Falls Among Older Adults and Preventive Methods

Svanhvít Ásta Jónsdóttir

Thesis for BS degree

Faculty of Health Promotion, Sport and Leisure Studies,

University of Iceland

UNIVERSITY OF ICELAND
SCHOOL OF EDUCATION

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Supervisor: Milan Chang Guðjónsson, Ph.D.

Faculty of Health Promotion, Sport and Leisure Studies
University of Iceland, School of Education
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Abstract

Populations are growing older worldwide and older adults are in greater risk of falling than younger people because of age-related functional decline and unfavorable environment. When older adults fall they are likely to sustain a fracture which also increases the risk of mortality. Hip fracture is the most dominant fracture type. Among the older population, those who have suffered hip fractures have the highest mortality rate. Experiencing a fall can result in fear of falling among older adults, causing them to be less physically active which further increases the risk of falling. Exercise is one of the preventive methods which can decrease the risk of falling among older adults.

Útdráttur

Hlutfall eldra fólks í löndum víðs vegar um heiminn er að hækka. Aldurstengdir þættir og óhagstætt umhverfi leiðir til þess að eldra fólki er hættara við að detta en ungu fólki. Beinbrot eru oftar en ekki afleiðing falls hjá eldra fólki. Beinbrot auka líkurnar á dauða meðal eldra fólks. Mjaðmabrot eru algengasta tegund beinbrota hjá eldra fólki. Meðal eldra fólks er hæsta dánartíðnin í hópi þeirra sem hafa orðið fyrir mjaðmabroti. Fall getur orðið til þess að eldra fólk þróar með sér „ótta við að detta”. Þessi ótti við að detta getur gert það að verkum að það hreyfir sig minna sem eykur líkurnar á því að verða aftur fyrir falli. Líkamlegar æfingar eru ein þeirra fyrirbyggjandi aðgerða sem draga úr líkum á falli meðal eldra fólks.

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Preface

I would like to take the opportunity to thank my thesis advisor, Milan Chang Guðjónsson (Ph.D.) for her guidance, professional insight, and support. My family and Kristinn Torfason (Ph.D.) for their patience and support. I would also like to thank Gréta Jakobsdóttir (Ph.D.) for her guidance.

This thesis was written solely by me, the undersigned. I have read and understand the University of Iceland Code of Ethics (https://english.hi.is/university/university_of_iceland_code_of_ethics) and have followed them to the best of my knowledge. I have correctly cited to all other works or previous work of my own, including, but not limited to, written works, figures, data or tables. I thank all who have worked with me and take full responsibility for any mistakes contained in this work. Signed:

Reykjavík 17 May 2020

Svanhvít Ásta Jónsdóttir

Definitions

- Body Mass Index (BMI): According to WHO (n.d.), BMI is defined as an individual's weight in kilograms divided by the square of the person's height in metres (kg/m2).
- Bone density: The measure of the amount of minerals in a specific volume of bone (NCI, n.d.). An Individual with a standard deviation (SD) within ± 1 has a normal bone density compared to a person with a SD of -2.5 or lower who is considered to have osteoporosis (NIH, 2018). Someone with a SD of -1 to -2,5 has low bone mass which is not as severe as osteoporosis (NIH, 2018).
- Cognitive ability: General process such as attention, memory, language, and executive functioning (Al-Aidroos, Said, & Turk-Browne, 2012).
- Cognitive function: Cognitive function is derived from the term cognition and is defined as many distinct functions believed to be components of the mind such as attention and memory (Benjafield, Smilek, & Kingstone, 2010).
- Cognitive processing speed: The ability to quickly process information (Lichtenberger, Alan S. Kaufman, & Nadeen L. Kaufman, 2012).
- Core Instability Strength Training (CIT): Exercises which challenge the trunk muscles and postural control, leading to potential benefits in trunk muscle strength, balance performance and spinal mobility (Granacher, Lacroix, Muehlbauer, Roettger, & Gollhofer, 2013).
- Fall: An event which results in a person coming to rest by accident on the ground or floor or other lower level (WHO, 2018).
- Fear of falling: Constant concern that regards falling, leading to avoidance of activities that the person is still able to perform (Tinetti & Powell, 1993).
- Foot drop: Being unable to lift the front part of the foot as a result of weakness or paralysis of the muscles that raise the foot, it can affect both feet or one foot (NINDS, 2019).
- Foot plantar pressure: Foot plantar pressure is a pressure field acting between the support surface and the foot while performing daily locomotor activities (Razak, Zayegh, Begg, & Wahab, 2012).

- Frailty: Clinical syndrome which leads to high vulnerability and negative health outcomes due to increase in age-related decline in both function and physiologic reserve among multiorgan systems (Campbell & Buchner, 1997). There are 5 symptoms which evaluate the risk of frailty and having 3 out these 5 symptoms means that an individual is suffering from frailty (Fried et al., 2001). Those 5 symptoms are: low grip strength, low energy, slowed waking speed, low physical activity, and/or unintentional weight loss (Fried et al., 2001).
- Glaucoma: Group of ocular disorders united by a clinically characteristic intraocular pressure-associated optic neuropathy (Casson, Chidlow, Wood, Crowston, & Goldberg, 2012).
- Good balance: The definition of having good balance is being able to regulate one's body position as well as maintaining it, whether in motion or still (NIA, 2017).
- Hypertrophy: Overgrowth or enlargement of an organ or part of the body due to the increased size of the constituent cells (Shiel, 2018).
- Nonagenarian: Person who is between 90 and 99 years old (Oxford Learner's Dictionaries, n.d.).
- One-repetition maximum (1-RM): The maximum amount of weight that a person can lift only once, using proper technique and form (Medical Dictionary for the Health Professions and Nursing, 2012).
- Osteoporosis: In 1997, osteoporosis was defined as a skeletal condition characterized by decreased density (mass/volume) of normally mineralized bone leading to decreased mechanical strength and thus making the skeleton more likely to fracture (Glaser & Kaplan, 1997). The definition was defined again in 2001 as a skeletal disorder characterized by a compromised bone strength which predisposes a person to an increased risk of fracture (NIH Consensus Development Panel on Osteoporosis Prevention, Diagnosis, and Therapy, 2001).
- Sarcopenia: In 2014, sarcopenia was defined as a condition characterized by loss of skeletal muscle mass and strength and even though it is primarily a disease among older adults, its development may be associated with conditions that are not only seen in older adults (Santilli, Bernetti, Mangone, & Paolini, 2014). In 2019, sarcopenia was clinically redefined as a muscle disease (muscle failure) rooted in adverse muscle changes that accrue across a lifetime which is common among older adults but can also occur earlier in life (Yang, Liu, Zuo, & Tang, 2019). Recently, the European Working Group on Sarcopenia in Older People (EWGSOP) defined sarcopenia more accurately (Yang et al., 2019).

- Tai Chi Chuan: Chinese martial art and a form of stylized and meditative exercise which is characterized by methodically slow circular and stretching movements and positions of bodily balance (Dictionary.com, n.d.).
- Vertigo: According to Shiel (2018), vertigo is a sensation of feeling as if the environment is spinning around or that oneself is spinning around, causing dizziness.
- Vestibular disorder: Disorder in the balance (vestibular) system in the inner ear due to immense range of conditions such as ear infections, medications toxic to the ear (ototoxic drugs), vertigo, Meniere's disease, acoustic neuroma, multiple sclerosis, syphilis, trauma, and epilepsy (seizure disorders), etc. (Shiel, 2018).

