse reproductive outcomes while one study investigated effects on the immune system of physiotherapists (Table 2). Statistically significant adverse reproductive outcomes reported were spontaneous abortion associated with exposure to MWD (odds ratio (OR): 1.28; 95% confidence interval (CI): 1.02–1.59)[31], congenital malformations (OR: 2.4; 95% CI: 1.2–6.1) and delayed time to pregnancy (>6 months) (OR 2.5, $p<0.05$) were associated with SWD exposure ≥5 hours (h)/week[32], altered gender ratio (low ratio of boys to girls) (OR 4.9, 95% CI: 1.6–17.9)[33], low birth weight (OR 2.75, 95% CI: 1.07–7.04))[34], and still birth (OR statistics not reported)[35] were associated with physiotherapists' occupational exposure to SWD.

However, some studies included in this literature review reported no statistically significant associations between spontaneous abortion and occupational exposure to MWD (OR 0.9–1.6, 95% CI: 1.02–1.59)[32] and SWD (OR 1.28, 95% CI: 0.09–3.79)[31, 32, 34].

In addition, there was no statistically significant association reported between SWD exposure and sub-fecundity / delayed time to pregnancy (>6 months) (OR 1.7, 95% CI: 0.7–4.1)[33], congenital malformations (OR 1.33–1.7, 95% CI: 0.6–4.3)[34–36], altered gender ratio (ratio for cases range 85–107, 95% CI: 61–127; ratio for controls range 101–106, 95% CI: 90–117)[35, 37], premature birth (<38 weeks) (both sexes OR 0.87, 95% CI: 0.48–1.59; for boys OR 3.2; 95% CI: 0.7–13.2 and for girls OR 0.9; 95% CI: 0.3–2.8)[33–35], low birth weight (<2,500 g) (OR for boys 5.9, 95% CI: 1.0–28.2 and OR for girls 0.7, 95% CI: 0.0–3.2)[33, 35, 37], still birth[35, 36], perinatal death / death in 1st year of life (OR 2.9; 95% CI: 0.6–10.7)[33, 35] associated with physiotherapists occupational exposure to RF EMFs from therapeutic diathermy devices.

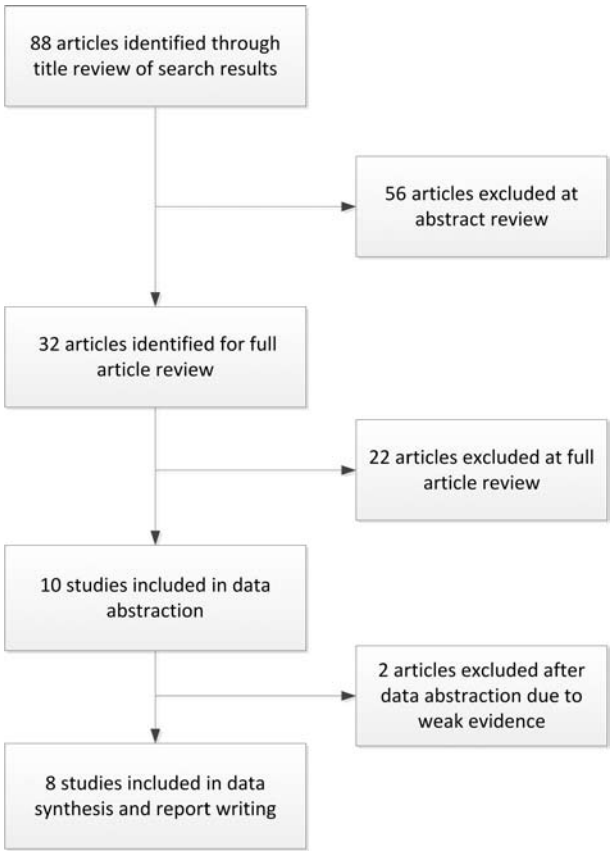

Fig. 1. Literature review process showing identified, excluded and included studies.

There was also no statistically significant effect of physiotherapists' occupational exposure to SWD and effects on the immune system[38].

