A Review Article: Environmental Hazards at Home and Ergonomics as Fall Prevention for Elderly Population

บทความปริทรรศน์: อันตรายจากสภาพแวดล้อมที่บ้านและการยศาสตร์ในการป้องกันการล้มสำหรับผู้สูงอายุ

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Abstract

This review is aimed to suggest opportunities where physiological concept may be useful to design trends to suit this rapid increase of elderly Thai population. A review of articles is presented to establish background information on the circumstance of the country which is entering the stage of becoming aging society. Also, the review provides comprehensive discussion from falls in older people to fall prevention which can be managed by interior design of the ergonomics concept. The review indicates that falls result from a complex interaction between personal factors (e.g., vision, hearing, posture, and gait) and environmental factors (environmental hazards) generating challenges and barriers related to the built environment (e.g., bathroom, built-in and loose furniture, flooring and stepping, and lighting). In this review, design recommendations which focus on bathroom function are described to promote better design integration with egonomics as a component of interior design for falls prevention strategy. Forming understanding of falls, what can increase chance of falls and what can be done as a precaution in terms of design will bring more possible opportunities to reduce the incidence, minimize chance of consequent injuries, improve overall well-being of older adults as well as possibly give inspiration on improving the quality of life.

Keywords

Environmental Hazards

Falls in Older People

Fall Prevention

Interior Design

Ergonomics

บทคัดย่อ

บทความนี้ นำเสนอแนวคิดทางสรีรวิทยาสู่แนวทางการออกแบบที่เหมาะสมสำหรับผู้สูงอายุจากสถานการณ์การก้าวเข้าสู่สังคมผู้สูงอายุของประเทศไทย การอภิปรายการล้มในผู้สูงอายุ ตลอดจนการป้องกันการล้มโดยการออกแบบสถาปัตยกรรมภายในทางการยศาสตร์ จากการศึกษาพบว่า การล้มเกิดได้จากการปฏิสัมพันธ์กันอย่างซับซ้อนระหว่างปัจจัยส่วนบุคคล ได้แก่ การมองเห็น การได้ยิน ท่าทางในการทรงตัว และการเดิน เป็นต้น ร่วมกับปัจจัยสภาพแวดล้อม กล่าวคือ อันตรายจากสภาพแวดล้อม เช่น ห้องน้ำ เครื่องเรือนแบบติดตั้ง และแบบลอยตัว พื้น และพื้นที่ต่างระดับ รวมถึง ระบบแสงสว่าง เป็นต้น โดยคำแนะนำการออกแบบห้องน้ำเพื่อป้องกันการล้มจากปัจจัยข้างต้นระบุในส่วนท้ายของบทความ ทั้งนี้ โดยหวังว่าการศึกษาเพื่อทำความเข้าใจถึงสาเหตุของการล้มในผู้สูงอายุ สามารถเพิ่มโอกาสทางการออกแบบสถาปัตยกรรมภายในให้มีความปลอดภัยมากยิ่งขึ้น ลดอุบัติเหตุจากการล้ม พัฒนาภาพรวมของสุขภาวะ และพัฒนาคุณภาพชีวิตในผู้สูงอายุ

คำสำคัญ
อันตรายจากสภาพแวดล้อม
การล้มในผู้สูงอายุ
การป้องกันการล้ม
สถาปัตยกรรมภายใน
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1. Introduction to situation of the Thai elderly

The term older adults can be defined as persons of age starting from 50 years (Organization, 2017). The most frequently used definition for an older person; nonetheless, is for people aged 60 years and over. The proportion of the senior Thai population aged 60 years and over was anticipated to increase from 8.7% in 2000 to 10.8% in 2010. The figure is predicted to develop to 15.2% and 30% in 2020 and 2050 respectively. The United Nations' latest estimate of the growth rate of such age group for Thai population is somewhat high with over 3% per year. It has been discussed that in around 19-23 years, the size of the population would double given the growth rate of 3 - 3.6% per year (Organization, 2015).

Thailand was the seventh most aged country among the eleven countries in South-East Asia in 1950. However, with older people filling out more than 10% of the population, the country now after Singapore has been the second most aged country in this region. This comparatively higher rate is a consequence of a decline in fertility and improvement in longevity. Thailand has encountered a situation of speedily expanding population of older adults with a sustained decline in mortality and fertility in the last three decades of the 20th century. In around year 2020, the inhabitants of this category will overtake the population of children which will happen for the first time in the country's record (Nations, 2002; Thailand, 1463).