1 Introduction

Globally, people are getting older (Roser, 2019; OECD Data, n.d., Figures 1 and 2) and older adults are more likely to fall due to age-related factors (WHO, 2018). Age-related factors that increase the likelihood of falls among older adults include loss of skeletal muscle and function (Yang et al., 2019), decrease in muscle strength (Balogun et al., 2017), decrease in bone density (Mayo Clinic Staff, 2019), balance disorders (NIA, 2017), poorer walking mechanism (Osoba, Rao, Agrawal, & Lalwani, 2019; Verlinden et al., 2013), loss of vision (Coleman, et al., 2007; Dhital, Pey, & Stanford, 2010), loss of hearing (Gopinath, McMahon, Burlutsky, & Mitchell, 2016; Lin & Ferrucci, 2012), impaired cognition (Allan, Ballard, Rowan, & Kenny, 2009; Taylor et al., 2014), and frailty (Cheng & Chang, 2017; Fhon et al., 2018).

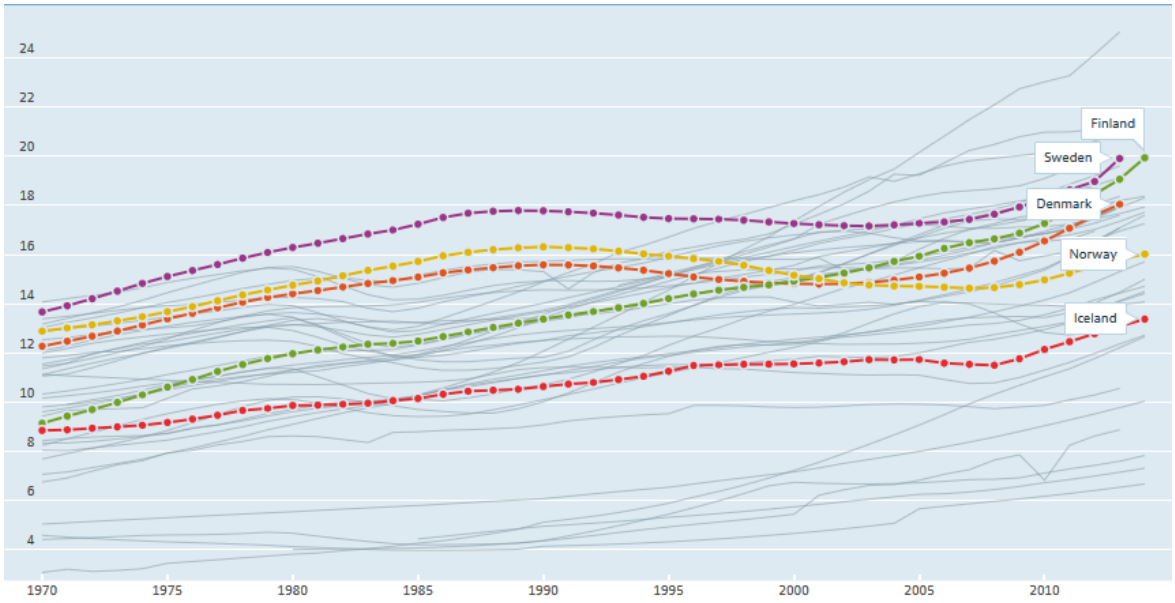

Figure 1. Increase in percentage of population of older adults internationally in 1970 and 2018. The x-axis shows year and y-axis shows percentage of population. Colored lines show the Nordic countries, while gray lines show other countries. Figure adjusted from: OECD Data, n.d.

The environment is also related with the risk of falls among older adults (Jósefsdóttir & Jónsdóttir, 2011; Landspítali - háskólasjúkrahús, 2007; Nicklett, Lohman, & Smith, 2017). Falls can have serious consequences and the negative impacts of falls among older adults include fractures (MedicineNet, 2004), long-term hospital care (Criss & Takacs, 2013; WHO, 2018), permanent disability (Hershkovitz, Pulatov, Brill, & Beloosesky, 2012; WHO, 2018), and higher rates of mortality (Bliuc et al., 2009; WHO, 2018). Falls among older adults can also lead to having a fear of falling (Maki, Holliday, & Topper, 1991; Rubenstein, 2006). Older adults with a high level of this

fear of falling are in even more danger of falling than older adults with low levels of fear of falling (Li, Fisher, Harmer, McAuley, & Wilson, 2003). Fear of falling can become a serious problem among older adults and lead to increased inactivity (Tinetti & Powell, 1993). However, it is important for older adults to remain active despite the fear of falling because higher inactivity makes older adults more likely to fall (Murphy, Williams, & Gill, 2002; Rubenstein, 2006). According to a report by WHO (2016), falls have a negative effect on the society since musculoskeletal conditions such as osteoporotic fractures place a heavy burden on the health system as well as on the individual. Therefore, it is important to develop preventive methods internationally to minimize the risk and the damage connected with falls (WHO, 2018). The purpose of this review is to determine what causes falls among older adults and how to prevent them.

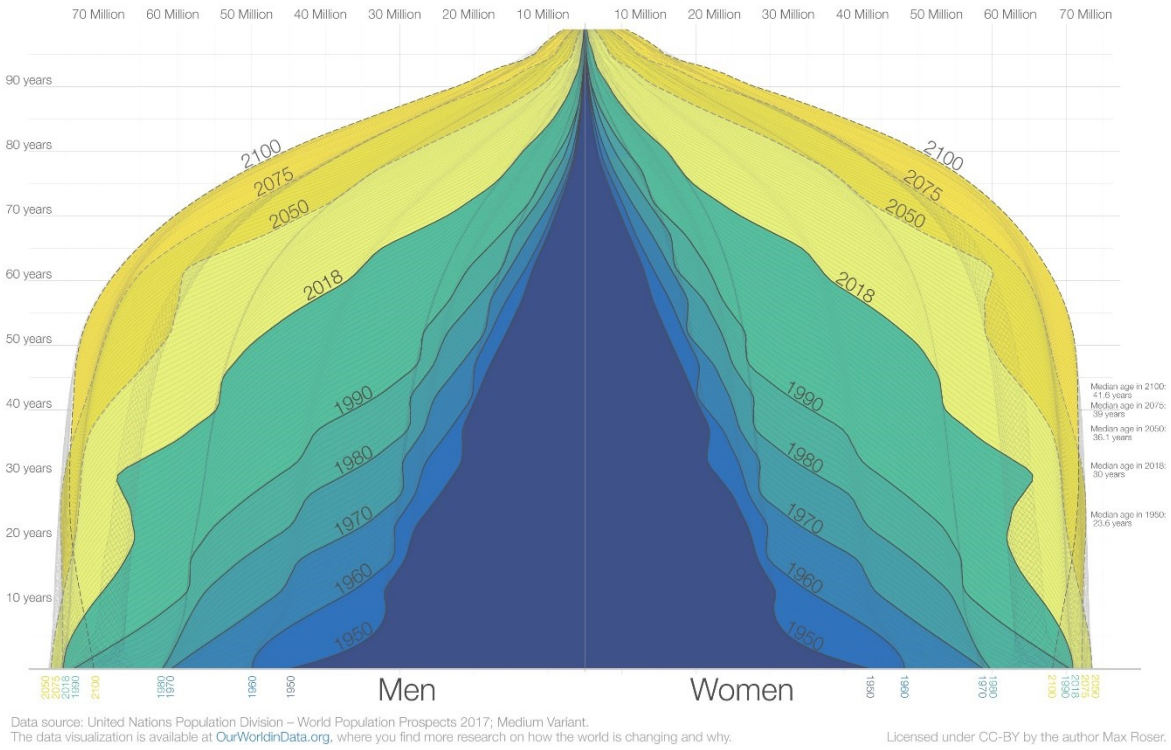

Figure 2. Age pyramid showing the global demography of the population from 1950-2100. Figure adjusted from: Roser, 2019.

