Bournemouth University

MS Society

Poole Hospital NHS
NHS Foundation Trust

Exergames in Neurorehabilitation

Dr Sarah Thomas
Bournemouth University Clinical Research Unit, UK

Mii-vitaliSe team members

Bournemouth University

Prof Peter Thomas (Epidemiologist & Statistician)

Dr Louise Fazakarley (Physiotherapist; Senior Lecturer)

Poole Hospital NHS Foundation Trust

Dorset MS Service:

Dr Charles Hillier (neurologist & lead of service); Sarah Collyer, Sarah Brenton (MS specialist physiotherapists)

Medical Physics:

Dr Steve Perring (Clinical Scientist)

Hull University

Prof Kathleen Galvin (qualitative expertise)

External advisor (creator of Wii-habilitation website)

Rebecca Scott

Service users

Jo Hickson and Kelly Jones

Bournemouth University

Acknowledgements

- This research was funded by the Multiple Sclerosis Society of the UK and Northern Ireland

- This study was approved by NRES Committee South Central - Southampton B (ref 12/SC/0420) (ISRCTN49286846)

- Safety Monitoring Committee members

Dr Mark Cossburn (neurologist); Kate Jupp (neurophysiotherapist)

Thanks to workshop participants & those who participated in the Mii-vitaliSe feasibility study

Barriers to traditional rehabilitation

- Access to facilities, accessibility and other ergonomic problems associated with the built environment
- Socio-environmental issues, motivational/psychological factors
- High costs of equipment for exercise/sports participation
- Boredom associated with conventional exercise equipment

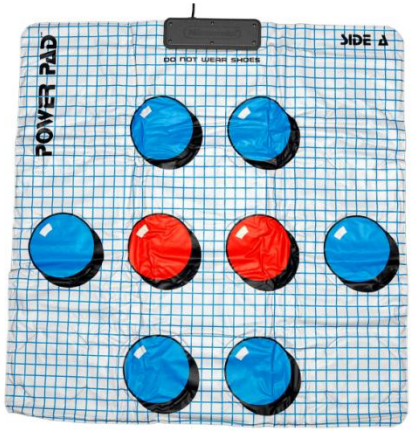
Mat Rosly M, Mat Rosly H, Davis OAMGM, Husain R, Hasnan H. Exergaming for individuals with neurological disability: a systematic review, Disabil Rehabil 2017; 39:727-735, DOI: 10.3109/09638288.2016.1161086

What is exergaming?

"Exergaming involves integrating physical activity into a video game environment that requires active core and/or body movements to control the in-game experience."

Mat Rosly M, Mat Rosly H, Davis OAMGM, Husain R, Hasnan H. Exergaming for individuals with neurological disability: a systematic review, Disabil Rehabil 2017; 39:727-735, DOI: 10.3109/09638288.2016.1161086

Early examples of exergaming



By True Tech Talk Time - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=45384772

Bogost I. The Rhetoric of Exergaming. Paper presented at the Digital Arts and Cultures conference, Copenhagen, Denmark. December 2005.

Well known low cost commercial platforms

Bournemouth University

Exergaming in clinical populations

- **Multiple sclerosis**
  (Plow, Finlayson, 2011; Nilsagård et al., 2012; Brichetto et al., 2013; Guidi, et al., 2013; Prosperini et al., 2013, 2014; Lozano-Quilis et al., 2014;Robinson et al., 2015; Pau et al., 2015; Taylor et al., 2015; Forsberg, 2015; Jonsdottir et al., 2018; Waliño-Paniagua et al., 2018)
- **Stroke rehabilitation**
  (Leder et al., 2008; Saposnik et al., 2010a, 2010b, Laver et al., 2013; Park et al. 2017; Aşkın et al., 2018; Henrique PPB et al., 2018)
- **Cerebral palsy**
  (Deutsch et al., 2008; Snider et al., 2010, Winkels et al., 2012; Chang et al, 2013;Knights et al., 2016; de Oliveira et al, 2016; Kassee et al., 2017)
- **Parkinson's disease**
  (Esculier et al., 2012, Pompeu et al., 2012; Pompeu et al., 2014)
- **Hospital inpatients**
  (Crotty et al., 2011,2012; Gargin & Pizzi, 2010;Knols et al 2016)
- **Acquired brain injury** (Gil-Gomez et al., 2011)
- **Systemic lupus erythematosus** (Yuen et al., 2011)
- **Diabetes** (Kempf & Martin, 2013; Theng, et al. 2015)
- **Total knee replacement** (Fung et al., 2012)
- **Depression** (Rosenberg et al., 2010)

