

**The Use of Interactive Game Technology to  
Improve the Physical Health of the Elderly:  
A Serious Game Approach to Reduce the  
Risk of Falling in Older People**

A thesis submitted by **Jaime A. Garcia Marin**  
in fulfilment of the requirements for the award of the degree  
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# Certificate of Original Authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text. I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Jaime A. Garcia M.



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# Abstract

The elderly population is growing dramatically both in Australia and globally. With age, the human body undergoes a series of changes that can lead to decline in mental and physical health. Decline in motor functions increases the risk of developing health problems such as postural instability, balance disorders or simply having a fall. Falling is the main cause of disability and fatality among the elderly. Statistics show that one in three older adults might experience a fall every year. This could be prevented with regular exercise. Exercises with a walking component have proven to reduce falls by 40%. However, compliance with physical activity is often poor due to the mode of delivery, which is often unattractive. One approach that might help alleviate this is the use of commercial video games to engage the elderly in physical exercise. However, this practice may have undesirable results as such games are not designed to provide therapeutic support for the elderly but instead to entertain a much younger audience.

This thesis aims to solve the above problem through the use of interactive game technology by testing that optimal results for the health of the elderly come from the combination of three elements:

- the integration of a formal method to assess progress towards and the achievement of the desired health outcomes,
- inclusion of meaningful tasks aligned with the specific health objectives
- an appropriate game design through the use of user-centred design methodologies.

Firstly, literature in the area of video games with health purposes for the elderly is reviewed to develop a clear understanding of the health issues and the research opportunities in the area. Secondly, a series of game prototypes is built and tested to investigate whether off-the-shelf game technology can be used to reliably perform a clinical test for fall risk assessment. Then a game is developed that aims to reduce the risk of falling by training a set of specific cognitive and physical functions that have been shown to be associated with falling. This prototype, known as the *StepKinnection* game, integrates the concept of an appropriate game design for the elderly, inclusion of meaningful tasks and the collection of stepping performance data. Thirdly, a series

of studies on independent-living people aged 65 years and over are conducted. These studies confirmed the ability to reliably perform a clinical test using off-the-shelf game technology, the acceptance and ease of use of the *StepKinnection* game, and the potential of *StepKinnection* to reduce the risk of falling in the elderly.

Finally, an analytical framework is developed for designing interactive games with health purposes for the elderly. This framework aims to assist the development of games aligned to particular health outcomes. This framework emphasises the importance of aligning the game goals to the expected health outcomes as well as the continuous assessment of progress and effectiveness.



# Publications Supporting this Thesis

The following is a list of accepted refereed publications resulting from this thesis.

## Journals

1. **Garcia, Jaime A**, Karla Felix Navarro, Daniel Schoene, Stuart T Smith, and Yusuf Pisan (2012), “Exergames for the elderly: Towards an embedded kinect-based clinical test of falls risk.” *Stud Health Technol Inform*, 178, 51-7.

## Conferences

1. **Garcia, Jaime A** and Karla Felix Navarro (2015), “Step Kinnection: A Fall Prevention Game Mindfully Designed for the Elderly.” In *Australia’s premier digital health, health informatics and e-health conference and expo, HIC2015*, HISA.
2. **Garcia, Jaime A**, Yusuf Pisan, Chek Tien Tan, and Karla Felix Navarro (2014), “Assessing the kinect’s capabilities to perform a time-based clinical test for fall risk assessment in older people.” In *Entertainment Computing - ICEC 2014*, 100-107, Springer.
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4. **Garcia, Jaime A** and Karla Felix Navarro (2014) “The Mobile RehApp<sup>TM</sup>: an AR-based mobile game for ankle sprain rehabilitation.” In *3rd International Conference on Serious Games and Applications for Health, SeGAH 2014*, IEEE.
5. Pisan, Yusuf, **Jaime A Garcia**, and Karla Felix Navarro (2013), “Improving lives: using microsoft kinect to predict the loss of balance for elderly users under cognitive load.” In *Proceedings of The 9th Australasian Conference on Interactive Entertainment: Matters of Life and Death*, 29, ACM.

