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SHORT PAPER

Effects of Exercise Interventions on Balance Function in Frail Older Adults: A Literature Review

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ABSTRACT

Frailty is an age-associated biological syndrome characterized by declines in multiple physiological domains, including balance, muscle mass and strength, flexibility, neuromuscular coordination and cardiovascular function. A quarter to a half of people over 85 years has frailty and are at significantly increased risk of falls, disability, care home admission and death. Although descriptive and systematic reviews have been written on the effects of balance training on balance performance in healthy older adults, none of these previous reviews analyze the effects of exercise interventions on balance in elderly with physical frailty. Thus, there is a need to define exercise prescription strategies to improve the functional capacity in elderly who are overall physically frail. This literature review will focus on exercise interventions that improved balance. In addition to these effects of training, the present review will identify other characteristics of the exercise interventions, such as the exercise intensity, and weekly frequency. The objective of this review is to present the evidence for the effectiveness of exercise interventions designed to improve balance in frail older adults.

＜Key-words＞
Frail, exercise intervention, older adults, fall, balance function.

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Ⅰ. Background

Frailty is an age-associated biological syndrome characterized by declines in multiple physiological domains, including balance, muscle mass and strength, flexibility, neuromuscular coordination and cardiovascular function (Hamerman, 1999; Campbell, Buchner, 1997). Frailty encompasses changes that are associated with aging, life styles, chronic diseases, and the interactions among older adults (Weiss, 2011). A quarter to a half of people over 85 years have frailty and are at significantly increased risk of falls, disability, care home admission and death (Fried, Tangen, Walsto, et al., 2001; Song, Mitnitski, Rockwood, 2010).

One of the main pathophysiological issues underlying the frailty syndrome is the loss of muscle mass that is induced by biological aging, such as sarcopenia. Sarcopenia is exacerbated by decreased physical activity, causing a decline in overall function that leads to frailty (Morie, Reid, Miciek, et al., 2010; Theou, Jones, Vandervoort, et al., 2010). Reducing the prevalence or severity of frailty could have considerable benefits for older people (Hamerman, 1999). Indeed, older adults who practice healthy lifestyles, participate in physical exercise, use clinical preventive services, and continue to engage with family and friends are more likely to remain healthy (Yamada, Arai, Sonoda, et al., 2012).

Some studies observed an impaired physical function of subjects who were not necessarily defined as frail subjects, but presented severe functional declines such as lower limb weakness, poor balance, and physical impairments induced by recent history of injurious falls (Morie, Reid, Miciek, et al., 2010; Garcia Garcia, Gutierrez Avila, Alfaro-Acha, et al., 2011; Kim, Susuki, Saito, et al., 2012; Freiberger, Häberle, Spirduso, et al., 2012). Thus, there is a need to define exercise prescription strategies to improve the functional capacity in elderly who are overall physically frail.

In addition, exercise interventions should focus on reducing the number of falls and improving balance and gait ability. Falls can result in disability, reduced poor quality of life. Measures of balance are known to predict fall risk in Frail older adults (Tiedemann, Shimada, Sherrington, et al., 2008). Fortunately, Exercise interventions can improve balance and a reduction in the risk of falling (Sherrington, Tiedemann, Fairhall, et al., 2011). Furthermore, balance is an important predictor of physical function to develop in this population must be discussed (Xue, 2011). Although descriptive and systematic reviews have been written on the effects of balance training on balance performance in healthy older adults (Lesinski, Hortobagyi, Muehlbauer, et al., 2015), none of these previous reviews analyzed the effects of exercise interventions on balance in elderly with physical frailty.

This literature review will focus on exercise interventions that improved balance. In addition to these effects of training, the present review will identify other characteristics of the exercise interventions, such as the exercise intensity, and weekly frequency. The

objective of this review is to present the evidence for the effectiveness of exercise interventions designed to improve balance in frail older adults.

Ⅱ. Methods

1. Literature sampling

We searched electronic databases of PubMed, MEDLINE and Google scholar. The last search was performed in January 21th, 2016.

Literature searched for keywords in 'frail older adults', 'exercise', 'balance function', 'exercise intervention', 'balance'. All databases were restricted to those published in english between January 1st, 2000 and January 21th 2016.

A total of 82 abstracts were identified from preliminary searching. Exclusion of 73 studies that did not meet the criteria resulted in al final sample of 9 studies.