Likewise, life expectancy at age 80 years is predicted to increase which means the oldest old person can live for more than 80 years. Then, the proportion of the oldest persons in the population is predicted to reach exponential growth provided the circumstance where there is a rise in scale of Thai people living up to age 80 years and on average living longer than that. Presently 590,000 people is the estimated number of the oldest old population which in 2025 will grow to 1.3 million and go beyond 3.5 million by 2050. This indicates that there will be a demand of prolonged duration of social security and welfare expense as well as increasing requirements for care of old people's ailment and incapability. The statistics suggest that Thailand has become an aging society already and will ultimately turn to a complete aged society in the next 20 years (Chuangchai & Suwanprasert, 2015; Nations, 2002; Thailand, 1463).

2. Characteristics of falls in elderly population

The review presents varied factors and circumstances suggested as possible characteristics of falls so that analytical insight of falls nature can be discussed. The review also has attempted to evaluate the evidence for each feature about falls such as terms, age, gender, lifestyle, physical health, and psychosocial impact in order to rule if they make significant aspects for interference and deliberation. Falls can be defined as "unintentionally coming to rest on the ground, floor or lower level which occurs from all causes that are unexpected" (Lord, Sherrington, Menz & Close, 2007). Statistics have indicated falls circumstance is different considerably from a Poisson distribution despite the fact that falls are often addressed as accidents (Lord et al., 2007). This signifies the link between causal procedures and falls; therefore, they are not simply occasional situations (Rubenstein, 2006, pp. ii37-ii41).

Age wise, after people reach 60 years of age, both falls occurrence and the seriousness of fall-related problems consistently increase. Figures suggest that approximately 35% to 40% of population aged 65 and older who are residents of community and healthy in general fall every year. The rates are higher after 75 years of age (American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention, 2001). Both physical efficiency and level of disclosure to environmental dangers are associated with an individual's risk of falling. Therefore, both

those living a sedentary lifestyle and those being physically active can be prone to falling in different circumstances (Freiberger & Menz, 2006a, pp. 261-267). More than one-third of older people in the falls prediction of a 1-year prospective study experienced at least one fall each year (Swanenburg, de Bruin, Uebelhart, & Mulder, 2010, pp. 317-321). This occurred with 30-60% of them where 10-20% required hospitalization (Rubenstein, 2006, pp. ii37-ii41).

The characteristics of falls seem to vary across genders and daily life activities. From research, it could be stated that women are more likely to fall inside their homes in the afternoon or the evening while men have a tendency towards falling outside their residence during leisure time activities (Berg, Alessio, Mills & Tong, 1997, pp. 261-268; Campbell et al., 1990, pp. 136-141). This may be explained by the concept that women are likely to spend a greater proportion of time indoors on household duties (Freiberger, & Menz, 2006b). Many previous reports also suggest to the same direction that females have tendency to be injured more which may link to the remark that it is challenging for them to get back up from the floor after falling (Kannus et al., 1999, pp. 1895-1899). Also, the risk of falls, as reported in a research, was higher amongst those older females who took four or more medicines and had poor body balance (Tripathy, Jagnoor, Patro, Dhillon & Kumar, 2015, pp. 1801-1805). A prospective cohort study of indoor fall injuries in community residence too found that elderly female adults who were concerned about falls and therefore attempted to restrain their activities ironically tended to suffer fall injuries (Hu, Xia, Jiang, Zhou & Li, 2015, pp. 259-264).

In contrast, typical falls occurring outside the house when older people undertake recreational activities scarcely result in severe injuries or hospital admission. It has been suggested the fractures rate that is under the average figure could come from sufficient bone density and postural control of older adults in the study. These factors could help prevent injuries when falls happen. Additionally, the study also found that physically active older adults who lived alone in the neighbourhood experienced a great falls rate (Freiberger & Menz, 2006a, pp. 261-267; Kannus et al., 1999, pp. 1895-1899).

It can be addressed that various causes can be accountable for falls. One of the potential risk factors is pain which appears to be continually overlooked. Mobility inadequacy, impaired gait, and balance deficits are all related to falls and are well-established internal risk factors. This can be assumed as common incident since up to 76% of the older population in the community experienced it. In particular, foot and chronic pain (hip and knee) are significant risk factors. The systematic review and meta-analysis suggested that people of older age who suffered from pain and also had fallen in the past 12 months were more likely to face a repeated fall in the future (Stubbs et al., 2014, pp. 175-187). Distinguishable risk factors such as weakness, unsteady gait, confusion and psychoactive medications are related to most falls (Lord et al., 2007). The challenge in daily life activities or in daily instrumental actions also could make the possibility twice as great (Bloch et al., 2010, pp. 895-903). In terms of consequences, falls are perceived to be one of the leading causes of unintentional injuries and mortality which affect the quality of life in older age.

