and low physical activity (Fried et al., 2001). The prevalence of frailty is greater in women than men, and increases which age. Frailty status, or the presence of frailty can predict disability and adverse outcomes, where those who are frail have a significantly higher risk of further debilitation, specifically in mobility, activities of daily living (ADL) and falls, eventually leading to hospitalization and death (Fried et al., 2004) (Table 1).

	Hazard Ratios Estimated Over 3 Years Frail (Versus Not Frail)
Worsening mobility disability	1.50**
Worsening ADL disability	1.98**
Incident Fall	1.29**
First hospitalization	1.29**
Death	2.24**

**p ≤ .05
ADL= activity of daily living

Table 1. Frailty status predicting disability, falls, hospitalizations, and death over 3 years. (Fried, L.P.; Ferrucci, L.; Darer, J.; Williamson, J.D. & Anderson, G. (2004). Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, Vol.59, No.3, pp. 255-263, by permission of the Gerontological Society of America.)

Falls are an especially serious problem among the elderly, as approximately 30% of community-dwelling older adults over the age of 65 experience falls every year. Falls are the leading cause of unintentional injury, functional decline, hospitalization, institutionalization, and increased healthcare costs. In order to prevent falls, a thorough understanding of the causes and risk factors for falls among the elderly is required for the development of effective preventative strategies.

Urinary incontinence, particularly in the elderly, is considered to be an important determining factor for admission into long-term care and has been associated with loss of independence, reduced quality of life, restricted social activities, increased anxiety and social isolation.

2. Risk factors

Many studies have demonstrated that geriatric syndromes are multifactorial, and shared risk factors including older age, cognitive impairment, functional impairment, and impaired mobility, are often associated with common geriatric syndromes of frailty, falls, and urinary incontinence. The identification and treatment of the risk factors that contribute to geriatric syndromes have been the focus in recent research.

2.1 Frailty

Frailty is highly prevalent in the elderly. Frailty often overlaps with (though is not synonymous with) comorbidity and disability, and is associated with several major chronic diseases such as cardiovascular disease, pulmonary disease and diabetes. Hence, treatments for frail older adults usually require specific care needs (Fried et al., 2004) (Fig. 1). With the presence of comorbid conditions, there may be competition between the treatments. The combinations of medications and treatment regiments may limit the desired effects of the treatments, or have adverse effects. Comorbidities lead to the over-use and mixing of prescription medication which is a risk factor for falls. Frailty, coupled with low bone mass is associated with increased risk of hip fractures which are a major threat to survival in the elderly. Research has shown that 17.4% of people who suffered hip fracture over the age of 65 died within 12 months of a fracture (Magaziner et al., 1989).

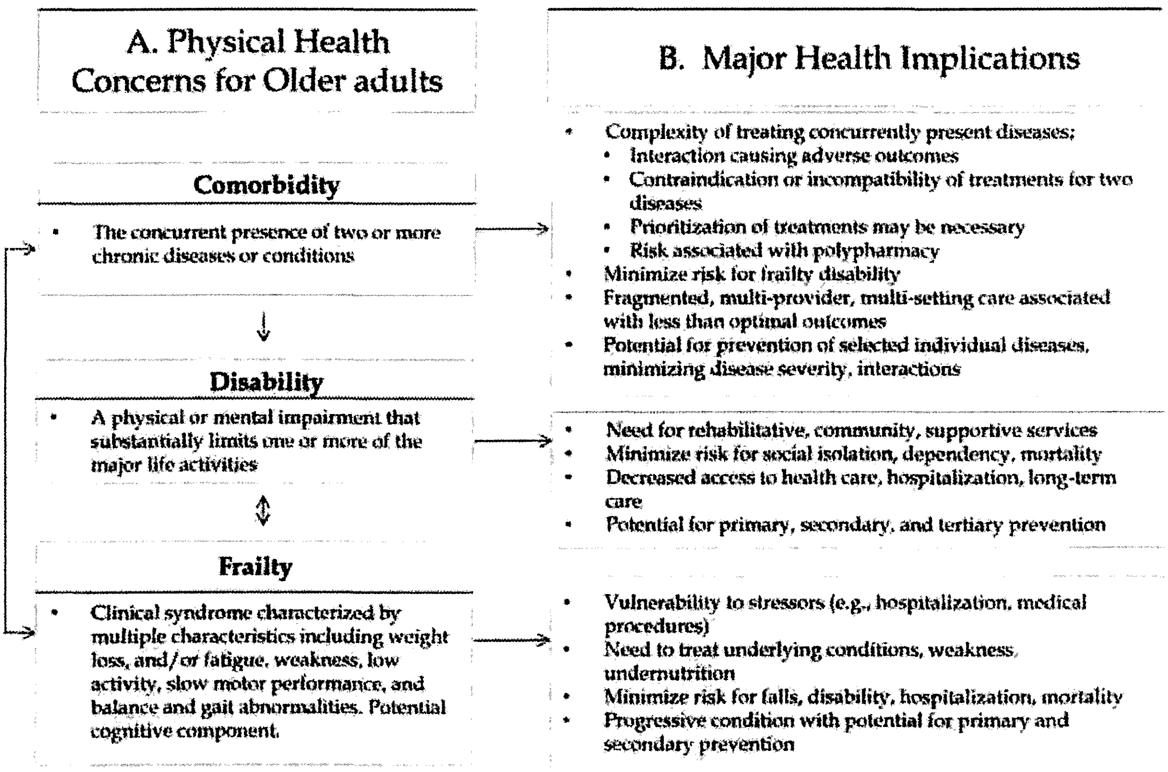


Fig. 1. Comorbidity, disability, and frailty: definitions and major health care implications. (Fried, L.P.; Ferrucci, L.; Darer, J.; Williamson, J.D. & Anderson, G. (2004). Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, Vol.59, No.3, pp. 255-263, by permission of the Gerontological Society of America.)

There are numerous factors that contribute to muscle weakness and loss of muscle mass in aging adults such as chronic disease, a sedentary lifestyle, and under-nutrition, where some factors can be reversed with lifestyle changes, and others need specific medications and cannot be reversed. Xue et al. (2008) hypothesized the cycle of frailty, as many of these factors can theoretically be unified into a cycle associated with decreasing energetics and functional reserve (Fig. 2) The core elements of this cycle, including weight loss, sarcopenia, decrease in strength and walking speed, as well as low activity, are commonly identified as clinical signs and symptoms of frailty.

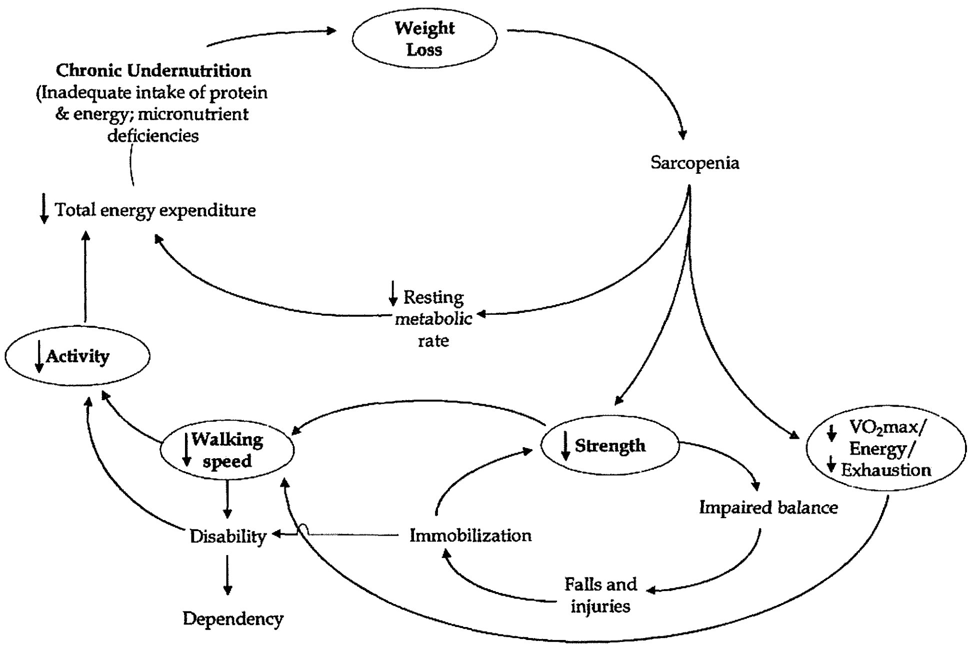


Fig. 2. Cycle of Frailty. (Xue, Q.L.; Bandeen-Roche, K.; Varadhan, R.; Zou, J. & Fried, L.P. (2008). Initial manifestations of frailty criteria and the development of frailty phenotype in the Women's Health and Aging Study II. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, Vol.63, No.9, pp. 984-990, by permission of the Gerontological Society of America.)