2 Ageing society

Around the world the proportion of older adults is increasing more rapidly than in the past, and it is estimated that in 2050 the proportion of the world's population aged 60 years and older will be 22% (2 billion people) compared to 12% (900 million people) in 2015 (WHO, 2018). The Nordic countries are no exception and the population in the Nordic countries including Iceland is becoming older (Jørgensen et al., 2019). The number of Icelandic men and women aged 75 years and older, as well as 90 years and older increased during the period of 1990-2014 (Jørgensen et al., 2019, Figure 1 and Table 1). The Icelandic nation is relatively younger than other European nations, however the Icelandic population is getting older which is shown by the linearly increased average age for the past 50 years (Hagstofa Íslands, n.d., Figure 3). Figure 4 shows that the age group over 65 in Iceland will significantly increase in the future (Hagstofa Íslands, 2019). In the year 2019, the percentage of people older than 65 years old was 14% of the total Icelandic population, Icelandic people over 65 years are estimated to be greater than 20% of the total population in 2035 and be over 25% in 2063 (Hagstofa Íslands, 2019).

Table 1. Increase in population of older adults in the Nordic countries between 1990 and 2014. Table adjusted from: Jørgensen et al., 2019.

		Females		Males	
		1990	2014	1990	2014
		Numbers (%)			
≥75 years	Iceland	6755 (5.3)	10,973 (6.8)	4671 (3.7)	8418 (5.2)
	Finland	193,988 (7.6)	292,699 (11.2)	84,736 (3.5)	176,607 (7.0)
	Norway	187,275 (8.8)	213,610 (8.4)	109,513 (5.2)	141,500 (5.5)
	Denmark	226,199 (8.7)	246,105 (8.7)	129,931 (5.1)	168,950 (5.5)
	Sweden	425,867 (9.8)	488,575 (10.0)	262,997 (6.2)	345,914 (7.1)
≥90 years	Iceland	625 (0.5)	1244 (0.8)	306 (0.2)	589 (0.4)
	Finland	10,091 (0.4)	32,693 (1.2)	2669 (0.1)	9734 (0.4)
	Norway	13,543 (0.6)	31,128 (1.2)	5359 ()	11,267 ()
	Denmark	16,482 (0.6)	30,703 (1.1)	6044 (0.2)	10,822 (0.4)
	Sweden	30,532 (0.7)	67,086 (1.4)	11,044 (0.3)	27,910 (0.6)

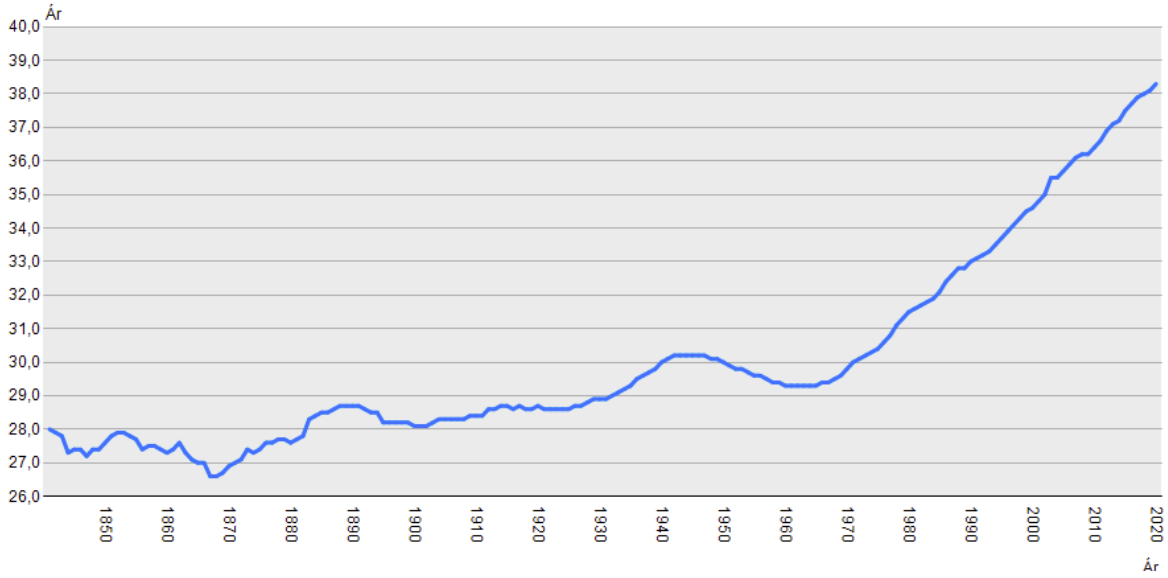

Figure 3. Average age of the Icelandic population from 1841 to 2020. Figure adjusted from: Hagstofa Íslands, n.d.

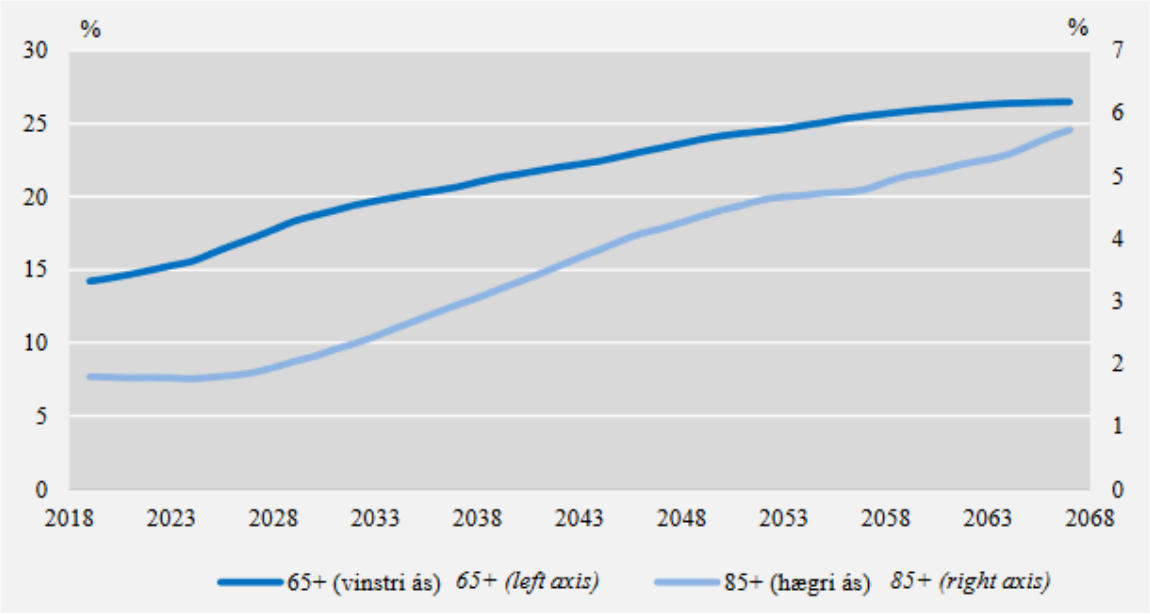

Figure 4. Dark blue line shows the proportion of people over 65 years, while the light blue line is the proportion over 85 years in Iceland between 2019 and 2068. Figure adjusted from: Hagstofa Íslands, 2019.