Falls situations that can present a precise etiology or reduce the differential diagnosis include immediately getting up from a lying or sitting position (orthostatic hypotension), trip or slip (gait, balance, vision disturbance or environmental hazard), drop attack (vertebrobasilar insufficiency), looking up or looking sideways (arterial or carotid sinus compression) and loss of consciousness (syncope or seizure). A likely explanation of falls may come from symptoms that occur close to falling moment. They can be dizziness or giddiness (orthostatic hypotension, vestibular problem, hypoglycaemia, or arrhythmia and drug-side effect). From research, older people with multiple sclerosis particularly experienced high numbers of falls that would be followed by injuries.

Furthermore, medications and accompanying medical problems may also be key causes (Rubenstein, 2006). It seems that how the elderly cover their feet cannot be underemphasized when it comes to falls. The study showed that older people who fell inside the house tended to be shoeless or wear socks inside their homes (Menz, Morris & Lord, 2006, pp. 174-180). At the time of indoor falls, 51.9% of the 765 elderly participants in a prospective cohort study at MOBILIZE Boston were barefoot, wearing socks without shoes or wearing slippers. This leads to the advice for older persons to wear shoes inside their homes whenever possible in order to minimize the risk (Kelsey et al., 2010, pp. 123-129). Athletic and canvas shoes (sneakers) have been proposed to be the styles of footwear that could help bring a relatively low risk of falls in older adults' everyday activities (Koepsell et al., 2004, pp. 1495-1501).

Falls can further be linked to specific activities. Study from urban, rural and slums areas of Chandigarh, India in a cross sectional survey was carried out with 300 participants. Most falls (75%) were reported to take place when older people carried out their personal hygiene practices such as toileting, bathing, etc. In such situations, the figure of consequent injuries was reported by 67% where lower extremities (37%) were the most usual spot of injuries. In addition, 8% were reported as fractures. Other than specific bathroom routine, falls have also been said to be related to a range of activities occurring during general movement such as walking, turning and moving between positions (Tripathy et al., 2015, pp. 1801-1805). Over 3 months, 150 participants prospectively noted real and near fall situations on a daily journal. On self-report survey with regards to whether the fallers were in a hurried stage, most fall happened when older adults in the study perceived they either were not in a rush at all (45% of falls) or they were hurrying as usual (27.6% of falls). In response to the general "cause of falling", most falls where a specific cause was identified were linked to the loss of balance (19.4% of falls). Tripping, legs giving way, and being distracted contributed to approximately 10% each (Gunn, Creanor, Haas, Marsden, & Freeman, 2014, pp. 538-545).

A consciousness about avoiding the environment that may require balancing skill (Zhang & Qin, 2012) may tackle vertigo and poor postural stability (visual, proprioception, exteroception and vestibular). This is one of the major reasons of falls (Tuunainen, Rasku, Jantti & Pyykko, 2014, pp. 10-16). Multiple fallers were reported to position themselves with a narrower stance width than non-fallers (Bloch et al., 2010, pp. 895-903). Elderly people, in general, have difficulties in controlling sideways center of mass motion and have a higher risk of sideways fall during gait, which is caused by the larger center of mass – center of pressure inclination angles in the medial-lateral direction (Yu, Yin-Zhi, Fei & Dong-Yun, 2014).

Apart from physical conditions, falls can be by-product of psychological and social effects. Almost one-third of the actual falls of the elderly population from the study were associated with the feeling of "somewhat more" fatigue than usual at the time of their falls. Further, 13.3% of them experienced falls when fatigue was reported to be "much more" than usual (Gunn et al., 2014, pp. 538-545).

A case-control study from hospital admissions in Brisbane, Australia was conducted with 387 participants residing in the community. It is suggested that psychosocial factors can crucially have an independent protective effect on hip fracture risk. Such influential factors may refer to the status of being presently married, residing in current dwelling for 5 years or more, owning private medical insurance, being resilient to stress, as well as having a greater level of life fulfillment and itigation on in social activities. Thus, injury prevention for the elderly population in relation to falls can be addressed by implementing healthy aging strategies that involve community-based approaches to improve older persons' psychosocial settings (Peel, McClure & Hendrikz, 2007, pp. 145-151).

