1. Please translate the following abstract into Chinese (15%), give an English title (5%) and 5 appropriate keywords (5%) for this abstract. (Article by Van der Heide JC, Otten B, Van Eykern LA, Hadders-Algra M. Exp Brain Res 2003;151:32-45.)

Abstract We evaluated the development of postural adjustments accompanying reaching movements in sitting children. Twenty-nine typically developing children aged, 2–11 years, and ten adults were studied with multiple surface electromyograms (EMGs) and kinematics during reaching in four conditions: sitting with the seat-surface oriented horizontally with and without an additional task load, and sitting with the seat-surface tilted 15° forward and 15° backward. The development of postural adjustments during reaching in a sitting position turned out to have a non-linear and protracted course, which is not finished by the age of 11 years. The development of these adjustments is characterised by variation, yet specific developmental sequences could be distinguished. Firstly, the development of postural adjustments during reaching from the age of 2 years onwards lacked a preference for an *en bloc* strategy, which consists of an in concert activation of the direction-specific neck and trunk muscles. Secondly, anticipatory postural muscle activity, which was consistently present in adults, was virtually absent between 2 and 11 years of age. Thirdly, the data demonstrated that with increasing age the head gradually becomes the dominant frame of reference. In addition, the study suggested that, in terms of postural control, the forward-tilted position is the most efficient one.

2. Please answer the following question (in English) according to the attached abstract of a perspective article. (Gregory CM, Bickel CS. Recruitment patterns in human skeletal muscle during electrical stimulation. Phys Ther 2005;85:358-365.)

Question 1) What are the common purposes of clinical usage of electromyostimulation? (10%)

Question 2) What are the authors' standpoint of clinical usage of electromyostimulation? (15%)

Electromyostimulation (EMS) incorporates the use of electrical current to activate skeletal muscle and facilitate contraction. It is commonly used in clinical settings to mimic voluntary contractions and enhance the rehabilitation of human skeletal muscles. Although the beneficial effects of EMS are widely accepted, discrepancies concerning the specific responses to EMS versus voluntary actions exist. The unique effects of EMS have been attributed to several mechanisms, most notably a reversal of the recruitment pattern typically associated with voluntary muscle activation. This perspective outlines the authors' contention that electrical stimulation recruits motor units in a nonselective, spatially fixed, and temporally synchronous pattern. Furthermore, it synthesizes the evidence that supports the contention that this recruitment pattern contributes to increased muscle fatigue when compared with voluntary actions. The authors believe the majority of evidence suggests that EMS-induced motor unit recruitment is nonselective and that muscle fibers are recruited without obvious sequencing related to fiber types. [Gregory CM, Bickel CS. Recruitment patterns in human skeletal muscle during electrical stimulation. *Phys Ther.* 2005;85:358–364.]

3. Please answer the following questions based on the information provided in the attached article. You may not need to read the whole article to answer the questions. (Article by Jan MH, Hung JY, Lin JCH, Wang SF, Liu TK, Tang PF. Effects of a home program on strength, walking speed, and function after total hip replacement. Arch Phys Med Rehabil 2004;85:1943-1951.)

   1) What are the research questions of the study? (10%)
   2) What are the null hypotheses? (10%)
   3) What the experimental design and methods of statistical analyses are used to answer the question and test the hypotheses? (20%)
   4) What are the results of the study? (10%)

Effects of a Home Program on Strength, Walking Speed, and Function After Total Hip Replacement

Mei-Hwa Jan, MS, PT, Jane-Yu Hung, MS, PT, Janice Chien-Ho Lin, MS, PT, Shwu-Fen Wang, PhD, PT, Tang-Kue Liu, MD, Pei-Fang Tang, PhD, PT

ABSTRACT. Jan M-H, Hung J-Y, Lin JC-H, Wang S-F, Liu T-K, Tang P-F. Effects of a home program on strength, walking speed, and function after total hip replacement. Arch Phys Med Rehabil 2004;85:1943-51.

Objective: To assess the efficacy of a home exercise program in increasing hip muscle strength, walking speed, and function in patients more than 1.5 years after total hip replacement (THR).

Design: Randomized controlled trial.

Setting: Kinesiology laboratory.

Participants: Fifty-three patients with unilateral THR were randomly assigned to the training (n=26) and control (n=27) groups. Patients in the training group were further divided into exercise-high (n=13) and exercise-low (n=13) compliance groups according to their practice ratio (high, ≥50%).

Intervention: The training group underwent a 12-week home program that included hip flexion range of motion exercises for both hip joints; strengthening exercises for bilateral hip flexors, extensors, and abductors; and a 30-minute walk every day. The control group did not receive any training.

Main Outcome Measures: Strength of bilateral hip muscles, free and fast walking speeds while walking over 3 different terrains, and functional performance were assessed by using a dynamometer, videotape analysis, and the functional activity part of the Harris Hip Score, respectively, before and after the 12-week period.

Results: Subjects in the exercise-high compliance group showed significantly ($P<.05$) greater improvement in muscle strength for the operated hip, fast walking speed, and functional score than those in the exercise-low compliance and control groups.

Conclusions: The designed home program was effective in improving hip muscle strength, walking speed, and function in patients after THR who practiced the program at least 3 times a week, but adherence to this home program may be a problem.

Key Words: Arthroplasty, replacement, hip; Exercise; Patient compliance; Rehabilitation.

TOTAL HIP REPLACEMENT (THR) is a well-accepted surgical procedure for patients with advanced arthritic disorders at the hip.[1,2] Patients with THR often present with a gradual decline in hip muscle strength 2 to 3 years after the operation.[3-6] Strength of the hip muscles has been shown to be an important predictor of walking speed and functional performance in patients with THR.[7,8] Research has also indicated that weakness of the muscles of the operated hip, especially that of the hip abductors, is a major risk associated with joint instability, prosthesis loosening, or other complications in these patients.[9-12] Therefore, continual practice of exercise programs, especially those with an emphasis on muscle strengthening given in the form of home programs, is important for patients with THR after hospital discharge, not only to prevent the declining of strength but also to maintain a highly functional level and to prevent complications.