2.2 Falls

In the recent decade, several epidemiologic studies have identified risk factors for falls. While the classifications of these risk factors have not always been consistent, they are generally classified as intrinsic, extrinsic, and environmental. Intrinsic risk factors include muscle weakness, gait and balance deficits, functional and cognitive impairments, and visual deficits, extrinsic such as the use of four or more prescription medications and bifocals, and environmental factors, which include poor lighting, loose carpets, and lack of bathroom safety equipment (American Geriatric Society et al., 2001). Low vitamin D levels are also significantly associated with a high prevalence of falls in elderly women, as well as low physical performance (Suzuki et al., 2008) (Table 2).

The most common risk factors for falls are muscle weakness, history of falls, gait deficit, balance deficit, use of assistive device, visual deficit, arthritis, impaired ADL, depression, cognitive impairment, and older age (over 80 years old) (American Geriatric Society et al., 2001). The risk of falling increases linearly with the number of risk factors, from 8.0% with none to 78.0% with four or more risk factors (Tinetti et al., 1988). Furthermore, those who experience falls once have a greater chance of recurrent falls, which may lead to a fear of falling. Some older adults may then begin restricting activities both indoors and outdoors. Not only does this lead to a further lack of physical activity, but research has shown that older persons who restrict activity for fear of falling are more physically frail and have greater burden of chronic conditions and depressive symptoms compared with those who do not restrict activity despite their fear of falls (Murphy et al., 2002).

	Male			Female		
Risk Factor	OR	95%CI	P	OR	95%CI	P
Age (yr)	1.02	0.95-1.10	NS	1.02	0.99-1.06	NS
Normal walking speed (0.1 m/s)	0.87	0.77-0.97	0.015	0.92	0.88-0.97	0.001
Albumin (g/dl)	1.69	0.45-6.33	NS	1.60	0.88-2.90	NS
25(OH)D (mg/ml)	1	0.95-1.06	NS	0.97	0.94-0.99	0.010

Dependent variable was "fall experience over the previous year" (yes=1; no=0).
NS= not significant

Table 2. Multiple logistic regression model of factors associated with fall experience. (Suzuki, T.; Kwon, J.; Kim, H.; Shimada, H.; Yoshida, Y.; Iwasa, H. & Yoshida, H. (2008). Low serum 25-hydroxyvitamin D levels associated with falls among Japanese community-dwelling elderly. *Journal of Bone and Mineral Research*, Vol.23, No.8, pp. 1309-1317, by permission of the American Society for Bone and Mineral Research.)

2.3 Urinary incontinence

There is general agreement on the multifactorial nature of incontinence. Permanent incontinence also is typically the result of neurological damage or, intrinsic bladder or urethral pathology. However, incontinence is associated with several potentially reversible conditions. Lower urinary tract function, environmental factors, physical and cognitive function, psychological distress, mobility, manual dexterity, medical conditions, and medications may all have an effect on urinary incontinence status in the elderly (Landi et al., 2003). The incidence of urinary incontinence is typically higher in women than men, and those who experience incontinence are usually older with lower functional fitness levels for both sexes. Although there is a large amount of information regarding the mechanisms and treatment options for urinary incontinence, little is known about the potentially reversible causes of this condition in community-dwelling elderly people. Several of the known causes that may be reversible include urinary tract infections, as they can cause the urge to void quite frequently, physical restraints and drastic limitations in mobility, and environmental hazards.

Lifestyle and functional fitness are significantly associated with the onset of urinary incontinence in community-dwelling elderly people (Kim et al., 2004) (Table 3).

3. Treatment for geriatric syndrome

Declines in functional fitness such as walking speed, muscle strength and balance ability in the elderly are strongly associated with the development of geriatric syndromes. Hence, exercise focusing on strength, balance, and mobility improvement, even into advanced age, is usually offered as a strategy for the reduction of frailty, falls, and urinary incontinence in the elderly.

Sex	Variable		OR	95%CI
Male	Age (per 1 yr)		1.23	1.11-1.38
	Plasma albumin (per 0.1 g/dl)		0.70	0.54-0.88
	Smoking status	non-smoker	1.00	
		previous smoker	1.53	0.56-4.59
		current smoker	2.33	0.82-7.61
Female	Grip strength (per 1 kg)		0.92	0.86-0.98
	Social role (per 1 point)		1.81	1.19-2.73
	BMI (per 1 kg/m^2)		1.10	1.01-1.20
	Smoking status	non-smoker	1.00	
		current smoker	7.53	1.36-41.63

Table 3. Multiple logistic regression model of risk factors associated with the onset of urinary incontinence

3.1 Frailty

Aging is characterized by a gradual decrease in muscle mass and muscle strength, which contributes to declines in physical function, increased disability, frailty, and loss of independence. Out of many factors associated with the development of frailty, muscle disuse and nutritional deficiencies are the factors that are potentially reversible or preventable through interventions and a more active lifestyle (Fiatarone et al., 1994).

3.1.1 Nutritional supplementation

Declines in muscle mass are related to declines in muscle protein synthesis rates in older adults. In order to resist and reverse the effects of muscle protein synthesis declines, protein or more specifically, amino-acids, have been the focus of research. Investigators have found that leucine enriched essential amino-acid mixtures are primarily responsible for amino-acid-induced muscle protein anabolism in the elderly. Amino-acid supplementation can increase muscle mass in this population; however, an increase in muscle mass is not always accompanied by an increase in muscle strength (Dillon et al., 2009). Essential amino-acid supplementation alone is probably insufficient in increasing muscle strength. Carbohydrate-rich supplements have also been examined for any effects on muscle strength and muscle mass. However, supplements rich in carbohydrates are inadequate for the purpose of increasing muscle mass and strength (Fiatarone et al., 1994). Vitamin D supplementation, which will be discussed further (see section 3.2.1) has also been shown to increase strength.

3.1.2 Exercise

Exercise in elderly individuals may potentially modify risk factors for age-associated reductions in muscle mass (Liu & Latham, 2009). Research has shown that high intensity resistance training is effective in counteracting muscle weakness and physical frailty in elderly people. More specifically, exercise interventions focused on the major muscle groups that are crucial for performing functional activities, are especially important for the reversal of muscle weakness.

Extensive research has confirmed that doing resistance training two to three times a week can improve physical function and functional limitations, and also reduce disability and muscle weakness in older people. Resistance training in elderly people produces increases in strength from 9 to 15% (Borst, 2004), and about 1.1 kg in lean body mass (Peterson et al., 2011). While more improvements are seen with high intensity and volume resistance training, moderate intensity exercises are also beneficial, and are much safer for aging adults. Exercise prescriptions must be of a safe intensity, duration and frequency to avoid further injury and complications (Taaffe, 2006) (Table 4).

