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- Physical therapies in 19th century Aotearoa/ New Zealand
- Upper limb rehabilitation template post-stroke
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PHYSIOTHERAPY NEW ZEALAND
Kōmiri Aotearoa

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MOVEMENT FOR LIFE

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The role of physiotherapy in the management of vulvodynia

Vulvodynia is an umbrella term used to describe pain or discomfort in the vulva, lasting for more than three months and for which no obvious aetiology can be found (Bornstein et al 2016). Understandably, the condition creates significant physical, psychological, and emotional issues for the woman affected and her intimate partner.

The clinical presentation of women with vulvodynia varies greatly, which means that taking a thorough history and performing a careful examination is essential for the interpretation of the presentation and for ruling out differential diagnoses of vulval pain (Cox and Neville 2012). This variability also means that there is no set recipe for managing someone with vulvodynia: each woman needs an individualised assessment and intervention plan that addresses the specific biological, psychological, and social factors contributing to her pain, and the impact of her pain on her life (Chalmers 2015).

Although physiotherapists are often the first point of contact for a woman with vulvodynia, it is important to also get a medical assessment because there are several conditions that can present as, or alongside, vulvodynia. Differential or co-existing diagnoses include dermatological conditions, both benign and malignant, vulvovaginal infections, and pudendal neuralgia. Where co-existing diagnoses have been excluded or effectively managed, physiotherapy can be effective in reducing pain and improving quality of life in women with vulvodynia (for example, Bergeron et al (2002), Goldfinger et al (2009), Hartmann et al (2007)). Due to the complex nature of vulvodynia, physiotherapists treating women with this condition should have advanced education in the field of women's health. Here we outline the evidence-based recommendations for the physiotherapy management of women presenting with vulvodynia.

Recommendation 1: Validation

Often the first step on a woman's road to recovery is having her pain validated as being real (Sadownik 2014). This validation can bring comfort and counter any thoughts she may have that the condition is imagined or 'all in her head'. It is often helpful to have the woman's partner present during these conversations to further legitimise her pain experience. Labeling the pain as vulvodynia validates that the pain exists but is not driven by sinister or harmful pathology. Evaluating the impact of pain on the individual's life (Chalmers 2015) is also validating and, critically, important for planning management.

Recommendation 2: Education

Patient education is considered best-practice for many pain conditions, including back pain (Reese and Mittag 2013), neck pain (Yu et al 2014), and fibromyalgia (Ablin et al 2013). While several narrative reviews advocate patient education for the treatment of vulvodynia (Cox and Neville 2012, Haefner et al 2005, Mandal et al 2010), the exact content of this education is vague. Previous research has highlighted the efficacy of pain biology education – so called 'explaining pain' – in patients with chronic low back pain (Moseley et al 2004). While no such research has been conducted in women with vulvodynia, there are similarities that exist between low back pain and vulvodynia, for example both are not usually associated with structural pathology; both involve changes in the central nervous system; and both benefit from a biopsychosocial approach. Best practice management of vulvodynia currently includes pain biology education that aims to increase the woman's understanding of the biological mechanisms underpinning their condition and to reduce the perceived threat associated with their pain.

Education on simple management techniques can also be beneficial (Goldstein and Burrows 2008). Women can be advised to avoid irritants (soaps or body washes, vaginal douching, having bubble baths, and using scented sanitary pads or tampons (Edwards 2003, Glazer and Ledger 2002)). The vagina has its own cleaning and pH regulatory mechanisms, mediated by a large amount of 'good' bacteria. There is no need to clean the inside of the vagina and the external vulva simply requires washing with warm water and patting dry with a towel. Moisturising the vulva after washing with a non-perfumed cream is recommended in clinical guidelines (Haefner et al 2005, Henzell and Berzins 2015), although supportive clinical studies are lacking.

Addressing a woman's sexual concerns is essential. There is no consensus on whether the best approach is to remain sexually active or to abstain, and it may differ from woman to woman. Abstinence may help patients to avoid aggravating factors but can also take a toll on intimate relationships. If a patient remains in a penetrative sexual relationship, they can be advised use olive or coconut oil as a lubricant because they are free of synthetic materials or perfumes.

Recommendation 3: Stress and anxiety reduction

Women with vulvodynia often relate the onset or exacerbation of their symptoms to stress and anxiety (Arnold et al 2006, Ehrström et al 2009). Relaxation techniques, in particular progressive relaxation, has positive physiological effects on those suffering from anxiety (Borkovec and Sides 1979). Most clinical guidelines on vulvodynia recommend relaxation (Haefner et al 2005, Mandal et al 2010, Reed 2006), although the exact method or dosage remains unclear. We recommend a gentle progressive muscle relaxation technique that includes the pelvic floor muscles (for example, the audio guide available from http://www.patricianeumann.com.au).

Recommendation 4: Pelvic floor muscle down-training

Women with vulvodynia often have pelvic floor muscle dysfunction (PFMD). Pelvic floor resting muscle tone is higher and contractions are slower and weaker in women with vulvodynia than in healthy women (Glazer et al 1998, White et al 1997). PFMD can be assessed by using a 1-finger digital examination of the muscles and/or by using biofeedback. If PFMD is observed, the aim of the intervention should be to reduce resting muscle tone. This is achieved through 'down-training' of the pelvic floor muscles, and can be performed independently or with the use of biofeedback.

Down-training the pelvic floor is difficult for most women. There are different techniques that can be used and not all women will respond to the same technique. Gentle contract-relax exercises, such as those used in a progressive muscle relaxation technique, can be helpful in improving a woman's proprioceptive awareness of her pelvic floor muscles (Bergeron et al 2002). Maximal pelvic floor muscle contractions, such as those made popular by Kegel (1948), are not supported. The focus of exercises should be on the relaxation of the pelvic floor muscles; a gentle, sub-maximal contraction followed by relaxation can be helpful for women to perceive the sensation of the pelvic floor relaxing. However, if these contractions evoke pain they should be avoided, with exercises focusing solely on relaxation. Specific dosage for pelvic floor down-training exercises is vague; however, two 20-minute sessions per day are often recommended (Edwards 2003, Hollis 2000).

Intravaginal biofeedback is a helpful addition to pelvic floor down-training exercises because it allows patients to visualise their muscle activity (Bergeron et al 2002). It is especially useful in its portability and affordability; patients can complete their pelvic floor down-training exercises at home and receive immediate feedback on their performance (Edwards 2003).

Recommendation 5: Referral

An effective management plan for vulvodynia will include addressing all of the biological, psychological, and social factors that contribute to a woman's pain. To address these factors appropriately, physiotherapists should not work alone: clinical guidelines recommend a multidisciplinary approach involving physiotherapists, medical doctors, gynaecologists, pain specialists, and counselors or psychologists (Mandal et al 2010).

Other clinical treatments

There are three other commonly used techniques for treating women with vulvodynia for which there is little supporting evidence: pelvic floor muscle release, vaginal dilators, and electrical stimulation. While their efficacy is unknown, it would seem prudent to consider the potential risks or side effects and the pressing need for further research. Pelvic floor muscle release has been used in combination with other treatments such as biofeedback and relaxation with good patient outcomes (Bergeron et al 2002); however, it is difficult to surmise the actual effect of the soft-tissue release technique. Relevant here is that the technique requires the insertion of a digit which is often painful for women with vulvodynia (Foster et al 2009) and the evidence to suggest that deep soft-tissue massage has no effect on the targeted effect - flexibility of soft-tissue (for example, Thomson et al (2015)). Despite these limitations, deep soft-tissue release remains a popular technique used to treat vulvodynia. Theoretically, vaginal dilators may be helpful to desensitise the vaginal introitus and allow women to regain confidence in engaging in sexual intercourse (Wylie et al 2004). However, again, there is currently little empirical support for this theory. There is one randomised controlled trial investigating the efficacy of transcutaneous electrical nerve stimulation (TENS) in the treatment of vestibulodynia, a subtype of vulvodynia (Murina et al 2008). That trial showed significantly improved pain scores in the TENS group versus the sham treatment group; however, these findings are yet to be replicated. The broad picture that emerges when available treatments for vulvodynia are appraised is one of desperate need for rigorous clinical studies and frank appraisal of pathophysiological models, some of which are retro-fitted to apparently effective interventions, some have been disproved and some, one might suggest, are nonsense.

Summary

The complex nature of vulvodynia can cause frustration for patients and clinicians alike. Physiotherapy can be an effective treatment for vulvodynia, although the specific techniques used to treat the condition can vary widely and much remains to be elucidated with regards to why some treatments seem to work. As the evidence currently stands, management plans for women with vulvodynia should be individualised and target the specific factors contributing to the individual's pain presentation, itself dependent on a thorough biopsychosocial assessment. Key components of a physiotherapy intervention will usually involve: (1) validating the pain as real, (2) educating women on pain biology and simple management techniques, (3) relaxation for stress and anxiety management, (4) pelvic floor muscle down-training, and (5) integration of care with other health professions, such that physiotherapists work alongside others professions to ensure that the specific biological, psychological, and social factors contributing to each woman's pain experience are addressed.

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Physical therapies in 19th century Aotearoa/New Zealand: Part 2 – Settler physical therapies

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ABSTRACT

This paper is the second of two reporting on a historiographic study of physical therapies in 19th century Aotearoa/New Zealand. This paper focuses on physical therapies practised by colonists, missionaries, pioneers, and other settlers to Aotearoa/New Zealand before 1900. The paper follows the methodological framework of the first paper and explores early medical development and some of the physical therapy practices of colonial settlers. We examine some of the living conditions experienced by colonial settlers and consider how 19th century ideologies contributed to a lack of formalised medical development in Aotearoa/New Zealand. We then explore the evidence of physical therapy practices and practitioners, who congregated mostly in the country's larger metropolitan centres, before concluding the paper with a discussion of some of the possible reasons for the distinct lack of physical therapies amongst the colonial settlers, when compared with the concurrent resurgence in physical therapy practices in Europe and North America.

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Key words: Masseur, Masseuse, Physical therapy, History, Aotearoa/New Zealand, Settler

INTRODUCTION

This paper reports on a study undertaken to examine why it appears that the physical therapies (massage and manipulation, electrotherapy, hydrotherapy and remedial exercise) were some of the most popular therapies in Europe and North America during the 19th century, but were almost completely absent from Aotearoa/New Zealand culture before 1900. In the paper, we detail the background to the study and outline a detailed historiographic account of existing texts, which show that there is some evidence of physical therapies being used by Māori prior to and during the 19th century. Subsequent papers will explore the practices of colonial settlers and argue that the particular nature of colonisation in New Zealand failed to create the conditions in which the physical therapies could flourish. We conclude these papers by arguing that although a few practitioners did establish themselves before 1900, accounts of their activities are incidental and piecemeal.

The origins of this study lie in five intersecting conditions. Firstly, physiotherapy in New Zealand celebrated its centenary in 2013, and the profession represents one manifestation of the physical therapies in an organised, disciplinary form. But this organisation only began in 1913, and in undertaking research into the profession's early history it appeared that there were few physical therapy practitioners in New Zealand prior to 1900. Secondly, a great deal of data exists indicating that the physical therapies were extremely popular and widely used in Europe and North America during the 19th century. And so thirdly, we assumed that many of the colonists who arrived in New Zealand from Australia, Europe and North America in the 19th century would have known about or been exposed to at least some of these therapies, and some may well have been practitioners themselves. Fourthly, we were aware that Māori used physical therapies as part of Indigenous healing practices, but that published accounts of massage and the use of thermal springs were limited. Finally, despite much of the development work taking place in the last two decades of the 19th century, the largest organised centre for the development of the physical therapies in New Zealand prior to 1913 – Rotorua Spa – did not become established until after 1901 with the creation of the world's first Department of Tourist and Health Resorts.

Given these five conditions, we asked what evidence existed for physical therapies in New Zealand; to what extent were they practised; by whom, where and when. The study used historiographic methods to identify and review texts from a wide range of primary and secondary sources, including published and unpublished manuscripts, period newspapers, personal accounts, photographs, registers and directories, available either online, through databases like *Papers Past*, or with first hand archival searching at Archives New Zealand, the Alexander Turnbull Library and the National Library.[1] Secondary texts were also examined for accounts of physical therapies and evidence of interest in the subject. Before presenting the findings of the study, we will unpack some of the context underpinning the study and explain in more detail how the texts were identified and read.

[1] All of the texts examined in this study were in the form of written documents. These inevitably privilege 'western' modes of historiographic recording. No primary oral accounts of Māori healing practices were identified, although some of these are reported by Pakeha in their own accounts of 19th century practices.

BACKGROUND

This paper is the second to report on a study undertaken to examine why it appears that the physical therapies (massage and manipulation, electrotherapy, hydrotherapy and remedial exercise), were some of the most popular therapies in Europe and North America during the 19th century, but were almost completely absent from Aotearoa/New Zealand before 1900. In the paper, we explore the lives of colonists, missionaries, pioneers, and other settlers during the 19th century, and examine the evidence for the existence of a small number of practising physical therapists from Australia, Europe and North America operating in larger population centres. We consider the living conditions of many of the settlers and speculate to what extent the atomisation and isolation of colonists limited the development of the physical therapies prior to 1900. We conclude the paper with a discussion of some of the reasons for the dearth of physical therapists and physical therapies in Aotearoa/New Zealand, with the exception of the Rotorua Spa, which is the focus for the third and final paper in the series.

To briefly recap, the rationale for this study lay in five intersecting conditions:

1. Knowledge of physiotherapy practices after 1913, but a sense that little existed before then;
2. The popularity of physical therapies in Europe and North America during the 19th century;
3. The assumption that many colonists would have known or practised physical therapies in their home country;
4. Evidence that Māori used physical therapies as part of indigenous healing practices;
5. The emergence of Rotorua Spa as a centre of organised physical therapy after 1901.

Given these five conditions, we asked what evidence existed for physical therapies in Aotearoa/New Zealand prior to the formation of the physiotherapy profession, World War I and the birth of the rehabilitation movement; and before state governments began to include physical therapy in organised formal health care services. We were interested to find out to what extent the physical therapies were practiced, by whom, where and when. To answer these questions, we analysed texts from a wide range of primary and secondary sources, including published and unpublished manuscripts, period newspapers, personal accounts, photographs, registers and directories, available either online, through published databases, or through first-hand archival searching. Secondary texts were also examined for accounts of physical therapies and evidence of interest in the subject.

In the previous paper titled *Physical therapies in 19th century Aotearoa/New Zealand: Part 1 – Māori physical therapies*, we showed that physical therapies were well known to Māori prior to colonisation. Unlike 'western' physical therapies, however, Māori practices were part of a holistic approach to treatment. Focusing on two 'orthopaedic' conditions (fractures and back pain) and two particular practices (massage and bathing), we argued that the physical therapies used by Māori bore many similarities to those practised by most cultures prior to colonisation, and that their results bore comparison with anything offered in the developing health care systems of the settlers who colonised Aotearoa/New Zealand after 1840.

Our focus now shifts to the settlers' experience, and the use they made of therapies that would have been well known to them in their home countries. To what extent were massage and manipulation, electrotherapy, hydrotherapy and remedial exercises practised and made available to ill and injured colonists? Where, and under what conditions, would a settler seek and receive physical therapies in Aotearoa/New Zealand prior to 1900? And were we correct to speculate that these therapies were underdeveloped and sparsely provided? If so, how might we make sense of this underdevelopment? We begin by considering a range of settler experiences, before exploring some of the practitioners who immigrated to Aotearoa/New Zealand in the second half of the 19th century.

SETTLER EXPERIENCES

In many ways, the colonisation of Aotearoa/New Zealand in the 19th century bore similarities to that of Australia and the United States. The Australian colonisation described by Charles Manning Clark, however, was one where many fraternal and 'mateship' ties developed as a necessary condition of bonding and indentured service (Clark and Cathcart 1993). Likewise, the rapid movement of settlers across America prior to 1900 was anchored to the development of population centres and the establishment of communities based on religious association (Turner 2008). With a few exceptions – the Presbyterian settlements in Otago, for instance – no such concentrated, collectivist colonisation occurred in Aotearoa/New Zealand. By contrast, the colonisation of Aotearoa/New Zealand was marked by a fierce individualism, atomisation and isolation (Fairburn 2013).

Aotearoa/New Zealand was aggressively marketed to people in Australia, England and North America as a new 'Arcadia'[2] in which a working 'man' might escape the grinding poverty, grime and class-based prejudice of their homeland and achieve 'competence.'[3] Werry describes the vision of a 'pastless, classless modernity against the background of a transcendent landscape by turns bucolic, primeval, and triumphantly sublime' (Werry 2011, p. xi). The simple idea that hard work would be enough for everyone to succeed was aggressively promoted by Edward Gibbon Wakefield's New Zealand Company and many others, who sought to take advantage of the country's abundant natural resources, space and temperate climate (Stuart 1971). Aotearoa/New Zealand was promoted as a worker's paradise that promised 'meat on every table, and…distance from the shadow of the workhouse door' (McLure 2004, p. 11). Furthermore, 'with nature's bounty so accessible [the settler]

[2] Arcadia was a term used as a metaphor for an idyllic land – a pastoral paradise. Arcadia is, in reality, a mountainous district in southern Greece that was thought to be the mythical home of the Greek god Pan.

[3] Achieving 'competence' was a term used to describe the ability to save enough money to buy one's own section of land and make a living from it.

did not have to engage in collective enterprise to accumulate wealth' (Fairburn 2013, p. 56).

The reality, however, was somewhat different, with social isolation, weak community structures and unpredictable work patterns common for many. The atomisation experienced by many settlers was produced, in part, by the rapid expansion of colonists into Aotearoa/New Zealand's plentiful and sparsely populated bush, the itinerant nature of missionary work for many settlers, and unpredictable work patterns. Sixty-two percent of the 165,000 working men registered in the 1881 census were in labouring classes, and their work was characterised by instability and frequent disruption. Farm work was mostly seasonal and vulnerable to poor harvests; manufacturing industry was small and uncompetitive when compared with imports, (and employers tended to employ boys and women to keep labour costs down); and building and construction moved through cycles of boom and bust, particularly during the Long Depression of the 1880s and 90s (Fairburn 2013).

It was labouring work, however, that was promoted most aggressively by community leaders who had already settled in the country, with some arguing that 'clerks and shopmen' would not rise in New Zealand, for the country's business houses were so small they employed few assistants' (Husthouse 1857). Various occupations were considered unwanted or oversupplied, including lawyers, clerks, tradesmen and office workers, bank clerks, and professional or trades people, and 'it was widely believed that people with particular vocations, a special expertise, a formal job training were ill adapted to the colony's needs' (Fairburn 2013, p. 54). This included health professionals.

Aotearoa/New Zealand's fierce individualism, unpredictable work patterns, and marginalisation of professional classes, had obvious implications for anyone wanting to practise the physical therapies, not least because of the slow growth and development of urban population centres. The national population in 1871 was reported as 267,000 people, spread over an area slightly more than 100,000 square miles (259,000 km^2). Few institutions existed to facilitate mixing and meeting and few kinship ties developed. There were few centres for social engagement and civic development, and voluntary organisations struggled to develop a critical mass to sustain them. There was little leisure time for organised recreational activity, and much of the work (gum-digging, forestry, gold mining and shepherding, for example), was isolating. Loneliness was commonly found among the many transient workers too, who were required to move continually to find work. But it was not only working men that experienced the privations of social isolation and the difficulties of surviving in the country's bountiful but unforgiving bush. Elizabeth Colenso, wife of William Colenso, pioneering missionary with the Christian Missionary Society and friend to many of Aotearoa/New Zealand's preeminent settlers, lived for nine years at a remote rural station in Ahuriri, south of Napier on the North Island's east coast. While William spent much of his time travelling the country doing his missionary work, Elizabeth was left as a sole parent to two. Elizabeth overcame some of her feelings of isolation by acting as a community nurse[4] and schoolteacher. Elizabeth saw no other Pākehā woman for the first seven years at Ahuriri and visitors were rare. It is perhaps telling that when she received an offer to help with the delivery of her second daughter from a 'neighbour' in Turanga near Gisborne, she responded by walking the 200km in mid-winter, eight months pregnant, with her 18 month-old daughter in tow.

Like Elizabeth Colenso's, the life of missionaries and colonial settlers was gruelling and hazardous, especially during the New Zealand Wars of the 1860s. As Ballantyne argues; 'Missionaries…routinely reflected on the physical consequences of the heavy labour, constant walking, and poor diet that accompanied missionary work…it seemed that death was never far from their door' (Ballantyne 2014, p. 7).

But the conditions for missionaries paled into insignificance in comparison with the lives led by the thousands of prospectors, or 'diggers' that entered the country after the discovery of gold in the 1850s;

Digging for gold was not healthy. A digger quickly wore out his young body, for he often lacked the clean water and good food that were his first needs if he was to keep well, and his work was hard and risky. A digging life not only weakened, sickened and wounded but could kill' (Eldred-Grigg, p.300).

Diggers were continually at risk of mortal illness and injury. They regularly fell down exposed mine shafts or were crushed under landslides or machinery. Worse still, living conditions for diggers were appalling with most suffering poor diets and physical exhaustion. Dysentery and typhoid were common and a complete lack of adequate sanitation created multiple vectors for the transmission of disease. Few men had family to fall back on, and there were numerous reports of '[s]ick men and boys [lying] helplessly in tents outside the town…for the digger who lacked cash to pay a hotel bill 'must rot' when he came down with typhoid' (Eldred-Grigg 2008, p. 303).

There was, therefore, no shortage of injury and illness that would have benefited from physical therapy, but formal and informal health services appear to have been severely limited, such that many men would have to risk their own livelihoods to help a fellow digger out of difficulty. Perhaps not surprisingly, the death toll among diggers during the 1860 gold rushes was heavier than that of the soldiers during the New Zealand Wars.

Part of the reason for the high morbidity and mortality rate in Aotearoa/New Zealand in the second half of the 19th century can be explained by the nature of the work undertaken by settlers, but Aotearoa/New Zealand was also a dangerous place for even the most cautious colonist. Numerous accounts exist of people stumbling into ngawha (boiling springs) in the middle of the night (see, for example, "About Volcanoes: Lecture by Mr. H. Hill, B.A," 1889, p. 2).

[4] Much of the early nursing history of Aotearoa/New Zealand began with the wives of missionaries undertaking untrained nursing work in their communities (see, for example Maclean 1932).

Many Victorian pioneers, settlers and travellers were enthralled by Aotearoa/New Zealand's untamed and uncultivated nature, but many were also unfamiliar with its flora and fauna, and there are many accounts of people simply starving to death while being surrounded by food that they had no knowledge how to process and consume. What made illness and injury so perilous though, was the relative absence of any formal medical services, a point of increasing concern among settlers as the century progressed, particularly in a country where death was so 'busy' (Eldred-Grigg 2008, p. 316).

EARLY MEDICAL AND SOCIAL WELFARE DEVELOPMENT

The early hospital system – such as it was – in Aotearoa/New Zealand was established prior to the New Zealand Wars and placed a big emphasis on the health of Māori. Hospitals in Auckland, New Plymouth and Wellington opened their doors in 1847, to be followed by Wanganui (1851) and Dunedin (1852), with subsidies provided by the British government (Dow 1995, p. 31). Māori use of the early hospitals went into decline after 1860 however, as a result of the New Zealand Wars, disruption of trade, and their susceptibility to introduced diseases. Many Māori chose to distance themselves from Pākehā medicine but many others also had their access restricted. As Claudia Orange has argued, 'settler interests obliterated almost all considerations of Māori welfare' (Orange 1994, p. 9).

