Table 1.1 Recent studies exploring force, airflow and / or pressure during chest wall vibrations

Authors, year, location	**Questions**	**Subjects, Physiotherapists**	**Measurements: Equipment**	**Relevant Findings**	**Comments: Strengths; *Limitations***
McCarren et al. 2006a *In* Australian Journal of Physiotherapy	1) Mechanical consequences of CWV 2) Effects of CWV on airflows and volumes	1 healthy adult, 16 physiotherapists	1) Force: Instrumented couch 2) Airflows: heated pneumotachograph 3) Chest movement: Inductive plethysmography	1) CWV mean (SD), Fmax 137 (67) N Fmean 74 (47) N Oscillations 5.5 (0.8) Hz 2) PEF_{CP} < 20% of PEF_{COUGH} 3) $PEF:PIF_{CP}$ < 1.1 ('gasp' breath) 4) PEF_{CP} equalled sum of PEFs from elastic recoil and CWV components	1. First simultaneous measurements of CWV force and flow 2. Separated components of CWV & demonstrated individual effects, including elastic recoil 3. Findings related to airway clearance theories *1 Indirect force measure; in single healthy subject* *2. Artificiality of dividing CWV components?* *3. High variability, but only 1 trace shown; no ranges.*
McCarren et al. 2006b *In* Australian Journal of Physiotherapy	Relationship of CWV, intra-pleural pressure, chest circumference and PEF	3 healthy adults, 7 physiotherapists	1) As for McCarren 2006a, plus 2) Oesophageal manometry (frequency spectral analysis of oscillations)	1) Mean (SD) peak IPP during CWV of 0.73 (0.89) cmH_2O 2) IPP_{CP} equalled sum of IPPs from elastic recoil and CWV components	1) Changes in IPP supported suggestion in initial paper that changes in PEF_{CWV} equalled the summed effects of CWV components *As for McCarren 2006a*
McCarren & Alison 2006 *In* European Respiratory Journal	Comparison of PEF and airflow oscillations during physiotherapy	18 adults with stable cystic fibrosis 1 physiotherapist	1) Airflows: heated pneumotachograph 2) Scaling of breathlessness 3) Audiotape recording coughs elicited	1) PEF_{CP} higher than for Flutter® percussions, Acapella® or PEP 2) $PEF:PIF_{CP}$ > 1.1 and mean (SD) oscillations 8.4 (0.4) Hz;	1) Subjects with airways disease 3) Findings related to airway clearance theories 2) Improved instructions caused slow inspiration 3) CWV did not elicit spontaneous cough

PEF_{CP} (IPP_{CP}) = Peak expiratory flow (intra pleural pressure) during the chest physiotherapy (CP) of deep breaths and chest wall vibrations (CWV). Frequ – frequency Note: Data are shaded as studies were not available at the inception of thesis research

Table 1.2 Summary of physiotherapy studies conducted in mechanically ventilated children

Authors	Year	Design	Population (number)	Participants	Interventions	Outcomes	Findings	Comments: Strengths; *Limitations*
Demont et al.	2007	Retrospective analysis	Neonates (362)	Chronic /acute lung disease	EFIT	CXR for PEA, brain lesions	Incidence PEA lower in those receiving physio	Clear subjective description. *Retrospective, no control. No 95% CI*
Almeida et al.	2005	Repeated measures: non-randomised	Infants <1y (22)	Acute obstructive respiratory failure	EFIT	ABG, PFT with CO_2SMO	RR ↑, SaO_2↑ PaO_2 /PAO_2↑ P(A–a)O_2 /PaO_2↓post-EFIT	Manual abdominal splinting *No control, exclusions debatable, inter-related outcomes, 1° outcomes?*
Main and Stocks	2004	Randomised cross-over in 24h	0-16y (100)	Mixed, paralysed in PICU or CICU	CCP with suction vs suction (both used Minf)	ABG, CO_2SMO, deadspace	Physiological deadspace ↑ post-physio	Physio may initially worsen V/Q relationship as secretions cleared
Main et al.	2004	Randomised cross-over in 24h	0-16y (100)	Mixed, paralysed in PICU or CICU	CCP with suction vs suction (both used Minf)	ABG, CO_2SMO, mechanics	Rrs ↓ and Crs↑ more likely post-physio.	Pre-treatment monitoring performed & large sample. Call to identify patient groups likely to benefit.
Bernard-Narbonne et al.	2003	Randomised	Infants (20)	Bronchiolitis	CCP with suction vs suction	SpO_2, VT, $TcPCO_2$	SpO_2 & VT↑ post-physio;	*No treatment details*, but state it is different from English colleagues
Al-Alayan	1996	Randomised CCP vs control	Neonates (63)	Mixed; no atelectasis	Mechanical vibs, PD & suction	CXR pre-Rx & post-extubation	No difference between groups	*No details of mechanical vibrator. No secretions present*
Hussey et al.	1996	Randomised	0-4y (67)	Post-cardiac surgery	Subgroups of CCP	Varying SpO_2↓ all groups	Treatment 'package' given determined SpO_2↓; worse in younger child	*No control; multiple-subgroups reduced power*
Galvis et al.	1994		Infants (57)	Lung atelectasis	Hyperoxyg'n, vibs, saline & suction	CXR	Lung re-expansion when mucus plugging	Subjective description *No control*

