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## Why you should publish with us, the New Zealand Journal of Physiotherapy

Within the current climate of evidence informed practice and exponential growth of health-related journals, our journal is a boutique journal; small but of high quality. Established in 1938, it is one of the oldest physiotherapy journals in the world. The mission of the New Zealand Journal of Physiotherapy is to serve the members of Physiotherapy New Zealand by publishing content that reflects excellence in research and professional issues relevant to the New Zealand and international physiotherapy communities.

Our niche is our focus on that which is uniquely Aotearoa New Zealand, and thus of high relevance to local professional practice, and on publications from new researchers and clinicians. Our Honorary Editorial Committee work hard to support authors who are new to peer reviewed journal writing and publication. Often these publications provide the hypotheses or evidence on which future large trials are based, or introduce innovative ideas into practice. Clinical knowledge is important and should be robustly disseminated to colleagues to enhance patient care and add to evidenced informed physiotherapy practice (Happell, 2012; Murray & Newton, 2008). Case reports, for example, can inform patient-centred and individualised care (Wardle & Roseen, 2014).

To this end, we invite manuscripts from new researchers and from clinicians; your voice is important to the building of local research capacity and capability as well as evidence and knowledge for physiotherapy practice.

The Honorary Editorial Committee would also like to thank the people listed below for their willingness and dedication in reviewing manuscripts submitted to the New Zealand Journal of Physiotherapy in 2017. Reviewers equally work hard to ensure the quality of our journal.

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# A pilot randomised clinical trial comparing the effect of video game dance training with ladder drills on agility of elite volleyball players

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## ABSTRACT

This randomised pilot study compared the effects of a six-week, dance video game training programme with traditional agility ladder drills. Twenty-seven elite volleyball players participated and the Illinois Agility Test was used as the primary outcome measure. Significant improvement was seen in agility scores of the video game dance group with both an intention-to-treat analysis (ITTA), (median [Mdn]=-0.95,  $p=0.028$ ), and per-protocol analysis (Mdn=-1.58,  $p=0.012$ ). The ladder drills group showed no significant change in agility with the ITTA (Mdn=-0.71,  $p=0.062$ ), but improvement was seen with the per-protocol analysis (Mdn=-0.85,  $p=0.028$ ). Between group comparisons showed no significant difference in agility scores for the ITTA ( $p=0.650$ ). However, with the per-protocol analysis, the video game dance training group demonstrated a significantly greater improvement in agility scores (Mdn=-1.58 sec;  $p=0.029$ .) compared with the ladder drills group (Mdn=-0.85 sec.). Changes observed for both analyses exceeded the minimal detectable change for the Illinois Agility Test, indicating that dance video game training may be a useful tool for clinicians wanting to enhance agility. Further research is warranted in this area.

**Roopchand-Martin, S., Chong, R.A., Facey, A., Singh, R., Mansing, A. (2018) A pilot randomised clinical trial comparing the effect of video game dance training with ladder drills on agility of elite volleyball players. *New Zealand Journal of Physiotherapy* 46(1): 6-11. doi:10.15619/NZJP/46.1.01**

Key words: Dancing; exercise; XBOX Kinect; athletic training

## INTRODUCTION

Agility is a complex psychomotor concept which includes both neuromuscular and cognitive components such as stimulus recognition and reaction, or execution of a response (Horička, Hianik, & Šimonek, 2014; Sheppard & Young, 2014). Agility typically involves considerable spatial or temporal uncertainty while initiating whole body movement with multi-directional changes, and rapid acceleration and deceleration (Sheppard & Young, 2014).

Much of the work done in relation to agility training involves programmes designed for speed, agility and quickness, and commonly utilises ladder drills (Parsons & Jones, 1998; Robinson & Owens, 2004; Sheppard & Young, 2014; Yap & Brown, 2000). The primary focus of this type of training is footwork mechanics, speed, and directional change. The movement patterns are relatively closed and stereotyped, which implies that ladder drills in isolation will not necessarily address all components of agility. Other approaches to agility training include functional training in open environments, which can challenge both the

perceptual and decision-making aspects of agility (Bloomfield, Polman, O'Donoghue, & Mcnaughton, 2007; Brughelli, Cronin, Levin, & Chaouachi, 2008; Horička et al 2014; Robinson & Owens, 2004; Serpell, Young, & Ford, 2011). For example, a training programme whereby athletes react to video recordings of rugby players executing specific movements, showed that the perceptual and decision-making aspects of agility were trainable (Serpell, Young, & Ford, 2011).

Dance training, using traditional dance instructors, and incorporating ballet, jazz, modern and character forms has been shown to improve agility in skiers (Alricsson, Harms-Ringdahl, Eriksson, & Werner, 2003; Alricsson & Werner, 2004). Other researchers have shown that dance training may improve balance, a component of agility, and suggested that this improvement may reduce the risk of falling in older adults (Federici, Bellagamba, & Rocchi, 2005).

Another approach to dance training is video gaming. Whilst research has shown the usefulness of active video gaming for

improving physical activity and fitness in children and adults (Biddiss & Irwin, 2010; Peng, Crouse, & Lin, 2012), less is known about its effect on motor control and movement. Studies exploring the impact of six weekly sessions of active video gaming on movement skill, concluded that this type of activity may not contribute significantly to the development of perceived or actual movement skills (Barnett, Ridgers, Reynolds, Hanna, & Salmon, 2015; Johnson, Ridgers, Hulteen, Mellecker, & Barnett, 2016). Barnett et al. (2015) utilised the Nintendo Wii gaming system for conducting their study, whilst Johnson et al. (2016) used the XBOX Kinect. These findings were contrary to that of Vernadakis, Papastergiou, Zetou, and Antgoniou (2015) who found that biweekly training, for eight weeks, using games on the XBOX Kinect resulted in significant improvements in object control skill. Improvements were maintained at one-month post intervention. The variability in findings were probably related to the level of immersion in the game, duration of training, the type of games used, the type of game controllers and the outcome measures.

Pasch, Bianchi-Berthouze, van Dijk, and Nijholt (2009) found that four movement specific parameters influenced level of game immersion: natural control, mimicry of movement, proprioceptive feedback and physical challenge. These authors concluded that gaming systems utilising hand-held controllers may not be the best choice for active video gaming targeting motor skills.

The XBOX Kinect is a camera-based gaming system which tracks the movements of each player's upper and lower limb segments and trunk as they engage in activity. For dance games, the players follow the moves of virtual onscreen dance instructors. The gaming programme matches the camera-detected movement of the player against that of the programme and provides individualised player feedback in the form of stars and points displayed on the screen. This type of individual feedback is provided during both individual and group play. The more precise a player is at replicating the dance moves the higher their scores. Unlike conventional dance training, the XBOX Kinect provides both intrinsic (visual, auditory, vestibular, somatosensory) and extrinsic (scores that rank performance, and indicators of accuracy of movement) feedback, which is ideal for motor learning (Roopchand-Martin, Nelson, Gordon, & Yee Sing, 2015). Research has shown that this type of training is acceptable to young persons and athletes (Adachai & Willoughby, 2014; Roopchand-Martin, Mason, & Gibson, 2016).

Rehabilitation of some athletes may involve agility training. For many facilities, space constraints may be a hindrance to therapists delivering open-chain, sport-specific training activities. Video gaming systems, like the XBOX Kinect, do not require much space and if dance video gaming is shown to be beneficial some therapists may find it feasible to integrate this into their rehabilitation programmes for athletes.

Volleyball is the fifth most popular sport in the world with an estimated 900 million spectators worldwide (Dawson, 2016) and 220 federations registered with the International Federation for Volleyball (International Federation for Volleyball, 2018). Training programmes for volleyball players include agility activities, yet we could not find any published research outlining specific

agility programmes for this group. This study sought to compare the effects of six weeks of dance training, using the XBOX Kinect, with traditional agility ladder drills on the agility of elite volleyball players at the University of the West Indies.

## METHODS

### Participants

The target group for this study was elite volleyball players from the University of West Indies volleyball club. Elite players were defined as persons who regularly competed in local and regional tournaments. Participants were excluded if they had a current musculoskeletal injury, which prevented them from performing physical activity, or if they were already involved in dance training. Groups of players were presented with the research during their training sessions, and recruited over a two-week period.

### Procedure

Following approval from the University's ethics committee (reference number: ECP 213,13-14) a six-week, pilot randomised clinical trial was conducted (Clinical Trials.gov Identifier: NCT02370368). Thirteen players were targeted for each group based on an effect size of 1, alpha level of 0.05 and power of 0.8. Participants were assigned subject numbers and, baseline evaluations consisting of agility testing and recording of age and gender, was conducted by two unblinded, final year physiotherapy students, who were trained by the researchers. Reassessments were done within two days of completion of the training programme by the same assessors. Computerised randomisation was undertaken prior to baseline evaluation, randomly assigning participants to either video game dance training or agility ladder drills. Participants were asked to refrain from engaging in any other physical activity training apart from the research activity and their normal volleyball training.

Agility was assessed with the Illinois Agility Test, which has been shown to be a valid and reliable test for use with athletes (Hachana et al., 2013; Roozen, 2004; Topend Sports, 2015). The minimal detectable change for this test was reported to be 0.52 seconds (Hachana et al., 2013). The TC Timing System (Brower Timing Systems <http://browertiming.com/products/tc-timing-system>, Utah, United States) was used to track time to complete the agility course. Participants were asked to warm up with 5 minutes of jogging. Following this, they began in prone lying, with their hands aligned with the TC motion start sensor. On the "go" signal, they rose and manoeuvred the course as fast as possible (Topend Sports, 2015). Three trials were performed and the shortest time to complete the course was recorded. A 5 minute rest period was allowed between trials. All participants did one trial run prior to actual data collection. During the trial run they were asked to go at a slow pace to avoid fatigue.

### Exercise Intervention

Both groups engaged in three training sessions per week for six weeks (the duration was determined based on the player's ability). Previous research involving video game training and motor skills have ranged from six to twelve weeks duration (Barnett et al., 2015, Peng et al., 2012).

The agility ladder drills were conducted in small groups, not exceeding four persons. Two ladders were laid out on the

ground approximately 122 cm apart. Each ladder was 457 cm long, 43.8 cm wide and the flat, plastic rungs were 38.1 cm apart. Training began with activities requiring relatively simple footwork and increased in complexity at two-week intervals. Throughout training, participants were encouraged to go as fast as they could. Each session lasted approximately 45 minutes and was led by a physiotherapy student who was trained by the researchers to conduct the routine.

The dance intervention utilised the Just Dance 2014 disc and the XBOX Kinect 360, which was connected to a multimedia projector. Images were projected onto a screen (350 cm wide and 250 cm high). The camera for the Kinect system was placed directly in front of participants. Training was undertaken in small groups of no more than four persons. At the start of each session a physiotherapy student set up a playlist to run for approximately 45 minutes. The programme began with simple dance routines and progressed to selections involving more complex choreography at two-week intervals. No feedback or guidance was provided apart from instructing participants to follow the virtual dance instructors as best as they could.

Participants were asked to report any aches, pains, discomfort or injuries to the principal investigator. Injuries were managed

by the qualified physiotherapist and orthopaedic specialist associated with the study.

### Statistical Analysis

Data were analysed using non-parametric tests; the Wilcoxon Rank Sign test was used for all within group comparisons and between group comparisons were assessed with the Mann Whitney U test. Both an intention to treat analysis (ITTA) and a per-protocol (including only those participants who completed the training protocol as prescribed) were undertaken. Six participants who withdrew were reassessed at the time of withdrawal and their data were used for their post-test value in conducting the ITTA. For the other six who withdrew, the initial agility scores were used for the missing data points. All analyses were done with an alpha level of 0.05.

### RESULTS

A total of 27 participants took part in this study (12 males, 15 females). Fourteen were randomised to the dance group and 13 to ladder drills. Fifteen (55.5% of participants) completed the study (Figure 1). Reasons for withdrawal included an increase in school workload, injury and other personal issues. A female participant in the ladder drills group developed severe knee

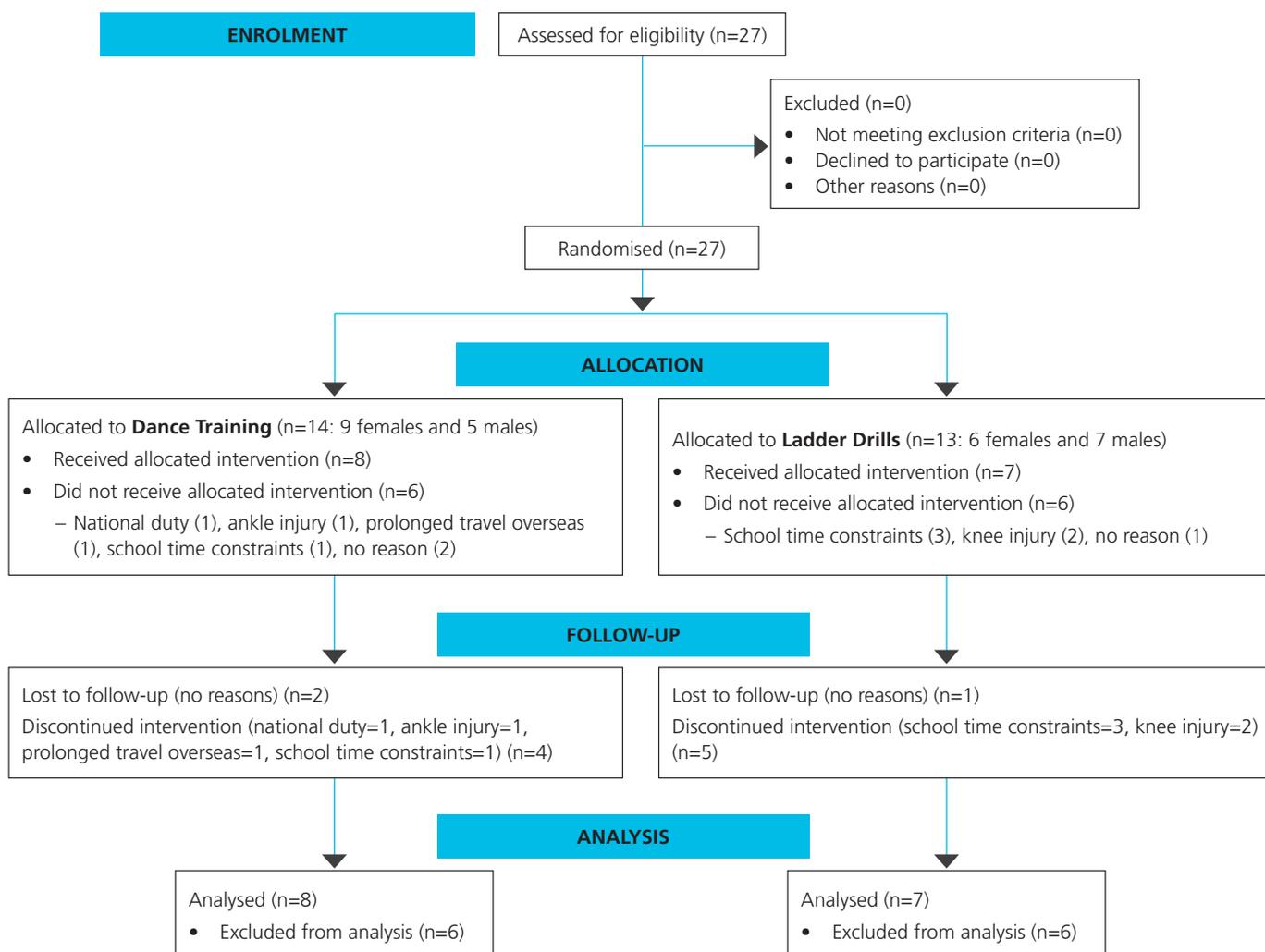


Figure 1: Study participants

pain and swelling after her first training session. Ultrasound investigation revealed features of tendinopathy, which was not detected at baseline, and the participant was withdrawn from the programme. Two adverse events were reported for the dance group: a minor hamstring strain and muscle soreness. Both participants received treatment and had no interruptions in their training schedule.

The baseline mean age was slightly higher for the dance (24.36 SD 5.66 years) compared to the ladder drills (23.54 SD 5.27 years) group. The mean age for both groups was higher at the end of the study (dance = 26.63 SD 6.18 years; ladder drills = 24.29 SD 6.62 years), indicating that withdrawal occurred among younger participants. A larger percentage of persons who withdrew (75%) were females. A Kolomgorov Smirnov test revealed normal distribution for pre- and post-test age and agility scores.

The ITTA showed an improvement in agility scores for both groups; with the median difference in agility scores exceeding the minimal detectable change (0.52 seconds) for the Illinois

Agility Test (Table 1). The results from the Wilcoxon Signed Rank test, however, showed this change to be significant for the group that did dance training (Mdn=-0.95, Z=-2.19, p=0.028, r=0.58), but not for the ladder drills group (Mdn=-0.71, Z=-1.87, p=0.062, r=0.52). The between group comparison showed no significant difference (U=81, p=0.650, r=0.09) in median agility changes.