3 Falls

As people get older they are more likely to suffer from a fall (WHO, 2018). Worldwide incidence of falls among older adults are increasing (AIHW, 2017; WHO, 2007, Figure 5). Falls among older adults often result in disability, admission to a long-term hospital care, and institutionalization (WHO, 2018). In the worst case a fall can result in death (Bliuc et al., 2009; WHO, 2018). According to Burns & Kakara (2018), the number of deaths as a consequence of falling is rising among older adults in the United States (Figure 6). Internationally, around 28-35% of older adults aged 65 years and older fall every year (Blake et al., 1988; Campbell, Reinken, Allan, & Martinez, 1981; Prudham & Evans, 1981; Tinetti & Kumar, 2010). The percentage of older adults aged 70 years and over who fall annually is even higher, or around 32%-42% (Downton & Andrews, 1991; Stalenhoef, Diederiks, Knottnerus, Kester, & Crebolder, 2002; Tinetti, Speechley, & Ginter, 1988). In Iceland, falls are the most common cause of accidents among older adults which is around 67% (Embætti landlæknis, 2017). Approximately 250 patients each year at Landspítali experience a fall, most of them are 67 years or older, and about 8% of those patients sustain a fracture (Landspítali - háskólasjúkrahús, 2007). One third of Icelandic people aged 65 years and older who fall will suffer from fractures and 7% of these cases are either a broken spine or a broken hip (Embætti landlæknis, 2017).

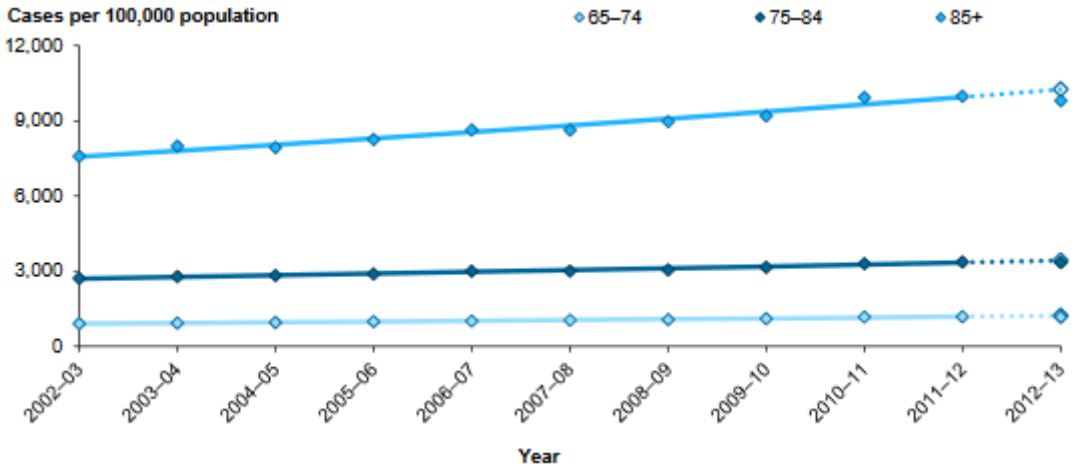

Figure 5. Number of falls leading to hospitalization in Australia 2002-03 and 2012-2013. Figure adjusted from: AIHW, 2017.

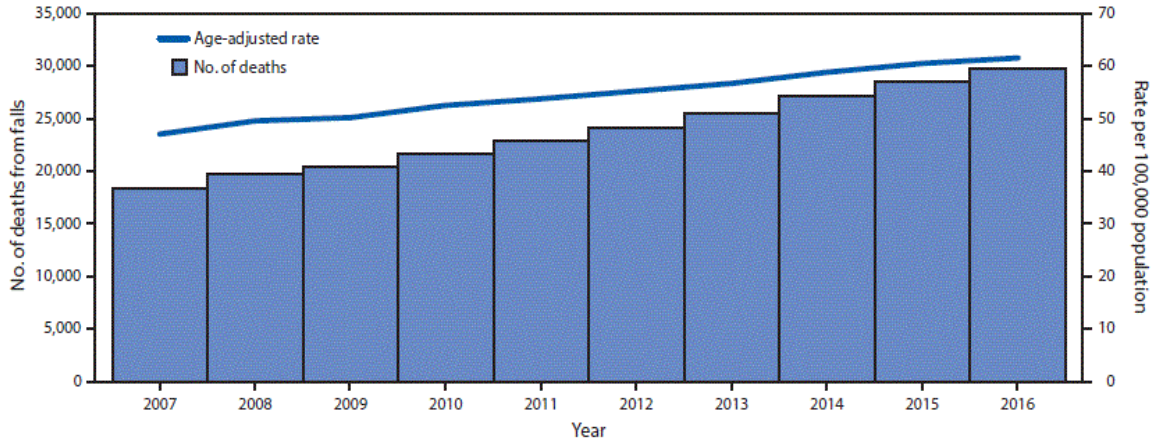

Figure 6. Deaths due to falls among older adults aged ≥65 years in the years 2007 and 2016 with age adjusted rates in the United States. Figure adjusted from: Burns & Kakara, 2018.

4 Fractures

When older adults fall they are likely to sustain a fracture (AIHW, 2017, Figure 7). The age group from 65-69 years old is most likely to suffer from a fall related fracture (AIHW, 2017, Figure 7). The proportion of fall related fracture decreases slightly with increasing age, but even then fractures remain the most common type of fall related injury (AIHW, 2017, Figure 7). Osteoporotic hip fracture has the highest mortality rate (Bliuc et al., 2009) and wrist fracture (distal forearm fracture) often precedes a hip fracture as well as other fractures, such as proximal humerus fractures, proximal femoral fractures, and vertebrae fractures (Crandall et al., 2015; Cuddihy, Gabriel, Crowson, O'Fallon, & Melton III, 1999). Osteoporotic fractures place a heavy burden on the health system as well as on the individual (WHO, 2016). Therefore, this section will discuss hip fractures, wrist fractures and forearm fractures and their economic cost as well as how to prevent fractures.

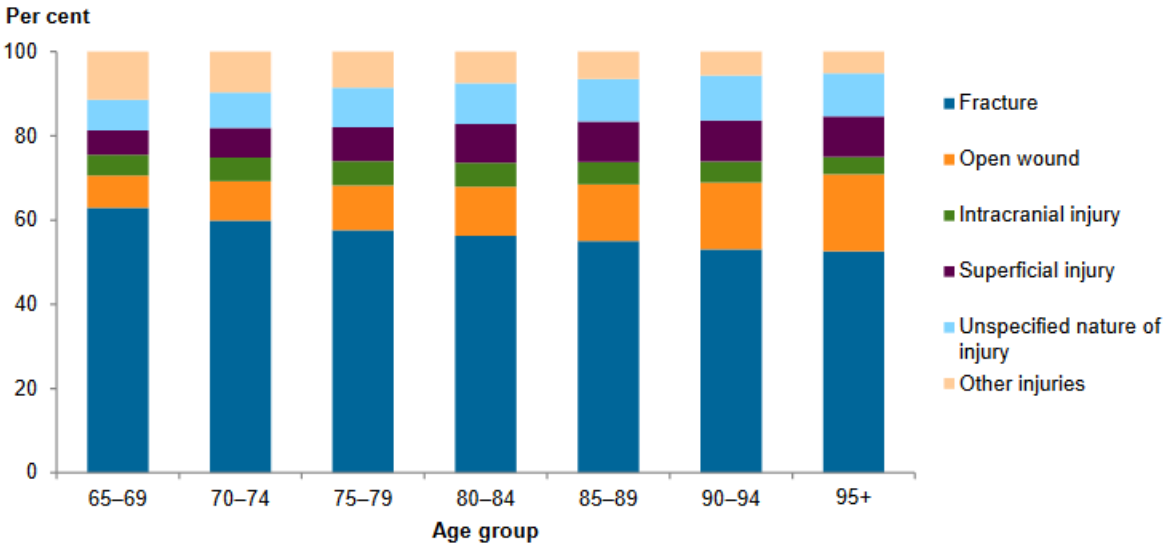

Figure 7. Type of injury due to hospitalized falls by age group in Australia 2012-2013. Figure adjusted from: AIHW, 2017.