2. Inclusion criteria

Based on the titles, abstracts and some parts of the articles when need, we screened the literature to select those articles meeting the inclusion criteria. The inclusion criteria following: (1) frail older adults, (2) defined with a clear operational definition or measurement of frailty. (3) exercise intervention in frail older adults. (4) report that measured balance function in frail older adults. (5) original analysis of an RCT for intervention group and control group receiving no treatment.

3. Exclusion criteria

The exclusion criteria following: (1) non frail older adults, (2) unpublished studies in english, (3) non exercise intervention in frail older adults. (4) non measured balance function in frail older adults. (5) non RCTs.

Ⅲ. Results

1. Participants and study characteristics

The included articles encompassed a sample of 1175 older adults, with a mean age of 83.4±4.6 years old. A total of 670 participants were community-dwelling older adults, 262 lived in residential care facilities, and 243 were recruited from rehabilitation teaching hospital. Four studies were conducted in Australia (Latham, Anderson, Lee, et al., 2003; Clemson, Fiatarone, Bundy, et al., 2012; Cadore, Casas-Herrero, Zambom-Ferraresi, et al., 2014; Kim, Suzuki, Kim, et al., 2015), three in Europe (Giné-Garriga, Guerra, Pagès, et al., 2010; Hagedorn, Holm, 2010; Fairhall, Sherrington, Lord, et al., 2014), one in the United States of America (Binder, Schechtman, Ehsani, et al., 2002), the last one in Asia (Kim, Suzuki, Kim, et al., 2015) (Table1).

<Table 1> characteristics of the included studies

Reference	sample			
	participants	Age, mean(SD)	Female,%	Setting
Binder et al. (2002)	n=115 from USA	83.0(4.0)	53%	Community dwelling
Cadore et al. (2014)	n=24 from Europe	91.9(4.1)	70%	Institutionalized
Clemson et al. (2012)	n=105 from Australia	84.0(4.3)	55%	Community dwelling
Faber et al. (2006)	n=238 from Europe	84.9(6.0)	79%	Institutionalized
Fairhall et al. (2014)	n=241 from Australia	83.3(5.9)	68%	Community dwelling
Giné-Garriga et al. (2010)	n=51 from Europe	84.0(2.9)	61%	Community dwelling
Hagedorn et al. (2010)	n=27 from Australia	81.1(6.0)	80%	Community dwelling
Kim et al. (2015)	n=131 from Asia	80.7(2.8)	100%	Community dwelling
Latham et al. (2003)	n=243 from Australia	79.1(6.9)	53%	Teaching hospitals

2. Intervention of the included studies

The intervention is summarized in Table 2. Five studies included multi component intervention (Binder, Schechtman, Ehsani, et al., 2002; Faber, Bosscher, Chin, et al., 2006; Giné-Garriga, Guerra, Pagès, et al., 2010; Clemson, Fiatarone, Bundy, et al., 2012; Cadore, Casas-Herrero, Zambom-Ferraresi, et al., 2014). In three of these five studies, the intervention involved balance training (Binder, Schechtman, Ehsani, et al., 2002; Faber, Bosscher, Chin, et al., 2006; Clemson, Fiatarone, Bundy, et al., 2012). One used intervention Leg extensor muscles, bench press exercise (Cadore, Casas-Herrero, Zambom-Ferraresi, et al., 2014), and functional based circuit training (Giné-Garriga, Guerra, Pagès, et al., 2010). The remaining four studies used non multi component intervention (Latham, Anderson, Lee, et al., 2003; Hagedorn, Holm, 2010; Fairhall, Sherrington, Lord, et al., 2014; Kim, Suzuki, Kim, et al., 2015). One study used an intervention home program of balance and lower limb training based on the Weight-bearing for Better Balance (WEBB) program (Fairhall, Sherrington, Lord, et al., 2014).One used an intervention computer feedback balance training (Hagedorn, Holm, 2010), and physical comprehensive training (Kim, Suzuki, Kim, et al., 2015), home-based

resistance training (Latham, Anderson, Lee, et al., 2003).