The cultural shift in relations between Māori and Pākehā after 1860 had the indirect effect of creating more space for the growing dependent Pākehā population.[5] After the initial mid-century hospital building programme, there was little further growth in organised health care, because there was little central funding or desire to coordinate care across the country, and most health care relied on a 'secondary and more discretionary system of charitable aid' (McClure 2013, p. 11). Many doctors operated in Aotearoa/New Zealand in the 19th century (Hocken 1909; Lawrenson n.d.), but few were subsidised or organised by central government, indeed there were only 15 subsidised doctors and dispensers employed by government in 1885, and only 30 by 1900 (Dow 1995, p. 32). Much changed after the 1891 election, however, with the Liberal Party instituting widespread social welfare programmes, including votes for women, old age pensions, factory reform and workplace arbitration (Hamer 1988).

Aotearoa/New Zealand remained a country of stark contrasts for much of the 19th century. While a few lived in relative comfort, spending their disposable income on servants, domestic luxuries and increasing leisure time, many toiled for long hours in poorly paid manual jobs:

Behind the sturdy, dignified facades of homes in tree-lined city streets, rough, draughty shanties were packed together three feet apart; rubbish filled the backyards, and the stench overwhelmed health visitors who claimed the squalor in these quarters was as bad as that of old-world slums… Any mischance, a father's broken arm or a daughter's teenage pregnancy, could reduce poor families to extreme hardship and mean that a parent had to apply for charitable aid for relief (McClure 1998, 30).

Despite the promise of Arcadian splendor and abundant natural resources, many of the people of Aotearoa/New Zealand survived the 19th century rather than prospered, and the living conditions for many were bleak. The death rate in Dunedin from communicable diseases was comparable with heavily industrialised English towns like Manchester (Dow 1995, p. 20), and rates of injury from industry and conflict, the sequelae of communicable diseases, and the natural consequences of congenital disability and ageing, all contributed to a need for health care services. When one considers how many of these problems would have benefited from ongoing rehabilitation and physical therapy, it is hard to understand how few physical therapists actually operated in Aotearoa/New Zealand prior to 1900. What evidence do we have, therefore, of physical therapies and physical therapists operating in Aotearoa/New Zealand in the 19th century?

PHYSICAL THERAPISTS

Despite the growing influence of pioneers and settlers from Europe and North America during the 19th century, few masseurs, medical electricians, hydrotherapists, balneologists or medical gymnasts appear in the archives before 1880. A search of the Papers Past archive (http://paperspast.natlib.govt.nz/cgi-bin/paperspast) for news media from the time for masseurs and masseuses shows only two results, and both of these are erroneous. From 1880 onwards, sporadic accounts of massage practices from around the colonies are interspersed with small items of local news. The Mount Ida Chronicle from November 1888, for example, mentions a masseuse who has administered massage to only one woman in her years of practice whose ribs have not been displaced due to corset wearing ("Local and General," 1888), while the Southland Times describes an 'An Old Fad Revived' in promoting massage as a job opportunity particularly suited to women (Southland Times, 1887). In the same year, the New Zealand Herald reprinted excerpts of Wilkie Collins' book The Legacy of Cain, which includes a masseuse as one of its main characters ("The Legacy of Cain," 1888), and reports that a masseur was put into a lunatic asylum in Paris ("Personal Notes," 1888). Beyond this there is little evidence of any significant interest or involvement of masseurs and masseuses in Aotearoa/New Zealand life.

Louise Shaw, in her recent history of the School of Physiotherapy in Otago has identified that;

[m]asseurs were not specifically identified in the Aotearoa/New Zealand census until 1901 and, even then, only 20 men and 38 women were recorded including 12 medical electricians and their assistants. It was not until the First World War that the number of massage practitioners increased dramatically; the 1916 census recorded 65 masseurs and 93 masseuses (Shaw 2013, p. 21).

[5] The percentage of people over 65, for example, increased from 0.71% in 1861 to 1.42% in 1881, and on to 4.05% in 1901. This compares with a relatively stable elderly population in England, which changed from 4.64 to 4.66 percent during the same 40 year span (Fairburn 2013, p. 166).

Despite this, we know of a handful of practitioners who plied their trade in Aotearoa/New Zealand before 1900. Most were masseurs or medical electricians, some were masseuses, and some were physicians incorporating massage and electrotherapy from their practices. With few exceptions, most operated in the major population centres. What are largely invisible in the archives are accounts of the women missionaries, overseas-trained nurses, and other women pioneers and settlers who acted as community nurses, and may have practised some form of rudimentary physical therapy as part of their healing practice. Wilson, for example, argues that;

[u]ntil the enactment of the Medical Practitioners Act of 1868, [and] the introduction of compulsory registration for doctors, there was considerable overlap between the roles of the various health care providers in New Zealand. Midwives, nurses and chemists often prescribed for and treated patients, and doctors occasionally provided 24 hour nursing care for wealthy patients (Wilson 1998, p. 15).

Similarly, accounts of Māori physical therapies almost disappear from the archives after the New Zealand Wars of the 1860s, perhaps pointing to the declining fortunes of Māori in general in the latter half of the 19th century.

The only non-metropolitan locations that serve as a focal point for physical therapy practices in Aotearoa/New Zealand before 1900 are the spa centres at Hanmer Springs, Te Aroha, Waiwera and, most significantly, Rotorua. After the Te Arawa tribe agreed to give up its land and become lease-holders over Rotorua's thermal springs region in 1880, the government acted quickly to cede control over all of the valuable thermal springs, passing the Thermal-Springs District Act in 1881 'to codify the process it had already begun in Rotorua, legislating on the principle of reserving thermal districts for the use of the nation' (McLure 2004, p. 14). Because of the significance of Rotorua to the history of physical therapy in Aotearoa/New Zealand, we will address it as a separate paper. Of the remaining practitioners, we have divided them into three groups: government appointees, maverick practitioners and others. This is somewhat arbitrary, however, since most practitioners needed to operate across a number of clinical spaces in order to make a living.

Government appointees

Honorary (meaning unpaid) hospital appointments were some of the few formal medical appointments made prior to 1890. In 1887, for example, Christchurch Hospital appointed Harcourt Gardner, ex-lecturer in electricity at Royal Polytechnic Institute in London, as 'Honorary Galvanist' in a part time role. Gardner's role was to treat the male patients with the galvanic battery, while his wife treated women outside hospital appointment times. Shaw reports that they treated such conditions as 'rheumatism, lumbago, neuralgia, spinal weakness, liver complaints and nervous exhaustion' (Shaw 2013, pp. 15-16). Six years later, the same hospital appointed another English migrant – Charles Mackinlay Hilson - to succeed Gardner (Bennett 1962). Hilson was an ex-medical student and had no formal medical qualifications, yet he treated sprains, nervous diseases and cases of paralysis when referred (Shaw 2013, p. 17). Interestingly, when Hilson resigned in 1895, after just two years in the post, it was 12 years before the hospital re-appointed to the position, suggesting that the post was not considered a high priority.

Honorary appointments were valuable because they provided legitimacy at a time before formal professional registration and regulation of health professions. They may have also been a source of private paying patients who could be seen in the practitioner's own rooms. Hilson, like his counterparts, ran his own private practice. Advertisements in the local paper – The Press – show that;

Mr Hilson, masseur, has commenced the practice of his profession in this city. Messages or letters may be left at Bennington's Chemist; address care Mrs Rawson, 177 Worcester Street ("Advertisements," 1893).

Adverts from 1893 indicate that Hilson saw patients between quite limited hours (2-3pm and 6-7pm). Later in 1894, Hilson was advertising that he was available 'At home' from 9-10am and from 7-7:30pm ("Advertisements," 1894), suggesting that the work available at the time was insufficient to maintain a significant practice in massage and medical electricity alone.

One way that practitioners attempted to promote their practice was through the publication of testimonials from patients who had been treated successfully. In 1893, for example, The Press published this review of Hilson's work from a patient;

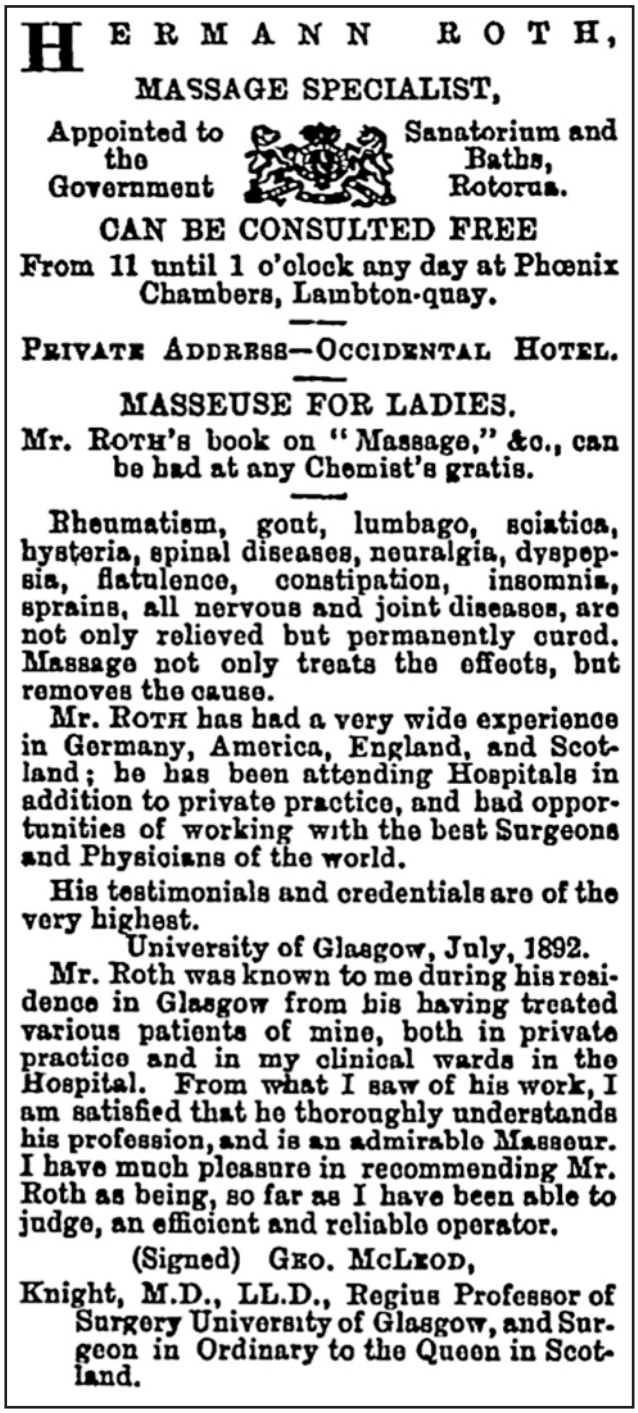
I was paralysed for about four years, and had lost all control over the lower limbs of my body, being so helpless as to have to be carried to my bed in the Hospital [sic], but after less than three weeks under the massage treatment of Mr. C. Mackinley Hilson, the Honorary Masseur to our local Hospital, I am now able to walk with [sic] any assistance whatever ("Public Thanks to Our Hospital," 1893).

Hilson, however, left Aotearoa/New Zealand in 1895, entering into private practice in Hobart, Tasmania. One year later, Wellington Hospital appointed its own Honorary Masseur – A. A. Howes. Like Hilson, Howes was obliged to consult privately as well as undertake work at the hospital. The Evening Post advertised that 'Messages may be left [for Howes] and consultations arranged for, at Giesen's Pharmacy, Willis-street [sic]. Telephone No. 644' (Evening Post, 1896).

Two of the more significant figures in physical therapy before 1900 were Herman Roth and his brother Gustave. Herman arrived in New Zealand in August 1893 as the first masseur formally appointed to the Government Sanatorium and Baths in Rotorua.[6] Roth established himself in Rotorua throughout each summer, in Auckland in May and June, and in Wellington for the rest of the year (New Zealand Herald, 1895). While in Wellington, Roth published a small brochure, entitled *Massage; Its History and Therapeutics*. In it he states that 'he has made arrangements for the erection of a private hospital at Rotorua, suitable for the accommodation and special treatment of invalids, where assistants—both male and female—will be in

[6] Herman Roth's work at the Rotorua Spa will be featured in more detail in the subsequent paper.

attendance, and a masseuse for ladies' (New Zealand Herald, 1895).



HERMANN ROTH,

MASSAGE SPECIALIST,

Appointed to the Government Sanatorium and Baths, Rotorua.

CAN BE CONSULTED FREE

From 11 until 1 o'clock any day at Phœnix Chambers, Lambton-quay.

PRIVATE ADDRESS—OCCIDENTAL HOTEL.

MASSEUSE FOR LADIES.

Mr. ROTH'S book on "Massage," &c., can be had at any Chemist's gratis.

Rheumatism, gout, lumbago, sciatica, hysteria, spinal diseases, neuralgia, dyspepsia, flatulence, constipation, insomnia, sprains, all nervous and joint diseases, are not only relieved but permanently cured. Massage not only treats the effects, but removes the cause.

Mr. ROTH has had a very wide experience in Germany, America, England, and Scotland; he has been attending Hospitals in addition to private practice, and had opportunities of working with the best Surgeons and Physicians of the world.

His testimonials and credentials are of the very highest.

University of Glasgow, July, 1892.

Mr. Roth was known to me during his residence in Glasgow from his having treated various patients of mine, both in private practice and in my clinical wards in the Hospital. From what I saw of his work, I am satisfied that he thoroughly understands his profession, and is an admirable Masseur. I have much pleasure in recommending Mr. Roth as being, so far as I have been able to judge, an efficient and reliable operator.

(Signed) GEO. McLEOD,

Knight, M.D., LL.D., Regius Professor of Surgery University of Glasgow, and Surgeon in Ordinary to the Queen in Scotland.

Figure 1. Advertisement for Herman Roth

Like many of his contemporaries, Roth was not averse to making bold claims that he could not only 'relieve' but 'cure' conditions such as 'Rheumatism, Gout, Lumbago, Sciatica, Paralysis, Hysteria, Spinal diseases. Neuralgia, Dyspepsia, Flatulence, Constipation, Sprains, Insomnia, all nervous and joint Diseases' ("Advertisement," 1895). Roth traded on his 'very wide experience in Germany, America, England, Scotland, and the Colonies' and the work that he done with 'the best Surgeons and Physicians of the world' ("Advertisement," 1895). Roth consulted in his rooms for limited hours each day, and charged 5s to 7 s 6d (equivalent to $NZ45-70)[7] for each consultation. Roth continued to be listed in the Post Office Directory as one of the few masseurs practising in Auckland in 1898-9. Roth's brother Gustave, however, was never listed as a massage practitioner.

Maverick practitioners

If Herman Roth presents the image of a professional practitioner developing a sober clinical practice in a new colony, his brother offers a different picture. Gustave Roth took over Herman's practice in 1898, and in the space of a few months had been convicted of stealing and then pawning a bicycle in Auckland ("A Masseur in Court," 1898), becoming a 'great favourite with the ladies' in Rotorua ("On the Bike: A Trip to Rotorua (by a Cyclist)," 1897), and becoming embroiled in a court case involving the spurious use of electrotherapy for the treatment of cancer, by an equally disreputable 'medical electrician and cancer specialist,' William Stanton ("Inquest on Mrs Hayden," 1899).

Roth's exuberance was perhaps emblematic of a class of practitioner that drew on the perceived power of medical electricity and massage to animate the torpid body: to galvanise and mesmerise, and restore the ailing body to health. Histories of late-Victorian medicine in Europe and North America are replete with accounts of charlatans, conmen and snake-oil salesmen, so we should not be surprised to find such characters appearing in New Zealand, particularly given the laissez-faire approach to practice regulation that existed before 1900.

'Professor' J.B. Thomas, 'Specialist in Medical Electricity, Massage and [the] Swedish movement Cure' professional phrenologist and physiognomist was one such practitioner. Between 1887 and 1893, Thomas visited Aotearoa/New Zealand, giving public lectures, character readings and electrotherapy demonstrations that offered 'entertainment interesting to all classes, to all ages, and to people of every standard of intelligence' (Tuapeka Times, 1893).

Thomas followed a trend after the 1880s for a few well-known galvanists like George Milner Stephen and 'Professor Richard, ME (medical electrician)' to visit New Zealand and offer public lectures and demonstrations of electrotherapy in local theatres (Broadley 2000). More interesting, perhaps, were the medical electricians that established their practices in the main centres after 1880. John Jenkins set up a 'Magnetic and Galvanic Healing Institute' in Rattray Street, Dunedin in 1883. Jenkins was interested in 'psychic potencies' of electrotherapy - unblocking flows of internal energy and revitalising patients (Shaw 2013, p. 18). His practice was so popular that 'by 1895, he had not only extended and renovated his premises, but had also installed his own generator and electric light fittings, long before there were municipal facilities' (2013, p. 18). 'Part scientist, part showman,

[7] Based on http://www.rbnz.govt.nz/monetary_policy/inflation_calculator/

Jenkins created a lifelike female automaton that glided about, turning her head and moving her eyes…'Electra' [lived in] an adjacent anteroom to his professional rooms, much to the delight of his clients' (2013, p. 18).

Perhaps the most well-known physical therapist in New Zealand before 1900 was, however, the Scottish blacksmith, animal 'doctor,' masseur, hairdresser and dentist, Matthew Guinan. Guinan was the first of four generations of practitioners in the South Island of Aotearoa/New Zealand to become physiotherapists.[8] Louise Shaw describes how he possessed the kinds of initiative, adaptability and skills that were 'necessary prerequisites for economic survival in the colonies' (2013, p. 18). Guinan arrived in Dunedin in 1875, aged 19, and settled in Kelso, a small settlement in Otago that was established in the year of his arrival. Here he worked as a blacksmith and horse 'doctor,' and began to gain a reputation for his 'magnetic touch' (Brownlie 1992). One of his medical innovations included the production of liniments and lotions that he sold from rooms that became known as 'Matt's Hospital.' Brownlie suggests that in the 1880s and 90s, people travelled from all over the country to visit him, filling up guest houses with 'invalids' (1992). Guinan became so successful that he was able to relocate to a practice in George Street, Dunedin in 1916 (Nicholls 2009).[9]

Other masseurs

It is likely that a number of other physical therapists operated throughout New Zealand prior to 1900, and some would only have been known locally. Some, like German-trained Margaret Culling, were operating in Rotorua in the 1890s alongside Alfred Grinders, Camille Malfroy and Arthur Wohlmann, who helped to establish the Rotorua Spa.[10] New Yorker D. Edwin Booth and his English wife Mary ran a successful practice in Dunedin in the last decade of the nineteenth century (Shaw 2013), while the trend for promoting massage by blind men and women extended to New Zealand, where Miss Annie Chamberlain was trained as a masseuse by 'a medical man' with the support of the Charity Organisation Society.

For most of these practitioners, the only way to obtain reliable work was through advertisements in the popular newspapers, medical referral and word-of-mouth. Some practitioners imported small appliances that were popular therapeutic novelties overseas. Dr. Forest's muscle roller, which was advertised in the Timaru Herald in 1892, claimed to cure 'The tired muscles or sprains, etc., of [the] footballer, as well as headaches, neuralgia, dyspepsia, constipation' ("Health, the New Method [Adv.]," 1892).

Notwithstanding these few cases, however, numbers of physical therapists in New Zealand prior to 1900 remained small. The Post Office directory of businesses lists only 11 registered masseurs in New Zealand in 1899: Miss Christina Cottman, P. M. Dewar, Miss McElwain, Herman Roth and William Stanton in Auckland; Miss A. Craig in Palmerston North; Miss Wildman in Wellington; A. E. Howes, Thomas B. Pike, and George Weston in Christchurch; and Miss Margaret O. Culling in Dunedin. There were a further four 'medical galvanists,' and 14 purveyors of private baths and hot springs located in the main regional centres or spa sites. The 1896 census reported that there were 703,000 non-Māori and 40,000 Māori residing in New Zealand, so if we take a generous view and call each of these purveyors and providers 'physical therapists' and assume that there were at least twice as many un-registered masseurs and masseuses practising within New Zealand at the end of the century, it would still equate to only one masseur or masseuse for every 7,500 people, or one therapist for every 1,000 square miles (2,590 km^2).[11]

DISCUSSION

The evidence presented here suggests the experience of physical therapy in the 19th century was somewhat different for colonists, pioneers and settlers than it had been for Māori. Where Māori practised physical therapies without a commercial imperative, making use of natural resources like hot springs and Aotearoa/New Zealand's abundant flora, Pākehā appear to have seen massage, electrotherapy, hydrotherapy and remedial gymnastics as exotic luxuries, only available in the metropolitan areas and dedicated therapeutic sites. The physical therapies were available to those who had surplus time and money and were not freely available to the vast majority of the population who had not achieved a 'competence' and eked out subsistence wages sufficient only to feed and house themselves and their growing families. Without organised health and welfare services prior to 1900, there were few opportunities for working people to enjoy private physical therapies.

Given that we know that many colonists acted as makeshift midwives, nurses and even surgeons in the agricultural settlements, gold fields and remote bush communities that were dotted throughout the country, it is likely that many also served as physical therapists, providing therapeutic massage and remedial exercises to help people recover from illness and injury. But data is sparse here and we are dependent on inference drawn from personal biographies, secondary accounts, and narrative histories, which all suffer, to varying degrees, from being romanticised accounts of events.

As much as there were differences in the way Māori and Pākehā practised the physical therapies, we also know that there were some similarities. Māori saw the physical therapies as intertwined with spiritual and herbal practices in the same

[8] Taxonomically speaking, Guinan was not, himself, a physiotherapist, since his practice ended before physiotherapy became a registered profession in 1921.

[9] An oral history interview discussing Matthew Guinan's legacy by his great grandson – Frank Weedon, who was himself a physiotherapist and lecturer at the School of Physiotherapy in Otago – can be heard here: http://www.100yearsofphysio.co.nz/oral-histories/frank-weedon/#.Vh_qJLRde38.

[10] These will be discussed in more detail in the final paper in this series.

[11] Some detailed accounts of Auckland's Turkish Baths, 'health suppliers' who provided physical therapy services, along with the biographies of an assortment of hygienic face masseuses, manicurists, hypnotists, hydropathists, convalescent home proprietors, doctors of magnetism and magnetic healers can be found in the 1902 *Cyclopedia of New Zealand* (http://nzetc.victoria.ac.nz/tm/scholarly/tei-corpus-cyclopedia.html).

way that Pākehā therapists combined the physical therapies with pharmacy and surgery. Prior to 1900, 'orthodox' medical practice had not been heavily inflected with 'germ theory' in New Zealand, and most medical practitioners were trained in the physical therapies (see, for example Ottosson 2011, 2015). Equally, Māori saw therapeutic practices as the province of a tohunga, in the same way that Pākehā believed that medical practitioners should be well trained and, ultimately, registered. Registration for physiotherapists would not, however, come into effect until 1921 in New Zealand, by which time physical therapy practices had received a boost from four related events: the Liberal government's investment in organised health and welfare services for the entire population; the development of the four main spa centres, most notably the Rotorua Spa; the successful registration of masseuses (before even midwives and nurses) in England in 1895; and the outbreak of World War I, which necessitated the deployment of masseuses to front-line medical care and the development of physical rehabilitation services for returning soldiers.

The most significant of these events for physical therapies in the 19th century was the development of the Rotorua Spa which, although not completed until 1908, followed more than 25 years of effort and investment, and an ongoing discussion about the economic and health benefits of physical therapies to people living in Aotearoa/New Zealand, and to those overseas. The development of the Spa, and its associated discourses, will be explored in the next paper.