4.1 Hip fractures

Osteoporosis causes more than 8.9 million fractures internationally each year (WHO, 2007). In a study among people aged 90 years and over, hip fracture was the most dominant fracture type (Klop et al., 2015). Among all osteoporotic fractures, hip fracture has the highest mortality rate (Bliuc et al., 2009). In Iceland, 270 hip fractures are reported annually (Jósefsdóttir & Jónsdóttir, 2011). The reported mortality for 1 year after sustaining a hip fracture is estimated to be between 14% and 58% internationally (Schnell, Friedman, Mendelson, Bingham, & Kates, 2010). Men have a higher risk of mortality following a hip surgery compared to women (Saletti-Cuesta, Tutton, & Wright, 2016). The one-year mortality risk was 32% for men and 18% for women in a study from the USA (Bass, French, Bradham, & Rubenstein, 2007). In Iceland, men are 2 times more likely to die within 3 months as well as 12 months following a hip surgery compared with women, even though women are 2 times more likely to sustain a hip fracture compared to men (Tables 2 and 3). Icelandic data on fractures is similar with other countries (Saletti-Cuesta et al., 2016; Skúladóttir et al., 2019).

Table 2. Icelandic mortality for older men and women within 3 months after hip surgery. Table adjusted from: Skúladóttir et al., 2019.

	Mortality, n (%)	OR (95% CI)[a]	OR (95% CI)[b]
Mortality < 3 months	150 (14)		
Gender			
Female	86 (11)	1.00	1.00
Male	64 (22)	**2.37** (1.64–3.42)	**2.28** (1.55–3.38)
Age group			
67–79 y	21 (6)	1.00	1.00
80–89 y	85 (16)	**2.71** (1.65–4.47)	**2.82** (1.69–4.68)
90–109 y	44 (24)	**4.47** (2.56–7.79)	**5.28** (2.95–9.43)
Marital status			
Married	46 (14)	1.31 (0.89–1.95)	1.03 (0.68–1.58)
Widow/Living a lone	104 (14)	1.00	1.00
Waiting time for surgery			
< 24 h	102 (14)	1.00	1.00
24.1–48 h	36 (14)	0.99 (0.66–1.51)	0.98 (0.64–1.49)
> 48.1 h	11 (22)	1.80 (0.88–3.68)	1.68 (0.81–3.47)
Number of ICD-10 diagnoses			
1	76 (13)	1.00	1.00
2-3	56 (15)	1.18 (0.81–1.72)	1.24 (0.84–1.82)
> 4	18 (20)	**1.88** (1.05–3.37)	**1.83** (1.01–3.31)

[a] Adjusted for age.
[b] Additional adjustments were made for gender, marital status, waiting time for surgery and number of diagnoses.

Table 3. Icelandic mortality for older men and women within 12 months after hip surgery. Table adjusted from: Skúladóttir et al., 2019.

	Mortality 0–12M, n (%)	OR (95% CI)[a]	OR (95% CI)[b]
Mortality < 12 months	263 (25)		
Gender			
Female	158 (21)	1.00	1.00
Male	105 (36)	**2.65** (1.75–3.19)	**2.30** (1.66–3.18)
Age			
67–79 y	51 (16)	1.00	1.00
80–89 y	133 (25)	**1.76** (1.23–2.52)	**1.80** (1.25–2.60)
90–109 y	79 (42)	**3.99** (2.61–5.98)	**4.52** (2.91–7.01)
Marital status			
Married	81 (25)	1.32 (0.96–1.81)	1.05 (0.74–1.47)
Widdow/Living a lone	182 (25)	1.00	1.00
Waiting time for surgery			
< 24 h	182 (25)	1.00	1.00
24.1–48 h	66 (25)	1.04 (0.75–1.45)	1.04 (0.74–1.45)
> 48.1 h	12 (24)	0.99 (0.50–1.96)	0.91 (0.45–1.82)
Number of ICD-10 diagnoses			
1	141 (24)	1.00	1.00
2-3	93 (24)	1.03 (0.76–1.40)	1.04 (0.76–1.43)
> 4	29 (33)	**1.68** (1.02–2.75)	1.63 (0.99–2.70)

[a] Adjusted for age.
[b] Additional adjustments were made for gender, age, marital status, waiting time for surgery and number of diagnoses.

4.2 Wrist and forearm fractures

The most common first fracture among women is a wrist (forearm) fracture, whereas for men wrist fracture is the third most common first fracture (Klop et al. 2015). Wrist fracture (distal forearm fracture) often precedes a hip fracture as well as other fractures, such as proximal humerus fractures, proximal femoral fractures, and vertebrae fractures (Cuddihy et al., 1999; Crandall et al., 2015). Less plantar pressure sensation, less dynamic control and worse ability to stand can lead to a wrist fracture (Baldursdóttir et al., 2018). A recent study reported a positive relationship between wrist fractures (distal radius fractures) and mortality among individuals aged 50 years old and over (Marchewka, J., Głodzik, Marchewka, W., & Golec, 2019). They concluded that men had 2.2 times higher mortality rate compared with women after sustaining a wrist fracture (Marchewka et al., 2019). However, other studies did not show a positive relationship between wrist fractures (distal radius fractures) and increased risk of mortality (Lee, J. W., Lee, Y.-B., Kwon, Yoo, & Choi, 2019; Shauver, Zhong, & Chung, 2015).

4.3 Cost for society

Musculoskeletal conditions such as osteoporotic fractures place a heavy burden on the health system both in developed and undeveloped countries as well as on the individual (WHO, 2016). In a study by Svedbom et al. (2013), the economic cost of osteoporotic fractures was 37 billion euros in Europe and the direct cost for osteoporotic fractures in the European society is estimated to become 77 billion euros in 2050 due to the increase in population of older adults (Kanis & Johnell, 2005). In the USA, the direct medical cost for the treatment for osteoporotic fractures in 1995 was $13,8 billion (Ray, Chan, Thamer, & Melton, 1997), while the medical cost in 2002 due to osteoporotic fracture was $16 billion and $22 billion in 2008 (Blume & Curtis, 2011). In Finland, the average cost related to individual injury from a single fall among older adults was US $3611, and the cost regarding the same matter in Australia was US $ 1049 (WHO, 2018).

5 Sarcopenia and muscle strength

Sarcopenia can both be linked to falls and fractures (Yang et al., 2019). Muscle strength and power begin to decrease by the age of 40 with greater decline in power (Cruz-Jentoft et al., 2019; Metter, Conwit, Tobin, & Fozard, 1997, Figures 8 and 9), and decrease in muscle strength increases the likelihood of falling among older adults (Balogun et al., 2017). Many factors affect muscle quantity and quality (Cruz-Jentoft et al., 2019, Figure 10). In a study by Van Ancum et al. (2018), lower muscle mass as well as lower hand grip strength increased the likelihood of falling among older men. Even though it is important to maintain muscle mass as people get older, maintaining muscle mass does not prevent older adults from losing muscle strength (Goodpaster et al., 2006). That is why older adults need to exercise to improve their muscle strength (Cadore et al., 2014) and reduce the negative effects of sarcopenia (Yoo et al., 2018).