Discussion

Unintended and excessive occupational exposure to RF EMFs leading to potential adverse health effects and pregnancy outcomes in physiotherapists operating SWD and MWD devices was reported in a number of studies conducted in the 1980s[6–8]. To assess the evidence of association between occupational expo-

Table 1. Case control studies (retrospective) of physiotherapists with respect to adverse reproductive outcomes and health effects

Study details		Population	Exposure	Comparison	Outcomes	Reviewers' assessment		
Reference	Study design		Type / mode of therapeutic diathermy devices - source of RF EMF exposure)			Evidence level (1=Highest)	Positive comments	Negative comment
Taskinen *et al.*[32] 1990	Case control; questionnaire; 204 SA cases; 46 CM cases	Finnish physio-therapists (f)	SWD 1–4 hr/wk >4 hr/wk	483 controls for SAs; 187 controls for CM cases	SA: N.S. after adjust; CM: OR 2.7;1.2,6.1* CM=N.S.	2	Validity: hospital discharge register; Finnish CM register; high rate of response	Study over 1973–82; potential recall bias
			MWD		SA, CM=N.S.			sample size insufficient power to assess
Larsen[36] 1991	Case control; telephone interviews; 57 CMs	Danish physio-therapists (f)	SWD	267 controls (normal births w/o CMs)	CMs=N.S. with exposure to high RF	2	Validity: Danish National birth and CMs registers; hospital admissions	Potential recall bias; lack of definition of 'high exposure'
Larsen *et al.*[33] 1991	Case referent study (270 cases) within cohort of 4,021 physio therapists; telephone interviews; 2,334 pregnancies; (1978–1985)	Danish physio-therapists (f)	SWD	316 controls (no adverse birth); matched for age, parity, offspring birthplace	SA, TTP, LBW, GAB, SB, PD=N.S.	2	Linked to registers of Danish birth and medical miscarriage; interviews uncovered additional confounders (eg. alcohol, tobacco use)	Potential recall bias; unknown exposure duration to RF
			High SWD exposure		Gender ratio (fewer males: 47.4%) OR 4.9; 1.6,17.9	2	High response rate	wide confidence interval
Kallen *et al.*[35] 1992	Case-control : cohort of 2043 births to 2018 physiotherapists (1973–78); questionnaire; N=111: 37 cases	Swedish physio-therapists (f)	SWD and MWD use in pregnancy	N=74, two controls per case; matched for parity, maternal age, season of delivery;	PB, LBW, SB, PD, CMs, Gender ratio: All outcomes slightly lower than expected; slightly higher PD/CM assoc with frequent SWD use (*)	3	National files matched to Swedish medical, birth/CM registers; 93% response rate; 5 y cohort	Potential recall bias; sample size inade-quate power to assess MWD; no OR calc; no exposure mea-sures; some cases w/o controls

Table 1. Case control studies (retrospective) of physiotherapists with respect to adverse reproductive outcomes and health effects (continued)

Ouellet-Hellstrom and Stewart[22] 1993	Nested case-control study; self-reported questionnaire; N=42,403; 1,753 SA cases, 12,949 potential controls	US physiotherapists (f)	Ever use SWD, MWD 6 mths prior to pregnancy or in 1st trimester	N=1,753 matched: maternal age & yrs between concept & q'aire	SA: MWD use 6 mths prior to pregnancy/ 1st trimester: OR; 1.28, 1.02,1.59**; SWD use=N.S.	2	6,684 therapists reported 1753 SAs; 58% physiotherapists ever used SWD/MWD	Potential bias due to recall and 40% non-response rate
Guberan *et al.*[37] 1994	Case-control; questionnaire N=1,781 pregnancies; 508 exposed to SWD	Swiss physiotherapists (f)	SWD/MWD exposure in 1st trimester	1,273 controls without SWD exposure	Gender ratio, LBW: no stat sig differences exposed versus unexposed	1	Measure of electrode power density; type, intensity & distance to operator; study size had power in excess 99% to detect as significant at the 1% level, a decrease in the gender ratio	Potential bias due to recall; recall >20 yrs
Tuschl *et al.*[38] 1999	Case-control: 18 exposed to SWD/MWD, interviews	Austrian physiotherapists (m/f)	SWD/MWD	13 controls not exposed SWD/MW, matched for age & sex	Immune system markers: leucocyte, lymphocyte count/activity: no stat sig difference between those exposed to SWD/MWD and controls	2	EMFs measured for 7 SWD & 11 MWD devices; SWD EMFs higher than OELs	No data on duration or frequency of exposure to devices; no individual exposure data
Lerman *et al.*[34] 2001	Nested case-control study; q'aire,telephone interviews; N=434 physiotherapists with 930 pregnancies; 300 cases	Israeli physiotherapists (f)	SWD use	630 controls with normal birth outcomes	SA: n=175, CM: n=45, PB: n=47: no stat sig associations; LBW : n=33: OR; 2.75; 1.07,7.04*	2	Matched by telephone interviews; hospital sick notes; LBW had positive dose response	No details of SWD duration/ frequency; self-reports w/o validity from other sources; possible selection bias

SWD=Short wave diathermy; MWD=Microwave diathermy; EMF=Electromagnetic Fields. OR=Odds Ratio. SA=Spontaneous abortion/Miscarriage; CM=Congenital malformation; LBW=Low Birth weight (<2,500 g); SB=Still Birth; TTP=time to Pregnancy; PD=perinatal death (foetal death >24 weeks pregnancy or SB or within the 1st 7 days of life; GAB=gestational age at birth; PB=Premature birth (<38 wks); Stat sig=statistical significance; $p<0.05$=*; $p<0.005$=**; $p<0.0005$=***. m=male, f=female; OEL=Occupational Exposure Limits; =adjustment; assoc=association; mnths=months; N.S.=Not significant; sig=significant; w/o=without.