CONCLUSION

In this paper we have focused on the settler experience and the effect that colonisation had on physical therapy practices before 1900. The particular cultural value Pākehā placed on independence and autonomy, and the possibilities that settlers could rid themselves of the privations of their homeland, led many into lifestyles that were physically demanding, isolated and hazardous. Despite this, few formal health care services were established, and an attitude of self-reliance accompanied a fierce independence.

As Māori cultural practices were slowly 'cleansed' by engineered conflicts, progressive economic reforms and colonial legislation, a vacuum was created in which Pākehā health practices could emerge. Lacking any formal infrastructure, however, physical therapies remained either the province of maverick practitioners, or luxurious indulgences of those with the surplus time and money. Physical therapies as we would come to know them in the early part of the 20th century would therefore be confined to a handful of practitioners in the four main metropolitan centres. The exceptions to this were the four spa centres at Hanmer Springs, Rotorua, Te Aroha and Waiwera, and the largest of these – Rotorua – became 'a haven for the colony's emerging Pākehā professional managerial class' and the wealthy invalid from overseas (Werry 2011, p. 22). It is to this celebration of the benefits of the physical therapies, consolidated in the complex interwoven discourses surrounding the Rotorua Spa that we turn in the third and final paper in this series.

KEY POINTS

1. Despite their popularity in Europe and North America, there is little evidence of the use of physical therapies by New Zealand settlers before 1900
2. Most physical therapies were confined to the larger metropolitan centres and were often eclectic and eccentric in their approach
3. People living in remote and rural locations had very poor access to health services and evidence suggests that their health suffered greatly as a result.

DISCLOSURES

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Development of a consensus approach to upper limb rehabilitation early post stroke amongst a cohort of Western Australian therapists.

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ABSTRACT

This study aimed to define commonly reported physiotherapy and occupational therapy terminology regarding rehabilitation interventions for moderate to severe upper limb deficits early post- stroke and to develop a consensus on 'standard' post-stroke upper limb rehabilitation across three stroke services. An audit was undertaken of all middle cerebral artery strokes admitted over a nine-month period to an acute tertiary hospital. Data were collected from 48 cases of middle cerebral artery stroke. Twenty four cases had moderate to severe upper limb impairment, and of these 16 were transferred to the two participating rehabilitation sites. A list of upper limb interventions documented in these 16 cases was distributed to therapists from the three participating sites (nine Physiotherapists, 13 Occupational Therapists) who subsequently attended focus groups. Definitions for reported interventions were developed, collated and refined until group agreement was reached using a modified Delphi method. Approaches to upper limb rehabilitation varied according to therapists' clinical experience and training background; however, definitions did not vary widely between services or disciplines. A consensus on 'usual care' for moderate to severe upper limb deficits within participating stroke services was developed from which a structured, individualised, impairment-based treatment template was produced for use in a subsequent interventional study.

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Key words: Stroke, Upper limb rehabilitation, Consensus

INTRODUCTION

According to the World Health Organisation (WHO 2015) stroke is the third most frequent cause of death and the leading cause of acquired adult disability in developed countries. About 15 million people suffer a stroke worldwide each year, and 5.5 million of these die while another 5 million are permanently disabled (World Stroke Organisation (2015).

The upper limb (UL) generally makes a poorer recovery post-stroke than the lower limb (LL) (Kong et al 2011). Approximately 60% of patients with severe to complete UL paresis are unable to achieve full dexterity after 6 months post-stroke (Kwakkel et al 2003, van Kuijk 2009); while 71% of patients with mild to moderate initial UL paresis achieve some dexterity at 6 months and therefore have a significantly better prognosis for recovery (Nijland et al 2010). The most common impairments affecting UL function post-stroke are decreased motor control, spasticity, decreased sensation and proprioception, pain, decreased range of movement, motor dyspraxia, inattention/neglect, diplopia, homonymous hemianopia, and impaired cognition (Brewer et al 2013).

Several rehabilitation 'treatment taxonomies' have been developed to assist in standardising, prescribing and progressing therapy, dissemination of interventions, training of novice practitioners, interdisciplinary communication and the conduct and reporting of research (Arya et al 2012, Hart et al 2014, McDonnell et al 2013, Rosewilliam et al 2009, Whyte et al 2014). These include the evidence-based clinical algorithm to facilitate standardised intervention, prescription and progression for UL rehabilitation post-stroke, developed by McDonnell et al (2013); and a 'meaningful-task specific training (MTST) model' which outlines the use of a specific number of common tasks, incorporating unilateral and bilateral practice (Arya et al 2012). Both taxonomies have been shown to be feasible to guide UL therapy in subacute stroke care, as well as to encourage independent practice and increase the number of repetitions and time spent in therapy, which may facilitate achievement

of the intensity of UL therapy recommended in the Australian and New Zealand Stroke Foundation stroke rehabilitation guidelines (Australian Stroke Foundation 2016, New Zealand Stroke Foundation 2016). These 'treatment taxonomies' add to a body of evidence that suggests that the content and intensity of UL rehabilitation can be standardised in a stroke population with various levels of impairment. Furthermore, it is feasible to implement such protocols in clinical practice and research studies (McDonnell et al 2013, Rosewilliam et al 2009, Wallace et al 2010).

In research trials of novel therapies the control condition is frequently described as 'usual care' without describing the actual intervention in sufficient detail to allow it to be replicated in a clinical setting. The literature has identified significant gaps in the reporting of non-pharmacological randomised controlled trials (RCT). In the extended Consolidated Standard of Reporting Trials (CONSORT) statement, Boutron et al (2008) provide a checklist of items to be reported in non-pharmacological trials, including a detailed description of interventions, procedures for individual tailoring of the intervention to participants according to their environment, details of how therapists' adherence with the treatment protocol(s) was monitored and provision of an explanation of any uncommon circumstances or modifications. Adherence to these guidelines can enable accurate recording and delivery of standardised interventions in non-pharmacological clinical trials.

This study was a preliminary phase of an RCT to explore non-invasive brain stimulation as an adjunct to UL rehabilitation post-acute stroke (Garcia-Vega et al 2016). Hence, this qualitative descriptive study aimed to inform the development of a package of 'standard care' for the subsequent interventional trial and a recording tool to facilitate an accurate description of the treatment given to each individual participant by: (a) defining commonly reported physiotherapy and occupational therapy descriptors of approaches to UL rehabilitation post-stroke and (b) developing a consensus amongst therapists regarding 'usual care' in the management of moderate to severe UL deficits post-stroke

METHODS

This study comprised four stages:

Stage I: Retrospective notes audit

The audit sought to accurately represent a cohort of patients admitted to three major Western Australian hospitals, where the subsequent pilot RCT was to be conducted. The intervention study only included first time ischaemic middle cerebral artery (MCA) territory strokes; therefore the audit was limited to this cohort. A report was generated including data on diagnosis, length of stay, and discharge destination from all neurological admissions with 'stroke-like' symptoms over a nine-month period at one acute tertiary centre. Diagnosis was subsequently verified from imaging reports via computed tomography (CT) and/or magnetic resonance imaging (MRI) and each case was categorised for stroke type (ischaemic or haemorrhagic, cortical or subcortical) and area of the brain affected. Medical records meeting the criteria were obtained and descriptions of physiotherapy and occupational therapy UL treatment during the inpatient admission of each case at the participating acute and rehabilitation centres were recorded. Treatment reports by all therapists (or allied health assistants) were screened to determine UL impairment severity and management during the acute phase of recovery and, for those with moderate to severe UL impairment, details of therapy were recorded. Where available, Chedoke McMaster Impairment Inventory (CMII) scores (Gowland et al 1993) were used to categorise patients' severity of UL impairment. Therapists' descriptive data were used to allocate impairment group when CMII scores were not available. A list of the most commonly documented interventions (more than 50% of patients receiving this treatment) in the acute and subacute rehabilitation settings was prepared from the audit data.

Stage II: Definition of UL interventions and consensus on 'usual UL rehabilitation' in participating services

A consensus on definitions of documented UL therapies provided to those audit cases who received both acute care and rehabilitation post-stroke in participating hospitals (n=16 cases) was developed using a modified Delphi process (Hsu and Sandford 2007). All therapists at the acute stroke service and the two sites where the audit cases underwent rehabilitation were invited to participate in a focus group to discuss the audit data. All participants gave written consent to participate. Focus group meetings were held separately amongst physiotherapists and occupational therapists at each site. Audit results were presented to attendees, followed by a discussion of the list of UL treatment interventions identified from the file audit. All therapists were asked to prepare definitions of the terminology, and definitions were discussed and agreed upon as a group. Once recorded and collated, therapists were offered the opportunity to modify the list if they did not consider it was a true representation of current UL rehabilitation practices at their site (Round 1). Therapists who were identified in the audit but who were no longer working at the site were contacted by electronic mail to provide input into the process. The meeting was facilitated by the principal investigator, while another researcher recorded definitions and additional comments. Definitions of the terminology were collated into a consensus document which was returned to all therapists for comment or amendment until there was complete agreement that it was a true representation of the various types of UL therapy offered by their service for individuals receiving UL rehabilitation following moderate to severe stroke (Round 2).

Stage III: Development of UL therapy template for acute and subacute stroke rehabilitation

Collated site summaries and definitions were used to inform the development of an intervention template and glossary of UL therapies used in early stroke rehabilitation by the participating centres which could be considered to represent a 'usual care' UL therapy package at these services (Round 3).

Stage IV: Use of UL template as a recording tool in a pilot RCT

A final version of the UL limb therapy template was utilised to inform individual therapy content, and to record the time allocated to each component as part of the subsequent interventional pilot RCT.

RESULTS

Stage I: Retrospective notes audit

A total of 169 'stroke-like' cases were identified over the nine-month period. Pathology from imaging reports (CT & MRI) confirmed 10 diagnostic categories (Figure 1).

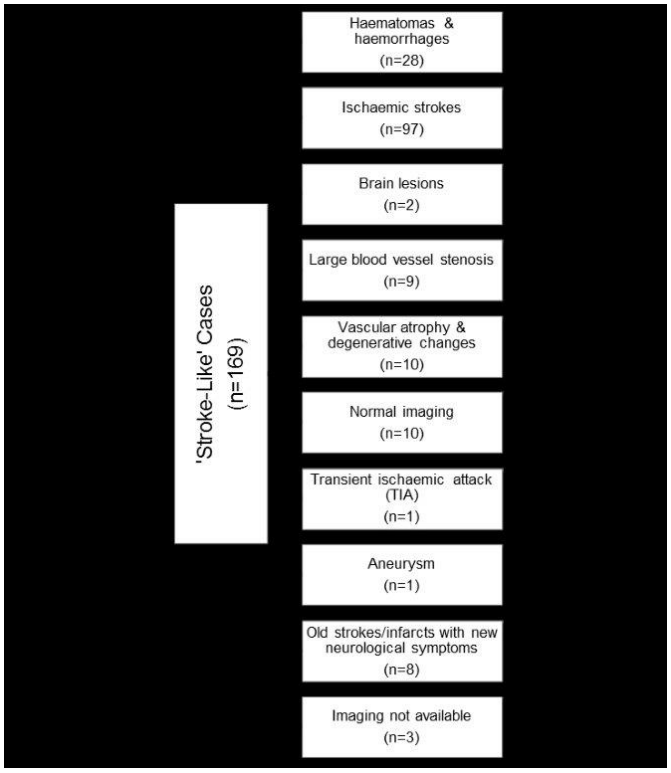

Figure 1: Retrospective notes audit 'stroke-like' diagnostic categories

Of the 97 ischaemic stroke cases identified, only 48 affected the MCA territory and/or a major MCA branch (ie 49.5% of total ischaemic stroke admissions) and these cases were included in the audit. It was determined that 22 patients had no UL impairment and two were sedated, therefore it was not possible to attain an accurate assessment of UL impairment. The 24 cases with UL impairment were classified into five categories according to CMII scores (Table 1).

Table 1: Upper limb impairment classification based on CMII scores (n=24)

Impairment Classification	CMII Score Range (Out of 7)
Severe (n=14)	1-2
Moderate-Severe (n=3)	2-3
Moderate (n=2)	3-4
Mild-Moderate (n=1)	4-5
Mild (n=4)	5-7

Notes: CMII, Chedoke McMaster Impairment Inventory.

Only 16 cases out of the 24 identified in the acute service audit were transferred to participating rehabilitation sites, and therefore, only these cases were included in this review of UL management. Eleven of the 24 included cases went to rehabilitation service one (over 65 stroke service); and five patients went to rehabilitation service two (under 65 stroke service), the remaining eight cases were discharged to transitional care placement (TCP) (n=1), Rehabilitation in the Home (RITH) (n=2), and home (n= 5). These cases were not included in this data set, as this study did not have ethics approvals for TCP and RITH and, therefore, medical records for rehabilitation in these cases were unable to be accessed. Audit data suggest that decisions to transfer patients to a rehabilitation facility were based primarily on impairment severity such as dense hemiplegia with motor and sensory components and global aphasia. Table 2 describes the demographics and UL impairment level on admission and discharge from the corresponding rehabilitation services of the 16 cases who were included in the audit.

Table 2: Demographic detail for the cases admitted to participating rehabilitation centres (n=16) from whom treatment details were examined

Patient	Age	Gender	CMII Admission	CMII Discharge	Reason for rehabilitation	LOS (days)	Final discharge destination
1	78	F	Arm: 5 Hand: 5 Mild	Arm: 5 Hand: 5 Mild	UL rehab, Global aphasia	33	LLC (Hostel)
2	71	M	Arm: 7 Hand: 6 Very Mild	Arm: 7 Hand: 6 Very Mild	UL rehab, HLB, visual imp	5	Home (ESD)
3	69	M	Arm: 1 Hand: 1 Severe	Arm: 1 Hand: 2 Severe	UL & LL rehab, pusher syndrome & motor/sensory neglect	100	HLC (Residential Institution)
4	85	F	Arm: 6 Hand: 6 Mild	Arm: 6 Hand: 6 Mild	High level balance & exercise tolerance	15	Home (ESD)
5	65	F	Arm: 1 Hand: 1 Severe	Arm: 2 Hand: 2 Severe	UL rehab, sitting balance	70	HLC (Transitional Care Placement)

6	71	M	Arm: 2 Hand: 2 Severe	Arm: 2 Hand: 2 Severe	UL & gait rehab & high level balance	67	Home (Home Link)
7	66	F	Arm: 1 Hand: 1 Severe	Arm: 1 Hand: 4 Severe-Moderate	UL & gait rehab, high level balance	59	Home (RITH then Stroke Clinic)
8	75	F	Arm: 7 Hand: 7 Nil Impairment	Arm: 7 Hand: 7 Nil Impairment	High level balance /mobility, gait rehab	67	Home
9	67	M	Arm: 7 Hand: 6 Very Mild	Arm: 7 Hand: 7 Nil Impairment	UL rehab (fine motor skills)	14	Home (ESD)
10	75	F	Arm: n/a Hand: n/a Mild	Arm: n/a Hand: n/a Very Mild	UL rehab	30	Home (ESD)
11	78	F	Arm: 7 Hand: 7 Nil Impairment	Arm: 7 Hand: 7 Nil Impairment	Cognitive rehab	1	Home (ESD)
12	60	M	Arm: 2 Hand: 2 Severe	Arm: 2 Hand: 2 Severe	UL & LL rehab (motor & sensory)	122	Home (RITH then outpatients)
13	51	M	Arm: 2 Hand: 2 Severe	Arm: 2 Hand: 2 Severe	UL & LL rehab (motor & sensory), gait rehab, high level balance	135	Unknown
14	59	F	Arm: 1 Hand: 1 Severe	Arm: 1 Hand: 1 Severe	UL & LL rehab (motor)	32	Rehab centre in New Zealand
15	64	M	Arm: 1 Hand: 2 Severe	Arm: 2 Hand: 2 Severe	UL & LL rehab (motor)	114	Home (RITH then outpatients)
16	58	F	Arm: 2 Hand: 2 Severe	Arm: 2 Hand: 2 Severe	UL & LL rehab (motor & sensory), gait rehab and high level balance	92	Home (RITH then outpatients)

Notes: CMII, Chedoke McMaster Impairment Inventory; M, male; F, female; LLC, low level care; LOS, length of Stay; HLC, high level care; ESD, Early Supported Discharge; RITH, Rehabilitation in The Home; UL, upper limb; LL, lower limb; n/a, not applicable.

Across the two disciplines, the six most common interventions in the acute rehabilitation setting (reported in more than 50% of cases) were: UL facilitation, sensory input, 'trunk work', ADL retraining, UL positioning and passive range of motion (PROM). Overall, physiotherapists incorporated more active and active-assisted interventions into their UL treatment compared to occupational therapists. It was noted that in the acute setting, physiotherapists focused on facilitating any UL or trunk movement, whilst in rehabilitation settings, therapists were more focused on task-specific practice such as reach and grasp and other fine motor skills - although facilitatory approaches were still utilised. Occupational therapists in both settings prioritised ADL retraining. Acute care occupational therapists focused their interventions on self-care tasks such as hair combing, tooth brushing and dressing tasks; whilst in rehabilitation therapists opted for tasks involving higher executive functions such as cooking, shopping, community access, return to driving and home discharge planning. The tasks chosen were age appropriate: for instance, workshop classes (for employment related activities) were offered in the younger rehabilitation setting.

Both groups used *'sensory input/re-training'* but this was documented much more frequently in the treatment records of physiotherapists than occupational therapists. Reach and grasp practice was only documented in about a third of the cases (physiotherapists 42%, and occupational therapists 29%) and education was more likely to be provided by occupational therapists than physiotherapists. The most commonly documented interventions in the acute and subacute rehabilitation settings are listed in Table 3 for physiotherapy and Table 4 for occupational therapy.

Table 3: Most frequently delivered physiotherapy interventions in the acute and sub-acute rehabilitation settings

Acute Rehabilitation	Frequency of Documentation (%)
Facilitation of Fractionated Movement	87.5
Sensory input / Retraining	58.3
Trunk Activation / Facilitation	50
Sub-Acute Rehabilitation	**Frequency of Documentation (%)**
Mobilisations (hands & shoulder)	100
Reach & Grasp practice	100
Facilitation of fractionated movement	100
Sensory / Proprioceptive input/retraining	87.5
Pelvic Tilts	80
Trunk Activation / Facilitation	77.5
Patient education: Self PROM	75
UL weight bearing with trunk movement	75
Muscle release for tone management	65
Scapular facilitation	60
PROM (shoulder)	55
Neuro Muscular Electrical Stimulation	50

Notes: UL, upper limb; PROM, passive range of motion.

Table 4 : Most frequently delivered occupational therapy interventions in the acute and sub-acute rehabilitation settings

Acute Rehabilitation	Frequency of Documentation (%)
ADL Retraining	92
Positioning	83.3
PROM / Ranging	75
Sub-Acute Rehabilitation	**Frequency of Documentation (%)**
Positioning	100
Active assisted UL Re-Training	100
ADL / Functional Retraining (Bilateral)	87.5
PROM / Ranging / Stretches	80
Oedema Management	75
Hand Exercises	75
Electric Wheel Chair Training	75
Sensory Re-training	50
Patient education: Self Management	50
Passive scapular mobilisation	50

Notes: ADL, activities of daily living; UL, upper limb; PROM, passive range of motion.

Stage II: Definition of UL interventions and consensus on 'usual UL rehabilitation' in participating services (Rounds 1 and 2)

Twenty two female therapists, comprising nine physiotherapists and 13 occupational therapists, participated in a total of five focus groups. The participating therapists' level of experience ranged from 10 months to 39 years in neurological rehabilitation. The average focus group duration was one hour per discipline at their corresponding sites. It is important to note that some of the participants in the focus groups were not the same therapists whose notes were audited due to staff rotating out of area. Two therapists - one no longer working at the same facility, the other on leave - participated in the modified Delphi process via electronic mail.

Definitions were reviewed twice by all therapists prior to reaching a final consensus. Agreed definitions for each intervention are provided in Appendix 1. For the most part, the terminology used in treatment notes was defined very similarly by both discipline groups. Unsurprisingly, theoretical knowledge underpinning treatment interventions was greater according to level of seniority and experience in the field of neurological rehabilitation. Therapists' treatment approach also varied due to their training background.

The data from the audit reflected a set of cases from two years prior to the focus groups; consequently, it was necessary to determine if they still represented the most commonly used UL interventions currently provided by each service. Therapists were also given the opportunity to add or change any of the intervention definitions, to represent their current practice and understanding. For instance, therapists opined that the term *'trunk work'* was too general and inaccurate; they suggested '*trunk activation/facilitation*' be used to describe this intervention. Other terms such as *'sensory bombardment'* were also amended to *'sensory input/re-training'*. Functional interventions were described in more detail than *'ADL re-training'*; and more complex tasks such as *'bimanual tasks or activities'* were included. Further elaboration was also given about the nature of specific "Bobath" interventions documented in the file audit.

Although time spent treating the UL was not able to be reported from the file audit, it was considered by group members that on average, patients received daily treatment of approximately 30 minutes duration per discipline for 5 days per week. These 30-minute sessions included assessments and all UL and LL therapy. Therapists were unable to quantify how much time they spent on average on UL specific therapy; however, they did express that it was likely to be minimal in the acute care facility.

Stage III: Development of UL therapy template in acute and subacute stroke rehabilitation (Round 3)

A template was developed from the data gathered from the audit and participants' additions and suggestions were incorporated in order to reflect current practice in early stroke rehabilitation at the participating centres (Appendix 2). The focus group discussions also allowed for the development of an accompanying glossary of definitions (Appendix 1).

The template outlines a repertoire of impairment-based interventions that may be used in the management of

individuals with moderate to severe UL impairment in the acute and subacute stages of rehabilitation post-stroke. The interventions are categorised as 'passive', 'active-assisted' or 'active' which may incorporate practice of a functional task. These commonly used terminologies were also categorised under sensory and motor specific interventions; as well as those addressing other impairments such as management of tone, oedema and inattention/neglect. Functional tasks were primarily categorised under 'ADL specific' and 'reach and grasp' tasks. Finally, other interventions less commonly reported were included such as splinting, handwriting skills, 'workshop' and mirror box therapy (Appendix 2).

Stage IV: Use of UL template as a recording tool in a pilot RCT

The template was tested for ease of use and feasibility of implementation in a pilot RCT where it was used to direct and record care within a standard set of choices applying to moderate to severe UL impairment (Garcia-Vega et al 2016). It was shown to be an efficient recording tool providing an accurate description of the treatment given to participants in the interventional trial; as well as facilitating documentation of the treatment for both research records and patient clinical handover between therapists.

DISCUSSION

The purpose of this study was to document common practices in UL rehabilitation within a group of acute and subacute stroke services and to achieve an agreement on definitions of treatment to inform the development of a standardised template of 'usual care' UL rehabilitation post-acute stroke for use in a subsequent interventional pilot study. This template was not intended to provide the most evidence-based or 'best practice' UL interventions, but rather to reach a consensus on care provided amongst a small group of stroke units in Perth, Western Australia.

The literature states that there is inadequate reporting of interventions in pilot and feasibility studies, as well as phase II RCT studies; and that researchers need to adhere to guidelines provided to describe a package of 'usual care' such as the extended CONSORT statement (Boutron et al 2008) and the 2010 CONSORT (Schulz et al 2010) update. Such standardised processes are necessary in order to ensure high quality research that characterises the control treatment as well as the novel one.

