International Journal of Gerontology 8 (2014) 6–11

Contents lists available at SciVerse ScienceDirect

International Journal of Gerontology

journal homepage: www.ijge-online.com

Original Article

Application of Pole Walking to Day Service Centers for Use by Community-dwelling Frail Elderly People☆

Susumu Ota [1]*, Hiroshi Goto [2], Remi Fujita [1,3], Midori Haruta [1], Yukari Noda [4], Koji Tamakoshi [5]

[1] *Department of Physical Therapy, School of Health Sciences, Nagoya University, Nagoya,* [2] *Department of Physical Therapy, School of Health Sciences, Toyohashi SOZO University, Toyohashi,* [3] *Department of Physical Therapy, Kibi International University Graduate School of Health Science Studies, Takahashi,* [4] *School of Social Work, Seirei Christopher University, Hamamatsu,* [5] *Department of Nursing, School of Health Sciences, Nagoya University, Nagoya, Japan*

ARTICLE INFO

Article history:
Received 11 October 2012
Received in revised form
19 February 2013
Accepted 11 March 2013
Available online 24 April 2013

Keywords:
community-dwelling frail elderly people,
physical function,
posture,
quality of life

SUMMARY

Background: In an aging society, it is important to provide community-dwelling frail elderly with ongoing social services to maintain and improve their physical function. The purpose of this study was to investigate the effects of physical fitness, posture, and quality of life (QoL) on community-dwelling elderly using pole walking at a day service center.

Materials and methods: Participants were recruited from day service users, and a control group and intervention (pole walking) group were randomly selected. Pole walking group members were allowed to use poles during walking and ambulation in the daily routine of a day service center for 3 months. Thirty-five and 22 participants in the control and pole walking groups, respectively, were measured for physical fitness, posture, and QoL at the baseline and at the final session, and the measurements were compared to pre- and postintervention levels in both groups.

Results: In the control group, a timed up and go test after 3 months was performed significantly slower than at baseline ($p < 0.05$, power = 0.13, effect size = 0.13). The Physical Component Summary score of the MOS 8-item Short Form Health Survey was significantly increased compared to the score at baseline ($p < 0.01$, power = 0.64, effect size = 0.47) in the pole walking group.

Conclusion: The effects of 3 months of pole walking on community-dwelling elderly day service users showed improved Physical Component Summary scores of higher QoL. However, there was no significant effect of physical functions due to the intervention.

1. Introduction

In aging societies, maintaining or improving the physical function, activities of daily living (ADL), and quality of life (QoL) of the elderly is important. It allows them to live independently and to have longer, healthier lives. The community care programs developed for these purposes have reduced the use of institutional care services and lowered mortality[1] in many countries. Japan introduced a universal-coverage long-term care insurance program in April 2000[2]. Day service is one of the major in-home services covered by the long-term care insurance program. It is a facility-based daytime program of nursing care providing meals and bathing, functional training, supervision, and socialization. It enables frail, older people who are in poor overall health, with multiple comorbid illnesses and varying physical or mental impairment, to remain in the community. The users of day service centers are also provided with transportation service, which enables participation in the day care service for the community-dwelling elderly who cannot travel from their home to the center by themselves, or do not have family members to take them there. For this reason, many frail elderly community-dwellers with deteriorated physical function are able to use day service centers. Therefore, intervention physical exercise used at day service centers must be one of the most adequate approaches for maintaining and improving physical function and ADL for the community-dwelling frail elderly. Moreover, because it was covered by the care insurance program, the day service center intervention could be continuously implemented. However, because only a few rehabilitation specialists (such as physical therapists and occupational

☆ The authors declare that they have no financial or non-financial conflicts of interest related to the subject matter or materials discussed in the manuscript.

* Correspondence to: Dr Susumu Ota, Department of Physical Therapy, School of Health Sciences, Nagoya University, 1-1-20 Daikominami, Higashi-ku, Nagoya, Aichi 461-8673, Japan.

E-mail address: susumu-ota@fg7.so-net.ne.jp (S. Ota).

1873-9598/$ – see front matter
http://dx.doi.org/10.1016/j.ijge.2013.03.010

therapists) are affiliated with such centers in Japan, the intervention exercises at a day service center must be kept simple; the day care service users visit a few times/week and they have little time for intervention in real conditions.