6. Felix Navarro, Karla, Elaine Lawrence, **Jaime A Garcia**, and Christian Sax (2011), “A dynamic and customisable layered serious game design framework for improving the physical and mental health of the aged and the infirm.” In *The Third International Conference on eHealth, Telemedicine and Social Medicine (eTELEMED 2011)*, 140-145.
7. Lawrence, Elaine, Karla Felix Navarro, **Jaime A Garcia**, and Christian Sax (2011), “Towards building health systems.” In *ICONS 2011, The Sixth International Conference on Systems*, 109-114.
8. **Garcia, Jaime A.**, Karla Felix Navarro, and Elaine Lawrence (2011), “Serious games to improve the physical health of the elderly: A categorization scheme.” In *CENTRIC 2011, The Fourth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services*, 64-71.
9. **Garcia, Jaime A** , Elaine Lawrence, Karla Felix Navarro, and Christian Sax (2011), “Heuristic evaluation for interactive games within elderly users.” In *eTELEMED 2011, The Third International Conference on eHealth, Telemedicine, and Social Medicine*, 130-133.

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Introduction . . . . .	1
1.2	Overview and Research Questions . . . . .	1
1.3	Hypotheses . . . . .	3
1.4	Research Purpose and Significance . . . . .	3
1.5	Research Methodology . . . . .	4
1.6	Key Contributions . . . . .	5
1.7	Thesis Structure . . . . .	6
1.8	Conclusion . . . . .	8
<b>2</b>	<b>Falls in the Elderly Population: An Overview</b>	<b>9</b>
2.1	Introduction . . . . .	9
2.2	Epidemiology and Consequences . . . . .	9
2.3	Risk Factors for Falling . . . . .	10
2.3.1	Declines in Physical Health . . . . .	10
2.3.2	Declines in Mental Health . . . . .	12
2.4	Prevention of Falls . . . . .	13
2.5	Conclusion . . . . .	14
<b>3</b>	<b>The Use of Video Games to Promote Health in the Elderly</b>	<b>15</b>
3.1	Introduction . . . . .	15
3.2	Video Games . . . . .	16
3.2.1	Players - <i>“You”</i> . . . . .	16
3.2.2	Objectives - <i>“Your goal”</i> . . . . .	16
3.2.3	Procedures - <i>“What you can do”</i> . . . . .	17
3.2.4	Rules - <i>“What you can’t do”</i> . . . . .	17
3.2.5	Resources - <i>“What you can use”</i> . . . . .	17
3.2.6	Conflict - <i>“What won’t let you reach the goal”</i> . . . . .	17

3.2.7	Outcome - “What happens when you reach the goal”	17
3.2.8	Challenge - “What keeps you engaged”	18
3.2.9	Story - “What plays with your emotions”	18
3.3	Serious Games for Health	18
3.4	Methodology for Game Categorisation	20
3.5	Inclusion Criteria for Game Categorisation	21
3.6	Review of Games for Health for the Elderly	23
3.7	Categorisation of Surveyed Health Games	30
3.7.1	Pad / Plate Force Driven Systems with Health Purposes for the Elderly	30
3.7.2	Wearable Sensor Systems with Health Purposes for the Elderly	31
3.7.3	Wii-based Systems with Health Purposes for the Elderly	33
3.7.4	Camera-based Systems with Health Purposes for the Elderly	34
3.7.5	Non-Commercial Game Technology Systems with Health Purposes for the Elderly	35
3.8	Discussion and Results	37
3.9	Focus of the Game Development Research	39
3.10	Conclusion	40
<b>4</b>	<b>Effects of Commercial Games on the Physical and Mental Health of the Aged</b>	<b>41</b>
4.1	Introduction	41
4.2	Background	42
4.3	Evaluation of Four Wii Fit Balance Games	43
4.4	Findings	47
4.5	Conclusion	49
<b>5</b>	<b>The <i>StepKinnection</i> Test: Building a Hybrid Clinical Test for Fall Risk Assessment</b>	<b>51</b>
5.1	Introduction	51
5.2	Background	52
5.3	Methodology	54
5.4	The Choice Stepping Reaction Time (CSRT) Test	56
5.5	Design Considerations	57
5.6	Enhancements to the Original CSRT Test	61
5.7	Refinements to the <i>StepKinnection</i> Test	62
5.7.1	Data Acquisition Accuracy	62
5.7.2	Incorporation of Complementary Balance Measures	63
5.7.3	Adaptability to User Skills	64

