Hong Kong Journal of Occupational Therapy (2015) 26, 9—13

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ORIGINAL ARTICLE

Effect of Cyber-Golfing on Balance Amongst the Elderly in Hong Kong: A Pilot Randomised Trial

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Received 5 January 2015; received in revised form 31 July 2015; accepted 9 August 2015
Available online 30 November 2015

KEYWORDS
balance;
cyber-golfing;
elderly;
exergaming

Summary *Background/Objective:* Recent evidence showed that golf can develop balance amongst the elderly. This study aimed at evaluating if exergaming, in particular cyber-golfing, can be a feasible and inexpensive alternative to this valuable exercise.
Methods: Twenty healthy community-dwelling elderly were recruited, and they were randomly assigned to either the experimental group ($n = 10$) or the control group ($n = 10$). Daily cyber-golfing training for 2 weeks was assigned to the participants of the experimental group, where regular table games with equal lengths and durations were arranged for the control group.
Results: The results revealed that the participants in the experimental group showed significantly better post-training performances in the functional-reach test, $F_{(2,17)} = 5.16$, $p = .04$, and single-leg-stance test, $F_{(2,17)} = 5.32$, $p = .03$, than those in the control group.
Conclusion: The results of this study suggest that cyber-golfing might be an alternative to golfing, which is capable of enhancing balance ability amongst community-dwelling elderly. The potential of exergaming as a clinical tool for geriatric rehabilitation was discussed.

Introduction

Ageing population and high falling rate amongst the elderly have raised serious concerns globally as well as in Hong Kong (Fong, Siu, Au Yeung, Cheung, & Chan, 2011; World Health Organization, 2007). Multiple risk factors contribute to the elderly fall problem (Zecevic, Salmoni,

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http://dx.doi.org/10.1016/j.hkjot.2015.08.001

Speechley, & Vandervoort, 2006). Amongst all, poor balance and standing stability are major attributes that can be improved by proper exercise (Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society, 2011). Golf is a sport that can develop balance, aerobic fitness, and physical health amongst the elderly. Owing to insufficient golfing facilities in Hong Kong, this valuable sport is inaccessible to many elderly. In recent years, the advancement of exergames allows people to exercise at home, and cyber-golfing appears to be an affordable alternative for the elderly (Anderson-Hanley et al., 2012; van Diest, Lamoth, Stegenga, Verkerke, & Postema, 2013). The aim of this study was to examine the effect of cyber-golfing on balance ability amongst the elderly in Hong Kong.

Amongst sports, golfing has many benefits. A previous research has identified better balance and standing stability in professional golfers as compared with amateurs, and significantly greater strength and flexibility over hips, torsos, and shoulders in skilled golfers than in novices (Sell, Tsai, Smoliga, Myers, & Lephart, 2007; Stemm, Jacobson, & Royer, 2006).

Golf may be particularly helpful to the elderly. A study of golf exercise for the elderly suggested that golfing improved the proprioception of their knee joints and their standing-balance control (Tsang & Hui-Chan, 2004). In addition, there were noticeable energy expenditure and glucose consumption after 18 holes of play (Murase, Kamei, & Hoshikawa, 1989). These studies appear to indicate that golfing may prevent the elderly from falling by enhancing their static-balance control.

Exergaming, also known as active video gaming, may be one option to encourage physical activities in the elderly. It is a combination of "exercise" and "gaming," which shows positive effects on general health and physical functioning.

Exergaming has been proven to improve the cognitive function in the elderly. A group of adult trainees improved significantly more in physical and cognitive (in terms of executive control and processing speed) functions than their control counterparts after engaging in 24 sessions of 1-hour exergame training (Maillot, Perrot, & Hartley, 2012; Verheijden Klompstra, Jaarsma, & Strömberg, 2013). Another study revealed that, after exergaming, in particular cyber-cycling, the elderly achieved better cognitive function than traditional exercisers, using the same amount of effort (Anderson-Hanley et al., 2012).