Exergaming in neurorehabilitation

Mat Rosly M, Mat Rosly H, Davis OAMGM, Husain R, Hasnan H. Exergaming for individuals with neurological disability: a systematic review, Disabil Rehabil 2017; 39:727-735, DOI: 10.3109/09638288.2016.1161086

- Focused on cardiometabolic responses & perceived exertion.
- Review included studies with spina bifida (n=9), cerebral palsy (n=37), SCI (n=11) & stroke (n=31).
- 12/17 types of exergaming interventions met the ACSMTM or WHO recommendations of ‘‘moderate intensity’’ physical activity.
- Can be used in home; can be engaging and enjoyable
- Feasible for individuals who are wheelchair dependent
- Exergaming ‘‘at least as good as’’ (and likely more enjoyable) than traditional exercise modalities, with equivalent aerobic dose-potency

Exergaming in stroke

Laver KE, Lange B, George S,Deutsch JE, Saposnik G, Crotty M. Virtual reality for stroke rehabilitation. Cochrane Database of Systematic Reviews 2017, Issue 11. Art. No.: CD008349. DOI: 0.1002/14651858.CD008349.pub4.

- 72 trials (2490 patients) included
- Study sample sizes generally small and interventions varied (in terms of treatment goals and VR devices used).
- Evidence mostly low quality (GRADE system)
- Only found an effect of VR on upper limb functioning when used as an adjunct to usual care (to increase therapy time) (SMD 0.49, 0.21 to 0.77, 10 studies, 210 participants, low-quality evidence)

Benefits of physical activity

If exercise were a pill, it would be one of the most cost-effective drugs ever invented

Dr Nick Cavill, Health Promotion Consultant

Bournemouth University

Activity levels in people with MS

deconditioning

fatigue

reduced self-efficacy

decreased levels of mobility

increased health risks

Motl RW, et al., Physical activity and multiple sclerosis: a meta-analysis. Mult Scler 2005; 11:459-463
Kinnett-Hopkins D, et al. People with MS are less physically active than healthy controls but as active as those with other chronic diseases: An updated meta-analysis. Mult Scler Relat Disord 2017;13:38-43.

Barriers to physical activity in MS

Physical

Pain, fatigue, mobility limitations, overheating

Psychological

Fear, embarrassment, lack of confidence/motivation, low mood, boredom, health beliefs

Social

No-one to exercise with, lack of support

Environmental

Transport, cost, lack of suitable facilities/expertise, lack of time/logistical support

Borkoles et al., 2008; Vanner et al., 2008; Stroud et al. 2009; Kayes, 2010; Kayes et al., 2011; Kasser 2012; Ploughman, 2017

Plow & Finlayson (2011)

Home-based Wii Fit™ exercise programme (14 weeks)

- PwMS who have minimal balance and mobility problems can safely use the Wii™ at home
- May be able to improve their fitness levels
- But use tended to stop at 7 weeks once the telephone support and monitoring stopped.

"It may be that a more patient-centered approach will help foster the internalization of goals related to playing Wii Fit. Strategies such as motivational interviewing and building skills related to problem solving and decision-making should be explored in future studies."

Plow M, Finlayson M. Potential benefits of Nintendo Wii Fit among people with Multiple Sclerosis: A longitudinal pilot study. Int J MS Care 2011; 13: 10.

Mii-vitaliSe: feasibility objectives

1. Finalise & optimise intervention; test study procedures
2. Collect standard deviations of outcome measures to inform a sample size calculation for a larger trial
3. Estimate adherence (via a self-reported daily play log)
4. Determine acceptability of study processes and Mii-vitaliSe intervention; obtain information about patterns/barriers to use
5. Gather feedback from physiotherapists about their experiences of delivering Mii-vitaliSe
6. Pilot a healthcare use measure

Development Phase

Mii-vitaliSe

Craig P, Dieppe P, Macintyre S, *et al*. Developing and evaluating complex interventions: the New Medical Research Council guidance. BMJ 2008;337:a1655.

It's important to be able to set your own limits as nobody knows your body like you do

Carrying out the exercise is the most important thing - it doesn't matter about the score

If the Wii™ gives me negative feedback, I just think it doesn't know my world

It brings families together who can all do the same thing, whatever ability level they are

Exercising at home makes it easier to exercise at the best time for me

It's important to be able to set your own limits as nobody knows your body like you do

Start with easy exercises that you can do, then try out others when you are used to the system and work out what's good for you

Key design aspects

- Use off-the-shelf-technology
- Encourage short bouts of exercise that can be accumulated
  (De Souto Barreto, 2015; Wen, et al., 2011)
- Incorporate
  - home-based element
  - behaviour change techniques
  - health professional support
- Monitor adherence/patterns of use
- Include long-term follow-up

de Souto Barreto P. Global health agenda on non-communicable diseases: has WHO set a smart goal for physical activity? BMJ 2015;350:h23.
Wen CP, Wai JP, Tsai MK, et al. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet 2011;378:1244–53.