The findings from the per-protocol analysis demonstrated significant improvements in agility scores from baseline for both the dance training (Mdn=-1.58, Z=-2.52, p=0.012, r=0.70) and ladder drills (Mdn=- 0.85, Z=-2.19, p=0.028, r=0.56) groups (Table 2). The Mann-Whitney test showed that improvements in the Illinois Agility Test scores were greater for video game dance training (Mdn=-1.58 sec.) than ladder drills (Mdn=-0.85 sec.), U=9, p=0.029, r=0.57 (Table 1). The within- and between-group changes exceeded the minimal detectable change for the Illinois Agility Test.

**Table 1: Intention to Treat Analysis (ITTA) of agility scores for video game dance training and ladder drills.**

ITTA	Video game Dance Training n=14 (9 females, 5 males)		Agility Ladder Drills n=13 (6 females, 7 males)	
	Pre-test	Post-test	Pre-test	Post-test
Initial Illinois Agility Test Scores (sec)				
Mean SD	19.32 SD 1.89	18.52 SD 1.92	18.87 SD 1.35	18.34 SD 1.62
Minimum	16.32	16.32	17.18	16.48
Maximum	23.78	22.18	21.50	21.08
Range	7.46	5.86	4.32	4.6
Median	18.98	18.67	18.55	17.68
Wilcoxon Sign Rank Test	*Mdn=- 0.95, Z=-2.19, p=0.028, r=0.58		*Mdn=- 0.71, Z=-1.87, p=0.06, r=0.52	
Mann Whitney Test	U=81, p=0.650, r=0.09			

Notes: SD, standard deviation; \*Mdn = Median difference, lower scores indicate faster completion of the test at the end of the study.

**Table 2: Per Protocol Analysis of agility scores for video game dance training and ladder drills.**

Per Protocol Analysis	Video game Dance Training n=8 (5 females, 3 males)		Agility Ladder Drills n=7 (1 female, 6 males)	
	Pre-test	Post-test	Pre-test	Post-test
Initial Illinois Agility Test Scores (sec)				
Mean SD	19.82 SD 1.89	18.27 SD 2.00	18.23 SD 1.13	17.37 SD 1.12
Minimum	18.06	16.35	17.18	16.48
Maximum	23.78	22.19	20.55	19.83
Range	5.72	5.84	3.37	3.35
Median	19.25	17.81	17.18	16.48
Wilcoxon Sign Rank Test	*Mdn=-1.58, Z=-2.52, p=0.012, r=0.70		*Mdn=- 0.85, Z=-2.19, p=0.028, r=0.56	
Mann Whitney Test	U=9, p=0.029, r=0.57			

Notes: SD, standard deviation; \*Mdn = Median difference, lower scores indicate faster completion of the test at the end of the study.

Although not an outcome of the study, it was noted that the athletes were very engaged in the gaming activity. They would often sing along while dancing and a competitive environment emerged as they attempted to beat their own scores as well as that of other participants. This competitive behaviour was not observed for the participants involved in the ladder drills programme.

## DISCUSSION

This pilot study sought to compare the effect of video game-based dance training with ladder drills on agility of volleyball players. The ITTA showed no difference between the two forms of training but did demonstrate a significant improvement in agility scores with dance training. The per-protocol analysis showed that dance training resulted in greater improvements in agility scores compared to ladder drills. The changes noted were well above the minimal detectable change for the Illinois Agility Test (Hachana et al., 2013), indicating that this type of training may lead to improvements in sport performance.

The training disc utilised in this study contained modern dance moves, with the music type being primarily popular and hip hop. The athletes knew all the songs and would often sing along while dancing. The feedback provided by the gaming system immediately created a competitive environment, with participants trying to beat their own scores as well as their group members. This training programme met the four parameters identified by Pasch et al. (2009) for greater game immersion (natural control, mimicry of movement, proprioceptive feedback, and physical challenge) and this could have contributed to the improvements noted. To create a similar competitive environment the ladder drills were also done in small groups. The degree of competition however, appeared to be much less than that of the dance group and this may have led to less effort during training compared to the dance group and therefore smaller changes.

As indicated previously, agility training should be an open activity involving considerable spatial or temporal uncertainty, in addition to physical and cognitive demands (Sheppard & Young, 2006). It was felt that the dance training used in this study met more of these characteristics as opposed to the ladder drills. The dance training required processing of constantly changing visual, auditory and proprioceptive information whilst performing complex, constantly changing, whole body movements through a wide range of motion. The ladder drills involved directional changes, acceleration and deceleration through a smaller range than that of the dance training and with less complex movement patterns. Movement combinations were more stereotyped and involved primarily footwork mechanics.

The trend for improvements in agility from dance training was like that reported by Alricsson and Werner (2004), who showed enhanced agility in young elite cross-country skiers following 3 and 8 months of dance training. The improvements in this study were larger than those of Alricsson and Werner (2004) and this may be due to differences in the agility outcome measure (hurdles compared to the Illinois Agility Test) and/or the type of dance training. The sessions in our study were accompanied by pop music with choreography requiring a wide range of complex movements, whereas Alricsson and Werner (2004)

utilised a traditional dance instructor with music combinations involving jazz, ballet, modern and character.

No other studies examining video gaming and motor skills have incorporated dance games. Despite the differences in game choice, our findings were like that of Vernadakis et al. (2015), who reported significant improvement in object control skills following video gaming training with the XBOX Kinect.

Differences in training duration could have also accounted for the conflicting findings between our study and others exploring the effects of video game training on motor skills. The total training exposure in our study was greater than that of Johnson et al. (2016) and Barnett et al. (2015) who concluded that video game training did not improve motor skills.

This study has some limitations that require consideration. Firstly, it was a small pilot study and therefore it is important to note that the findings cannot be generalised to other volleyball players. Both groups were involved in their regular volleyball training, in addition to the study intervention. Since the researchers did not track attendance to regular training, variability in degree of training may have had an impact on the results and we could not account for this in our analysis. Neither the evaluators nor trainers were blinded to group allocation (due to the nature of the study it was not possible to blind the trainers), and this could have led to some degree of bias.

## CONCLUSION

This pilot study showed improvements in agility scores of elite volleyball players with video game dance training and indicates that there is a need for further research exploring the role of dance video gaming as an agility training tool. Further research is also warranted to compare the effectiveness of this method of training with other established agility training programmes such as agility ladder drills and field drills with cones. Sports physiotherapists may wish to consider exploring dance video gaming as an optional modality for agility training with volleyball players.

## KEY POINTS

1. Video game dance training with the XBOX Kinect may be useful as an agility training tool for volleyball players.
2. Further research should be done comparing video game dance training with established forms of agility training for athletes.

## DISCLOSURES

This research was funded by the Principal's New Initiative Grant, the University of the West Indies, Mona Campus.

There are no competing interests by any of the authors. We, the authors declare that we have no financial affiliation (including research funding) or involvement with any commercial organisation that has a direct financial interest in any matter included in this manuscript.

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# An App to encourage social interaction by children with Autism Spectrum Disorder: A proof of concept study

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## ABSTRACT

Children with Autism Spectrum Disorder (ASD) can demonstrate impaired social and communication skills. This project explored whether the app 'Talk With Me' assisted children with ASD to communicate with others. Eight participant families, with children aged between 3-11 years, were interviewed before and after using the app in their homes or social situations. Children engaged with the app early on, but engagement decreased over the study period, primarily due to the limited number of conversations available to them, which were, for some children, either too hard or too easy or not interesting enough. Most families perceived their child to have gained increased confidence and participation at school, and improved turn-taking during conversations. 'Talk With Me' appears to have potential for assisting children with ASD to develop communication and conversational skills. Further development to enable customisation of the app by families would increase its relevance to individual children's needs and interests.

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Key words: Autism, ASD, Communication, Conversation, App, Children, Technology

## INTRODUCTION

Autism spectrum disorder (ASD) refers to a range of neurological disorders that affect social and communication skills (Lord, Cook, Leventhal, & Amaral, 2000). The disorder is characterised by degrees of impaired social behaviour, deficits in communication and language skills, and by unusual, restricted, or repetitive behaviours (Lord, Cook, et al., 2000). ASD is approximately 4.5 times more common in males than females (Centres for Disease Control and Prevention, 2016b). The prevalence of individuals diagnosed with ASD is markedly increasing with an estimated one in 160 people worldwide (World Health Organisation, 2017), with a prevalence in the

United States of one in 68 in 2016, compared to one in 150 people in 2000 (Centres for Disease Control and Prevention, 2016b). The increasing prevalence is likely due to broadening of diagnostic concepts, service availability and increased awareness of ASD in the lay and professional public (Elsabbagh et al., 2012). ASD affects 1 in 100 people, or approximately 46,930 people in New Zealand (NZ) (Ministry of Health, 2017).

In most cases, the condition becomes apparent in the first five years of life (World Health Organisation, 2017) because of observed differences in behavioural development compared with peers, such as turning away from others during social interactions or having difficulty joining group activities. However,

as it is a spectrum disorder, all behaviours vary in pervasiveness, severity and onset and no two individuals will exhibit all of the same behaviours (Lord, Risi, et al., 2000).

Impaired communication and social interaction are core symptoms of a diagnosis of ASD (Centres for Disease Control and Prevention, 2016a). Difficulty with pragmatics, or the use of language in social contexts, is common in children with ASD (Jones & Schwartz, 2009; L. Koegel, Park, & Koegel, 2014). Such children can have little or no functional speech and reduced engagement in turn-taking or reciprocal conversations. These children may show reduced ability to initiate and expand on conversational topics, ask about the interests of their peers, take into account others' points of view, or provide relevant responses in a conversation (Hadwin, Baron-Cohen, Howlin, & Hill, 1997; L. Koegel et al., 2014; Paul, Orlovski, Marcinko, & Volkmar, 2009; Peterson, Garnett, Kelly, & Attwood, 2009). In typically developing children, a variety of conversation skills, such as question asking, develop early in their preschool years. As these skills become increasingly sophisticated throughout development, this leads to a larger variety of opportunities for social interaction (R. Koegel, Bradshaw, Ashbaugh, & Koegel, 2014). Without systematic intervention, individuals with ASD may be at risk of social withdrawal and isolation (L. Koegel et al., 2014), which could result in difficulty developing and maintaining relationships with others, feelings of loneliness, and higher rates of depression and/or anxiety (R. Koegel, Kim, Koegel, & Schwartzman, 2013; Lord, Risi, et al., 2000).

It is estimated that up to 50 percent of people with ASD do not use speech functionally. Instead, they use an augmentative and alternative communication (AAC) system to supplement their existing speech or act as a primary mode of communication (Mirenda, 2013). Since the development of tablet technology, many communication apps have become available to function as an AAC device, using pictures, symbols and speech generating technology to assist people to express their needs. These apps have become popular as they are relatively low-cost and require considerably less time to set up and maintain than conventional AAC systems (Still, Rehfeldt, Whelan, May, & Dymond, 2014; Xin & Leonard, 2015). However, we believe that although AAC systems are beneficial, they are typically operated by a single user to express their needs, in contrast to enabling a collaborative conversation. For example, when being taught to use an AAC device, making requests is often the initial focus for intervention (Still et al., 2014).

Indeed, much of the research investigating use of AAC devices on tablets for children with ASD is focused on the child's ability to communicate their physical needs or initiate requests. There is little evidence to support use of a tablet or iPad® for collaborative conversation. One study has investigated if teaching communicative turn-taking with an iPad® would promote social interaction in five preschool children with complex communication needs (Therrien, 2016). Four of the five participants had a formal diagnosis of ASD. The participants were provided with an AAC application on an iPad® and received turn-taking training from a doctoral student in special education. The author found that four of the five participants had increased turn-taking in independent sessions with peers.

Although a positive outcome, the study was resource intensive as the participants received turn-taking training between one and three times a week for three months.

Researchers from Callaghan Innovation, a government agency that works to make NZ businesses more innovative through technology, and from the University of Otago have worked together for many years on development and use of technology for children with ASD (Graham et al., 2016; Jordan, King, Hellersteth, Wirén, & Mulligan, 2013; Mulligan et al., 2017; Mulligan, Rowland, Sandland, Potterton, & Kanagasabai, 2015). The intent of this work has been to promote development of skills in social interaction by children with ASD. The study by Graham et al. (2016) investigated use of Talk With Me, an app to encourage social interaction by six adolescents with a diagnosis of ASD aged 12 to 19 years. The study compared use of the app displayed on a large touch pad screen for children to engage in a simple turn-taking conversation with the children's usual way to make conversation, which was via traditional AAC devices and Picture Communication Symbols. It was found that use of the app improved social interaction, attention and independence, and the adolescent participants showed high levels of enjoyment compared to when using their other communication systems. The findings from the Graham et al. study (2016) encouraged us to explore use of the app in the home context.

The intent of the Talk With Me app is for children with ASD to experience, practise and learn what neuro-typical children would consider social niceties of conversation, such as asking questions, turn-taking and providing appropriate answers, and thereby to facilitate development of their social interaction skills. The app has a variety of conversational topics which the children can select to practise sentence development, question asking and turn taking.

## METHODS

This proof of concept study aimed to explore whether the app, 'Talk With Me' when used on an android tablet or iPad®, has potential as a tool for developing communication and conversational skills in children with ASD in the home environment. Participant families with children or adolescents with ASD from a metropolitan area in NZ were recruited via an invitation email from Autism NZ Inc. This nationwide organisation has over 6,300 members consisting of parents and caregivers for children with ASD, teachers, and public interested in the condition (Autism New Zealand Inc., 2017).

Interested parents/caregivers contacted the researchers, who provided them with written information about the study, after which they provided written consent to participate with their child in the study, which was preceded by a first semi-structured interview with parents/caregivers. These interviews were conducted via email or telephone (15 – 30 minutes). Each participant family was then provided access to the app for a period of time (intended to be eight weeks) on their own iPad® or tablet or one belonging to Callaghan Innovation. Brief education on its use was provided by staff of Callaghan Innovation (MK, SG). Participant families were encouraged to use the app with their child to help facilitate communication

through conversation with people, for example, family members and peers. No specific instructions were given as to how often or when to use the app.

A second semi-structured interview was undertaken following 6-8 weeks' use of the app (see Table 1 for interview questions). These interviews were with the parents/caregivers of the child at a place of their choice, with or without the child present, or via

telephone, and took 15-40 minutes. Verbal consent was gained from participant families before audio recording the interviews. We used a qualitative descriptive approach (Vaismoradi, Turunen, & Bondas, 2013) in order to report perspectives of those who hold the knowledge and experience about the topic of interest (Neergaard, Olesen, Andersen, & Sondergaard, 2009). The research was approved by the University of Otago Ethics Committee (ref 11/195).

**Table 1. Semi structured interview questions**

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Before use of the app

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- We would like to learn more about your child/adolescent, about their communication methods and their behaviours.
- Please tell us about your child (for example, how old are they, are they an only child or do they have siblings, what do they enjoy doing, what do they dislike doing .... and anything else you would like to share about your child).
- In what way/s does your child/adolescent currently communicate with their family/peers/strangers?
- How much verbal communication does your child/adolescent have with you, their peers, family or strangers?
- Please would you tell us about your child/adolescent's methods of making their needs known to you, their peers, family or strangers?
- Does your child use sentences to communicate?
- How long are these sentences?
- Is your child able to focus on the topic of conversation and participate in a conversation even if not using words? How long will they do this for?
- Does your child attend to the person talking with them? How long will they do this for? For example, do they make eye contact or show other indications of participating in the conversation?
- Does your child show interest in/communicate about a topic they have not initiated? How long might they do this for, how often might they do this?
- How are your child/adolescent's social interactions with other people, for example other children, their siblings, their friends other adults or strangers?
- Does your child exhibit repetitive or restricted patterns of behaviour? Please explain, we are after as much detail as possible, for example, type of behaviour and when it occurs.
- How much experience with using a tablet does your child have?
- How often does your child/adolescent use a tablet?

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After use of the app

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- As a parent/caregiver, how did you find using the app 'Talk With Me' with your child/adolescent? Please explain – we are after as much detail as possible.
  - How engaged with the app did you and your child remain over time?
  - In your opinion, do you think using the app 'Talk With Me' has made a difference to the manner in which your child/adolescent communicates and interacts with you, verbally and socially, and with others (for example, their siblings, peers, strangers) and participates in family and community life? In what ways? Please explain – we are after as much detail as possible.
  - In what ways do you think the app 'Talk With Me' could be improved/customised for use? Please explain.
- 

### Data analysis

Data were analysed using an inductive thematic approach (Braun & Clarke, 2006). Each interview was transcribed by a member of the team; a second member reviewed the transcripts for accuracy. Then team members (AE, MG, TR, MS) independently familiarised themselves with the data by reading through each transcript twice, highlighting important features of the data that were relevant to answering the research question and building up a profile of the participating children. Researchers (AW, AE, MG, TR, MS, HM) then worked collaboratively to code a transcript and describe the codes,

thus creating a coding template. AE, MG TR and MS then worked in pairs to code the remaining transcripts using the coding template. Any new codes were discussed by the team before being added to the template. The team then had many discussions about grouping the codes, and synthesised these into sub themes and themes.

