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DO PHYSICAL FUNCTION IN NURSING HOME RESIDENTS CHANGE DURING THEIR STAY?

L. YONG[1], P. UPENDRANATHA REDDY[2], J. TAN[3], D. AVERS[4], P.-H. ONG[5], W.-P. WONG[5]

1. MOH Holdings, Singapore; 2. Woodlands Health Campus, Singapore; 3. NTUC Health, Singapore; 4. College of Health Professions, Upstate Medical University, New York; 5. Singapore Institute of Technology, Singapore. Corresponding author: Limin Yong, MOH Holdings, Singapore, limin.yong@mohh.com.sg, +65 91004283

Abstract: *Background:* Decline in physical function is associated with increased frailty and hospitalization, resulting in decline of mental status and loss of functional independence. Nursing homes engage residents with variable intensity and frequency of physical activities to reduce functional decline. However the extent to which the physical function of nursing home residents change (that is, improve, maintain or decline) remains unknown. *Objectives:* The aims of this study were to document the change in physical function and functional category among 222 nursing home residents over a period of 9 months; and to identify the factors associated with changes in their physical function. *Design:* This is a longitudinal and multi-site study, with outcomes measured at point of recruitment and measurements repeated every three months for nine months. *Setting:* Three nursing homes in Singapore. *Participants:* A total of 222 residents (59% male and 41% female) with a mean age of 77.4 years, and an average length of stay of 64 days, participated in the study. Participants did not differ significantly from the 698 total residents in terms of age, number of medical comorbidities and physical function. The key exclusion criteria preventing participation in the study were cognitive status (MMSE < 11) and being placed on cardiac and pulmonary precautions. *Measurements:* Physical function was measured using the following outcome measures: sit and reach for flexibility, single leg stance for balance, 5 times chair-stand for overall lower extremity muscle strength, 10-meter walk tests for gait speed, and Modified Barthel Index (MBI) for activities of daily living (ADL). Participants were categorised into functional categories ("Fun", "Functional", "Frail", "Failure") for each test. Factors that are potentially associated with changes in physical function such as number and type of physiotherapy sessions received, number of hospitalisations, age, and length of stay, Charlson Comorbidity Index, and baseline Geriatric Depression Scale were also recorded. *Results:* There were significant improvements between baseline to 3rd month in flexibility (sit and reach distance from toe in centimeters) [2.69; 95% confidence interval [CI] = 1.05, 4.34; p = .001], balance (single leg stance in seconds) [8.46; 95% CI = 6.81, 10.12; p < .001), MBI [5.06; 95% CI = 2.61, 7.51; p < .001] but not strength and gait speed. Improvements were maintained until 9th month except on flexibility test. Gait speed significantly improved between baseline and 9th month [0.13, 95% CI = .009, .242; p = .035]. The group that improved the most were those who were in the "Failure" group at baseline. Number and type of physiotherapy sessions as well as number of hospitalisations was found to be associated with the extent of improvement in physical function. *Conclusions:* The study suggests that current rehabilitation framework at these nursing homes has the potential to enhance the physical function of residents who are in the earlier stage of their nursing home stay. Modifiable variables such as number and types of physiotherapy sessions appear to be significant factors associated with these outcomes. Hence, further studies examine the optimum frequency and type of physiotherapy sessions for this population.

Key words: Physical function, nursing home, longitudinal.

Introduction

Age-related decline in physical function among older people is well documented (1). Although such functional decline has not been well defined, Schwartz (2) has described the slippery slope of functional decline in older people as consisting of "Fun", "Function", "Frailty" and "Failure" categories. "Fun" category refers to older people who are physically able to perform any activity at will; "Function" means those who are physically able to perform only those activities within their limited physical capacity; "Frailty" refers to those who require assistance with basic and instrumental activities of daily living (ADL); and "Failure" refers to those are bedbound and completely care-dependent.

Functional decline in older people can occur rapidly, resulting in functional losses in mental status and ability to accomplish ADL (3). Functional decline is also frequently associated with institutionalization in the older persons (4). Residents in nursing homes (NH), for instance, have been shown to experience functional decline (5).