What is Mii-vitaliSe?

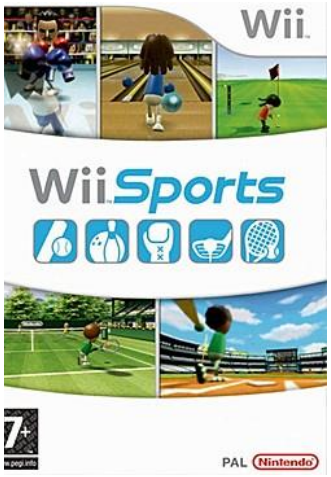
Orientation sessions (hospital) with physiotherapist
(Weeks 1 & 2)

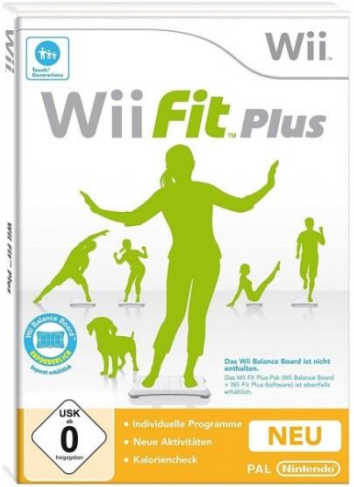
Wii™ set up at home + balance board + software
(Week 3) plus home visits (Weeks 7 & 16)

Ongoing support by physiotherapist
(Weeks 5 & 12 and Week 20 onwards)

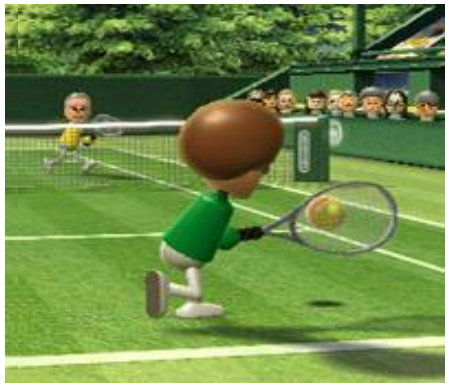
Resources to support ongoing use
(guidance book, personal activity workbook, daily play log, signposts to other resources)

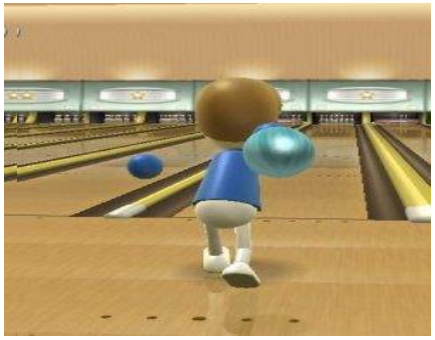
Mii-vitaliSe - software





Bournemouth University





Bournemouth University

Behaviour change techniques

- Build motivation (information provision)
- Motivational interviewing (a ‘dance’ not a ‘wrestle’)
- Weighing up the pros and cons (decisional balance)
- Self-monitoring
- Planning (action planning)
- Goal setting (implementation intentions)
- Dealing with barriers (coping planning/challenging unhelpful thoughts)
- Support and feedback
- Reframing setbacks and building in flexibility

Your own coping planner

Start off by writing down two barriers and ways of overcoming them.

POSSIBLE OBSTACLES/ BARRIERS TO CHANGE	HOW WILL I RESPOND?
IF....	THEN.....
Can't be bothered to get up.	Think positively + remind myself that the Wii is fun. Think of goals
I think it will be a detriment to my eyes.	20 min eyes shut bef + after sessions. Wear dark glasses.
TV in use by others.	Book my slots + say they can have a go afterwards!

POSSIBLE OBSTACLES /BARRIERS TO CHANGE	HOW WILL I RESPOND?
IF....	THEN....
TV in use by others	Book my slots and say they can have a go afterwards!