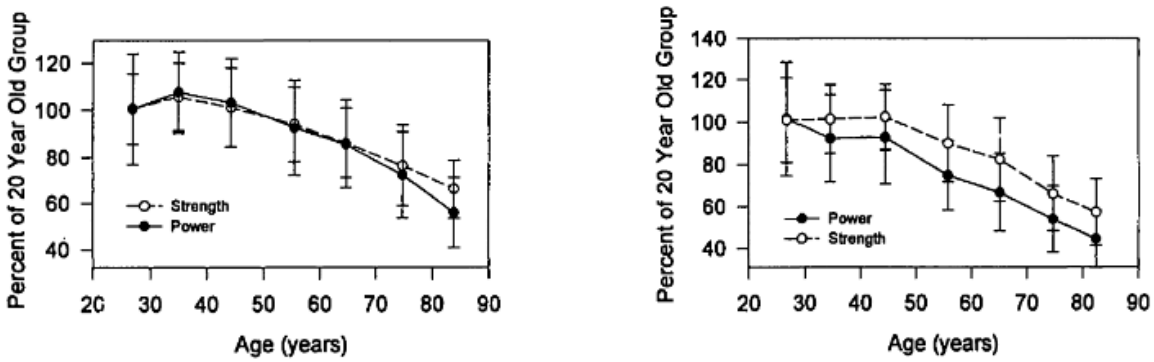

Figure 8. Age associated loss in strength and power for men (left) and women (right) in the upper extremities described as a percentage of values obtained by 20 years old study participants. Figure adjusted from: Metter, Conwit, Tobin, & Fozard, 1997.

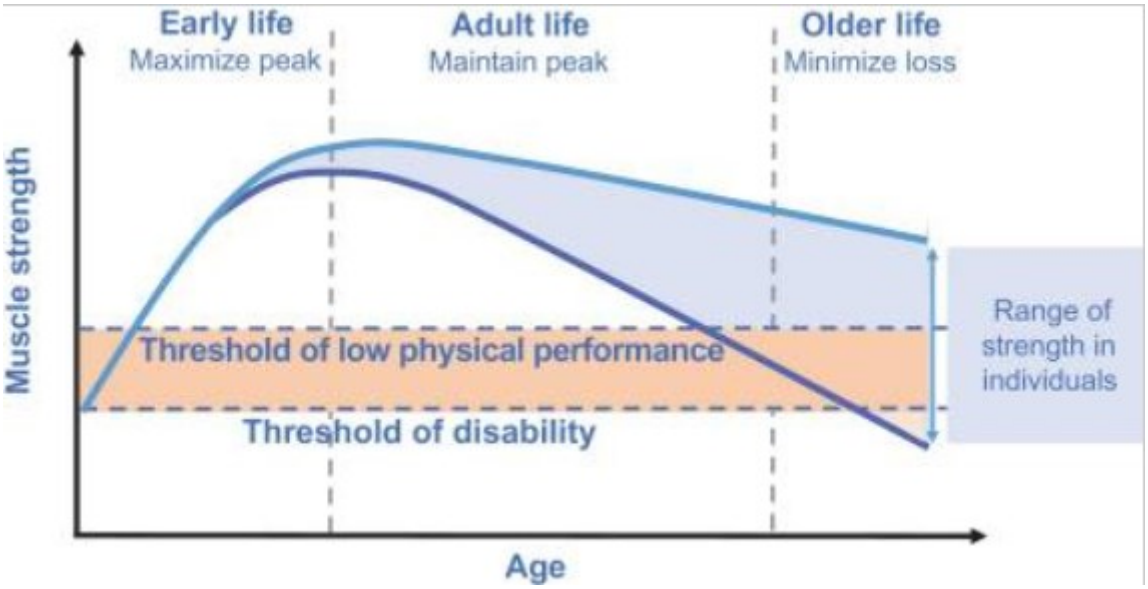

Figure 9. Age associated decrease in muscle strength. Figure adjusted from: Cruz-Jentoft et al., 2019.

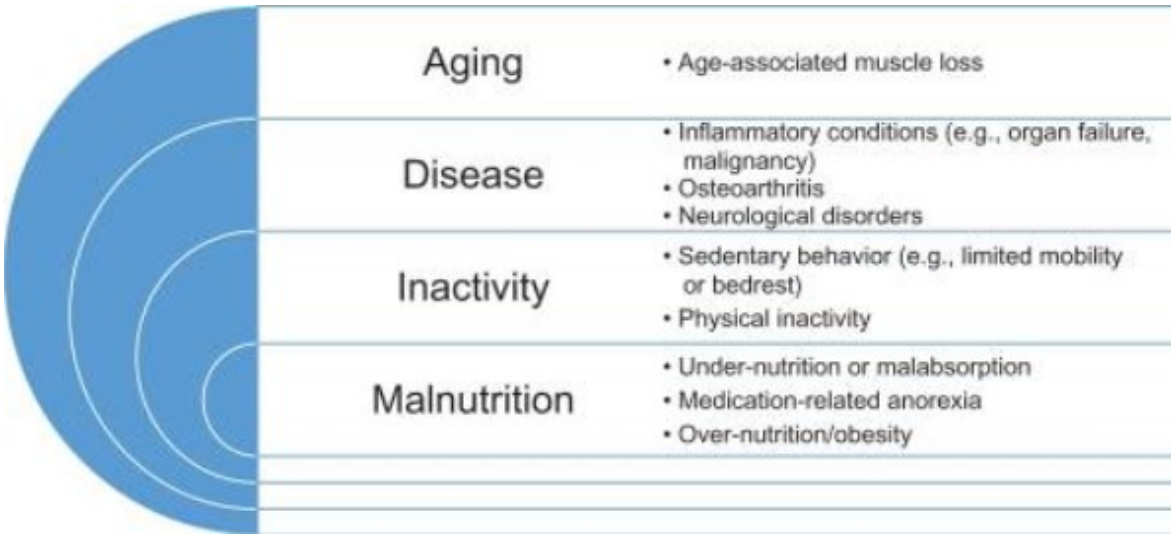

Figure 10. Primary factors (ageing) and secondary factors (disease, inactivity, and poor nutrition) that affect muscle quantity and quality. Figure adjusted from: Cruz-Jentoft et al., 2019.

5.1 Osteoporosis

The number of people suffering from osteoporosis will increase due to the ageing of populations (Cosman et al., 2014). Women experience more dramatic bone loss due to menopause (Riggs, Khosla, & Melton III, 2002). In the first 8-10 years after the beginning of menopause, the bone loss in the trabecular and cortical bones is most rapid (Riggs et al., 2002, Figure 11) and osteoporosis can lead to a fracture caused by a fall (Mayo Clinic Staff, 2019). In Iceland, osteoporosis causes approximately 1300 fractures every year (Jósefsdóttir & Jónsdóttir, 2011).

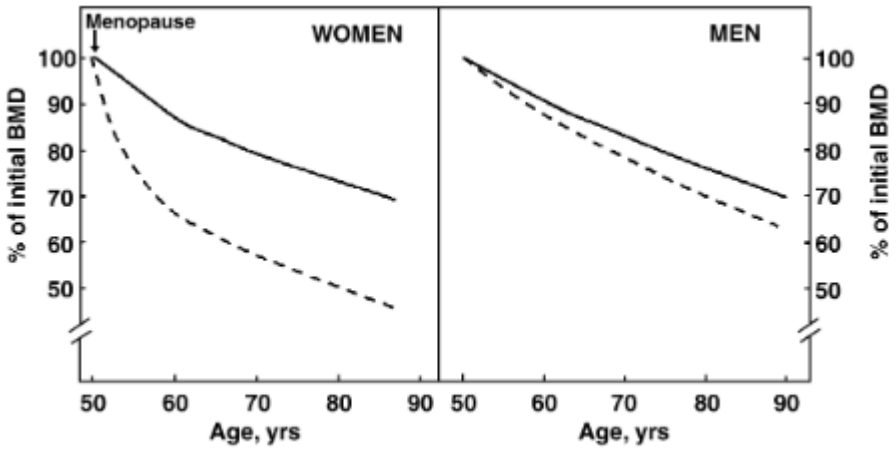

Figure 11. Age-related bone loss in women and men from numeral longitudinal and cross-sectional studies where the dashed lines show trabecular bone and the solid lines represent cortical bone. Figure adjusted from: Riggs, Khosla, & Melton III, 2002.