Muscle strength loss is a critical factor contributing to functional decline. Older people experience an average decrease in muscle strength by approximately 1-2% every year (1, 6). In NH residents, reduced hand grip strength (16.5 ± 7.7 kg) and low physical activity (79.4% classified as having low physical activity <600 MET minutes per week) have been observed (7). Low mean walking speeds (0.37± 0.26 m/s; 75% of residents had speeds <0.5m/s) are also prevalent among NH residents (8). This is in fact linked to reduced muscle strength and balance in NH residents (9-11), with evidence that such reduction could be either reversed or slowed down with supervised and individually tailored physical exercises (12, 13).

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The baseline physical and cognitive impairments among NH residents are key predictors of functional decline (5). Other contributing factors include poor postural balance, low body mass index, impaired vision, impaired hearing, social isolation and depression (14). Functional decline is associated with low health-related quality of life in older people (15-18) and NH residents (19). Given the evidence of functional decline in NH residents, reversing and delaying this decline should be an important NH care goal (7, 8, 12, 13). Increasingly, NH is incorporating physical exercise programs in the care of their residents. However, whether decline in physical function change as a result of including physical exercises in NH care remains to be investigated. Therefore, the aims of this study were to firstly determine the change among NH residents over nine months in their physical function and functional category according to Schwartz (2); and secondly to identify the factors associated with changes in their physical function.

Methods

The study protocol was approved by the University Institutional Review Board (Singapore Institute of Technology, Project No. 20170027).

Design

This study adopted a longitudinal design, involving three NHs with a total capacity of 800 beds. The NHs are located in the east, west and central part of Singapore.

Participants

Residents who scored at least 11 points on the Mini-Mental State Examination (MMSE) (20) and were able to follow simple verbal instructions (in order to participate in the assessments and physiotherapy sessions) were enrolled into the study. Residents requiring cardiac precautions, with untreated deep vein thrombosis or pulmonary edema, Parkinson's Disease Hoehn and Yahr Stage 4 and above, with existing contractures, or were on palliative care or non-weight bearing status were excluded. Altogether 278 residents were included in the final analysis. Informed consent were sought and obtained.

Procedure

Participants underwent a battery of tests measuring their physical function. These tests included sit and reach test for flexibility, single leg stance for balance, 5-times chair stand for lower extremity muscle strength, 10-meter walk test for gait speed and Modified Barthel Index (MBI) for ADL. Trained research assistants who had completed standardized training and were assessed to be competent performed these tests.

All participants performed active range of movement exercises to upper and lower limbs for 5 minutes as warm-up prior to the physical tests. The participants were allowed to rest for 3 minutes between tests.

Flexibility

Sit and reach test

This is a test of back and hamstring muscle flexibility (21, 22). Residents sat on their bed, with legs extended and back supported at 90 degrees. The soles of the feet were placed flat against a box. Both knees were maintained in extension. They were then instructed to reach forward with their hands towards their toes as far as possible. The best distance of the tips of the fingers to the toes in three attempts was then measured in centimetres and recorded.

Balance

Single leg stance

This test measures the ability to maintain postural control while standing on one leg (23). With eyes open and hands on the hips, residents were instructed to stand on a single leg while maintaining the other leg off the floor for as long as possible. The test was stopped if the patient was not able to maintain their hands on the hips or standing on one leg. Both legs were tested. The best performance out of three attempts was recorded in seconds for each leg.

Gait Speed

10-meter walk test

This is a test of mobility, power, and quality of aging (24). Residents were instructed to walk 10 meters at their preferred walking speed. They were given two meters of space for acceleration and deceleration. The duration to complete the walk was measured in seconds. The best time out of three trials were recorded.

Lower Extremity Strength

5-times chair stand

This test required residents to be seated in the middle of a chair (17 inches height, placed against a wall), without an arm rest, with their back straight and feet approximately shoulder-width apart. The feet were on the floor at an angle slightly posterior to the knees. Arms were crossed and held against the chest. The residents were then instructed to rise to a full stand and return back to their initial seated position five times (25). The time taken to complete this was measured in seconds.

Functional markers

Participants' performance in the physical tests was categorized as fun, functional, frail or fail (2, 26).

