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Original article

Exploring the clinical use of ultrasound imaging: A survey of physiotherapists in New Zealand

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In Memoriam: *Rachael De Jong (1996–2017):* This paper is dedicated to the memory of Rachael. A very bright star, taken too soon. The world and physiotherapy profession are less bright without you. Rest easy.

Keywords:
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ABSTRACT

Background: In New Zealand ultrasound imaging (USI) is being used increasingly by physiotherapists. To fully understand the extent to which physiotherapists in New Zealand are using USI, it is necessary to evaluate not only the context of its clinical use but also the barriers preventing its uptake.
Objectives: To examine the field and scope of use of USI, the type and content of training and the barriers restricting physiotherapists from using the technique.
Design: Cross-sectional observational design utilising an Internet-based electronic survey.
Method: An electronic survey built on the design of previous research with guidance from an expert review panel. Participants were included if they were New Zealand registered physiotherapists.
Results: Of the 465 participants who responded, 433 were eligible to complete the survey. There were 415 participants who completed the survey, 24% who said they used USI whilst 76% did not. For those using USI, the uses were varied including those within a rehabilitative paradigm (i.e. biofeedback; 52%) and also diagnostic (49%). USI training was also varied ranging from formal to informal. The main barriers preventing physiotherapists from using USI were lack of training, access to equipment, and equipment expense.
Conclusions: The participants reported a variety of clinical uses of USI and levels of training. A better understanding of the clinical uses and benefits of USI would enhance both training and clinical uptake. With the identification of barriers limiting physiotherapists' use of USI, ways to overcome these in New Zealand can now be explored further.

1. Introduction

Over recent decades, anecdotal evidence suggests there has been a growth in physiotherapists' clinical use of ultrasound imaging (USI). The combination of increased research, growth of USI training opportunities and the development of ultrasound technologies has seemingly led to USI becoming a more viable tool for physiotherapists to augment their practice.

There is a paucity of research that has formally ascertained the use of USI by physiotherapists. Three published surveys of physiotherapists, conducted in Australia (Jedrzejczak and Chipchase, 2008; McKiernan et al., 2011) and the United Kingdom (Potter et al., 2012), sought to highlight the uses and level of training of USI and concluded similar findings in certain areas. Firstly, a majority of respondents worked within musculoskeletal physiotherapy, predominantly using USI as a biofeedback tool to examine muscle function, particularly for muscles of the trunk (Jedrzejczak and Chipchase, 2008; McKiernan et al., 2011; Potter et al., 2012). Although a majority of participants had received USI training, the training varied in duration, content and teacher experience (McKiernan et al., 2011; Potter et al., 2012). Furthermore, the training was often incongruous between the content offered and the clinical needs of physiotherapists (Potter et al., 2012).

Although these studies highlighted interesting findings regarding training and uses of USI, they did not explore either the barriers preventing physiotherapists from using USI and the scopes of practice for physiotherapists to use USI. It is important to understand the barriers that prevent physiotherapists from using USI, as this knowledge would provide insights into ways of overcoming them. Furthermore, a

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potential barrier to using USI could be a lack of understanding regarding scopes of practice. The physiotherapy community has been proactive in defining different uses of USI, particularly those more suitable to physiotherapy practice, such as distinguishing between diagnostic and rehabilitative USI (Teyhan, 2007; Whittaker et al., 2007b). However, these definitions do not necessarily define or shape scopes of practice for USI use by physiotherapists.

The use of rehabilitative USI is becoming popular amongst members of the physiotherapy profession, but their ability to use USI to support and aid clinical diagnosis could potentially be beneficial. However, it is evident that a different skill-set and level of training is required for both rehabilitative and diagnostic USI (Jedrzejczak and Chipchase, 2008; Potter et al., 2012; Whittaker et al., 2007b). In addition, the consensus on specific scopes of practice that define the circumstances and methods in which physiotherapists can utilise USI is unclear. In part, this lack of clarity stems from the absence of and inconsistent standards and scopes of practice provided by different national and international regulatory bodies to define USI use in physiotherapy.

An understanding of the barriers preventing physiotherapists from using USI is needed to fully understand the landscape. Several barriers reported include lack of access and cost of ultrasound equipment, time restrictions for clinical appointments, lack of patient suitability and lack of training (Jedrzejczak and Chipchase, 2008; McKiernan et al., 2011). However, to date, no research has formally examined these barriers.

Anecdotal evidence suggests that USI use by physiotherapists in New Zealand is increasing, so it is timely to formally examine the situation, context and environment. Therefore, the aim of this study was to survey New Zealand registered physiotherapists to identify the field and scope of USI use; the type and content of USI training; and barriers to using it.

2. Materials and methods

This study was a cross-sectional observational design utilising an Internet-based survey of New Zealand registered physiotherapists. Three phases included: 1) survey development; 2) face validity testing through expert consultation; and 3) survey distribution and data collection.

2.1. Survey development

The initial survey utilised several aspects of the survey conducted by Potter et al. (2012). These included the uses of USI, training, and participant demographics and professional details. Specific questions in two other key domains in the current survey were: 1) scopes of practice for the use of USI in New Zealand and 2) the barriers preventing physiotherapists from using USI.

2.2. Face validity testing via expert panel

As reported in previous surveys (Jedrzejczak and Chipchase, 2008; Potter et al., 2012), a panel of experts in the field of USI was assembled to provide feedback and guidance for the current survey. As the current survey featured new domains of interest and also specifically targeted the New Zealand context, the panel members were all New Zealand citizens. This expert panel consisted of nine members: two specialist musculoskeletal sonographers, one radiologist, five physiotherapists (four musculoskeletal, one with mixed musculoskeletal/neurorehabilitation role) and one dual trained physiotherapist/sonographer. All expert panel members were using USI within their clinical practice. Four panel members (two sonographers and two physiotherapists) were involved in USI education and research.

After providing consent to take part in the survey face validity testing, each panel member was sent the initial survey. This consisted of 42 items across three domains of interest: 1) field and scope of practice for use of USI; 2) level of training in the use of USI; and 3) identification of barriers to the use of USI. Panel members were also provided with an appraisal worksheet to assess the face validity of the survey, which included a critique of individual items and domains of interest, and an opportunity to provide general feedback about the survey, for example clarity of questions, survey flow and logic.