(1) Multi component intervention

Three (Binder, Schechtman, Ehsani, et al., 2002; Giné-Garriga, Guerra, Pagès, et al., 2010; Cadore, Casas-Herrero, Zambom-Ferraresi, et al., 2014) of the Five (Faber, Bosscher, Chin, et al., 2006; Clemson, Fiatarone, Bundy, et al., 2012) selected studies provided a description of the intervention with regard to the intensity of the exercise. The participants started with an initial intensity of 2 sets of 6-8 repetitions with the final intensity of 3 sets of 8-12 repetitions (Binder, Schechtman, Ehsani, et al., 2002). And the participants underwent an intensity 8-10repetitions (Cadore, Casas-Herrero, Zambom-Ferraresi, et al., 2014). In the other, participants underwent intensity 2sets of 6-8repetitions (Giné-Garriga, Guerra, Pagès, et al., 2010). Two studies, the intervention were tailored to the needs of the participants (18 Faber, Bosscher, Chin, et al., 2006; Clemson, Fiatarone, Bundy, et al., 2012).

(2) Non Multi component intervention

Two (Latham, Anderson, Lee, et al., 2003; Hagedorn, Holm, 2010) of the Four (Fairhall, Sherrington, Lord, et al., 2014; Kim, Suzuki, Kim, et al., 2015) selected studies provided a description of the intervention with regard to the intensity of the exercise. The intensity of the exercises was 3set of 10-15 repetitions (Hagedorn, Holm, 2010). And In the other, participants underwent intensity 3set of 8 repetitions for each exercise (Latham, Anderson, Lee, et al., 2003). Two studies, the intervention were tailored to the needs of the participants (Fairhall, Sherrington, Lord, et al., 2014; Kim, Suzuki, Kim, et al., 2015).

3. Outcome Measures

The intervention is summarized in Table 2. Balance was examined in nine studies. Binder et al. used Berg Balance Scale (BBS) Time up and go (TUG) test. Cadore et al. measured using Frailty and injures: cooperative studies of intervention techniques-4 (FICSIT-4) static balance test and TUG. Clemson et al. used eight level scales, 3m walk time, Faber et al. used Performance Oriented Mobility Assessment (POMA), FICSIT-4 static balance test, TUG. Fairhall et al was measured 4m walking test, Giné-Garriga et al. used Semi tandem, Tandem, Single leg standing test. And Hagedorn et al. measured using TUG, BBS, Kim et al. used TUG, Latham et al. used TUG and BBS.

<Table 2> Intervention of the included studies

Reference	Intervention	Outcome measures	Findings
Binder et al. (2002)	9months, 3/week, 60-90 min/set. Initial Intensity : 2 sets 6-8 repetitions 65% 1RM Final Intensity: 3 sets 8-12 repetitions 80% 1RM Exercise: balance training, resistance training, endurance training.	Balance: BBS	No significant in balance.
Cadore et al. (2014)	12 weeks, 2/week, 40 min/set. Intensity : 8-10 repetitions 40-60% 1RM Two exercises: leg extensor muscles, bench press.	Balance: FICSIT-4, TUG.	Significant increase in balance.
Clemson et al. (2012)	12 months, 3/week. Exercise: balance and lower limb strength.	Balance: Eight level scale, 3m walk time, Activities specific balance confidence scale.	Significant increase in balance. (Eight level scale, 3mwalk time)
Faber et al. (2006)	20 weeks, 90 min/set. 1/week for 4 weeks 2/week for 16 weeks Exercise: functional walking, balance exercises.	Balance: POMA, FICSIT-4, TUG	Significant increase in balance.
Fairhall et al. (2014)	12 months, 3-5/week, 20-30 min/set. Exercise: home program of balance and lower limb training based on the WEBB program	Balance: 4m walking tests.	No significant in balance.

Giné-Garriga et al. (2010)	12 weeks, 2/week, 45 min/set. Intensity: 1-2 sets 6-8 repetitions Exercise: functional based circuit training.	Balance: Semi tandem, Tandem, Single leg standing.	Significant increase in balance.
Hagedorn et al. (2010)	12 weeks, 2/week, 90min/set. Intensity: 3sets 10-15 repetitions Exercise: computer feedback balance training	Balance: TUG, BBS, One leg balance,	Significant increase in balance.
Kim et al. (2015)	12 weeks, 2/week, 60 min/set. Exercise: Physical comprehensive training	Balance: TUG	Significant increase in balance.
Latham et al. (2003)	20 weeks, 3/week, 60 min/set. Intensity: 3 sets 8 repetitions, 30~40% 1RM Exercise: home-based resistance training.	Balance: TUG, BBS.	No significant in Balance.

BBS; Burg Balance Scale,
FICSIT-4; Frailty and injures: cooperative studies of intervention techniques-4 static balance test,
MTUG; Modified TUG test, POMA; Performance Oriented Mobility Assessment,
SPPB; Short Physical Performance Battery.