The template developed from the consensus process in this study was utilised to plan and document the 'usual care' component of treatment in a safety and feasibility pilot RCT of non-invasive brain stimulation and UL rehabilitation post-acute stroke (Garcia-Vega et al 2016). This approach to standardising and documenting current rehabilitation practices did cause feelings of unease amongst some of the participating therapists, as their notes/documentation were audited by the principal investigator who is also one of their peers. This was one reason why focus group sessions were held separately for the three sites involved and for the two disciplines. However, it was made clear to participants that the rationale behind developing a 'standard of care' template was not to assess current practice against evidence based guidelines, but to achieve a consensus on a standard UL 'therapy package' to be delivered by a research therapist, which would be acceptable to the clinicians whose patients were involved in the subsequent interventional pilot study.

This process of involving clinicians in the consensus development allowed therapists to have confidence that the treatment given during the intervention phase was similar to that which they would have provided to their patients. This helped to gain therapists' compliance with non-treatment of the UL during the subsequent interventional study, which preserved the integrity of the intervention protocol, as per recommendations by Boutron et al (2008) and Schulz et al (2010).

Protocol differences exist between the way the template reported here was developed and previous literature. For instance, the template described by McHugh et al (2014) sourced rehabilitation interventions from a much wider population of therapists via a national survey in the UK; while the present study focused on data from one metropolitan acute and two subacute stroke services. Similarly to the UL therapy protocol developed by Rosewilliam et al (2009), the UL template developed from this study was based on an audit of UL interventions in stroke rehabilitation, which were categorised as passive, active assisted, and active. This categorisation allowed clear and concise documentation of intervention provided. However, Rosewilliam et al's (2009) protocol provides more specific guidance on progression of treatment than the current UL rehabilitation template, which was intended to offer an array of options, so that the research therapists could use their clinical judgement to guide the provision of individualised rehabilitation programmes.

Other authors have taken a different approach to the development of treatment templates. An example is McDonnell et al's (2013) evidence-based clinical algorithm, which standardises prescription and progression of UL interventions for people following stroke. This algorithm is structured around 18 critical impairments and covers a range of five domains: sensation, passive range of movement, strength, unilateral and bilateral dexterity. The therapists who contributed to the current template identified similar impairments and domains as McDonnell et al (2013). Similarly, the national survey of UK stroke rehabilitation practice by McHugh et al (2014) reported five main treatment categories, ranging from passive to most active, and was even inclusive of assistive technologies.

Other 'treatment taxonomies' have standardised rehabilitation approaches beyond therapy content, such as the treatment protocol developed by Wallace et al (2010) that provides a standardised intensity-based prescription of UL rehabilitation in a cohort of individuals with chronic stroke. Wallace et al (2010) demonstrated that UL therapy can also be standardised in relation to intensity, and can be goal-orientated and tailored regardless of stroke severity. This approach allowed the implementation of individualised rehabilitation, which was well tolerated by patients and therapists, and was feasible to administer in a multisite trial. Similarly, in the current study, the standardised template was found to be feasible to implement in a multisite clinical trial. It provided an array of interventions suitable for patients with moderate to severe sensorimotor UL impairments, and specifically tailored to patients in the acute and subacute stages of rehabilitation post-stroke. One caveat is

that the protocol developed by Wallace et al (2010) was based on a chronic stroke cohort, and may not be suitable for use in acute stroke rehabilitation. For instance, the protocol requires one hour of therapy per day for 10 consecutive working days. Based on feedback from the participants in this study, anything longer than 30-minute sessions in an acute stroke population may have not have been feasible to administer due to patient tolerance and staffing issues.

The main variations of the treatment descriptors recorded in the present study appeared to be due to the level of experience, training background and knowledge of individual clinicians, both inter- and intra-professionally. Some therapists were more biased towards practice based on the Bobath concept (British Bobath Association 2009), while other therapists referred predominantly to the Motor Re-learning approach (Carr and Shepherd 2010); hence their descriptions were more reflective of the task specific practice model. There were some discipline specific differences. For instance, physiotherapists were more likely to approach facilitation of UL movement and trunk activation proximally using techniques such as 'scapular setting' (see Appendix 1 for a detailed definition); conversely, the occupational therapists most commonly approached treatment of poor trunk control via activation of the hand, for instance involving tasks such as reach and grasp retraining. Some therapists included a lot of focus on regaining trunk and pelvic control prior to addressing the UL deficits, whilst others approached UL retraining within the context of a functional task. These opposing viewpoints were a point of discussion amongst therapists, some of whom recognised that the Bobath terminology documented was not contemporary with recent descriptions (British Bobath Association 2009). There were discrepancies between same site therapists (occupational therapists versus physiotherapists) in regard to description of practices such as sensory re-training, facilitation of movement (proximal versus distal), and postural sets. In general, physiotherapists were more familiar with the Bobath approach than occupational therapists. Despite these variations it was possible to get agreement on definitions of the documented interventions amongst therapists in all participating services.

There were a number of limitations on the present study. The UL template was not intended to be based on 'best practice' or 'most evidence based care' but on what was 'usual care' in the participating services as described by focus group participants. Consequently, it does not necessarily equate with recommendations from international guidelines for management of the hemiplegic UL. However, clinicians involved in the consensus development have suggested that this template could be used to guide students and novice clinicians, as well as facilitating the delivery of research interventions. This template is not intended to be a representation of the practice of all therapists working in stroke services in the Perth metropolitan area where data were collected, nor indeed across other stroke services in Western Australia, as it may be limited by particular features of the practice of the participating therapists. Although these agreed definitions may be useful to other therapists trying to describe 'usual care' in their practice, this was not the intended purpose of the template.

In summary, UL rehabilitation after stroke cannot be a 'one size fits all' recipe; it must be tailored to stage of recovery, severity of impairment and individual patient factors. Previous UL rehabilitation paradigms have been informed by audits, national surveys or summaries of evidence-based practice, with different protocols providing progression options, ways to promote therapy intensity or an array of interventions categorised from passive, active assisted and active (Arya et al 2012, McDonnell et al 2013, McHugh et al 2014, Rosewilliam et al 2009). Current CONSORT guidelines (Boutron et al 2008, Schulz et al 2010) also provide a framework for reporting both control and novel interventions in non-pharmacological research studies. In the present study, a UL intervention template was developed based on a file audit and subsequent discussion amongst therapists to agree on definitions and practice that comprised 'usual care' in their services. It provided a framework of current and realistic UL rehabilitation practice at the participating acute and rehabilitation facilities in the one metropolitan area, which was subsequently successfully used to inform and document 'usual care' in an interventional trial of the addition of non-invasive brain stimulation to UL rehabilitation in acute stroke (Garcia-Vega et al 2016).

CONCLUSION

The template that has been developed from this study provides a structured impairment-based approach that could allow therapists to individualise their treatments within a set of well-defined interventions including development of functional skills, specific task-practice and application of manual techniques. This template has the potential to be used to inform a 'standard package of care' for rehabilitation of moderate to severe UL deficits post-stroke, in addition to providing a standardised recording tool in clinical research trials, which may facilitate accurate and time efficient documentation and replication of the care provided across services.

KEY POINTS

1. Common practices in UL rehabilitation (acute and sub-acute) were explored amongst therapists from a small group of acute and rehabilitation stroke services. The main findings were: (1) terminology used was defined very similarly by both physiotherapy and occupational therapy discipline groups; and (2) differences in treatment focus amongst therapists appeared to be due to the degree of experience and training background of individual clinicians, both inter- and intra-professionally.
2. Across the continuum of care, physiotherapists tended to use more active interventions such as facilitation of fractionated movement, sensory / proprioceptive input, task re-training, trunk activation/facilitation and joint mobilisation (hands and shoulder), whilst occupational therapists in the acute setting reported more passive interventions such as PROM and UL positioning, with functional task-oriented retraining becoming the focus in the subacute stages of rehabilitation.
3. The template developed in this study provides a concise and easy to use tool to guide and document rehabilitation for those with moderate to severe UL deficits in the acute and subacute stages post-stroke.

PERMISSIONS

Ethical approval was granted by the Sir Charles Gairdner Hospital (SCGH) and Osborne Park Hospital (OPH) Human Research Ethics Committee (trial number 2012-127); reciprocal ethics approvals from Royal Perth Hospital (RPH) (reference number REG 12-021), and The University of Western Australia (reference number RA/4/I/6040) were also obtained.

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I declare on behalf of myself and the other authors that we know of no competing interests (financial, professional or personal) which may be perceived to interfere with or bias any stage of the writing or publication process. This includes, but is not restricted to, any factors that may influence full and objective presentation of the article, peer review and editorial decisions.

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APPENDICIES

APPENDIX 1: DEFINITIONS OF UPPER LIMB REHABILITATION INTERVENTIONS

1. Passive Interventions: Interventions that do not require patient participation and are performed by a therapist or therapy assistant.

- **PROM / Ranging:** These terms were considered to be interchangeable. This technique can be done in all positions (side lying, supine, standing). It entails taking individual joints of the UL through full available and pain free range passively (unassisted by patient). Passive movements aim to maintain joint ROM and muscle length. PROM/ranging is not commonly used as an isolated practice; it can be part of mobilisations and sensory re-training, eg finger PROM, 'scapula setting' and passive ranging of hand and wrist. PROM can also be done in proprioceptive neuromuscular facilitation (PNF) patterns and 'PNF ranging' was defined as passive movements in a PNF pattern which may or may not include verbal prompting.
- **UL Stretch:** is a sustained passive stretch to maintain joint ROM and muscle length. Stretches involve use of air splints, inhibition techniques to decrease overactivity, and manual stretching.
- **UL Mobilisations (trunk, scapula, hands and shoulder):**
    - **Scapular** - both hands are placed on the scapula to mobilise it on the trunk e.g. movements of elevation, depression, protraction and retraction. This can involve movement of the scapula on trunk and trunk on scapula. Also documented as **passive scapular mobilisations** which are commonly incorporated in passive and active assisted ranging (either in supine, side lying, or sitting). This provides sensory input and aims to strengthen scapular movements leading to overall better UL movement and function. This may be performed during a functional task.
    - **Shoulder** - anterior-posterior (AP) and caudad mobilisations of the glenohumeral head.
    - **Wrist** - radio-ulnar, interphalangeal (IP) mobilisations.
    - **Hand** - to mobilise joints when stiff and painful, also to increase sensory input, decrease tone, improve acceptance of base of support.
- **UL positioning and C- cushion:** Maintaining a good biomechanical alignment of the affected UL limb throughout the day. This may include using supports such as c-cushion, lap trays, shoulder sling, shoulder cuff and other equipment. It also entails patient, staff and family education regarding keeping the glenohumeral joint and all other joints of the UL in an optimal position. These strategies are predominantly used at rest when the patient is either in bed or sitting in a chair but not actively using the limb (outside of opportunities for functional use of the UL). However, they may also be used when the patient is eating meals, in the shower etc. The Occupational Therapists noted that it is most likely to be documented as "positioning" in future.
- **Shoulder Taping:** for subluxed shoulder to increased glenohumeral stability in the presence of weak proximal muscles and to improve the alignment between the head of the humerus and the glenoid fossa. Taping can be used prior to facilitation to aid with normal movement patterns. In regards to shoulder subluxation management, some centres use a shoulder cuff support rather than providing taping.
- **Splinting (Soft):** aims to achieve stretch of muscles and maintain ROM of the joints and soft tissue length from hand to elbow, also to decrease tone. Often used at night time so it does not impair active movement. Also used to maintain skin integrity and facilitate hygiene.
- **Thermoplastic splinting:** to maintain joint integrity and muscle length via custom made thermoplastic splints. Soft splinting is mostly used for the management of hygiene issues in the presence of high tone (palm protectors, elbow splints).

2. Active-Assisted and Active Interventions: interventions that are facilitated by a therapist, or performed with supervision.

- **UL Movement Facilitation:** active-assisted exercise with the therapist using manual facilitatory techniques, such as muscle tapping, and modifying their input in response to patient's motor activity. This category may include joint compression, distraction at the shoulder, scapula, elbow, wrist and fingers with support as required in order to facilitate normal movement patterns. It may include verbal cues from therapist, external focus of control cues and directing the patient's visual attention to the affected limb.
- **UL Facilitation of Fractionated Movement:** facilitation of 3-joint movements usually starting with initiation in wrist extension (out of synergy). UL facilitation includes functional tasks such as reach and grasp practice, always with a functional goal or target. Positions may include supine, sitting or standing. Trunk constraints in sitting or standing may be used, including graviceptor activation. 'Hand on body' can also provide tactile feedback to the patient e.g. putting their own hand on their head. Other terms which may be used interchangeably: Facilitation of **UL - exercise (hand on head), reaching practice in sitting with AP and lateral pelvic tilts** (precursory to reaching activities).
- **Reach and Grasp Practice/ Reaching facilitation:** active-assisted movement through normal kinematic pattern for reach, grasp and release with modification of support in response to motor output. Manual handling given by the therapist includes sensory and proprioceptive input via auditory and tactile feedback through scapula, upper arm into elbow and wrist extension, supination, and finger extension then finger flexion to grasp. Should incorporate use of props and objects when possible and appropriate. Practice must be task specific and address a functional goal.

The UL could be facilitated proximally or distally and against gravity, in accordance to the patient's deficit(s). For instance the UL could be facilitated to reach to the patient's knee or to a specific target in lying, sitting and standing. Therapists provided facilitation of trunk activation prior to the reaching task and guided reach task specific techniques. A number of therapists indicated use of 'trunk activation techniques' prior to reach and grasp tasks. **Trunk Activation** in particular refers to using Bobath strategies to augment truck control, weight bearing and weight shifting. Work on the pelvis and trunk is often incorporated into a functional task such as reaching - often starting proximally and working to improve distal control. This category may include seating review and provision of cushioning in the wheel chair to activate or dampen trunk activity as required. Also UL reaching activities to activate the trunk without any specific technique applied to the trunk. Trunk facilitation is commonly done to enable functional reach for an object outside the patient's base of support.

- **Active Assisted Ranging / ROM:** therapist provides facilitation/inhibition, in association with sensory and proprioceptive input and key points of control, working from the shoulder control down to fine wrist and hand movement. The whole body posture is also considered when promoting normal movement patterns. Remedial and compensatory approaches can include use of equipment. This task includes a functional and purposeful component such as reaching for a cup, grooming, feeding. Other terms that may be used interchangeably:
    - **Functional Reaching Facilitation and Active-assisted UL re-training. PNF movement facilitation:** Active assisted facilitation as required using PNF patterns.
    - **Trunk Work/ Activation / Facilitation/ Alignment:** Refers to the therapist's use of manual facilitation of selective activity of the trunk in order to gain/improve postural control. It could also incorporate selective activity of the upper limb on a stable trunk such as activation of side flexors in combination with reaching forward and leaning outside of base of support (i.e. internal and external displacement). Techniques commonly used in sitting include: lumbo-pelvic tilts, lateral and anterior-posterior pelvic tilt mobilisations, thoracic flexion and extension over a stable pelvis. This facilitation aims to disassociate trunk and pelvis via the thorax or central key points (CKP). Dissociation of CKP is also known as 'central key point (CKP) facilitation'. Therapists with more recent Bobath course attendance suggested that the term CKP is no longer current.

Proximal Stability:

- **Scapular Facilitation / Setting:** Also documented as **Proximal Stability Exercises**. Postural control must be achieved first prior to facilitating a stable/ set scapula. The affected hand is placed on a stable surface (contactile response); the therapist provides manual techniques in order to activate the scapular stabilisers. Proximal stability work can also be done in a weight bearing position in sitting.
- **UL weight bearing exercises:** weight bearing and weight shifting on the plinth or bolster, always on an extended arm. Also in side lying (side sitting or forward lean sitting), weight bearing through the arm for elbow, shoulder and scapula control. This allows setting of the scapula. **UL weight bearing (hands on plinth):** this refers to a position rather than a treatment technique.

3. Interventions for Sensory and Proprioceptive Impairments:

- **Sensory & Proprioceptive re-training / input:** This includes providing opportunities for patients to increase their awareness of forms and location of sensory input to the body such as light touch, detecting sharpness, temperature, compression, traction, weight bearing exercises, massage, touching different textures, proprioception, visual and auditory input. Refers to any techniques used in order to tap into the sensory system. Sensory work to the hand particularly to the finger tips and movement creases i.e. distal palmar crease and thenar, hypothenar muscles and webspaces e.g. asking the patient to find these anatomical areas. Manual techniques include scratching/pricking (also pinch, prod, rub) applied to the finger tips e.g. thumb and index finger apposition and input to the palmar creases, finger and hand joint mobilisations (compression / distraction), passive movements of hand / fingers. Sensory stimulation can also be applied to the lateral aspect of the hand with joint approximation and compression techniques. Other forms of sensory input may include face stimulation with a face cloth and visual attention to task (i.e. tracking with eyes and head turning), progressing to sensory input to the shoulder, elbow, wrist and fingers on the affected side. Scapula- mobilisations and sensory/proprioceptive feedback e.g. Tapping on the inferior scapular border. Proprioceptive input can also be applied to the wrist and triceps with joint mobilisations proximally and distally. Sensory retraining / input also includes patient and **family education re: sensory input to UL**.

  Some therapists indicated that they use specific sensory re-training protocols, such as the Carey el al (2011) approach where possible; patients are encouraged to complete sensory discrimination and sensory stimulation tasks independently. Sensory retraining can be remedial (in the presence of specific deficits) or have the purpose of increasing attention to the affected upper limb also known as **UL awareness** i.e. "finding the hand".
- **Stereognosis training:** reaching into a bag and using tactile skills to recognise objects (stereognosis).
- **Recognition of hot/cold, and sharp/ blunt input:** These are more commonly used as an assessment tool and to inform type of sensory re-training required light touch versus sharp/blunt.

4. Tone Management:

- **UL Releases/Mobilisations for Tone Management:** a manual technique applied repetitively by the therapist which incorporates 'muscle releases' with distraction and a rotatory component in order to improve muscle length.

This technique is applied slowly and is modified by the therapist according to patient's response i.e. muscle 'letting go' or increasing tone. This technique is documented as **"mobilisation of muscles with rotation"**.

5. Oedema Management for the UL: Includes techniques such as neuromuscular electrical stimulation (NMES), bandaging, and use of compressive gloves, manual oedema mobilisation, and patient education on self-management. **Massage and glove:** using compressive gloves, retrograde massage, passive and active ranging, education for patients and family members. May include vibration in combination with elevation and positioning with c-cushions. **Retrograde massage** was defined as massaging the UL positioned above heart level, starting at a distal point (tips of fingers, wrist/forearm) towards the proximal aspects (shoulder) towards the heart.

6. Functional Interventions:

- **ADL/ Functional Retraining:** Includes specific training in personal care skills including those required for showering, dressing, eating, toileting, bed mobility, and domestic chores e.g. meal prep/ kitchen skills, laundry, showering, dressing, cognitive and perceptual re-training in community access, money management and leisure activities. **Bilateral activities** integrating both arms into ADLs, eg holding a jar with one hand and taking the lid off with the other hand or picking up a cup with both hands. Both remedial and compensatory approaches are utilised as indicated. This training may incorporate family members and education/ training. In some rehabilitation centres therapists may use the occupational therapy gym and a short stay functional training unit or the patient's home to provide a more realistic training environment. Graded discharges such as day leave or weekend leave are also considered part of ADL retraining and would be likely to involve task skill retraining in meaningful daily activities such as grooming, feeding, dressing, showering and toileting. For females it may encompass applying makeup, brushing hair and applying moisturiser. For men personal care tasks include brushing hair, shaving, brushing teeth and washing face.
- **Fine motor skills practice:** fine motor skills such as grasp, release, finger / thumb opposition, pincer grasp, facilitation of hand activity by working on intrinsic muscles of the hand and lumbrical muscle control. This category can include in hand manipulation of objects including props like beads, cards, nuts, bolts, buttons/ zips, and hand writing skill practice. **Handwriting practice/ pen skills:** with moderate to severe strokes this is likely to refer to training of writing/ pen skills with the unaffected upper limb as a compensatory strategy. For mild to mild-moderate impairments this is a graded process, series of handouts, templates. The use of different pen aids and surfaces may be incorporated as required. Functional tasks such as bimanual 'highly skilled' tasks like doing buttons up will also be included as appropriate. Also documented as **"Dexterity exercises"**, however therapists prefer to call it **"fine motor retraining"**. Fine motor skill practice tasks might require adequate alignment of the shoulder joint and scapular setting techniques.

7. Patient & Family Education:

- **Patient education regarding self PROM:** usually involves teaching the patient to administer PROM using the unaffected hand to assist and passively move the affected hand/ limb.
- **Self-Management of UL:** this includes self PROM and education to increase safe self-management and handling of affected UL (e.g. prompting the use of cues such as "where is your arm?"). Specific instruction will be needed for oedema, ranging, positioning, implications of sensory loss, and inattention to avoid learned non-use and increase independence with ADLs. This category includes use of sensory kits and individualised programmes (eg for texture discrimination training). **UL exercises (hand out):** includes strengthening, coordination, positioning, and oedema management. Includes task specific exercises with functional outcomes.
- **Hand exercises:** strengthening by using theraputty, or resistance bands. Handouts outlining types of exercises are issued to patients. Exercises usually include opposition practice, isolation of finger movements and fine motor skills. **Theraputty exercises:** active finger movement against graded resistance for fine motor skills, strengthening of the hand muscles, sensory and proprioceptive input, bilateral tasks (simultaneously and alternating). Occupational Therapists issue an exercise sheet to patients.
- **Family education re: sensory input and positioning:** in regards to sensory input especially in the hand and arm, advice and guidance may be given to family including about: massage, pressure, scratching and light touch. Also advice would be provided reinforcing current management of the above and UL handling and positioning.

Additional interventions which participating therapists indicated were also used at their facilities:

- **Visualisation / mental imagery or practice / guided imagery:** a perceptual experience initiated by the patient, this could include mental imagery of a certain movement or functional task.
- **Attention practice:** encompasses getting the patient to attend to their affected UL via visual attention. This requires frequent prompting from the therapist. Visual constraint (covering unaffected UL with a towel).
- **De-sensitization:** use of sensory techniques described above to ameliorate oversensitive hand, forearm, or proximal UL.
- **Mirror Box therapy:** by using a box with a mirror on one side. The patient places the unaffected UL into outside of the box facing the mirror, and the affected UL in the inside of the box. The patient sees a reflection of the unaffected hand where the affected hand would be from an anatomical point of view. The patient completes a series of finger and wrist exercises at the same time as receiving 'artificial' visual feedback that the affected hand is now moving. Therapists indicated that patients complete a pre-mirror box activity such as right and left discrimination cards, and that at their

facility mirror therapy is completed independently by the patient as adjunct to sessions. However, mirror therapy can also be completed as part of a rehabilitation session and some therapists are combining this with NMES.

- **Neuromuscular electrical stimulation (NMES):** Facilitation of motor activity especially in shoulder, wrist and finger flexors and extensors. NMES is used to initiate and augment motor control; patients are encouraged to actively participate. Can be used in combination with the mirror box. Usually NMES is applied to the affected shoulder (over supraspinatus and posterior deltoid) to achieve glenohumeral joint re-alignment and improve subluxation or to wrist extensors to facilitate the initiation of reaching movements.
- **Manual wheel chair training and positioning:** this incorporates use of the unaffected upper limb and the affected limb as able. The task involves manoeuvring of wheelchair around the ward, community and even home.
- **Electric Wheel Chair (EWC) Training:** used as compensation for mobility and cognition. Also used for training neglect.
- **Workshop:** this term refers to a designated space with tools and experienced staff in wood and metal craft. The main aim is to integrate the upper limb, as a stabiliser or to manipulate tools, during bimanual tasks. Activities also involve cognitive planning.

Reference:

Carey L, Macdonell R, Matyas T (2011). SENSe: Study of the Effectiveness of Neurorehabilitation on Sensation - A Randomized Controlled Trial. *Neurorehabilitation and Neural Repair* 25(4):304-313.