Two investigators (RE, SB) received all feedback from the expert panel following the first round review. As a consequence, changes were made to the questionnaire. The second version consisted of five domains of interest: 1) professional and demographic details; 2) scopes of practice; 3) barriers to using USI; 4) uses of USI; and 5) training. For participants who responded that they did use USI, version two of the survey consisted of 72 items, whilst for participants who did not use USI, 22 items were included. The large discrepancy in number of items between the two groups is reflected by the exclusion of questions relating to clinical use and training for those not using USI.

The second version of the survey was sent to each member of the expert panel for their final review and comments, which shaped the final survey. Following the second review, the number of domains and items remained the same. The final survey included items that were single and multiple-choice questions, open-ended questions and questions utilising Likert scales.

Finally, a pilot test was conducted where the survey was sent to three randomly chosen New Zealand registered physiotherapists who were independent and naïve of the current research. They were asked to complete the survey and provide specific information about the sequence of the items and their understanding and interpretation of them. A number of changes were made to the survey following this pilot review to improve survey flow and logic of questions.

2.3. Survey distribution and data collection

The final survey was hosted on the Internet-based survey site, SurveyMonkey (2015) which enabled secure and anonymous survey participation (including consent to participate) and anonymous data collection. The SurveyMonkey site created a web-based link and a social media link to the survey, which were posted on the relevant web pages and social media forums utilised by Physiotherapy New Zealand (PNZ), which is the professional organisation for physiotherapists in New Zealand. Survey links were also posted on the web pages and/or social media forums of several of the special interest groups (SIGs) of PNZ, including the New Zealand Manipulative Physiotherapists Association, Sports Physiotherapy New Zealand and the Physiotherapy Acupuncture Association of New Zealand. Furthermore a snowballing technique, as utilised by Potter et al. (2012), was used to encourage survey participants to forward the web and/or social media links within their own networks.

Ethical approval to conduct this research was granted by the Auckland University of Technology Ethics Committee (reference: 16/352). The survey was active for three months (mid-September to mid-December 2016).

2.4. Data analysis

Data were exported from SurveyMonkey and analysed using the Statistical Package for the Social Sciences software (SPSS 23.0, IBM Corp., Armonk, NY, USA). For closed or multiple choice questions, data were presented as frequencies and percentages based on the number of valid responses per item. For open-ended questions, similar responses were grouped into like categories, and then frequencies and percentages were calculated for the valid responses for each category. In order to compare the demographic and professional details between those physiotherapists who used USI (termed '*users*') to those who did not use USI (termed '*non-users*') non-parametric chi-square tests were utilised with the significance level set at $p < 0.05$. To compare the content covered for formal versus informal training, percentage differences were calculated from the percentage value for content delivered for

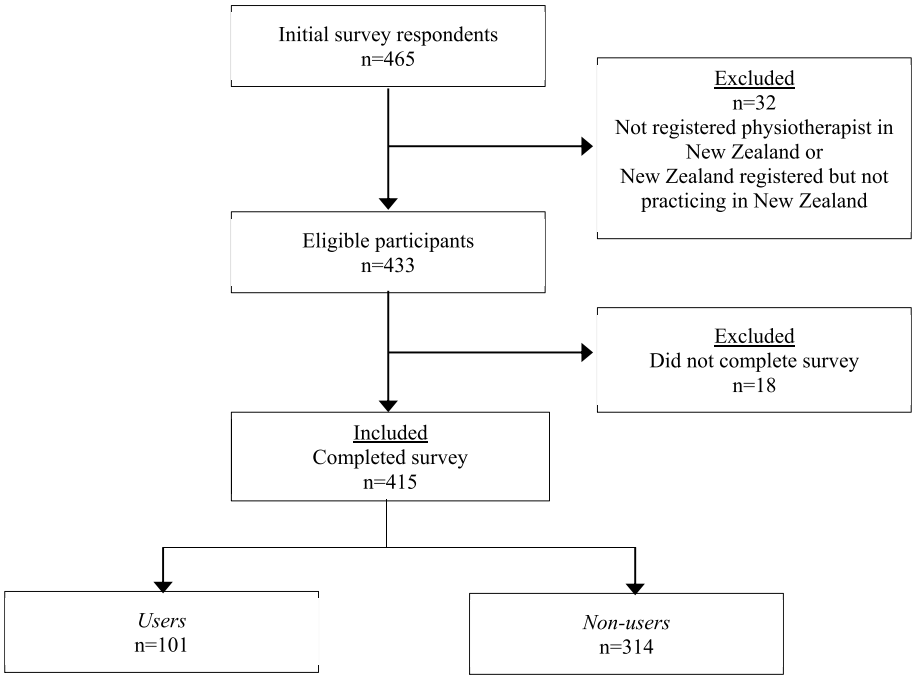

Fig. 1. Prototypical STARD diagram to report flow of participants through the study.

formal training against the percentage value for content delivered for the informal training.

3. Results

3.1. Survey response

Of 465 participants who responded to the survey (Fig. 1), 32 were excluded, as they were not New Zealand registered physiotherapists, leaving 433 eligible participants who consented to complete the survey. Of these, 18 did not finish the survey to a point whereby their use of USI (or otherwise) could be determined. It was therefore not possible to include these 18 participants, as the responses that were available provided no meaningful data for the objectives of the survey. This left 415 respondents that were included in the analysis. The survey was designed in a manner that required a response to all questions. Questionnaires that had missing responses to items were deemed to be incomplete. Therefore the numbers of valid responses, for each item, have been reported along with the respective percentage of responses, given the total number of responses. For several items the percentage values totalled above 100%, which indicated the participants gave multiple responses for one item (as allowed for certain items).

In line with similar surveys (Potter et al., 2012), it was difficult to determine the specific number of registered physiotherapists who were aware of the current survey. At the end of March 2016, 4703 annual practicing certificates were issued to New Zealand registered physiotherapists (Physiotherapy Board of New Zealand, 2016). Therefore the response rate for 433 eligible participants represented 9% of New Zealand registered physiotherapists.