Furthermore, a systematic review found that the elderly with a history of heart failure, whilst enjoying exergaming, experienced improved balance and reported better quality of life and empowerment (Verheijden Klompstra et al., 2013). Lamoth, Caljouw, & Postema (2011) also discovered that the period task performance and balance amongst a group of healthy elderly were better after exergaming.

In summary, these findings indicated that exergaming could be a feasible alternative to facilitate physical participation of healthy community-dwelling elderly in Hong Kong with a view of bettering their balance ability.

As previous research had established that golfing might prevent the elderly from falling by enhancing their static-balance control, this study hypothesised that cyber-golfing might have a similar effect on their standing-balance control. A 2-week cyber-golfing training programme targeted to improving static balance in community-dwelling elderly in Hong Kong was implemented and its effects examined.

Methods

Participants

A convenient sample of 20 healthy community-dwelling elderly from an elderly day activity centre was recruited. Their mean age was 69 years old with a range from 65 years old to 78 years old. Thirteen of them were females and seven were males. All participants reported no major physical illness, could walk without assistance, and had no previous golfing or exergaming experience. The approval was given by the Human Research Ethics Committee of the Hong Kong Institute of Education, and a written informed consent was obtained from each participant.

Procedures

The participants were randomly assigned into either the experimental or control group. In the experimental group, 10 participants received daily cyber-golfing training for 2 weeks. For the control group, regular table games with equal lengths and durations were arranged. For the participants in the experimental group, two 30-minute demonstration sessions were conducted before the experimental procedures. Standby assistance and demonstration of the golf swing were given at the beginning of and during the demonstration sessions.

All participants received pretraining and post-training evaluations on their risk of fall by the timed up-and-go test (TUGT), and their static balance by the single-leg-stance test (SLT) and the functional-reach test (FRT).

The evaluations and the demonstration and training sessions were supervised by a trained research assistant.

Cyber-golfing

An Xbox 360 Kinect (Microsoft Corporation, Hong Kong) was used. An exergame called "Tiger Woods PGA Tour 13" was adopted in the training sessions. The 10-hole gaming mode was selected. All participants were required to finish the whole game in each session, which lasted for 30—45 minutes.

Measurement

TUGT

The participants were required to sit on a chair with their hips all the way to the back of the seat with arms resting. A piece of tape was marked on the floor 3 m away from the chair as the point of return. Upon the signal "go," the participants stood up, walked at a regular pace to the tape, turned around, walked back to the chair, and sat down. The time of the procedure was recorded (Morris, Morris, & Iansek, 2001; Ng & Hui-Chan, 2005; Podsiadlo & Richardson, 1991). An untimed practice trial was given before testing.

Table 1 Summary of the Basic Demographic Data of the Participants, and the Differences in Age and Sex Between the Experimental and Control Groups.

	Experimental group (n = 10)	Control group (n = 10)	t[a]	χ^{2}[b]	p
Mean age (SD)	70.4 (5.4)	68.0 (3.0)	1.24	—	.24
Male:female	3:7	4:6	—	.22	.64

Note. SD = standard deviation.
[a] The t test analysis of the age difference between the experimental and control groups.
[b] The chi-square analysis of the sex difference between the experimental and control groups.

SLT

The participants were asked to stand with eyes open and arms on the hips before standing unassisted on one leg. They were timed from the moment one foot flexed off the floor to the time when it touched the ground or the standing leg, or an arm left the hips (Springer, Marin, Cyhan, Roberts, & Gill, 2007).

FRT

The participants were asked to stand with one shoulder close to the wall, and then leant forward (with feet flat on the floor) as far as possible without losing balance, falling forward, or taking a step. The knuckle position of the middle finger at the point of furthest reach was recorded. The participants performed the test three times, and the average was determined as the functional-reach distance (Duncan, Weiner, Chandler, & Studenski, 1990).