Walking with poles has become widespread as a recreational exercise and sport. Using poles theoretically increases the weight-bearing area, and is assumed to stabilize walking for the elderly. There are several reports on the effects in patients with Parkinson's disease[3] and intermittent claudication[4]. Pole walking is one of the styles used for walking with poles. The pole walking technique involves placing the pole in the front position (Fig. 1), which is the same method used with the T-cane. Therefore, pole walking was assumed to be a simpler walking technique for elderly people.

From the above, incorporating pole walking during walking or ambulation in the daily routine of day service centers is assumed to be an appropriate and adequate health intervention for the elderly in day service centers in real conditions. The purpose of this study was to investigate the effects pole walking application would have on the physical fitness and QoL of community-dwelling elderly using day service centers. Additionally, because using poles is expected to improve posture[5], which is related to physical fitness in elderly people,[6,7] the effect of pole walking on whole body posture was also examined in this study.

2. Materials and methods

2.1. Participants

Prior to the start of the study, its contents were first introduced in the Hanaso-kai, a day service center self-study group, at an explanatory meeting in Toyohashi City. The eligibility criteria of the day service center were registered by the long-term care insurance program. Participants who were recruited from five day service center facilities gave their consent after a previous explanatory meeting. The five facilities were randomized using randomly selected table numbers, with the intervention group (pole walking group) having two facilities, and the control group having three facilities. Inclusion criteria were being able to walk independently or to walk under supervision, to attend the day service twice/week, and to have no severe cognitive impairment (no orientation disorder and being able to do a 3-digit span backward). The exclusion criterion was the inability to use poles because of palsy of the hands and fingers. The baseline used as the first session in this study was from August 2010 to September 2010. The second session, established as final analysis after 3 months of intervention, was from November 2010 to December 2010.

Overall, a total of 66 participants (pole walking group: 28 individuals; control group: 38 individuals) were measured as the first outcome. The baseline characteristics and all measurements of the participants are shown in Table 1. All participants were informed as to the nature of the study, and informed consent in writing was obtained, as required by the Ethics Committee of the School of Medicine, Nagoya University.

Thirty-five and 22 participants in the control and pole walking groups, respectively, were evaluated in the second session, 3 months after the first session. A total of nine participants could not be measured at the second session (Refused to assess; $n = 2$, Sickness; $n = 4$, Bone fracture; $n = 1$, Leave day service; $n = 1$, Missed last visit; $n = 1$, Fig. 2). Differences in participant characteristics between both groups in the final analysis are shown in Table 1.

2.2. Intervention

Pole walking was used as the intervention for three months at day service centers the participants attended. Pole walking requires use of the pole in a diagonal position, though the pole makes contact with the ground in front of the body (forward pole position; Fig. 1). The length of the pole was adjusted to 65% of the participant's height. Pole walking was applied to the ambulation for ADL and walking as long as the participants could attend the daily

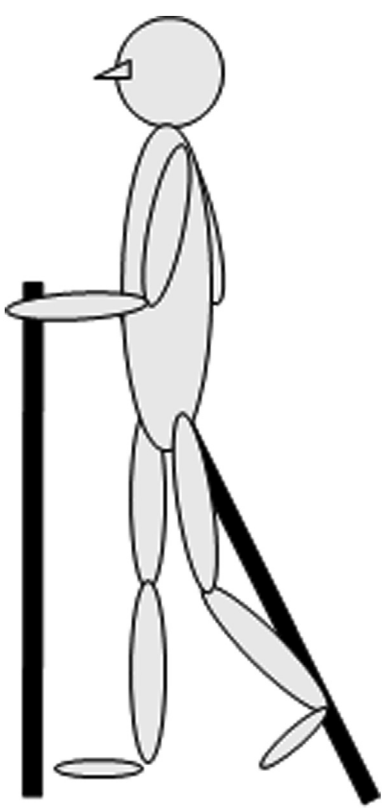

Fig. 1. Pole walking. Pole is positioned diagonally and makes contact with the ground in front of the body (forward pole position).

Table 1
Demographic and clinical characteristics of participants.