3.2. Professional and demographic details

3.2.1. Demographic details and physiotherapy training

The majority of participants were female (279/415; 67%) and were aged either 25–29 years (107/415; 26%) or 30–34 years (94/415; 22%) (Table 1). Almost half of participants did not hold a postgraduate qualification (192/415; 46%) and were either employed (225/415; 54%) or self-employed (149/415; 36%). It is not unusual to have mixed employment in New Zealand, and this was reflected in the responses. The majority of participants indicated their main type of work was clinical (374/415; 90%) (Appendix 1). The four regions where the most participants were located were Auckland (241/415; 58%), Wellington (34/415; 8%), Waikato (31/415; 8%), and Canterbury (25/415; 6%). This geographical spread is reflected nationally with those listed as the four largest populated regions in New Zealand (Statistics New Zealand, 2017).

When comparing the '*users*' versus '*non-users*' groups, there were no statistically significant differences ($p \geq 0.05$) in any of the demographic variables between the groups, except for significantly ($p < 0.027$) more *users* holding a postgraduate qualification than *non-users*.

3.2.2. Professional details

The significant majority of participants worked in private practice (338/415; 81%) (Appendix 1). The fields of work with the highest representation were musculoskeletal physiotherapy (357/415; 86%) and sports physiotherapy (182/415; 44%). PNZ is the professional organisation that represents physiotherapists in New Zealand (Physiotherapy New Zealand, 2017), with a majority of participants (329/415; 79%) being members of PNZ. Membership of the regional branches and SIGs showed similar trends, respectively, to geographical location of work (Table 1) and field of work (Appendix 1). There were no significant differences in any of the professional variables between the *users* and *non-users*.

3.3. Scope of practice

In answer to the question regarding whether New Zealand physiotherapists have a scope of practice to use USI, 9% (39/415) of participants answered "no scope of practice" and 47% (193/415) answered "I don't know". There were 44% (184/415) of participants who thought that New Zealand physiotherapists do have a scope of practice to use

Table 1
Demographic details and physiotherapy training.

	Total sample (%) n = 415	Users (%) n = 101	Non-users (%) n = 314	Statistic	Significance (p value)
Gender				$\chi^2(1) = 1.54$	0.214
Male	136 (32.8%)	28 (27.7%)	108 (34.4%)		
Female	279 (67.2%)	73 (72.3%)	206 (65.6%)		
Age (years)				$\chi^2(9) = 7.22$	0.614
20–24	37 (8.9%)	10 (9.9%)	27 (8.6%)		
25–29	107 (25.8%)	22 (21.8%)	85 (27.1%)		
30–34	94 (22.7%)	21 (20.8%)	73 (23.2%)		
35–39	73 (17.6%)	20 (19.8%)	53 (16.9)		
40–44	44 (10.6%)	10 (9.9%)	34 (10.8%)		
45–49	28 (6.7%)	10 (9.9%)	18 (5.7%)		
50–54	19 (4.6%)	7 (6.9%)	12 (3.8%)		
55–59	11 (2.7%)	1 (1.0%)	10 (3.2%)		
60–64	1 (0.2%)	0 (0%)	1 (0.3%)		
65–69	1 (0.2%)	0 (0%)	1 (0.3%)		
Postgraduate Qualification				$\chi^2(5) = 12.62$	0.027
None	192 (46.3%)	37 (36.6%)	155 (49.4%)		
Postgraduate certificate	75 (18.1%)	17 (16.8%)	58 (18.5%)		
Postgraduate diploma	63 (15.2%)	24 (23.8%)	39 (12.4%)		
Masters degree	74 (17.8%)	19 (18.8%)	55 (17.5%)		
Graduate entry doctoral degree	1 (0.2%)	1 (1.0%)	0 (0%)		
Doctoral degree	10 (2.4%)	3 (3.0%)	7 (2.2%)		
Geographical location				$\chi^2(14) = 7.67$	0.906
Northland	3 (0.7%)	0 (0%)	3 (1.0%)		
Auckland	241 (58.1%)	62 (61.4%)	179 (57.0%)		
Waikato	31 (7.5%)	6 (5.9%)	25 (8.0%)		
Bay of Plenty	18 (4.3%)	4 (4.0%)	14 (4.5%)		
Gisborne	0 (0%)	0 (0%)	0 (0%)		
Hawke's Bay	11 (2.7%)	2 (2.0%)	9 (2.9%)		
Taranaki	3 (0.7%)	0 (0%)	3 (1.0%)		
Wellington	34 (8.2%)	9 (8.9%)	25 (8.0%)		
Marlborough	2 (0.5%)	1 (1.0%)	1 (0.3%)		
West Coast	1 (0.2%)	0 (0%)	1 (0.3%)		
Canterbury	25 (6.0%)	6 (5.9%)	19 (6.1%)		
Otago	21 (5.1%)	7 (6.9%)	14 (4.5%)		
Southland	3 (0.7%)	0 (0%)	3 (1.0%)		
Manawatu-Wanganui	19 (4.6%)	3 (3.0%)	16 (5.1%)		
Tasman	1 (0.2%)	0 (0%)	1 (0.3%)		
Nelson	2 (0.5%)	1 (1.0%)	1 (0.3%)		

n = participant numbers; χ^2 = chi-square statistic.

Table 2
Scopes of practice.

"Please comment about your understanding of the scope of practice that New Zealand physiotherapists can use ultrasound imaging"	Total sample (n = 170)
Rehabilitative USI only (not for diagnostic purposes)	92 (54.1%)
Can use USI with appropriate level of training/competency	23 (13.5%)
Ability or refer for USI investigation, so must have scope of practice to use USI	14 (8.2%)
Rehabilitative USI and Diagnostic USI	12 (7.1%)
Diagnostic USI	8 (4.7%)
Assumed scope of practice as know colleagues using USI	7 (4.1%)
Other	14 (8.2%)

USI, and they reported a wide variety of different uses that they believed were included in the scope of practice (Table 2).

3.4. Barriers to using USI

A significant majority (314/415; 76%) of respondents were *non-users*, 93% (292/314) of whom responded to items about the barriers that prevented them from using USI. Numerous barriers were identified

Table 3
Barriers to using USI.