Table 2. List of adverse reproductive outcomes and effects on the immune system associated with physiotherapists' exposure to RF EMFs from SWD and MWD devices reported in reviewed studies

Exposure (RF EMF source / mode of diathermy device)	Outcomes	Statistically significant	Not statistically significant
MWD	Spontaneous abortion (gestation >10 weeks)	OR 1.28 (95% CI: 1.02–1.59)[31]	OR 1.8 (95% CI: 0.8–4.1)[32]
SWD	Spontaneous abortion (gestation >10 weeks)	None	OR 1.07 (95% CI: 0.09–1.24)[31] SWD ≥5 hours/week exposure: OR 1.6 (95% CI: 0.9–2.7)[32] OR 1.4 (95% CI: 0.7–2.9)[33] OR 0.9 (95% CI: 0.64–1.27)[34]
SWD	Sub-fecundity / Delayed time to pregnancy (>6 months)	SWD exposure ≥5 hours /week=OR 2.5, $p<0.05$[32]	OR 1.7 (95% CI: 0.7–4.1)[33]
SWD	Congenital malformations in physiotherapists' offspring	SWD exposure 1–4 hours/week=OR 2.4 (95% CI: 1.2–6.1; $p<0.05$)[32]	OR 1.33, (95% CI: 0.68–2.75)[34] Observed cases (n=27) less than the expected (n=32)[35] OR=1.7 (95% CI: 0.6–4.3)[36]
SWD and MWD	Altered gender ratio (low ratio of boys to girls)	SWD exposure associated with altered gender ratio (i.e. low ratio of boys compared to girls) OR=4.9 (95% CI: 1.6–17.9)[33]	SWD exposure: Observed cases higher than expected (1.08 vs. 1.06) N.S.[35] SWD exposure: gender ratio for cases=107 (95% CI: 89–127) and controls=101 (95% CI: 90–113); MWD exposure: gender ratio for cases=85 (95% CI: 61–118) and controls=106 (95% CI: 96–117) - N.S.[37]
SWD	Low birth weight (<2,500 g)	Combined male and female offspring=OR 2.75 (95% CI: 1.07–7.04, $p=0.03$), for male offspring OR=3.7 and for female offspring OR=2.9)[34]	For boys OR 5.9 (95% CI: 1.0–28.2, p=0.087), for girls OR 0.7 (95% CI: 0.0–3.2)[33] Observed cases < expected (64 vs. 92)[35] OR statistics not reported[37]
SWD	Still birth (death >24 week pregrancy)	OR statistics not reported[35]	OR 2.9 (95% CI: 0.6–10.7)[33] Observed cases (i.e. 7) < expected (i.e. 12)[35]
SWD	Premature birth (<38 weeks)	None	For boys OR 3.2 (95% CI: 0.7–13.2), for girls OR 0.9 (95% CI: 0.3–2.8)[33] OR 0.87 (95% CI: 0.48–1.59)[34] Observed cases (i.e. 170) < expected (i.e. 200)[35]
SWD	Perinatal death / death in 1st year of life	None	OR 2.9 (95% CI: 0.6–10.7)[33] Observed cases (i.e. 16) < expected (i.e. 23)[35]
SWD	Immune system parameters (i.e. total leucocytes and lymphocytes, and lymphocyte activity)		SWD over exposure did not produce statistically significant differences in the immune parameters of the cases compared to the controls[38]

CI=Confidence interval; EMFs=electromagnetic fields; MWD=microwave diathermy; OR=odds ratio; RF=radiofrequency; SWD=shortwave diathermy.

sure to RF EMFs from therapeutic diathermy devices and adverse reproductive outcomes and health effects among physiotherapists, we systematically reviewed literature published in the last two decades (i.e. from 1990 to 2010) using the PICO (also reported as PECO) framework[24].

The findings of the reviewed studies for adverse reproductive outcomes are conflicting. For example, the association of physiotherapists' occupational exposure to RF EMFs from therapeutic diathermy devices and the occurrence of spontaneous abortion, sub-fecundity / delayed time to pregnancy (>6 months),

altered gender ratio, low birth weight (<2,500 g), still birth and congenital malformations in the offspring of physiotherapists have been supported as well as rejected, as shown in Table 2. In addition, no statistically significant association has been found between physiotherapists' exposure to SWD and MWD and the adverse outcomes of premature birth (<38 weeks), or perinatal death (death in 1st year of life) or effects on physiotherapists' immune system (Table 2). Therefore, firm conclusions with respect to the association of RF EMFs and adverse reproductive outcomes cannot be made[5].