Make a note of specific goals you would like to achieve in the next few weeks (remember to make them specific - what, when, where, how):

MY SMART Goal 1 Start 31-10-13

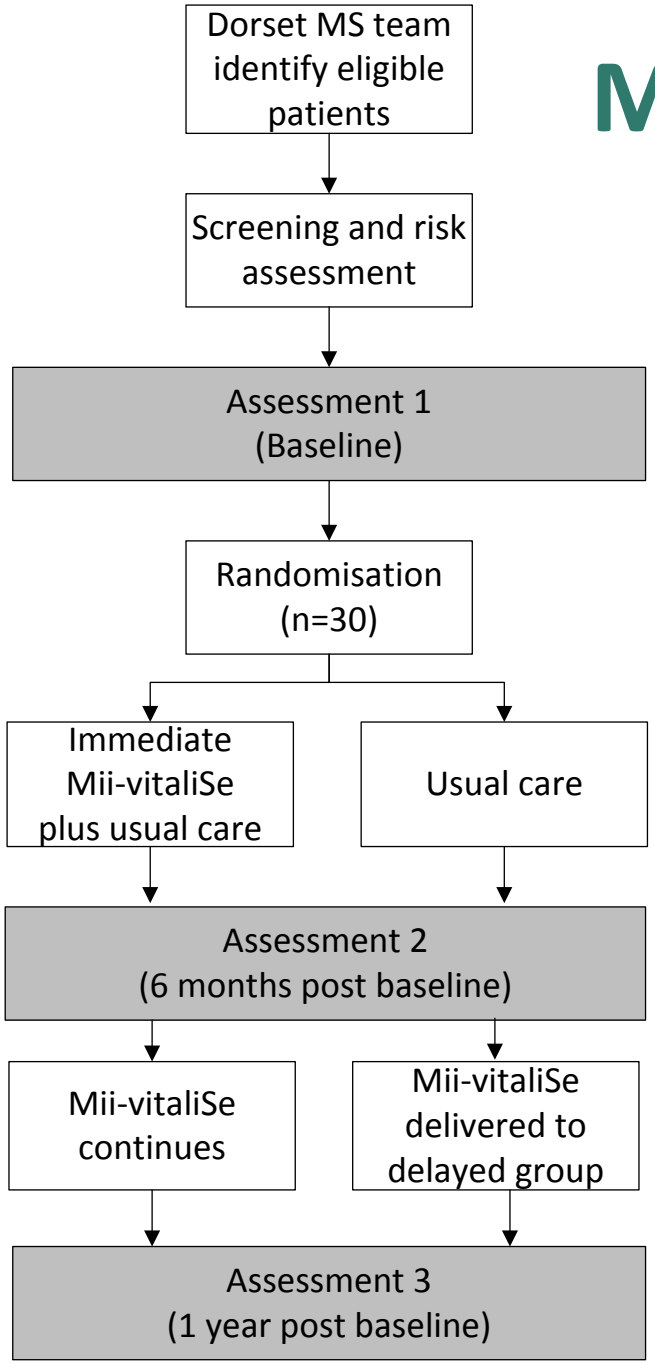
S	PECIFIC?	Use the Wii for at least 30 mins a day
M	EASURABLE?	Piggy
A	CHIEVABLE?	Time table it in.
R	ELEVANT?	Will aid fitness
T	IME-BASED	Review after 1 week Discuss with Sarah at 2 weeks

MY SMART Goal 2

S	PECIFIC?	End of balancebubble
M	EASURABLE?	✓
A	CHIEVABLE?	✓
R	ELEVANT?	Yes, for my pride!
T	IME-BASED	

S	**PECIFIC**	*Use the Wii for at least 30 mins a day*
M	**EASURABLE**	*Fit Piggy*
A	**CHIEVABLE**	*Timetable it in*
R	**ELEVANT**	*Will aid fitness*
T	**IME-BASED**	*Review after 1 week. Discuss with Mii-vitaliSe physio at 2 weeks*

Bournemouth University



Main eligibility criteria

- Adults with diagnosis of MS
- Ambulatory
- Fulfil risk assessment criteria
- 'Inactive'
- Not relapsed in past 3 months
- Not regular Wii™ users
- No medical contraindications

Bournemouth University

Outcome measures

- **Adverse events**
- **Balance, gait, mobility, motor coordination**
  - 2 MWT, Step Test, Steady stance test, I-TUG
  - Gait-stride time rhythmicity, static posturography
  - 9HPT
- **Physical activity**
  - GLTEQ, ActivPAL™
- **Self-efficacy**
  - MSSE, SCI-ESES
- **Psychological wellbeing, fatigue & quality of life**
  - HADS, EQ-5D-5L, MSIS-29, FSI, SF-36
- **Adherence/patterns of use**
- **Health care utilisation**

Play log/calendar

WEEK 18: My Daily Wii™ Log — **Date: Saturday** 1 / 3 / 14

Did you use the Wii™ today? NO

Please indicate why not:

- ☐ not scheduled to
- ☐ forgot
- ☐ MS relapse
- ☐ unwell
- ☐ other, please describe below:
- ☐ no time
- ☐ too tired
- ☐ others using it