"For what reasons do you not use ultrasound imaging (USI)?"	All sample (n = 292)
No training	216 (74.0%)
No ultrasound machine on site	212 (72.6%)
Equipment is expensive	108 (37.0%)
Lack of training to feel confident	87 (29.8%)
Don't understand potential uses for USI in my practice	67 (22.9%)
Time constraints don't allow USI to be used	37 (12.7%)
No specific remuneration available for providing an USI service	32 (11.3%)
No interest in using USI	32 (11.0%)
Lack of support for providing an USI service from management	28 (9.6%)
Lack of confidence	26 (8.9%)
Lack of supervision	19 (6.5%)
Patients not willing to pay for USI	16 (5.5%)
Ultrasound machine on site but not available for use	11 (3.8%)
Patients not suitable for USI	11 (3.8%)
Lack of competence inspite of training	10 (3.4%)
Patients unable to comply with instructions	3 (1.0%)
Patients not willing to be scanned	2 (0.6%)
Ultrasound machine on site and available for use but different from that used in training	1 (0.3%)
Incorrect type and/or number of ultrasound probes	1 (0.3%)
Other	7 (2.4%)

Table 4
Content of formal and informal training.

Content of training	Formal (n = 43)	Informal (n = 48)	Percentage difference (%)
	n (%)	n (%)	
How to operate the ultrasound machine ("knobology")	34 (79.1)	30 (62.5)	23.4
How to enhance the quality of the image	30 (69.8)	24 (50.0)	33.1
Understanding and identifying artefacts	30 (69.8)	16 (33.3)	70.8
Using USI as a biofeedback tool	30 (69.8)	15 (31.2)	76.4
Background physics of USI	30 (69.8)	15 (31.2)	76.4
Practical use of USI (scanning) on other course members	28 (65.1)	27 (56.3)	14.5
Safety issues around the use of the ultrasound machine	28 (65.1)	19 (39.6)	48.7
Shown more than one type of transducer	25 (58.1)	24 (50.0)	15.0
How to take structural measurements (e.g. CSA, thickness, width etc.) of soft tissues (eg. muscle, tendon, nerve etc.)	23 (53.5)	13 (27.1)	65.5
Understanding variations in soft tissue structure	23 (53.5)	12 (25.0)	72.6
Research that shows the reliability and validity of USI	23 (53.5)	11 (22.9)	80.1
Shown more than one ultrasound machine	18 (41.9)	13 (27.1)	42.9
Ergonomics of ultrasound machine use and scanning	18 (41.9)	9 (18.8)	76.1
Ethical and/or professional considerations (e.g. scope and codes of practice, consent, storage of data, etc.)	15 (34.9)	8 (16.7)	70.5
Practical use of USI (scanning) on patients	14 (32.6)	16 (33.3)	2.1
Interpretations of types of muscle activity (e.g. isometric or dynamic contractions)	14 (32.6)	5 (10.4)	103.3
How to standardise measurements of soft tissue (see item above)	9 (20.9)	4 (8.3)	86.3
Use of Doppler imaging	8 (18.7)	6 (12.5)	39.7

(Table 3) of which the top four were: lack of training (216/292; 74%) or lack of training to feel confident to use USI (87/292; 30%), no ultrasound machine on site (212/292; 72%) and ultrasound equipment being expensive (108/292; 37%).

Participants were asked to comment on how they thought the barriers to using USI could be mitigated (Appendix 2). Of the *non-users* who described barriers, 97% (282/292) answered this question with the top four suggestions to mitigate barriers: undertaking training (101/282; 36%), improving access and/or availability of training (65/282; 23%), providing access to ultrasound equipment (59/282; 21%) and more affordable ultrasound equipment (47/282; 17%).

3.5. Clinical uses of USI

Only 24% (101/415) of respondents were *users* of USI. There were a wide variety of contexts in which USI was used along with variety in the amount and frequency of use (Appendix 3). The four most common uses were: biofeedback (40/77; 52%), to aid clinical diagnosis (38/77; 49%), to assess soft tissue trauma and monitor healing (21/77; 27%), and to monitor treatment outcome (14/77; 18%). Participants were also asked to rate the importance they perceived USI to be for their practice (Appendix 3), with the largest percentage (18%) scoring the importance 5/10 (0 = not at all important; 10 = very important).

3.6. Training

In the *users* group, 43% (43/101) had received formal training, with 26 of them having also received informal training. Furthermore, 48% (48/101) of *users* had received informal training only whilst 10% (10/101) had received no training.

With regard to the content of training received (Table 4), formal training courses consistently had more content on each of the topics identified, which would imply that formal training was more comprehensive. This was reflected by self-reported competency in several domains regarding their use of USI (Figs. 2 and 3). Participants who received formal training consistently rated themselves as being 'competent' or 'somewhat competent', across most aspects of USI, more than participants who received informal training, or no training. The content items with the largest percentage differences between formal versus informal training included (shown as a percentage difference): interpretations of muscle activity (103%), standardisation of measurements (86%), research regarding reliability and validity of USI (80%), using USI for biofeedback (76%) and background physics of USI (76%) (Table 4).

As a key aspect of rehabilitative USI is for the assessment of different body tissue morphology and function (Teyhen, 2011; Whittaker and Stokes, 2011), it was of interest to assess the different content items of USI training received in respect to different body tissues. The majority of training courses (both formal and informal) assessed muscles (most commonly the trunk and pelvic floor muscles) without any other body tissues being covered (Appendix 4).

4. Discussion

This study was the first to investigate New Zealand registered physiotherapists about their use (or lack of use) of USI. Although the sample size captured a small proportion of New Zealand registered physiotherapists (9%), the key demographic and professional variables of physiotherapists in New Zealand were reflective of the survey sample. As was the case with previous surveys (Jedrzejczak and Chipchase, 2008; McKiernan et al., 2011; Potter et al., 2012), the majority of participants were female, worked in a clinical capacity, were employed in private practice and practiced within the musculoskeletal field. These findings are not surprising as they reflect the demographic and professional trends seen in New Zealand (Physiotherapy Board of New Zealand, 2016) and are similar for those reported in other countries (Jedrzejczak and Chipchase, 2008; McKiernan et al., 2011; Potter et al., 2012).