	Intervention ($n = 28$) mean (SD)	Control ($n = 38$) mean (SD)	*p*
Age (y)	82.9 (7.4)	82.6 (5.9)	0.874
Sex, male/female**	9/19	4/34	0.09
Height (cm)	148.1 (7.7)	143.3 (8.1)	0.017*
Weight (kg)	48.0 (10.7)	49.0 (11.0)	0.717
Timed up and go test, normal walking time	14.9 (5.6)	15.8 (5.9)	0.540
One-legged standing time with eyes open	3.8 (3.3)	4.4 (3.4)	0.418
Back muscle strength	33.3 (20.1)	26.4 (13.3)	0.102
Knee extension strength, right	124.9 (48.1)	142.3 (42.2)	0.124
Knee extension strength, left	122.6 (49.3)	141.6 (47.2)	0.117
Upper cervical angle	125.6 (11.5)	127.4 (12.1)	0.527
Neck slope angle	36.9 (9.4)	37.6 (12.0)	0.800
Thoracic spine angle	42.9 (13.1)	40.2 (15.3)	0.456
Lumbar spine angle	−8.7 (13.4)	−9.8 (11.5)	0.733
Pelvic plane angle	1.5 (8.9)	3.6 (8.1)	0.308
Knee joint angle	20.9 (8.1)	19.5 (10.3)	0.557
SF-8 Physical Component Summary	47.1 (6.2)	45.0 (7.0)	0.217
SF-8 Mental Component Summary	50.1 (6.2)	49.6 (6.3)	0.728

Data are presented as second, kg, or degree unless otherwise stated.
*Difference of continuous variables between intervention and control by unpaired *t* test. Significant differences at $p < 0.05$. **Fisher's exact test.
SF-8 = MOS 8-item Short Form Health Survey.

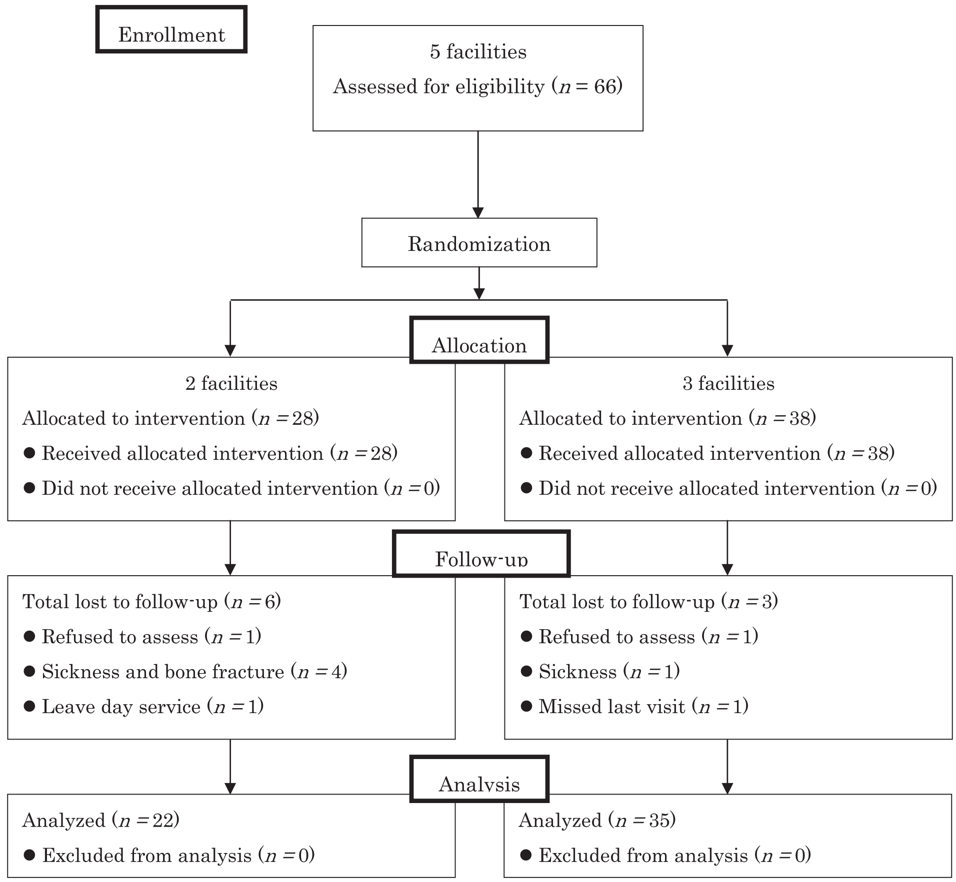

Fig. 2. Flow diagram showing participants in the study.

routine of each day service center. Participants in the control group were allowed to follow their usual schedule each day at their day service centers. The walking poles used were Revita-2 (Sinano Co., Nagano, Japan).

2.3. Assessment

Measurements of physical fitness, posture, and QoL were evaluated pre- and postintervention. All measurements were performed at the day service centers.