Activities of daily living

MBI

The MBI measures ADL and includes ratings of bowel and bladder control, personal hygiene, toilet use, feeding, transfer, mobility, dressing, stairs climbing and bathing. The total score on the MBI ranged from 0-100; the higher the score, the better the physical function for ADL (27).

Other variables

Variables that could influence changes in the participants' physical function were collected: age, length of stay in the NH, number of medications prescribed and comorbidities were collected at the beginning of the study. Comorbidities were categorized using the Charlson Comorbidity Index (CCI): the higher the score, the more likely the predicted outcome would result in mortality or higher resource use (28). Additionally, the resident's psycho-emotional status was measured using the Geriatric Depression Scale (GDS) (29). The GDS is a 30-item questionnaire in which the participants were asked to rate their responses to statements such as "Do you feel pretty worthless the way you are now?" The higher the score on the GDS, the poorer the psycho emotional status of the resident. Scores above 10 indicates likely depression.

All measurements were made at the start of study, 3rd month, 6th month and 9th month. Throughout the duration of the study, participants continued with the existing programs in the NH. They attended a combination of individual physiotherapy sessions, group sessions and exercise circuit training conducted by the physiotherapy assistants under the supervision of physiotherapists in the respective NH. The number of sessions attended by each participant was according to his or her needs and abilities. The number of sessions attended by each participant was recorded.

Data analyses

There were less than 5% missing data from the physical function outcome measures collected throughout the duration of the study. In this study, we chose the method of retaining all data by conducting a "mean imputation" to fill missing data (30). Each missing value was replaced with the mean of the observed values for that variable. Comparisons of the standard deviation and distribution pre- and post- missing value imputation showed that both were not distorted with "mean imputation".

IBM SPSS® Statistics version 25 (IBM, New York) was used for data analyses, using two-tailed tests with significance value set at $p < .05$. Paired sample t-tests were conducted to determine whether the absolute differences in physical function over the four time points were statistically significant. As multiple pairwise comparisons were conducted, the criteria for statistical significance were adjusted using the Bonferonni correction method. Improvements in absolute score (in seconds or centimeters) might not necessarily make any functional changes to a person's physical ability. To test whether the functional categories of residents improve, a Wilcoxon signed-rank test was conducted with resident's functional category status at baseline compared to that at 9th month.

Bivariate correlations and multiple regression (using stepwise approach) were conducted to examine the relationship between key factors (age, length of stay, number of physiotherapy sessions, CCI, number of hospitalisations, GDS and falls) and the dependent variable, which is the changes in performance on the physical functional tests. Variables with a $p<0.05$ were considered for inclusion in subsequent multivariable model.

A one-way ANOVA followed by post-hoc pairwise comparison using the Tukey test were conducted to determine which of the above factors were significantly different between residents who improved versus those who maintained or declined in their physical function.

Results

Participant profile

Out of the 278 residents enrolled, six were transferred to other care facilities, 24 died, 15 were discharged, and 233 completed the study. From these, 11 residents were unable to complete more than three of the five physical outcome measures at all-time points. Therefore, data from 222 residents (91 females and 131 males) were analysed in this study.

Participants ranged from 52 to 104 years of age (mean M = 77.4, standard deviation SD = 9.4). Their CCI scores were 0-13 (M = 6.04, SD = 1.85). At the start of the data collection, their MBI scores ranged from 2 to 94 (M = 47.9, SD = 22.0) and their GDS scores from 0-14 (M = 5.5, SD = 3.5). Participants had between 1-27 different types of medications (M = 9.94, SD = 4.03). Participants' length of stay ranged from 8 to 248 days (M = 64, SD = 48) at the point of recruitment. During the study period, participants were hospitalised 0-7 times (M = 0.84, SD = 1.37) and had 0-4 upper respiratory tract infection episodes (M = 0.29, SD = 0.62).

The top five reasons for admission into the NH were lack of caregiver (27.5%), family unable to support (27%), family unable to cope (15.8%), strained relationship with family (6.8%) and person unsafe to be home alone (2.3%).

These 222 participants were fairly representative of the overall resident population (n = 698) in the three NHs with the exception of average length of stay. The overall NH resident population demographics are as follows – age: ranged from 49 to 104 years of age (mean M = 79.2, SD = 9.1); CCI scores: ranged from 0 to 17 (M = 6.72, SD = 1.89); MBI scores: ranged from 0 to 94 (M = 46.8, SD = 22.7); number of hospitalisations: ranged from 0 to 11 (M = 0.91, SD = 1.41). The overall NH resident population had a longer average length of stay: ranged from 6 to 304 (M = 77, SD = 61).