5.7.4	Ability to Assess Stepping under the Dual-Task Paradigm . . . . .	64
5.8	Conclusion . . . . .	66
<b>6</b>	<b>Assessing the Validity of the <i>StepKinnection</i> Test for Fall Risk Assessment</b>	<b>69</b>
6.1	Introduction . . . . .	69
6.2	Background . . . . .	70
6.3	Equipment for Evaluation . . . . .	71
6.3.1	Mat-based Reaction Time Device . . . . .	71
6.3.2	Kinect-based Reaction Time Device . . . . .	71
6.4	Participants for Evaluation . . . . .	72
6.5	Evaluation 1: Consistency of the Kinect to Collect Time-Based Measurements . . . . .	73
6.5.1	Procedures . . . . .	73
6.5.2	Statistical Analysis . . . . .	74
6.5.3	Results . . . . .	74
6.5.4	Findings . . . . .	75
6.6	Evaluation 2: Validity of the Kinect measure of the CSRT Test . . . . .	75
6.6.1	Procedures . . . . .	75
6.6.2	Statistical Analysis . . . . .	76
6.6.3	Results . . . . .	76
6.6.4	Findings . . . . .	77
6.7	Conclusion . . . . .	78
<b>7</b>	<b>The <i>StepKinnection</i> Game: Developing a Fall Prevention Game for the Elderly</b>	<b>81</b>
7.1	Introduction . . . . .	81
7.2	Background . . . . .	82
7.3	Game Design Guidelines Based On Age-Related Changes . . . . .	83
7.3.1	Guideline 1: Concentration . . . . .	83
7.3.2	Guideline 2: Challenge . . . . .	84
7.3.3	Guideline 3: Player Skills . . . . .	84
7.3.4	Guideline 4: Control . . . . .	84
7.3.5	Guideline 4: Feedback . . . . .	84
7.4	Building a Game for Fall Prevention: Prototype 1 . . . . .	85
7.5	Evaluation of Prototype 1 . . . . .	87
7.5.1	Procedures . . . . .	87
7.5.2	Results . . . . .	89
7.5.3	Observation . . . . .	92

7.5.4	Findings . . . . .	92
7.6	Building a Game for Fall Prevention: Prototype 2 . . . . .	92
7.7	Evaluation of Prototype 2 . . . . .	100
7.7.1	Procedures . . . . .	100
7.7.2	Results . . . . .	100
7.7.3	Findings . . . . .	101
7.8	Discussion . . . . .	101
7.9	Conclusion . . . . .	102
<b>8</b>	<b>Investigating the Long-Term Effects of Playing with the <i>StepKinnexion</i> Game</b>	<b>103</b>
8.1	Introduction . . . . .	103
8.2	Participants . . . . .	104
8.3	Study Design . . . . .	106
8.4	Intervention . . . . .	106
8.5	Assessing Changes in Physical and Mental Health . . . . .	108
8.5.1	Procedures . . . . .	108
8.5.2	Outcome Measures . . . . .	113
8.5.3	Statistical Analysis . . . . .	114
8.5.4	Results . . . . .	114
8.5.5	Findings . . . . .	120
8.6	Assessing Ease of Use, Enjoyment and Adherence . . . . .	124
8.6.1	Procedures . . . . .	124
8.6.2	Outcome Measures . . . . .	124
8.6.3	Statistical Analysis . . . . .	124
8.6.4	Results . . . . .	124
8.6.5	Findings . . . . .	134
8.7	Evaluating the Validity of the Stepping Performance Data Collected During Gameplay	134
8.7.1	Procedures . . . . .	134
8.7.2	Outcome Measures . . . . .	135
8.7.3	Statistical Analysis . . . . .	135
8.7.4	Results . . . . .	135
8.7.5	Findings . . . . .	137
8.8	Discussions . . . . .	137
8.9	Conclusion . . . . .	138

<b>9</b>	<b>The Analytical Framework and Conclusions</b>	<b>141</b>
9.1	Introduction . . . . .	141
9.2	Research Rationale and Outcomes . . . . .	142
9.3	The Analytical Framework . . . . .	144
9.3.1	Entertainment . . . . .	145
9.3.2	Therapeutic Support . . . . .	146
9.3.3	Assessment . . . . .	146
9.4	Answers to the Research Hypotheses . . . . .	146
9.4.1	Hypothesis 1 - Off-the-shelf Game Technology . . . . .	147
9.4.2	Hypothesis 2 - Embedded Clinical Test . . . . .	147
9.4.3	Hypothesis 3 - Mindful Design for the Elderly . . . . .	148
9.5	Conclusions and Future Directions . . . . .	148
	<b>Bibliography</b>	<b>173</b>
	<b>Appendices</b>	<b>175</b>
<b>A</b>	<b>Heuristic Evaluation Data</b>	<b>177</b>
A.1	Comments on the <i>Bubble</i> Game . . . . .	178
A.2	Comments on the <i>SkateBoard</i> Game . . . . .	179
A.3	Comments on the <i>TableTilt</i> Game . . . . .	180
A.4	Comments on the <i>Tightrope</i> Game . . . . .	181
A.5	Summary of Problems Found By Category . . . . .	182
<b>B</b>	<b>Technical Validation Kinect vs MAT Data</b>	<b>183</b>
B.1	Correlation of Time-Based Measurements . . . . .	184
B.2	Kinect and MAT measurements of Reaction Time (RT), Decision Time (DT) and Movement Time (MT) . . . . .	185
<b>C</b>	<b>Usability Assessment Data</b>	<b>187</b>
C.1	Responses to the System Usability Scale (SUS) . . . . .	188
C.2	Responses to the Flow State Scale (FSS) . . . . .	189
C.3	Responses to the Play Experience Scale (PES) . . . . .	192
C.4	Responses to the Physical Activity Enjoyment Scale (PACES) . . . . .	194
<b>D</b>	<b>12-Week Intervention Study Data</b>	<b>197</b>
D.1	Outcome Measures - Baseline Assessment . . . . .	198
D.2	Outcome Measures - First Month Assessment . . . . .	199