Data analysis

To compare the pretraining performance between the experimental and control groups, independent t tests were used. In addition, analyses of covariance were conducted to evaluate the differences in post-training SLT, FRT, and TUGT between the experimental and control groups after adjusting the pretraining SLT, FRT, and TUGT scores.

Results

Table 1 shows a summary of the comparison of the demographic data of the participants in the experimental and control groups. No statistical differences were found in age (t = 1.24, degree of freedom = 18, p = .24) and sex (χ^2 = .22, p = .64) between the experimental and control groups.

The independent-sample t test analysis found no significant difference between the experimental and control groups in the performances of the three pretraining assessments (Table 2).

The results of the analysis of covariance revealed that an overall statistically significant difference in post-training SLT between the experimental and control groups upon adjustment of their means for pretraining SLT score, $F_{(2,17)} = 5.32$, $p = .03$, with the effect size of .24 (Table 3, Figure 1). Likewise, there was a significant difference in post-training FRT between the two groups after similar adjustments, $F_{(2,17)} = 5.16$, $p = .04$, with the effect size of .23 (Table 3, Figure 2). No difference was found in post-training TUGT between the two groups, $F_{(2,17)} = .41$, $p = .53$ (Table 3).

Discussion

The World Health Organization suggests regular physical activities as a preventive measure against diseases (World Health Organization, 2011). In recent years, considerable evidences have shown that participation in a physical activity is closely related with physical and psychological health. A systematic review of longitudinal observation studies indicated an association between higher levels of physical activity and reduced risk of cognitive decline and dementia (Blondell, Hammersley-Mather, & Veerman, 2014). Moreover, a study on community-dwelling elderly found that the ability to walk more than 100 steps per minute predicted a reduction in mortality (Brown, Harhay, & Harhay, 2014).

The elderly in Hong Kong lack physical-activity participation. A study on Hong Kong elderly found that 62.5% of males and 58.2% of females did not take part in any leisure-time physical activity (Lam, Ho, Hedley, Mak, & Leung, 2004). Lack of physical activity may result in lower-limb weakening and impairment of balance, which were found to be significant predictors of falls in community-dwelling elderly (Chu, Chi, & Chiu, 2005). This may account for our high fall rate of 270 per 1,000 persons annually.

However, there are barriers to taking part in a physical activity amongst the elderly. Firstly, such participation requires the ability to travel independently (Lim & Taylor, 2005). Secondly, there may be problems of accessibility of

Table 2 The t Test Results Comparing the Experimental and Control Groups on the Pretraining Scores.

	Group						95% CI for mean difference	t	p	df
	Experimental			Control						
	M	SD	N	M	SD	n				
TUGT	13.2	4.1	10	10.7	2.8	10	−81, 5.83	1.59	.13	18
SLT	15.0	16.9	10	17.5	16.6	10	−18.30, 13.11	−.35	.73	18
FRT	24.8	6.1	10	25.1	5.6	10	−5.71, 5.27	−.08	.94	18

Note. CI = confidence interval; df = degrees of freedom; FRT = functional-reach test; SD = standard deviation; SLT = single-leg-stance test; TUGT = timed up-and-go test.

Table 3 Analysis-of-Covariance Results Comparing the Post-Training Single-Leg-Stance Test, Functional-Reach Test, and Timed Up-and-Go Test Between the Experimental and Control Groups After Adjusting the Pretraining Single-Leg-Stance Test, Functional-Reach Test, and Timed Up-and-Go Test Scores.

	Sum of squares	df	Mean square	*F*	*p*	Effect size
SLT						
Model	4,321.755[a]	2	2,160.877	168.641*	<.001	.952
Intercept	316.815	1	316.815	24.725*	<.001	.593
Pretraining SLT score	4,313.318	1	4,313.318	336.623*	<.001	.952
Group	68.127	1	68.127	5.317*	.03	.238
Error	217.829	17	12.813			
Total	13,144.610	20				
Corrected total	4,539.584	19				
FRT						
Model	588.949[b]	2	294.475	216.446*	<.001	.962
Intercept	3.406	1	3.406	2.504	.13	.128
Pretraining FRT score	584.245	1	584.245	429.435*	<.001	.962
Group	7.013	1	7.013	5.155*	.04	.233
Error	23.128	17	1.360			
Total	14,367.090	20				
Corrected total	612.078	19				
TUGT						
Model	226.334[c]	2	113.167	48.194*	<.001	.850
Intercept	.208	1	.208	.089	.77	.005
Pretraining TUGT score	207.478	1	207.478	88.358*	<.001	.839
Group	.964	1	.964	.410	.53	.024
Error	39.919	17	2.348			
Total	3,064.758	20				
Corrected total	266.253	19				