### RESULTS

Twenty-one families replied by email expressing interest in the study. Nineteen subsequently requested information and consent forms for the study. Written consent was subsequently

received from nine participant families. Eight participant families agreed to be interviewed before and after using the app and downloaded the app to their personal iPad® or tablet.

The eight child participants in the study were between three and 11 years old (mean age 7.25 years of age) (see Table 2). All participants had experience with a tablet whether it be through school or in the family environment. However, length of use varied from 20 minutes to more than five hours per day. Parents/caregivers reported their children required varying levels of support for verbal and non-verbal communication. None of the children were able to put more than 15 words together in a sentence, and one was only able to say three consecutive words. Five of the eight families said their children had difficulty putting their thoughts into words to express their feelings. Families reported that their child's sentences were commonly disjointed, lacked structure, complexity or the correct tense, and at times made little sense. For example *"he hit my lip in classroom, you know his hand"*. Parents reported children could get lazy communicating with those closest to them as they knew family members would quickly figure out what they required or wished for, so would use few words or point to what they wanted. The children struggled in receiving and comprehending information, finding it a challenge to read a situation. In this regard one parent voiced that his child's mind must be *"a very noisy place"*. Parents reported their child struggled with social cues and conversational etiquette such as turn-taking and acknowledging the other person in a conversation. Children did not typically maintain eye contact with those they were talking to, especially when these were strangers. Many of the children were perceived by their families to want to make friends but lacked the skills to do so.

**Table 2: Demographic information for the eight child participants**

Variable	Values
Sex	
Male	7
Female	1
Age (years)	
Range	3-11
Mean (SD)	7.25 (2.9)
Living with	
Parent(s)	6
Parent + other	1
Grandparent	1
Education	
Primary School	7
Kindergarten	1
Estimated words spoken per sentence (range)	3-15

We identified three themes pertaining to the usability of the app: 'Engagement', 'Transferred Skills and Behaviours', and 'Improving the App' (Table 3).

**Table 3. Themes and subthemes**

Themes	Subthemes
A. Engagement	Initiation Context of use App engagement
B. Transferred Skills and Behaviours	Perceived benefit of app
C. Improving the App	Customisation of the app Target child's ability

### Theme A: Engagement

Engagement encompassed active involvement and interest in using the app. For a child to engage in 'conversation' via use of the app 'Talk With Me', they first needed to initiate the use of it or agree to use it with a partner. Half of the parents reported that it was the parent that initiated use of the app, but once introduced to it, the child found the app fun and interesting. Two children initiated use of the app themselves. The caregiver of one of these children said that the child *"initiated [use of it] also with some of his friends and I think that's a really cool thing"*. Two families perceived that initiation and engagement were difficult, as the app competed with other applications on the tablet. For example, *"he likes it, but yeah when you've got YouTube, minions games and all that sort of other bad things it's a tough competition. It's like comparing, you know, fruit bursts versus [plainer] lollies"*. A parent of one of the youngest children said that her child *"would get out of [the app] and look at YouTube on the iPad" [instead]*.

All children used the app at home. Additionally, three children used the app outside of their homes, two at school with friends, and one with their speech therapist. The participant families approached use of the app in different ways. Over half of them used it as a game. One parent commented, *"it's a game, but then it's real life skills"*. Two families used it as an educational tool for their child, and set aside time for 'homework' in order to get their child to use the app on a daily basis. One child appeared to randomly pick through the conversational pictures with little or no apparent purpose. Two of the parents reported that their child became possessive of the app, not wishing to share it in the intended way with others. These children played both sides of the 'conversation' on the app by themselves.

Initial engagement with the app ranged from five minutes to two hours. Families of those children who used the app for a longer period of time at the beginning of the study reported that this was because their child wanted to explore the app or systematically work through the 'conversations'. However, reported engagement with the app throughout the study period decreased over time. This was true even for the two children who engaged for two hours on first obtaining the app. Families felt that lack of engagement during a 'conversation' and over the study period was due to an array of reasons. These included: the child having a short concentration span, losing interest because the app was too challenging for them, becoming bored because the child could already verbalise the 'conversations', losing interest once completing all the 'conversations', the topics

on the app not falling into the child's area of 'special interest', or the child learning the set 'conversations'. One family, however, reported that their child became increasingly engaged throughout the study period and *"the more he uses it the more he likes it"*.

In summary, this theme demonstrated early engagement with the app, continuing engagement when the app was meaningful or useful to the child, and that engagement ceased when use of the app was no longer meaningful.

### Theme B: Transferred skills and behaviours

Some families reported perceived benefits following their child's use of the app. Common transferred skills and behaviours included increased confidence and increased participation at school. One child was able to describe his drawings, which he had not done before, and another was said to be more confident in conversation with friends. Two of the eight families highlighted that the app had aided with learning social norms for communication. An example of this was a child who began to use eye contact and, once finished his turn, would look expectantly at the other person in the conversation and wait for a reply. He had also learned new words from the app and used these appropriately with his parents outside the context of the app. Of the parents who had noticed some benefits of using the app with their child, half were unsure if the behavioural changes they had observed were actually attributable to the app or to something else. In contrast, three families had not observed any changes in communication or participation in conversation with others following the use of the app.

### Theme C: Improving the App

Participant families provided several suggestions for improvement of the app. The majority of parents said the app seemed like a good starting point, but needed more development. The ability to personalise or customise the app via the addition of personal images (e.g. photographs), and other 'conversations' was suggested by the majority of the families as a way to increase the level of purposeful use of the app. These families suggested that the addition of being able to add their own photographs would allow the content of the app to become more relevant to their child's context because recognition of meaningful and customisable pictures and phrases would help to increase meaning and engagement for their child. There were many suggestions as to new categories for conversation. Three parents were surprised that there was no category for school, and said that this would be very helpful because it had relevance to their child. Examples of making the app more suited to specific child or family interests were camping, or the game Minecraft®. A category to address social behaviour, emotions, and anxiety was also a suggestion as these were ideas children found difficult to communicate. One parent suggested the app could be used as a tool to prepare the child for new or challenging experiences *"like if it's travel or something like that, you can add photos of the actual things, like what the inside of an aeroplane is going to look like"*.

Four parents suggested having differing levels of challenge within the app. This was because their child appeared to have found it too basic, because the conversations were below the child's literacy level, or alternatively too complex for their level

of understanding. Having the option of longer, more complex conversations and progressions to build on would be of help to some children. There was also a suggestion of adding in a rewards system, for example, through stars or points, to maintain the interest of the child.

Specific features of the app design were identified by parents for improvement. In particular, the font size was deemed too small, and the accent and pronunciation of some words used by the voice in the app sounded foreign. Two parents commented that the conversation was not voiced smoothly, and one commented on the speed of delivery of the speech as being too fast. In summary, this theme shows that customisation and an improved breadth of relevant topics, as well as differing levels of challenge and attention to the voicing on the app should increase the amount of purposeful use of the app.

## DISCUSSION

The aim of this proof of concept study was to explore whether the app 'Talk With Me' has potential as a tool for developing communication and conversational skills in children with ASD in the home environment. The eight participant families agreed the app was a good starting point and had potential, although it needed more development if their child was going to stay engaged with it for a longer period of time.

It was the families with children between five and nine years of age who reported positive behavioural changes in their children during the study. This may indicate that the app in its current version is most appropriate for children in this age bracket. However, biological age for children with ASD is not an indicator of their developmental level. Indeed some children may continue to display impaired social behaviour, and deficits in communication and language skills, into their teenage or even later years, depending where they are on the Autism spectrum and/or whether they received appropriate intervention early on. The children of this age in our study exhibited common traits in that they had the desire to be social but struggled to verbalise their thoughts and emotions. In addition, they had a limited attention span, especially with topics they had not initiated. They were selective about who they interacted with and did not maintain eye contact, especially with strangers. Yet, parents reported that during the study period their children displayed improved confidence, turn-taking and increased participation in conversations in their home situation and for some of them, outside of the home environment. These changes however, should not be presumed to be solely attributable to the app. Contextual factors such as social experiences with family and friends, school, extracurricular activities and use of other technology likely influenced children's behavioural communication, as would childhood development. The children from the three families who perceived no particular benefit for their children in using the app were at either end of the three to 11 year age range of our participants. A possible reason for this could be the youngest child's inability to understand the concepts and language of the app, and the older two being more advanced in their communication ability than the app would allow.

The short time period in which the app was trialled may not have been long enough for parents to gauge usability and

applicability of the app. However, as all but one of the children began to disengage within one to two weeks after receiving the app, we suggest that it is not a matter of using the app for longer to see improvements; rather it is about finding ways to increase engagement and usage. Furthermore, participant families all volunteered to take part in the study. This could mean that they had a high level of interest in developing their child's conversation and communication skills and in their child's education and development overall. Many of the parents had actively sought other interventions to improve their child's social and communication skills, for example speech therapy and holiday programmes where children socialise with their peers. This high level of interest in their child may have motivated use and initiation of the app.

An interesting and unforeseen finding from our study was the way in which the app was used by two children who mainly used the app alone, taking part in both sides of the conversation. A large systematic review that focused on the technology most widely used as support for school students with ASD to communicate, suggested that technology can be used to compensate and help students by reducing the anxiety produced by real social situations (Aresti-Bartolome & Garcia-Zapirain, 2014). However, they also argued that if the user only interacts with the technology, this could cause further problems with social relationships and isolation. Although taking part in both sides of a conversation was not how use of the app Talk With Me was intended, it could be argued that there are potential benefits to be gained from this approach. Indeed, listening to the words, saying them aloud, and picking up on the idea of conversational norms of asking questions and receiving replies may be of benefit to a child even if they are not yet capable of taking turns as was the intention of the app.

The ability to customise the app would allow for various levels of ability, different topics of interest and relevance, and personalisation of words and pictures, thus making the app more engaging and effective. The concept of customisation aligns with the study by Aresti-Bartolome and Garcia-Zapirain (2014), which found that most apps for those with ASD are generic, with a lack of an ability to personalise the tool to meet specific needs. The addition of photos of the child and their familiar environment, along with self-selected and meaningful phrases, would therefore be a useful improvement. The children in our study were selective about which things they did and did not like, for example, certain foods and favourite toys or colours. We therefore recommend that the app be extended to include the ability to individually customise it, so that families include meaningful conversations, topics and pictures for their child.

Into the future, we suggest the app should be trialled outside of the home environment, for example, in schools. Furthermore, we agree with our participant families' suggestions that the app has potential for use by children with other communication disorders. However, this would require further trialling after more development of the app itself.

In conclusion, the study found that the app 'Talk With Me' has potential as a useful tool for developing communication and conversational skills in children with ASD, although children

tended to find it difficult to remain engaged with the app and lost interest in its use over time. This innovative app nevertheless has potential, but requires the ability to be customisable to have a wider variety of categories and conversations to improve engagement.

## KEY POINTS

1. Children with ASD engage with technology, therefore an app that encourages development of conversational communication would seem appropriate to minimise social isolation.
2. Unlike other apps, Talk With Me encourages development of two way conversations as opposed to communication for one's needs only.
3. Talk With Me shows promise as a way of including children with ASD in life situations via development of conversational norms.
4. An app such as Talk With Me has potential as a tool for physiotherapists to communicate meaningfully with children with ASD.

## DISCLOSURES

No funding was obtained to undertake this study. Authors report no conflicts of interest.

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# Engagement in exercise for people with Parkinson's: What is meaningful?

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## ABSTRACT

Whilst it is suggested that exercise is integral in the management of Parkinson's, there is minimal literature exploring this population's perceptions about exercise, and how these perceptions relate to standardised physical outcome measures. This mixed method study explored participants' views on an exercise programme which was offered as part of an intervention in a randomised controlled trial for people with Parkinson's. Participants in the intervention group (n=21) received an exercise programme and a cognitive enrichment programme while the control group (n=20) continued with usual care. Semi-structured, face to face, audio-recorded individual or group interviews were undertaken with the intervention group and data analysed thematically. Quantitative data extracted from the clinical trial included the 6 Minute Walk Test and the mini-Balance Evaluation Systems Test (mini-BESTest). The themes: 'Having trust in professional guidance', and 'An understanding and supportive environment' contributed to the overarching theme of 'A sense of individual empowerment'. Together the themes demonstrated meaningful holistic benefits gained by participants, which differed from the non-statistically significant quantitative results from the clinical trial. Small group tailored exercise effectively addressed multiple cornerstones of health in people with Parkinson's, creating an overall sense of individual empowerment. This study also suggests that research may overemphasise reporting of standardised physical outcomes to the detriment of what participants perceive as meaningful outcomes.

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Key Words: Parkinson disease; Exercise; Qualitative research; Outcome assessment

## INTRODUCTION

Parkinson's disease is the second most common neurodegenerative condition worldwide (Pringsheim, Jette, Frolkis, & Steeves, 2014). It affects approximately 1% of people over 60 years old, with prevalence increasing to around 4% of people aged over 80 years (De Lau & Breteler, 2006; Hirsch, Jette, Frolkis, Steeves, & Pringsheim, 2016). While traditionally labelled as Parkinson's disease, this condition is not in fact a

disease, nor is it communicable. Thus, instead of Parkinson's disease, people diagnosed with this condition refer to it as Parkinson's (Parkinson's UK, 2017; The Parkinsonism Society of New Zealand, 2017). We have therefore used the term Parkinson's instead of Parkinson's disease in this research report.

Parkinson's occurs as a result of pathophysiological changes to the substantia nigra (Jankovic, 2008) resulting in both motor and non-motor symptoms (Bonnet & Houeto, 1999; Mandir

& Vaughan, 2000). Individuals diagnosed with Parkinson's are almost six times more likely to develop dementia compared to the general population (Aarsland et al., 2001). They are also more susceptible to the effects of inactivity, as the effect of this condition on the basal ganglia leads to decreased activation of motor neurons, thus accelerating muscle atrophy (Glendinning & Enoka, 1994).

Exercise in general has physiological benefits such as improved coronary blood flow, body composition, insulin sensitivity, blood lipid ratios and decreased blood pressure (Hambrecht et al., 2000; Warburton, Gledhill, & Quinney, 2001). It can therefore be argued that it is extremely important for people with Parkinson's to exercise regularly. A large systematic review and meta-analysis found good evidence of the benefits of exercise for people with Parkinson's, with improvements in physical function, health-related quality of life, leg strength, balance, and gait speed and quality (Goodwin, Richards, Taylor, Taylor, & Campbell, 2008). There is an emerging body of evidence examining perceptions of exercise by people with Parkinson's (Crizzle & Newhouse, 2012; O'Brien, Dodd, & Bilney, 2008; Sheehy, McDonough, & Zauber, 2017). While some studies have identified the importance of exercise in a group environment (Crizzle & Newhouse, 2012; Lötze, Ostermann, & Büsing, 2015; O'Brien et al., 2008; Sheehy et al., 2017), others have looked at exercise as a way to promote self-efficacy and improve quality of life (Combs et al., 2013; Lötze et al., 2015; Rodrigues de Paula, Teixeira-Salmela, Coelho de Moraes Faria, Rocha de Brito, & Cardoso, 2006). There is however, limited research that examines the perceptions of people with Parkinson's of small group, tailored exercise delivery.

This mixed method study, nested in a larger randomised controlled trial (RCT), aimed to explore the perceptions of participants in the intervention arm of a physiotherapist-delivered small group, tailored exercise programme, as a way to explore feasibility for exercise interventions for people with Parkinson's. A secondary aim was to compare and contrast the perceptions of undertaking exercise in this way, to the results of standardised physical outcomes.

## METHODS

The RCT explored the effect of physical and cognitive enrichment, through enhanced physical and cognitive exercise, on decline to dementia in adults (>60 years of age) diagnosed with idiopathic Parkinson's. Eligible individuals for the RCT were identified through Christchurch Neurology clinics or the New Zealand Brain Research Institute (NZBRI) database. Individuals who lived in the Canterbury region, diagnosed with idiopathic Parkinson's, without any other atypical movement disorders, were screened in 2016 for inclusion in the RCT using the Conversion to Dementia score developed by the NZBRI (Dalrymple-Alford, Anderson, Farrer, & colleagues, 2016). They were invited to participate in the RCT if they had a Conversion to Dementia score of > 5%, meaning they were at risk of developing dementia in the next four years, but were not yet classified as having mild cognitive impairment. Individuals were excluded if they had current involvement in any NZBRI longitudinal studies on cognitive changes in Parkinson's, were involved in other studies that included pharmacological

intervention, were currently using any medications that could impact cognition, had any other current or past neurological or psychiatric conditions, or had a poor comprehension of the English language. They were also excluded if they had a history of major illness in the past year, alcohol or substance abuse or learning disability.