Only a few studies have reported the effect of home exercise programs for patients with THR. Sashika et al[13] showed that a 6-week home exercise program—consisting of hip flexion range of motion (ROM) and low-resistance strengthening exercises for the hip abductors, flexors, and extensors—significantly improved the strength of these muscles and walking speed in patients 6 to 48 months after THR. Their study revealed that a home exercise program could be a cost-effective intervention program to improve strength and walking ability of these patients.[13] However, it remains unknown whether Sashika's program would show concomitant effects in improving the ability of the patients to perform daily functional activities such as stair climbing or using public transportation. In addition, walking exercise, known as an effective alternative strengthening method to improve the strength of the hip abductors on the operated side,[14] is among the most commonly practiced functional activities for patients with THR.[15-17] It was of interest to investigate whether a home program consisting of both muscle strengthening and walking exercises would significantly improve hip muscle strength and functional ability in patients after THR.

The effectiveness of a home exercise program relies not only on the content of the program per se but also on patients' compliance with the program. Oldridge et al[18] and Ice[19] have reported that the participants' compliance with home exercise programs significantly influenced the exercise effects. It is worth noting that the patients who participated in the study by Sashika[13] showed a mean compliance level of approximately 70%. It was possible that the participants' high compliance with the home program was another main factor that led to significant improvement in their muscle strength and walking speed. We wondered whether patients with THR would have as much improvement as that reported by Sashika[13] if their compliance with a home program was not as high as 70%.

The purpose of this investigation was to evaluate the efficacy of a home exercise program in improving hip muscle strength, walking speed, and functional ability in patients after THR. The designed home program included low-resistance isotonic strengthening exercises of bilateral hip abductors, extensors, and flexors; 1-legged stance; and a 30-minute walk, 7 days a

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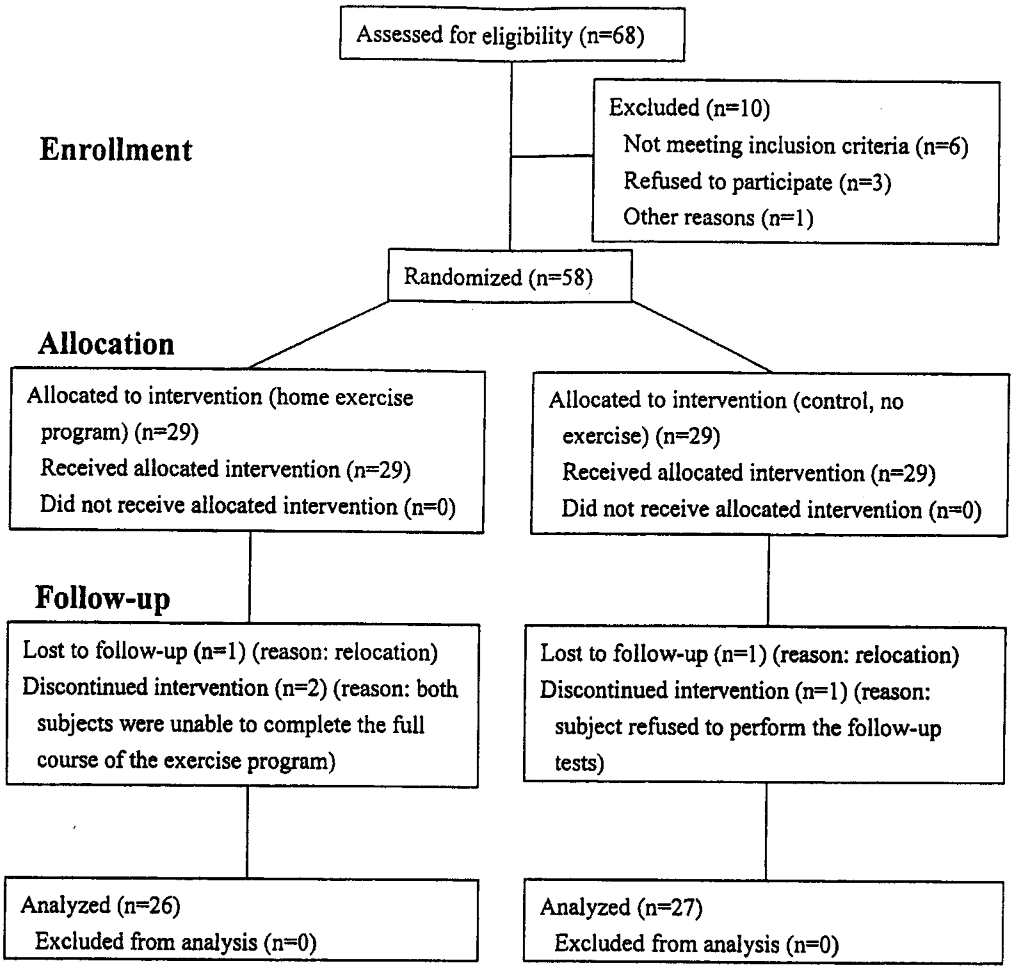

Fig 1. The clinical trial profile of this study.

week for 12 weeks. An isokinetic dynamometer; tasks of walking on hard level-ground, sponge, and grass surfaces; and functional activity part of the Harris Hip Score were used to assess patients' hip muscle strength, walking speed, and functional ability, respectively. Participants' compliance with the home program was also recorded for further analysis of the potential influence of compliance on exercise effects.

METHODS

Participants

Participants of this study were recruited from the Department of Orthopedics, National Taiwan University Hospital. The inclusion criteria of participants were having undergone the primary THR at least 1.5 years before the study, their primary THR being performed by the same orthopedic surgeon (TKL) using the anterolateral approach, no revision afterward, and being able to walk independently without any assistive device. The exclusion criteria consisted of acetabular and/or femoral prosthesis failure and a comorbidity such as cardiopulmonary, neurologic, or cognitive diseases. Fifty-eight patients initially participated in this study. All signed an informed consent document approved by the Ethics Committee of the National Taiwan University Hospital. Subjects were randomly assigned to the exercise (n=29) and control (n=29) groups. Five subjects (3 exercise, 2 control) dropped out because of relocation or unwillingness to continue in the study. A total of 53 patients (26 exercise, 27 control) completed the full study (fig 1).

Home Program

For the exercise group, a 12-week daily home exercise program was prescribed. The home exercise program consisted of hip flexion ROM exercises for bilateral hip joints (2 sets by 10 repetitions/set); isotonic strengthening exercise for bilateral hip flexors, extensors, and abductors with low-resistance weight (1kg for women, 2kg for men) tied on the ankle (2 sets by 10 repetitions/set for each muscle group); additional strengthening of the hip abductors with 1-legged stance on each leg (2 sets by 10 repetitions/set, holding for 5s each repetition)[13,20] (fig 2); and a 30-minute walk at a comfortable-speed.