Physical fitness Knee extensor strength, back muscle strength, one-legged standing time with eyes open test, and the timed up and go (TUG) test were used to the physical fitness test. The respective methods used to measure each item are described below.

Isometric knee extension strength was tested twice using a hand-held dynamometer (MicroFET2; Hoggan Health, Salt Lake City, UT, USA). The maximum isometric muscle strength of both legs was measured while the participant was sitting on a chair without a backrest and the knee was flexed to 90°. A testing pad was attached to the front lower leg of the participant and strapped to the leg of the chair. The participant was instructed to push the pad with maximal strength. Two trials were conducted, and the peak force of the higher score was recorded.

Back muscle strength was determined from the maximal isometric strength of the trunk muscles in a standing posture with 30° lumbar flexion using a back muscle strength meter (TTM; Takei Co. Ltd., Kanagawa, Japan). The maximum strength in each trial was measured, and the maximum force from two trials was used in the final analysis.

For the one-legged standing time with eyes open test, the length of time participants were able to stand on one leg with their hands placed on their waist was measured using a stopwatch. The dominant leg was measured twice, and the maximum length of time was taken as the measured value. The dominant side was determined as the leg used to kick a ball.

The TUG procedure includes rising from a chair, walking 3 m, turning around, walking back, and sitting down again[8]. The participants were asked to walk 3 m at normal speed.

Health-related QoL Health-related QoL (HRQoL) was measured by MOS 8-item Short Form Health Survey (SF-8)[9]. SF-8 consists of single items/scales that describe each of the eight dimensions of health in the MOS 36-item Short Form Health Survey: general health, physical function, role physical, bodily pain, vitality, role emotional, mental health, and social function. The physical and mental summary scales were computed according to the SF-8 manual. A higher score indicates better functioning and less symptoms. The Physical Component Summary and Mental Component Summary were used in this study.

Posture evaluation The measurement of whole-body posture was used according to previous reports[10,11]. Eleven spherical colored, reflective markers with a diameter of 30 mm were attached to specific anatomic landmarks of participants' bodies in the standing position (Fig. 3). An ear marker was attached to the center of the earphone with an ear hook, and the other face marker was attached to the midpoint between the right corner of the mouth and the right nasal ala. Thoracic vertebra (T1), T3, T11, lumbar vertebra (L1), sacral vertebra (S2), anterior superior iliac spine, greater trochanter, lateral epicondyle, and lateral malleolus also had markers attached.

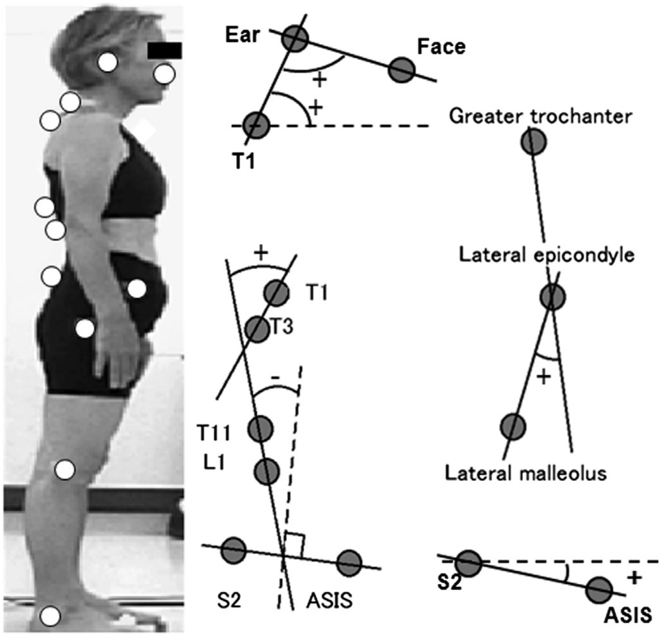

Fig. 3. Marker placement and angle definition: upper cervical angle [face–ear–thoracic vertebra (T1)]; neck slope angle (absolute value to horizontal line: the angle between the line of ear and T1 and horizontal broken line); thoracic spine angle [the angle between the line of T1 and T3 and the line of T11 and lumbar vertebra (L1)]; lumbar spine angle (the angle between the line of T11 and L1 and the perpendicular line to the line of sacral vertebra (S2) and anterior superior iliac spine); pelvic plane angle (absolute value to horizontal line: the angle between the line of the S2 to anterior superior iliac spine and horizontal broken line); and knee joint angle (the angle between the line of greater trochanter and lateral epicondyle and the line of lateral epicondyle and lateral malleolus).