In the larger RCT, 41 eligible consenting participants were randomised to the intervention (n=21) or control group (usual care) (n=20). Participants in both groups completed pre- and post-intervention cognitive and physical outcome measures. Cognitive measures included a range of neuropsychological and neuropsychiatric tests. The physical measures were the Unified Parkinson's Disease Rating Scale (UPDRS) (Movement Disorder Society Task Force on Rating Scales for Parkinson's Disease, 2003), the Six-Minute Walk Test (6MWT) (Steffen & Seney, 2008) and mini-Balance Evaluation Systems Test (mini-BESTest) (Leddy, Crowner, & Earhart, 2011). The UPDRS is comprised of four sections, including a motor section, and provides a means to monitor Parkinson's related disability and progression (Movement Disorder Society Task Force on Rating Scales for Parkinson's Disease, 2003). The 6MWT measures distance walked on a flat surface over six minutes as a way to gauge aerobic capacity and endurance (Steffen & Seney, 2008). The mini-BESTest is a shortened version of the BESTest that includes only 16 of the original 36 items and is believed to measure dynamic balance (Leddy et al., 2011). These tests have been shown to be reliable and valid in this population (Leddy et al., 2011; Steffen & Seney, 2008). The tests were administered by a trained, blinded assessor as part of the larger RCT.

The intervention group undertook an eight month programme of supervised physical activity and cognitive enrichment exercises. Supervised physical exercise was offered to the intervention group at a community physiotherapy clinic. Participants had a one hour weekly session, in small groups of three to five attendees. There were four sessions on offer each week, with sessions provided by the five clinic physiotherapists, and participants were given some choice as to preference for their own session, depending on numbers of attendees in a particular session. The programme comprised a combination of aerobic, progressive resistance and balance exercises in a circuit setting. The physiotherapists prescribed tailored exercises to reflect individuals' physical capacity. During each session, participants gave feedback of perceived exertion using the Borg Rate of Perceived Exertion (RPE) scale (Borg, 1982). Participants were asked to exercise at a moderate intensity (12 to 14 on the Borg RPE scale), thereby maintaining exercise intensity as exercise capacity improved over time.

This study, nested in the larger RCT, took a mixed method research approach, incorporating both quantitative and qualitative data, to allow for a broader examination and understanding of the research topic (Creswell, 2007; Johnson, Onwuegbuzie, & Turner, 2007). Quantitative data (UPDRS motor, 6MWT and miniBESTest) were obtained from the larger RCT. Adherence data to the exercise programme were obtained from attendance sheets kept by the physiotherapy clinic.

All 21 participants randomised to the intervention group were invited to participate in a semi-structured, audiotaped interview

before or after their last exercise session, at a time and place that was convenient for them. Interviews, undertaken by a researcher who had no previous involvement with any of the participants (HM), were conducted in small groups of two to four participants, or individually according to participant preference. Interview questions, asked in a conversational format, explored participants' experience of engaging in the individually tailored, small group exercise programme for people with Parkinson's (Appendix 1). The Health and Disability Ethics Committee, New Zealand, provided approval for the study, reference 15/NTB/161.

### Data Analysis

We calculated the means and standard deviations for the physical outcome measures and the adherence data. We also compared the physical outcome measure results between the intervention and control groups using confidence intervals (CI) and two-tailed Z-tests.

An inductive approach (Braun & Clarke, 2006) was used to analyse the interview data for themes. An independent transcriber contracted for the study transcribed and uniformly formatted the interviews. To ensure contextual accuracy, all audio files were listened to by at least three members of the research team and corrections were made to the transcripts where necessary. Transcripts were then distributed amongst the research team for coding. Information pertinent to the research question was highlighted, coded and given a descriptor. Codes for each transcript were listed. Once the initial readings and coding were complete, transcripts were re-read independently by all other members of the research team. Together, the codes were cross-checked, any additional codes identified, and the codes were collated into a list, thereby obtaining a visual record of the codes. Via extensive and iterative research team discussions and mind mapping, we then grouped the codes into categories, then into subthemes and eventually themes (Farmer, Robinson, Elliott, & Eyles, 2006; Onwuegbuzie & Leech, 2007).

## RESULTS

Table 1 provides a demographic overview of the study participants in the intervention group. Table 2 summarises the results of the quantitative data from participants in the intervention and control groups. The intervention group comprised 13 males and eight females with a mean age of 69.4 (SD 6.8) years and a mean UPDRS motor score of 32.5. Attendance at the exercise programme was high at 84%. There were 13 males and seven females in the control group with a mean age of 69.8 (SD 5.4) years and a mean UPDRS of 28.4.

At baseline, comparison of UPDRS (motor) scores for the control and intervention groups showed a clinically significant difference of 4.1 points between the groups. On average, participants in the intervention group scored 9.8 metres less ( $p=0.63$ ) in the post-intervention 6MWT compared to pre-intervention. In contrast, the control group walked 14.8 metres further ( $p=0.55$ ) on their 6MWT at the end of the trial period compared to their initial distance. Mini-BESTest scores decreased 0.6 points ( $p=0.52$ ) over the trial period for the intervention group, compared to a decrease of 0.1 points ( $p=0.96$ ) for the control group.

**Table 1: Participant demographics at entry to larger RCT (intervention group)**

Participant	Sex	Age (years)	Symptom duration (years)
1	M	82	14
2	M	70	6
3	F	67	2
4	F	74	4
5	M	82	6
6	F	74	5
7	F	62	14
8	M	65	19
9	M	68	10
10	F	82	11
11	M	76	2
12	M	63	6
13	F	69	9
14	M	61	9
15	F	65	2
16	M	74	4
17	M	61	3
18	F	65	23
19	M	62	1
20	M	68	6
21	M	64	10

Notes: M, male; F, female; RCT, randomised controlled trial

All 21 intervention group participants were interviewed (15-40 minutes). All interviews were held at the physiotherapy clinic where they had undertaken the exercise sessions. Most interviews were undertaken in a small group of up to four people, with five participants requesting an individual interview. Three themes were evident in the interview data: 1) Trust in professional guidance; 2) An understanding and supportive environment, and 3) A sense of individual empowerment. Although the three themes were separate entities, with each encompassing separate subsets of the data (Table 3), they were also intrinsically linked. Themes one and two, when applied through the conduit of a small group tailored exercise programme, contributed to the overarching theme of 'A sense of individual empowerment'. This relationship is demonstrated in Figure 1. The themes are described below, with subthemes and supportive quotes taken from transcripts and linked to participants (e.g. P1 = participant 1, etc.).

**Table 2: Summary of outcomes measured (intervention and control groups)**

		Intervention Group (n=21)					Control Group (n=20)				
		Mean	SD	CI		P value	Mean	SD	CI		P value
				Lower	Upper				Lower	Upper	
6MWT (metres)	Pre	304.6	61.6	-31.0	50.8	0.63	293.6	76.6	-64.9	35.2	0.55
	Post	294.8	69.4				308.4	77.6			
Mini-BESTest (max score 28)	Pre	19.9	5.6	-2.5	4.9	0.52	21.1	6.0	-3.8	4.0	0.96
	Post	19.3	6.0				21.0	6.2			
Exercise adherence (%)		84.1	12.5								
Intervention v Control											
UPDRS (motor)	Pre	32.5	13.4	-12.8	4.7	0.35	28.4	14.3			

Notes: CI, confidence interval; SD, standard deviation; 6MWT, 6 Minute Walk Test; UPDRS, Unified Parkinson's Disease Rating Scale; P value, significance value set at <0.05; mini-BESTest, mini-Balance Evaluation Systems Test

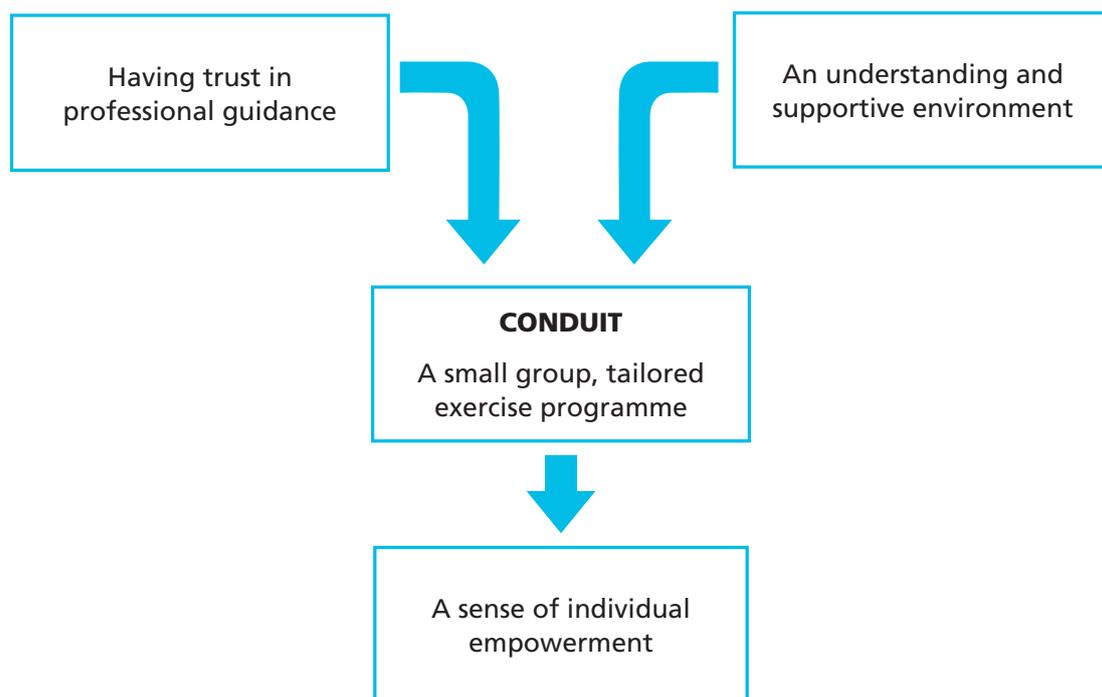
**Table 3: Summary of subthemes and themes**

Themes	Subthemes
Trust in professional guidance	<ul style="list-style-type: none"> <li>• Physiotherapist knowledge about how Parkinson's affects the body and activities of daily living. Ability to tailor exercise programme to individual needs</li> <li>• Ability to modify exercise programme so that it challenges the individual participant</li> <li>• "Professional leadership" of the group</li> </ul>
An understanding and supportive environment	<ul style="list-style-type: none"> <li>• Camaraderie between group members</li> <li>• Empathy from group members who understand the challenges of living with Parkinson's</li> <li>• Encouragement received and given within the group</li> <li>• Accountability of belonging to the group</li> </ul>
A sense of individual empowerment	<ul style="list-style-type: none"> <li>• The feeling of improved self-efficacy</li> <li>• The feeling of self-actualisation</li> <li>• Functional gains resulting from undertaking exercise</li> <li>• The feeling of taking back control of one's life after diagnosis with Parkinson's</li> </ul>

### Theme 1: Having Trust in Professional Guidance

This theme pertains to the repeated reflection of many participants around the benefits of having a trained physiotherapist guiding their exercise programme. This theme was derived from a number of subthemes outlined in Table 3. Participants valued their physiotherapist's knowledge of Parkinson's and their understanding of how Parkinson's affects the body. Participants identified how this felt different to their previous experiences of fitness instructors/personal trainers: "In a normal gym] you wouldn't have someone overseeing who's got the knowledge of what Parkinson's can do and the effect it can have." (P9). Furthermore, participants were less inclined to engage in exercise groups where there was a lack of professional guidance: "I looked at going to a gym... but nobody running the gyms or anybody involved had any experience in managing Parkinson's." (P20). They also felt understood and "challenged within the routine" (P14) because

their physiotherapist was able to individualise the group programme to suit participants' differing physical capabilities. Thus individualising the programme as opposed to "a series of exercises for the sake of it" (P17), created the feeling of a safe, enabling environment and allowed participants to build confidence to challenge their capacity. Moreover, it resulted in holistic and functional benefits: "[the exercises] have helped me enormously. Whether it has helped me more mentally than physically I don't know, but the whole combination has been pretty good" (P7). Participants built feelings of rapport with and trust in the physiotherapist, because of his/her ability to work with each participant personally to suit their level of capability, to prescribe an individualised, variable but sufficiently challenging exercise programme. Participant 11 exemplified this when he said "modifications were given to me [by the physiotherapist] in consultation with me... It gives me a challenge to achieve". By having the physiotherapist



**Figure 1: A model for the development of 'A sense of individual empowerment'**

present, participants felt encouraged to push themselves with the exercises: *"Having someone overseeing what you're doing makes you try that little bit harder"* (P4). Another participant reflected *"she was watching us all the time making sure she didn't overtax us, but we were pushing ourselves"* (P1). Participants described how they were encouraged by the physiotherapist to reach a level on the Borg RPE scale where they were 'moderately challenged' even if the complexity or level of exercise had to differ depending on how they felt on a particular day.

### **Theme 2: An understanding and supportive environment**

The second theme alludes to the benefits that participants reported from being immersed in the small group setting. This setting provided the opportunity to engage with other individuals who also live with Parkinson's and who therefore understood the inherent challenges resulting from living with the condition. This theme included a number of subthemes (Table 3), illustrated below.

A strong and repeated message throughout the interviews was the enjoyment and motivation gained from the small group setting: *"an ordinary gym tends to be bigger, and a little more impersonal as a result, whereas this is quite a cosy little group"* (P19). Other community gyms were not perceived as able to emulate the understanding and supportive environment created in the small group setting, and hence were not as well received: *"I still do belong to [a gym] and I was going along there at times to [an exercise class] but I felt a bit out of it. They encouraged me but I was clumsy and just couldn't do the things they were doing"* (P8). For our participants, a shared diagnosis of Parkinson's meant bonds were formed within the

group as participants were *"all in the same boat"* (P7). Such commonality created an empathetic and supportive environment with understanding and camaraderie between group members: *"others know what it's like to be the way we are [and] I don't feel so alone"* (P4). This context provided encouragement, competition and fun: *"Well, I've got to beat [named participant] and [another named participant] has got to beat me..."* (P11). Indeed, social interaction with *"like-minded people"* (P5) was a large motivator for weekly participation, because it kept participants accountable to the group. It also provided *"incentive to put extra effort in"* (P3).

Attendance at the group provided an opportunity for what was perceived as routine exercise (for example, static cycling and squats), as well as an *"opportunity to do exercise you wouldn't otherwise do"* (P1) (such as walking along a balancing beam). Participants enjoyed the *"social side of [the group]"* (P20). As Participant 1 mused *"it's no fun sitting out in the garage on your own"* (his usual place for exercise).

### **Theme 3: A Sense of Individual Empowerment**

Our final, overarching theme describes the perceived individual and personal gains resulting from the first two themes (Table 3). Participants described a sense of individual empowerment via feelings of increased self-worth and belief in their ability to be proactive in self-managing their condition: *"[I've learnt that] how you control your life with Parkinson's is up to you. It's only you that can do it"* (P3). An understanding and supportive environment combined with trust in professional guidance provided participants the confidence to engage in tailored exercise: *"That uncertainty when I arrived has gone to total confidence by the time I left"* (P14). Participants were able to transfer exercising to the home environment; *"I've started doing*

weights at home as well. This [programme] has encouraged me to do that" (P8). Through the conduit of exercise, the theme shows the developing self-efficacy and self-actualisation of the participants leading to an individual's sense of empowerment. Overall, this manifested in participants reporting increased confidence to participate in meaningful activities of daily living, with many participants also reporting functional gains. For example, one participant reported now being able to perform activities independently: "[The carers] used to make my bed and help me do my washing, but now I take over a lot of those things back again" (P14). Other participants reported increased ease with daily activities, such as carrying shopping bags into the house from the car and doing "more work in the garden" (P20). Others said they had returned to physical recreational activities, which they had previously given up. This included cycling and running. One participant reported being able to jump without losing balance and felt more confident about not falling because of increased strength and confidence in their physical capability. Participant 9 boasted "I started off at 1 kilogram and I can lift 5 [kilograms] now". Overall, participants felt able to take back control from what they had previously perceived as a dominating force in their lives: the diagnosis of Parkinson's. One participant regained sufficient strength to "steer the car [when driving]" (P14). Although a practical example, this could be a metaphor reflecting participants' sense of empowerment; to 'steer' their lives back in the direction of their choosing.

## DISCUSSION

This study explored perceptions about small group exercise for people with Parkinson's who are at risk of decline to dementia, and examined the effect of exercise from a number of perspectives. Analysis of the UPDRS motor scores showed a clinically significant difference between the intervention and control groups at baseline with the intervention group having a higher score, indicating a more severe level of motor impairment (Shulman et al., 2010). Therefore, outcomes between the two groups cannot be compared and may indicate lack of power in the larger study. It was surprising that the intervention group did not achieve quantifiable improvements in physical outcome measures given that the literature provides good evidence for the effect of exercise on physical function. Nevertheless, participants reported they derived wider and holistic benefits from attending the small group, tailored exercise programme. Many participants found the group environment and professional guidance offered in this setting to be very motivating, supportive and enabling. It appeared to result in improved self-efficacy and the power to separate themselves from their diagnosis and restore a sense of personal identity. Overall, we identified this as development of a sense of individual empowerment. Our findings support an Australian study by O'Brien et al., (2008) who also reported that a small group, tailored exercise programme for people with Parkinson's resulted in benefits broader than just physical outcomes. However, two studies from Australasia cannot be seen as providing sufficient information in this area of interest to inform elsewhere in the world and thus this requires further exploration.