Measurements

The isometric muscle strength of bilateral hip extensors, flexors, and abductors was tested by using a Cybex 6000[a] isokinetic dynamometer. High reliability on testing the strength of hip muscles using this machine has been reported.[21] Standard positioning method was used to test all of these muscles.[22,23] For testing the strength of hip abductors, subjects laid on their side and facing away from the dynamometer, with the

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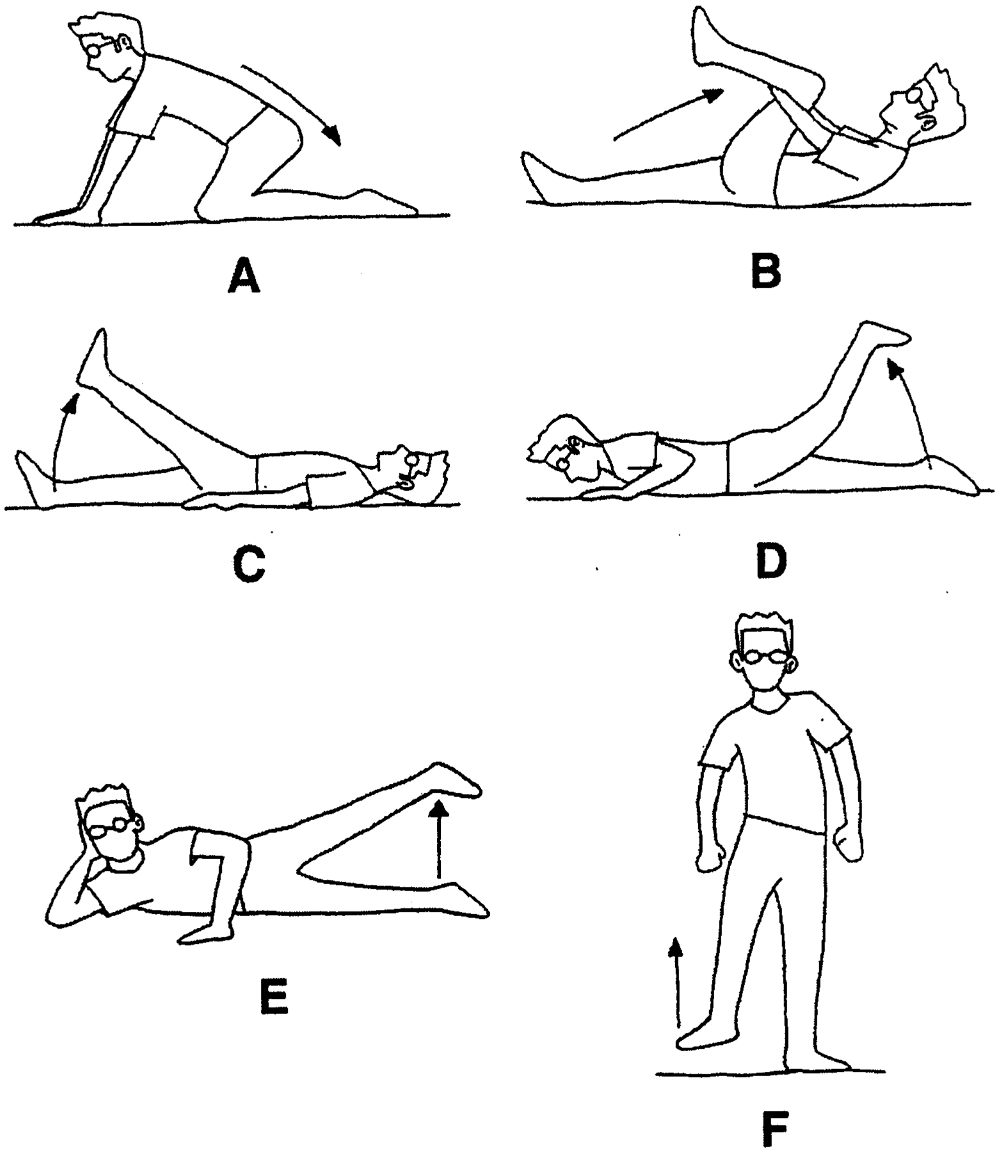

Fig 2. Illustrations of the exercises of the home program used in this study. (A, B) Hip flexion ROM exercises; (C) hip flexor strengthening exercise; (D) hip extensor strengthening exercise; (E) hip abductor strengthening exercise; and (F) 1-legged stance exercise.

tested hip on the top and aligned with the axis of the moment arm. The tested hip joint was placed and supported at 15° of abduction. The test pad of the moment arm was placed on the distal, lateral portion of the thigh of the tested leg. The patient's pelvis and the distal femur of the nontested leg were fixed to the testing table using a strap. Testing hip flexor and extensor strength was performed with the patients lying supine. The knee on the tested side hung freely over the edge of the testing table, whereas that on the nontested side was supported in an extended position. The test pad of the moment arm was placed on the distal, anterior portion of the thigh of the tested leg. The patient's pelvis was fixed to the testing table using a strap. The test angles for hip extensors and flexors were set at 60° and 30° of hip flexion, respectively.

We used the functional activity part of the Harris Hip Score[24-26] (table 1) to measure the functional ability of these patients. This part included 4 activity items, including assessment of patients' ability to climb stairs, to put on socks and shoes, to sit on a chair for a period of time, and to use public

Table 1: Functional Activity Part of the Harris Hip Score

Activity Items and Performance	Score
Stairs	
Normally	4
Normally with banister	2
Any method	1
Not able	0
Put on socks and tie shoes	
With ease	4
With difficulty	2
Unable	0
Sitting	
Any chair, 1h	5
High chair, 30min	3
Unable to sit 30min any chair	0
Enter public transportation	
Able to use public transportation	1
Not able to use public transportation	0

transportation. The score ranges from 0 (inability to perform any of the items) to 14 (highest level of function). Söderman and Malchau[26] have reported high validity and reliability in using the Harris Hip Score to measure the clinical outcome of patients after THR.

To test walking speed, subjects were asked to walk at free and fast speeds on a 12-m level-ground hard surface and a 8-m grass surface and at free speed on a 12-m long spongy surface. The sponge was 10cm in height, and the hardness measure was shore 000 (medium hardness). All walking trials were recorded with a digital video camera.[b] The camera was equipped with an internal clock, which could accurately measure time to a tenth of a second.