Participants wore black fitting shirts and short pants during video recording. The right side of the participants was videotaped as they stood with bare feet in a quiet erect position for 5 seconds and watched a target adjusted to eye height. Participants placed both hands lightly on a stable anterior support approximately at the groin. Patients each had their postures measured three times.

Fig. 3 illustrates the angle definitions and calculations. The location of each skin reference marker on the 5-second videotaped images taken by a digital videocamera (GR-D850; JVC, Tokyo, Japan) was automatically digitized at a frequency of 60 samples/second using a Total motion coordinator Lite (Toso System Ltd., Ageo city, Japan). The average from the three measurements of these posture data was used in the final analysis.

Increasing upper cervical spine angles indicate increasing chin-up, and decreased neck slope angles show the increasing forward head position as a negative change. An increasing thoracic spine angle indicates increasing thoracic kyphosis. Increasing lumbar spine angles denote increasing lumbar flexion. An increasing pelvic plane angle indicates an increasing anterior pelvic tilt.

2.4. *Reliability study*

Prior to the study, the intratester reliability of each angle measurement was established on 2 separate days (Day 1 and Day 2).

Intratester reliability of each angle was assessed using intraclass correlation coefficient (ICC). The standard error of measurement was calculated using the following equation: standard deviation $\times(\sqrt{1} - \text{ICC})$. To further investigate the real change beyond measurement error of whole-body posture in assessing each angle, the smallest real difference[12] was used to indicate the magnitude of change (or differences between populations) that would exceed the expected trial-to-trial variability. The smallest real difference was calculated using the following equation: $1.96 \times \sqrt{2} \times$ standard error of measurement[12]. In other words, the smallest real difference is the smallest measurement change that can be interpreted as a real difference. Descriptive statistics of each angle on two separate occasions and test–retest reproducibility results are presented in Table 2.

2.5. *Data analysis*

Differences in participant characteristics and sex ratio between both groups were analyzed using unpaired *t* test and Fisher's exact test. Differences between all data of pre- and postintervention in each control and pole walking group were analyzed using paired *t* test. All analyses were performed using SPSS version 16 (IBM Japan, Chuo ward, Tokyo, Japan). The significance level was set at $p < 0.05$.

3. Results

The changes in measurements between pre- and postintervention in the control group were presented in Table 3. TUG after 3 months was significantly slower than it was at baseline ($p < 0.05$). Neck slope angles and pelvic plane angles were significantly decreased ($p < 0.05$). The lumbar spine angle was also significantly decreased ($p < 0.01$).

The average total implementation time of pole walking was 229.3 minutes, and the average length of time with pole walking/day and its frequency of use/week were 9.7 minutes and 2.0 times, respectively. The changes in measurements between pre- and postintervention with pole walking are presented in Table 4. Upper cervical angle was significantly decreased compared to the angle at baseline ($p < 0.01$), and the pelvic plane angle was significantly decreased ($p < 0.05$). The Physical Component Summary of the SF-8 was significantly increased compared to the score at baseline ($p < 0.05$).

4. Discussion

There were no significant differences in almost all of the data between both groups at baseline (Table 1). Only the differences in height between groups were significant. Although there was no significant difference in the sex ratio between the groups ($p = 0.09$), the difference in height was assumed to be affected by the sex ratio (male/female: intervention group 9/19, control group 4/34).

The differences in all measurement changes in the pole walking group were found to be Physical Component Summary and the posture measurements such as upper cervical angle (chin-up-down) and pelvic plane angle. By contrast, the significant changes in the control group were obtained in TUG, neck slope angle (forward head position), lumbar spine angle, and pelvic plane angle. All

Table 2
Descriptive statistics of each angle on two separate occasions and test–retest reproducibility results.

	Day 1 (°) mean (SD)	Day 2 (°) mean (SD)	ICC	SEM	SRD
Upper cervical angle	102.7 (5.1)	102.7 (4.3)	0.84	2.0	5.6
Neck slope angle	52.7 (4.2)	52.4 (3.1)	0.90	1.3	3.7
Thoracic spine angle	39.1 (12.7)	38.6 (12.2)	0.97	2.3	6.5
Lumbar spine angle	−21.6 (8.7)	−23.4 (10.9)	0.92	2.4	6.7
Pelvic plane angle	5.3 (1.5)	6.1 (2.2)	0.86	0.6	1.6
Knee joint angle	5.3 (4.6)	5.0 (3.9)	0.80	2.0	5.6

ICC = intraclass correlation coefficient; SEM = standard error of measurement; SRD = smallest real difference.