Table 1
Summary of physical functional and psycho-emotional measures over the 9-month period

Outcomes	Baseline M (SD)	3rd month M (SD)	6th month M (SD)	9th month M (SD)	Baseline vs. 3rd month p value *significant	Baseline vs. 9th month p value *significant
Sit and Reach (cm from toe)	25.2 (12.5)	22.5 (13.7)	25.2 (12.8)	24.4 (14.5)	<.001*	.43
Single Leg Stance (R) (seconds)	3.6 (7.4)	12.1 (12.8)	15.4 (12.8)	14.8 (13.1)	<.001*	<.001*
Single Leg Stance (L) (seconds)	3.7 (7.9)	11.5 (12.7)	14.9 (12.9)	13.9 (13.1)	<.001*	<.001*
Gait Speed (m/s)	.83 (.87)	.9 (.72)	.94 (.69)	.96 (.72)	.22	.034*
Chair Stand (seconds)	22.4 (11.3)	21.7 (10.5)	23.4 (12.4)	22.8 (12.9)	.42	.64
MBI	47.9 (22)	53 (20.5)	53.3 (21.2)	53.4 (21.8)	<.001*	<.001*
GDS	5.7 (3.3)	5.4 (3.0)	5.6 (3.1)	5.8 (3.1)	.3	.46

Physiotherapy sessions (with therapy assistants) received

Individual

93% of the participants received these sessions, ranging from 1 to 151 sessions (Median = 20) per person throughout the 9-month period.

Group therapy

96% of the participants received these sessions, ranging from 1 to 264 sessions (Median = 137.5) per person throughout the 9-month period.

Exercise Circuit

81.5% of the participants received these sessions, ranging from 1 to 123 sessions (Median = 6) per person throughout the 9-month period.

Absolute changes in physical function status

Table 1 above summarises the changes in physical function of residents throughout the study.

Over the first 3-month period, residents significantly improved in flexibility, balance, and overall physical function but not lower extremity muscle strength (time taken to complete 5 chair stands) and gait speed. The largest gain in function appears to occur within this first 3-month period (between baseline and 3rd month), with the exception of gait speed, which residents showed a steady increase in performance over time, reaching significance at 9th month. The significant gains made between baseline and 3rd month on the sit and reach test was not maintained at 9th month. Below are further details of the analyses between time points for the various physical functional outcome measures.

Flexibility

Sit and Reach

There was a significant increase in sit and reach test scores between baseline and 3rd month [2.69; 95% confidence interval [CI] = 1.05, 4.34, p = .001]. Participants were able to reach forward by 2.7 cm closer to target between baseline and 3rd month. This gain was however not maintained at the end of the 9-month period.

Balance

Single Leg Stance

There was a significant increase in single leg stance on the right leg between baseline and 3rd month [8.46; 95% CI = 6.81, 10.12, p < .001]. Participants continued to improve between 3rd and 6th month [3.28; 95% CI = 1.65, 4.91, p < .001]. There were no significant difference between 6th and 9th month, but performance at 9th month was still significantly better than that at baseline [11.16; 95% CI = 9.35, 12.96, p < .001].

There was a significant increase in single leg stance on the left leg between baseline and 3rd month [7.75; 95% CI = 5.71, 9.8, p < .001]. Participants continued to improve between 3rd and 6th month [3.47; 95% CI = 1.88, 5.06, p < .001]. There were no significant difference between 6th and 9th month, but performance at 9th month was still significantly better than that at baseline [10.24; 95% CI = 8.22, 12.27, p < .001].

Gait Speed

10-meter walk test

There was a significant increase in gait speed only between baseline and 9th month [.13; 95% CI = .01, .24, p = .035].

Lower extremity Strength

Chair stand test

There was a significant improvement in time taken (in seconds) to perform five chair stands only between 3rd and 6th month [-1.66; 95% CI = -.22, -3.09, p = .024].