APPENDIX 2: TEMPLATE OF COMMONLY USED UL INTERVENTIONS IN ACUTE AND SUB-ACUTE STROKE REHABILITATION

<table>
<tr><th colspan="4">ACUTE & SUB-ACUTE UPPER LIMB REHABILITATION</th></tr>
<tr><td>Pt's ID:</td><td colspan="2">Session No:</td><td rowspan="2">Observations:</td></tr>
<tr><td>Date:</td><td colspan="2">Location:</td></tr>
<tr><td>Time:</td><td colspan="3" rowspan="2">Subjective:</td></tr>
<tr><td>Therapist:</td></tr>
<tr><td colspan="4">List of Impairments:</td></tr>
<tr><td colspan="4">Patient's Goals:</td></tr>
<tr><td colspan="2">Passive Interventions</td><td colspan="2">Time:_____</td></tr>
<tr><td colspan="2">☐ PROM / Ranging
☐ PNF patterns "PNF ranging"
☐ UL Stretch
Specify Joints / Muscles:</td><td colspan="2">UL Mobilisations (Specify patient's position)
☐ Trunk
☐ Scapula
☐ Glenohumeral joint: AP or PA / Caudad
☐ Hand / wrist: wrist, lumbricals, interosseous, MCPJ, ICPJ, thumb, radio-ulnar.
Comments:</td></tr>
<tr><td colspan="2">UL Positioning</td><td colspan="2">Time:_____</td></tr>
<tr><td>☐ Use of C-Cushion to maintain neutral position</td><td>☐ Shoulder sling or hemi cuff</td><td>☐ Lap Tray</td><td>☐ UL Trough</td></tr>
</table>

Active and Active–assisted Interventions	**Time:**_____
☐ UL Facilitation of Movement ☐ UL Facilitation of Fractionated Movement ☐ Active Assisted ROM/Ranging **Specify Joint(s):**	**Reach & Grasp Practice** ☐ Reaching facilitation from therapist ☐ Proximal facilitation ☐ Distal facilitation
Comments: (e.g. Functional task, manual handling from therapist including sensory & proprioceptive input+/- use of props and objects)	

Trunk Work / Activation / Facilitation	**Time:**_____
☐ Lumbo-Pelvic disassociation ☐ Lateral pelvic tilts ☐ Anterior- posterior pelvic tilts	☐ Thoracic flexion & extension over a stable pelvis ☐ UL reaching activities to activate trunk.

Proximal Stability	**Time:**_____
☐ Scapular Facilitation / Setting **Comment:** (e.g. position, weight bearing vs non-weight bearing)	**UL weight bearing exercises** ☐ In sitting: weight shifting on the plinth with UL extended, hand in contact with the plinth ☐ In standing: weight bearing UL with trunk movement

Interventions for Sensory and Proprioceptive Impairments	**Time:**_____
Sensory Input / Retraining ☐ Input to fingertips scratching / pricking / rubbing / prodding ☐ Joint compression & distraction ☐ Tactile input with various textures ☐ Input into palmar creases (Distal palmar & thenar crease) ☐ Hot /Cold or sharp/blunt input	**Neglect / Inattention** ☐ Face Stimulation (light touch) ☐ Visual attention to affected UL ☐ Auditory input (verbal cues from therapist) ☐ Eye tracking & head rotation for inattention / neglect ☐ Electric wheel chair training: for training neglect **Stereognosis** ☐ Reaching into box/bag & recognising objects **Manual Techniques** ☐ Mobilisations (hand – MCP lumbricals, wrist) ☐ Massage

Tone Management	**Time:**_____
☐ Muscle releases (rotatory component)	☐ UL mobilisations (Joint, muscles)

Oedema Management	**Time:**_____		
☐ NMES ☐ Bandaging ☐ Elevation / Positioning	☐ Gloves ☐ Manual Oedema Mobilisation	☐ Patient Education ☐ Retrograde Massage	☐ Active Ranging ☐ Passive Ranging

Functional Interventions **Time:**_____

ADL Retraining

☐ **Task-skill specific retraining** (circle one or multiple):
Grooming, feeding, dressing, showering & toileting.
Females: Applying makeup, moisturising, brushing hair.
Males: brushing hair, shaving, brushing teeth, washing face.

☐ **Domestic chores:** meal prep, kitchen skills, laundry, leisure activities

☐ **Bilateral activities integrating both ULs in ADLs.**

☐ **ADL retraining in the functional training unit** (aka "The Flat")

☐ **Bimanual tasks**
Specify task:

Hand Fine Motor Skills Practice **Time:**_____

☐ Grasp & Release
☐ Finger / thumb opposition
☐ Pincer grasp
☐ Theraputty exercises
☐ Dexterity exercises

☐ Facilitation of intrinsics and lumbricals (e.g. in hand manipulation of objects)

☐ Manipulation of objects such as buttons, zips, beads, cards, nuts, bolts, pegs, tops, lids (Circle one).

Comments:

Patient & Family education re: management of UL **Time:**_____

Self-Management of UL

☐ Patient education re: self PROM
☐ Handling of paretic UL
☐ Oedema self-management including positioning.
☐ Sensory input (individualised sensory kits for texture discrimination)
☐ Increase UL awareness i.e. for inattention or neglect (avoid non-use)
☐ Manual wheel chair training

Family Education

☐ Sensory input
☐ UL handling and positioning

Hand exercises

☐ Strengthening exs – use of theraputty or resistance bands

ADJUNCT INTERVENTIONS

Neuromuscular Electrical Stimulation (NMES) **Time:**_____

Reason(s): Muscles/

☐ Spasticity / Dystonia
☐ Oedema
☐ Shoulder subluxation
☐ Facilitation of motor activity

Joint targeted:

Settings & Time:

Mirror Box **Time:**_____

☐ Right and Left discrimination Cards
☐ Mirror box therapy
☐ Visualisation /Mental Imagery

Comments:

Workshop / Vocational Practice **Time:**_____

Describe activity involving the ULs:

Goals:

Handwriting Practice / Pen Skills **Time:**_____

☐ **Mild- Mod UL impairment:** templates, handouts, use of pen aids and surfaces
☐ **Moderate – Severe UL Impairment:** Compensatory strategies with unaffected UL

Splinting		**Time:**_____
☐ Thermoplastic ☐ Soft	**Reason:** ☐ To maintain joint integrity ☐ To maintain muscle length ☐ To decrease tone i.e. palm protectors & elbow splints	**Comments:**

Shoulder Taping			**Time:**_____
☐ Management of subluxation	☐ For stability of weak proximal muscles	☐ Prior to UL facilitation to assist with normal movement patterns	**Comments:**

A benchmarking project of physiotherapy in Australian and New Zealand adult major trauma services

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ABSTRACT

Traumatic injury places a great burden on individuals and society. As mortality plateaus in mature trauma systems, there is an increasing shift towards understanding patients' morbidity and functional outcomes. Physiotherapy plays a key role in recovery after traumatic injury, but little is currently known about its role in the acute hospital setting for trauma patients. This study aimed to document physiotherapy service structure and practice in adult major trauma services (MTS) across Australia and New Zealand. A survey was distributed electronically to physiotherapists working within designated MTS (n=25), achieving a 92% response rate (n=23). Physiotherapy service delivery, expertise and availability varied greatly. Only seven sites (30%) had a dedicated trauma physiotherapist with this showing a trend towards an association with major trauma admissions (provided by the Australian Trauma Registry; p=0.07). Only eight (35%) had blanket referral systems for physiotherapy review, which was significantly associated with having a dedicated specialised physiotherapist (p =0.015). Most ran a five day/week service for all patients with priority cover over the weekends (78% n=18). Future research should explore the benefits of specialised trauma physiotherapy roles in optimising patient outcomes in order to standardise this across all trauma centres in Australia and New Zealand.

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Key words: Physiotherapy, Wounds and injuries, Physical therapy modalities, Multiple trauma, Benchmarking.

INTRODUCTION

Traumatic injury is the most common cause of death in those aged less than 45 years in Australia and New Zealand (NZ) and the fourth highest regardless of age (Australian Institute of Health and Welfare 2014, Ministry of Health New Zealand 2006, 2015). Organised systems of trauma care that exist in both countries have been shown to reduce mortality (Ashley et al 2015, Cameron et al 2008, Gabbe et al 2011) and central to this system design is the categorisation of hospitals to provide designated levels of trauma care (from Level I to Level IV). Requirements for Level I trauma centres include defined hospital infrastructure such as a helipad landing site and access to emergency operating theatres 24 hours a day, as well as specified healthcare professionals. The professionals included are pre-hospital, specialist medical and nursing staff, with little mention of allied health or rehabilitation team members such as physiotherapy. Most designated Australian and NZ major trauma services (MTS) fulfil Level I or II criteria.

As these systems mature, there is an increasing shift towards measuring the quality of life for survivors and their morbidity over time (Cameron et al 2006). Care at MTS has been shown to improve functional outcomes (Gabbe et al 2016, MacKenzie et al 2008, Nirula and Brasel 2006), but the reasons for this are unknown. It has been suggested that this may, in part, relate to greater clinical expertise, experience and staffing levels within allied health (Gabbe et al 2012), whose interventions are specifically focused on this aspect of patient recovery.

Physiotherapists are an integral part of the trauma team. Their input is primarily concerned with the resolution or reduction of impairments and disabilities and the promotion of mobility, functional ability and quality of life through examination, evaluation, diagnosis, and physical intervention (Calthorpe et al 2014). Previous research has shown early physiotherapy intervention can improve early function after hip fracture (Kimmel et al 2016a) or admission following trauma (Calthorpe et al 2014). It has also been shown to reduce hospital length of stay (LOS) (Calthorpe et al 2014; Kimmel et al 2012; Kimmel et al 2016a). Early functional mobility was measured using the modified Iowa level of assistance score (mILOA), which has been shown to be reliable and valid in an acute hospital population (Kimmel et al 2016b). The implications of this emerging evidence relating to trauma care and health care systems could be profound. With a modest investment in acute inpatient physiotherapy services, it may be possible to reduce overall costs and improve patient outcomes. However, it is important to engage physiotherapists working within MTS to participate in comparative benchmarking work as a step towards

understanding optimal physiotherapy service delivery before commencing clinical practice benchmarking (Ellis 2006).

In Australia and NZ, little is currently known about the structure of physiotherapy services to trauma patients. In Canada, comparative work found great variability of physiotherapy service structure within their MTS but key findings included a five day a week full physiotherapy service to trauma patients with priority-only coverage at weekends. Additionally, the majority worked within a separate physiotherapy department structure, where management decisions and quality assurance focused on the best interests of the physiotherapy department as a whole rather than necessarily being patient or unit specific (Fisher et al 2012).

The primary purpose of this study was to document current physiotherapy service structure and practice in the adult MTS across Australia and NZ. Additionally we aimed to ascertain what factors are associated with the amount and type of physiotherapy intervention to trauma patients.

METHODS

A purpose-designed survey was undertaken to collect information regarding the characteristics of physiotherapy service provision at MTS in Australia and New Zealand. This information was matched, where available, with quantitative information describing MTS admission numbers, LOS and discharge destination. The project was approved by the Alfred Research and Ethics committee as a low risk project (579/14).

The Australian adult MTS were identified through the inaugural report published by the Australian Trauma Registry (Alfred Health 2014) and the NZ adult MTS from a publication regarding their systems (Paice 2007). Twenty-five sites were identified in total; 19 in Australia and six in NZ.

Since no validated tool existed for benchmarking trauma physiotherapy services, a survey was designed using 16 open and closed ended questions. This was divided into three sections: trauma service model of care, trauma physiotherapy service provision and patient scenarios. The scenarios were included to help better understand the assessments and interventions physiotherapists complete with specific patient groups. These scenarios reflected the diverse nature of trauma patients from young to older adults, with varying severity of injury and pre-existing comorbidities. All involved at least two separate injuries and respondents were asked what input they would give to the patient on a defined day in their hospital stay. The initial version was pilot-tested by two senior physiotherapists who worked in Australian adult MTS and one physiotherapist who worked in a Victorian metropolitan trauma service. Based on their feedback, the survey was altered and finalised (Appendix).

The physiotherapy managers were contacted via email and requested to provide the contact details for the most senior physiotherapist who managed the trauma patients at their institution. The survey was distributed electronically via SurveyMonkey (SurveyMonkey Inc.) and included a cover letter inviting participation. Participants were informed that completion of the survey would indicate their consent. Where required, reminder emails for non-responders were distributed.

To receive the most accurate information with regards to major trauma patient admissions, LOS and discharge destination at each MTS, the Australian Trauma Registry (ATR) was used. This registry was developed as part of the Australian Trauma Quality Improvement Program (AusTQIP), a collaboration of the 26 designated Australian MTS (adult and paediatric), with the aim to provide an evidence base for trauma quality improvement and development of performance indicators. The ATR included the bi-national minimum dataset (BMDS) developed by the collaborative Australian and New Zealand National Trauma Registry Consortium (Palmer et al 2013). Although NZ were involved in the development of the BMDS, NZ MTS data were not included in the ATR. Request to access the data items listed using the ATR data access policy was undertaken with permission received in writing from the ATR manager. Data items extracted were: major trauma patient admission numbers, acute hospital length of stay and discharge destination for the period 2010- 2012. Provided data were coded but were re-identifiable to allow them to be linked to the survey information where possible.

Statistical Analysis

Survey results and ATR data items (where available) were combined together into a spreadsheet. Numerical data were analysed using SPSS version 22.0 for Windows (IBM Chicago, IL). Continuous data were presented as means and standard deviations or medians and interquartile ranges for data not normally distributed. To explore any relationships between major trauma patient admission numbers, LOS and discharge destination with trauma unit and physiotherapy service structure, either an independent samples t-test or a non-parametric Mann-Whitney U test was performed. To explore relationships between trauma and physiotherapy service structure, a Chi-squared test was performed. Open-ended responses were grouped according to themes and the responses to case scenarios were reported as percentages.

RESULTS

Twenty five questionnaires were distributed with a response rate of 92% (n=23). Of these, 18 were from Australia and five from NZ. For the ATR data items requested, 70% (n=16/23) had complete data available, one site had incomplete data and two sites had not contributed any data to the ATR at the time of the study. Overall, complete survey and ATR data were available from 15 of the 25 sites (60%). All available data were used for the analysis.

Table 1 summarises the responses to key questions regarding trauma unit and physiotherapy service. Only five (22%) of the 23 respondents worked in a hospital with a dedicated trauma bedcard; that is, the ability to admit a trauma patient and continue their care throughout their acute hospital stay until discharge. In all other MTS, trauma patients were admitted under sub-specialty units such as Neurosurgery, Orthopaedics and General Surgery. Of these sites without a dedicated trauma bedcard, three described a "trauma service" that helped coordinate all trauma patients' care across the hospital. Seven of the 23 sites (30%) had a dedicated trauma physiotherapist defined as being either allocated to the trauma unit or identified as the key physiotherapist who managed trauma patients.

Table 1: Trauma service and physiotherapy service characteristics

Characteristic	Number of MTS n=23 (%)
Dedicated trauma bedcard	5 (22)
Dedicated trauma physiotherapist	7 (30)
Blanket referral* for physiotherapy review	8 (35)
Out of business hours physiotherapy service	3 (13)
On-call physiotherapy service	8 (35)
Weekend physiotherapy service for prioritised patients only	18 (78)
Weekend physiotherapy service for all patients	5 (22)

Notes: MTS, Major trauma service.
*Blanket referral is where all trauma patients are seen (referral not needed)

Of those sites with a trauma bedcard, 60% (n=3/5) also had a dedicated trauma physiotherapist, whereas of those sites without a trauma bedcard (n=18/23), only 22% (n=4/18) had a dedicated trauma physiotherapist (p=0.10). Of those sites with a dedicated trauma physiotherapist (n=7/23), five (71%) physiotherapists were full-time senior specialists supported by mainly rotating seniors and juniors, many of whom worked within trauma in a part-time capacity only. These specialist trauma physiotherapists reviewed trauma patients in various locations across the hospital including: the emergency department (ED), intensive care unit (ICU), wards and out-patient clinic. At the other 16 sites without a dedicated trauma physiotherapist, trauma patients were seen by an array of other specialised and rotational physiotherapists of varying levels of seniority, including but not limited to ICU, cardiothoracic, plastics, orthopaedics, neurosurgery, ED, burns, general surgery, spinal and rehabilitation.

The 2012 ATR data revealed a wide range of major trauma patient admission numbers across Australian MTS with a median of 342 admissions per year (n=17 sites, IQR 177-385 admissions) and a mean length of stay of 9.3 days (n=17, SD 1.9 days). On average, the percentage of major trauma patients discharged home was 52% (n=16, SD 10.2) and to rehabilitation was 31% (n=16, SD 9.7). Sites with greater numbers of major trauma patient admissions tended to be more likely to have a dedicated trauma physiotherapist (median 541 vs 240 admissions, p=0.07). Similarly those with greater admission numbers tended to be more likely to have a dedicated trauma bedcard (median 774 vs 314 admissions, p=0.13).

Only 35% (n=8/23) of respondents reported their site had a blanket referral for physiotherapy review of trauma patients. This involved a systematic review of all trauma admissions by a physiotherapist to establish current needs, identify any potential problems and implement an early therapy regime as required. Those sites with a dedicated trauma physiotherapist (n=7/23) were significantly more likely to have a blanket referral for physiotherapy review (p=0.02). All sites (n=23) provided a physiotherapy service to trauma patients from Monday-Friday during business hours (8am - 4.30pm), with three sites also providing extended later hours coverage until around 8pm every weekday only. Eight sites (35%) also provided an "on-call" service. This service was identified as being for high risk patients with a deteriorating respiratory issue where further physiotherapy input would be beneficial out of usual business hours. This service was available to all patients within the MTS hospital, not just trauma patients. One site also included discharges and priority casting within their "on-call" service. One further site reported no structured "on-call" system, but identified they did provide an out of hours service on a needs basis for a defined group of cervical/upper thoracic spinal cord injured patients. With regards to weekend physiotherapy service provision, five sites (22%) provided a full business hours service, with all other sites providing a reduced/ prioritised service only.

Only three sites (13%) reported collecting any standardised outcome measures for physiotherapy interventions. These included the burns specific health scale or BSHS (Blades et al 1982); the modified Iowa level of assistance score or mILOA (Kimmel et al 2016b) and the de Morton Mobility Index (de Morton et al 2008). Time points for administering these measures to trauma patients varied.

Trauma physiotherapy specific clinical guidelines, assessment tools, pathways and competencies were used within 48% (n=11/23) of the sites. Of the respondents, 74% (n=17/23) reported they run trauma specific education sessions for physiotherapy staff, usually as part of their physiotherapy department in-service training. One site also reported they run an annual trauma lecture series and basic trauma day for physiotherapists available to both internal and external staff. Some physiotherapists also attended trauma team education sessions, along with other trauma activities as detailed in table two.

Table 2: Physiotherapy attendance at trauma team activities

Trauma team activity	Number of MTS where physiotherapists attends n=22 (%)
Handovers	10 (45)
Ward rounds	9 (41)
Unit meetings	12 (55)
Unit audits	3 (14)
X-ray meetings	7 (32)
Education sessions	12 (55)
No attendance at any activities	3 (14)

Notes: MTS, Major trauma service.

Just over a quarter of respondents (n=6/23) reported their physiotherapy staff were involved in research related to trauma patients, although 87% (n=20/23) were interested in being part of future collaborative physiotherapy research. There was also keen interest in being part of a trauma network aimed at supporting and sharing knowledge and skills for those working with trauma patients (91%, n=21/23).

Patient Scenarios

Responses to the four patient case studies are detailed in table three, with full details of each case listed in the survey (Appendix). At all but one site, all patient cases would have been seen by physiotherapy on a weekday, but weekend input varied case by case from being seen at only 52% up to 100% of sites. There was consensus around some assessments and interventions performed, particularly with regards to musculoskeletal assessment and mobilisation, exercises and discharge planning which were completed by at least 87% of physiotherapists across the cases. Other assessments and intervention appeared to be more varied. Several physiotherapists reported that their intervention would depend on physical assessment findings. Time spent on all activities varied greatly (range 0 minutes - 25 minutes).

DISCUSSION

This study shows that there is a great variation of physiotherapy service delivery, expertise and availability within Australian and NZ adult MTS. Sites with more major trauma admissions tended to be more likely to have a dedicated trauma physiotherapist. Specific case scenarios also highlighted the varied assessment and intervention trauma patients receive across the different sites. Physiotherapists' participation in trauma team activities, trauma specific education and trauma related research also differed, although interest in collaborative research work and a supportive trauma network was high.

The variability in service provision described in this study is similar to that found in 2012 within Canadian MTS (Fisher et al 2012). These authors' research focused on models of service delivery in relation to specific hospital management structures and physiotherapy patient caseload numbers, particularly examining how the state of Ontario compared to the rest of Canada. However, comparison can be made around physiotherapy service delivery. In Canada, 89% (n=17/19) of their MTS ran a physiotherapy service five days/week with cover to priority patients only over the weekend which was similar to our finding of 78% (n=18/23) of sites providing this structure of service delivery. Further details of the physiotherapy service delivery in Canada with regards to referral process and specialisation however were not examined, so broader comparisons are limited.

In the absence of any established guidelines around optimal physiotherapy service delivery within MTS, it is not surprising that services varied across sites. Only the sites with a blanket referral for physiotherapy review (35% of sites) ensured that all trauma patients would have a physiotherapy assessment. Elsewhere, input relied on a referral, or was dependent on patient admission location or medical team allocation. Combined with the fact that a full physiotherapy service only occurred on weekdays and not weekends at the majority of sites (n=18/23, 78%), it is likely that physiotherapy input for patients would often be inconsistent, even within each individual MTS. One initiative that has been shown to increase physiotherapy referral rates and reduce time to physiotherapy assessment in an Australian MTS is the addition of a trauma case manager to the trauma team (Curtis et al 2006). However, it could be argued that even this referral process is not as effective as a blanket physiotherapy referral given only 55% of all trauma patients in that study received any physiotherapy and not until a median time point of 1.5 days into their hospital stay (Curtis et al 2006). Given early and more intensive physiotherapy has been shown to improve functional independence (Calthorpe et al 2014, Khan et al 2012) and reduce length of stay (Kimmel et al 2012, Pendleton et al 2007), a more consistent approach to referrals and staffing may improve patient and organisational outcomes.

Despite the presence of an admitting trauma bedcard being regarded as essential in MTS care (Royal Australasian College of Surgeons 2014), only 22% of centres fulfilled this criterion. A potential flow on effect of not having a trauma bedcard or admitting service is that trauma patients may not always be cared for in a specialist trauma ward or unit, but rather be "outliers" on other specialist wards where nursing and allied health staff may be unfamiliar with their management and access to their medical team may be less frequent (Civil 2005).

Table 3: Patient scenarios

Case Scenario	Physiotherapy input weekday/weekend n (%)	Neurological assessment n (%)	Musculoskeletal assessment n (%)	Respiratory assessment n (%)	Exercises n (%)	Mobilisation n (%)	Respiratory intervention n (%)	Discharge planning n (%)
Case 1	22 (96) / 15 (65)	18 (78)	21(91)	13 (57)	16 (70)	22 (96)	8 (35)	22 (96)
Case 2	23 (100) / 21(91)	11 (48)	22 (96)	23 (100)	21 (91)	23 (100)	23 (100)	21 (91)
Case 3	23 (100) / 12 (52)	8 (35)	23 (100)	11 (48)	23 (100)	23 (100)	6 (26)	21 (94)
Case 4	23 (100) / 23 (100)	6 (26)	20 (87)	23 (100)	20 (87)	23 (100)	23 (100)	20 (87)

Note: All percentages calculated from the n = 23 responses.