Combinations of both exercise and nutritional supplementation have also been studied by researchers. Amino-acid supplementations alone have beneficial effects such as increasing walking speed, and exercise itself also has beneficial effects of improving physical function. Exercise and amino-acid supplementation together have significant effects in enhancing muscle mass, strength and functional fitness. The combination of high resistance exercise and a high carbohydrate mixture containing small amounts of soy protein is effective in the enhancement of muscle strength. High resistance exercise alone increases both muscle mass and strength, while the carbohydrate supplementation alone does not (Fiatarone et al., 1994). Further research is still needed to investigate which supplementations coupled with exercise, or alone, are most effective.

Resistance training program recommendations	
Exercises	8-10 that target the major muscle groups
Repetitions	8-12 per set. When able to achieve 12 repetitions, increase resistance so that 8 repetitions are possible
Sets	Minimum of 1, preferable 2-3 per exercise with 1-2 minutes rest between sets
Frequency	1-3 days per week with at least 48 hours between sessions
Velocity	2-3 seconds concentric and 2-3 seconds eccentric. Some sets of rapid concentric movements can also be included
Breathing	Normal breathing on each repetition (no breath holding)
Duration	Less than 1 hour

Table 4. Resistance training program recommendations. (Taaffe, DR. (2006). Sarcopenia – exercise as a treatment strategy. *Australian Family Physician*, Vol.35, No.3, pp. 130-134. ©2011 *Australian Family Physician*. Reproduced with permission from The Royal Australian College of General Practitioners. Text and images copyright of *Australian Family Physician*. Permission to reproduce must be sought from the publisher, The Royal Australian College of General Practitioners).

3.2 Falls

The development of effective preventative strategies to reduce the fall rate in community-dwelling elderly people who are at risk of falling require a better understanding of the modifiable risk factors for falling. Among the numerous risk factors for falling, those that are considered modifiable include muscle weakness, impairments in balance and gait, and the use of multiple prescription medications. These risk factors can be modifiable through behavioral strategies such as muscle strengthening exercises, balance and gait training, and education about nonpharmacologic treatments to reduce the number of prescription medications used (Tinetti et al., 1994). Furthermore, the occurrence of falling rises with increasing number of risk factors present; therefore, strategies targeted to reduce these modifiable risk factors may be effective in the prevention of falls.

3.2.1 Vitamin D supplementation

In several trials of older individuals at risk for vitamin D deficiencies, vitamin D supplementation improved strength, function, and balance in a dose-related pattern. A high daily vitamin D supplementation dose (about 700-1000 IU) can reduce the risk of falls by approximately 20%; although small doses (less than 400 or 700 IU) may not be sufficient to reduce falls (Bischoff-Ferrari et al., 2009).

3.2.2 Exercise

Falls in older people are not purely random events but can be predicted by assessing a number of risk factors. Some of these risk factors such as decreased muscle strength, impaired balance, and gait deficit can be modified using exercise, whereas poor vision, and psychoactive medications require different strategies. Exercise can be used as a fall prevention intervention on its own or as a component of a multifaceted program. The pooled estimate of the effects of exercise was that it reduced the rate of falling by 17.0% (Sherrington et al., 2008). Home-based and tailored group exercise classes seem to be effective in reducing falls by improving balance and muscular strength. Also, while home hazard management (e.g. removing tripping hazards) and vision screening are not markedly effective in reducing falls when used alone, they add value when combined with an exercise program (Day et al., 2002).

3.2.3 An exercise-based falls prevention program

Exercise programs designed for fall prevention in elderly people should address three major areas - strength, balance and gait. People at high risk of falling due to muscle weakness, balance impairment, and gait deficit should be instructed to perform low or moderate intensity exercise containing safe and simple movements at entry level.

Strength training

A moderate-intensity strength training program aimed to reduce falls should target the major muscles such as the tibialis anterior, soleus, quadriceps femoris, iliopsoas, tensor fasciae latae, and sartorius (Fig. 3). Tripping is a leading cause of falls in community-dwelling elderly people, responsible for up to 53% of falls in this population (Blake et al., 1988). Trips may be associated with weakness of the tibialis anterior muscle, which would cause low toe-clearance or walking in a "shuffling" manner where the toes do not lift off the ground sufficiently to avoid small obstacles that may cause trips.

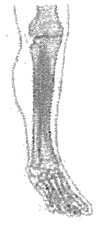
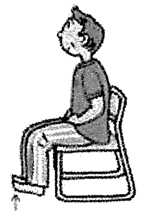
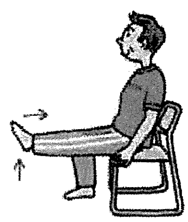
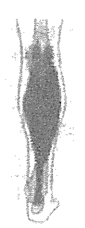
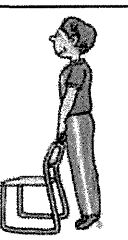
Target Muscle	Exercise	Exercise Description
Tibialis Anterior 	Seated Toe Raises 	Place hands in comfortable position while seated. Lift toes of both feet as high as possible with the heels still on the floor. Hold for 3-5 seconds, breath normally, and slowly lower toes to the floor. Perform 8-10 repetitions. Remind participants to not rock the body back when raising toes.
Quadriceps 	Seated Knee Extension 	Lift one leg still bent at the knee while inhaling, and extend the leg without "locking" the knee (keep knee slightly bent) while exhaling. Bend the knee again, with the hip still flexed, and place the foot on the floor. Perform 8-12 repetitions, and repeat on the other side. Remind participants to not lean back while lifting the leg, or extending the knee.
Soleus and Gastrocnemius 	Heel Raises 	Stand tall with feet flat, shoulder-width apart. Hold on to back of a chair for support. Slowly lift both heels off the floor while exhaling. Hold for 5-10 seconds, breath normally, and slowly lower the heels to the floor. Repeat 10 times.

Fig. 3. Examples of lower extremity strength training exercises.

Balance and gait training

Training is crucial for the improvement of balance in the elderly, and static as well as dynamic and lateral balance exercise have been recommended for reducing falls. Balance exercises progress from holding on to a stable supporting structure such as a chair, to performing the exercises independent of support. Not all elderly people will necessarily start at the first level of each exercise or be prescribed all the balance exercise such as one-leg standing, tandem stance, tandem walking, and side step (Fig. 4).

The results of a large scale study, known as the Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) trials, suggest that exercise interventions (flexibility, resistance, balance) and Tai Chi for elderly people reduce the risk of falls (Province et al., 1995). To evaluate the effect of Tai Chi on functional fitness and falls, it is necessary to analyze the characteristic movements of Tai Chi. Tai Chi consists of a series of smooth movements linked together in a continuous sequence of whole body weight-shifting, with a low center of gravity. Also, Tai Chi movements involves shifting the weight forward and standing on one foot while lifting the other foot an inch off the floor, which contributes to the improvement of static balance. Moreover, the safe completion of the steps requires an adequate amount of dynamic balance, postural strength, and lateral stability (Li et al., 2004). Participants in the FICSIT trial were instructed on correct foot placement and posture, standing in a semi-squat position, which requires substantial lower extremity strength. These movements are directly or indirectly related to improvement of functional fitness.

Target Balance Type	Exercise	Exercise Description
Static Balance	One-Leg Stand 	Stand tall with feet flat, shoulder-width apart. Lightly hold on to back of a chair for support or place hands on the hips. Slowly lift one foot off the floor while exhaling. Hold position for 10 seconds, breath normally, and slowly lower the foot to the floor. Repeat by lifting the other leg. Perform 2-3 sets per day.
Dynamic Balance	Tandem Walk 	Stand tall with feet flat on the floor, near a wall or railing for safety. Place one foot directly in front of the other foot, allowing the heel of the front foot to touch the toes of the back foot. Repeat with the other foot. Continue for 10 steps.
Lateral Balance	Cross Step 	Place a piece of tape or draw a line (refrain from anything that may cause trips) on the floor. Begin by standing with both feet together on one side of the tape. Lift the foot farther from the tape, and place it forward (diagonal) on the other side of the tape in a cross-fashion. Shift weight to the front foot, cross the other foot and place on the other side of tape. Note: Both feet do not come together. Continue for 10 steps.