The practice ratio, defined as the number of days during which the subject actually carried out the program divided by the program duration in days (7d/wk×12wk=84d), was calculated for each subject and was used as the measure of exercise program compliance for each subject.[13]

Procedure

All subjects underwent an initial baseline assessment of hip muscle strength, functional ability, and walking speed in sequence. Isometric muscle strength tests of bilateral hip extensors, hip flexors, and hip abductors muscles were performed for each subject by using the Cybex 6000 isokinetic dynamometer. Routine calibration for the Cybex machine was performed before testing each subject. Muscles of the nonoperated hip were tested first, followed by those on the operated side. For muscles on the same side, the hip abductors, flexors, and extensors, were tested in sequence. The isometric testing for each muscle consisted of 3 trials within which each subject was asked to exert a maximal effort against the testing pad without causing pain and to sustain the effort for 5 seconds. A 30-second rest period was given between trials for testing the same muscle group, and a 1-minute rest was given between testing of different muscle groups. It took approximately 30 minutes to complete the muscle strength test for each subject. The peak torque value of each muscle group, after the correction for gravity, was recorded for each trial.

After the muscle strength test, an experimenter (JYH), a senior physical therapist with 6 years of clinical experience, assessed subjects' performance on the functional activity part of Harris Hip Score. Afterward, each subject undertook the walking speed test, including 3 free- and fast-speed walking trials each for walking on the level-ground hard surface and grass surface and 3 trials of free-speed walking on the spongy surface. Subjects were instructed to walk at the self-selected comfortable speed for the free-speed trials and to walk as fast as possible for the fast-speed trials. The sequence of walking speed tests was conducted in order of increasing task difficulty, starting with walking on level-ground hard surface, followed by walking on a grass surface, and finally on the spongy surface. Free-speed trials were tested before the fast-speed trials for each surface condition.

After the initial evaluation, experimenters provided patients in the exercise group with illustrated and verbal instructions, as well as demonstrations, to show them how the home exercises should be performed during the 12-week training period. To record compliance with the program during this period, subjects were also asked to keep a daily record of how often they performed the exercises. Visits to any physical therapy (PT) department were not allowed during the 12-week period. An experimenter (JYH) telephoned each subject every week to check whether subjects had any difficulty in carrying out the home program. Patients were asked to return to the laboratory to receive further instructions on the exercise techniques, when necessary. Subjects in the control group were neither allowed to visit any PT clinic, nor did they receive any instructions or telephone calls regarding any exercises during the 12-week period.

At the completion of the 12-week period, all subjects completed the follow-up assessment of muscle strength, walking speed, and functional ability within 1 week. The testing procedure was the same as that used in the initial baseline assessment. Subjects in the exercise group were asked to turn in their daily record of exercise compliance.

Data and Statistical Analysis

Descriptive statistics were used to depict subjects' demographic characteristics, including age, sex, height, weight, months after THR, and side of the THR. For the muscle strength test, the maximal peak torque recorded among the 3 trials tested for the same muscle group was used for further statistical analysis. For each walking trial, walking speed was first calculated by dividing the distance of the corresponding walking path by the time taken by each subject to complete the walking path. Then, the average walking speed for each walking condition was calculated among the 3 walking trials of the same walking condition and was used for further statistical analysis.

At the end of the 12-week period, we noted that half of the patients in the exercise group showed a compliance rate of greater than or equal to 50% with the program, whereas the other half showed a compliance rate of less than 50%. Because previous studies have shown significant influences of compliance on the outcome of exercise training,[13,14,27] we further divided the exercise group into the exercise-high (n=13) and exercise-low (n=13) compliance groups with the cut-point set at 50% of compliance. The medians (and ranges) of the practice ratio for the exercise-high and -low compliance groups were 73.2% (50%–100%) and 23.3% (11.5%–41.6%), respectively. The chi-square test was used to compare the distribution in sex and the operated side of THR of the demographic data across the 3 groups. One-way analysis of variance (ANOVA) was used to compare other demographic data and pretraining values in muscle strength, walking speed, and functional score among the 3 groups to test whether the 3 groups were in general comparable in their pretraining physical status.

Two paired t tests were then conducted to determine whether there were any significant differences between the pre- and posttraining values in muscle strength and walking speed for the exercise-high compliance, exercise-low compliance, and control groups, respectively. The Wilcoxon signed-rank test was used to test differences between the pre- and posttraining values in functional score for all 3 groups. In addition, another two 1-way ANOVA procedures were used to compare changes from the initial baseline to follow-up assessments on muscle strength and walking speed among the 3 groups. The Kruskal-Wallis rank test was used to compare changes from the initial baseline to follow-up assessments for functional score among the 3 groups. A P value of .05 or less was considered significant for all statistical analyses. The independent t test with Bonferroni adjustments ($P<.017$) was used as the post hoc test of the 1-way ANOVA procedures.

RESULTS

Table 2 presents the demographic information of the exercise-high compliance, exercise-low compliance, and control groups. There was no significant difference in age, sex distribution, body weight, months after THR, or side of THR among the 3 groups ($P>.05$). The control group, however, showed a slightly greater body height than the other 2 groups ($P<.05$).

Table 3 shows the maximal isometric peak torque of bilateral hip abductors, flexors, and extensors muscles; walking speed;

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Table 2: Demographic Data for the 3 Groups of Subjects

Subject Characteristics	Exercise Groups: High Compliance (n=13)	Exercise Groups: Low Compliance (n=13)	Control Group (n=27)	P
Age (y)	58.8±12.9	59.3±10.3	57.0±12.8	NS
Sex (female/male)	9/4	8/5	10/17	NS
Height (cm)	159.5±7.6	158.5±4.6	163.0±9.7	<.05
Weight (kg)	137.7±22.2	142.4±22.7	141.8±21.4	NS
Months after THR	54.2±46.5	72.2±51.6	76.0±52.0	NS
Side of THR (L/R)	7/6	7/5	14/13	NS

NOTE. Values are mean ± standard deviation (SD), except for sex and side of THR.
Abbreviations: L, left; NS, not significant; R, right;

and functional score of the 3 groups before and after the 12-week period. The ANOVAs and the Kruskal-Wallis rank test showed no significant difference in the baseline pretraining values of all these measurements among the 3 groups ($P>.05$). The statistical results revealed that, after completion of the 12-week home exercise program, subjects in the exercise-high compliance group showed significant ($P<.05$) improvement in muscle strength of bilateral hip muscles, in free and fast walking speed while walking on different terrains, and in functional score. Subjects in the exercise-low compliance group did not reveal any significant changes in muscle strength, walking speed, or functional score before and after training ($P>.05$). The control group showed a slight decrement in all measurements after the 12-week period, but the decrement was not statistically significant ($P>.05$).