3. The relative importance of personal risk factors for falls (Intrinsic factors)

Sensory impairments in vision and hearing are usually found to happen with the elderly and frequently they are referred to as characteristics of the aging process. Some of these impairments are caused by intrinsic aging processes occurring in the sense organs and their neural and brain components. The peripheral receptor cells of the ear's cochlea and the eye's retina permanently established at birth with no turnover and regeneration in later life also play a part in contributing to the functional decrements in vision and hearing (Timiras, 2007).

3.1 Vision and hearing to body balance

Previous studies such as a prospective study of visual acuity, co-existing hearing impairment, and poor standing balance as predictors of falls (n = 428) with 1-year follow-up have shown that impaired vision could affect postural stability and increase the risk of falls in elderly people (Kulmala et al., 2009). Vision is key in maintaining balance by giving the nervous system constant new data about the location and flow of body segments in coordination with one another as well as with the environment (Lord & Ward, 1994, pp. 452-460). The study of visual function, peripheral sensation, strength, reaction time and sway with 156 paticipants found that moving visual fields could activate a strong sense of self-motion, and misguided visual cues could bring about considerable rises in sway (Lord & Menz, 2000, pp. 306-310). Independent predictors of growing sway in older people were the weak performances in tests of distant contrast sensitivity and stereopsis, a measure of depth perception (Lord, 2006, pp. ii42-ii45). This indicates that the correct perception of visual stimuli and depth is key to producing a visual reference frame for body stabilization in connection with its surroundings. Vision produces a vital provider of balance ; therefore, impaired vision is an important independent risk factor for falls and fractures. The major impairment associated with falls seems to be the reduced ability to detect low contrast hazards, to determine distances and to perceive spatial relationships. This is likely to be particularly important when older people walk up or down the stairway and when they are in the unfamiliar environment (Lord, 2006, pp. ii42-ii45; (Lord & Menz, 2000, pp. 306-310).

From the National Center for Health Statistics: Trends in Vision and Hearing among Older Americans, approximately one-fourth of adults aged 65 and older showed a symptom of deafness (Desai, Pratt, Lentzner, & Robinson, 1995; Levy, Slade & Gill, 2006, pp. 1348-1353) because of receptors change and extinction of hair cells in cochlear (Goble, Coxon, Wenderoth, Van Impe & Swinnen, 2009, pp. 271-278). Hearing and vestibular organs are anatomically closely localized. The eighth cranial nerve's function is to serve shared fluid-filled bony compartments and blood circulation and they have comparable mechanosensory receptor hair cells, which detect sound, head movements, and orientation in space. People make a remark on the surroundings or avoid hazardous environment potentially leading to falls by the help of hearing function which brings about acoustic information of the environment (Viljanen et al., 2009, pp. 63-67). Poor vision can increase the risk of falls especially when it is accompanied with absence of hearing or balance and this can get worse when impaired vision takes place together with lack of both hearing and balance ability (Kulmala et al., 2009, pp. 162-167).

3.2 Postural stability and gait to proprioception as sense of space

Postural stability can be described as the ability of an individual to control the body position, or more precisely its mass center, within certain bounds of space, referred to as stability limits. Stability limits are boundaries in which the body can preserve its position without adjusting the base of support (Lord et al., 2007). Normal elderly persons have a tendency towards declining skill to control postural balance in

standing in response to unpredicted disturbance and during voluntary stepping. Such fall in postural stability in older people can be addressed by the loss of muscle durability (Melzer, Benjuya, Kaplanski & Alexander, 2009, pp. 119-123), visual acuity (Lord, 2006), peripheral sensation, vestibular function and central processing of afferent inputs (Melzer, Benjuya & Kaplanski, 2004, pp. 602-607). A 1-year prospective study of force plate variables to forecast the risk of multiple falls in elderly population residing in the community with 277 paticipants has reported the impaired performance on a range of balance tests in fallers compared to non-fallers (Swanenburg et al., 2010, pp. 317-321). However, the ability of balance tests to predict falls is limited when used in isolation (Lord et al., 2007). A comparison of postural stability between fallers and non-fallers in the elderly study found that elderly population who experienced recurrent falls had increased sway in narrow base stance especially in the medial-lateral direction (Melzer et al., 2004, pp. 602-607). The increase of loss of stability and the declining foot sensation in older adults were also reported to be relevant to falls. When in standing posture, cutaneous mechanoreceptors at the soles of the feet provide postural balance. Thus, older adults with less feet sensation can have greater instability and a higher risk of falls since they might not correctly notice when the gravity center reaches them. Forefoot anesthesia is likely to be vital in maintaining postural balance mainly when closing eyes. Thus, plantar insensitivity may have an impact on postural control with sensory loss occurred regularly I older people (Melzer et al., 2009, pp. 119-123).