YES

NUMBER OF SESSIONS (lasting 10 mins or more) 1

TOTAL MINUTES PLAYED 24

WHEN USED Wii™ *(tick all that apply)*	MAXIMUM EFFORT USED TODAY *(tick one)*	TODAY I PLAYED *(tick one):*
☑ morning	☐ light *(no change in breathing)*	☑ alone
☐ afternoon	☑ moderate *(breathing harder, can maintain conversation)*	☐ with others
☐ evening	☐ vigorous *(unable to maintain conversation)*	☐ combination

GAMES PLAYED TODAY (tick ALL that apply):

Wii Sports		Wii Sports Resort				Wii Fit Plus	
Tennis	☐	Swordplay	☐	Golf	☐	Body Test	☐
Bowling	☐	Wakeboarding	☐	Bowling	☐	Yoga	☐
Baseball	☐	Frisbee	☐	Powercruising	☐	Strength	☐
Golf	☐	Archery	☐	Canoeing	☐	Aerobics	☐
Boxing	☐	Basketball	☐	Cycling	☐	Balance	☐
		Table tennis	☐	Airsports	☐	Training Plus	☑

OTHER GAME(S) PLAYED/USED, PLEASE GIVE DETAILS:

How much did you enjoy your Wii™ time today? (circle one number):

Not at all 0 1 2 3 4 5 6 7 8 (9) 10 *Very much*

Rate your average level of fatigue today: (circle one number):

Not at all fatigued 0 1 2 (3) 4 5 6 7 8 9 10 *As fatigued as I could be*

Please note any problems experienced (e.g. pain, stiffness, soreness, fatigue, dizziness, nausea, fall or near fall) that you consider to be associated with using the Wii™:

Best score in balance bubble + obstacle course + tilt city!

Any other comments:

Wii™ Calendar Play Log

Completing this Wii™ Calendar Play Log

As part of Mii-vitaliSe we would like you to continue to complete a Wii™ play log **every day**. Keeping a record will help you to keep track of your activity and can help you to motivate you.

1. **If you HAVE NOT used the Wii™:** Put a **CROSS** in the box corresponding to the day and date.

2. **If you HAVE used the Wii™: TICK** the box corresponding to the day and date and write down the total number of minutes you have used the Wii™ on the day.

Example of how to complete the Calendar Play Log:

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
						1 ×
2 ✓ 30 mins	3 ×	4 ×	5 ✓ 10 mins	6 ×	7 ✓ 20 mins	8 ✓ 35 mins
9 ×	10 ×	11 ✓ 10 mins	12 ✓ 40 mins	13 ✓ 20 mins	14 ×	15 ✓ 40 mins

Bournemouth University

Qualitative component

- Physiotherapist notes
- 25 semi-structured interviews with purposive sample of participants *(age, gender, educational level, prior experience of home gaming systems and adherence)*
- Interviews with 2 physiotherapists who delivered intervention