Furthermore, comparison of the changes in muscle strength of the operated hip after the 12-week period among the 3 groups, by using ANOVA, showed that subjects in the exercise-high compliance group showed significantly ($P<.05$) greater improvement than those in the exercise-low compliance and the control groups. For the strength of the muscles on the nonoperated hip, subjects in the exercise-high compliance group showed significantly ($P<.05$) greater improvement in hip flexor strength than those in the exercise-low compliance group and significantly greater improvement in hip abductor and flexor strength than subjects in the control group ($P<.05$).

Regarding changes in walking speed, subjects in the exercise-high compliance group showed significantly ($P<.05$) greater improvement in fast walking speed on level-ground and grass surfaces than those in the exercise-low compliance and control groups. As to the free speed for walking on level-ground, grass, and spongy surfaces, subjects in the exercise-high compliance group showed significantly ($P<.05$) greater improvement than the control group. There was no significant difference between the exercise-high compliance and the exercise-low compliance groups in the change of free walking speed.

With respect to the changes in functional score of the 2 exercise groups and the controls after the 12-week period, subjects in the exercise-high compliance group showed significantly ($P<.05$) greater improvement in functional score than subjects in the exercise-low compliance and the control groups. Furthermore, the exercise-low compliance group also showed a

Table 3: Comparison of Pre- and Posttraining Values in Muscle Strength, Walking Speeds, and Functional Score for the 3 Groups of Subjects

Outcome Measures	Exercise Groups: High Compliance		Exercise Groups: Low Compliance		Control Group	
	Pre	Post	Pre	Post	Pre	Post
Strength (Nm)						
Operated side						
Abductors	54.2±17.1	64.9±17.8*	52.4±20.7	54.8±21.6	55.7±17.7	52.0±21.0
Flexors	49.2±20.0	57.5±22.3*	48.9±18.2	48.4±14.8	54.2±22.5	50.8±21.2
Extensors	70.1±21.4	79.6±20.9*	72.0±24.8	70.5±28.1	74.8±31.1	72.5±24.2
Nonoperated side						
Abductors	60.5±18.1	67.1±17.5*	61.5±16.1	63.7±21.1	63.3±20.1	62.3±23.1
Flexors	56.4±19.7	67.4±15.8*	59.3±18.3	60.8±20.6	62.3±20.0	59.5±21.2
Extensors	84.8±23.8	91.9±30.1*	82.4±16.5	85.3±32.5	87.4±38.7	87.1±23.8
Walking speed (m/min)						
Level-free	63.8±6.3	71.9±11.3*	64.1±8.9	64.7±9.2	66.1±13.2	62.6±10.8
Level-fast	85.0±11.4	98.6±17.8*	88.5±6.4	89.7±14.7	85.8±15.0	81.0±7.8
Grass-free	63.0±13.5	78.6±18.1*	61.5±16.9	65.0±15.1	61.9±12.4	59.0±14.1
Grass-fast	78.7±9.1	95.4±10.6*	76.3±8.7	74.2±9.0	78.6±12.6	73.8±7.2
Sponge-free	57.1±7.6	62.2±14.6*	56.5±8.7	55.2±13.8	57.0±11.4	51.6±13.8
Functional score	11.7±0.8	13.1±0.6*	12.4±1.2	12.7±1.7	12.4±1.1	12.0±1.4

NOTE. Values are mean ± SD.
Abbreviations: Fast, fast walking speed; Free, free walking speed; Grass, grass surface; Level, level surface; Pre, before 12-wk period; Post, after 12-wk period; Sponge, spongy surface.
*$P<.05$.

significantly ($P<.05$) greater increase in functional score than the control group after the 12-week period.

DISCUSSION

Results of this study revealed that our home exercise program, which emphasizes hip muscle strengthening and walking exercise training, was effective in improving hip muscle strength, walking speed, and functional mobility of patients with THR. However, such positive effect was evident only if the patients had a compliance rate greater than 50% with the program.

Subjects had received THR at least 1.5 years before participating in the study. All showed reduced strength of bilateral hip muscles compared with age-matched healthy controls reported in the literature.[28-30] Therefore, significant decrease in bilateral hip muscle strength existed in these patients. Given that the progressive weakness of the muscles of the operated hip is highly likely to lead to joint instability, functional limitation, disability, and other complications in patients after THR,[9,10] exercise programs that emphasize muscle strengthening are critical not only to prevent strength decline but also to maintain high functional level and to prevent complications. Furthermore, for these patients, exercises given in the form of home-based programs may be a more convenient, practical, and economical exercise prescription than PT outpatient programs.

Characteristics of the Home Program

The 12-week home exercise program used in this study was designed specifically for patients with THR, and we provided an illustrated guide to make the exercises easy to learn. The hip flexion ROM exercise was aimed at relieving the limitation of hip flexion ROM, a problem commonly seen in patients with THR.[31,32] In addition, our program placed special emphasis on hip abductor strengthening through a combination of isotonic antigravity hip abduction exercises, the 1-legged stance practice, and walking exercises. This was based on the consideration that all of our subjects received the anterolateral approach to THR and, therefore, the hip abductors of the operated side was the most vulnerable to instability among all of the hip muscles.[33,34] Past research has also shown that decline in hip abductor strength on the operated side is among the most common problems in patients with THR.[33,34] Furthermore, given that walking ability was an important functional outcome measure after THR surgery,[4,9,35] our program differed from those used in the previous studies by incorporating a 30-minute daily walking exercise into the program. It was expected that the daily practice of walking would enhance the ability of these patients to perform other functional tasks, such as using public transportation and going up and down stairs.