The juxtaposition of the non-statistically significant quantitative results against the perceived benefits reported by participants in qualitative interviews, begs the question as to whether research should continue to place emphasis on quantitative outcomes in a 'disease-centred approach' as opposed to a person or patient-centred approach (Zhao, Gao, Wang, Liu, & Hao, 2016). Te Whare Tapa Whā (Durie, 1998) was developed to capture the Māori philosophy of Hauora (wellbeing), which encompasses holistic health and wellbeing (Rochford, 2004). The model which is being integrated into healthcare in New Zealand (Ministry of Health, 2017) has four dimensions (Taha Tinana (physical health/wellbeing), Taha Wairua (spiritual health/wellbeing), Taha Hinengaro (mental/emotional health/wellbeing) and Taha Whānau (social health/wellbeing) which interlink and are each equally important for overall wellbeing. Traditional emphasis in health research and practice both globally and in New Zealand encompasses only physical health, with less or no consideration for the other dimensions that underpin holistic models of health and wellbeing, such as Te Whare Tapa Whā. Our study reiterates the importance of considering all four cornerstones of Te Whare Tapa Whā. Indeed, our participants clearly valued not only their perceived physical gains from participating in the group exercise sessions, but also the social, mental/emotional and spiritual gains resulting in a sense of individual empowerment.

The model we propose for development of 'A sense of individual empowerment' Figure 1 represents how the interview data interacted and can be seen to reflect the holistic nature of Te Whare Tapa Whā. Our model demonstrates the relationship between the three themes that occurred through participating in a small group tailored exercise programme. We therefore suggest that the two themes of 1) Having trust in professional guidance and 2) An understanding and supportive environment are integral components to the development of theme 3) A sense of individual empowerment. It is conceivable that this model could be used in other settings with an alternative conduit. For example, Stephen et al., (2014) explored components of an internet-based therapist-led live chat cancer support group, and two of the important components that were identified were the "important role of the facilitator" and "shared understanding and connection". Through an internet-based cancer support group, patients felt more open about discussing their problems and expressing their emotions to other individuals. A sense of empowerment was not specifically expressed in the study. However, the act of expressing one's emotions to others has been demonstrated to have therapeutic effects in moderating emotional stress and facilitating personal goal setting (Stanton & Low, 2012). It can therefore be argued that the benefits received from a group environment, whether online or face-to-face, give rise to a sense of control over one's emotions and health, and therefore contribute to a sense of individual empowerment.

Contrary to the American College of Sports Medicine exercise guidelines of 2-3 times per week for older adults (Nelson et al., 2007), and a recent review exploring effective exercise training in the older population (Bouaziz et al., 2016), our participants attended the exercise intervention group only once a week. Literature about exercise dose for people with

Parkinson's suggests that a minimum of 2-3 sessions per week is necessary to result in changes to physical function (Allen et al., 2010; Corcos et al., 2013; Ellis et al., 2005). Indeed, the lower frequency of exercise sessions per week in the larger RCT in which our study was nested, may have contributed to the lack of significant results in physical improvement in the intervention group. However, the RCT has not yet collated self-reported data pertaining to other physical activity participants undertaken over the course of the study. In addition, at baseline for the RCT (Peterson et al., 2017), the UPDRS motor scores showed a difference of 4.1 points between the two groups. The clinically important difference for the UPDRS motor ranges from minimal (2.3-2.7) to moderate (4.5-6.7) (Shulman et al., 2010). This suggests that the control and intervention group, were clinically different at baseline and therefore possibly not comparable. However, many of our participants reported fluctuating symptoms (Storch et al., 2013), therefore UPDRS scores taken at one time point may not be truly reflective of a person's fluctuating motor ability.

An interesting result in this study was the high rate of adherence, i.e. attendance and participation rates, in the exercise intervention over the eight month period. A number of recent reviews found that adherence to exercise interventions in the older adult population varies from 58% to 86% (Farrance, Tsofliou, & Clark, 2016; McPhate, Simek, & Haines, 2013; Picorelli, Pereira, Pereira, Felício, & Sherrington, 2014), and is generally higher if the exercise programmes are supervised (Picorelli et al., 2014). Lower levels of adherence were associated with group exercise interventions that had a duration of  $\geq 20$  weeks,  $\leq 2$  sessions per week, or interestingly, if the programmes included flexibility exercises (McPhate et al., 2013). In theory, participants in the intervention arm of our study should have had lower adherence scores, given that the exercise class was only once a week for a lengthy period. Research suggests that improved exercise adherence to community-based exercise for people over 65 years of age arises from social connectedness, participant-perceived benefits, programme design, empowering/energising effects, instructor behaviour and personal characteristics of attendees (Farrance et al., 2016). We believe the higher adherence rate evidenced in our study can be explained by the model which we have developed (Figure 1). Both themes which feed into the conduit of small group, tailored exercise had subthemes relating to accountability and commitment. In addition, the resulting sense of individual empowerment encouraged participants to believe they could make a change in their lives, and they, therefore, were eager to keep going with the programme. We believe that adherence can be explained by all three of our themes, and that the participants' experiences as represented by the themes contributed to their level of adherence. Indeed, a study by Crizzle and Newhouse (2012) that examined participation in a Parkinson's specific hydrotherapy programme for older adults reported similar motivators for attendance - having a reassuring instructor, structure and support arising from the group, and improved psychological wellbeing derived from perceived physical improvements. Thus, we hypothesise that our model could be applied with other exercise formats to reap similar benefits in terms of adherence.

In the context of measuring meaningful outcomes, the findings of this study demonstrated the importance of considering not only the use of standardised measures of physical function, but also of gathering subjective data as a means of gauging improvement. Combining the two approaches provides a more holistic view about the benefits of an intervention. Overall, we discovered how individually tailored exercise, offered in small group settings with 'like-minded people', can be an effective conduit for delivery of meaningful outcomes.

## CONCLUSION

In this study, participants valued the holistic benefits they gained from participating in an exercise programme and a small group tailored programme is an effective way to deliver exercise to individuals with Parkinson's. The results of this study suggest that the 6MWT and mini-BESTest did not capture the holistic gains reported by individuals. The model we created, that links our three themes, begins to examine which factors are important in creating a meaningful environment in which to engage in exercise. Participants reported regaining the ability to perform functional activities previously lost to them, as well as the ability to apply what was learnt in the small group classes to maintain and improve physical activity levels in other environments. Perhaps research places too much emphasis on standardised measurable gains, compared to meaningful improvements reported by participants. We believe that research limited to measuring standardised physical outcomes to investigate improvements in an individual's physical abilities, neglects important aspects of a person's overall function and wellbeing. Finally, we propose that the use of the model we developed, using alternate conduits, could produce similar outcomes to this study for other population groups.

## KEY POINTS

1. People with Parkinson's value individually tailored, small group exercise, supervised by physiotherapists who understand the characteristics and fluctuations common to living with Parkinson's. This should be considered in the design of future exercise programmes for this population.
2. Te Whare Tapa Whā or other similar holistic models could be considered as a useful framework when creating exercise programmes for people with Parkinson's (and possibly other neurological conditions) in order to address all cornerstones of health and wellbeing.
3. The model we created, which integrates our three themes, could potentially be used with alternate conduits to elicit similar holistic health benefits.

## DISCLOSURES

The authors report no conflicts of interest.

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# Appendix 1

## Interview guide

- 1 Overall how has it been for you to front up each week at the exercise group? What has kept you coming?
2. What had been your experience/s of partaking in physical activity/exercise prior to this study?
- 3 Now I'd like you to think back to the beginning. What was it like for you on first being given an appointment at the physiotherapy clinic and then, what was it like joining an exercise group?
- 4 How has it been for you since? How has it been for you to exercise in this way?
- 5 Tell me about the feasibility/practicality – in terms of convenience, ease of access, time and travel commitment.
- 6 Can you tell me about the acceptability/tolerability – have you had to take into account/or has exercising had an effect on energy/fatigue, tremor and medication management?
- 7 Is there anything about the group itself that you particularly enjoy or perceive benefit from? Why? When did this start/stop happening?
- 8 Is there anything about the fact that you have done this in a group that you did not/do not particularly like? Why? When did this start/stop happening?
- 9 Is there anything about coming to this physiotherapy clinic itself that you don't enjoy/would like to have changed, or that you have particularly enjoyed?
- 10 Do you have any definite plans for exercising when this study ends? What are these? Would you know where to find information to assist in making decisions about continuing with exercise once you end here?
- 11 Has being involved in this study encouraged you to incorporate exercise into your daily life? What motivates you to exercise?

## Participants' experiences of a mixed-ability yoga series

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### ABSTRACT

The practice of yoga encourages individuals to work within their own bodies to bring balance and health to the mind, body and spirit, providing relief for symptoms of chronic conditions. The purpose of this study was to explore the experiences of individuals participating in a series of mixed-ability yoga classes. Barriers and facilitators to their participation were also explored. Seven participants were recruited from the mixed physical and mental ability yoga classes. Semi-structured interviews were used to collect data. Thematic analysis was used to analyse the data and develop themes. Prominent themes were Engagement Partnerships, Physical Activity Beliefs, Supported Participation and Concepts of Disability. These themes provided insight into the experiences of participants and the facilitators and barriers that influenced their participation. Additionally, themes were supported by literature on group cohesion and self-efficacy that highlight the potential for change to group exercise classes with cross over into rehabilitation classes. The importance of appropriate adaptation through skilled instructors was key to the success of the mixed-ability yoga series, as was the promotion of inclusion and understanding of perceptions of disability. Participants experienced health benefits from the mixed-ability yoga class. The fundamental concepts of the class can be applied in physiotherapy practice to promote physical activity for all.

**Bevis, A., Waterworth, K., Mudge, S. (2018) Participants' experiences of a mixed-ability yoga series. *New Zealand Journal of Physiotherapy* 46(1): 29-35. doi:10.15619/NZJP/46.1.03**

Key words: Disability, Adaptation, Inclusion, Yoga, Health, Qualitative research, Physical activity

### INTRODUCTION

Yoga is a physical activity in which individuals of all walks of life are able to participate. Research suggests that people who experience disability are less likely to engage in physical activity than their non-disabled peers (Lundberg, McCormick, & Tibbs, 2011; Singh, 2012). A lack of physical activity and complications from long term health conditions place the disabled population at greater risk of obesity, cardiovascular disease and diabetes (Keegan et al., 2014; Kehn & Kroll, 2009; Reinders, Bryden, & Fletcher, 2015; Harder, Parlour & Jenkins, 2012). Adaptive physical activity encourages participation by removing potential and perceived barriers including lack of accessibility, limited financial resources or reduced confidence (Anderson & Heyne, 2012; Bantjes, Schwartz, Conchar & Derman, 2015; McCall, Thorne, Ward & Heneghan, 2015; Ross, Bogart, Logan, Case, Fine & Thompson, 2016).

Adaptation, inclusion and mixed-ability are three principles central to the ethos of this study. Lundberg et al. (2011) describes adaptive sport and recreation as the "modification of a given sport or recreation activity to accommodate the varying ability levels of an individual" (p. 1). Inclusion is defined as a collective effort to allow people to participate, whereby differences are normalised through differentiated instruction (Andreason, 2014). Inclusive physical activity fosters an environment that gives people a 'sense of belonging' through peer support and awareness of different abilities (Rimmer, Riley, Wang, Rauworth & Jurkowski, 2004). Mixed-ability is a concept,

in the context of the yoga series, which utilises principles of inclusion and adaptation to encourage participation, and involves individuals of different levels of physical ability (Tomlinson, 2001). We were unable to find published literature on this style or format of group exercise delivered as a component of physiotherapy intervention.

Adaptive yoga, considered an accessible physical activity, has been investigated through qualitative research as an adjunct to traditional therapeutic interventions including physiotherapy for individuals with health conditions including stroke, spinal cord injury, cerebral palsy and cancer. It has been shown to provide benefits comparable to those in non-disabled populations, including better sleep, stress relief and improvements in strength and flexibility, measured through scales including the visual analogue scale (VAS) and the perceived stress scale (PSS) (Curtis et al., 2015; Garrett et al., 2011; McCall et al., 2015; Patel, Newstead & Ferrer, 2012). Although a significant cardiovascular response would not necessarily be expected from adaptive yoga, participants perceive improved cardiovascular fitness (Alexander, Innes, Selfe and Brown, 2013).

Given the proposed benefits of mixed-ability and adaptive physical activity, an initial series of mixed-ability yoga classes was offered to the public in November 2014. In total, five eight-week series were offered from November 2014 to November 2015. Participants could join at any time and continue from one series to the next.

The aims of the classes were to operationalise the principles of mixed-ability, inclusion and adaptation and promote these concepts in exercise prescription. An individual introductory session was conducted to discuss expectations, concerns and current mobility; attendee responses informed individualised adaptations provided by the yoga instructor. During sessions, time was invested for introductions between participants and also when new people joined. Participants were given the option to stand, sit in an adaptive or standard chair or use their own wheelchair in a circle formation. The series operated in eight-week blocks, was composed of primarily seated Iyengar yoga postures that focused on meditation, visualisation and physical exercises including sun salutations, upper limb stretches and core activation. Each class was 60 minutes in duration, and cost NZ\$12.50 to attend with an average of seven to ten participants.

Although adaptive yoga has been explored in different patient populations, the experiences of participants involved in a mixed-ability yoga series have not yet been described. Developing a better understanding of the experiences of those attending and what helps or hinders participation in a mixed-ability yoga class could inform programme refinements and development of a class template, that could be introduced into community leisure programmes and inform rehabilitation practice.

The specific aims of this study were to explore:

- a) how participants describe their experience of participating in a series of adaptive yoga classes, and
- b) the facilitators and barriers participants perceived to taking part in a series of adaptive yoga classes.

## METHODS

### Study Design

A qualitative approach was employed for this study as it is valuable for exploring the meaning of a particular phenomenon and appropriate for investigating the research questions (Giddings & Grant, 2007). Qualitative descriptive methodology can be used to develop practice insights, yield working hypotheses and for “assessing, developing and refining clinical interventions for vulnerable populations” (Sullivan-Boylai, Bova & Harper, 2005, p. 127; Neergaard et al., 2009).

### Participants

Inclusion criteria were that participants had a) attended at least two yoga classes in the last year and b) were able to give informed consent to be interviewed by a researcher. Exclusion criteria were those unable to give informed consent. Participants were recruited by personal invitation from the final eight-week block of classes in November 2015. Information sheets were provided and participants provided their details to researchers if they wished to participate. In total, seven participants were recruited from a pool of typically ten class members. Research participants will only be described in general terms to protect their anonymity (see Table 1).

Of the research participants, five out of seven had long term conditions including chronic pain, spinal cord injury, developmental disability, cardiopulmonary disease and musculoskeletal injuries. Participants were broadly representative of the yoga class members; all had participated in at least 2 sessions and several had participated in multiple sessions; and they came from any of the five series that occurred over the year. One of the yoga class members who participated in this study was a registered physiotherapist.

### Instructors

Two yoga instructors have been involved in running the yoga class at different times; both had experience making individual adaptations for disabled or older yoga students, though had not previously worked with a mixed-ability class. One yoga instructor took the classes during the study and was supported by physiotherapy students in providing adaptations for participants, done through touch or equipment including tennis balls for tactile cues, straps for increased stretching or blocks to change the base of the posture. All yoga class participants did the same positions at the same time and the class was delivered as a whole, though each posture was adapted to suit each individual's physical limitations. For example, the instructor would secure a belt around the waist of a wheelchair user attached to their chair to allow them to complete a forward bend without fear of falling and provide overpressure with their hands to increase the stretch.

### Data Collection

This study was undertaken from December 2015 to February 2016. The study was granted ethical approval by AUTECH (Application No. 15/ 269).

**Table 1: Description of participants**

Pseudonym	Age (years)	Main mobility aid		Long term health condition or impairment
		wheelchair	walker	
Maadi	60			
Maysie	71	yes		yes
Eve	72		yes	yes
Clementine	29	yes		yes
Poppy	54	yes		yes
Marita	57			
Anna	25			yes

Data were collected by way of face-to-face semi structured individual interviews as we anticipated that some participants may have sensory impairments such as hearing impairment, therefore individual interviews would best accommodate this. Interviews were conducted between December 2015 and January 2016, following the last block of classes for the year. Interviews were conducted in a conversational style, guided by an interview schedule (Appendix 1), audio recorded with consent and took up to 60 minutes in duration.

Following the completion of all interviews, all paper forms were scanned, converted to PDF files and stored electronically. Digital recordings were securely electronically stored. Interviews were transcribed using intelligent verbatim. Participants selected their own pseudonym, with all identifying features removed from transcribed data. Participants were given a gift voucher as koha for partaking in the study.

### Analysis

Thematic Analysis (TA) is an analytical approach to data analysis not tied to any particular theoretical framework that is used to find patterns across data sets, not just within them (Braun, Clarke & Terry, 2015; Braun & Clarke, 2006; Clarke & Braun, 2013). Familiarisation and coding of the transcribed data was completed by AB. KW coded the first two transcripts in conjunction with AB to facilitate rigor. Theme development using semantic and/or latent codes to identify similarities and differences across the data was completed by AB (Braun, Clarke & Terry 2015; Braun & Clarke, 2006). Theme generation was derived from the data, informed by the interview questions and codes from the data set by AB and agreed upon by all researchers (Braun & Clarke, 2006). Participants were not invited to provide feedback on the findings.