Table 2
Wilcoxon signed rank test indicating changes in functional status from baseline to 9th month

Outcomes	Improved	Declined	Maintained	T value	p value * significant
Sit and Reach	32	23	167	1.87	.062
Single Leg Stance	129	23	70	8.4	< .001*
Gait Speed	31	20	171	0.8	.22
Chair Stand	72	48	102	2.24	.025*

Table 3
Changes in functional status over a 9-month period for residents who were "Failures" at baseline

Outcomes	"Fun" (9th month)	"Functional" (9th month)	"Frail" (9th month)	"Failure" (9th month)	% of "Failures" who improved
Sit and Reach	3	11	15	156	29/185 (15.7%)
Single Leg Stance	42	9	28	47	79/126 (62.7%)
Gait Speed	1	0	22	146	23/169 (13.6%)
Chair Stand	2	6	31	16	39/55 (70.9%)

Table 4
Significant differences between the improved, declined and maintained group for the different physical outcome measures

Physical outcome measures	Factors affecting physical outcomes	Changes in function	Mean	SD	F value	p value (two-tailed)
Sit and Reach	Length of stay	Improved	499.06	224.5	5.31	.006
		Declined	357.04	150.47		
		Maintained	392.51	180.39		
	Group Therapy sessions	Improved	146.5	89.11	4.52	.012
		Declined	82.91	77.06		
Single Leg Stance	Group Therapy sessions	Improved	140.26	83.98	3.56	.03
		Declined	90.26	87.6		
	Hospitalisation	Improved	.74	1.2	3.27	.04
		Declined	1.52	2.02		
		Declined	1.47	2.08		
Chair Stand	Medication	Improved	9.25	3.61	4.02	.019
		Declined	11.31	4.59		
	Group Therapy sessions	Improved	147.97	83.95	3.68	.027
		Declined	104.77	83.39		
	Hospitalisation	Improved	.82	1.36	5.29	.006
		Declined	1.38	1.91		
BADL-MBI	Hospitalisation	Improved	.68	1.15	3.13	.046
		Declined	1.16	1.65		

Overall physical function

Modified Barthel Index

There was a significant difference in MBI score between baseline and each of the 3 subsequent time points. Baseline vs 3rd month [5.07; 95% CI = 2.61, 7.52, p < .001]; baseline vs 6th month [5.38; 95% CI = 2.9, 7.87, p < .001]; baseline vs 9th month [5.51; 95% CI = 3.02, 8.0, p < .001].

Table 5
Factors that significantly associated with improvements in physical function between baseline and 9th month

Factors		Functional Outcomes	Correlation (r value)	p value (one-tailed)	% of variance (R^2)	F value	p value (two-tailed)
Physiotherapy provided	Group Therapy sessions	Sit and Reach	.147	.028	2.2	4.882	.028
	Circuit Training sessions	Single Leg Stance (Right)	.137	.042	1.9	4.182	.042
Health status	Hospitalisation	MBI	-.192	.004	3.7	8.39	.004

Functional categorical changes in physical abilities

Changes in rank

For most of the outcome measures, most of the residents maintained their functional category, with the exception of single leg stance where most residents (58%) had improved. For the rest of the outcome measures, more residents had shown improvements than a decline in function. A summary of the results can be found in Table 2.

Upon examination of the data, it was found that the group that showed greatest improvements were those in the "Failure" category. Table 3 summarises the shift in the functional categories for each outcome measure in this group of residents.

Difference between participants who improved, declined and maintained function

The key factors that differentiated those who improved and those who declined in function were number of group therapy sessions and hospitalisation throughout the study period. This indicates that physiotherapy interventions and health status were two important factors. Table 4 summarises the differences that were significant.

Factors associated with improvements in physical function of NH residents

How much the above factors contributed to the improvements in physical function was assessed with multiple regression. Table 5 summarises the relationships that were significant.

Improvements in physical function were higher with more physiotherapy interventions provided. Conversely, the worse their health i.e. greater number of hospitalisations, the lower the improvement in physical function. These factors accounted for between 1.9 to 3.7% of variance in improvements in various physical functions.

Interestingly, the CCI scores of nursing home residents were neither significantly correlated nor contributory to a significant amount of variance in the various physical functions measured in this study. CCI was however positively correlated with age. The older the residents were, the higher their CCI scores, $r = .271$, $p < .001$.