Case 1: 75 year old female two days post fall with C6 and wrist fracture just cleared to mobilise.
Case 2: 25 year old male post motor vehicle accident, day one post laparotomy and ankle fixation with eight fractured ribs and smoking history.
Case 3: 50 year old female four days post motorbike accident with left femoral nail and fixation of L3 fracture who has so far managed only to sit out of bed.
Case 4: 80 year old male three days post fall at home with right pubic rami and five fractured ribs with flail and intercostal catheter with secretion retention and increasing oxygen requirements

Sub-optimal nursing care has been demonstrated with trauma patients "out-lying" in three UK hospitals with "positively dangerous" potential implications identified (Lloyd et al 2005). In this survey, only seven (30%) sites had a dedicated trauma physiotherapist, with just five of these reported as senior permanent full-time positions; not surprisingly these tended to be sites with more trauma admissions. In other centres, patients were seen by an array of specialist and rotational physiotherapists with varying levels of experience. It is therefore possible that similar effects may occur for physiotherapy care. Although such research has not been undertaken in a trauma specific context, an association between organisational structure and clinical outcomes has been demonstrated in other patient populations and provides support for specialist health clinicians (Strasser et al 2005). The MTS should consider this in the context of physiotherapy service provision and recognise trauma physiotherapy as a defined speciality. University postgraduate qualifications are emerging in this area for allied health clinicians, which may assist with this process, although further evaluation to optimise service delivery and patient outcomes must also be a priority. Participation in trauma team activities was low, presumably due to few dedicated trauma physiotherapists and varied trauma and physiotherapy team service structure. Of particular note is that physiotherapists attended ward rounds at less than 50% of the sites, despite research that shows their participation in this activity can reduce trauma patient hospital length of stay (Dutton et al 2003).

Only three respondents reported using any objective measures of treatment outcome with their patients. This may be due to the paucity of evidence around the best outcome measure for use in this diverse population. Recently the mILOA has been shown to be responsive, reliable and valid in patients following trauma in the acute setting (Calthorpe et al 2014, Kimmel et al 2016b). Additionally, the Functional Independence Score (FIM) motor subscore at acute hospital discharge has been shown to be a predictor of 6 month functional outcome and return to work (Gabbe et al 2008), although its ease of use in the acute hospital and its limitations in the younger trauma patient are unknown.

The case scenarios provided some information around current usual physiotherapy practice with regards to assessments and interventions performed in specific common trauma patient case examples. Despite some consensus around assessment and intervention requirements, variability in practice remained evident. This demonstrates the need for stronger evidence to guide physiotherapy practice for trauma patients, although currently only 26% are involved in any such research. This reflects a need to build capacity in trauma physiotherapy research, the interest for which was found to be high with 87% interested in collaborative work and 91% interested in a trauma network to support allied health clinicians.

Limitations

Due to the variation in physiotherapy service structure to trauma patients across Australia and NZ, it was not always possible to identify one key trauma physiotherapist at each site and the survey may have been completed by more than one physiotherapist working in various areas. As a result, the survey responses may be influenced by the speciality of the physiotherapist answering the questions. Years of experience or expertise specifically in the area of trauma were also not sought in the questionnaire. As we only accessed the data items from the ATR, these were not available for any of the NZ sites, limiting our analysis of these factors and their relationship to service delivery. Interpretation of the case scenarios may have been influenced by limited details provided, so it may have been difficult for physiotherapists to accurately report their treatment approach without more specific information on assessment findings.

CONCLUSION

This study is the first to provide information around current physiotherapy practice within Australian and NZ MTS. Most MTS do not have an admitting trauma bedcard and do not have a dedicated trauma team co-ordinating their care beyond the first 24 hours of their admission. Physiotherapy service and structure at the MTS was related to major trauma patient admission numbers, with higher volume sites tending to be more likely to have a dedicated trauma physiotherapist. This factor also impacted on trauma patient access to physiotherapy, with those sites also more likely to have blanket referral for physiotherapy.

The variability documented in this study highlights the need for robust evidence to underpin trauma physiotherapy and service delivery models. Future research should focus on the role of the trauma physiotherapy specialist within a trauma team in an attempt to ensure consistent high quality care, optimal patient outcomes and organisational efficiency.

KEY POINTS

1. There is great variation of physiotherapy service delivery, expertise and availability within Australian and NZ adult MTS.
2. Sites with higher numbers of major trauma patient admissions are more likely to have a dedicated trauma physiotherapist and a blanket referral system for physiotherapy review.
3. Most sites ran a five day/week physiotherapy service for all trauma patients with priority-only cover during the weekends.
4. Future research should explore the benefits of specialised trauma physiotherapy roles in optimising patient outcomes.

PERMISSIONS

Ethics approval for this study was obtained from the Alfred Health Human Research Ethics as a low risk project (579/14).

DISCLOSURES

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The authors declare no conflicts of interest.

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APPENDIX

SURVEY TO PHYSIOTHERAPISTS

Trauma Service Model of Care

Q1. What is your trauma service model of care?

- Dedicated Trauma unit for all trauma patients from admission to discharge
- (Trauma bedcard)
- Trauma admission unit where patients are admitted for a designated time period (up to 24 hrs) for assessment and then transferred to subspecialty units
- Trauma admissions immediately triaged to subspecialty units (no dedicated trauma unit or bedcard)
- Other (please state)

Q2. Please select the trauma team activities that the trauma physiotherapist (or any physiotherapist) would usually attend:

- Handover
- Ward Rounds
- Unit meetings
- Unit audits
- X-ray rounds
- Education sessions
- Other (please state)

Trauma Physiotherapy

Q3. Do you have a dedicated trauma physiotherapist/s (who is allocated to the trauma unit or who is the main person to treat trauma patients within your model of care)? Yes or No

Q4. What is the referral process for physiotherapy review of trauma patients?

- Blanket referral (all trauma patients seen by physio)
- Referral only
- Self-referred
- Other (please state)

Q5. Please state the grade and speciality of the staff who treat the trauma patients and if possible their full time equivalent (FTE) (e.g: 1.0 FTE, grade 2 orthopaedic, 0.2 FTE grade 3 ICU).

Q6. If you have a dedicated trauma physiotherapist, what areas of the acute hospital do they cover?

- ICU
- Ward
- ED
- Other
- N/A

Q7. What is the service provision for the trauma patients?

- Monday to Friday
  - Business hours only
  - Early/Late service
  - 24 hour cover
- Saturday and Sunday (dedicated to Trauma unit or trauma patients)
  - Reduced/priority service
  - Business hours only
  - Early/Late service
  - 24 hour cover
  - Other

Q8. Do you use any standardised outcome measures or collect any data on physiotherapy intervention for trauma patients in the acute setting? Yes or No

Q9. If yes:

- What data is collected? Open comment box
- At what time points? Open comment box
- Who collects it? Comment box
- Do you routinely use? Yes or No

If yes, please comment

Q10. Do you use any physiotherapy specific trauma clinical guidelines, pathways or competencies for your patients or physiotherapy staff? Yes or No.

If yes, please give details below.

Q11. Do you run education sessions for physiotherapy staff in trauma management? Yes or No.

If yes, please give details below.

Q12. Are your physiotherapy staff involved in any research related to trauma patients (either as a primary investigator or assisting other staff)? Yes or No.

Q13 Patient Scenarios

Patient 1

75 year old female who fell down steps at the shops two days ago.

Injuries sustained:

- C6 fracture managed in a cervical collar for 6 weeks
- Right wrist fracture managed in a plaster of paris (POP) and non-weightbearing (NWB)

Social History (SH): fit, well and independent mobility. Lives alone.

Previous Medical History (PMH)-nil

Her spine has otherwise just been cleared to mobilise.

Would she be seen by physiotherapy:

- Mon-Fri only?
- Weekend?

After reading the patient's medical notes, reviewing imaging and any relevant other information, what would your first physiotherapy review involve? And how long approximately in minutes would each component take? (Multiple options and time taken for each allowed)

- Full neurological assessment
- Full musculoskeletal assessment
- Full respiratory assessment
- Exercises
- Mobilisation including gait aid provision
- Respiratory intervention
- Discharge planning
- Other- please comment

Patient 2

25 year old male involved in a motor vehicle accident yesterday on a background of alcohol and drug use.

Injuries sustained:

- Perforated right diaphragm requiring a laparotomy and repair
- Fractured right ribs 5-12 with haemopneumothorax managed with an intercostal catheter (ICC)
- Left ankle fracture requiring surgery and an open reduction internal fixation (ORIF), NWB leg for 6 weeks

PMH: Smokes 20 cigarettes/ day and regular recreational drug use.

SH: Usually fully independent and lives at home with his mother.

His pain is well controlled and his respiratory status stable on two litres of oxygen via nasal cannula.

He is now day one post his laparotomy and ankle ORIF. Spine has been cleared.

Would he be seen by physiotherapy:

- Mon-Fri only?
- Weekend?

After reading the patient's medical notes, reviewing imaging and any relevant other information, what would your first physiotherapy review involve? And how long approximately in minutes would each component take? (Multiple options and time taken for each allowed)

- Full neurological assessment
- Full musculoskeletal assessment
- Full respiratory assessment
- Exercises
- Mobilisation including gait aid provision
- Respiratory intervention
- Discharge planning
- Other- please comment

Patient 3

50 year old female after a motorbike accident four days ago.

Injuries sustained:

- Left mid-shaft femur fracture requiring an intramedullary nail four days ago, NWB on leg
- L3 burst fracture requiring ORIF three days ago, no neurological involvement and no post-op position or mobility restrictions

PMH- nil

SH- lives with supportive husband in a single level house. No steps to access.

So far she has managed just a transfer to sit out of bed with assistance of 2 physiotherapists.

Would she been seen by physiotherapy:

- Mon-Fri only?
- Weekend?

After reading the patient's medical notes, reviewing imaging and any relevant other information, what would your physiotherapy review involve today (day four post admission)? And how long approximately in minutes would each component take? (Multiple options and time taken for each allowed)

- Full neurological assessment
- Full musculoskeletal assessment
- Full respiratory assessment
- Exercises
- Mobilisation including gait aid provision
- Respiratory intervention
- Discharge planning
- Other- please comment

Patient 4

80 year old male after a fall at home three days ago onto his coffee table.

Injuries sustained:

- Right pubic rami fracture: conservative management, weightbear as tolerated
- Five right rib fractures (with radiological and clinical flail) and associated haemothorax and ICC

PMH- Atrial fibrillation, osteoporosis, obese

SH- usually lives alone but does require a four wheeled frame to walk outdoors further than 100 metres.

He is currently requiring humidified oxygen (approximate FiO2 of 40%) via a face mask for Sp02 of 93% and has only managed to sit out of bed once using a gutter frame and assistance of two physiotherapists.

He is limited by pain and also has evidence of secretion retention.

Would he been seen by physiotherapy:

- Mon-Fri only?
- Weekend?

After reading the patient's medical notes, reviewing imaging and any relevant other information, what would your physiotherapy review involve today (day 3 post admission?) And how long approximately in minutes would each component take? (Multiple options and time taken for each allowed)

- Full neurological assessment
- Full musculoskeletal assessment
- Full respiratory assessment
- Exercises
- Mobilisation including gait aid provision
- Respiratory intervention
- Discharge planning
- Other- please comment

Q14. Would you be interested in being part of future collaborative physiotherapy research? Yes or No

Q15. Would you be interested in being part of a trauma network aimed at supporting and sharing knowledge and skills for those working with trauma patients? Yes or No

Q16. Would you like to be acknowledged in any publications or presentations? Yes or No

Thank you for your time completing this survey. Please do not hesitate to contact me if you have any questions regarding this information.

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The Alfred

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Psychosocial correlates of physical activity levels in individuals at risk of developing diabetes mellitus: A feasibility study.

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ABSTRACT

Recognition of psychosocial factors associated with physical activity (PA) levels will facilitate development of targeted behavioural interventions to promote PA. The aims of this feasibility study were to screen individuals at risk of diabetes mellitus (DM), to quantify their physical activity (PA) levels and to investigate the associations between PA levels, exercise self-efficacy (ESE), psychological flexibility (PF) and health-related quality of life (HRQoL). Twenty-six adults at risk of developing DM were recruited. Participants' demographics, anthropometrics, ESE, PF and HRQoL, step counts using pedometers and self-reported PA levels (New Zealand physical activity questionnaire) over a 7-day period were collected. Participants' mean (SD) age, weight and BMI were 41.4 (13.2) years, 71.4 (17.5) kgs, and 26.39 (8.41) kg/m^2, respectively. Based on daily step counts, 32% of participants were classified as "low active". Mean (SD) scores of ESE, PF, HRQOL: physical (PCS) and mental component scores (MCS) were 3.4 (0.9) and, 47.8 (6), 51.4 and 49.2, respectively. ESE and MCS scores were positively associated with vigorous PA minutes/week (R^2= 0.17; p=0.04) and moderate PA minutes/week (R^2=0.20; p=0.03), respectively. This feasibility study highlights the potential association of positive psychosocial attributes in determining PA levels in a cohort of individuals at risk of developing DM.

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Key words: Prediabetes; Physical Activity; Self-efficacy; Psychological flexibility; Quality of life

INTRODUCTION

The New Zealand Adult Nutrition Survey (2013) reported a 7% prevalence of diabetes mellitus (DM) in the New Zealand population, with a higher prevalence of pre-diabetes (26%) among Māori and Pacific people (Coppell et al 2013). Prediabetes refers to a state in which people are at high risk of developing diabetes (Eikenberg and Davy 2013). The high prevalence of pre-diabetes in those who identify as Māori and Pacific is concerning, as it represents a lead measure for the incidence of diabetes (Tabak et al 2012).

Modifiable risk factors for the development of DM include diet and physical activity (PA) (Orozco et al 2008). Several randomised controlled trials conclude that increasing PA with or without inclusion of a healthier diet results in reduction of DM development rates (Laaksonen et al 2005, Orchard et al 2005). Furthermore, public health recommendations on PA thresholds have been proposed to promote health and reduce the risk of developing chronic diseases such as DM (Haskell et al 2007). Despite these PA health recommendations and with a supporting body of research, many adults choose not to exercise, even when they know PA is key to maintaining and improving their health (Bauman et al 2012). A range of personal, social and environmental factors have been shown to influence an individual's decision to initiate or maintain levels of PA (Battistelli et al 2012, Bauman et al 2012).

Health behaviours can be explained using a psychosocial framework such as 'social cognitive theory' (Bandura 2004). This theory explains that a health behaviour is based on complex interactions between three key variables: behaviour, the person, and the environment (Bandura 2004). A key construct based on social cognitive theory is self-efficacy, which refers to "beliefs in one's capabilities to organise and execute the courses of action required to produce given attainments" (Bandura 1997). Higher levels of self-efficacy have been consistently identified as a positive psychological mechanism behind exercise adherence among clinical and non-clinical populations (Allen 2004, Izawa et al 2006). Furthermore, increased self-efficacy has been recognised as a strong mediator of lifestyle change interventions which result in successful outcomes (Papandonatos et al 2012, Rhodes and Pfaeffli 2010).

Recently, psychological flexibility (PF) and experiential avoidance have been recognised as important factors in understanding purposeful behaviour while dynamically representing well-being and life satisfaction (Kashdan and Rottenberg 2010). Psychological flexibility refers to the ability to be in the present moment with full awareness and openness to experiences based

on one's own life values (Hayes et al 2006). Several unhealthy behaviours have been associated with poor PF. In regard to PA, PF has been considered an aversive cognitive situation that can be associated with physical inactivity (Kangasniemi et al 2014). Interventions which target improving one's PF, such as acceptance and commitment therapy, have achieved positive health behaviours including increasing PA among physically inactive adults and reducing weight in obese individuals (Kangasniemi et al 2015, Lillis et al 2009).

Diabetes is one of a range of chronic health conditions that have a significant impact on Health Related Quality of Life (HRQoL) (Brown et al 2004). Cross-sectional and longitudinal studies have identified positive associations between PA domains and HRQoL in various clinical and non-clinical population groups (adolescents, middle aged and older adults) (Bize et al 2007, Klavestrand and Vingård 2009). Research has also identified similar associations in individuals with pre-diabetes (Taylor et al 2010). However, such associations are primarily based on self-report measures of PA (Taylor et al 2010). In addition, decreasing HRQoL has been reported in individuals with newly diagnosed and chronic type-2 DM, but not in those with pre-diabetes (Marcuello et al 2012, Seppälä et al 2013). Since physical and mental health characteristics vary significantly between those with and without DM and those with pre-diabetes (Tapp et al 2006), it can be argued that health-related perceptions that influence behaviour are also different. In addition, there are reports suggesting that lower levels of perceived stress, depression and anxiety are associated with higher levels of PA in individuals with impaired glucose tolerance (Delahanty et al 2006) and in those with diabetes (Sacco et al 2007, Sacco et al 2005).

The influence of psychological profiles, such as PF, HRQoL and ESE on objective PA levels has not yet been determined in individuals who are at risk of developing DM. Before investigating new variables of interest (such as PF) as a potential predictor of PA levels in a fully-powered sample, it is justified to establish cross-sectional associations in a smaller number of individuals. In addition, the feasibility of using simple screening tools (such as self-report questionnaires) to recruit participants with a risk of developing DM needs to be assessed. Therefore, the aims of this feasibility study were to: (1) identify participants at risk of developing DM, using self-reported risk screening tools; (2) gather feasibility data related to PA levels via self-reported and objective measures; and psychosocial factors including exercise SE, PF, and HRQoL, and (3) determine the cross-sectional associations between PA levels and selective psychosocial factors such as exercise SE, PF, and HRQoL. Establishing such bivariate associations between the selected range of factors and PA levels could provide direction to choose suitable variables for conducting definitive studies on predictive associations, which will further facilitate the development of potential targets for interventions and thus reduce the impact of chronic diseases.

METHOD

Study design and ethical approval

This study was a cross-sectional investigation that was conducted between November 2013 and January 2014. Ethical approval was granted from The University of Otago Human Research Ethics Committee (Ref.no: D13/396), Dunedin, New Zealand.

Participants

A consecutive sampling strategy was used to recruit 26 adults (aged 18-60 years) with a risk of developing type-2 DM who were living in the Dunedin community. Participants were recruited from the University of Otago via email invitation and from the wider Dunedin community through flier advertisements. Interested volunteers contacted the research administrator for confirmative eligibility screening procedures. Each participant's risk of developing DM was identified using an online screening tool (Diabetes New Zealand, Auckland branch) that was administered by telephone by the clinical research administrator. Those who were at or above the "at risk" level of risk of developing DM were included in the study. Participants were excluded if they had the following conditions or situations: a current history of muscle and/or bone disorders, surgery in the last 6 months, heart or lung illnesses that restricted their current PA levels, a recommendation by a health professional not to engage in PA or any formal programme that aimed to increase their PA levels. All participants provided informed written consent to participate in the study.

Outcome measures

Physical activity measures

The New Zealand Physical Activity Questionnaire-Long Form (NZPAQ-LF) is a 7 day recall of total PA administered through an interview method. It is a validated measure of PA within the New Zealand population that includes many New Zealand cultural activities such as kapa haka (Boon et al 2010). Over a 7 day period, participants' ambulatory levels were quantified using pedometers (Yamax Digi-Walker SW-200, Japan) which possess moderate test-retest reliability and good validity (Kooiman et al 2015). Participants were instructed to record the number of steps they took each day in a step count log. Participants were instructed to turn the pedometer on in the morning as soon as they got out of bed, and to record the duration of time in which they took off the pedometer throughout the day for any particular reason, and any activity they performed that was not running or walking. The intensity levels of other activities besides running or walking were recorded based on the intensity definitions from the NZPAQ-LF.

Psychosocial measures

Stage of readiness (i.e. current participation or plans to participate in planned PA) was measured using the Exercise Stages of Change questionnaire (Astroth et al 2010, Dannecker et al 2003), a questionnaire used previously in a pre-diabetic population (Delahanty et al 2006). Exercise self-efficacy was assessed using a validated ESE scale (Marcus et al 1992). Participants rated their confidence on a scale of 1-5 with 1 being not at all confident and 5 being completely confident, with the mean score taken as the final score for self-efficacy. Level of PF was assessed using the Acceptance and Action Questionnaire (AAQ-II), a validated and reliable outcome measure (Bond et al 2011). The AAQ-II is a 10-item Likert-type questionnaire that assesses one's ability to take a non-judgemental approach to one's own internal events, so that the person can focus on the present moment and act in a way that is congruent with their

values and goals, rather than merely reacting to their internal events (e.g., fears, urges, prejudices). Each item was rated from 1 (never true) to 7 (always true), with the total score indicative of overall PF. Participants' HRQoL was quantified using the Short Form (SF)-36v2 (Quality Metric software™), a 36-item tool that measures eight domains (physical function, role limitations owing to physical problems, bodily pain, general health perception, vitality, social functioning, role limitations owing to emotional problems and mental health). Two summary scores are provided: the physical health component summary score (PCS) and the mental health component summary score (MCS), with the overall score ranging from 0–100, with higher scores indicating better HRQoL (Scott et al 1999).

Procedure

Participants' age, sex, ethnicity, occupation and educational status were documented. Height, weight, waist and hip circumference were measured (Seca Alpha Model 770, Chino, CA, USA). Four-site skin fold measurements were taken using callipers (Slim Guide Creative Health Products, Plymouth Michigan) as per the American College of Sports Medicine assessment guidelines (2010). The Audit-C was used as a validated screening tool for alcohol misuse (Bush et al 1998). In addition to eligibility assessment, participant's risk of developing of DM within 10 years was scored using a validated risk screening tool, the Finnish Diabetes Risk Score (FINDRISC) (Zhang et al 2014). According to the FINDRISC classification, a score of 12-14 is considered 'moderate risk' (estimated that 1 in 6 people will develop type 2 DM); 15–20 represents 'high risk' (estimated that 1 in 3 will develop disease), and > 20 is deemed to be 'very high risk' (estimated that 1 in 2 will develop disease) (Zhang et al 2014). In addition, sub-maximal exercise capacity was quantified using the six minute walk test (Crapo et al 2002).

Data processing

The amount of moderate and vigorous exercise was used to calculate metabolic equivalent (MET)-minutes per week, calculated as the MET intensity multiplied by the minutes for each class (moderate and vigorous) of activity over the seven day period (Maddison et al 2007). Activity levels were classified as "low", "moderate", or "high" based on the International Physical Activity Questionnaire (IPAQ) scoring protocol (www.ipaq.ki.se). Total minutes of moderate and vigorous activity for each participant were calculated to classify participants as either "active" or "inactive" according to their ability to meet the New Zealand Physical Activity Guidelines (NZPAG) of ≥150 minutes/week or ≥30 min/day on ≥5 days per week, as previously reported (Boon et al 2010). Based on their average daily step count, participants were also categorised into activity levels of "sedentary", "low active", "somewhat active", "active", and "highly active" (Tudor-Locke and Bassett 2004).

Statistical analyses

Statistical analyses were performed using SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). Descriptive statistics were calculated for demographic, anthropometric, PA and psychosocial variables (ESE, PF, HRQOL measures-PCS and MCS), activity levels based on IPAQ, NZPAG, and step count classifications. Alcohol intake scores of ≥4 for men and ≥3 for women were considered indicative of alcohol misuse based on AUDIT-C (Bush et al 1998).