4. Effects of exercise intervention

In six (Faber, Bosscher, Chin, et al., 2006; Giné-Garriga, Guerra, Pagès, et al., 2010; Hagedorn, Holm, 2010; Clemson, Fiatarone, Bundy, et al., 2012; Cadore, Casas-Herrero, Zambom-Ferraresi, et al., 2014; Kim, Suzuki, Kim, et al., 2015) of nine studies, balance was significantly increased after exercise intervention in the community-dwelling frail older adults (Giné-Garriga, Guerra, Pagès, et al., 2010; Hagedorn, Holm, 2010; Clemson, Fiatarone, Bundy, et al., 2012; Kim, Suzuki, Kim, et al., 2015) and Institutionalized frail older adults (Faber, Bosscher, Chin, et al., 2006; Cadore, Casas-Herrero, Zambom-Ferraresi, et al., 2014). In three other studies (Binder, Schechtman, Ehsani, et al., 2002; Latham, Anderson, Lee, et al., 2003; Fairhall, Sherrington, Lord, et al., 2014), no significant effects of the exercises were found in the balance.

Ⅳ. Considerations and Conclusions

The literature review found that exercise has statistically significant positive effects on balance as opposed to usual activity living for frail older adults. And Exercise intervention has shown to improve balance in community dwelling and institutionalized frail older adults.

This review included nine studies, with a total of 1175 older adults, average 83.4 ± 4.6 years old. In six of nine studies, balance was significantly increased after exercise intervention in frail older adults. And four of these six studies, the exercise intervention included multi component intervention (Faber, Bosscher, Chin, et al., 2006; Giné-Garriga, Guerra, Pagès, et al., 2010; Clemson, Fiatarone, Bundy, et al., 2012; Cadore, Casas-Herrero, Zambom-Ferraresi, et al., 2014), Two of six studies, exercise intervention was not multi component exercise (Hagedorn, Holm, 2010; Kim, Suzuki, Kim, et al., 2015). These results, Multi component interventions showed largely positive results in improving balance in frail older adults.

Multi component intervention appear to be the most effective exercises for improving balance of frail older adults (Faber, Bosscher, Chin, et al., 2006; Giné-Garriga, Guerra, Pagès, et al., 2010; Clemson, Fiatarone, Bundy, et al., 2012; Cadore, Casas-Herrero, Zambom-Ferraresi, et al., 2014). Cadore et al. observed that 12 weeks of leg extensor muscles, bench press exercises by using resistance variable machines, significant effects on the balance in institutionalized frail older adults. Clemson et al. determined that 12 months of balance and lower limb strength exercise increased balance (Eight level scale and 3m walk time) in community dwelling frail older adults. Faber et al. determined that 20 weeks of functional walking and balance exercise increased static balance and dynamic balance (POMA, FICSIT-4, TUG) in institutionalized frail older adults. Giné-Garriga et al. observed that 12 weeks of functional based circuit training increased static balance(Semi tandem, tandem, single leg standing) in community dwelling frail older adults. Binder et al. observed that 9 months of balance training, resistance training, endurance training, but no significant in balance.

Non multi component intervention, In two (Hagedorn, Holm, 2010; Kim, Suzuki, Kim, et al., 2015) of four studies (Latham, Anderson, Lee, et al., 2003; Fairhall, Sherrington, Lord, et al., 2014), balance was significantly increased after exercise intervention in the community-dwelling frail older adults (Hagedorn, Holm, 2010; Kim, Suzuki, Kim, et al., 2015). Hagedorn etal. determined that 12 weeks of computer feedback balance training increased static balance and dynamic balance. Kim et al. determined that 12weeks of physical comprehensive training increased dynamic balance. In other two studies (Latham, Anderson, Lee, et al., 2003; Fairhall, Sherrington, Lord, et al., 2014), Fairhall et al. observed that 12 months of WEBB programs not increased dynamic balance. And Latham et al. observed that 20 weeks of Home based resistance training not increased

balance in Teaching hospitals frail older adults.

Those that appeared to have the greatest impact were muscle strengthen exercise, walking and functional exercises, balance exercise, circuit exercise, and multiple exercise types. An effective exercise intervention protocol for frail older adults is characterized by an intervention period of 12-20 weeks, a intervention frequency of two times per week, total 24-40 intervention set. Hence, further study is necessary to improve physical function without balance in frail older adults.

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