From the 415 valid responses, 101 participants (24%) were *users* compared to 314 (76%) *non-users*. This proportion of *users* is substantially higher than an Australian study by Jedrzejczak and Chipchase (2008), who reported 12% of their 664 respondents as *users* of USI. The study by Jedrzejczak and Chipchase (2008) is nine years old, which is relevant, as this represents a period of time over which increased use of USI by physiotherapists is reported anecdotally. Although only comparable to one other survey (Jedrzejczak and Chipchase, 2008), the findings from the current study might indicate an increased use of USI by physiotherapists. However, it is important to note that the current study only surveyed 9% of registered physiotherapists in New Zealand and therefore the level of USI reported may not necessarily be a true

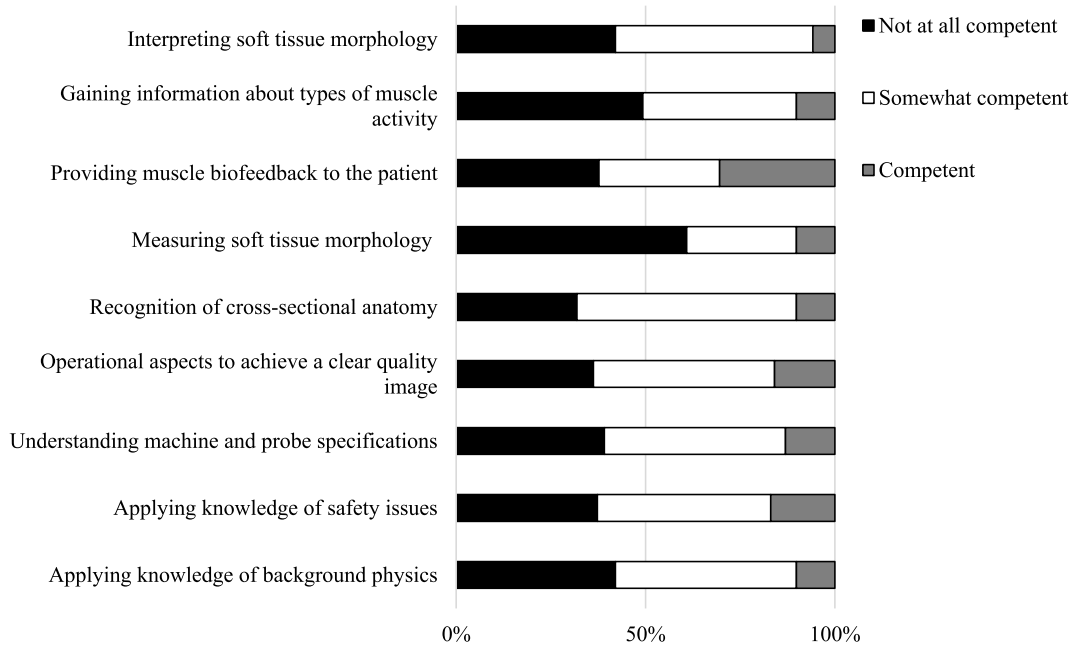

Fig. 2. Perceived competency of specific skills: all respondents (n = 69).

representation for the whole cohort. A large international study is warranted to provide a more accurate overview of the use of USI by physiotherapists.

For all demographic and professional variables assessed, the *users* and *non-users* groups were similar on all of these variables with the exception of postgraduate training. There were significantly more *users* who had a postgraduate qualification compared to *non-users*.

The results indicate that there is general uncertainty as to whether USI falls within the New Zealand physiotherapists' scope of practice. The Physiotherapy Board of New Zealand (PBNZ), in accordance with

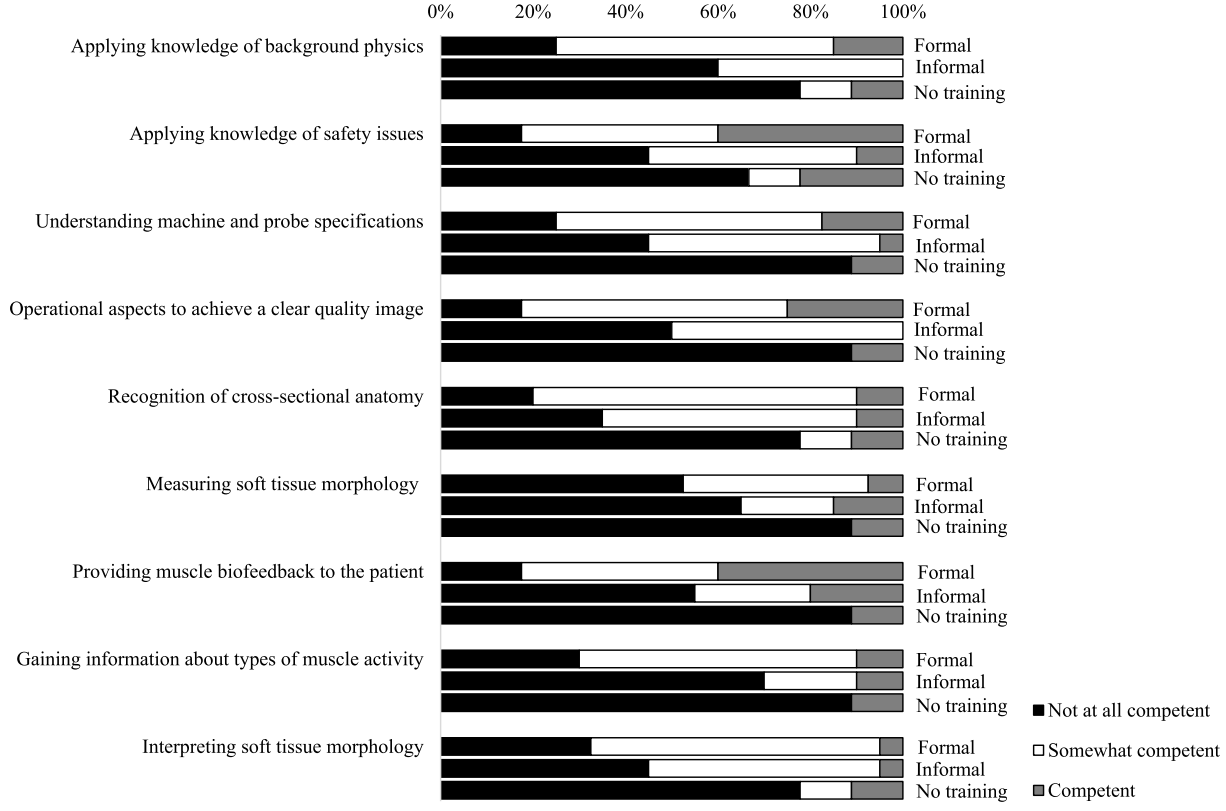

Fig. 3. Perceived competency of specific skills: Formal vs Informal vs No training (n = 40, 20, 9).