Note. df = degrees of freedom; FRT = functional-reach test; SLT = single-leg-stance test; TUGT = timed up-and-go test.
* $p < .05$.
[a] $R^2 = .952$ (adjusted $R^2 = .946$).
[b] $R^2 = .962$ (adjusted $R^2 = .958$).
[c] $R^2 = .850$ (adjusted $R^2 = .832$).

facilities, and environmental convenience is highly correlated with physical activity (Ball, Bauman, Leslie, & Owen, 2001; Humpel, Owen, & Leslie, 2002).

The results of the present study showed that the static balance of the experimental group was improved after 2 weeks' cyber-golfing. One explanation could be cyber-golfing provided similar benefits as real golfing in enhancing their balance. During cyber-golfing, the swinging motion required repeated shifting of body weight between two legs, which might improve the proprioception of the knee joints (Tsang & Hui-Chan, 2004). Besides, the physiological demand of the exergame might help fortify the muscle strength and physical tolerance. Further research on the underlying biomechanics of cyber-golfing should be conducted.

Evidence-based and home-based programmes using exergames should be developed with safety issues studied. The potential of exergaming as a clinical tool for geriatric rehabilitation is also worth exploring.

The results of this study affirmed the proposition that cyber-golfing, being entertaining and more accessible,

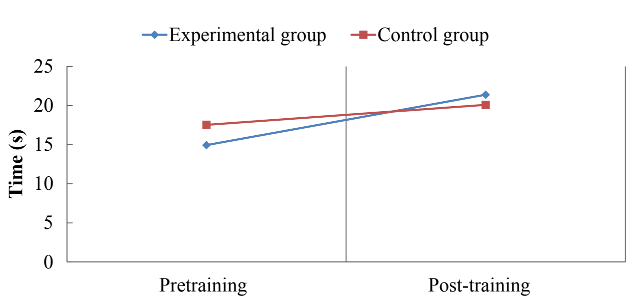

Figure 1 The estimated marginal means of the pre- and post-training single-leg-stance tests.

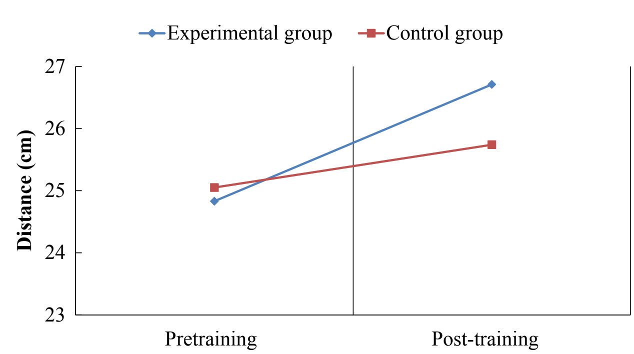

Figure 2 The estimated marginal means of the pre- and post-training functional-reach tests.

might enhance the physical-activity participation of the community-dwelling elderly in Hong Kong, and improve their static-balance performance. Cyber-golfing, therefore, may be considered a therapeutic activity for static-balance training in geriatric care.

Limitations

This study had two limitations. Firstly, the source of sample was limited and its size was small. To generalise the results for the elderly at large, more participants at different physical conditions should be involved. Secondly, as the general physical capacity might be different amongst the participants, the level of pretraining physical conditions of the experimental and control groups should be controlled and matched.

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