Discussion

In this study, participants were fairly representative of the overall NH resident population with the exception of their average length of stay at point of recruitment. The difference in average length of stay suggests that our findings may be more applicable to residents who are in the earlier stage of their nursing home stay.

Our study shows that with physiotherapy and physical exercises incorporated in NH care, 29% of the residents have demonstrated improvements, 57% maintained their functional abilities without functional decline, whereas only 14% have shown decline in their functional abilities across the outcome measures over a 9-month period. These findings are similar to that of a recent systematic review of literature from 1983 till 2011, showing that most residents either maintain or improve their functional status (10).

Improvements were recorded in balance, gait speed and overall physical function, but not flexibility and strength. Analyses of the results showed that the group with the greatest improvements were those in the "Failure" category. Improvements from "Failure" category to the "Fun", "Functional" and "Frail" categories were made by 13.6% of residents on the gait speed test, 15.7% on the flexibility test, 62.7% on the balance test, and 70.9% on the chair stand test. This implies that quantitative improvements in physical test scores could be translated to physical functional gains. Findings from this study agree with those of clinical trials examining the role of intensive physical exercise programs in NH residents (12, 13).

In this study, the total number of medications, the number of medical comorbidities (CCI), upper respiratory tract infections, and bowel and bladder continence did not have any significant relationship to the physical outcome measures of the NH residents. This finding contradicts some authors' speculation that comorbidities are predictive of functional decline in NH residents (9). One study shows that medications and comorbidities could predict functional decline (11), however, it has not included any physical exercise program as in the present study.

The number of group therapy sessions and hospitalisation throughout the study period were also found to differentiate between those who had improved and those who had declined in physical function. This suggests that therapy and health

status are two important factors contributing to improvements in physical function amongst the NH residents. Previous studies supported the association between number of physiotherapy sessions and extent of improvement in physical function (31-34). Conversely, the worse their health, as indicated by hospitalisation episodes in this study, the lower the improvement in physical function. Whilst the health status of the NH residents are dependent on many factors, some of which might be non-modifiable, the number of physiotherapy sessions can be increased in the NH setting. In Singapore, currently there are 72 NHs with 12,000 beds; the Ministry of Health targets to increase the number of NH beds to 17,000 by the year 2020 (35). The scaling-up reflects the increasing demand for NH beds. However, unless the NH residents' physical function improves to the point of discharge, the number of beds will not necessarily meet the demand from an ageing population. Incorporating and optimizing the number of physiotherapy sessions could potentially be one strategy to contribute to improvement of NH residents' physical function.

There are policy implications. The finding that the greatest improvement is shown among those whose baseline functional category is labelled "Failure" challenges the traditional view that those who are in failure category of functional mobility, are often considered low on the potential for rehabilitation. This finding offers implications for NH administrators and policy-makers where funding rehabilitative services in NHs could be reviewed.

Study limitations

Although data were collected on the amount of individual, group and exercise circuit therapy sessions with therapy assistants, other physical activities carried out at the NH accommodation level, including occupational therapy, nursing and volunteer-led activities, were not accounted for. Hence, the extent to which these other activities contributed to the physical outcomes could not be ascertained. In addition, this study excluded residents with moderate to severe cognitive impairments. Hence, results cannot be generalised to all NH residents, given that many of them have cognitive impairment. There was a 16% attrition rate of participants secondary to discharge from NH (back to their own home) and deaths. The performance of this pool of residents was not represented in the study analyses.

Future directions

Future studies could investigate the optimal amount and frequency of physical exercises for NH residents. This knowledge could help NH organizations allocate health care resources more effectively. Other studies could examine the reasons for hospitalization and how the health status of NH residents could be improved. Further studies could also incorporate economic evaluation such as cost-effectiveness analysis.

Conclusion

Our study suggests that incorporating physical exercises into the daily activities of NH residents in the earlier stage of their stay has the potential to enhance the physical function of these residents. Given that physical exercises is a modifiable factor and can be easily incorporated into the daily care plans of residents in the NH, further studies could examine the optimum frequency and type of physiotherapy sessions for residents who are in the earlier stage of their nursing home stay to maximise this potential.

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