Fig. 4. Examples of balance and gait exercises.

3.3 Urinary incontinence

The common treatments for urinary incontinence include surgery, drug therapies, and behavioral treatments. Behavioral treatments such as pelvic floor muscle (PFM) exercises and bladder training are recommended as a first line of treatment in the management of urinary incontinence, because of the potential benefits with few risks and no side effects. Urinary incontinence is usually classified into three different types: stress, urge, and mixed. Stress incontinence is urine leakage associated with increased abdominal pressure such as coughing, sneezing, laughing, heavy lifting, standing, running, or other types of physical activity. Urge incontinence is leakage associated with running water, or an urge to void and not being able to reach the toilet in time. Mixed urinary incontinence is when characteristics of both stress and urge incontinence types are present.

3.3.1 Pelvic floor muscle exercise

PFM exercises (Fig. 5), initiated by Kegal in 1948, is hypothesized to enhance urethral resistance by increasing the strength and endurance of the periurethral and perivaginal muscles and by improving the anatomic support to the bladder neck and proximal urethra (Kegel, 1948). These exercises are the preferred treatment for stress incontinence but have recently been recommended for urge or mixed incontinence because of reflex bladder inhibition associated with pelvic floor muscle contraction. The efficacy of PFM exercises in improving urine leakage has been validated by many investigators, and the improvement rate has been reported to range widely from 17 to 84% (Bo, 1995).

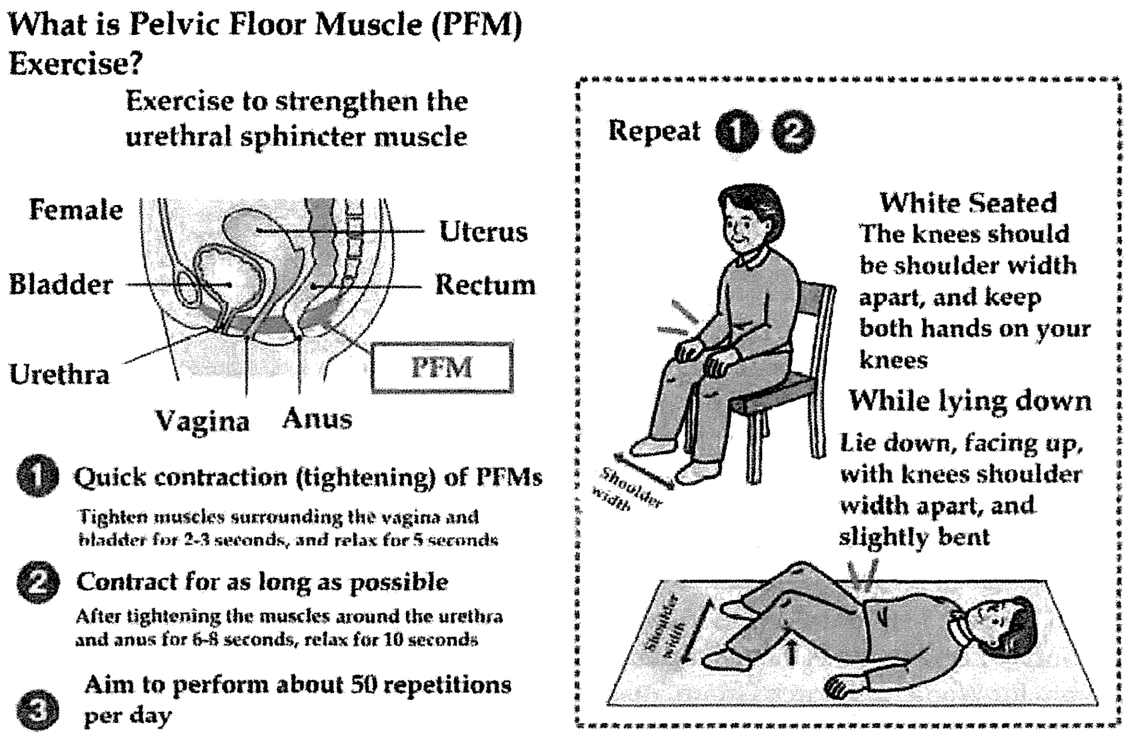


Fig. 5. Pelvic floor muscle exercise for the prevention of urinary incontinence.

At the beginning of PFM training, it is important to teach the elderly people participating in a training program, the structure of the PFM in order to gain awareness of these muscles. The participants should be taught that straining the abdomen would increase the abdominal pressure and would exert load on the PFM. Training should focus on how to exert force on the PFM without excessively straining the abdomen. Most exercise regimens are designed to strengthen the fast and slow-twitch fibers located at the pelvic floor. PFM exercise programs often incorporate alternations of fast contractions, usually held only for about three seconds, sustained contractions, where the participants would hold the contraction for about six to eight seconds, and ten-second relaxation periods between the contractions. The PFM exercises are usually performed in the seated, lying, and standing positions with the legs apart, and the emphasis placed on training of the PFM and relaxing of the other muscles.

The durations of the exercise training periods vary between 3 weeks and 6 months. Bladder training appears to have its greatest efficacy at 6 weeks; PFM exercise appears to be best between 11 to 12 weeks; and combined bladder training and PFM exercise seems to be most effective between 8 to 12 weeks of training (Wyman et al., 1998) (Fig. 6).

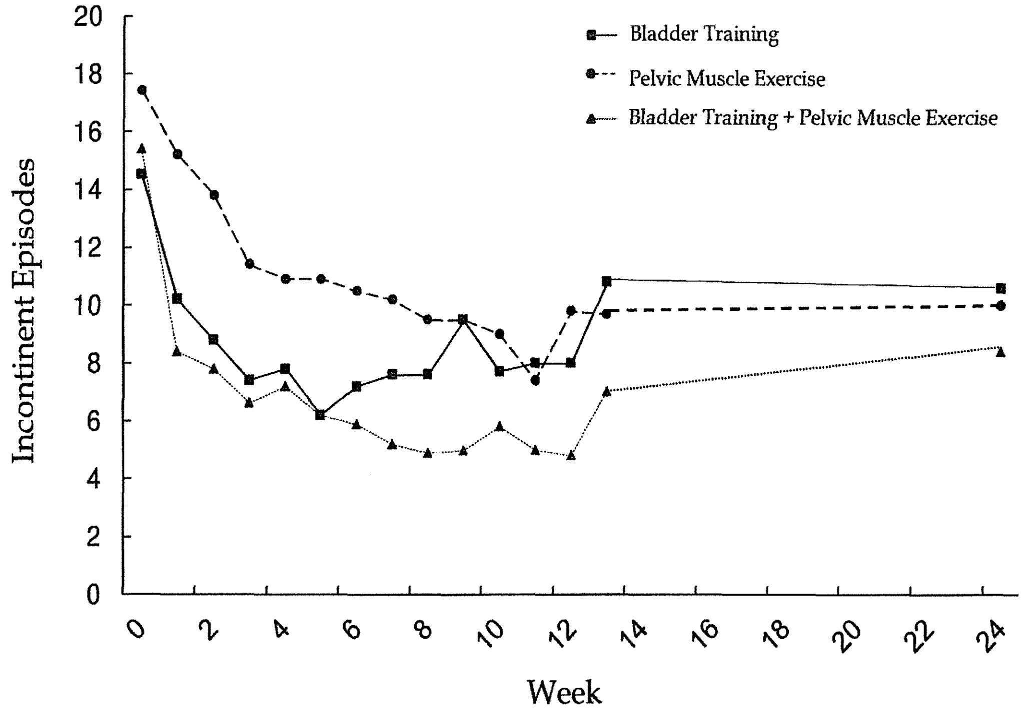


Fig. 6. Change in mean weekly number of incontinent episodes over time by treatment group. (Wyman, J.F.; Fantl, J.A.; McClish, D.K. & Bump, R.C. (1998). Comparative efficacy of behavioral interventions in the management of female urinary incontinence. Continence Program for Women Research Group. *American Journal of Obstetrics and Gynecology*, Vol.179, No.4, pp. 999-1007, with permission from Elsevier).