When standing upright, two-thirds of the body's mass is positioned two-thirds of the body height from the ground, seriously balancing on two narrow legs with only feet directly touching the ground. Objecting the basic mechanical engineering concepts, such position needs an advanced postural balance system for the body to stay vertical. Nonetheless, continuously starting a forward fall and then playing back this force by proper positioning of the leading limb is required in order for the body to move forwards (Wu, Wang, Xiao & Gu, 2014; Zhang, & Qin, 2012, pp. 6915-6918). Most falls occur when older people are at the stage of walking. Selection of foot placement appears to be important in controlling of trunk movements. A direct relationship is difficult to establish as both narrow and wide foot placements have been associated with instability and falls. The movement patterns of the head and pelvis provide a more direct indicator of body stability during gait. It has been suggested that older people who could face the high risk of falls exhibit erratic and arrhythmic movement patterns which may interfere with stable vision, thereby increasing the risk of obstacle contact. Older adults could be associated with suboptimal movement strategies when stepping over or avoiding obstacles, walking on steps and responding to trips and slips (Lord et al., 2007; Rubenstein, 2006, pp. ii37-ii41).

Proprioception is the sense of one's position in space which is vital for efficient contact with the surroundings. The loss of proprioceptive acuity has been directly correlated with falls and would result in lack of functional freedom in older people (Suetterlin & Sayer, 2014, pp. 313-318). Proprioception in older persons can be improved by training which would aid in reducing the likelihood of slip-induced falls (Sohn & Kim, 2015, pp. 693-703). It can also help in postural steadiness as well as static and dynamic stability that will provide advancement in gait and balance capacity to finally reduce fall threats (Martinez-Amat et al., 2013, pp. 2180-2188).

4. Environmental hazards in elderly people's homes (Extrinsic factors)

Built environment has direct link to daily life activities. Alteration related to age in later life can lead to the decline of older adults' general skills. The underlying assumption is that the less competent an individual, the greater the impact that the built environment has on him or her. By decreasing

surrounding barriers, the built environment can enhance an individual's overall capability to function (Hwang, Cummings, Sixsmith & Sixsmith, 2011, pp. 246-257).

Most homes were reported to house possible hazards and a number of older persons' falls were from tripping or slipping inside their places. The review of environmental risk factors at home for older people's exposure to falls indicated that only home hazards may not entirely lead to falls. Instead, the physical abilities of older adults and their contact with surrounded stressors can be even more key. It has been discussed that household environmental hazards may promote more dangers for the older people who have a fair balance, whereas those with weak ability to balance have less contact to the threats. Also, those with good movement ability are likely to have more skills to endure them (Lord, Menz & Sherrington, 2006, pp. ii55-ii59). A cross-sectional survey of 425 paticipants in Australia found, the elderly who were never visited by the service providers at least twice had a tendency towards having more than five hazards at home compared to those visited weekly or more often (Carter, Campbell, Sanson-Fisher, Redman & Gillespie, 1997, pp. 195-202). Additionally, it was found that older persons without a record of preceding falls had a 4-fold risk of falls in connection with the presence of six or seven home hazards compared to those without the home risks (Van Bemmel, Vandenbroucke, Westendorp & Gussekloo, 2005, pp. 63-67). However, the older adults in the research with the history of preceding falls surprisingly had no increased risk of falls even though they had increasing numbers of home hazards and also had a greater risk to fall.

Many fall accidents come from the interaction between distinguishable surrounding danger and increased individual sensitivity to hazards from accumulated impacts of age and disease (Rubenstein, 2006, pp. ii37-ii41). From the study of environmental hazards with 570 intervention paticipants lived in 452 homes, all homes had at least one fall-related hazard (Stevens, Holman & Bennett, 2001, pp. 1442-1447). The bathroom was identified as the most unsafe room in older people's home. Two or more hazards found in the bathroom frequently were related to floor surfaces, poor lighting, an absence of appropriate grab bars or handrails, steps, objects on the pathway, poor design of furniture, bad placement of furniture as well as the toilet design. Falls have been reported to occur mostly in bathrooms (Feldman & Chaudhury, 2008, pp. 82-95; Gill, Williams, Robison & Tinetti, 1999, pp. 553-556). Also, for those who had experienced falls in the study, the most dangerous area for them was a bathroom (LÖK & Akin, 2013, pp. 120-128).