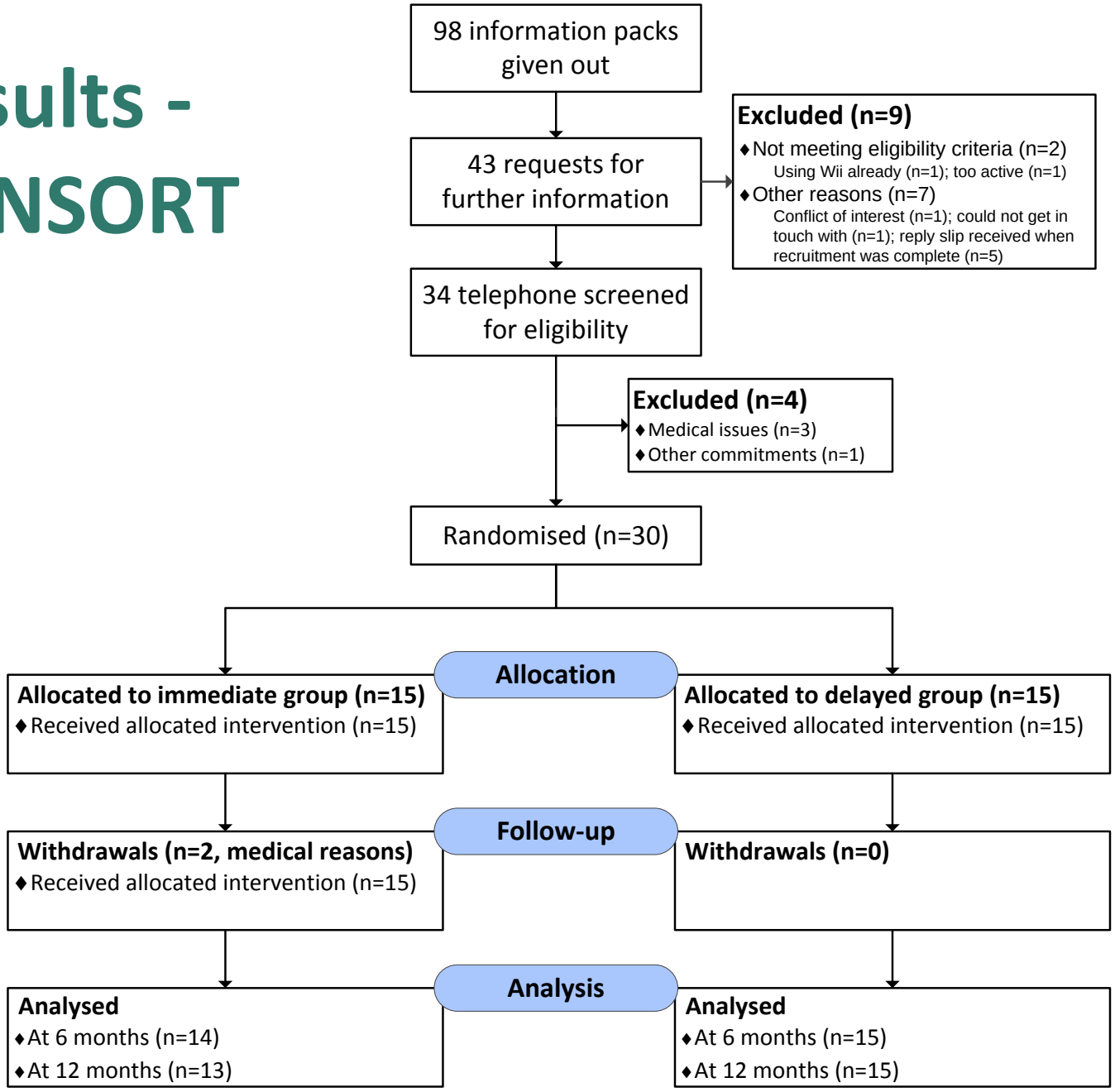
Plow M, Finlayson M. A qualitative study exploring the usability of Nintendo Wii Fit among persons with multiple sclerosis. Occ Ther Int 2014;21:21-32.
Forsberg A, Nilsagård Y and Boström K. Perceptions of using videogames in rehabilitation: a dual perspective of people with multiple sclerosis and physiotherapists. Disability Rehabil 2015;7:338-44.

Results - descriptives

Age (mean [SD] range)	49.3 [8.7] 33-65
Gender (female : male)	27 : 3
Self-reported disease type	
Benign	1 (3%)
Relapsing remitting	21 (70%)
Secondary progressive	5 (17%)
Primary progressive	1 (3%)
Don't know	2 (7%)
Time since diagnosis	
<1 yr	3 (10%)
1-5 yrs	11 (37%)
6-10 yrs	7 (23%)
11-15 yrs	3 (10%)
>16 yrs	6 (20%)
Not used home gaming	18 (60%)
Doesn't do ≥30 mins of activity that increases breathing rate on any days in a typical week	13 (43%)

	Adapted Patient Determined Disease Steps (APDDS) Scale Description	Frequency
0	No problems and no limitations	-
1	Some mild symptoms, mostly sensory but do not limit my activity.	-
2	Some noticeable symptoms from my MS but they are minor and have only a small effect on my lifestyle.	5
3	Symptoms as above, but no limitations in my walking ability. However, I do have significant problems due to MS that limit daily activities in or ways.	1
4	MS does interfere with my activities, especially walking. Am able to walk for at least 300-500 metres without help or rest, and I can work a full day, but athletic or physically demanding activities are more difficult than they used to be. I usually don't need a stick or assistance to walk, but I might need some assistance during an attack.	7
5	Can walk 100-200 metres without help/rest, but often use a stick or some or form of support, especially outside. Always need assistance when walking > 200 metres. Many daily activities are limited.	16
6	Need a stick/single crutch, or someone to hold onto, to walk up to 100 metres. Can get around house/ building by holding onto furniture/walls for support. Might use wheelchair for longer distances. My activities are limited.	1

Results - CONSORT



Bournemouth University

Results - feasibility objectives

- Study processes acceptable
- 97% questionnaire booklets returned; low levels of missing data
- Most outcome measure results in the direction of benefit for the immediate group
- ActivPAL™ - 90% data available
- Intervention costs: £684 per participant (incl. £300 equipment cost)