Authors	Year	Design	Population (number)	Participants	Interventions	Outcomes	Findings	Comments: Strengths; *Limitations*
Reines et al.	1982		0-9y (44)	Post-cardiac surgery	CCP vs suction only	CXR, ABG Length of stay	CCP more atelectasis & longer stay	Important possible adverse events highlighted *but Clinical style of treatment debatable*
Raval et al.	1987		Neonates (20)	RDS, in 1st 24hrs life	CCP& suction vs suction only	PaO_2/FiO_2, Blood gases, Sputum, pH, IVH	No group difference except IVH worse CCP	Important possible adverse events highlighted *but Clinical style of treatment debatable*
Tudehope and Bagley	1980	Randomised cross-over	Neonates (15)	RDS	'contact-heel perc.' (CHP) vs 'mask perc' MP vs electric toothbrush	ABG	PaO_2↑ MP & CHP, not electric toothbrush	Subjective description of 'contact heel percussions'
Fox et al.	1978	Cross-over	Neonates (13)		Hyperinfl'n vs mech. vibs & suction	ABG	O_2↓ post suction & hyperinf'n	*Inadequate washout times & confusing design. Small sample size*
Finer and Boyd	1979	Randomised	Neonates (42)	Vent, mixed; included secretion disorders	PD, finger-tip vibs & suction vs PD & suction	ABG CXR	PaO_2↑ post-physio No PEA with physio	Subjective description finger-tip vibrations (rate, time, area, displacement). Same physiotherapist
Finer and Boyd	1978	Randomised cross-over	Neonates (20)	Vent, Prem, mixed; on O_2 therapy	PD, perc & suction vs PD & suction	ABG	PaO_2↑ post-physio	Subjective description contact-heel perc (rate, time, area, displacement). Same physiotherapist
Etches & Scott	1978	Cross-over	Neonates (6)	Vent, Mixed	Suction alone vs CCP	Sputum weight	↑ sputum weight CCP	*Small sample size & order not randomised*
Holloway et al.	1969	Double-blind, randomised	Neonates (51)	Vent, Tetanus Controls: spont. resp.	CCP then hyperinf vs hyperinf	ABG	$PaCO_2$ & PaO_2↓ post CCP;	Age-matched controls *Multiple sub-groups reduced power*

Note: Data from shaded studies were not available at the inception of thesis research. ABG – arterial blood gas, CCP – conventional chest physiotherapy [comprising postural drainage, vibrations, percussions], Crs – respiratory compliance, CXR – chest X-ray, EFIT – expiratory flow increase technique, IVH – intra-ventricular haemorrhage, Minf – manual lung inflations, PaO_2 – partial pressure of arterial oxygen saturation, PAO_2 - partial pressure of alveolar oxygen saturation, PEA – Post-extubation atelectasis, Perc – percussion, PD – postural drainage, Prem – preterm, PFT – pulmonary function tests, Rx – treatment, Rrs – respiratory resistance, RR – respiratory rate, SpO_2 – transcutaneous oxygen saturation, SaO_2 – arterial oxygen saturation, Spont Resp spontaneously respiring, $TcPCO_2$ – transcutaneous PCO_2, Transcut – transcutaneous, Vibs – vibrations, VT – tidal volume, V/Q – ventilation/perfusion

Table E.1 Potential product development schedule

Product	Description	Partners	Status	Markets
Chest physiotherapy training aid	Pressure sensing mats that can be used at home by carers to both train and monitor the application and outputs of chest physiotherapy and also within the hospital setting to monitor clinical practice of both physiotherapy and potentially CPR techniques	Novel (pressure mat) Southampton/ UCL, Institute of Child Health (analysis software and clinical development & evaluation)	First evaluation & pilot study (Southampton) complete and paper published in 2007 in *Physiological Measurement* Further paediatric clinical trials are ongoing (GOSH) Preliminary adult trial in progress (UCL, Institute of Child Health); more data required	- Schools of Physiotherapy - Schools of Nursing - Medical Schools - Carers of children & adults with chronic chest disorders (CF Foundation, Chest Heart & Stroke Association etc) - First aid units/training centres, especially if it could also monitor CPR - Loaned within the community
Manikin for training physiotherapists, doctors and nurses - adult - child - infant	A highly realistic manikin (chest, airway & lungs) that physiotherapists, doctors & health professionals can use during training in intubation, bronchoscopy, manual hyperinflations and chest physiotherapy	Trucorp (manikin) UCL, Institute of Child (assistance with prototype developments & evaluation)	In development	- Schools of Nursing - Schools of Physiotherapy - Medical schools - Hospital paediatric & adult medical/surgical units & ICUs (i.e. all units)
Manikin with integrated pressure-sensing mat - physiotherapy training tool	A manikin that enables active monitoring and feedback on chest physiotherapy and/or CPR for training medical professionals, paramedics, home carers and first aiders	Trucorp (manikin) Novel (pressure mat) UCL, Institute of Child Health (validation and optimisation)	Longer term future prospective project	As above but also in the GP health centres, first aid units, paramedic units, and loaned out within the community

CF – cystic fibrosis, CPR – cardio-pulmonary resuscitation, GOSH – Great Ormond Street Hospital for Children, GP – General Practitioner, UCL – University College London