3.3.2 Fitness exercise

Several studies have reported that obesity and high body mass index (BMI) are associated with urinary incontinence. Presumably, increases in body weight causes increases in abdominal-wall weight, hence increasing intra-abdominal pressure and intra-vesicular pressure (Bo, 2004). Therefore, reductions in abdominal fat from exercise may contribute to decreasing intra-abdominal pressure, causes improvements in urethral sphincter contraction, and therefore decreased risk of urinary incontinence (Fig. 7; Fig. 8). Weight reduction is desirable for women complaining of urinary incontinence (Subak et al., 2009). Bump et al. (1992) found that surgically induced weight loss in obese women significantly reduces weekly incontinence episodes.

Although a direct cause-effect relationship between obesity and incontinence has not yet been established, there is evidence that weight reduction or decrease in BMI may be beneficial for treatment of incontinence. Kim et al. (2007) investigated the distribution of subjects cured from urinary incontinence according to tertiles of BMI, maximum walking speed, and adductor muscle strength, found that a significantly higher proportion among those who were cured of incontinence episodes, demonstrated improvements in BMI and walking speeds (Kim et al., 2007). Therefore, weight reduction, decrease in BMI, and increase in walking ability are desirable qualities for the treatment of urinary incontinence (Table 5).

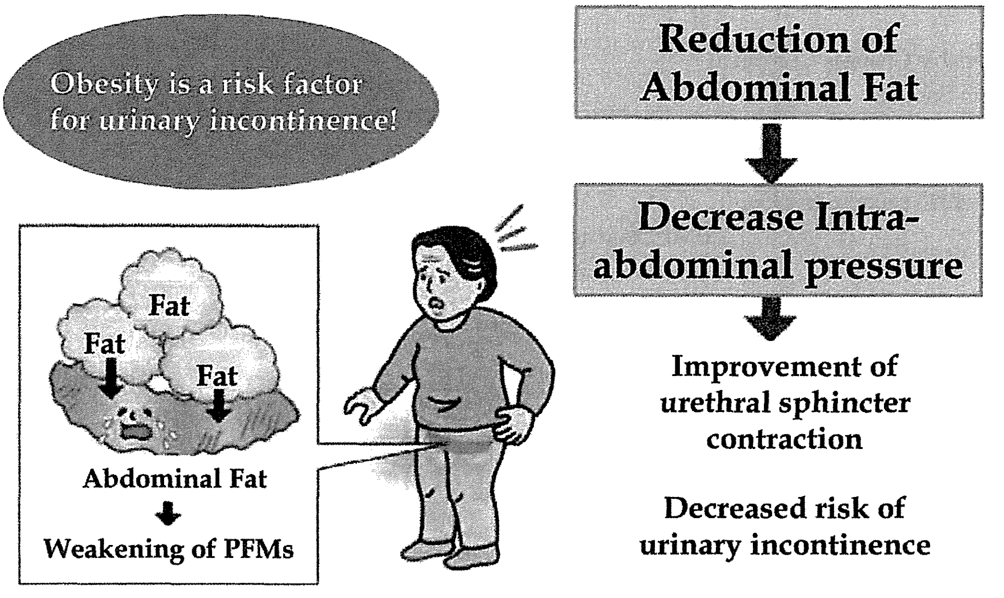


Fig. 7. Strengthening exercises to reduce abdominal fat prevents urinary incontinence

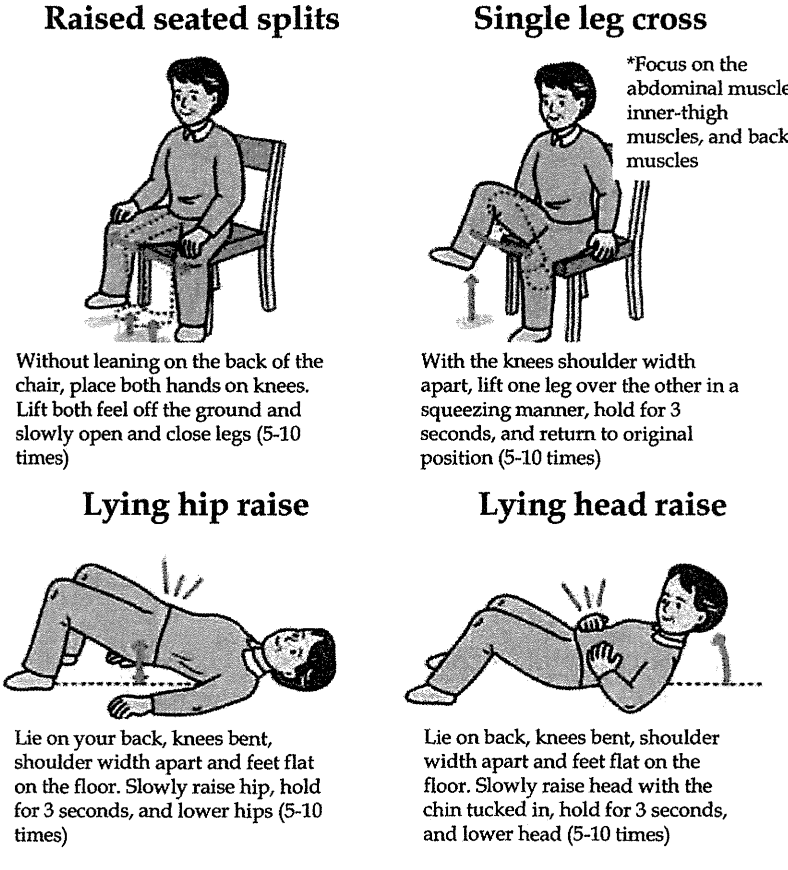


Fig. 8. Examples of exercises aimed to reduce abdominal fat.

Variable Changes Compared with Baseline		Cured of Urine Leakage n(%)	Cochran's Q value	p- value	Post-hoc †
3-month exercise (n=33)					
BMI	Decreased (D)	16 (48.5)	7.091	0.029	D,N>I
	No change (N)	13 (39.4)			
	Increased (I)	4 (12.1)			
Maximum walking speed	Increased	17 (51.5)	6.545	0.038	I>D
	No change	11 (33.3)			
	Decreased	5 (15.2)			
Adductor muscle strength	Increased	11 (33.3)	4.545	0.103	
	No change	6 (18.2)			
	Decreased	16 (48.5)			
1-Year Follow-up (n=20)					
BMI	Decreased	10 (50.0)	3.700	0.157	
	No change	3 (15.0)			
	Increased	7 (35.0)			
Maximumn walking speed	Increased	10 (50.0)	6.100	0.047	I>D
	No change	8 (40.0)			
	Decreased	2 (10.0)			
Adductor muscle strength	Increased	9 (45.0)	3.100	0.212	
	No change	8 (40.0)			
	Decreased	3 (15.0)			

Table 5. Cured of urine leakage according to body mass index (BMI), maximum walking speed, and adductor muscle strength tertiles. (Kim, H.; Suzuki, T.; Yoshida, Y. & Yoshida, H. (2007). Effectiveness of multidimensional exercises for the treatment of stress urinary incontinence in elderly community-dwelling Japanese women: a randomized, controlled, crossover trial. *Journal of the American Geriatrics Society*, Vol.55, No.12, pp. 1932-1939, with permission from the American Geriatrics Society.)