Results - feasibility objectives

- Play Log ~ 20% of days left blank *(assumed Wii™ not used on these days)*
- Mean Wii™ use:
  - ~ 30 mins x 2 days/week during 1st 6 months
  - ~ 30 mins x 1 day/ week during 2nd 6 months
- Most tended to exercise alone in the morning or afternoon with light to moderate intensity
- Balance, yoga and aerobics - most common activities.
- 'No time', 'too tired' and 'feeling unwell' - most frequent reasons for not exercising
- No serious adverse events

Qualitative - overview

- Most were positive about the Mii-vitaliSe intervention
- Materials comprehensive and helpful
- Contact time with physios - ‘about right’
- Professional input considered important to ensure people were safe and adequately supported

Key themes identified

Facilitators	Barriers
‘Exercise on tap’	Physical
Fun	Psychological
Benefits	Environmental
Setting goals; establishing a habit	Wii™-related
Making adaptations	
Physiotherapist support	

EXERCISE ON TAP

*"I just love the fact that in my own sitting room I can just get my equipment out and I don't have to dress up or anything…..it's there, you've got your **exercise on tap.**"*

FUN

*"….. it's like **a fun way of physio** really, I say physio, it is, a fun way of physio because you're moving about and it has helped my, I haven't tripped over for ages."*

SUPPORT

It's been really nice because of all the contact and encouragement that you get and I do think that that's important, you know, I don't think that you could just say to somebody there you go there's your Wii™ get on with it.

GATEWAY

Yeh I'm walking further now than I've than I could so now I'm here I walk into town nearly every day …… I think physically the Wii did help me but also in itself it's sort of a motivation to sort of make you get out more and do things and yeah I just felt better about myself.

Benefits

- Increased physical activity and fitness
- Improved mood
- Feel-good factor; energising
- Reduced anxiety and stress
- Increased confidence
- Better sleep and general wellbeing
- Improved balance, posture and strength
- Better hand-eye coordination
- Increased walking endurance
- Symptom relief
- Quality family time
- Gateway to other activities

Motivators/facilitators

- Immersive, fun, convenient
- Creating a habit/routine
- Choice of games
- Functional improvements
- Sense of achievement
- Setting goals
- Playing with others
- Encouragement/support
- Keeping play log
- Accountability
- Making adaptations

Barriers

Physical

- Not feeling safe using balance board
- Injuries unrelated to Wii™
- MS symptoms and fluctuations, relapse
- Pain (some pre-dating Wii™)

Psychological

- Lack of routine
- Mood & motivation - fine line between accountability as a motivator and a pressure
- Bringing MS to forefront of mind

Environmental

- Lack of time
- Life pressures and priorities
- Home constraints (1 TV, small space)
- Need to move furniture to set up equipment
- Weather (when sunny want to be outside)

Wii™-related

- Setting up equipment
- Synching balance board & remotes
- Placing Wii-remote into charging cradle
- Orienting the cursor
- Connecting Nunchuk
- Navigating Wii menu - repetitive

Threapleton K, Drummond A, Standen P. Virtual rehabilitation: what are the practical barriers for home-based research? Digital Health. 2016;2:1–11.

Overall

"I've really enjoyed the experience. And, it's been something that has made me more active which I very much appreciate. I've found it has made me fitter and toned me, which I'm very, very pleased about and given me a sort of exercise ethic. And sort of just speaking very generally, it has made me feel, it's occupied my mind, it's given me a focus and I think probably that's a very good thing, to have another focus. I mean physical things and exercise have never been a focus. I like to walk but sometimes haven't been able to walk quite as much cos I've been tired. I've felt it's sort of distracted me and given me energy."

"I think in the beginning it, the motivation of actually signing up for something and therefore you have a duty to play your part was important …..you've committed to something …… And then once you start to see the results then you become self-motivated I think whereas …….for me that part of filling those forms in is over but I'm still doing it, so I am now self-motivated."

Mii-vitaliSe physiotherapists' perspectives

- Steep learning curve
- Thinking outside the box
- Liked collaborative approach
- Helpful seeing people in own homes
- Insights into what goes on behind the scenes
- Balance board useful clinical assessment tool
- Orientation sessions to > 1 person - variable success
- Follow-up calls time-consuming; need to emphasise: 'not checking up on you'

Conclusions

- Mii-vitaliSe provides a model for supporting people with MS to become more physically active
- Targets use in areas that might be particularly relevant for people with MS such as balance and mobility
- Helps ensure equipment is used safely
- Helps achieve long term use by incorporating psychological principles and behaviour change techniques.
- Future RCT seems warranted (but swift pace of technology)
- Offers potential for incorporation into routine patient care

References and thank you ☺

Bogost I. The Rhetoric of Exergaming. Paper presented at the Digital Arts and Cultures conference, Copenhagen, Denmark. December 2005.