The study of population-based prevalence rates of potential environmental hazards of 1,000 paticipants in New Haven, Connecticut suggested that prevalence of most hazards from built environment was high. Two or more hazards were found 59% in the bathroom and 23% to 42% in other rooms such as living room, kitchen, bedroom and hallways (Gill et al., 1999, pp. 553-556). Environmental problems frequently found at the residence of older persons include lack of grab bars in the tub or shower and lack of protection against bathroom slipping (Lan, Wu, Chang & Chen, 2009, pp. 335-338). Built environment that is not suitable such as a built-in seat or chair in the bathroom that is too high in height can be seen as a crucial environmental hazard in residential place. Some evidence indicated that the type of surface on which older people fall could affect the likelihood of suffering an injury (Lord et al., 2007). Therefore, the older people's homes are potentially dangerous since falls occurring inside the house could result from an interaction between stimulators of the surroundings and physical skills as well as risk-taking circumstance (Carter et al., 1997, pp. 195-202; Lord et al., 2006, pp. ii42-ii45). The interaction between physical function, the perception of risk and exposure to risk remains an area requiring further evaluation (Lord et al., 2007).

Although the participants have no record of preceding falls, they have an increased risk of falling because of home hazards (Van Bemmel et al., 2005, pp. 63-67). The development of the strategy to make home environment safer for the elderly is important not only for removing possibility of disability but also for preventing fall-related accidents (Lan et al., 2009, pp. 335-338). In residence of older people, fall hazards are everywhere. The intervention can result in a small reduction in the mean number of hazards per house. Many study subjects have taken such action but they involved only removing a few hazard potentials. The impact of the intervention in achieving self-report action to reduce hazards was high (Stevens et al., 2001, pp. 1442-1447).

Home hazards as the built environmental factor have been recognized as a contributing factor to falls in older adults. Adjusting the home environment to prevent or reduce the number of falls is likely to be reasonable for everyone using the safer environment. A key factor for healthy aging is the built environment. Person-environment fit can have a considerable effect on quality of life, attachment to place, and sense of well-being and belonging (Friesen, Brémault-Phillips, Rudrum & Rogers, 2016, pp. 18-34). The results from the study of the relationship between home modifications and aging-in-place, using the ENABLE-AGE United Kingdom sample (376 participants) demonstrated that those who had home modifications carried out tended to live longer at their existing residence than those who did not and also proved that home modifications had positive impact on older people's living quality (Hwang et al., 2011, pp. 259-264). The study of role of the environment to avoid fall both at home and in the community indicated that multifactorial interventions, including risk assessments, physical activity, and environmental modifications can help reduce fall incidents (Pynoos, Sabata & Choi, 2005, pp. 41-54).

Housing can be perceived as the core of personal autonomy and social participation, especially for elders. The physical environment is an important determinant that might require long-term care services. It has been studied that home modifications could strengthen the personal and social meaning of home for the senior citizens and could help lessen their dependence on others in performing daily activities (Hwang et al., 2011, pp. 246-257).

5. Preventing falls in older adults with ergonomics

Ergonomics is an applied science focusing on the study of human-centered design. It is identified as the architecture of engineering design to decrease fatigue and discomfort through the use of interior and product design with innovation and safey factor (Openshaw & Taylor, 2007). Designing by using human factors and ergonomics systems approach will mitigate risks of falls and offer an innovative solution for an embedded improvement (Hignett & Wolf, 2016, pp. A1-3). Thus, ergonomics design can be seen as a precautionary design rather than simply a corrective one. Additionally, it is believed the premise that is built with ergonomics approach can offer protected, non-polluted, and sanitary residence (Ahasan, Campbell, Salmoni & Lewko, 2001, pp. 175-185). With regard to interior design interference, the article suggests strategies for preventing falls with bathroom design interventions including the guildline for bathroom layout design, built-in and loose furniture design, flooring and stepping design, lighting design as well as design consideration.

5.1 Ergonomics to interior design

Ergonomics is in association with design of sustainable settings when proper housing is developed. The design that is user-oriented can enable ergonomics to assist older people who encounter challenges on certain situations. The results of research usually done with end-users as sample group are shared with engineers and designers. It is believed that with more focus on applying ergonomics with house design, older people then can have sufficient power and support in this issue (Ahasan et al., 2001,

pp. 175-185). Considering the dynamics of elders' everyday life, there is evidence to support a progressive reduction of the spatial range of activities, especially for people at very old age. For instance, a significant bending posture may correspond to posture pain when reaching up, or bending down to retrieve objects that may lead to lack of balance and injuries caused by falls (Tinetti, Speechley & Ginter, 1988, pp. 1701-1707). People in this age group tend to spend time at home with interior environments more than younger people do. Thus, interior space is a key living space for older people, both in the fashion of time spent at home and settings for routines and activities. The interior space of home may become a place of safety and security. Indeed, a person's residence may become sacred, a locale in which he or she feels protected and shielded from an intimidating world outside (Bouwhuis, 2003, pp. 232-246; Rowles, Oswald & Hunter, 2003, pp. 167-194). The concept of ergonomics in interior design has been used to minimize barriers and increase supportive features to facilitate participation in activities of daily living and leisure. Among many other possibilities, ergonomics awareness in interior design can potentially reduce the number of falls at home (Pynoos, Steinman, Do Nguyen & Bressette, 2012, pp. 137-155).