While the details of the beneficial effects that exercise may have on the different types of urinary incontinence is not entirely clear, the current literature seems to suggest that PFM and fitness exercises are beneficial for all three types of urinary incontinence after a training period of three months. However, the effects of exercise training are maintained more in those with stress incontinence compared with those urge or mixed incontinence (Kim et al., 2011a) (Table 6).

Recently, other treatment methods including abdominal and lower back heating have been introduced. The heating may have positive effects on renal function such as renal sympathetic nerve activity suppression, promotion of bladder voiding, and increasing frequency of urination.

The heat and steam generating sheet (HSGS) can be any thin, flexible filmed sheet that generates heat and steam immediately after unsealing. When the sheet is placed on the body, the temperature of the skin surface rises to 38 to 40℃and it continues to generate heat

Variables[a]	G[b]	Baseline	3-month exercise	7-month follow-up	ANOVA[c] G×T	p Value
Body Weight (kg)	I	52.0 ± 8.9	51.9 ± 8.8	50.9 ± 8.9	F=5.78	0.018
	C	53.9 ± 8.2	53.9 ± 8.2	53.9 ± 8.1		
BMI (kg/m^2)	I	23.7 ± 3.4	23.5 ± 3.0	23.2 ± 3.1	F=11.49	0.001
	C	24.1 ± 2.9	24.0 ± 2.7	24.4 ± 3.4		
WC (cm)	I	78.8 ± 10.3	77.8 ± 9.7	77.7 ± 9.9	F=4.06	0.041
	C	79.3 ± 10.4	79.2 ± 10.5	78.9 ± 9.6		
UWS (m/sec)	I	1.2 ± 0.2	1.2 ± 0.2	1.2 ± 0.2	F=2.79	0.099
	C	1.1 ± 0.3	1.1 ± 0.3	1.1 ± 0.2		
MWS(m/sec)	I	1.7 ± 0.4	1.8 ± 0.4	1.8 ± 0.4	F=5.10	0.027
	C	1.7 ± 0.4	1.6 ± 0.3	1.6 ± 0.4		
GS (kg)	I	19.0 ± 4.7	20.7 ± 5.0	19.8 ± 5.7	F=0.37	0.547
	C	19.0 ± 4.2	20.2 ± 3.5	19.5 ± 3.8		
AMS (kg)	I	20.5 ± 7.1	24.1 ± 7.7	24.3 ± 7.9	F=11.00	0.001
	C	21.2 ± 4.8	22.1 ± 4.8	21.8 ± 4.9		
ULS (point)	I	5.0 ± 1.0	3.0 ± 2.0	3.6 ± 2.2	F=7.64	0.007
	C	5.1 ± 1.0	4.4 ± 1.6	4.8 ± 1.6		
Cure of urine leakage	I	0.0	44.1	39.3	21.96	<0.001
	C	0.0	1.6	1.6		
Cure of urine leakage in intervention group	Stress	0.0	63.2[d]	66.7[e]	15.77	<0.001
	Urge	0.0	35.0[d]	26.1[e]	7.49	0.032
	Mixed	0.0	40.0[d]	30.0[e]	9.56	0.016

[a] Data are presented as mean and standard deviation.
WC=waist circumference; UWS=usual walking speed; MWS=maximum walking speed; GS=Grip strength; Ams=adductor muscle strenght; ILS=urine leaking score.
[b] G=group, I=intervention group, C=control group
[c] ANOVA=analysis of variance, T=time.
Chi-square and p values are from generalized estimating wquation.
Cochran's Q-value.
[d] Kruskal-Wallis test : chi-square=1.99, p=0.391
[e] Kruskal-Wallis test : chi-square=10.28, p=0.008
(Scheffe's *post-hoc*=stress >urge, mixed urinary incontinence)

Table 6. Cured of urine leakage after the 3-month exercise between the intervention and control groups. (Kim, H.; Yoshida, H. & Suzuki, T. (2011a). The effects of multidimensional exercise treatment on community-dwelling elderly Japanese women with stress, urge, and mixed urinary incontinence: A randomized controlled trial. *International Journal of Nursing Studies*, doi:10.1016/j.ijnurstu.2011.02.016, with permission from Elsevier.)

and steam for over 5 hours. Research has suggested that the HSGS in combination with exercise yields the highest cure rates of urinary incontinence compared with exercise or the HSGS alone. The HSGS also has beneficial effects for the different urinary incontinence types. Research reveals higher cure rates in those with stress urinary incontinence with the combination of both exercise and heat; however, there is strong evidence that the HSGS can be used as a supplementary treatment method in order to enhance the effects of exercise on those with urge, mixed, and stress urinary incontinence (Kim et al., 2011b) (Table 7).

Type of UI	Ex+HSGS n=37	Ex n=35	HSGS n=37	GE n=34	χ^2 value	P-value*
Stress UI, %(n)	61.5(8)	53.8(7)	25.0(3)	9.1(1)	8.94	0.030
Urge UI, %(n)	50.0(7)	16.7(2)	13.3(2)	0.0(0)	12.88	0.005
Mixed UI, %(n)	40.0(4)	30.0(3)	30.0(3)	0.0(0)	3.02	0.389
Total cure rate	51.4(19)	34.3(12)	21.6(1)	2.9(1)	21.89	<0.001

UI=urinary incontinence; Ex=exercise group; HSGS=heat and steam generating sheet group; GE=general education group.
*Kruskal-Wallis test.

Table 7. Cure rate of urinary incontinence according to urinary incontinence type and intervention group. (Kim, H.; Yoshida, H. & Suzuki, T. (2011b). Effects of exercise treatment with or without heat and steam generating sheet on urine loss in community-dwelling Japanese elderly women with urinary incontinence. *Geriatrics and Gerontology International*, doi: 10.1111/j.1447-0594.2011.00705.x, with permission from the Japan Geriatrics Society.)

	After 3-month exercise			After 7-month follow-up		
Variable	Adjusted OR *	95%CI	*p* Value	Adjusted OR *	95%CI	*p* Value
Amount of urine leakage	0.69	0.39-0.98	0.049	0.78	0.26-1.88	0.600
Frequency of urine leakage	1.16	0.24-5.79	0.856	1.63	0.73-4.01	0.248
Compliance to exercise	1.03	1.01-1.16	0.048	1.13	1.02-1.29	0.031
Decreased of BMI	0.67	0.48-0.89	0.011	0.78	0.60-0.96	0.028
Increased of walking speed	0.97	0.91-1.04	0.414	0.99	0.94-1.06	0.913
Period of urine leakage	1.01	0.91-1.13	0.919	1.01	0.91-1.14	0.913

Table 8. Adjusted odds ratios for cure of urine leakage after intervention and the 7-month follow-up. (Kim, H.; Yoshida, H. & Suzuki, T. (2011a). The effects of multidimensional exercise treatment on community-dwelling elderly Japanese women with stress, urge, and mixed urinary incontinence: A randomized controlled trial. *International Journal of Nursing Studies*, doi:10.1016/j.ijnurstu.2011.02.016, with permission from Elsevier.)

3.3.3 Predictor variables

Multiple characteristics that may influence the treatment outcome such as age, gender, urine loss frequency and amount, incontinence type, duration of urinary incontinence, chronic conditions, medications, and functional fitness as well as adherence to the prescribed exercise regimen have been examined. Many previous studies have emphasized that compliance to exercise is the key factor to long-term success (Lagro-Janssen & van Weel., 1998; McDowell et al., 1999), and confirmed that BMI reduction have positive influences on urge, mixed and stress UI treatment (Kim et al., 2011a) (Table 8).