Borkoles E, Nicholls AR, Bell K, et al. The lived experiences of people diagnosed with multiple sclerosis in relation to exercise. Psychol Health 2008;23:427–41.

Craig P, Dieppe P, Macintyre S, *et al*. Developing and evaluating complex interventions: the New Medical Research Council guidance. *BMJ* 2008;337:a1655.

de Souto Barreto P. Global health agenda on non-communicable diseases: has WHO set a smart goal for physical activity? BMJ 2015;350:h23.

Forsberg A, Nilsagård Y and Boström K. Perceptions of using videogames in rehabilitation: a dual perspective of people with multiple sclerosis and physiotherapists. Disability Rehabil 2015;7:338-44.

Garcia-Agundez A, Folkerts A K, Konrad R, Caserman P, Tregel T, Goosses M, Göbel S, Kalbe E, Recent advances in rehabilitation for Parkinson's disease with Exergames: A systematic review. J Neuroeng Rehabil 2019;16:17.

Kasser SL., Kosma M. . Health beliefs and physical activity behavior in adults with multiple sclerosis. Disabil Rehab 2012;5:261-268.

Kayes NM, McPherson KM, Taylor D, et al. Facilitators and barriers to engagement in physical activity for people with multiple sclerosis: a qualitative investigation. Disabil Rehabil 2011;33:625–42.

References and thank you ☺

Kayes NM, McPherson KM, Schluter P, Taylor D, Leete M, Kolt GS. Exploring the facilitators and barriers to engagement in physical activity for people with multiple sclerosis. Disabil Rehabil 2011;33:1043–53.

Kinnett-Hopkins D, Adamson B, Rougeau K, Motl RW. People with MS are less physically active than healthy controls but as active as those with other chronic diseases: An updated meta-analysis. Mult Scler Relat Disord 2017;13:38-43.

Laver KE, Lange B, George S,Deutsch JE, Saposnik G, Crotty M. Virtual reality for stroke rehabilitation. Cochrane Database of Systematic Reviews 2017, Issue 11. Art. No.: CD008349. DOI: 0.1002/14651858.CD008349.pub4.

Mat Rosly M, Mat Rosly H, Davis OAMGM, Husain R, Hasnan H. Exergaming for individuals with neurological disability: a systematic review, Disabil Rehabil 2017; 39:727-735, DOI: 10.3109/ 09638288.2016.1161086

Motl RW, McAuley E, Snook EM. Physical activity and multiple sclerosis: a meta-analysis. Mult Scler 2005; 11:459-463

Ploughman M. Breaking down the barriers to physical activity among people with Multiple Sclerosis-a narrative review. *Phys Ther Rev* 2017; 22:1-9.

Plow M and Finlayson M. Potential benefits of Nintendo Wii Fit among people with Multiple Sclerosis: A longitudinal pilot study. Int J MS Care 2011; 13: 10.

Plow, M. and Finlayson M. A qualitative study exploring the usability of Nintendo Wii Fit among persons with multiple sclerosis. Occ Ther Int 2014;21:21-32.

Bournemouth University

References and thank you ☺

Stroud N, Minahan C, Sabapathy S. The perceived benefits and barriers to exercise participation in persons with multiple sclerosis. Disabil Rehabil 2009;31:2216–22.

Thomas S, Fazakarley L, Thomas PW, *et al*. Testing the feasibility and acceptability of using the Nintendo Wii in the home to increase activity levels, vitality and well-being in people with multiple sclerosis (Mii-vitaliSe):protocol for a pilot randomised controlled study. BMJ Open 2014;4:e005172. doi:10.1136/bmjopen-2014-005172.

Thomas S, Fazakarley L, Thomas PW, *et al*. Mii-vitaliSe: a pilot randomised controlled trial of a home gaming system (Nintendo Wii) to increase activity levels, vitality and well-being in people with multiple sclerosis. BMJ Open 2017;7:e016966. doi:10.1136/bmjopen-2017-016966.

Threapleton K, Drummond A, Standen P. Virtual rehabilitation: what are the practical barriers for home-based research? Digital Health. 2016;2:1–11. https://doi.org/10.1177/2055207616641302.

Vanner EA, Block P, Christodoulou CC, Horowitz BP, Krupp LB. Pilot study exploring quality of life and barriers to leisure-time physical activity in persons with moderate to severe multiple sclerosis. Disabil Health J 2008;1:58-65.

Wen CP, Wai JP, Tsai MK, et al. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet 2011;378:1244–53.

saraht@bournemouth.ac.uk Twitter: @SThomasBU

https://www.bournemouth.ac.uk/research/projects/ms-research-bournemouth-university

Bournemouth University