5.2 Bathroom design

Benefits should occur to older people once the designers and the authority in charge of retired people's housing can include user comments as well as the available suggestions from scholars into their thoughts. This is to give more accessible spaces at the design stage when building new things and to modify or apply the ideas when dealing with existing buildings. Space can cause a number of architectural obstacles and therefore some older people's activities in the bathroom can alter since their hygiene practices are challenged by space. For such reason, specific reflection in this matter shall be applied with design approach so that the older people can carried out their daily routines. To go beyond simple operation and discover potential techniques of making the integration to help older people become more likeable practice would be an interesting goal to achieve (Morales, Rousseau & Passini, 2012, pp. 1-21).

The ground floor should have a bathroom which should also be on the same floor as the bedroom. It is usual that in the bathroom fall will take place since it is frequently used for grooming and sanitary purpose. Slipperiness in a bathtub can be tackled by using a rubber mat with suction cups, friction tape, or nonslip decals. Also, both older people and design professionals sometimes fail to spot the possibility of sink-related injuries since people often hit the sink while falling or slipping. The shower or tub should contain non-slip strips and the floor should not become slippery either inside or outside when being wet. A raised edge before the shower is generally not safe. Scatter rugs is not recommended but if it is really needed, a nonskid backing type should be used. A shower seat or bath bench can be used as well as a shower hose so that older people can take a bath in sitting position. Elevating the toilet seat can also simplify sitting. Bath oils should be used with caution and should be applied not in the tub to avoid slick surface. Soap, shampoo, and towels should be easily grabbed. Installed in a bathroom's first-in-a-series electrical outlet or at the circuit breaker, a ground fault interrupter can immediately stop power if a plugged-in electrical device such as hair dryer held by an elderly person who falls has contact with water. For the entrance, adequate maneuver spaces while opening and closing the exterior doors is needed. Outdoors should also have sufficient clearance between vehicles to allow a mobility assisted older person to swing around his or her vehicle's door. The unlocking function should also be installed from both inside and outside the bathroom door to ensure assistance can come quickly (Hazen & McCree, 2001, pp. 27-52; Rogers, Rogers, Takeshima & Islam, 2004, pp. 29-39).

5.3 Bathroom built-in and loose furniture design

Grab bars are recommended in bathtubs, showers, and at toilets since they are useful for people of all ages especially older persons. When older people move across barriers or up and down in the bathroom, they can hold onto the bars. The bar is helpful for position changing and for balance while lowering the body to sit as well as for steadiness of a person with shaky footing. Grab bars can be attached to the side of the tub, through the tile, or to structural supports in the wall. Some may recommend brass, wooden, or nylon bars or bars coordinating with other fixtures in the bathroom because some people link conventional stainless steel bars with institutions. Floor mounted grab bars is not recommended as tripping may happen. Instead, a fold down bar is helpful if the toilet and bidet are adjacent to each other. It should be noted that a towel rack should not be used instead of a grab bar because it cannot support a person's weight sufficiently. Using grab bars alone then can reduce confusion about support capabilities (Gilmore Andes & Beamish, 2008, pp. 139-169; Hazen & McCree, 2001, pp. 27-52).

Vertical supports are for sitting down and standing up from the toilet while the side supports are equally appreciated during toilet use. These supports are suggested to be attached since they are great importance for the physical condition of elders (Dekker, Buzink, Molenbroek & de Bruin, 2007, pp. 109-118). Recommendation for vertical bars, however, could be a controversy. Some researchers propose vertical bars while some prefer angled bars. Vertical bars are not suggested by other scholars since the hand can slip through the bar length itig horizontal bars are seen as simple and useful so they become a itigation. A non-slip or flat finish bar should be considered to achieve certain catch and to avoid reflected glare off the surface. Also, it is crucial to ensure about a comfortable handrail surface texture to be not too smooth or too rough (Afifi, Parke & Al-Hussein, 2014a, pp. 107-132, 2014b, pp. 117-125). For an older person, grab bars of which color is coordinated with the bathroom fittings may be more itigation satisfactory (Hazen & McCree, 2001, pp. 27-52).