D.3 Outcome Measures - Second Month Assessment . . . . . 200

D.4 Outcome Measures - Third Month Assessment . . . . . 201

D.5 Wilcoxon Matched Pair Signed Rank Tests Between Baseline and Assessment 1, 2  
and 3 . . . . . 202

D.6 Wilcoxon Matched Pair Signed Rank Tests Between Assessment 1-2, 1-3 and 2-3 . 203

D.7 Responses to the System Usability Scale (SUS) . . . . . 204

D.8 Responses to the Flow State Scale (FSS) . . . . . 205

D.9 Responses to the Play Experience Scale (PES) . . . . . 208

D.10 Responses to the Physical Activity Enjoyment Scale (PACES) . . . . . 210

D.11 Participants' Adherence Throughout the Intervention . . . . . 212

D.12 Comparison of Game CSRT Times and Test CSRT Times . . . . . 213



# List of Tables

3.1	Gaming design criteria for stroke rehabilitation programs serving elderly users (Flores et al., 2008) . . . . .	22
3.2	Criteria for including games in the categorisation . . . . .	23
3.3	Summary of the surveyed systems with health purposes for the elderly . . . . .	25
3.4	Camera-based systems with health purposes for the elderly . . . . .	26
3.5	Kinect-based systems with health purposes for the elderly . . . . .	27
3.6	Pad / Plate force driven systems with health purposes for the elderly . . . . .	28
3.7	Wii-based systems with health purposes for the elderly . . . . .	28
3.8	Wearable sensor systems with health purposes for the elderly . . . . .	29
3.9	Non-commercial game technology systems with health purposes for the elderly . . . . .	30
4.1	Description of six health experts used for evaluation of commercial games . . . . .	43
4.2	Description of the four Wii balance games . . . . .	45
4.3	Usability problems found by six health experts . . . . .	48
5.1	Elderly-appropriate game features, adapted from Flores et al. (2008) and Garcia Marin et al. (2011b). . . . .	60
6.1	Evaluation 1: Correlation of stepping events (per panel) . . . . .	75
6.2	Evaluation 2: Correlation of timing variables (per panel) . . . . .	77
6.3	Evaluation 2: Correlation of CSRT, MT and DT . . . . .	77
7.1	Structure of Prototype 1, based on “Structure of a Game” by Fullerton et al. (2008) . . . . .	87
7.2	Descriptive statistics for the perceived ease of use and suitability of the Prototype 1 game . . . . .	91
7.3	Structure of Prototype 2, based on “Structure of a Game” by Fullerton et al. (2008) . . . . .	99
8.1	Characteristics of the 10 study participants . . . . .	105
8.2	Summary of results from 10 outcome measures at baseline and 3 assessments . . . . .	123
8.3	Descriptive statistics for the perceived ease of use and suitability of the game . . . . .	130