Table 3
Parameters for preintervention (Pre) to postintervention (Post) comparisons in the control groups ($n = 35$).

	Pre mean (SD)	Post mean (SD)	p^*
Timed up and go test, normal walking time	15.7 (5.8)	16.5 (6.4)	0.028*
One-legged standing time with eyes open	4.5 (3.4)	4.3 (3.0)	0.684
Back muscle strength	25.7 (13.7)	27.9 (17.6)	0.254
Knee extension strength, right	140.7 (43.0)	138.5 (50.3)	0.760
Knee extension strength, left	139.7 (48.7)	132.1 (53.8)	0.258
Upper cervical angle	127.6 (11.7)	128.9 (11.4)	0.203
Neck slope angle	37.6 (11.9)	34.6 (10.5)	0.010*
Thoracic spine angle	41.4 (15.4)	42.1 (15.7)	0.493
Lumbar spine angle	−10.7 (10.7)	−5.0 (11.2)	<0.001*
Pelvic plane angle	3.6 (8.2)	1.5 (7.3)	0.014*
Knee joint angle	19.4 (10.4)	19.5 (9.7)	0.936
SF-8 Physical Component Summary	45.4 (7.1)	45.6 (7.0)	0.872
SF-8 Mental Component Summary	49.5 (6.3)	49.6 (5.7)	0.925

Data are presented as second, kg, or degree.
* Difference of continuous variables between pre- and postintervention by paired t test. Significant differences at $p < 0.05$.
SF-8 = MOS 8-item Short Form Health Survey.

of the significant changes in the control group were negative changes in frail elderly people.

Additionally, a subanalysis was conducted on the control group TUG and the intervention group's Physical Component Summary of SF-8, which showed significant differences in main outcomes using two-way repeated-measures analysis of variance [(pre- vs. postintervention) × the facilities] to adjust the facilities. The results of the analyses in both TUG and Physical Component Summary of the SF-8 were significantly different between pre- and post-intervention to adjust the facilities ($p = 0.030$, $p = 0.023$, respectively).

For the primary outcome, TUG in the control group 3 months after baseline was significantly decreased, whereas TUG in the pole walking group counterpart was not. TUG has been widely used as a physical function test for elderly people, and reportedly has a relation with the risk of fall rate[13], fear of falling[13,14], instrumental activity of daily living disability[14], and balance[8]. Therefore, participants in the pole walking group were assumed to maintain the factors, which have important roles in the physical function of elderly people.

However, the power was 0.13 and the effect size was 0.13. For this reason, we could not conclude that TUG in control group was delayed between pre- and postintervention. Finally, we could not obtain the effect of pole walking for TUG.

For the second primary outcome of Physical Component Summary of the SF-8, the Physical Component Summary was significantly improved, but only in the pole walking group. The Physical Component Summary is associated with physical function[15] and physical activity[16]. However, the results of this study do not reflect improvement of physical functions, such as strength of the knee extensor and back muscle, one-legged standing time with eyes open, and TUG. One intervention study using pole walking[17] reported a tendency of the Physical Component Summary to improve ($p = 0.057$) by 6 weeks of intervention. Using a tool (pole) in pole walking could affect the Physical Component Summary compared to walking without the pole. However, the power and the effect size of the Physical Component Summary in the intervention group of the present study was 0.64 and 0.47, respectively. It is necessary to recognize the improvement in the Physical Component Summary of HRQoL under the power and the effect size.

For the posture alignment, the upper cervical angle was decreased from 127.0° to 122.6° due to intervention in the pole walking group, and the change was significant by paired t test. However, the positive change in upper cervical angle with pole walking was 4.4°, and the smallest real difference of the upper cervical angle was 5.6°. This change was not larger than the smallest real difference of the smallest measurement change in this posture assessment. Therefore, we could not conclude that the upper cervical angle was significantly improved. In the same way as considered for the smallest real difference, all of the significant posture changes in both groups were within each smallest real difference without the pelvic plane angle. We have concluded that the effects by these intervention conditions were not affected by the posture alignments.

Pelvic plane angles of control and pole walking groups were significantly decreased 2.1° and 2.7°, respectively, and the changes were > 1.6° of the smallest real difference. Decreased pelvic plane angle, which indicates decreased anterior pelvic tilt, would be related to the posteriorized center of body mass. Therefore, any change in the reduced anterior pelvic tilt should be a negative one for the elderly in both groups for 3 months.