### FINDINGS

Four themes were identified in the data that related to participant's experiences and the facilitators and barriers to their participation in the mixed-ability yoga series. The themes were called: Engagement partnerships, Physical activity beliefs, Supported participation and Concepts of disability. Each of the four themes and associated notions are explained and supported by participant quotes from the data.

#### Theme One: Engagement Partnerships

This theme defined the context in which the mixed-ability yoga class occurred. All participants spoke of how the yoga class had been adapted to suit their personal needs and how these adaptations enriched their experience of participating in group physical activity. As Maysie suggested, *"You go at your pace and with your ability and that is a very important thing to be able to do because I can't think of another place where you can do that"*. Adaptations and use of equipment that were suggested by the yoga instructor facilitated participation, with Anna commenting that, *"I feel that she has a real understanding... she adapts it but she always kind of tries it out to see if this is going to work"*. This was suggestive of the trial and error technique of the yoga instructor, who helped participants tailor poses when they were unable to mimic the instructor. Others in the class took on roles to assist such as Marita (Marita is a class participant, however she is also a physiotherapist), who described her role in the class; *"I kind of watch bodies a lot"*

*and "sometimes giving the instructor feedback"* to enhance the experience of others in the class.

These experiences facilitated the development of participants' trust in the yoga instructor, empowering them to complete increasingly complex poses such as facilitated trunk rotations, with support from helpers. Eve stated, *"There's someone there, whether it's the trainer or ... someone who will help you to either complete something or do something or work out a different way of doing it"*. The balance of power in the instructor/participant relationship was considered equal as the instructor had knowledge of the practice and encouraged participants' knowledge of their bodies. The suggested adaptations encouraged participants to see beyond their own understanding of traditional yoga classes as only for able bodied individuals, which had previously been a barrier to involvement in physical activity. *"I was a bit surprised at the adaptations and the effect that they had, like, I wasn't quite sure what adaptive yoga meant really and I was, I was quite surprised that those small adaptations like placing somebody's body in position using a pillow... the effect that that had on people"* (Marita). Participants found their attitudes towards physical activity were altered following participation in the yoga series by highlighting what was considered important for the individual in regard to what constitutes physical activity.

#### Theme Two: Physical activity beliefs

Participants' beliefs about physical activity changed during the mixed-ability yoga classes, as they transcended the described complications and limitations of living with impairment(s), providing fundamental physical, mental and emotional benefits for the participants. These benefits were described by Clementine as having, *"...that complementary aspect of muscle movement, muscle relaxation, breathing exercises, all the kind of things to ease the chronic aspects of having a physical disability"*. These elements of yoga are typical of musculoskeletal and cardiorespiratory physiotherapy practice and in the context of the classes were considered part of a holistic view of the person rather than focus on their specific limitations.

Following participation in the yoga series, participants described increased confidence in their ability to perform activities of daily living and achieve self-determined goals. This confidence allowed them to overcome barriers to participation including ill health, *"I needed it this time more than ever since this last exacerbation, I have lost my confidence and this is why I made it a goal to get back to after I got over this"* (Eve). Other barriers described were previous bad experiences of physical activity that was not suited to participants' abilities, discussed by Maysie as *"wheelchair people don't lean forward too much, we don't go on the floor"*, and fear of injury.

Conservation of energy and the non-competitive environment were emphasised to make the yoga experience enjoyable. As Maysie said, *"We need to do it sitting down and it's amazing what you can do sitting down"*. The desire to maintain current levels of health and mobility was considered a favourable by-product of participation, particularly for those with unpredictable health conditions. Poppy indicated, *"I might not have improved but at least I'm maintaining as much mobility as I can"* [as a wheelchair user]. Despite differences in participants'

reasons for taking part in the series, participant accounts agreed that the emphasis of the series was on what a member could achieve in the classes. Maysie elucidated her thoughts as, "Everyone is going to do it how they can do it and to the best of their ability".

### Theme Three: Supported Participation

Central to this theme were accounts of a shared connection between the different members of the group as an unexpected benefit to the yoga series. Maysie suggested that, "it's a safe place in here and we're all doing stuff together because it's good for us, you know, it's helping us physically and it's making this wonderful connection with friends that you never would meet normally". Participants described their relationships with other group members and the yoga instructor as good friends with whom they shared a mutually rewarding experience.

The importance of individual preference was also emphasised with each participant having opportunities to voice any concerns, opinions or requests as part of the structure of the class, which Marita describes through the importance of "keeping up the time for a kind of reflection and discussion about what's going on for different people in the class". The group connection between members was identified as a key facilitator in participation and engagement in the yoga class, which Marita details, "by participating you become kind of a member ... of the team, and in that way you assist others to understand kind of their own body and yourself".

A sense of belonging through membership to the group was fostered among the participants and the concept of inclusion became fundamental to the ethos of the class as participants felt accepted by other class members, summarised by Clementine as, "come as you are". The sense of belonging felt by participants is discussed as, "when you have a disability you are perhaps in the minority, well you are normally, now in this set of circumstances, they are in the majority, which is rather nice" (Maadi).

### Theme Four: Concepts of disability

This theme emphasises the dynamic relationship that participants described between the physical limitations of their disability and their attitudes towards living with a disability. Clementine said, "I can still work, I can still contribute, but you don't, you often become quite distrustful of your body". Other participants discussed an initial fear of injury through doing yoga as a result of their body's inability to perform the demands of the tasks. This distrust resulted in perceived or actual limitations, which developed into psychological barriers to participation in physical activity. Barriers included perceptions of physical activity as unsafe or inaccessible to participants, in particular those in wheelchairs, as Poppy articulated, "I was concerned about the things, that the things, that I couldn't do and I was kind of wondering oh, that as I call it that kind of 'fear factor' comes in for me". This psychological and logistical barrier was overcome in the class as the instructor provided physical support to Poppy during poses, such as those that required weight shifting to facilitate the experience of the yoga pose.

In contrast, other participants spoke passionately about defying perceptions of experiencing disability. Through adaptation,

participants felt that the class offered a level playing field, as equipment was incorporated to promote participation in complex poses. Marita reflected how the use of equipment enabled members to participate meaningfully, "It surprised me that they, once they were in position with the yoga blocks and things, how it facilitated them to have an experience". For Marita, the use of blocks under her feet promoted correct posture and increased basal expansion.

Participation rather than performance was celebrated within the class as Clementine suggested, "You can still develop a confidence in your body and a confidence in being physically active even if it's a reduced capacity" and participants credited the mixed-ability yoga class with having, "...given me the strength to carry on with my life the way I am" (Maysie). This ethos was unique to what participants had experienced before in traditional exercise classes, which promoted functional outcomes as opposed to participation.

## DISCUSSION

The importance of appropriate adaptation through skilled yoga instructors for participants of the mixed-ability yoga series, facilitation of group cohesion and inclusion were key findings of this study. These components provided participants with a safe and accepting environment in which to participate in yoga and throughout the series, individuals' understanding and perceptions of what it meant to live with a disability were challenged. Participants reported the experience as positive and beneficial to their physical, mental and emotional health. All members of the group enjoyed the class, and learnt more about themselves and others as they worked towards personal and unspecified group goals. The findings of this study provide physiotherapists with a useful adjunct to consider to promote the health of disabled people. Similar examples are rare to find in physiotherapy practice however adapting activity to promote inclusion, group cohesion and participation may have significant value for disabled clients.

Our findings identified that the use of individualised adaptation by the yoga instructor encouraged engagement between the participants and allowed the members to achieve their version of the poses with support. Thus an approach of instructor-led adaptations should increase engagement to achieve self-determined goals. This is best implemented through open dialogue with clients to determine the focus of each class, time for comments and handouts for a home programme for clients to continue their practice independently or under supervision from a physiotherapist.

Our study identified inclusion as an important element in the development and continued success of the yoga series. Inclusion was actively developed at the beginning of the series when time was taken by the yoga instructor for introductions. This helped develop group cohesion, providing participants with a social support network and membership to a group, something that had previously been a barrier in other activity contexts. We suggest that this type of active inclusion could be used in other types of mixed-ability physical activity settings as research indicates that cohesion has been found to predict adherence within the context of group-based exercise programmes (Dunlop et al., 2012). It is apparent from our findings that the social

support received from fellow participants was important in facilitating participation and encouraged people to overcome barriers, such as low confidence. Making use of this approach could help physiotherapists promote participation in physical activity among patient populations and promote inclusion as a primary goal of any group-based rehabilitation intervention or exercise.

Adaptive yoga promoted participation in physical activity for individuals with varied physical limitations along the spectrum of disability. Among those participants who identified as having an impairment, the majority described their experience of disability as a challenging aspect of their lives. Following their participation in the yoga series, many participants felt empowered and reconsidered their experiences of disability, relating closely to the social model theory. The social model theory rests upon the distinction between disability, which is socially created, and impairment, which is a physical attribute of an individual's body (Corker & French, 1999; Strathern & Stewart, 2011). Initially, participants were concerned about safety, specifically fear of injury. Following their experiences in the series, participants credited the ability of the class to push the boundaries of what they thought was possible to achieve with their bodies prior to participation. The majority of participants found that their initial expectations were vastly different to what they experienced and their concerns were overcome through the course of the yoga series.

What constitutes physical activity for the participants does not meet ACSM recommendations however, for most their physical ability was limited and participation in adaptive yoga was perceived as valuable to their overall wellbeing. Similar findings were identified by Mudge, Kayes, Stavric, Channon, Kersten and McPherson, 2013, in which participants spoke of having a broader view of living well, including aspects of social, emotional and physical wellbeing as opposed to a view commonly emphasised by health professionals of physical activity for the prevention of obesity and long term health conditions.

A recommendation of this study is the importance of understanding a client's personal beliefs around their disability, specifically for managing rehabilitation expectations and goal setting. Additionally, finding appropriate physical activities will build confidence and independence through a holistic approach with the client at the centre of the rehabilitation team. This would be considered the primary goal of rehabilitation practice and services (Gibson et al., 2015).

### Study limitations

Limitations of this study were noted. The qualitative descriptive methodology can be considered less interpretive and more simplistic than other qualitative methodologies, although this critique often misunderstands the intent of the method to stay close to the participants' words (Sandelowski, 2010). The analytical process has been criticised as subjective as descriptions will depend on the researchers' perceptions, however this was mitigated through involving more than one researcher in the analytical process (Sandelowski, 2010; Neergaard et al., 2009). The role of KW in the development of the yoga series could be considered a potential bias in the study, however this was mitigated through AB recruiting, conducting interviews, and

leading analysis and the removal of identifying features of participants from transcripts.

### Implications and recommendations for research and clinical practice

No formal outcomes measures were used in this study therefore we cannot conclude any causal relationship between the classes and the benefits that participants experienced, however participants were consistent with their positive views of the class and made their own links between the class and any reported personal benefits. Our research suggests there is merit to further investigation regarding whether the benefits of the class were supported by its method of delivery as an intervention.

A key implication of this study for physiotherapists to consider is the value of using mixed-ability settings in their own practice to promote engagement and participation. Physiotherapists should have an understanding of clients' perception of disability, their thoughts and concerns about their physical limitations and self-efficacy. The importance of knowledgeable adaptive instruction was recognised to be a valuable facilitator to participation and inclusion was essential to developing a community within a physical activity class, providing benefits beyond the physical body. Physiotherapists should focus on building rapport and trust with clients, as our study concluded that when skilful and individualised adaptations were used, patients' self-efficacy increased and they were more likely to have increased engagement. An example in practice would be an inclusive activity such as Tai Chi for people with a range of impairments and health conditions, with support provided by physiotherapists to adjust the activity to their needs in a social community environment.

### CONCLUSION

This study provides an initial picture of the experiences, facilitators and barriers to participating in a mixed-ability yoga series in New Zealand. The findings indicate the suitability of mixed-ability yoga as a physical activity that could be encouraged among the disabled population and clinicians who work with them as an adjunct to rehabilitation therapy interventions. Participants' experiences provided indications of the health benefits of adaptive yoga and the importance of appropriate adaptation within an inclusive setting. Additionally, the mixed-ability yoga series model could be offered to consumers of group-based rehabilitation interventions or exercise programmes with a focus on increasing awareness of inclusion, adaptation and participation in physical activity.

### KEY POINTS

1. Individualised adaptation by those knowledgeable of the human body can increase self-efficacy and perceived benefits from participation in adaptive physical activity.
2. Emphasis should be placed on taking time for introductions within the group to promote inclusion and the development of a sense of increased engagement with group based community rehabilitation.
3. Clinicians should discuss clients' personal beliefs of their abilities or impairments and their expectations of participation in an adaptive activity.

4. The development of an inclusive and adaptive mindset from physiotherapists can enhance clients' outcomes beyond physical improvements.

## DISCLOSURES

Funding for this study was provided by Faculty of Health and Environmental Sciences at AUT University, through the Summer Student Research Award 2015/2016.

There were no conflicts of interest for the primary researcher or primary supervisor. A potential conflict of interest was identified for Kate Waterworth, who developed the initial mixed-ability yoga programme as well as being heavily involved in this research project. This was ameliorated by her not being involved in recruitment and strict management of de-identified transcripts for analysis.

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# Appendix 1

## Interview Guide

\*Introduce interview on record (i.e. Your name, date, time, location, pseudonym)

\*Begin Interview

Thanks so much for agreeing to participate in this research project/ interview.

- I wondered if you could start off by describing the (one) **yoga class for me** in your words (in detail),
- (Prompt to cover what happens when arrive, position (ie seat),
- **What is taught** (postures, meditation, breathing, any **adaptations** – who knows to adapt/ is helped?)
- Who takes what **roles**, layout, use of space, any changes week – week, any changes between series)
- What is there a certain feel to the room?
- **PUSH FOR EXAMPLES**

Did you meet anybody (teacher, PT/ OT/ student) before beginning a class? (Or talk on phone/ email).

What happened then/ there?

How did you find out about the series?

What made you **interested in coming along**?

Did you have **any concerns** before you began?

Were these addressed before you started or along the way (or unresolved)?

- In what way, how?

What do you particularly **enjoy about attending**? (What is it about that makes it better than the other parts of the class?)

What would you say are the benefits to you/what are you getting out of yoga?  
**SPECIFIC**

Do you think there are other benefits to other people in the class?

In what ways do you think attending the class has **been useful for you**?

Have you noticed any **'changes'/ improvements**?

(Body/ mind? Posture, breathing, mobility, function, physical activity, tension, mood, community/ friends network...)

Would you (do you) recommend the class to others/ friends? Why/ why not?

Do you think that there should be more opportunity for more members of the public to attend such a class? Why/ why not?

If you were organising the class, what would you do **differently**?

Are there **any changes** you would like to see in the class in the future?

Are there any aspects of the class/ series that you think could be improved?

**Hypothetically, if the class were to be altered**, would you take anything out?

Had you any experience of yoga before these classes? What?

**Other physical activity involvement?**

Do you consider yoga to be physical activity?

Any involvement in adaptive/ inclusive/ mixed ability activities? (Happy with these terms?)

What, why, benefits, challenges? (Do you relate that to yoga?)

Any changes in physical activity involvement since beginning yoga? (Type, frequency, duration)

How does **yoga compare to other physical activities**?

Do you have a sense that your physical fitness has changed as a result of the class? In what ways?

How about **function**? (Is anything getting easier to do?)

Any other changes to body structures? (Strength, flexibility etc)

**On the days you come to the class, what does your morning consist of/ look like?**

**Is there anything in your morning schedule that makes it easy/difficult to come to the class?**

Is it **easy** for you to attend the class? What do you need to do to make it happen?

What **helps** you to attend the class (transport, cost, other people, location, attitude)

Do you come by yourself or with someone?

Are there any days that you don't make it? Why not? → **Imagine** if you weren't able to come?

Are there any **general obstacles** to your attendance? How do you manage these?

What things would make it easier/ make you more likely to attend?

Is there any person/people who help you with coming to the class?

Would anything make a **significant difference** (so that you would definitely be able to go)? What about for other people?

\*\* When closing (decision making – why do you decide to go to yoga?)

Overall how would you **sum up your experience** in one sentence?

Anything you think it is important for **health professionals** (PT/OT/Dr) to know about this experience/ type of experience?

(Comparing with rehab/therapy/ alternative therapies)

How long do you think you will be participating in yoga for?

Anything else you would like to add/ share?

Thanks so much.