Bivariate linear regression analyses ($p \leq 0.20$) and Pearson's correlation statistics ($p \leq 0.05$) were performed to determine associations and correlations between PA levels (step counts, total MET minutes/week, minutes of moderate and vigorous activities), and measures of interest (ESE, PF, PCS and MCS). Due to insufficient sample size, multiple linear regression analysis was not conducted. Assumptions for regression analysis were evaluated (Field 2012). One participant failed to wear the pedometer during the study period, and this resulted in a total of 25 step count data samples for analysis.

RESULTS

Of the 26 participants identified to be at risk using the online screening tool (Diabetes New Zealand, Auckland branch), 10 (38.5%) individuals had scores ≥ 12 in the FINDRISC screening tool, representing a moderate-very high risk of developing DM. The participants' demographic and anthropometric data are presented in Table 1. Four female participants and one male participant were classified as 'hazardous drinkers'.

Table 1: Participant characteristics

	Total sample ('at risk' group) n=26	**'FINDRISC group'* (a subset of 'at risk' group) n=10**
Age (years) Mean (SD)	41.4 (13.2)	49.9 (9.9)
Ethnicity, n (%)		
NZE	11 (42.3)	4 (40)
Chinese	4 (15.4)	1 (10)
Maori	3 (11.5)	1 (10)
Indian	3 (11.5)	1 (10)
Others	5 (19.3)	3 (30)
Weight (kg) Mean (SD)	71.4 (17.5)	81.0 (23.0)
Height (cm) Mean (SD)	164.5 (6.2)	162.9 (3.5)
BMI (kg/m2) Mean (SD)	26.39 (6.4)	30.43 (8.41)
Body fat (%) Mean (SD)	M: 17.64 (3.55) F: 27.40 (5.18)	M: 23.64 (0) F: 30.71 (4.16)
W/H ratio Mean (SD)	M: 0.9 (0.07) F: 0.84 (0.05)	M: 0.99 (0.01) F: 0.86 (0.04)

Note: BMI, body mass index; F, female; M, male; n, number of participants; NZE, New Zealand European; Others, Canadian, Irish, Welsh; SD, standard deviation; W/H, waist to hip ratio.

*Indicates ≥ 12 score on FINDRISC tool

Descriptive measures of PA levels, psychosocial factors and other variables are presented in Table 2. Fifty percent of participants were in the maintenance stage of exercise change. Based on the IPAQ classification, 54% of the participants were included in the "low" activity category, however, for the NZPAG classification, 23% of participants were classified as "non-active". Based on average daily step count, 31% of participants were classified as "low active". (Table 2).

Table 2: Descriptive indices of physical activity levels and psychosocial factors

	Categories	Total sample ('at risk' group) n=26	'FINDRISC group'* (a subset of 'at risk' group) n=11
Average six-minute walk distance (m)	NA	550	522
Physical activity levels NZPAG classification n (%)	Active	20 (76.9)	8 (80)
	Non-Active	6 (23.1)	2 (20)
IPAQ classification n (%)	Low	14 (53.8)	7 (70)
	Moderate	9 (34.6)	2 (20)
	High	3 (11.5)	1 (10)
Average 7-day step count n (%)	Sedentary	1 (3.8)	0
	Low active	8 (30.8)	4 (40)
	Somewhat Active	7 (26.9)	4 (40)
	Active	3 (11.5)	1 (10)
	Highly Active	6 (23.1)	1 (10)
Stages of change n (%)	Maintenance	13 (50)	5 (50)
	Action	2 (7.7)	0 (0)
	Preparation	5 (19.2)	2 (20)
	Contemplation	5 (19.2)	3 (30)
	Pre-contemplation	1 (3.8)	0 (0)
ESE, mean (SD)	NA	3.4 (0.9)	3.7 (0.9)
AAQ-II, mean (SD)	NA	48 (6)	47 (5)
HRQoL, mean (SD)	PCS	51 (12)	51 (6)
	MCS	49 (9)	49 (10)

Notes: AAQ-II, Acceptance and Action Questionnaire II, a measure of psychological flexibility; ESE, exercise self-efficacy; HRQoL, Health Related Quality of Life (SF-36V2); IPAQ, International Physical Activity Questionnaire; MCS, mental component score, NA, not applicable; NZPAG, New Zealand Physical Activity Guidelines; PCS, physical component score.

* Indicates ≥12 score on FINDRISC tool.

The mean scores for ESE, PF (AAQ-II), PCS, and MCS were 3.4, 48, 51 and 49, respectively (Table 2). ESE scores were independently associated only with vigorous minutes (R^2= 0.17; p=0.04) and MET minutes/week (R^2= 0.08; p=0.16), but not with moderate minutes and step counts (p>0.20) (Table 3). MCS demonstrated a significant moderate positive correlation (r=0.41; p=0.04) with total MET minutes/week and explained a 17% of total variance (R^2= 0.17; p=0.04) of total MET minutes/week. Also, MCS demonstrated a significant moderate positive correlation (r=0.45; p=0.03) with vigorous minutes/week and explained 20% of total variance (R^2= 0.20; p=0.03) of vigorous minutes/week. However, PCS scores were not associated with PA measures (MET minutes/week, total moderate and vigorous minutes), whereas PCS scores demonstrated a small magnitude of association with step counts (R^2= 0.10; p=0.13). None of the PA measures (subjective or objective) were associated with PF (AAQ-II scores).

Table 3: Relationships between physical activity levels and psychosocial factors

Variables	Average 7-day step counts		MET (min/week)		TVIG (min)		TMOD (min)	
	Bivariate regression	Correlation	Bivariate regression	Correlation	Bivariate regression	Correlation	Bivariate regression	Correlation
	B (95%CI)	R^2 (R)	B (95%CI)	R^2 (R)	B (95%CI)	R^2 (R)	B (95%CI)	R^2 (R)
ESE	992 (-822, 2806) p=0.27	0.05 (0.23) p=0.27	375 (-158, 908) p=0.16*	0.08 (0.28) p=0.16*	39 (2, 76) p=0.04*	0.17 (0.41) p=0.04*	-7 (-91, 78) p=0.87	0.00 (0.03) p=0.87
AAQ-II	160 (-131, 452) p=0.27	0.05 (0.23) p=0.27	15.7 (-69, 100) p=0.70	0.01 (0.08) p=0.70	-0.3 (-7, 6) p=0.92	0.00 (-0.02) p=0.92	4 (-9, 16) p=0.57	0.01 (0.12) p=0.57
PCS	103 (-31, 236) p=0.13*	0.10 (0.32) p=0.13*	18 (-26, 61) p=0.41	0.03 (0.17) p=0.41	1 (-2, 4) p=0.45	0.02 (0.16) p=0.45	1 (-6, 7) p=0.80	0.00 (0.05) p=0.81
MCS	69 (-118, 255) p=0.46	0.03 (0.16) p=0.46	56 (2, 109) p=0.04*	0.17 (0.41) p=0.04*	1 (-3, 6) p=0.51	0.02 (0.14) p=0.51	9 (1, 17) p=0.03*	0.20 (0.45) p=0.03*

Notes: AAQ-II-Acceptance and Action Questionnaire-II; BMI, body mass index; ESE, exercise self-efficacy; MCS, mental component score; MET, metabolic equivalents; NA, not applicable; PCS, physical component score; R, Pearson's correlation coefficient; TMOD, time spent on moderate activities; TVIG, time spent in vigorous exercise.

*p value < 0.05 level; Bivariate regression analysis: * p≤0.20

DISCUSSION

This feasibility study is one of the first in the New Zealand health literature to provide subjective and objective PA levels and measures of psychological attributes in a small sample of individuals at risk of developing DM, recruited from the community. We have demonstrated that it is feasible to identify and recruit adults (n=26) at risk of DM using a risk screening tool (administered by telephone) and to collect objective physical activity data within a relatively short period of time (5 weeks).

The results of this feasibility study demonstrate that the majority of participants (50-70%) were classified as "low active" based on the IPAQ guidelines, whereas based on the NZPAG, a smaller proportion of participants (~20%) were classified as "non-active". However, based on average daily step count, the majority of participants in both groups (30-40%) were classified as either "low active" or "somewhat active". Psychological flexibility (AAQ-II scores) was not associated with either subjective or objective measures of PA. In contrast, ESE and MCS scores were positively associated with vigorous PA minutes/week and moderate PA minutes/week, respectively.

Variations in PA levels were observed depending on the type of tool/classification scheme used for determining PA levels. The NZPAG are derived from the World Health Organisation (2010) Global Recommendations on PA for health, which includes a minimum PA target for health enhancement and prevention of non-communicable diseases. The step count incorporates all running or walking activity performed by individuals throughout the day with 10,000 steps a day associated with indicators of good health. The step count goal of 10,000 is based upon the theory that those walking 30 minutes a day achieve at least 10,000 steps. Therefore, in the context of these results, it appears our participants may have over-estimated the amount of PA they performed on a daily basis when completing the NZPAQ (Maddison et al 2007). Furthermore, many of the participants did not meet the required PA levels to reduce their risk of developing DM. However, step counting has its limitations as it only measures PA performed by walking or running and cannot account for other PA that may be measured by the NZPAQ and therefore counted towards meeting the NZPAG. Through this feasibility study, limitations of using the self-report PA tools and pedometers were identified, which in turn indicates the need for using robust PA monitoring tools (e.g. accelerometers) in future research.

In this study, average ESE scores are higher when compared to a similar New Zealand age group cohort (Mansi et al 2015). It should be noted, however, that the referenced cohort, unlike those in our study, was derived from a rural community as a part of a pedometer-driven walking programme (Mansi et al 2015). Substantial literature supports that higher self-efficacy beliefs are associated with positive health behaviours including initiation and adherence to exercise (Delahanty et al 2006, Kosma et al 2004, McAuley 1993). Interestingly, this study demonstrates that an individual with higher ESE will engage in higher duration of vigorous physical activity. However, there was no association between moderate amounts of PA and step counts. The results of the current study are in contrast with recent research on individuals with type-2 DM in which a positive association

between moderate PA and step counts was identified (Heiss and Petosa 2016). These conflicting findings suggest that the ESE construct may not be sufficient to explain moderate PA levels in individuals at diabetic risk. Additionally, ESE may not be a mediating factor for interventions which target improving individuals' participation in moderate levels of PA. Future studies can use various components of self-efficacy dimensions (task, scheduling and coping ESE) (Rodgers et al 2008) in order to investigate the association between subjects' self-efficacy and their participation in moderate and/or vigorous PA levels.

In contrast to ESE scores, mental HRQoL is a strong determinant of moderate PA levels, but not of vigorous PA levels, suggesting that those individuals with higher mental health scores will engage in moderate PA, but not necessarily in vigorous PA (Aoyagi et al 2010, Balboa-Castillo et al 2011, Mota et al 2005). The participants' physical and mental health scores (both in total sample and the sub-sample) in this study are within the normal range of New Zealand's population means (Scott et al 1999). Previous studies have shown that HRQoL is not associated with adults who have achieved or surpassed their minimum standards of daily PA in terms of step counts (Aoyagi et al 2010, Yasunaga et al 2006). However, in this same cohort, self-perceived mental health was not associated with walking levels or participation in vigorous PA. Other studies investigating mental health and PA levels of a diabetic population (Eckert 2012) have similar findings. This study identified positive mental health as a key factor that may motivate individuals at risk of developing DM to engage in moderate levels of PA. However, in order to confirm this finding, longitudinal study designs are needed to test this hypothesis on individuals who are pre-diabetic.

A recent meta-analysis (Kan et al 2013) concluded that a small but significant cross-sectional association exists between depression and insulin resistance (pre-diabetic state). However, this study did not attempt to screen for clinical depression and other mental health issues. Considering participants' scores were within the normal scores of mental health (based on HRQoL), and a positive association between mental health scores and PA levels, one can infer that participants may not have been clinically depressed at the time of study participation. However, this claim may not be valid, since this study did not account for potential intake of anti-depressants by the study participants.

Levels of PF in this study are much lower (mean (SD): 48 (6)) than previous studies where average scores ranged from 55-59 in both physically active and inactive adults (Kangasniemi et al 2014, Mutikainen et al 2015). Such scores may be associated with the low levels of activity observed among majority of participants. Indeed, a previous study demonstrated that physically active adults demonstrated better mindfulness skills (a component of PF) in comparison to less physically active adults (Kangasniemi et al 2014). Contrary to some literature (Kangasniemi et al 2014, Kangasniemi et al 2015), we observed a non-significant association between PF and PA measures, indicating that individuals with or without greater PF engage in similar levels of PA. In support of our findings, a recent study (Mutikainen et al 2015) also reported no association between PF and PA levels, suggesting that future research should use an exercise-specific AAQ version in place of the generic AAQ-II questionnaire (Forman et al 2009).

Strengths and future research recommendations

This is the first study which measured both subjective (NZPAQ-LF) and objective (step counts) measures of PA in a New Zealand population who were at risk of developing DM. In this study, we attempted to account for any activity performed without the pedometer being on, or activities such as cycling and swimming which are not measured by the pedometer, by having participants log such extra activities. A total of six participants across the study recorded activity they performed not measured by the pedometer. This may substantiate that few participants actually performed purposeful PA outside of walking and strengthens our results that based on pedometer activity, PA levels are low within this population. This feasibility study has identified personal factors, particularly mental health, to influence PA levels in a small sample of individuals with DM risk. Preliminary evidence for such associations of generic mental health with PA levels indicates the need for identifying the potential influence of other mental health disorders (e.g. depression) on PA levels. In addition, this study indicates the need for identifying factors associated with sedentariness, a key risk factor for all-cause mortality, cardiovascular disease, and type 2 DM (Bjork Petersen et al 2014, Wilmot et al 2012). Exploring a range of factors (personal, social and environmental, policy) of sedentary behaviour in individuals with disease risk (e.g. pre-diabetes) can be helpful to plan specific interventions targeting to modify such factors influencing their PA profiles and sedentary behaviour.

Study limitations

Limitations of this study include a small sample size, the use of pedometers to measure PA levels, the absence of a control group and not accounting for prescription medications for the treatment of depression. Considering this is a feasibility study, a multiple linear regression analysis was not attempted, thus limiting the generalisability of these findings. Since this study used an unadjusted R-square to explain the potential relationships, caution is warranted in interpreting the magnitude of variance that was explained between the variables of interest. Another key limitation of our study was that the online public health screening tool (Diabetes New Zealand, Auckland branch) used to screen participants has not yet been validated. Despite this limitation, due to its feasibility, ease of use, and specificity to New Zealand's population, it served as an appropriate tool for this study. This online tool allows health professionals to easily assess patients for diabetes risk, which facilitates early risk factor screening, and planning life-style based interventions and appropriate referral for confirmative lab-based investigations. However, further research is needed to develop a validated diabetes risk screening tool for New Zealand's multi-ethnic population.

CONCLUSION

It is feasible to screen adults (n=26) at risk of DM using an online screening tool. Low levels of PA were observed among the majority of participants who have risk factors for the development of type-2 DM. Preliminary findings on associations between positive mental health and exercise self-efficacy and objective levels of PA clearly indicate the need for assessing psychological factors for effective planning of PA interventions to reduce the risk of chronic disease development. No

association was found between psychological flexibility and measures of PA levels, suggesting that future research should use exercise-specific psychological flexibility measures. However, these observed relationships need to be confirmed in a larger sample of pre-diabetic individuals using prospective longitudinal designs for further generalisability of these findings.

KEY POINTS

1. Screening for diabetes risk using validated questionnaires is feasible in research settings.
2. Low levels of PA were observed among the majority of participants with diabetic risk.
3. Higher ESE beliefs are associated with higher amounts of vigorous PA.
4. Better mental health (HRQoL) is associated with higher amounts of moderate PA.

PERMISSIONS

Ethical approval for this study was granted from The University of Otago Human Research Ethics Committee (Ref.no: D13/396), Dunedin, New Zealand. All participants have provided their written consent to participate in this research.

DISCLOSURES

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Plasticity and motor recovery after stroke: Implications for physiotherapy

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ABSTRACT

Despite advances in prevention and acute management of stroke and a proliferation of motor rehabilitation trials over the last decade, disability rates after stroke remain high. This commentary considers recent evidence, which suggests that it is time to extend our thinking beyond the model of cortical use-dependent plasticity that has underpinned much of physiotherapy stroke rehabilitation for the last 20 years. The discovery of a fixed, proportional recovery of impairment has led to a renewed focus on how rehabilitation may interact with spontaneous biological recovery. There is also increasing interest in use-dependent plasticity in the *white matter* as a possible mechanism for improving motor recovery after stroke. These emerging areas in stroke rehabilitation research have yet to be fully investigated, but provide some promise for future trials. In the interim, becoming familiar with all aspects of neural plasticity after stroke may help to equip physiotherapists with greater understanding of the mechanisms of stroke recovery and enable critical decision-making around the selection and timing of interventions after stroke.

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Key words: Stroke, Plasticity, Rehabilitation, Motor recovery

INTRODUCTION

Stroke is a leading cause of disability, with up to 50% of stroke survivors experiencing ongoing disability and 30% requiring assistance for activities of daily living (Roger et al 2012). Despite advances in the prevention and acute management of stroke, the prevalence of stroke survivors living with disability is increasing worldwide (Feigin et al 2014).

The number of randomised controlled trials (RCTs) in motor rehabilitation after stroke has increased three-fold in the last 10 years (Veerbeek et al 2014). These RCTs have investigated a variety of physiotherapy interventions after stroke, with around half aimed at arm and hand recovery and a third aimed at gait and mobility (Veerbeek et al 2014). The strength of evidence supporting physiotherapy interventions after stroke has increased since a systematic review in 2004 (Van Peppen et al 2004). However positive effect sizes are small (5-15%) and a disappointingly large proportion of studies indicate that the experimental interventions produce equal, rather than better, results when compared with conventional physiotherapy (Veerbeek et al 2014). What is contributing to the small effect sizes in stroke rehabilitation research? Is it a lack of efficacy of the intervention, when the research is conducted during recovery, how the effects of the intervention are measured, or a combination of all of these factors?

One possible explanation is that the research is conducted primarily in the chronic stage after stroke, which means the intervention has no chance to interact with spontaneous biological recovery. Spontaneous biological recovery occurs during the first three months when the brain is in a state of heightened neuroplasticity (Krakauer et al 2012). This is not only the time when most recovery occurs (Jorgensen et al 1995, Kwakkel et al 2006) but also when most rehabilitation takes place. A systematic review by Stinear and colleagues (2013) found only 6% of good quality RCTs in motor rehabilitation enrolled all participants within the first 30 days of stroke. Therefore, the evidence base for therapies aimed at improving voluntary movement during this sub-acute stage is quite small. The mechanisms underlying therapy effects are likely to be quite different at the chronic stage to those during the sub-acute stage (Raghavan et al 2010, Stinear et al 2013). This limits the generalisability of trials conducted in chronic stroke to clinical practice, as most therapy is delivered in the sub-acute stage.

Small effect sizes may also reflect selection of outcome measures that are not sensitive to the proposed mechanisms of the intervention (Jolkkonen and Kwakkel 2016, Veerbeek et al 2014). Clarity about what the intervention is targeting (such as movement quality, speed, the ability to complete a task or return to functional activities) is critical both in choosing a sensitive outcome measure and understanding the biological rationale for the intervention (Bernhardt et al 2016, Buma et al 2013).

Trial design issues aside, the hunt is still on for an intervention that is able to increase stroke recovery above what is currently possible with conventional physiotherapy. New insights into neural plasticity early after stroke may provide some direction.

The purpose of this commentary is two-fold. Firstly, to consider recent developments in the study of spontaneous biological recovery and use-dependent plasticity after stroke, and secondly, to discuss how motor training interacts with recovery mechanisms. We then consider what this means for the practising physiotherapist.

DISTINCTION BETWEEN IMPAIRMENT AND FUNCTION

One challenge in reviewing the literature in stroke rehabilitation is the interchangeable use of terms such as functional recovery, motor recovery, motor impairment and compensation (Levin et al 2009). Defining these terms clearly will reduce confusion. For the purposes of this commentary, motor impairment refers to the ability to perform a *movement* and can be evaluated with measures of strength and motor control. Function refers to the ability to perform a *task* and can be measured as task completion or time taken to complete the task.

True neurological recovery requires resolution of *impairment*, which allows movements and activities to be performed in the *same* way as before the stroke (using the same neural connections and motor patterns). Functional recovery, however, can still occur without full resolution of impairment. Compensation for residual impairment enables the recovery of function by using alternative neural connections and/or different patterns of muscle activity. For example, during a reaching task, the patient may compensate by: accessing different neural connections; altering the timing of muscle activation resulting in an altered movement pattern; using a combination of shoulder abduction and flexion instead of pure flexion; using an alternate grip; and/or they may lean forward with the trunk. These compensations allow the patient to achieve a functional reach, despite their residual impairment.

Improvement in function can occur without any change in impairment, and recovery of impairment does not always lead to functional improvement (Buma et al 2013, Kitago et al 2013, Kwakkel et al 2015). As the use of task-specific training has become established in stroke rehabilitation (Winstein and Kay 2015), most motor outcome measures assess functional recovery. These measures assess whether a task is completed or not, or how fast it is completed, rather than how *well* it is completed. They are unable to distinguish between an improvement in function due to a reduction in impairment, or an improvement in function due to compensation (Kitago and Krakauer 2013). Yet, this distinction is critical in understanding the biological mechanisms of recovery and therefore in understanding the role of physiotherapy in this process (Zeiler and Krakauer 2013).

SPONTANEOUS BIOLOGICAL RECOVERY AND PROPORTIONAL RESOLUTION OF IMPAIRMENT

Spontaneous biological recovery is motor recovery that occurs in the absence of motor training after ischaemic injury to the brain (Cramer 2008, Nudo 2011, Zeiler and Krakauer 2013) and has been reported in both animals and humans after stroke (Carmichael 2010, Krakauer et al 2012, Nudo 2011). Ischaemia in the peri-infarct area triggers a cascade of effects (Xing et al 2012) ultimately resulting in upregulation of genes responsible for neuronal growth (heightened neuroplasticity), increases in long term potentiation (enabling strengthening of synapses and improved neurotransmission), alterations in excitation and inhibition via neurotransmitters in the lesioned cortex and axonal sprouting around the infarct site (Brown et al 2007, Carmichael 2006, Hagemann et al 1998, Zeiler and Krakauer 2013). This period of heightened sensitivity in the brain begins within hours of stroke onset and lasts up to one month in animals and around three months in humans, although the time frame may vary with individuals or stroke severity (Carmichael 2006, Cramer 2008, Krakauer et al 2012). Rapid improvements occur in both impairment and function during this sensitive period.

The importance of spontaneous biological recovery in the resolution of *impairment* after stroke has been established by the discovery of the Proportional Recovery Rule. Prabhakaran et al (2008) investigated the resolution of impairment in the upper limb using the Fugl-Meyer scale (FM) in 41 patients with stroke. The FM scale is used to measure strength and motor control in the affected limb (Fugl-Meyer 1980). Patients were assessed within 72 hours of stroke and again three and six months after stroke. The degree of initial impairment was defined as the maximum FM score possible minus the baseline FM score. For example, if a patient scores 26 / 66 on baseline FM, their initial impairment is 66 – 26 = 40 points. Prabhakaran et al (2008) discovered that by three months after stroke, patients reduced their impairment by an almost fixed amount of 70%. In other words, patients recovered 70% of the movement (at an impairment level) that they lost due to the stroke. Using the example above, this means that although the maximum improvement available was 40, the actual increase in FM score was only 0.7 x 40 = 28, making the final FM score 26 + 28 = 54.