Changes in Hip Muscle Strength

Our results showed significant improvement in the muscle strength of bilateral hip muscles for the exercise-high compliance group but not for the exercise-low compliance and control groups. Previous reports have shown that the strength of the hip muscles improved markedly 1 to 2 years after THR[9,13,35,36] and gradually declined afterward. Only 2 of our subjects received the THR at 18 months before study participation; the rest received the THR at least 24 months before the study. Thus, hip muscle strength in these chronic patients might have continued to decline had no particular exercise programs been given to them. We observed this tendency of muscle strength reduction in our patients in the control group. Thus, our results suggest that the prescribed home program was effective not only in preventing further muscle strength reduction but also in improving the strength of these chronic patients who showed high compliance (≥50% practice ratio) with the program.

We hypothesized that such strengthening effect would result from a combination effect of the low-resistance muscle strengthening, 1-legged stance, and walking exercises. Sashika et al[13] reported that a 6-week daily low-resistance, low-repetition (20 repetitions/day) strengthening home exercise alone was sufficient to improve hip abductor strength on the operated side in patients whose post-THR interval was less than 4 years and whose exercise compliance rate was approximately 70%. Significant effects of low-intensity strengthening exercise, such as using Therabands, on improving hip muscle strength have also been reported in elders with functional limitations.[37-39] Thus, our low-resistance strengthening exercise program was an economical and effective home program option for patients with THR.

In our home program, the 1-legged stance was incorporated to enhance strengthening of the hip abductors. The 1-legged stance exercise has been suggested as an appropriate task for hip abductor strengthening. By using magnetic resonance imaging, Kumagai et al[40] reported a significant increase in signal intensity from the hip abductors of the stance leg after 1-legged stance, indicating that these muscles were highly used during such a stance. In addition, Sashika[13] found that patients with THR who practiced low-resistance strengthening exercises of the hip abductors on the operated side plus 1-legged stance had significantly greater improvement in the strength of these muscles than those who practiced just the low-resistance exercise.

The incorporation of the daily walking exercise into our home program was based on biomechanics literature[41,42] that shows contractions of the hip flexors, extensors, and abductors are important contributors to normal walking. For example, the hip abductors start to activate in the late swing phase of the gait cycle, become highly activated (approaching 100% of maximal voluntary contraction) during the early stance phase, and continue firing until the end of the midstance phase.[41,42] Therefore, it is possible that daily walking exercises would increase the strength of these 3 major groups of hip muscles through repetitive use.

Furthermore, it is worth noting that the (absolute) magnitude of strength improvement was in general greater for the hip muscles on the operated side than for those on the nonoperated side, except for the hip flexors. Two possibilities might account for this phenomenon. First, the strength levels of the hip muscles on the nonoperated side of our patients were relatively higher compared with the general population of patients with THR.[6,43] Therefore, less room for strength improvement was left for muscles on the nonoperated side. Second, in this study, the absolute dosage (intensity, frequency, duration) was the same for muscles of both the operated and the nonoperated hips. Given that the strength of the operated hip muscles was in general weaker before starting the training period, the muscles on this side in fact received more exercise than their counterparts on the other side, in a relative sense. Therefore, greater improvement was observed for the muscles on the operated side.

Another interesting finding regarding the magnitude of hip muscle strength improvement on the operated side was that hip abductor strength improved the most, followed by flexor and extensor strength. We hypothesized that this result might be because of the fact that the hip abductors were highly trained through all 3 types of exercises—including the isotonic strengthening, 1-legged standing, and walking exercises—whereas the flexors and extensors were mainly trained through the isotonic strengthening and walking exercises.

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Walking Speed and Ability to Walk on Uneven Terrains

Our results showed that only the exercise-high compliance group showed significant improvement in walking speed across all conditions. More important, after training, the mean of the free walking speed of the exercise-high compliance group was 71.9m/min, approaching that of healthy adults of similar ages. Walking speeds of the exercise-low compliance group and the control groups did not improve in any of these walking conditions. Therefore, it appears that our home program can effectively improve the walking speed of patients with THR who show high compliance with the program.

Furthermore, according to the extent of speed improvement for the exercise-high compliance group, it appeared that walking speed improved significantly when these patients walked on the grass surface, less so when they walked on level-ground hard surface, and least when they walked on the spongy surface. These results suggest that the home program was also effective in improving agility and ability to maintain balance on more difficult walking tasks such as walking on uneven terrains.

We hypothesized that the overall improved walking speed in all walking conditions was primarily attributable to the improved hip muscle strength. Past research has shown much evidence that improvement in hip muscle strength contributes to improved walking speed in patients receiving surgery after trochanteric hip fracture.[8,44] Furthermore, Sashika et al[13] showed that after a 6-week daily low-resistance, low-repetition strengthening home exercise, patients within 4 years after THR improved hip abductor strength on the operated side by 68% (to 28.5Nm); meanwhile, the free walking speed of these patients improved by 7.1% (to ≈69m/min). In our study, for the exercise-high compliance group, strength for all hip muscles investigated improved significantly (8.4%–19.7%) after the home program. In addition, further analysis on the data revealed high (r=.72, P<.05) and moderate (r=.57, P<.05) correlations between improved hip abductor strength on the operated side with increased fast walking speeds for walking on level-ground and grass surfaces, respectively. Therefore, the improved free and fast walking speeds in our patients may be likely attributable to the improved hip muscle strength, especially that of the hip abductors on the operated side.

Regarding the improved ability of our patients to walking on the grass and spongy surface conditions, we hypothesized that this might result from the concomitant improvement in maintaining stability during walking after our training program. Many researchers have pointed out that the hip abductors play an important role in maintaining lateral stability during walking,[45,46] mainly through the production of a sufficient torque to counterbalance the torque produced by body weight during the single support phase of walking.[37,47] Results of our study showed that the improvement in abductor strength was the greatest (19.7% or 10.7Nm) among all hip muscles of the operated hip, and this improvement could potentially contribute to the control of lateral stability needed for walking on the grass and spongy surfaces. Another factor contributing to the improved stability during walking may come from the practice of daily walking exercise itself. Roberts[48] reported that a 6-week walking exercise program (30min/session by 3 sessions/wk) significantly improved postural stability of older adults during 2-legged and 1-legged stance under eyes open and closed conditions. This finding suggested that walking exercise could effectively improve postural stability in older adults.