# Measuring lateropulsion following stroke: a feasibility study using Wii Balance Board technology

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## ABSTRACT

The aim of this pilot study was to determine the feasibility and utility of using Wii Balance Board-derived centre of pressure data as measures of balance in people with lateropulsion following stroke. Ten individuals with lateropulsion, between one and twelve weeks post stroke, participated in this study. Participants were assessed on four occasions over a two-week period, performing a number of tasks sitting and standing on the Wii Balance Board, in addition to clinical measures. Feasibility was determined by participant retention and the percentage of testing occasions ceased prematurely. Clinical utility was explored through visual analysis of the Wii Balance Board-derived data. Participant retention was 100%. Cessation of testing due to discomfort or fatigue occurred 20% of the time. For the static balance tasks, mediolateral amplitude emerged as a variable of interest. Wii Balance Board-derived centre of pressure data from static sitting and standing tasks appeared to capture useful information about individuals with varying degrees of lateropulsion and displayed change over time. The use of Wii Balance Board technology as a measure for balance in individuals with lateropulsion appears feasible. A larger measurement study is required to establish the reliability and validity of this technology in this important clinical sub-group.

**Birnbaum, MA., Brock, K., Clark, RA., Hill, KD. (2018) Measuring lateropulsion following stroke: a feasibility study using Wii Balance Board technology. *New Zealand Journal of Physiotherapy* 46(1): 36-42. doi:10.15619/NZJP/46.1.06**

Key words: Lateropulsion, Stroke, Feasibility, Centre of pressure.

## INTRODUCTION

Lateropulsion following stroke is a distinct disorder of postural control, where individuals have an altered perception of body verticality (Perennou et al., 2008). People with lateropulsion push themselves toward their paretic side, and actively resist passive correction of the altered posture back to or beyond midline (Davies, 1985; Perennou et al., 2008). At its most severe, lateropulsion prevents individuals from being able to sit independently and can affect rehabilitation outcomes (E. Clark, Hill, & Punt, 2012; Danells, Black, Gladstone, & McIlroy, 2004).

There is limited research about the measurement and rehabilitation of individuals with lateropulsion following stroke. Measurement scales have primarily been used to assess postural control in this patient population (Koter et al., 2017). While force platforms are considered the gold standard for measuring postural control in various clinical groups, these are not readily available within the clinical environment.

The Nintendo Wii Balance Board (WBB) is a portable, inexpensive device, which when operated with customised software, may

be used to capture data such as centre of pressure (COP) in the clinical setting. The main advantage of the WBB over laboratory-based systems is the ability for it to be taken to individuals with lateropulsion early following stroke. The WBB has been shown to be reliable (Chang, Levy, Seay, & Goble, 2014; R. A. Clark et al., 2010; Scaglioni-Solano & Aragon-Vargas, 2014), can acquire comparable data to a laboratory force platform when assessing standing balance (Chang et al., 2014; R. A. Clark et al., 2010; Scaglioni-Solano & Aragon-Vargas, 2014), and has been used to assess seated postural control in people with severe knee osteoarthritis (Pua et al., 2013). Whilst no studies have investigated the use of WBB technology with stroke survivors with lateropulsion, the use of this technology with this patient population may provide a greater understanding of the postural control deficits experienced by individuals with lateropulsion. This would enable physiotherapists to focus therapy targeting the identified postural control deficits with stroke survivors with lateropulsion. The delivery of more effective physiotherapy for recovery of lateropulsion has the potential to promote better outcomes, decrease hospital length of stay and reduce long term dependency in the community.

Given lateropulsion significantly impacts on an individual's balance abilities in sitting and standing, it is important to establish the feasibility of using WBB technology to capture COP data with these individuals prior to undertaking a longitudinal measurement study. The purpose of this study was to investigate the feasibility and utility of using a WBB to assess postural control in sitting and standing in individuals with lateropulsion early following stroke. This will then inform a larger longitudinal study with the aim to establish the reliability and validity of this novel technology in this important subgroup of stroke survivors.

## METHODS

### Participants

Individuals between one and twelve weeks post stroke who demonstrated signs of lateropulsion (score of two or more on the Burke Lateropulsion Scale) (Babyar, White, Shafi, & Reding, 2008) were recruited following admission to the Stroke and Rehabilitation Units of St. Vincent's Hospital Melbourne. Other inclusion criteria were: (1) able to sit with back and arm support for three seconds; (2) follow at least a one stage command verbally or with gesture; (3) tolerate a 20 minute physiotherapy session; and (4) provide informed consent. Exclusion criteria were pre-existing co-morbidity limiting community mobility

(defined as a Functional Ambulation Classification of less than six) (Holden, Gill, & Maglozzi, 1986) and weight greater than 112 kilograms due to weight restrictions of the transfer bench utilised for the sitting tasks. To ensure testing occurred with individuals across a spectrum of functional abilities, ten participants were recruited, including at least three individuals with more severe stroke who were unable to stand at the first assessment. The study was approved by the human research ethics committees of participating institutions. Written consent was obtained from all participants prior to inclusion.

### Procedures

Participants were assessed sitting on a WBB that was securely fastened to a transfer bench. Individuals were initially assessed sitting with and without arm support. If able, participants then performed a series of dynamic sitting balance tasks, including reaching sideways and picking up an object from behind (Gorman, Radtka, Melnick, Abrams, & Byl, 2010). For participants who could stand, balance was also assessed standing on a WBB. Standing tasks included standing with and without arm support, and a number of dynamic tasks such as looking behind while standing (Berg, Maki, Williams, Holliday, & Wood-Dauphinee, 1992). A full list of the included tasks in sitting and standing can be found in Table 1.

**Table 1: Balance tasks performed in feasibility study, and an abbreviated assessment suite for future research**

Tasks performed in feasibility study	Recommended future abbreviated task set
<p>Sitting</p> <ul style="list-style-type: none"> <li>• Sit with arm</li> <li>• Sit without arm</li> <li>• Shift weight to non-paretic side</li> <li>• Shift weight to paretic side</li> <li>• Sitting eyes closed</li> <li>• Arm raise test</li> <li>• Reaching sideways</li> <li>• Picking up object from behind</li> </ul>	<p>Sitting</p> <ul style="list-style-type: none"> <li>• Sit with arm</li> <li>• Sit without arm</li> <li>• Reach for cup in front within arm's length</li> <li>• Reach for cup on non-paretic side beyond arm's length</li> </ul>
<p>Standing</p> <ul style="list-style-type: none"> <li>• Stand using arm</li> <li>• Stand without arm</li> <li>• Shift weight to non-paretic leg</li> <li>• Shift weight to paretic leg</li> <li>• Standing eyes closed</li> <li>• Turning head while standing</li> <li>• Standing feet together</li> </ul>	<p>Standing</p> <ul style="list-style-type: none"> <li>• Stand using arm</li> <li>• Stand without arm</li> <li>• Reach for cup in front within arm's length</li> <li>• Reach for cup on non-paretic side beyond arm's length</li> <li>• Sit to stand</li> <li>• Standing feet together</li> </ul>

The WBB yields measures of COP similar to those obtained from a laboratory force platform (R. A. Clark et al., 2010). Centre of pressure is defined as the location of the vertical ground reaction force from a platform and is considered the neuromuscular response to movement of the centre of mass (Winter, 2009). The WBB was wirelessly connected to a laptop via Bluetooth, controlled by custom-programmed software similar to a freely available version ([www.rehabtools.org](http://www.rehabtools.org)) and

sampled COP data at the native frequency of approximately 40Hz. Data were acquired from each of the four load sensors, lowpass filtered at 10Hz, resampled to 100Hz using spline interpolation, and lowpass filtered again at 6.25Hz to attenuate signal noise as per Clark et al. (2017). Prior to testing, the Wii Balance Board was calibrated by placing a series of known loads on each of the four load sensors, creating the force calibration, then applying loads at known positions to calibrate for the

centre of pressure positions. This was done in accordance with a previously described protocol (Clark, RA. et al., 2010). The WBB generated a number of output variables of interest, including total, mediolateral and anteroposterior COP path velocity.

In addition to the instrumented measures, a series of clinical measures were performed including the Burke Lateropulsion Scale (D'Aquila, Smith, Organ, Lichtman, & Reding, 2004), the Postural Assessment Scale for Stroke (Benaim, Perennou, Villy, Rousseaux, & Pelissier, 1999) and the Functional Independence Measure (motor domain) (Dodds, Martin, Stolov, & Deyo, 1993). Instrumented and clinical measures of lateropulsion and postural control were taken on day one and day two, and then repeated a fortnight later (day 14 and day 15).

### Outcomes

Feasibility was assessed by participant retention, and adherence to assessment procedures, with thresholds set at 80% (Oxford Centre for Evidence-Based Medicine. Levels of Evidence, 2009). Occasions where testing was required to be stopped prematurely at the request of patients (e.g. fatigue or discomfort) were also recorded. Wii Balance Board-derived COP data were analysed visually by graphing performance for each condition and individual over the four testing occasions to investigate clinical utility, and as a first step examination of responsiveness.

### Data analysis

Demographic data of participants was presented using descriptive statistics including median, interquartile range and frequency. For centre of pressure variables, including anteroposterior amplitude, mediolateral amplitude and total path velocity, median and interquartile range were calculated for each task for day 1 and day 15 data. Percentage change was also calculated and is the difference between day 15 and day 1 scores divided by the day 1 score. Statistical analyses could not be performed due to the small sample size included in this study.

### RESULTS

Ten individuals participated in this study between April and November 2014, including three individuals who were unable to stand initially. The median (range) age of participants was 66.5 (42-89) years and the time of the initial assessment post stroke was 24 (15-44) days. Three of the 10 participants had Burke Lateropulsion Scale scores indicating moderate (n=2) or severe (n=1) lateropulsion. The median Functional Independence Measure (motor domain) score at initial assessment was 32. Other baseline characteristics for participants are summarised in Table 2.

Participant retention for the study was 100%, with all 10 participants completing data collection on all four testing occasions. The median time taken to complete the instrumented measures was 27.5 minutes for both day 1 (range 5-45 minutes) and day 15 (range 5-35 minutes) assessment occasions. Testing was ceased prematurely due to discomfort sitting on the WBB for a prolonged period of time (two participants, 7.5% of assessment occasions) and due to fatigue (two participants; 12.5% of assessment occasions). Table 3 outlines the participants' ability to complete each test item during the day 1 assessment session.

**Table 2: Baseline characteristics of participants**

Variable*	
Age (years)	66.5 [59-75]
Time post stroke (days)	24 [20-30]
Gender, male	4 (40%)
Side of hemiparesis, left	7 (70%)
Pathology	
Infarct	4 (40%)
Haemorrhage	2 (20%)
Both	4 (40%)
Severity of lateropulsion (BLS scores)	4.5 [3-11.5]
Mild (2-8)	7 (70%)
Moderate (9-12)	2 (20%)
Severe (13-17)	1 (10%)
PASS scores	21.5 [11-24]
FIM Motor scores	32 [24-38]

Notes: BLS, Burke Lateropulsion Scale; D1, Day 1; FIM, Functional Independence Measure; PASS, Postural Assessment Scale for Stroke. \*Values are median [interquartile range] or frequency (percentage) unless specified

Sitting using arm support was the only task that could be completed by all participants on each testing occasion. Two participants with moderate lateropulsion were unable to complete all of the dynamic sitting tasks initially but could do so by day 15. The participant with severe lateropulsion was unable to perform any dynamic tasks nor sit without arm support over the two week testing period. The seven individuals with mild lateropulsion could successfully perform all sitting tasks on each testing occasion. Six of these individuals could also be assessed standing at initial assessment. No participants could perform all of the included standing tasks day one, however five individuals could do so by day 15. Overall, nine participants progressed to being able to perform tasks on day 15, which they could not complete initially. No adverse events or falls occurred during the testing sessions.

Centre of pressure data is presented in Table 4. For the static sitting and standing tasks, mediolateral amplitude displayed greatest capacity for change over the study period. Visual examination of the COP graphs revealed that pronounced COP variability was observed when individuals were performing balance tasks at the upper end of their level of ability. Three participants showed instability with static sitting initially, with COP variability reducing two weeks later. An example of this for a participant with moderate lateropulsion sitting without arm support is provided in Figure 1(a). Of the six participants who could perform the static standing tasks initially, four displayed marked instability on day one, which improved by day 15. An example of this for a participant with mild lateropulsion standing unsupported can be found in Figure 1(b). As these figures

**Table 3: Participants' ability to complete each test item (✓) or not (x) (day 1)**

Participant number	Severity*	Sitting test number†								Standing test number‡						
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7
1	Mild	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	x	x
2	Mild	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x
3	Mild	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	x	x
4	Moderate	✓	✓	x	x	x	x	x	x	x	x	x	x	x	x	x
5	Mild	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	x
6	Mild	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x
7	Moderate	✓	✓	✓	✓	✓	✓	x	✓	x	x	x	x	x	x	x
8	Severe	✓	x	x	x	x	x	x	x	x	x	x	x	x	x	x
9	Mild	✓	✓	✓	✓	✓	✓	✓	x	x	x	x	x	x	x	x
10	Mild	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x

Notes: \* Rated by BLS scores; † Sitting test 1=sit with arm support; test 2=sit no arm support; test 3=sit shift weight non-paretic; test 4=sit shift weight paretic; test 5=sit eyes closed; test 6=sit arm raise test; test 7=sit reaching sideways; test 8=sit pick up object from behind; ‡ Standing test 1=standing with arm support; test 2=standing without arm support; test 3=stand shift weight to non-paretic leg; test 4=stand shift weight to paretic leg; test 5=stand eyes closed; test 6=turn head while standing; test 7=standing feet together.

demonstrate, the mediolateral COP amplitude measure showed a greater level of initial variability and displayed a greater capacity for change over time compared to the anteroposterior COP amplitude measure for both the static sitting and standing tasks. The variability observed for the dynamic tasks in both positions was more difficult to interpret in the absence of normative data. This was further confounded by the nature of some of the included dynamic tasks. For example, participants were asked to reach sideways as far as possible in sitting. The use of maximal reach rather than reach to a pre-determined target was found to introduce further variability between trials. Weight bearing symmetry could not be measured due to difficulty accurately aligning the participants to the centre of the WBB for testing.

## DISCUSSION

The aim of this study was to determine the feasibility of using WBB technology as a novel measure of postural control in individuals with varied severity of lateropulsion. The use of the WBB for this purpose was shown to be feasible with no drop-outs. However, the higher rate of premature cessation of testing from fatigue or discomfort indicates that the number of tasks could be reduced to minimise this and optimise data completeness. Based on the study findings, an abbreviated task set for future research using the WBB for stroke survivors with lateropulsion has been recommended (Table 1).

The WBB-derived mediolateral COP variability measures obtained from the static sitting and standing tasks appeared to capture useful information regarding postural control for individuals with varying degrees of lateropulsion and detect change over time. The COP data reveals that the balance control mechanisms are very active in these individuals in balance tasks that are possible but difficult, without the individual finding a stable balance point. As they improve, they are able to achieve improved balance stability in the task.

Use of WBB technology for this purpose is not without its limitations. These include the need for specific equipment and training, including a computer, customised software and modified transfer bench, and the cost associated with this; as well as the potential issues that may arise when utilising Bluetooth and battery operated systems. Force platforms are considered a gold standard for measuring postural alignment in static and dynamic tasks. However they are expensive, and generally not available in rehabilitation in-patient and out-patient services for patients with stroke. The WBB as utilised in this study, is cheap, (less than \$AUD 200), portable, easily stored, and requires minimal training for use compared to standard types of force platforms.