6 Balance

As people get older, walking speed and balance performance gets worse (Osoba et al., 2019) resulting in a fall among older adults (NIA, 2017; Szanton, Roth, Nkimbeng, Savage, & Klimmek, 2014). Good balance is important for older adults to be independent since it involves being able to perform daily activities without complications such as walking, climbing stairs, bending over, and getting up from a chair (NIA, 2017). Several things can affect one's balance (Baldursdóttir et al., 2018; Coleman, et al., 2007; Dhital et al., 2010; Landspítali - háskólasjúkrahús, 2007; NIA, 2017; Shiel, 2018; Szanton et al., 2014). Having a problem with balance can be the result of inner ear disturbance and vertigo (NIA, 2017). Vertigo can be caused by problems with vision (Shiel, 2018). Poor balance can be the result of age-related loss in vision (Coleman, et al., 2007; Dhital et al., 2010) and instability in legs (Landspítali - háskólasjúkrahús, 2007). Some medications e.g. heart-related medicine, sleeping medicine and sedatives can cause decrease in physical stability (Landspítali - háskólasjúkrahús, 2007) as well as medications that affect the central nervous system (Szanton et al., 2014). Older adults with less plantar pressure sensation, less dynamic control, and worse ability to stand were more likely to sustain a wrist fracture (Baldursdóttir et al., 2018).

6.1 Gait pattern

Older adults are more likely to have poor walking mechanism (Rubenstein, 2006). As people get older, their gait speed decreases (Osoba et al., 2019; Verlinden et al., 2013), especially when performing complex walking tasks (Shumway-Cook et al., 2007). Step length also decreases with higher age (Verlinden et al., 2013). Slower gait speed and shorter step length increases the risk of falling (Figueiro, Plitnick, Mary S. Rea, Gras, & Mark S. Rea, 2011; Mortaza, Abu Osman, & Mehdikhani, 2014; Osoba et al., 2019). Older adults can develop gait disorders such as foot drop which increases fall risk (NINDS, 2019). Foot drop leads to scuffing the toes along the ground resulting in "steppage gait" (NINDS, 2019). In order to compensate for foot drop the person raises the foot higher by bending the knees (NINDS, 2019). It is important to notice that even though older adults can walk independently under simple conditions, it does not necessarily mean that they are able to perform the same under complex walking tasks (Shumway-Cook et al., 2007).

6.2 Vision and hearing

As people get older, vision decreases (Dhital et al., 2010) which negatively affects gait and balance that further increases the likelihood of falls (Coleman, et al., 2007; Dhital et al., 2010; Szanton et al., 2014). Older adults are more likely to lose their balance and fall when they have fewer visual cues (Rubino, 2002) or due to visual perturbations (Osoba et al., 2019). Glaucoma affects functional abilities in a negative manner among older adults (Lee, Wood, & Black, 2020). Age-related hearing loss (presbycusis) gradually occurs in most people as they grow older (NIDCD, 2018). It is one of the most common conditions affecting older adults (NIDCD, 2018), and it is linked with falls as well (Gopinath et al., 2016; Lin & Ferrucci, 2012). Asymmetrical vestibular function also increases the likelihood of falls as well as wrist fractures (Baldursdóttir et al., 2018; Kristinsdóttir et al., 2001) and hip fractures among older adults (Kristinsdóttir, Jarnlo, & Magnusson, 2000).

7 Impaired cognition and speed of processing

As people get older, they have more difficulty performing complex tasks (Murman, 2015) due to their cognitive decline (Murman, 2015; Roberts & Allen, 2016) and loss of perception (Roberts & Allen, 2016). Older adults with impaired cognition are more likely to suffer from a fall (Allan et al., 2009) and sustain a fracture (Taylor et al., 2014). Poor performance in complex walking tests such as fast-pace walking tests and dual-task tests is associated with possible cognitive decline (Rosso et al., 2019). Memory related illnesses also increase the risk of falling among older adults because they misjudge their own ability (Landspítali - háskólasjúkrahús, 2007). It is important to notice that older adults without mobility disability under simple conditions may have difficulty with walking under complex walking conditions because these conditions require executive cognitive function (Shumway-Cook et al., 2007). Types of cognitive functions that are not well-preserved as people get old are certain executive functions, attentional functions and episodic long-term memory (Nyberg, Lövdén, Riklund, Lindenberger, & Bäckman, 2012). Deterioration in cognitive processing speed also occurs with increasing age (Eckert, Keren, Roberts, Calhoun, & Harris, 2010; Kerchner et al., 2012).

8 Fear of falling

Fear of falling can lead to a fall among older adults (Friedman, Munoz, West, Rubin, & Fried, 2002). It is a constant concern of falling which causes avoidance of activities which the person is still able to perform (NCOA, 2018; Tinetti & Powell, 1993). Older adults with a high level of fear of falling are 4 times more likely to report a fall in the past 3 months compared to those with low levels (Li et al., 2003). Although fear of falling can develop after a fall (Maki et al., 1991; Rubenstein, 2006), fear of falling can also develop among those who have never fallen (Tinetti et al., 1988). Older adults with the fear of falling tend to develop a gait disorder called “phobic” gait or “fear of falling gait” which is characterized by holding onto items such as walls, chairs, tables and other furniture as well as walking extremely carefully as if the floor was icy (Rubino, 2002). Another symptom for this gait is taking short steps without elevating the foot high enough above the ground resulting in sliding or shuffling movements (Kurlan, 2005). Finally, fear of falling makes older adults quit activities that they are still capable of doing (Tinetti & Powell, 1993), which ironically further increases the risk of falling (Murphy et al., 2002).

8.1 Environment

One of the reasons for older adults to be afraid of physical activity is unsafe and uncomfortable environment (Chaudhury, Campo, Michael, & Mahmood, 2016). The unfavorable environment forces older adults to be less physically active (Nicklett et al., 2017). Stairs can pose a threat to older adults especially if it is slippery, steep, broken or without railing (Szanton et al., 2014). People riding bicycles must be aware that cycling close to a walking person can be very startling for older adults (Chippendale & Boltz, 2015). The same applies for people skateboarding on sidewalks (Chippendale & Boltz, 2015). Other environmental factors include unstable furniture (Rubenstein, 2006), sloped walkways, wet subway floors, open or uneven grates, cracked sidewalks and streets, potholes, puddles (Chippendale & Boltz, 2015), and floors with slippery ice, cords, or wet (Jósefsdóttir & Jónsdóttir, 2011). Landspítali also reported that environmental factors (whether at home or at infirmaries) such as slippery floors, loose mattings, too high set beds or insufficient lighting were considered as causes for increased risk of falling in Iceland (Landspítali - háskólasjúkrahús, 2007). Older adults walk slower in dim light (Figueiro et al., 2011) which puts them in more danger of falling (Mortaza et al., 2014). Older adults who suffer from poor bladder control should also be careful not to rush to the bathroom to avoid falls (Landspítali - háskólasjúkrahús, 2007).

Inaccessibility or long travel distance to important places such as senior centers, gyms and shops reduces physical activity among older adults (Inoue et al., 2011). Older adults

are less likely to go to a gym because they often do not offer a lower impact program (Chippendale & Boltz, 2015). Gyms full of young people or highly skilled young men exercising could lead older adults to feel intimidated or unwelcome, leading them to avoid the gym (Chippendale & Boltz, 2015). The weather also plays a major role in physical activity among older adults because drastic weather conditions force older adults to stay inside (Chippendale & Boltz, 2015). When it is windy, icy or when it snows older adults are less likely to go outside (Chippendale & Boltz, 2015).