8.4 Descriptive Indicators of Adherence and Progression . . . . . 133

# List of Figures

3.1	Modified version of the Dance Dance Revolution game developed by Smith et al. (2009) . . . . .	31
3.2	BASE game for balance developed by Doyle et al. (2010) . . . . .	32
3.3	Game for fall rehabilitation developed by Uzor et al. (2013) . . . . .	33
3.4	SilverBalance game for balance training developed by Gerling et al. (2010) . . . . .	34
3.5	Webcam-based system that delivers Otago exercises (Burke et al., 2009a) . . . . .	35
3.6	Assistive robot to deliver arm exercises for the elderly (Fasola and Mataric, 2010) . . . . .	36
3.7	Multi-touch table system to deliver training for upper limbs (Annett et al., 2009) . . . . .	37
4.1	Frequency of the problems identified by the six health experts . . . . .	48
5.1	Nintendo Wii Balance Board . . . . .	53
5.2	Microsoft Kinect Sensor . . . . .	54
5.3	Original Choice Stepping Reaction Time (CSRT) test (Lord and Fitzpatrick, 2001) . . . . .	57
5.4	Interacting with the <i>StepKinnnection</i> test (Garcia et al., 2014a) . . . . .	57
5.5	The <i>StepKinnnection</i> Test for fall risk assessment (Garcia et al., 2014a) . . . . .	58
5.6	Parameters the therapist can select and tune in <i>StepKinnnection</i> test (Garcia et al., 2014a) . . . . .	61
5.7	Calibration stage incorporated into the <i>StepKinnnection</i> system (Garcia et al., 2014a) . . . . .	63
5.8	Implementation of the postural sway measure (Garcia et al., 2014a) . . . . .	63
5.9	Simplified version of the Stroop test: the word matches the colour the word was written in (Garcia et al., 2014a) . . . . .	65
5.10	Implementation of the Stroop test: the word does not match the colour the word was written in (Garcia et al., 2014a) . . . . .	65
5.11	Maths workout activity: the system reads out a maths question and the user replies verbally (Garcia et al., 2014a) . . . . .	66
6.1	MAT version of the CSRT Test (Schoene et al., 2011) . . . . .	71
6.2	Interacting with the <i>StepKinnnection</i> System . . . . .	72

6.3	mHealth Laboratory at the University of Technology Sydney	73
6.4	Comparison between average reaction times obtained with the Kinect and the MAT per participant per panel	78
7.1	Prototype 1: First version of the main menu	86
7.2	Prototype 1: First version of the stepping task	86
7.3	Prototype 1: First version of the “Results” screen	87
7.4	Prototype 2: Interacting with the redesigned game	94
7.5	Prototype 2: Navigating through the main menu	95
7.6	Prototype 2: Refined stepping tasks	95
7.7	Prototype 2: Training motor inhibition	95
7.8	Prototype 2: Rewarding the player for taking rapid reactive steps	96
7.9	Prototype 2: Result presentation	96
7.10	Prototype 2: The “Pause” Pose	97
7.11	Prototype 2: Personalisation settings	98
8.1	Design of the 12 week intervention study with 4 week follow-up	106
8.2	Technology components of the <i>StepKinnnection</i> system	107
8.3	Baseline assessment: Mini cog clock drawing task	108
8.4	Assessment: Gait speed test	109
8.5	Assessment: Timed up and go (TUG) test	109
8.6	Assessment: MAT version of the Choice Stepping Reaction Time test	110
8.7	Assessment: Kinect version of the Choice Stepping Reaction Time Task	110
8.8	Assessment: Inhibitory Choice Stepping Reaction Time (iCSRT) task.	111
8.9	Assessment: Letter digit substitution test	111
8.10	Assessment: Stroop interference test	112
8.11	Assessment: Static balance test with six poses	113
8.12	Assessment: Five repeats sit to stand test	113
8.13	Results: Gait speed test - Normal walking	115
8.14	Results: Gait speed test - Fast walking	115
8.15	Results: Timed up and go (TUG) test	116
8.16	Results: MAT-based Choice Stepping Reaction Time	117
8.17	Results: Kinect-based Choice Stepping Reaction Time test	117
8.18	Results: Inhibitory Choice Stepping Reaction Time test	118
8.19	Results: Letter digit test	118
8.20	Results: Stroop interference test	119

8.21	Results: Static balance test . . . . .	120
8.22	Results: Five repeat sit to stand test . . . . .	120
8.23	Participants' responses to questions on enjoyment and instructions . . . . .	125
8.24	Participants' responses to questions on engagement and immersion . . . . .	125
8.25	Participants' responses to questions on appealing, playability and requirement of assistance to play . . . . .	126
8.26	Participants' responses to questions on accuracy of the controllers . . . . .	127
8.27	Participants' responses to questions on the level of difficulty, challenge and potential benefits for physical and mental health . . . . .	128
8.28	Participants' responses to questions on adherence . . . . .	129
8.29	Participants' adherence throughout the 12 week intervention . . . . .	132
8.30	Results: Comparison between the validated CSRT test and the CSRT measure taken by the <i>StepKinnection</i> Game . . . . .	136
8.31	Results: StepKinnection embedded CSRT test . . . . .	136
9.1	Analytical framework for designing interactive games with health purposes for the elderly . . . . .	145