the Health Practitioners Competence Assurance Act 2003 (Ministry of Health, 2017), specifies the scopes of practice of licenced physiotherapists. The physiotherapy 'General Scope of Practice' is intentionally broad and does not include (or exclude) specific therapies, techniques or assessment tools (Physiotherapy Board of New Zealand, 2008). If physiotherapists employ specific assessment tools, such as USI, that were not included in their undergraduate education they must demonstrate competence in this field of practice through "relevant and appropriate education and training specific to that field" as stated in the PBNZ's position statement 'Practising in a Defined Field' (Physiotherapy Board of New Zealand, 2015). It is possible that the lack of a specified USI guideline or position statement may have led to the uncertainty as reflected in the survey results. Furthermore, this uncertainty is likely to be perpetuated given that USI is an emerging tool for physiotherapists and its use in physiotherapy is still evolving. It is hoped that the findings of this research will improve the understanding in this regard. There is clearly a need for both national and international regulatory bodies to acknowledge this situation and to work with professional leaders to establish guidelines to provide certainty for scope of practice and training.

The majority of the current participants classified themselves as *non-users*. This survey is the first published research that has specifically explored the barriers that prevent physiotherapists from using USI. The barriers identified included lack of training, no access to ultrasound equipment, lack of competence and the perception that ultrasound equipment was expensive and therefore unaffordable. Although the current study did not seek to ask *non-users* about training, similar barriers were identified by Potter et al. (2012) for physiotherapists who were *non-users* but who had received training in USI.

Lack of USI training was a major barrier, as there are limited USI training opportunities in New Zealand. The generalist courses aimed to train sonographers (New Zealand Medical Radiation Technologists Board, 2017) are not targeted to physiotherapists. There is one formal tertiary level USI course targeted to physiotherapists (Auckland University of Technology, 2017) with the remainder of courses being offered informally (i.e. not through a tertiary education institution).

Another key barrier identified was a lack of ultrasound equipment, which was clearly aligned to beliefs around the prohibitive cost of ultrasound equipment. This issue was compounded by the lack of a clear structure to specifically charge a dedicated fee for the USI service (e.g. as a value-added or stand-alone service) as well as the time limitations due to the duration of clinic appointments. In New Zealand physiotherapists have the ability to set their own private fee structures but this would not be as easily achieved for service fees set by external funders such as government funders and insurance companies.

The potential confusion concerning scopes of practice for using USI could also be a barrier, as evidenced by some participants not being aware of the clinical uses and benefits of USI. Participants suggested that these barriers could be overcome by the provision of guidelines for clinical use and benefit, information about the clinical benefits of USI and how these can add clinical value, and improved research evidence to support the use of USI. The onus therefore falls upon researchers and clinicians using USI to ensure that the benefit of USI for physiotherapists, along with accurate representation about scopes of practice, are disseminated appropriately.

Although 24% of respondents were *users*, it was apparent that USI in clinical practice is limited. The large majority of *users* employed USI for between 1 and 5 h per week and with 1–10% of their patients (Appendix 3). This level of use is similar to that reported by Potter et al. (2012). The clinical uses of USI amongst *users* varied, with greatest use being biofeedback, also identified by Potter et al. (2012).

Of interest was the number of respondents who appear to be using USI in a diagnostic capacity. Distinctions have been made between rehabilitative versus diagnostic USI (Teyhen, 2006; Whittaker et al., 2007a). The main reason for these distinctions was to draw attention to the differing levels of training and content needed for competent use of rehabilitative USI, in contrast to that required to be competent in diagnostic USI (Teyhan, 2007; Whittaker et al., 2007a). The level of training required to use USI in a diagnostic capacity needs to be commensurate to allow accurate diagnoses to be made.

Of the *users*, 42% had received formal training whilst 48% had received informal training. These findings were similar to those reported by Potter et al. (2012), although their participants had received slightly more formal (52%) compared to non-formal (48%) training. Of concern was the 10 *users* (10%) who had received no training at all. However, this figure is lower than 32% reported by McKiernan et al. (2011) and 20% by Jedrzejczak and Chipchase (2008).

It was clear that formal training was more comprehensive, covering a wider range of content areas compared to non-formal training, a trend also identified by Potter et al. (2012). Of concern, however, was the disparity between formal and non-formal training in key areas critical for the understanding and interpretation of USI. As USI is operator dependent (both in operation and interpretation), it is essential that physiotherapists using USI do so with the necessary level of training to limit the potential for diagnostic or therapeutic inaccuracies (Jedrzejczak and Chipchase, 2008; McKiernan et al., 2011; Whittaker and Stokes, 2011; Whittaker et al., 2007a). In this regard, differences favoured formal training in critical areas such as the background physics of USI, understanding and identifying artefacts, safety issues and ethical and/or professional considerations. Our study findings have supported those of other authors (McKiernan et al., 2011; Whittaker and Stokes, 2011) in terms of USI training for physiotherapists needs to be led by experts in the field and designed specifically for the needs of physiotherapists. Formal training for diagnostic USI is paramount and courses are widely available. For rehabilitative USI, whilst formal training is preferable, it is less accessible and some physiotherapists have taken up USI without any training at all. If informal training is deemed necessary, to avoid physiotherapists adopting rehabilitative USI without training, it should be conducted by formally trained USI experts and include the critical aspects to USI practice that are more commonly involved in formal training, e.g. physics of USI, safety (including artefacts) and ethics.

Whilst it is agreed that guidelines should be implemented to direct training and competence (Leech et al., 2015; Teyhan, 2007; Whittaker and Stokes, 2011; Whittaker et al., 2007a), there is a lack of consensus regarding the threshold level and content of training that is adequate for physiotherapists to use USI. This issue has not been resolved to date and provides active debate within the physiotherapy USI community.

4.1. Strengths, limitations and future research

There were two strengths in our study. One, we used the survey conducted by Potter et al. (2012 as a basis for our study in terms of the study design and face validity testing by means of engaging with an expert panel. Two, despite our sample being small, the demographic analysis suggested that the sample was representative of the general physiotherapy community in New Zealand.