9 Conclusion

In conclusion, preventive methods for falls are gain in body mass index (Shen et al., 2016), safe environment (Chaudhury et al., 2016; Nicklett et al., 2017), and having a healthy lifestyle (Murman, 2015), including exercise (Guirguis-Blake, Michael, Perdue, Coppola, & Beil, 2018; Senderovich, Tang, & Belmont, 2017), being physically active in daily life (Lagerros et al., 2017), getting mental stimulation (Murman, 2015), and having a nutritious diet (Anagnostis, Dimopoulou, Karras, Lambrinoudaki, & Goulis, 2015; Embætti landlæknis, 2016). Particularly, exercise is an important factor to reduce fall risk among older adults (Guirguis-Blake et al., 2018; Senderovich et al., 2017). According to Lýðheilsustöð (2008), older adults should exercise for at least 30 minutes every day of medium intensity. If it is not possible to exercise for 30 minutes straight, it is perfectly acceptable to divide those 30 minutes into couple of shorter session e.g. 2 sessions of 15 minutes or 3 sessions of 10 minutes over the day. Murman (2015) recommends that older adults engage in physical activity and mental stimulation to live a healthy life.

Exercise has a positive effect on bone mineral density (BMD) and muscle mass (Senderovich et al., 2017). Exercise such as combined strength training and weight-bearing exercises can slow bone loss and assist in building strong bones (Mayo Clinic Staff, 2017). Both aerobic and resistance training as well as combined exercise regimes can prevent the negative effects of sarcopenia (Yoo et al., 2018). Twelve weeks of multicomponent exercise program composed of high-speed resistance training with balance and gait exercises reported many positive effects on physical health (Cadore et al., 2014). These positive effects included improved one-repetition maximum (1-RM) and strength (Cadore et al., 2014). Other positive effects included improved maximal dynamic strength, power output values, cross-sectional area (CSA) of the high density muscle tissues in knee flexors and quadriceps muscles, functional outcomes (e.g. balance and the ability to rise from a chair) as well as promoted muscle hypertrophy (Cadore et al., 2014). All these factors reduced incidents of falls among frail nonagenarians (Cadore et al., 2014).

Balance exercises are also very important for older adults to prevent falls (Sherrington et al., 2017). It is reported that Pilates and yoga training increase dynamic balance as well as static balance among older adults (Irandoust & Taheri, 2016). Exercises such as Tai Chi Chuan and core instability strength training (CIT) can be used to improve walking performance and balance and thus decrease the risk of falls among older adults (Hosseini et al., 2018; Granacher et al., 2013). Walking exercises is a way to improve gait performance among older adults (Osoba et al., 2019). Physical therapy also helps to prevent falls among older adults by individually tailored training to improve gait performance (Rubenstein, 2006). Multisensory training improved postural control among

older adults who have suffered from a wrist fracture (Baldursdóttir et al., 2020). Virtual reality training is a relatively new method that can improve balance among older adults (Duque et al., 2013; Osoba et al., 2019). The use of auditory prosthesis improves balance for older adults (Lacerda, e Silva, de Tavares Canto, & Cheik, 2012). Using a walking cane and/or modifying shoes also helps to prevent falls (Rubenstein, 2006). Balance and posture exercises should be conducted at a medium force whereas strength training exercises should be conducted of at least moderate intensity (Senderovich et al., 2017). Low intensity training consisting of 3 sessions each week lasting 45 minutes over the period of 8 weeks reduced the risk of falls among older adults (Morgan, Virnig, Duque, Abdel-Moty, & DeVito, 2004). Therefore, older adults who cannot perform exercise every day at a medium force can still perform exercise at low intensity (Morgan et al., 2004).

Older adults should be careful when it comes to high-intensity training (Senderovich et al., 2017). Particularly, for older adults without training experience or sufficient physical capacity, high intensity exercises can be dangerous (Senderovich et al., 2017). It is not necessary for older adults to join rehabilitation or sports facilities nor to be a part of organized exercise programs to be physically active (Lagerros et al., 2017). Exercise can be done in many forms in daily life such as performing household work, cleaning, gardening, commuting, or cycling (Lagerros et al., 2017). It may even be easier for older adults to maintain such activities compared with arranged exercise plans (Lagerros et al., 2017).

Getting proper nutrition is a part of leading a healthy lifestyle which decreases the likelihood of falls (Anagnostis et al., 2015; Mayo Clinic Staff, 2017; Murman, 2015). Age-related cognitive decline can be decreased by regulating medical conditions and staying clear of alcohol and other neurotoxins (Murman, 2015). Avoiding too much alcohol consumption as well as smoking can assist in reducing bone loss (Mayo Clinic Staff, 2017). Anti-resorptive agents medicine can also help people with high risk of osteoporosis development (Mayo Clinic Staff, 2017). Vitamin D is especially important for postmenopausal women since it has positive effect on muscle strength and physical performance (Anagnostis et al., 2015). Sufficient vitamin D, calcium and protein intake are protective factors against osteoporosis and falls, although not everyone agrees on the importance of protein intake for bone density (Nordin, 2009; Mayo Clinic Staff, 2017). Nutritional recommendation for the older adults in Iceland includes, 1) daily protein intake should be 10-20% of the total energy intake for people aged 65 years and older (Embætti landlæknis, 2016), 2) daily intake of calcium for people aged 61 years and older should be 800 mg, and 3) daily intake of vitamin D for people aged 61-74 years old should

be 15/20 µg, whereas daily intake of vitamin D for people aged 75 years and over should be 20 µg (Embætti landlæknis, 2016).

Gain in body mass index (BMI) can be preventive against fractures (Shen et al., 2016). According to Shen et al. (2016) the likelihood of sustaining a major osteoporotic fracture (MOF) decreases with increase in BMI, but the increments were very little after reaching a BMI of 30 kg/m^2. This is despite the fact that femoral strength index (SI) reduces as BMI increases (Shen et al., 2016). Higher BMI increases bone mineral density (BMD), cross-sectional area (CSA) and cross-sectional moment of inertia (CSMI) of the bones (Shen et al., 2016). A Global Longitudinal Study of Osteoporosis in Women found a positive relationship between unintentional weight loss of 10 pounds (lb) or more, and hip fracture, spinal fracture and a clavicular fracture (Compston et al., 2016).

Finally, evidence also shows that making the environment safer and favorable for older adults reduces the risk of falling as well as encourages older adults to be more physically active (Chaudhury et al., 2016; Nicklett et al., 2017). It is reported that grocery home delivery service for older adults during bad weather reduces the risk of falling among older adults (Chippendale & Boltz, 2015). Uninterrupted walking paths with sufficient walking space and benches for rest also provide encouragement for older adults to walk more (Chippendale & Boltz, 2015). Particularly, surroundings with beautiful nature encourages older adults to walk outdoors (Chippendale & Boltz, 2015). Regarding physical activity as a preventive factor, engaging in social events and family support seem to encourage older adults to be more physically active (Chippendale & Boltz, 2015) whereas loneliness is associated with low physical activity (Smith, Banting, Eime, O'Sullivan, & van Uffelen, 2017).

Visiting a senior center also promotes physical activity (Chippendale & Boltz, 2015). Providing appealing food at the senior center for older adults is important in order for them to visit the center more often (Chippendale & Boltz, 2015). Some older adults even visit more than once a day and go to various senior centers because of diverse activities in each different center (Chippendale & Boltz, 2015). Offering low intensity training programs at gyms can also be more appealing to older adults (Chippendale & Boltz, 2015). It is reported that hospital-based fall prevention programs that increase physical activity among older adults, decrease the odds of falling (Chippendale & Boltz, 2015). As a preventive exercise program regarding falls, Tai Chi Chuan is one of the well-known exercises that decreases the fear of falling among older adults (Hosseini et al., 2018). Using interdisciplinary approach regarding both functional and medical matters as well as including home repair could increase daily function for older adults (Huang, Turner, & Brandt, 2018; Szanton et al., 2014).

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