Functional Mobility

Our findings showed that only the exercise-high compliance group had significant improvement in functional score after the intervention period. Closer inspection of the data showed that the functional scores (mean, 12.6) of our patients in all 3 groups in fact approached the full point score (14). The primary functional limitations of most of our patients (75.5%) were on the stair climbing and using public transportation items. For 80.8% of subjects in the exercise-high and -low compliance groups, improvement in functional score was also primarily on these 2 items after the home program intervention. We hypothesized that patients' limitations in performing stair climbing and using public transportation may be because of muscle weakness at the hips and insufficient walking speed.[49,50] It has been suggested that a gait speed of 72m/min is needed for a person to cross a traffic intersection safely.[51] For our patients to access public transportation. the ability to walk in the community and across an intersection is frequently a prerequisite. Our data showed that the mean of the free walking speed on level-ground surface of the participants in the exercise-high compliance also approached the speed of 72m/min, suggesting that after our intervention, these patients were able to walk safely in the community. Therefore, their functional scores were also improved.

Compliance With the Home Program

Our results pinpoint that the compliance level plays an important role in determining the efficacy of a home exercise program. These findings were in good agreement with many previous studies,[13-15,52,53] which also showed the significant influence of compliance on the outcomes of exercise home programs prescribed to patients with hip fracture and community-dwelling older adults. Subjects in our exercise-high compliance group all had a compliance level at or above 50% (median, 73.2%). Because the program was prescribed as a daily exercise program, one could speculate that the exercise-high compliance group practiced the program at least 3 times a week. This exercise frequency is comparable to the effective exercise programs that were prescribed to patients receiving outpatient clinical strength training.[39,52,53]

It is worth noting that, in our study, compliance was low (<50%) in half of the exercise group. We speculated that the intensity and duration of the home program may be 2 primary factors resulting in subjects' low compliance. In the 6-week strengthening home program designed by Sashika,[13] subjects were asked to perform the program twice a day for 15 to 20 minutes per session; in contrast, it took our subjects approximately 50 to 60 minutes (30min for walking, 20–30min for strengthening and 1-legged stance) to complete the program everyday. In addition, our program was 12 weeks long, which might have posed some difficulty for some subjects to maintain a high level of compliance throughout the study period. Furthermore, when we investigated the differences in subject characteristics between the exercise-high compliance and exercise-low compliance groups, we found that subjects in the low-compliance group generally lived a sedentary lifestyle before participating in our study and were more likely to report being fatigued after exercising. Therefore, subjects' characteristics or lifestyle may also contribute to the compliance level. Further studies are needed to determine the most important factors predicting subject compliance with a home program.

CONCLUSIONS

The results of our study suggest that patients who undergo THR should be encouraged to participate in long-term active

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exercises postoperatively. Our home program, emphasizing strengthening of the hip muscles, especially the hip abductors, and walking exercises, not only effectively prevented the reduction in strength but also promoted functional ability of these patients with THR. Therefore, practicing an appropriate home program could be a convenient and economical alternative for these patients to maintain muscle strength and high functional level long-term after THR. However, compliance with home program significantly affects the efficacy of the program. A minimum frequency of 3 times per week is highly recommended to achieve significant training effects with the program.