A limitation of this study was that 18 participants did not complete the survey. This may have been due to the *users* group having to answer 72 items, which is beyond the recommended level of questions to hold a participant's interest (Forrest, 1999). In contrast the *non-users* had to answer only 22 items, which appeared to be an appropriate level for a survey of this type (Forrest, 1999; Potter et al., 2012).

5. Conclusion

The results of this survey indicated approximately a quarter of registered physiotherapists, who responded to the survey, are using USI. The clinical uses of USI by this group are varied, but mainly reflect the common uses reported for rehabilitative USI. Training in use of USI is also varied, with more comprehensive training offered in formal courses. The scopes of practice regarding the use of USI by physiotherapists in New Zealand remain unclear. This might present a barrier for the almost three quarters of physiotherapists in New Zealand

who are not using USI. Other barriers included cost and access to equipment. Future research should investigate ways of overcoming the barriers that impede the use of USI in physiotherapy.

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Appendix 1. Professional details: type of employment, scope of work and professional affiliations

	Total sample (n = 415)	Users (n = 101)	Non-users (n = 314)	Statistic	Significance (*p* value)
Employment Status				$\chi^2(3) = 7.81$	0.050
Employed	225 (54.2%)	48 (47.5%)	177 (56.4%)		
Self-employed	149 (35.9%)	36 (35.6%)	113 (36.0%)		
Employer	37 (8.9%)	15 (14.9%)	22 (7.0%)		
Other	4 (1.0%)	2 (2.0%)	2 (0.6%)		
Type of work				$\chi^2(6) = 7.80$	0.253
Clinical	374 (90.1%)	89 (88.1%)	285 (90.8%)		
Management	17 (4.1%)	5 (5.0%)	12 (3.8%)		
Teaching/education	12 (2.9%)	2 (2.0%)	10 (3.2%)		
Research	5 (1.2%)	1 (1.0%)	4 (1.3%)		
Clinical and Management	3 (0.7%)	1 (1.0%)	2 (0.6%)		
Clinical and Education	2 (0.5%)	2 (2.0%)	0 (0%)		
Other	2 (0.5%)	1 (1.0%)	1 (0.3%)		
Work relationships				$\chi^2(4) = 1.48$	0.830
Work alone	29 (7.0%)	9 (8.9%)	20 (6.4%)		
Other physiotherapists	236 (56.9%)	59 (58.4%)	177 (56.4%)		
Multidisciplinary/interprofessional team	136 (32.8%)	30 (29.7%)	106 (33.8%)		
Teachers and academics	13 (3.1%)	3 (3.0%)	10 (3.2%)		
Other (Not Working)	1 (0.2%)	0 (0%)	1 (0.3%)		
Place of Employment[a]					
Private practice	338 (81.4%)	88 (87.1%)	250 (79.6%)		
Sports team or sports institute	104 (25.1%)	35 (34.7%)	69 (22.0%)		
Public hospital/clinic	52 (12.5%)	5 (5.0%)	47 (15.0%)		
Private organisation	26 (6.3%)	5 (5.0%)	21 (6.7%)		
University	24 (5.8%)	5 (5.0%)	19 (6.1%)		
Private hospital	10 (2.4%)	3 (3.0%)	7 (2.2%)		
Community	5 (1.2%)	0 (0%)	5 (1.6%)		
Government organisation and/or NZDF	2 (0.5%)	0 (0%)	2 (0.6%)		
Vocational assessment and rehabilitation	2 (0.5%)	1 (1.0%)	1 (0.3%)		
Research facility	1 (0.2%)	1 (1.0%)	0 (0%)		
Other	4 (1.0%)	1 (1.0%)	3 (1.0%)		
Animal physiotherapy, not working, consultant, medical device sales and marketing					
Scope of work[a]					
Musculoskeletal	357 (86.0%)	93 (92.1%)	264 (84.1%)		
Sports	182 (43.9%)	59 (58.4%)	123 (39.2%)		
Occupational health	79 (19.0%)	18 (17.8%)	61 (19.4%)		
Aged care	50 (12.0%)	5 (5.0%)	45 (14.3%)		
Neurology	50 (12.0%)	2 (2.0%)	48 (15.3%)		
Hand therapy	33 (8.0%)	8 (8.0%)	25 (8.0%)		
Cardiorespiratory and/or cardiovascular	33 (8.0%)	1 (1.0%)	32 (10.2%)		
Women's health	32 (7.7%)	14 (13.9%)	18 (5.7%)		
Paediatrics	22 (5.3%)	2 (2.0%)	20 (6.4%)		
Mental health	1 (0.2%)	0 (0%)	1 (0.3%)		
Other	16 (3.9%)	4 (4.0%)	12 (3.8%)		
Pain, oncology, lymphoedema, research, education, spinal cord injuries, animal physiotherapy, clinical pilates, vestibular rehabilitation, orthopaedics, wheelchairs and seating					

Years of experience				$\chi^2(3) = 3.52$ 0.318
0–5	129 (31.1%)	33 (32.7%)	96 (30.6%)	
6–10	107 (25.8%)	19 (18.8%)	88 (28.0%)	
11–15	73 (17.6%)	20 (19.8%)	53 (16.9%)	
16+	106 (25.5%)	29 (28.7%)	77 (24.5%)	
PNZ member				$\chi^2(1) = 0.75$ 0.386
Yes	329 (79.3%)	77 (76.2%)	252 (80.3%)	
No	86 (20.7%)	25 (23.8%)	61 (19.7%)	
PNZ regional branch (n = 330)				$\chi^2(10) = 7.75$ 0.653
Auckland	118 (35.9%)	23 (29.9%)	95 (37.7%)	
North Shore	56 (17.0%)	18 (23.4%)	38 (15.1%)	
Waikato/Bay of Plenty	41 (12.5%)	8 (10.4%)	33 (13.1%)	
Wellington	33 (10.0%)	9 (11.7%)	24 (9.5%)	
Canterbury	22 (6.7%)	5 (6.5%)	17 (6.7%)	
Middle Districts	21 (6.4%)	3 (3.9%)	18 (7.1%)	
Otago	20 (6.1%)	7 (9.1%)	13 (5.2%)	
Hawkes Bay	9 (2.7%)	2 (2.6%)	7 (2.8%)	
Nelson/Marlborough	6 (1.8%)	2 (2.6%)	4 (1.6%)	
Northland	2 (0.6%)	0 (0%)	2 (0.8%)	
Southland	1 (0.3%)	0 (0%)	1 (0.4%)	
Special Interest Groups of PNZ[a]				
Not a member	80 (19.3%)	17 (16.8%)	63 (20.1%)	
Sports Physiotherapy New Zealand	128 (30.8%)	37 (36.6%)	91 (29.0%)	
NZMPA	81 (19.5%)	22 (21.8%)	59 (18.8%)	
PAANZ	56 (13.5%)	9 (8.9%)	47 (15.0%)	
Occupational Health	53 (12.8%)	10 (9.9%)	43 (13.7%)	
Hand Therapists	25 (6.0%)	7 (6.9%)	18 (5.7%)	
Pelvic, Women's and Men's Health	15 (3.6%)	9 (8.9%)	6 (1.9%)	
Neurology	14 (3.4%)	0 (0%)	14 (4.5%)	
Older Adult	7 (1.7%)	0 (0%)	7 (2.2%)	
Cardiothoracic	5 (1.2%)	0 (0%)	5 (1.6%)	
Physiotherapy in Mental Health	2 (0.5%)	0 (0%)	2 (0.6%)	
Paediatric	4 (1.0%)	0 (0%)	4 (1.3%)	