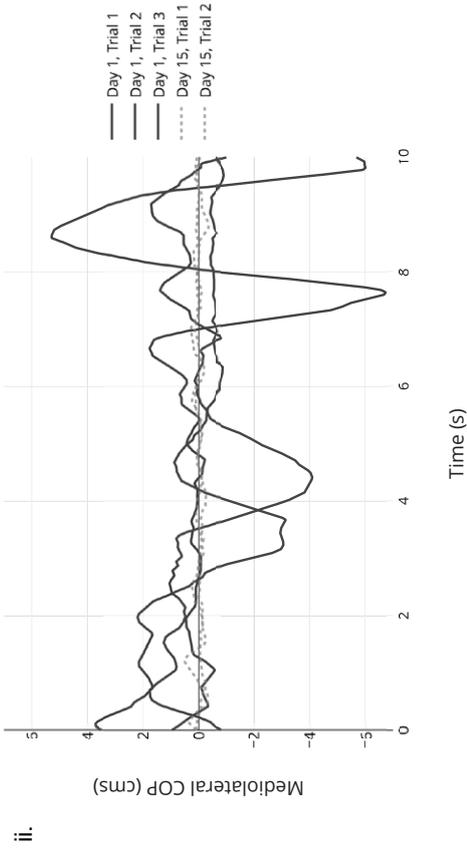
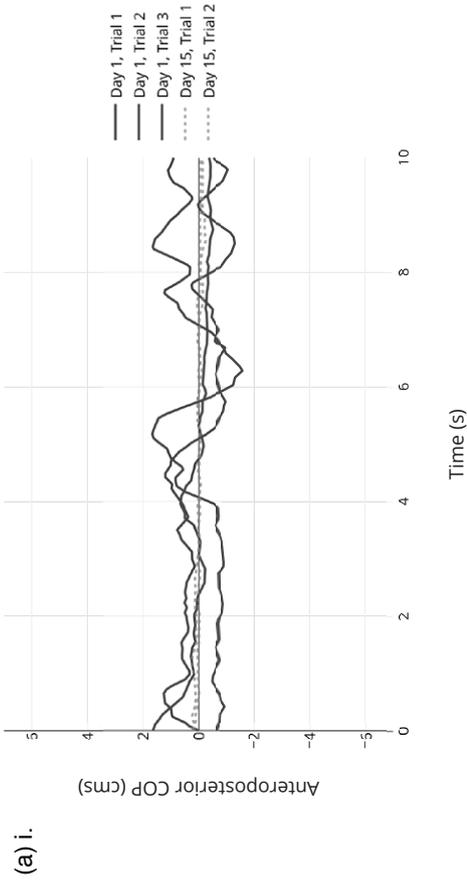
A number of limitations need to be considered when interpreting the results of this pilot study. Firstly, the small sample size restricted the ability to perform statistical analyses

**Table 4: Centre of pressure data (median [interquartile range] or median (range))**

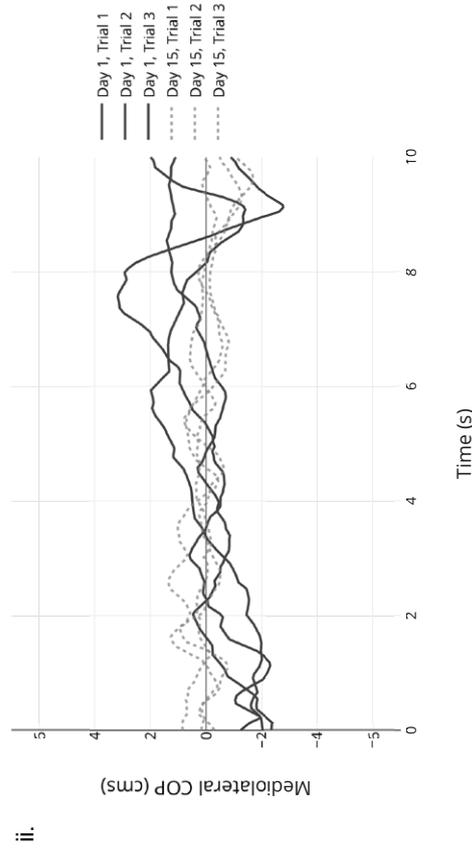
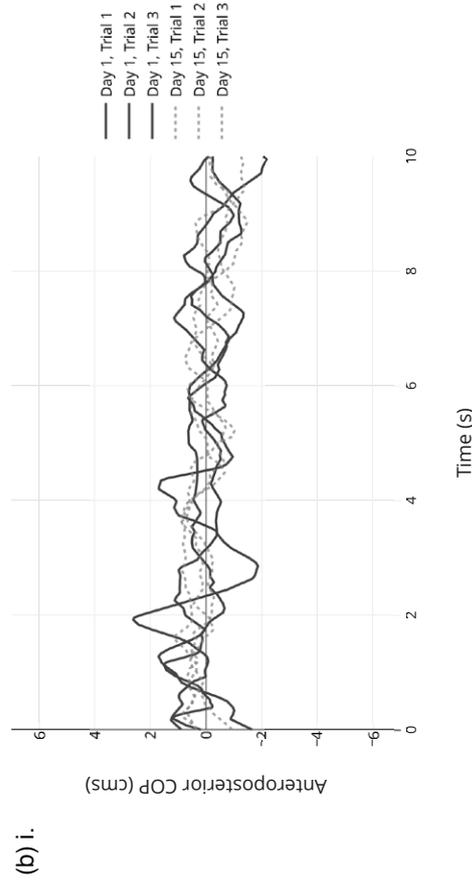
Task	n	D1			D15			Percentage change		
		AP amplitude	ML amplitude	Total path velocity	AP amplitude	ML amplitude	Total path velocity	AP amplitude	ML amplitude	Total path velocity
<b>SITTING TASKS</b>										
Sit with arm support	10	0.46 [0.22,0.73]	0.47 [0.25,0.92]	0.72 [0.58,1.54]	0.33 [0.24,0.44]	0.35 [0.22,0.52]	0.56 [0.44,0.69]	-28% [9%,-39%]	-25% [-13%,-44%]	-22% [-24%,-55%]
Sit no arm support	9	0.38 [0.32,1.54]	0.75 [0.39,3.43]	0.69 [0.49,2.57]	0.38 [0.32,0.56]	0.48 [0.31,0.60]	0.47 [0.40,0.68]	-1% [-2%,-64%]	-36% [-20%,-82%]	-32% [-18%,-74%]
Shift weight- NP	8	1.18 [0.87,1.32]	5.62 [4.10,7.02]	1.65 [1.42,2.43]	1.42 [0.63,1.66]	6.34 [4.66,8.50]	1.76 [1.06,2.03]	20% [-27%,26%]	13% [14%,21%]	6% [-26%,-17%]
Shift weight- P	8	1.43 [0.86,1.01]	5.86 [2.98,4.26]	1.35 [1.24,1.31]	1.69 [0.76,2.62]	8.26 [3.41,8.81]	1.52 [0.94,2.10]	18% [-12%,159%]	41% [15%,107%]	12% [-24%,61%]
Sitting eyes closed	7	0.50 [0.43,0.62]	0.72 [0.61,1.15]	0.60 [0.51,0.79]	0.33 [0.28,0.55]	0.52 [0.44,1.01]	0.55 [0.48,0.61]	-34% [-35%,-12%]	-28% [-28%,-12%]	-8% [-6%,-22%]
Arm raise test	7	1.47 [0.93,1.52]	2.47 [1.06,3.72]	1.89 [1.38,3.63]	1.54 [0.85,2.20]	2.54 [1.50,3.94]	2.69 [1.32,4.48]	5% [-8%,44%]	3% [4%,6%]	42% [-4%,24%]
Reaching sideways	6	1.38 [0.77,1.82]	7.41 [5.58,9.03]	1.72 [1.60,2.28]	1.69 [1.00,2.18]	7.88 [5.94,11.29]	1.74 [0.94,2.10]	22% [30%,19%]	6% [6%,25%]	1% [-41%,-8%]
Pick up object	7	2.01 [1.17,2.44]	3.38 [2.63,4.89]	1.80 [1.31,2.76]	1.49 [1.03,2.16]	4.08 [3.20,5.17]	1.74 [1.25,2.46]	-26% [-13%,-11%]	21% [21%,6%]	-3% [-4%,-11%]
<b>STANDING TASKS</b>										
With arm support	6	2.03 [1.30,2.23]	1.89 [1.02,2.17]	1.31 [1.25,1.49]	1.59 [1.05,1.80]	0.87 [0.57,1.10]	1.10 [0.89,1.33]	-22% [-19%,-19%]	-54% [-44%,-50%]	-16% [-29%,-10%]
Without arm support	6	2.80 [2.61,3.34]	4.00 [2.27,5.09]	2.70 [2.24,2.92]	2.89 [2.35,3.45]	2.55 [1.61,4.13]	2.92 [1.63,3.07]	3% [-10%,3%]	-36% [-29%,-19%]	8% [-27%,5%]
Shift weight- NP	6	3.51 [3.03,4.74]	4.27 [3.68,5.14]	3.01 [2.82,3.88]	3.97 [2.33,6.61]	5.63 [3.34,7.05]	2.91 [2.45,4.13]	13% [-23%,39%]	32% [-9%,37%]	-3% [-13%,6%]
Shift weight- P	4	4.88 [3.69,6.24]	6.94 [4.77,8.62]	3.88 [3.31,4.67]	3.72 [2.28,5.11]	8.22 [4.97,9.05]	3.65 [2.87,4.96]	-24% [-38%,-18%]	18% [4%,5%]	-6% [-13%,6%]
Eyes closed	3	4.13 [2.91,5.34]	3.37 [1.47,3.73]	3.16 [3.16,5.85]	3.52 [2.76,3.86]	2.50 [2.08,3.21]	3.21 [2.39,3.77]	-15% [-5%,-28%]	-26% [41%,-14%]	1% [-24%,-36%]
Turn head	3	6.14 [3.00,9.58]	2.50 [2.42,10.05]	3.64 [2.87,11.94]	6.86 [3.72,7.49]	6.03 [3.01,6.45]	5.35 [3.68,6.77]	12% [24%,-22%]	142% [25%,-36%]	47% [28%,-43%]
Feet together	0				2.91 (2.49,4.00)*	3.52 (2.86,4.42)*	3.41 (2.62,4.06)*			

Notes: AP, Anteroposterior; D, Day; ML, Mediolateral; NP, non-paretic side; n, number; P, paretic side; Values are median [interquartile range] or (range); Percentage change calculated by  $\frac{D15 - D1}{D1}$   
\* only three measures available

## AP



## ML



**Figure 1: Centre of pressure (COP) movement variability over time (seconds) for (a) task of sitting without arm support for a participant with moderate lateropulsion; (b) standing unsupported for a participant with mild lateropulsion. Interactive versions of these figures are available to view online at <http://www.rehabtools.org/pusher-syndrome-balance.html>.**

**(a) Sitting without arm support for a participant with moderate lateropulsion:**

i. Anteroposterior (AP) COP movement variability Day 1 (average AP amplitude 2.65; average AP path velocity 1.20) and Day 15 (average AP amplitude 0.38; average AP path velocity 0.29)

ii. Mediolateral (ML) COP variability Day 1 (average ML amplitude 8.27; average ML path velocity 2.74) and Day 15 (average ML amplitude 0.76; average ML path velocity 0.60)

**(b) Standing unsupported for a participant with mild lateropulsion:**

i. AP COP movement variability Day 1 (average AP amplitude 3.64; average AP path velocity 1.92) and Day 15 (average AP amplitude 2.42; average AP path velocity 1.27)

ii. ML COP movement variability Day 1 (average ML amplitude 4.61; average ML path velocity 1.40) and Day 15 (average ML amplitude 2.19; average ML path velocity 0.99)

As these figures demonstrate, postural instability was present for both individuals on day one for the different tasks, particularly in the mediolateral plane. The postural instability observed improved for both participants in both directions over the two-week period. This corresponded with an improvement in the individuals' lateropulsion measures."

in this study. Secondly, although 100% retention was achieved, some participants did find the tasks fatiguing, and / or caused discomfort, which may limit the utility of this approach in some patients with stroke. Thirdly, the nature of some of the included dynamic tasks introduced further variability between trials, which had not been anticipated. The abbreviated task set developed for future research includes standardised tasks with pre-determined targets in order to minimise this (Table 1). Finally, the absence of normative values for the balance tasks included also made it difficult to interpret the WBB-derived data, particularly for the dynamic tasks. Given the promising results of the feasibility study, the research team have commenced a normative data collection project with the abbreviated task set presented in Table 1 to address this need.

## CONCLUSIONS

The use of WBB technology appears feasible to assess sitting and standing balance in individuals following stroke with lateropulsion using a reduced number of modified tasks, structured to minimise variability between trials due to task performance. A larger longitudinal measurement study is required to establish the reliability and validity of this technology in this important clinical sub-group. Given laboratory-based systems are often inaccessible to this patient population, use of WBB technology may provide a greater insight into the postural control deficits experienced by individuals with lateropulsion, which cannot be obtained from clinical measures alone.

## KEY POINTS

1. The use of Wii Balance Board technology appears feasible to assess sitting and standing balance in individuals following stroke with lateropulsion undergoing rehabilitation.
2. Using Wii Balance Board technology as a research tool may capture useful information about balance in individuals with lateropulsion, and inform future physiotherapy trials investigating the effectiveness of specific interventions targeting lateropulsion.

## DISCLOSURES

This work was supported by the St Vincent's Hospital, Melbourne Research Endowment Fund [grant number 25.2012] and through an Australian Government Research Training Program Scholarship. The Authors declare that there is no conflict of interest.

## PERMISSION

The study was approved by the human research ethics committees of St. Vincent's Hospital Melbourne (LRR 084/13) and Curtin University (HR 174/2013). Written informed consent was obtained from all participants prior to inclusion.

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## Handball load and shoulder injury rate: a 31-week cohort study of 679 elite youth handball players.

**Moller, M., Nielsen, R. O., Attermann, J., Wedderkopp, N., Lind, M., Sorensen, H., & Myklebust, G. (2017). Handball load and shoulder injury rate: a 31-week cohort study of 679 elite youth handball players. *British Journal of Sports Medicine*, 51(4), 231-237. doi:10.1136/bjsports-2016-096927**

### OBJECTIVE

The aim of this study was to investigate the association between load, physical attributes (strength, range of motion [ROM], and scapular dyskinesia) and shoulder pain in junior handball athletes.

### METHODS

A cohort study of 679 junior elite handball players. Primary outcome measures were shoulder strength (internal rotation, external rotation and abduction), ROM (internal and external rotation) and scapular dyskinesia. Following assessment, participants were categorised into "abnormal" or "normal" groups depending on the outcome of the tests. Over 31 weeks the players were monitored weekly for shoulder pain and load. An increase in weekly training and match load relative to the previous four weeks was categorised into three groups: (1) load increase of less than 20% (reference group); (2) load increase of 20% < 60%; and (3) load increase of more than 60%. The association between load, physical attributes and injury were examined.

### RESULTS

Compared to the reference group there was a clear association between shoulder injury and an increased load of 20% in players with either reduced external rotation strength (hazard ratio [HR] 4.0; 95% confidence interval [CI] 1.1 to 15.2,  $p=.04$ ) or scapular dyskinesia. (HR 4.8; 95% CI 1.4 to 12.8,  $p=.01$ ) There was also a clear association between shoulder injury and load in groups that increased their loading by more than 60% (HR 1.91; 95% CI 1.0 to 3.70,  $p=.05$ ).

### CONCLUSION

Large increases in shoulder load are clear contributors to shoulder injury in this sample of adolescent handball players. Athletes with reduced external rotational strength and scapular dyskinesia have heightened sensitivity to shoulder injury with smaller increases in load.

### COMMENTARY

Shoulder pain is a common injury in elite handball players with the average weekly prevalence being approximately 28% during the season (Clarsen, Bahr, Andersson, Munk, & Myklebust, 2014). This condition is also highly prevalent in other throwing and overhead sports such as baseball (Amin et al., 2015). In terms of shoulder injury, load and physical attributes such as scapular dyskinesia, reduced strength and glenohumeral ROM are independent risk factors for injury (Amin et al., 2015; Clarsen et al., 2014; Drew & Finch, 2016; Hulin, Gabbett, Lawson, Caputi, & Sampson, 2016). This however, is the first study to investigate a combination of physical attributes and load and their impact on shoulder injuries.

Pre- and post-season screens were conducted on 679 junior handball athletes who were then categorised into abnormal and normal groups for shoulder strength, ROM and scapular function. Loading and shoulder pain data were collected through the season (31 weeks) using a SMS reporting system (SPEX sports injury surveillance system). Prior to the study, strength (dynamometry) and ROM (inclinometry) measures were deemed reliable through a separate pilot, with the ICC test-retest coefficients all being high (0.95-0.99). Measures of scapular stability had already been examined in a previous reliability study.

This study was of high quality with a large sample size and inclusion of reliable outcome measures. There were however a few limitations. The athletes had to self-report episodes of shoulder pain using a text system and although the response rate was high (88-97%) episodes may have been missed that otherwise may have been reported by a physiotherapist. Random measurement error may have also been present with the categorisation of the physical attributes. The authors reported no systemic bias with their methodology or the four selected physiotherapists that carried out the testing.

Over the season 68 injuries were sustained to the dominant arm. Analysis of the injuries showed that a large increase in exposure/load to handball (>60%) increased the shoulder injury risk (HR 1.91; 95% CI 1.0 to 3.70,  $p=.05$ ). This has been supported in previous literature in multiple other sports such as Australian football and rugby league (Drew & Finch, 2016; Hulin et al., 2016). However, the most clinically relevant finding of that study was those athletes with reduced external rotation strength/scapular dyskinesia who increased their weekly load between 20% and 60%, were between 4.0 (HR 4.0; 95% CI 1.1 to 15.2  $p=.04$ ) and 4.8 (HR 4.8; 95% CI 1.4 to 12.8  $p=.01$ ) times more likely to sustain an injury when compared to the reference group.

The clinical implications of this paper are significant as it highlights the interaction of risk factors against load. The authors have identified reduced external rotation strength and scapular dyskinesia as the most important physical risk factors that affect shoulder pain in junior handball athletes. Glenohumeral external rotation strength is a risk factor that can be easily addressed through a strengthening programme and accurately measured using the author's dynamometry testing protocol. Dynamometry for strength measurement is becoming a more accessible tool for physiotherapists and can provide a numerical value to help athletes with setting and achieving goals. The findings of this study are relevant to recent literature that supports the use of strengthening exercises to reduce the prevalence of shoulder injuries in handball athletes (Andersson, Bahr, Clarsen, & Myklebust, 2016). The scapular dyskinesia risk factor is slightly harder to address as there are many more variables to consider;

however, if other risk factors could not be addressed, it would be advisable that a more conservative approach to loading is recommended (<20% weekly increase in load).

Shoulder injuries are common in throwing athletes. However, identification of reduced external rotation strength and scapular dyskinesia, accompanied by load modification for athletes with these risk factors, may contribute to reducing the prevalence of injury.

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