4. Conclusion

Geriatric syndromes are highly prevalent and associated with substantial morbidity and poor outcomes. Various factors cause frailty, falls, and urinary incontinence in elderly people including chronic disease, lack of physical activity, malnutrition, and aging itself, some of which are unpreventable. Exercise and nutritional supplementation are among the beneficial treatments promoting healthy and independent lifestyles in the elderly.

Evidence reveals that exercise targeted at reducing risk factors is an effective strategy for treating geriatric syndromes in elderly people. Progressive and moderate-intensity exercise should be encouraged among elderly people to minimize the degenerative physical and mental function that occurs with aging.

5. References

American Geriatrics Society, British Geriatrics Society, & American Academy of Orthopaedic Surgeons Panel on Falls Prevention. (2001). Guideline for the prevention of falls in older persons. *Journal of the American Geriatrics Society,* Vol.49, No.5, pp. 664-672.

Bischoff-Ferrari, H.A.; Dawson-Hughes, B.; Staehelin, H.B.; Orav, J.E.; Stuck, A.E.; Theiler, R.; Wong, J.B.; Egli, A.; Kiel, D.P. & Henschkowski, J. (2009). Fall prevention with supplemental and active forms of vitamin D: a meta-analysis of randomized controlled trials. *British Medical Journal,* Vol.399, pp. 843-846.

Blake A.J.; Morgan, K.; Bendall, M.J.; Dallosso, H.; Ebrahim, S.B.J.; Arie, T.H.D.; Fentem, P.H. & Bassey, E.J. (1988). Falls by elderly people at home: prevalence and associated factors. *Age and Ageing,* Vol.17, No.6, pp. 365-372.

Bo, K. (1995). Pelvic floor muscle exercise for the treatment of stress urinary incontinence: an exercise physiology perspective. *International Urogynecology Journal,* Vol.6, pp. 282-291.

Bo, K. (2004). Pelvic floor muscle training is effective in treatment of female stress urinary incontinence, but how does it work? *International Urogynecology Journal,* Vol.15, pp. 76-84.

Borst, S.E. (2004). Interventions for sarcopenia and muscle weakness in older people. *Age and Ageing,* Vol.33, No.6, pp. 548-555.

Bump, R.C.; Sugerman, H.J.; Fantl, JA. & McClish, D.K. (1992). Obesity and lower urinary tract function in women: effect of surgically induced weight loss. *American Journal of Obstetrics and Gynecology,* Vol.167, No.2, pp. 392-397.

Day, L.; Fildes, B.; Gordon, I.; Fitzharris, M.; Flamer, H. & Lord, S. (2002). Randomised factorial trial of falls prevention among older people living in their own homes. *British Medical Journal,* Vol.325, No.7356, pp. 128-134.

Dillon, E.L.; Sheffield-Moore, M.; Paddon-Jones, D.; Gilkison, C.; Sanford, A.P.; Casperson, S.L.; Jiang, J.; Chinkes, D.L. & Urban, R.J. (2009). Amino acid supplementation increase lean body mass, basal muscle protein synthesis, and insulin-like growth factor-1 expression in older women. *The Journal of Clinical Endocrinology and Metabolism*, Vol.94, No.5, pp. 1630-16347.

Fiatarone, M.A.; O'Neill, E.F.; Ryan, N.D.; Clements, K.M.; Solares, G.R.; Nelson, M.E.; Roberts, S.B.; Kehayias, J.J.; Lipsitz, L.A. & Evans, W.J. (1994). Exercise training and nutritional supplementation for physical frailty in very elderly people. *The New England Journal of Medicine*, Vol.330, No.25, pp. 1769-1775.

Fried, L.P.; Tangen, C.M.; Walston, J.; Newman, A.B.; Hirsch, C.; Gottdiener, J.; Seeman, T.; Tracy, R.; Kop, W.J.; Burke, G. & McBurnie, M.A. (2001). Frailty in older adults: evidence for a phenotype. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, Vol.56, No.3, pp. M146-456.

Fried, L.P.; Ferrucci, L.; Darer, J.; Williamson, J.D. & Anderson, G. (2004). Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, Vol.59, No.3, pp. 255-263.

Inouye, S.K.; Studenski, S.; Tinetti, M.E. & Kuchel, G.A. (2007). Geriatric syndromes: clinical, research, and policy implications of a core geriatric concept. *Journal of the American Geriatrics Society*, Vol.55, No.5, pp. 780-791.

Kegel, A.H. (1948). Progressive resistance exercise in the functional restoration of the perineal muscles. *American Journal of Obstetrics and Gynecology*, Vol.56, No.2, pp. 238-248.

Kim, H.; Yoshida, H.; Hu, X.; Yukawa, H.; Shinkai, S.; Kumagai, S.; Fujiwara, Y.; Yoshida, Y.; Furuna, T.; Sugiura, M.; Ishizaki, T. & Suzuki, T. (2004). Risk factors associated with onset of urinary incontinence in community-dwelling elderly population: a 4-year follow-up study. *Nihon Koshu Eisei Zasshi*, Vol.51, No.8, pp. 612-622 [Article in Japanese].

Kim, H.; Suzuki, T.; Yoshida, Y. & Yoshida, H. (2007). Effectiveness of multidimensional exercises for the treatment of stress urinary incontinence in elderly community-dwelling Japanese women: a randomized, controlled, crossover trial. *Journal of the American Geriatrics Society*, Vol.55, No.12, pp. 1932-1939.

Kim, H.; Yoshida, H. & Suzuki, T. (2011a). The effects of multidimensional exercise treatment on community-dwelling elderly Japanese women with stress, urge, and mixed urinary incontinence: A randomized controlled trial. *International Journal of Nursing Studies*, Vol.48, pp.1165-1172.

Kim, H.; Yoshida, H. & Suzuki, T. (2011b). Effects of exercise treatment with or without heat and steam generating sheet on urine loss in community-dwelling Japanese elderly women with urinary incontinence. *Geriatrics and Gerontology International*, Vol.11, pp.452-459.

Lagro-Janssen, T. & van Weel, C. (1998). Long-term effect of treatment of female incontinence in general practice. *British Journal of General Practice*, Vol.48, pp. 1735-1738.

Landi, F.; Cesari, M.; Russo, A.; Onder, G.; Lattanzio, F. & Bernabei, R. (2003). Potentially reversible risk factors and urinary incontinence in frail older people living in community. *Age and Ageing*, Vol.32, No.2, pp. 194-199.

Li, F.; Fisher, K.J.; Harmer, P.; Irbe, D.; Tearse, R.G. & Weimer, C. (2004). Tai chi and self-rated quality of sleep and daytime sleepiness in older adults: A randomized controlled trial. *Journal of the American Geriatrics Society*, Vol.52, pp. 892-900.

Liu, C.J. & Latham, N.K. (2009). Progressive resistance strength training for improving physical function in older adults. *Cochrane Database of Systematic Reviews*, Vol.8, No.3, CD002759.

Magaziner, J.; Simonsick, E.M.; Kashner, T.M.; Hebel, J.R. & Kenzora, J.E. (1989). Survival experience of aged hip fracture in patients. *American Journal of Public Health*, Vol.79, No.3, pp. 274-278.

McDowell, B.J.; Engberg, S.; Sereika, S.; Donovan, N.; Jubeck, M.E.; Weber, E. & Engberg, R. (1999). Effectiveness of behavioral therapy to treat incontinence in homebound older adults. *Journal of the American Geriatrics Society*, Vol.47, pp. 309-318.

Murphy, S.L.; Williams, C.S. & Gill, T.M. (2002). Characteristics associated with fear of falling and activity restriction in community-living older persons. *Journal of the American Geriatrics Society*, Vol.50, pp. 516-520.

Peterson, M.D.; Sen, A. & Gordon, P.M. (2011). Influence of resistance exercise on lead body mass in aging adults: A meta-analysis. *Medicine and Science in Sports and Exercise*, Vol.43, No.2, pp. 249-258.