Nordic walking (a physical activity similar to pole walking) has also become a widespread recreational exercise. Its effects have been described as increased oxygen consumption and heart rate compared to ordinary walking, without increasing the walker's perception of exertion[18–20]. Positive effects for patients with depression[21], Parkinson's disease[3], and cardiovascular diseases[22] have also been reported. Moreover, other effects such as reducing the load on the lower extremity with Nordic walking compared to ordinary walking have been described in the literature[23]. Nordic walking has been reported to increase stride and walking speed compared to level walking[23,24]. Pole walking is assumed to have effects similar to Nordic walking. Moreover, the pole front position (pole walking) is the same method used with a T-cane. Therefore, the pole front technique was assumed to be a simpler technique for middle-aged and elderly people compared to Nordic walking. The technique of walking with poles in Nordic walking allows walkers to place the pole in a diagonal position and angle it backward until it makes contact with the ground between both feet in the sagittal plane (backward pole position) according to the definition of Nordic walking on the International Nordic Walking Federation website[5]. Nordic walkers are also recommended to receive instruction from a licensed instructor. Compared to Nordic walking, pole walking can be more simply applied to community-dwelling elderly people.

There are several limitations in this study. The first is random allocation of the facilities. It should have allocated participants

Table 4
Parameters for preintervention (Pre) to postintervention (Post) comparisons in the intervention groups ($n = 22$).

	Pre mean (SD)	Post mean (SD)	p^*
Timed up and go test, normal walking time	15.0 (6.2)	16.0 (6.0)	0.095
One-legged standing time with eyes open	3.9 (3.6)	3.2 (2.4)	0.325
Back muscle strength	34.4 (21.1)	35.7 (22.6)	0.517
Knee extension strength, right	125.0 (47.9)	139.1 (48.3)	0.091
Knee extension strength, left	120.7 (47.8)	130.6 (50.4)	0.379
Upper cervical angle	127.0 (11.8)	122.6 (12.5)	0.003*
Neck slope angle	35.2 (9.4)	34.9 (11.2)	0.782
Thoracic spine angle	45.2 (11.4)	47.7 (11.6)	0.145
Lumbar spine angle	−9.8 (10.5)	−7.7 (10.6)	0.190
Pelvic plane angle	1.6 (8.2)	−1.1 (9.1)	0.048*
Knee joint angle	19.6 (7.4)	17.9 (8.7)	0.477
SF-8 Physical Component Summary	47.9 (6.2)	50.8 (4.3)	0.006*
SF-8 Mental Component Summary	51.1 (5.7)	51.2 (4.4)	0.954

Data are presented as second, kg, or degree.
* Difference of continuous variables between pre- and postintervention by paired t test. Significant differences at $p < 0.05$.
SF-8 = MOS 8-item Short Form Health Survey.

within the same day care service center, because both groups should undergo the same conditions except for pole walking. However, this random allocation was unavoidable, because of the requirements made by representatives of day care services. The second limitation was the small intervention, which was pole walking for 9.7 minutes/day and twice/week. However, the purpose of the present study included investigation of the effects in a day care service center that was supported by the social security system (long-term insurance) in real conditions, for possibly continuous intervention for community-dwelling frail elderly. In reality, the possible time for pole walking was twice/week and 10 minutes/day in the day service center. Although participants were not allowed to engage in new physical exercises for 3 months, it would be difficult to predicate that the positive effect derives only from intervention.

There are two important and novel findings in this study. First, the effects of pole walking during 3 months for community-dwelling elderly day service users were the improved Physical Component Summary ($p < 0.01$, power = 0.64, effect size = 0.47). Second, pole walking could be applied to day services in real situations and ordinary daily living as part of the long-term insurance program. This means that this intervention could be carried on as one of the day service's long-term care approaches for community-dwelling frail elderly.

Acknowledgments

We are very grateful to the participants and the staff of the day service centers, Nanohana, Yayoi Ohjuen, Yoshidagata, Hosho Life, Aichi Clinic, and Kosumosu, for their generous cooperation. The study was supported by the Japan Society for the Promotion of Science (Grant-in-Aid for Scientific Research [C] number 21500467).