In most of the studies included in this review, reproductive outcomes were studied in relation to only female physiotherapists' occupational exposure to RF EMFs. There is some evidence that paternal occupational exposure to RF EMFs can be associated with adverse birth outcomes such as preterm birth and congenital malformations[4] suggesting there is a need for research on reproductive outcomes involving male physiotherapists.

In addition, there are a number of limitations in these studies, offered in the reviewers' comments column in Table 1. Most of the studies were conducted retrospectively over a period of several years such as eleven years by Taskinen *et al*.[32] twenty years by Guberan *et al*.[37] and over an indefinite period by others[31, 34]. Thus, assessment of level and duration of exposure to RF EMFs in these studies may be subject to poor recall[5]. Additionally there may be differential recall of exposure between cases and controls, although there is no good evidence that cases with a reproductive outcome such as a miscarriage report greater exposure to specific agents after the event compared to the reporting prior to the event[39]. Retrospective assessment of exposure without measurement as validation is however a major limitation of findings from all case control studies and reinforces the need for prospective studies beginning prior to any outcome of interest.

Some of the reviewed studies, such as Larsen[36], Tuschl *et al*.[38] and Lerman *et al*.[34] investigated effects of high exposure to radiofrequency radiation (RFR) but gave no specific details of the duration, intensity, and mode of such high exposure. Even if such details are available, they require validation. Epidemiological methods (such as case control studies) can only show associations and not causation and occupational exposure to RFR is also only one source of EMFs; other sources outside of the physiotherapists' workplace should be included for a valid measure of RFR exposure.

There is also a need to address the high non-response rate for example 40% non-response rate in the study by Ouellet-Hellstrom and Stewart[31]; hence, their findings might be undermined by non-response bias. Data in most of the studies included in this review were usually obtained through multiple sources (Table 1) but single sources such as self-reported data were used[37], which were not verified from other sources such as the medical records and / or registers of births and abortions.

Overall, the major flaws in most of the reviewed studies were lack of data on three key parameters i.e. the intensity and the duration of RFR exposure and the distances from SWD and MWD devices at which RFR exposure occurred. Information on these three parameters is essential for determining the level of physiotherapists' occupational exposure to RF EMFs in the light of occupational exposure limits suggested in the International Commission of Non-Ionising Radiation Protection (ICNIRP) Guidelines 1998[40]. In addition, a recent study published by Shah and Farrow (2013)[1] have reported that the occupational exposure limits for RF EMFs suggested in the ICNIRP Guidelines[40] are exceeded at the distance of 1 m from pulsed SWD (PSWD). The latter has been designated as a safe operating distance for physiotherapists. Exposure to PSWD and CSWD should be determined separately but there was no such distinction in the reviewed studies, which reported exposure to only SWD but not the two modes mentioned above.

The other main weaknesses of these studies were the use of retrospective study design and self-report that could have a significant recall bias. In addition, data on ORs were not available for all studies included in this review. In the light of such limitations, it was not possible to pool together the results and produce forest plots and conduct meta-analyses. Therefore, we have presented findings from all reviewed studies in Table 2 for categorisation of all adverse health effects whether significant or not for illustration purposes with respect to the type of diathermy devices. In addition, we could not reflect on the biological mechanism of the reported adverse health effects and/or pregnancy outcomes as explanation of biological mechanisms is beyond the remit of this review; detailed coverage of potential biological mechanisms can be found in reports of the IARC[41] and the ICNIRP[20].

It is however suggested that the adverse health effects due to physiotherapists' over exposure to RF EMFs from PSWD and CSWD devices need to be studied with reference to the intensity of RF EMFs and the distance from the devices. There is therefore a need for further research preferably using prospective study designs to establish any universal statistically significant association between the physiotherapists' occupational exposure to RF EMFs from the use of PSWD, and CSWD devices in physiotherapy practice.

Conclusions

This review has identified inconsistent evidence with respect to adverse health effects and reproductive outcomes due to physiotherapists' occupational exposure to RF EMFs from CSWD, PSWD and MWD devices. Therefore further research, preferably with prospective studies of cohorts of physiotherapists focusing on the intensity and duration of RF EMFs exposure and the distance from therapeutic diathermy device are warranted.

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Ethics approval: Not applicable because this was a review of published literature.

Conflict of interest: The authors declare that they have no conflict of interest.

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