This phenomenon of proportional resolution of impairment in the upper limb after stroke has since been replicated in several other studies (Byblow et al 2015, Feng et al 2015, Marshall et al 2009, Winters et al 2015, Zarahn et al 2011). A study by Lazar et al (2010) examined resolution of impairment in aphasia after stroke and reported that it also follows proportional recovery between baseline and 90 days. This finding supports the theory that proportional recovery may be generalisable across other functional domains (Winters et al 2015). The proportional resolution of impairment is consistent across patient samples from four different countries, with different rehabilitation services and for patients of both genders, all ages and ethnicities. This indicates that it is likely to reflect a fundamental spontaneous biological recovery mechanism, about which we currently know very little (Byblow et al 2015, Krakauer and Marshall 2015, Prabhakaran et al 2008).

Another interesting finding is the lack of influence of physiotherapy and occupational therapy on proportional resolution of impairment. Byblow et al (2015) measured impairment using the FM at 2, 6, 12 and 26 weeks after stroke in 93 patients. Patients were separated into: 1) a standardised therapy cohort who received 30 minutes of upper limb therapy five days a week for four weeks in addition to standard care, and 2) a variable therapy cohort who received standard care with therapy dose determined by the treating therapist based on clinical judgement (ranging from 0 to 803 minutes of total upper limb therapy time). Participants with functionally intact corticospinal tracts (CST) followed the proportional recovery rule regardless of their initial impairment, the group they were in or their therapy dose, indicating that therapy did not have an influence on resolution of impairment (Byblow et al 2015, Krakauer and Marshall 2015). These results indicate that current physiotherapy practice has not yet found a way to enhance spontaneous biological recovery (resolution of impairment) early after stroke.

Some patients with severe initial impairment exhibit proportional recovery, while others do not and recover by less than 70%, or not at all. Unfortunately, there is no clinical assessment that can identify which patients will follow the 70% rule and which ones will not. A recent study showed that a functional CST is required to achieve proportional resolution of impairment. Patients whose CST is no longer able to transmit descending motor commands do not exhibit proportional resolution of impairment (Byblow et al 2015), and these patients also achieve a poor functional recovery of the upper limb (Stinear 2010, Stinear et al 2012). These findings demonstrate that without a viable connection between the brain and the muscles, any neuroplastic reorganisation occurring in the cortex, whether due to spontaneous biological processes or use-dependent plasticity, is largely redundant.

It is not clear why proportional resolution of impairment sits at 70%, and not some other number. This threshold may reflect inefficient and incomplete re-myelination of damaged axons in the descending motor pathways (Byblow et al 2015, El Waly et al 2014). This possibility, and other potential mechanisms, remain to be explored.

To date, there have been no published studies investigating proportional recovery in the lower limb. For the lower limb, there are more projections to the corticospinal pathway from the contralesional (unaffected) cortex than for the upper limb (Dawes et al 2008, Jang et al 2005). There are also several alternative pathways involved in generating movement in the legs and trunk such as the vestibulospinal and reticulospinal tracts which receive bilateral inputs (Jang et al 2013, Matsuyama and Drew 2000, Nathan et al 1996). This means the damage from the stroke may be compensated for by other existing motor pathways and descending control from the contralesional cortex. For these reasons, it is possible that if proportional recovery of the lower limb does occur, it may differ from the upper limb.

The proportional recovery rule enables clinicians and researchers alike, for the first time, to quantify spontaneous biological recovery after stroke in humans. While using functional outcome measures remains an essential part of research into interventions aimed at improving function, the inclusion of impairment-based measures may assist in understanding the neurobiological mechanisms underpinning the recovery process, ultimately targeting future therapies more effectively.

To summarise these findings, return of movement at an *impairment* level after stroke is a spontaneous process controlled by biological mechanisms, which occurs in the first three months after stroke and is not influenced by current therapy practices. This does not mean that rehabilitation early after stroke is ineffective but rather that it promotes neurological compensation (such as cortical reorganisation) in order to improve function rather than restoring damaged neural networks.

USE-DEPENDENT PLASTICITY

Neuroplasticity can be defined as "the ability of the nervous system to respond to intrinsic or extrinsic stimuli by reorganising its structure, function and connections" (Cramer et al 2011).

The discovery that the brain has the capacity to change in response to both experience and injury transformed our understanding of mechanisms underlying training effects and learning both in the healthy and injured brain (Nudo 2006, Winstein and Kay 2015).

Use-dependent or experience-dependent plasticity was originally discovered in animal models. Motor training was found to increase synaptic efficacy and long term potentiation (strengthening of synapses), and induce synaptogenesis, axonal sprouting and formation of dendritic spines (Brown et al 2009, Carmichael 2006, Jones et al 1999, Krakauer et al 2012). These cellular effects are accompanied by enlargement of the cortical motor map specific to the limb involved in the training (Nudo 2006, Nudo et al 1996a).

The concept of plasticity has driven our rationale for rehabilitation, however there are some challenges inherent in applying research in animal models to stroke recovery in humans. Firstly, the rodent brain is structurally quite different from the human brain with much less white matter relative to grey matter (Wang et al 2016). Secondly, in animals, a stroke is artificially induced in a specific and localised area (usually the motor cortex). This creates a pure cortical infarct which spares adjacent cortical areas and white matter pathways (Wang et al 2016). In contrast, in humans, the majority of stroke damage is likely to be in *subcortical* regions (Bogousslavsky et al 1988, Corbetta et al 2015, Kang et al 2003, Wessels et al 2006), with damage not only to grey matter but also to ascending and descending white matter tracts and white matter connections between cortical and subcortical structures (Corbetta et al 2015, Wang et al 2016). This results in a disruption in the brain's ability to transmit a message not only via descending pathways to the muscles, but also between cortical regions.

In other words, our understanding of neuroplasticity comes from examining pure cortical infarcts in animals with great capacity for reorganisation within surrounding grey matter, and is being applied to stroke in humans, which is predominantly a white matter disconnection problem (Corbetta et al 2015).

The distinction between pure cortical damage and subcortical damage is important when considering the effects of stroke and how neuroplasticity shapes stroke recovery. Stinear and colleagues (2012) reported that recovery of upper limb function after stroke requires a functional CST. No amount of training-induced cortical plasticity will enable motor function to improve if the white matter motor pathways are irreparably damaged, as there is very little capacity within the human motor system to use alternative pathways (Krakauer and Marshall 2015).

Synaptic (grey matter) plasticity

Synaptic plasticity occurs in the cortical grey matter through mechanisms such as synaptogenesis, increased synaptic efficacy and altered neurotransmitter levels. Animal research forms the basis of our understanding of synaptic plasticity in the human brain, and provides some fundamental concepts of motor learning and plasticity such as the importance of therapy intensity (MacLellan et al 2011), time-sensitivity (Biernaskie et al 2004, Biernaskie and Corbett 2001, Carmichael 2006) and the effect of environmental enrichment (Biernaskie and Corbett 2001, Johansson and Ohlsson 1996, Krakauer et al 2012).

Synaptic plasticity is sensitive to many inputs from other regions of the cortex (Murphy and Corbett 2009), which is why reward, motivation, attention, the environment, task variation and challenge are important (Biernaskie and Corbett 2001, Winstein and Kay 2015, Wulf et al 2012). A study in squirrel monkeys compared the effects of simple task repetition (practice) with learning a new task and reported that changes in cortical motor map representation only occurred after training on the new task, not with simple high repetition practice (Plautz et al 2000). This means that synaptic plasticity occurs with motor *learning* not with repetitive practice alone (Remple et al 2001).

Further research in motor learning in both healthy adults and adults with stroke has highlighted three main principles for motor learning. In order for learning to occur, the motor training must be challenging (both in intensity and difficulty), it must be progressive and adapted over the practice period (variability and novelty are important), and the patient must be motivated (the task must be meaningful). These principles have led to the development of task-oriented training as the recommended rehabilitation focus for motor skill learning after stroke (Cramer et al 2011, Winstein and Kay 2015).

Synaptic plasticity drives functional recovery after stroke, and large gains may be made early after stroke, often in the face of residual impairment. This is achieved through the use of neurological compensation (cortical reorganisation and increasing efficiency of surrounding synapses) (Buma et al 2013, Kitago and Krakauer 2013, Moon et al 2009, Whishaw et al 2008). There are two important points to remember when embarking on a rehabilitation programme aimed at improving synaptic plasticity. Firstly, time frame is critical. Once outside the sensitive period of the first three months after stroke, the capacity for neuroplasticity in the stroke brain returns to that of the non-injured brain (Biernaskie et al 2004, Carmichael 2006, Krakauer et al 2012). Harnessing the heightened plasticity in the first three months is essential.

Secondly, although functional recovery occurs largely through synaptic plasticity, it is still reliant on intact white matter (Borich et al 2014, Corbetta et al 2015, Jang et al 2010). Irreparably damaged motor tracts prevent the message from being sent to the muscles. For the upper limb, it is possible to identify which patients have sustained severe damage to the white matter pathways and which patients have spared white matter pathways using a combination of clinical assessments, transcranial magnetic stimulation and magnetic resonance imaging (Stinear et al 2012). Unfortunately, this type of prediction algorithm has not yet been established in the lower limb.

White matter plasticity

White matter plasticity occurs in the white matter tracts through mechanisms which promote structural changes such as remyelination of axons and axonal sprouting (Brown et al 2007, Clarkson et al 2013, Fields 2005, McIver et al 2010, Wang et al 2016, Zheng and Schlaug 2015). These changes may contribute to recovery of transmission in the motor pathways. White matter plasticity may contribute to spontaneous biological recovery (Carmichael 2006, Dancause et al 2005, Zeiler and Krakauer 2013) and research in animal models has shown that it is also use-dependent (Clarkson et al 2013, Fang et al 2010, Sanchez et al 1998). Increased axonal firing in response to activity stimulates the proliferation of oligodendrocytes which are responsible for remyelination of the axons and may also provide the stimulus for axonal sprouting, and synaptogenesis (Carmichael and Chesselet 2002, Juraska and Kopcik 1988, McIver et al 2010, Simon et al 2011).

We do not know yet how to promote white matter plasticity after stroke, but the hypothesis is that there is a training response that is dose-dependent (Bengtsson et al 2005, Fields 2005, Kwon et al 2012, Nudo 2011). Exactly how many repetitions are required to generate a change in white matter has not been investigated in humans, but it is expected to be very high (Krakauer et al 2012). One study in humans has attempted to look at the effects of training on white matter (Scholz et al 2009). Twenty-four healthy adults underwent a six-week training programme for a juggling task. The authors concluded that training improved the structural organisation of the axonal bundles, possibly due to increased myelination and/or axon calibre. They hypothesised that this may lead to increased conduction velocity and better synchronisation of descending motor commands (Scholz et al 2009). This preliminary work in healthy adults provides some direction for future research into promoting white matter plasticity in humans. Other potential avenues for investigating white matter plasticity interventions after stroke are pharmacological interventions such as medications that interact with myelin formation, neurophysiological interventions, such as non-invasive brain stimulation, or robotics to support high-repetition practice.

MOTOR TRAINING AND USE-DEPENDENT PLASTICITY

Motor training makes up the bulk of physiotherapy rehabilitation after stroke and aims to improve function through skill learning and adaptation. The highly neuroplastic state that exists in the first months after stroke means that the brain is primed for growth and change. However this plasticity is not targeted, but occurs indiscriminately throughout the cortex (Zeiler and Krakauer 2013). This means the plasticity can be either adaptive, leading to an improvement in function (Cohen et al 1997, Dancause and Nudo 2011), or maladaptive, leading to loss of function or other negative consequences such as seizures or pain disorders (Karl et al 2001, Nudo 2006, Prince et al 2009).

Examples of maladaptive motor plasticity after stroke are the development of compensatory movement patterns out of proportion to the level of impairment and cortical reorganisation due to learned non-use (Krakauer 2006, Sunderland and Tuke 2005, Whishaw et al 2008, Winstein and Kay 2015, Wolf et al 2006). Motor training may facilitate adaptation and prevent maladaptation by directing and shaping the cortical reorganisation as it occurs (Carmichael 2010, Huang et al 2008, Kitago and Krakauer 2013, Nudo et al 1996b). A useful analogy for this is to imagine a tree planted in exceptionally fertile ground. Rapid growth occurs randomly in all directions and requires pruning to shape and increase the efficiency of the growth, analogous to the role of the physiotherapist in rehabilitation after stroke.

One reason that task specific functional training may primarily promote compensatory reorganisation is that there is usually an incentive and a requirement for the task to be completed immediately. This means that the brain may choose to bypass the damaged networks in favour of compensation in order to achieve the goal. This form of reinforcement learning may lead to preferential selection of these alternative motor strategies in the future and establishing a new motor pattern to complete the task (Huang et al 2011, Kitago and Krakauer 2013).

There have been suggestions that early motor training should only include very high intensity impairment training in the absence of functional training, in order to reduce early compensation and to promote attempts to access the damaged neural pathways (Krakauer et al 2012). However, this approach is highly impractical in a setting where health resources are limited and patients are intent on getting home as soon as possible. Returning *some* focus to impairment training and increasing focus on quality of movement rather than task completion may start to lead us in the right direction.

Gains in function produced by motor training carried out six months or more after stroke are almost certainly due to compensatory mechanisms, and for this reason, improvements will be relatively small (Lefebvre et al 2015, Raghavan et al 2010, Zeiler and Krakauer 2013). By this time, the impairment resolution process is complete. Training in the chronic stage teaches the patient how to use the movement that they already have in a more effective way (Kwakkel et al 2015). There is evidence that improving function occurs in the absence of further impairment resolution, however, the effects of the residual impairment do contribute to the poor quality and increased energy expenditure of the movement (Massie et al 2009, Page et al 2008).

A small study recently investigated the neurological basis for constraint-induced movement therapy (CIMT) in patients with chronic stroke (Kitago et al 2013). They demonstrated that a two-week programme of CIMT improved functional use of the arm as assessed with the action research arm test (ARAT). However, joint kinematic data and upper limb motor impairment (FM) showed no improvement after CIMT (Kitago et al 2013). In other words, CIMT did not improve their movement patterns or underlying impairment. This is an example of using an impairment assessment alongside a functional one to establish that functional improvements were a result of neurological compensation rather than restoring damaged networks.

WHAT DOES THIS MEAN FOR PHYSIOTHERAPY AFTER STROKE?

Spontaneous biological recovery and use-dependent plasticity are powerful drivers towards recovery early after stroke. Understanding the difference between neurological recovery in the first 12 weeks after stroke and in the chronic stage will help direct the physiotherapist in decision making about a particular treatment modality in both stages of stroke recovery.

The discovery of proportional resolution of impairment, for the first time, provides insight into the ceiling effect on stroke recovery we so often see in our patients. This research necessitates a shift in thinking away from the classic neuroplasticity model which has long suggested that the brain has unlimited capacity to keep remodelling and changing with skill learning throughout adulthood. Although the capacity of the cortex to undergo synaptic plasticity after stroke is the same as in a healthy adult, damage to white matter structures places some definite limitations on the beneficial effects of this reorganisation. Quite simply, if there is no way to communicate between the brain and the body, there is no capacity for motor recovery no matter how much cortical reorganisation occurs. Fortunately, in most patients with stroke, damage to the white matter connections is not complete, providing a substrate for communication between the reorganised cortex and body.

There is an abundance of research attempting to improve stroke outcomes through variations on current therapy (all based on task-dependent training to promote synaptic plasticity), yet results are unimpressive. An important new question for the field is how can we improve the resolution of impairment? Can we find an intervention that raises the ceiling above 70%? It is time to try to find a way to work with and enhance spontaneous biological recovery. This may be an opportunity for physiotherapists to align themselves closely with neuroscience researchers in order to find an answer that is applicable in a clinical setting.

In the interim, the role of physiotherapy after stroke has not changed. It is still to teach patients how to move in the most efficient way possible and to live their lives to the best of their ability with the impairments that they have. Our new understanding that the neural mechanisms underlying functional recovery are largely compensatory provides a stronger rationale for a treatment approach focused on retraining movement patterns that minimise unnecessary compensation.

And finally, the analogy of a kayak in a white water rapid may be useful to describe the recovery journey after stroke. Imagine the stroke survivor in the kayak. The force of the river is the powerful drive that the brain has towards recovery after stroke. The patient can either choose to let the flow of the river dictate their recovery or they can take up the paddle and move forward more quickly with some control of their direction. Ultimately, the river widens, the flow lessens, and the person ends up in a calm lake as the spontaneous recovery period finishes. At this point, every move forward is unassisted by flow, and relies solely on the efforts of the paddler. Progress is slow and much more difficult. Our role as physiotherapists is to teach the patients how to use the paddle to shape the direction and speed the trajectory of their recovery, so that when they reach the "lake" they are able to continue making their own gains over time.

KEY POINTS

1. Spontaneous biological recovery of the upper limb results in fixed proportional resolution of impairment.
2. Task specific motor training promotes use-dependent plasticity through neurological compensation rather than restoring damaged neural networks.
3. Both spontaneous biological recovery and use-dependent plasticity rely on a functioning corticospinal tract to relay the message from the brain to the body.

4. As impairment does not continue to resolve at the chronic stage, the time post stroke is an important clinical consideration when delivering upper limb therapy after stroke.

DISCLOSURES

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Whiplash injury or concussion? A possible biomechanical explanation for concussion syndromes in some individuals following a rear-end collision.

Elkin BS, Elliott JM, Siegmund GP (2016) Whiplash injury or concussion? A possible biomechanical explanation for concussion syndromes in some individuals following a rear-end collision. Journal of Orthopaedic & Sports Physical Therapy 46(10): 874-885. doi: 10.2519/jospt.2016.7049

BACKGROUND

Whiplash-associated disorder and concussion are clinical presentations that share a number of common traits. Both of these diagnoses are typically based upon a history of trauma to the neck or the head, in association with presenting signs and symptoms. These conditions can plausibly occur concurrently, creating a diagnostic challenge for clinicians.

OBJECTIVE

To quantify the brain strains that may occur during rear-end motor vehicle collisions (MVCs) as compared to brain strains resulting from potentially concussive American football helmet blows, including variation with differing head kinematic parameters.

METHODS

Kinematic data from two experiments; one examining the biomechanics of head restraint impacts following rear-end MVCs, and the other examining kinematics of American football helmet rear blows, were entered into a finite element model of the human brain. This model calculated the magnitude of resulting theoretical brain strains for both kinematic conditions, including variations in parameters such as impact speed, head restraint position for rear-end MVCs and neck position for American football helmet blows.

RESULTS

Modelling indicated that magnitude of brain strain increased linearly with angular velocity change of the head for both the rear-end MVC and American football helmet rear blow conditions. Brain strains were higher in the cerebrum than the cerebellum and brain stem, and conditions with the head restraint in a lowered position led to higher brain strains than conditions with the head restraint in the raised position. Brain strains from rear-end MVCs were typically less than the low speed American football helmet rear blows (5.5 m/s); however one rear-end MVC trial with a lowered head restraint resulted in a brain strain magnitude similar to high speed (9.3 m/s) American football helmet rear blows, an impact that has previously been linked with concussion.

CONCLUSION

These findings indicate that head kinematics in a rear-end MVC have potential to generate brain strains associated with concussion. The position of the head restraint appears to be a significant factor in injury biomechanics. Clinicians managing individuals following a whiplash injury from a rear-end MVC should be mindful of concussion as a potential concurrent diagnosis.

COMMENTARY

This study presents novel data that model a relationship between head and neck kinematic factors and brain strain in rear-end MVCs, a mechanism of injury that can be associated with whiplash, and American football helmet rear blows, a mechanism of injury linked with concussion. Kinematic data were entered into a finite element mathematical model of the human brain in order to calculate brain strain, which is an estimate of the mechanical response of brain tissue to observed forces. The authors report that brain strain was employed as an outcome measure, rather than simply using peak kinematic data, as brain strain has previously been linked with neuronal injury.

Findings of this study may be extrapolated to infer a potential biomechanical link between rear-end MVCs and potential for concussion in some collisions. Such an insight is valuable for physiotherapists, medical practitioners and other healthcare professionals who assess and treat individuals following a whiplash injury, as it highlights the need to consider concussion in clinical assessment and decision-making after a rear-end MVC.

Results also suggest that position of the head restraint may be of significance in the biomechanics of a rear-end MVC, as a lowered head restraint position was associated with higher levels of brain strain, and in turn, a theoretical increased risk of concussion. This finding has direct clinical utility, as it suggests that asking about the position of the head restraint in the subjective examination of a patient following a rear-end MVC may provide important insight when assessing an individual's risk of having sustained a concussion.

It should be noted, however, that these results do not suggest that every whiplash injury is accompanied by concussion, as just a small portion of the MVC trials generated brain strains comparable to the helmet blows. Rather these findings serve to remind clinicians to utilise their clinical reasoning skills, apply a broad approach to differential diagnosis, and be wary of whiplash symptoms that can mirror concussion symptoms, such as headaches, neck pain, dizziness or anxiety. Concussion should be assessed, diagnosed and managed by a medical practitioner (Accident Compensation Corporation, 2016; Elkington & Hughes, 2016). As such, if a physiotherapist is suspicious that a patient (whiplash or otherwise) may have sustained a concussion, referral to our medical colleagues is essential for optimal patient management.

The primary limitation to be considered when interpreting these results is that this study relies on mathematical modelling of head kinematics to make inferences regarding brain strain and, in turn, assumes that this model is a valid and accurate predictor of risk of concussion. Nonetheless, this study provides physiotherapists with biomechanical evidence that may be translated to a clinical setting, suggesting that clinicians should be aware of concussion as a potential co-existing diagnosis for individuals presenting with a whiplash injury following a rear-end MVC.

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The Case of the Missing Body

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"I am stronger than I think. That sounds very strange." In Jenny Powell's 2016 book titled "The case of the missing body", she writes through her character Lily about living with severe proprioceptive deficits. Lily spent her entire life feeling that it was normal to only feel the sensation of her head, like it was floating on a disconnected body. It wasn't until she decided to make a change and reached out to her reliable physiotherapist Patrick that things changed. The next year was full of tears of joy and frustration as Lily began to discover what it's like to feel her own body.

Jenny Powell is a Dunedin based creative writing teacher and her book reads in a journalistic style with an informal timeline and no chapters. This made it difficult to go back and re-read sections, but I believe the style reflected the author's purpose. In the introduction Jenny wrote, "Here is Lily's Story. Her story is my story, but in order to write it I have to step back, and examine it from a distance…" With the addition of some of her poetry, Jenny tells her story in a unique and authentic way.

My initial read of this book left me wanting more. I realised as I was reviewing it that I wanted a conclusion, a win, a recovery. However Lily's story is not finished, her challenges are continuing beyond the pages of the book. It wasn't until I reflected back that I realised all of the positive changes Lily made to her body image, physical fitness, and emotional wellbeing.

This book provides an insightful, first person view on living with proprioceptive deficits. As a physiotherapist it can be easy to get frustrated teaching exercises to patients who lack body awareness. Lily appreciates how her physiotherapist Patrick asked the right questions and was patient, kind, and supportive throughout the process. This book reminds us how important it is to have compassion and treat the whole person, not just a health condition or injury.

I can also see this book being beneficial for people who are living with proprioceptive deficits or any persistent condition that limits their activity. It is written in layman's terms, with only a small number of references. There is minimal literature written from the patient perspective about this condition, and this book could be valuable to give people hope and to motivate them to find their own bodies.

This book isn't meant to teach you about proprioceptive deficits and how to treat them. It is an uplifting example of how as physiotherapists we have an amazing ability to touch people's lives in a positive way. Jenny illustrates how a little patience and kindness can go a long way to improving someone's wellness. By reading this book it also puts you in the shoes of someone with severe proprioception issues, and gets you to awkwardly walk a couple of miles in their shoes.

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