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References

1. Nilsdotter AK, Roos EM, Westerlund JP, Roos HP, Lohmander LS. Comparative responsiveness of measures of pain and function after total hip replacement. Arthritis Rheum 2001;45:258-62.
2. Furnes O, Lie SA, Espehaug B, Vollset SE, Engesaeter LB, Havelin LI. Hip disease and the prognosis of total hip replacements: a review of 53,698 primary total hip replacements reported to the Norwegian Arthroplasty Register 1987-99. J Bone Joint Surg Br 2001;83:579-86.
3. Murray MP, Gore DR, Brewer BJ, Mollinger LA, Sepic SB. Joint function after total hip arthroplasty: a four-year follow-up of 72 cases with Charnley and Muller replacement. Clin Orthop 1981; Jun(157):119-24.
4. Older J. Low-friction arthroplasty of the hip. A 10-12-year follow-up study. Clin Orthop 1986;Oct(211):36-42.
5. Bachmeier CJ, March LM, Cross MJ, et al. A comparison of outcomes in osteoarthritis patients undergoing total hip and knee replacement surgery. Osteoarthritis Cartilage 2001;9:137-46.
6. Jan MH, Lin CH, Liu TK. Hip muscle torque in patients with total hip replacement. Formosan J Phys Ther 2002;27:111-8.
7. Hamadouche M, Kerboull L, Meunie A, Courpied JP, Kerboull M. Total hip arthroplasty for the treatment of ankylosed hips. J Bone Joint Surg Am 2001;83:992-8.
8. Vaz MD, Kramer JF, Rorabeck CH, Bourer RB. Isometric hip abductor strength following total hip replacement and its relationship to functional assessments. J Orthop Sports Phys Ther 1993; 18:526-31.
9. Long WT, Dorr LD. Functional recovery of noncemented total hip arthroplasty. Clin Orthop 1993;Mar(288):73-7.
10. Perrin T, Dorr LD, Perry J, Gronley J, Hull DB. Functional evaluation of total hip arthroplasty with five to ten years follow-up evaluation. Clin Orthop 1985;May(195):252-60.
11. Dorr LD, Wan Z. Causes of and treatment protocol for instability of total hip replacement. Clin Orthop 1998;Oct(355):144-51.
12. Lachiewicz PF, Soileau ES. Stability of total hip arthroplasty in patients 75 years or older. Clin Orthop 2002;Dec(405):65-9.
13. Sashika H, Matsuba Y, Watanabe Y. Home program of physical therapy: effect on disabilities of patients with total hip arthroplasty. Arch Phys Med Rehabil 1996;77:273-7.
14. Burton DS, Imrie SH. Total hip arthroplasty and postoperative rehabilitation. Phys Ther 1973;53:132-40.
15. Kuster MS. Exercise recommendations after total joint replacement: a review of the current literature and proposal of scientifically based guidelines. Sports Med 2002;32:433-45.
16. Kishida Y, Sugano N, Sakai T, et al. Full weight-bearing after cementless total hip arthroplasty. Int Orthop 2001;25:25-8.
17. Morlock M, Schneider E, Bluhm A, et al. Duration and frequency of every day activities in total hip patients. J Biomech 2001;34: 873-81.
18. Oldridge NB, Donner A, Buck CW, et al. Predictors of dropout from cardiac exercise rehabilitation: Ontario exercise-heart collaboration study. Am J Cardiol 1983;51:70-4.
19. Ice R. Long-term compliance. Phys Ther 1985;65:1832-9.
20. Baker AS, Bitounis VC. Abductor function after total hip replacement. J Bone Joint Surg Br 1989;71:47-50.
21. Burnett CN, Betts EF, King WM. Reliability of isokinetic measurements of hip muscle torque in young boys. Phys Ther 1990; 70:244-9.
22. Davies GJ. A compendium of isokinetics in clinical usage and rehabilitation techniques. 3rd ed. La Crosse (WI): S&S Publishers; 1992.
23. Dvir Z. Isokinetics. New York: Churchill Livingstone; 1996.
24. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fracture: treatment by mold arthroplasty. J Bone Joint Surg Am 1969;51:737-55.
25. Shields RK, Enloe LJ, Evans RE, Smith KB, Steckel SD. Reliability, validity, and responsiveness of functional tests in patients with total hip replacement. Phys Ther 1995;75:169-79.
26. Söderman P, Malchau H. Is the Harris Hip Score system useful to study the outcome of total hip replacement? Clin Orthop 2001; Mar(384):189-97.
27. Söderman P, Malchau H, Herberts P, Zügner R, Regnér H, Garellick G. Outcome after total hip arthroplasty. Acta Orthop Scand 2001;72:113-9.
28. Pyka G, Lindenberger E, Charette S, Marcus R. Muscle strength and fiber adaptations to a year-long resistance training program in elderly men and women. J Gerontol 1994;49:M22-7.
29. Arokoski MH, Arokoski JP, Haara M, et al. Hip muscle strength and muscle cross sectional area in men with and without hip osteoarthritis. J Rheum 2002;29:2187-95.
30. Cahalan TD, Johnson ME, Liu S, Chao EY. Quantitative measurements of hip strength in different age groups. Clin Orthop 1989;Sep(246):136-45.
31. Borja F, Latta LL, Stinchfield FE, Obreron L. Abductor muscle performance in total hip arthroplasty with and without trochanteric osteotomy. Radiographic and mechanical analyses. Clin Orthop 1985;Jul-Aug(197):181-90.
32. Bellamy N, Buchanan WW. A preliminary evaluation of the dimensionality and clinical importance of pain and disability in osteoarthritis of the hip and knee. Clin Rheumatol 1986;5:231-41.
33. Downing ND, Clark DI, Hutchinson JW, Colclough K, Howard PW. Hip abductor strength following total hip arthroplasty: a prospective comparison of the posterior and lateral approach in 100 patients. Acta Orthop Scand 2001;72:215-20.
34. Ritter MA, Harty LD, Keating ME, Faris PM, Meding JB. A clinical comparison of the anterolateral and posterolateral approaches to the hip. Clin Orthop 2001;Apr(385):95-9.
35. Neumann L, Freund KG, Sorenson KH. Long-term results of Charnley total hip replacement: review of 92 patients at 15 to 20 years. J Bone Joint Surg Br 1994;76:245-51.
36. Chandler HP, Reineck FT, Wixson RL, McCarthy JC. Total hip replacement in patients younger than thirty years old. J Bone Joint Surg Am 1981;63:1426-34.
37. Lord SR, Lloyd DG, Nirui M, Raymond J, Williams P, Stewart RA. The effect of exercise on gait patterns in older women: a randomized controlled trial. J Gerontol A Biol Sci Med Sci 1996;51:M64-70.
38. Krebs DE, Jette AM, Assmann SF. Moderate exercise improves gait stability in disabled elders. Arch Phys Med Rehabil 1998;79: 1489-95.
39. Judge JO, Underwood M, Gennosa T. Exercise to improve gait velocity in older persons. Arch Phys Med Rehabil 1993;74:400-6.
40. Kumagai M, Shiba N, Higuchi F, Nishimura H, Inoue A. Functional evaluation of hip abductor muscles with use of magnetic resonance imaging. J Orthop Res 1997;15:888-93.

(背面仍有題目,請繼續作答)

41. Smith LK, Weiss EL, Lehmkuhl LD. Brunnstrom's clinical kinesiology. 5th ed. Philadelphia: FA Davis; 1996.
42. Lyons K, Perry J, Gronley JK, Barnes L, Antonelli D. Timing and relative intensity of hip extensor and abductor muscle action during level and stair ambulation. Phys Ther 1983;63:1597-605.
43. Shih CH, Du YK, Lin YH, Wu CC. Muscular recovery around the hip joint after total hip arthroplasty. Clin Orthop 1994;May(302): 115-20.
44. Walheim G, Barrios C, Stark A, Broström LA, Olsson E. Postoperative improvement of walking capacity in patients with trochanteric hip fracture: a prospective analysis 3 and 6 months after surgery. J Orthop Trauma 1990;4:137-43.
45. Winter DA. Anatomy, biomechanics and control of balance during standing and walking. Waterloo (ON): Univ Waterloo; 1995.
46. Barr AE, Backus SI. Biomechanics of gait. In: Nordin M, Frankel VH, editors, Basic biomechanics of the musculoskeletal system. 3rd ed. Baltimore: Lippincott Williams & Wilkins; 2001. p 440-57.
47. Neumann DA. Hip abductor muscle activity in persons with a hip prosthesis while carrying loads in one hand. Phys Ther 1996;76: 1320-30.
48. Roberts BL. Effects of walking on balance among elders. Nurs Res 1989;38:180-2.
49. Costigan PA, Deluzio KJ, Wyss UP. Knee and hip kinetics during normal stair climbing. Gait Posture 2002;16:31-7.
50. Riener R, Rabuffetti M, Frigo C. Stair ascent and descent at different inclinations. Gait Posture 2002;15:32-44.
51. Sherrington CH, Lord SR. Home program to improve strength and walking velocity after hip fracture: a randomized controlled trial. Arch Phys Med Rehabil 1997;78:208-12.
52. Fatouros IG, Taxildaris K, Tokmakidis SP, et al. The effects of strength training, cardiovascular training and their combination on flexibility of inactive older adults. Int J Sports Med 2002; 23:112-9.
53. Hauer K, Rost B, Rutschle K, et al. Exercise training for rehabilitation and secondary prevention of fall in geriatric patients with a history of injurious falls. J Am Geriatric Soc 2001;49:10-20.

Suppliers

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b. Model NV-DR1; Matsushita Electric Industrial Co, 1-2, 1-chome, Shiba Koen, Minato-ku, Tokyo, Japan.