n = participant numbers; χ^2 = chi-square statistic; NZDF = New Zealand Defence Force; PNZ = Physiotherapy New Zealand; NZMPA = New Zealand Manipulative Physiotherapists Association; PAANZ = Physiotherapy Acupuncture Association of New Zealand.

[a] Responses to question not mutually exclusive (statistical comparison not possible due to multiple responses).

Appendix 2. Mechanisms to mitigate the barriers for using USI

"Please comment on how you believe the barriers that you've identified above, that prevent you from using ultrasound imaging, could be removed or negated"	All sample (n = 282)
Undertake training	101 (35.8%)
Improved access and/or availability of training	65 (23.0%)
Have access to ultrasound equipment	59 (20.9%)
More affordable ultrasound equipment	47 (16.7%)
Provide specific remuneration for USI	36 (12.8%)
Provide guidelines for the clinical uses and benefits of USI	28 (9.9%)
Highlight how USI may offer added clinical benefit/value	23 (8.2%)
Improved research evidence to indicate uses and benefits of USI	22 (7.8%)
USI training within undergraduate programmes	17 (6.0%)
USI training within postgraduate programmes	15 (5.3%)
Ongoing supervision	11 (3.9%)
Increase clinical time for USI use	8 (2.8%)
Support from employer to use USI	4 (1.4%)
Provide a specific scope of practice	4 (1.4%)
Other	7 (1.7%)

Appendix 3. Clinical uses of using USI

	n (%)
Context of using USI (n = 77)[a]	
Biofeedback tool	40 (51.9%)
To assist in making a diagnosis of injury and/or pathology	38 (49.4%)
Assessment of soft tissue trauma and monitor healing	21 (27.3%)
Monitoring outcome of treatment	14 (18.2%)
Training other physiotherapists how to use USI, including specific rehabilitative or treatment techniques	12 (15.6%)
Evaluating muscle structure (e.g. shape, pennation angle, muscle fascicle length, fatty infiltration etc.)	8 (10.4%)
Measuring cross-sectional area (CSA) and/or volume of soft tissues	7 (9.1%)
Research	5 (6.5%)
Measuring linear soft tissue thickness and/or width	5 (6.5%)
Training other clinicians (e.g. podiatrists, GP's etc.) how to use USI	1 (1.3%)
Other (e.g. measuring bladder volume and bladder emptying)	1 (1.3%)
Hours per month using USI (n = 77)	
1–5 h	60 (77.9%)
6–10 h	12 (15.6%)
11–15 h	4 (5.2%)
16–20 h	0 (0.0%)
21–25 h	0 (0.0%)
26–30 h	1 (1.3%)
More than 30 h	0 (0.0%)
Percentage of patients that USI is used (n = 77)	
1–10%	33 (42.9%)
11–20%	18 (23.4%)
21–30%	5 (6.5%)
31–40%	3 (3.9%)
41–50%	1 (1.3%)
51–60%	0 (0.0%)
61–70%	2 (2.6%)
71–80%	3 (3.9%)
81–90%	0 (0.0%)
91–100%	0 (0.0%)
How important is USI in your clinical practice? (0 = not at all important, 10 = very important)	
0/10	6 (7.8%)
1/10	3 (3.9%)
2/10	7 (9.1%)
3/10	11 (14.3%)
4/10	2 (2.6%)
5/10	14 (18.2%)
6/10	9 (11.7%)
7/10	11 (14.3%)
8/10	8 (10.4%)
9/10	3 (3.9%)
10/10	3 (3.9%)

[a] Participants were able to select multiple items. n = participant numbers.

Appendix 4. Muscle groups and other tissues trained to image

	All Sample (n = 77) n (%)	Formal (n = 43) n (%)	Informal (n = 22) n (%)
Muscle groups			
Anterolateral abdominal wall	39 (50.6)	28 (65.1)	11 (50.0)
Multifidus and/or other spinal extensors	30 (39.0)	27 (62.8)	3 (13.6)
Pelvic floor	27 (35.1)	23 (53.5)	4 (18.2)
Lower limb muscles	26 (33.8)	19 (44.2)	7 (31.8)
Upper limb muscles	25 (32.5)	19 (44.2)	6 (27.3)
Bladder	13 (16.9)	12 (27.9)	1 (4.5)
Diaphragm/respiratory muscles	8 (10.4)	8 (18.6)	0 (0.0)
Cervical spine musculature	4 (5.2)	4 (9.3)	0 (0.0)
Other tissues			
None	48 (62.3)	29 (67.4)	19 (86.4)
Tendons	11 (14.3)	9 (20.9)	2 (9.1)
Ligaments	6 (7.8)	4 (9.3)	2 (9.1)
Nerves	3 (3.9)	3 (7.0)	0 (0.0)
Bone	3 (3.9)	2 (4.7)	1 (4.5)
Vascular system	1 (1.3)	1 (2.3)	0 (0.0)
Other	1 (1.3)	1 (2.3)	0 (0.0)
Recesses, fossae			

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