Province, M.A.; Hadley, E.C.; Hornbrook, M.C.; Lipsitz, L.A.; Miller, J.P.; Mulrow, C.D.; Ory, M.G.; Sattin, R.W.; Tinetti, M.E. & Wolf, S.L. (1995) The effects of exercise on falls in elderly patients. A preplanned meta-analysis of the FICSIT Trials. Frailty and Injuries: Cooperative Studies of Intervention Techniques. *The Journal of the American Medical Association*, Vol.273, No.17, pp. 1341-1347.

Sherrington, C.; Whitney, J.C.; Lord, S.R.; Herbert, R.D; Cumming, R.G & Close, J.C.T. (2008). *Journal of the American Geriatrics Society*, Vol.56, pp. 2234-2243.

Subak, L.L.; Wing, R.; West, D.S.; Franklin, F.; Vittinghoff, E.; Creasman, J.M.; Richter, H.E.; Myers, D.; Burgio, K.L.; Gorin, A.A.; Macer, J.; Kusek, J.W. & Grady, D. (2009). Weight loss to treat urinary incontinence in overweight and obese women. *The New England Journal of Medicine*, Vol.360, No.5, pp. 481-490.

Suzuki, T.; Kwon, J.; Kim, H.; Shimada, H.; Yoshida, Y.; Iwasa, H. & Yoshida, H. (2008). Low serum 25-hydroxyvitamin D levels associated with falls among Japanese community-dwelling elderly. *Journal of Bone and Mineral Research*, Vol.23, No.8, pp. 1309-1317.

Taaffe, DR. (2006). Sarcopenia—exercise as a treatment strategy. *Australian Family Physician*, Vol.35, No.3, pp. 130-134.

Tinetti, M.E.; Speechley, M. & Ginter, S.F. (1988). Risk factors for falls among elderly persons living in the community. *The New England Journal of Medicine*, Vol.319, No.26, pp. 1701-1707.

Tinetti, M.E.; Baker, D.I.; McAvay, G.; Claus, E.B.; Garrett, P.; Gottschalk, M.; Koch, M.L.; Trainor, K. & Horwitz, R.I (1994). A multifactorial intervention to reduce the risk of falling among elderly people living in the community. *The New England Journal of Medicine*, Vol.331, No.13, pp. 821-827.

Tinetti, ME.; Inouye, SK.; Gill, TM. & Doucette, JT. (1995). Shared risk factors for falls, incontinence, and functional dependence. *The Journal of the American Medical Association*, Vol.273, No.17, pp. 1348-1353.

Wyman, J.F.; Fantl, J.A.; McClish, D.K. & Bump, R.C. (1998). Comparative efficacy of behavioral interventions in the management of female urinary incontinence. Continence Program for Women Research Group. *American Journal of Obstetrics and Gynecology*, Vol.179, No.4, pp. 999-1007.

Xue, Q.L.; Bandeen-Roche, K.; Varadhan, R.; Zou, J. & Fried, L.P. (2008). Initial manifestations of frailty criteria and the development of frailty phenotype in the Women's Health and Aging Study II. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, Vol.63, No.9, pp. 984-990.

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ORIGINAL ARTICLE

Accuracy of segmental multi-frequency bioelectrical impedance analysis for assessing whole-body and appendicular fat mass and lean soft tissue mass in frail women aged 75 years and older

M Kim and H Kim

BACKGROUND/OBJECTIVE: We aimed to examine the accuracy of segmental multi-frequency bioelectrical impedance analysis (SMF-BIA) for the assessment of whole-body and appendicular fat mass (FM) and lean soft tissue mass (LM) in frail older women, using dual-energy X-ray absorptiometry (DXA) as a reference method.
SUBJECTS/METHODS: All 129 community-dwelling Japanese frail older women with a mean age of 80.9 years (range, 75–89 years) from the Frailty Intervention Trial were recruited. The agreements between SMF-BIA and DXA for whole-body and appendicular body composition were assessed using simple linear regression and Bland–Altman analysis.
RESULTS: High coefficients of determination (R^2) for whole-body FM ($R^2 = 0.94$, s.e. of estimate (SEE) = 1.2 kg), whole-body LM ($R^2 = 0.85$, SEE = 1.4 kg), and appendicular FM ($R^2 = 0.82$, SEE = 1.1 kg) were observed between SMF-BIA and DXA. The R^2 coefficient for appendicular LM was moderate ($R^2 = 0.76$, SEE = 0.8 kg). Bland–Altman plots demonstrated that there was systematic (constant) bias (that is, DXA minus SMF-BIA) with overestimation of whole-body FM (bias = − 1.2 kg, 95% confidence interval (CI) = − 1.5 to − 0.1) and underestimation of whole-body LM (bias = 2.1 kg, 95% CI = 1.8–2.3) by SMF-BIA. Similar, the appendicular measurements also demonstrated systematic bias with overestimation of appendicular FM (bias = − 0.3 kg, 95% CI = − 0.5 to − 0.1) and underestimation of whole-body LM (bias = 1.5 kg, 95% CI = 1.4–1.7) by SMF-BIA. In addition, the individual level accuracy demonstrated a non-proportional bias for whole-body LM ($r = 0.08$, $P = 0.338$) and appendicular FM ($r = 0.07$, $P = 0.413$).
CONCLUSIONS: SMF-BIA had acceptable accuracy for the estimation of whole-body and appendicular FM and LM in frail older women, although SMF-BIA underestimated LM and overestimated FM relative to DXA.

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Keywords: body composition; bioelectrical impedance analysis; sarcopenia; frailty

INTRODUCTION

Frailty is an important and common geriatric syndrome that is described as a status of increased vulnerability resulting from the loss of complexity in resting dynamics involving multiple physiological systems with advancing age.[1] The prevalence of frailty increases with age, from 3.9% at 65–74 years to 11.6% at 75–84 years and to 25% in people older than 85 years. In addition, frailty is more prevalent in women than in men.[1] Sarcopenia is a loss of skeletal muscle mass and size that occurs with aging.[2] Although many definitions of sarcopenia have been reported,[3–5] current definitions focus on loss of appendicular skeletal muscle mass as well as low muscle strength and low physical performance.[6] The European Working Group on Sarcopenia in Older People consensus definition of sarcopenia is based on three stages: the presarcopenia stage involves low muscle mass with normal muscle strength and physical performance; the sarcopenia stage involves low muscle mass and either diminished muscle strength or physical performance; and severe sarcopenia combines all three factors.[6] Several pathophysiological overlaps between sarcopenia and frailty have been observed.[7] Thus, age-related loss in muscle mass and strength are a major component in the development of frailty in the elderly.[8,9] Moreover, frailty is associated with a decline in muscle mass and quality and a parallel increase in fat mass (FM).[10] Measurement of body composition, including FM and muscle mass in older populations provide important information about their nutritional status. Therefore, the understanding of the body composition of frail elderly populations is an important part of clinical assessment with a goal of optimal prevention and treatment strategies.

Dual-energy X-ray absorptiometry (DXA) is an accepted method for the estimation of whole-body and segmental body fat and fat-free mass (FFM), which includes lean soft tissues and bone minerals.[11–13] However, DXA has disadvantages for use in clinical settings, such as the high cost of equipment, risk of radiation exposure and lack of access to instruments. For clinical use, bioelectrical impedance analysis (BIA) has been used as an attractive alternative method.[4,14,15] BIA is a portable, non-invasive, easy to use and convenient method for the patient, and it is also relatively inexpensive compared with other methods.[16] Of the BIA devices developed over the years, segmental multi-frequency (SMF)-BIA devices have advantages

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Author contributions: Both authors designed the study together. MK developed the study concept and design, analysed and interpreted the data, and prepared the manuscript. HK recruited subjects, assisted with statistical analysis and reviewed the manuscript for accuracy.
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