References

1. Kuzuya M, Masuda Y, Hirakawa Y, et al. Day care service use is associated with lower mortality in community-dwelling frail older people. *J Am Geriatr Soc*. 2006;54:1364–1371.
2. Campbell JC, Ikegami N. Long-term care insurance comes to Japan. *Health Aff (Millwood)*. 2000;19:26–39.
3. van Eijkeren FJM, Reijmers RSJ, Kleinveld MJ, et al. Nordic walking improves mobility in Parkinson's disease. *Move Disord*. 2008;23:2239–2243.
4. Oakley C, Zwierska I, Tew G, et al. Nordic poles immediately improve walking distance in patients with intermittent claudication. *Eur J Vasc Endovasc Surg*. 2008;36:689–694. discussion 695–686.
5. International Nordic Walking Federation. *Definition of Nordic Walking*. 2013. http://inwa-nordicwalking.com/?page_id=37 [accessed 15.04.13].
6. Katzman WB, Vittinghoff E, Ensrud K, et al. Increasing kyphosis predicts worsening mobility in older community-dwelling women: a prospective cohort study. *J Am Geriatr Soc*. 2011;59:96–100.
7. Kado DM, Huang MH, Nguyen CB, et al. Hyperkyphotic posture and risk of injurious falls in older persons: the Rancho Bernardo Study. *J Gerontol A Biol Sci Med Sci*. 2007;62:652–657.
8. Podsiadlo D, Richardson S. The timed "up & go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc*. 1991;39:142–148.
9. Fukuhara S, Suzukamo Y. *Manual of the SF-8 Japanese Version*. Kyoto: Institute for Health Outcomes & Process Evaluation Research; 2004.
10. Tully EA, Wagh P, Galea MP. Lumbofemoral rhythm during hip flexion in young adults and children. *Spine (Phila Pa 1976)*. 2002;27:E432–E440.
11. Kuo YL, Tully EA, Galea MP. Video analysis of sagittal spinal posture in healthy young and older adults. *J Manip Physiol Ther*. 2009;32:210–215.
12. Beckerman H, Roebroeck ME, Lankhorst GJ, et al. Smallest real difference, a link between reproducibility and responsiveness. *Qual Life Res*. 2001;10:571–578.
13. Yamada M, Uemura K, Mori S, et al. Faster decline of physical performance in older adults with higher levels of baseline locomotive function. *Geriatr Gerontol Int*. 2012;12:238–246.
14. Kwan MM, Lin SI, Chen CH, et al. Sensorimotor function, balance abilities and pain influence timed up and go performance in older community-living people. *Aging Clin Exp Res*. 2011;23:196–201.
15. Garber CE, Greaney ML, Riebe D, et al. Physical and mental health-related correlates of physical function in community dwelling older adults: a cross sectional study. *BMC Geriatr*. 2010;10:6.
16. Bertheussen GF, Romundstad PR, Landmark T, et al. Associations between physical activity and physical and mental health—a HUNT 3 study. *Med Sci Sports Exerc*. 2011;43:1220–1228.
17. Ota S, Hase K, Kaji D, et al. Chukoureisya wo taisyoutoshita pole walking no koukanituite. *J Clin Sports Med*. 2009;26:1189–1194. [Article in Japanese].
18. Church TS, Earnest CP, Morss GM. Field testing of physiological responses associated with Nordic walking. *Res Q Exerc Sport*. 2002;73:296–300.
19. Porcari JP, Hendrickson TL, Walter PR, et al. The physiological responses to walking with and without Power Poles on treadmill exercise. *Res Q Exerc Sport*. 1997;68:161–166.
20. Rodgers CD, VanHeest JL, Schachter CL. Energy expenditure during submaximal walking with exerstriders. *Med Sci Sports Exerc*. 1995;27:607–611.
21. Suija K, Pechter U, Kalda R, et al. Physical activity of depressed patients and their motivation to exercise: Nordic Walking in family practice. *Int J Rehabil Res*. 2009;32:132–138.
22. Collins EG, Langbein WE, Orebaugh C, et al. Cardiovascular training effect associated with polestriding exercise in patients with peripheral arterial disease. *J Cardiovasc Nurs*. 2005;20:177–185.
23. Willson J, Torry MR, Decker MJ, et al. Effects of walking poles on lower extremity gait mechanics. *Med Sci Sports Exerc*. 2001;33:142–147.
24. Knight CA, Caldwell GE. Muscular and metabolic costs of uphill backpacking: are hiking poles beneficial? *Med Sci Sports Exerc*. 2000;32:2093–2101.