Older adults were reported in a study to miscalculate the possibility of toilet-related injuries. This type of injury mostly takes place when a person falls off the toilet or he or she loses steadiness on standing position. Then, falling against the toilet will follow. Stability of furniture can facilitate older people's steadiness of body. A properly proportioned chair can assist in maintaining the hip, knee, ankle joints and the natural lordosis of the spine. The sturdy material is recommended for elevated toilet seat which stays in shape and is attached firmly to the toilet base. A toilet back support and seat belt can be helpful if balance control for sitting position is a challenge. Light-activated and weight-activated flush controls can also help in removing uncomfortable reach to wash after finishing (Hazen & McCree, 2001, pp. 27-52).

Mobility in the bathroom may be made easier by further consumer products and strategy. Using a wet room in stead of a bathtub can tackle balancing issue over a bathtub edge. An extended shower bench which is applied for sliding over the bathtub rim as well as a hand-held shower which can assist with showering on the bench are recommended. Shower doors might not be of sufficient support with an over-the-bathtub-rim bench, so a shower curtain is suggested. A hydraulic bath lift using water pressure to raise and lower a seated person in the bathtub can also be of assistance. For an older person operating an assistive mobility device such as a wheelchair, walker, crutches, or cane, clearance radius should be particularly taken into account (Hazen & McCree, 2001, pp. 27-52).

5.4 Bathroom flooring and stepping design

It is extremely important to make the floor safe. Once interation between the foot and the floor decreases, loss of footing may occur. Lack of traction

can happen when the floor is wet or slick. These two conditions usually lead to a fall. The bathrooms should then have skid-resistant flooring that when wet would not become slippery. Waxes and polished floors can be very slippery so they are not recommended. Clutter is a potential risk for tripping so it should not be found at any floors. Also, walking paths should be free from all telephone and electrical cords. It is not sufficient to be aware of having non-slip floors only. Well fitting shoes or slippers with non-slip soles should also be used while socks, loose-fitting slippers, leather or other slippery soles, and high heels are not recommended (Rogers et al., 2004, pp. 29-39).

Steps provide a place to travel from level to level and it can be tricky for older adults to make an accurate judgment during their movement. Poor lighting often has an impact on miscalculating the dimensions of the steps. Also, a person's foot can get caught on or coverings that are in poor condition. Although steps are clearly visible, as light shadow casts upon them, this will affect depth perception and make it less likely for a person to judge their step move correctly (Hazen & McCree, 2001, pp. 27-52).

To help support an older person as he or she shifts his or her weight over, handrails on each side need to fit one's grasp, allowing clearance for knuckles but not an arm, as well as maintaining a comfortable arm height. Also, steps should have securely fastened and easy to grip railings on each side. The surface can be painted with porch paint to which sand has been added to increase friction. Steps should be big and in good shape with non-slip surfaces and with the edge are being obviously marked both inside and outside the house. Edges of treads must be clearly visible. Paint or non-skid treads to highlight edges is recommended. Steps painted with alternating colors can better distinguish between steps and steps can be enlarged so that there will be more stepping space. All walkways and steps should be visible with light and free from any objects (Hazen & McCree, 2001, pp. 27-52; Rogers et al., 2004, pp. 29-39).

5.5 Bathroom lighting design

Lighting is crucial when assessing a home for fall-related possibilities. Bathroom should contain the overall good condition of lighting which was defined as sufficient quantity of light, appropriate direction of the light, good color and contrast, and does not cause glare (America, 2007). The lighting must be adequate with the minimum light levels recommended by IESNA (Illuminating Engineering Society of North America) standards so that water or other potential hazards can be easily noticed. The overall inside areas of the house should be clearly visible with lights that are glare-free. At least 100-watt bulbs are recommended (note that some light fixtures take a maximum of 60 watts). To minimize glare, avoiding glossy floor finishes as well as using an indirect source of lighting are helpful. Glare also can be reflected from other surfaces, such as glossy paint, a shiny laminated table top, or water from a pond. All light switches should be within a simple reach and located near each doorway. Thus, lights can work before one gets in the room. Additionally, motion-, voice-, or sound-sensing light switches can be applied so as one goes into the room, lights can function (Hazen & McCree, 2001, pp. 27-52; Rogers et al., 2004, pp. 29-39). Dim light may be used with particular consideration. Assessors from a study of lighting levels in the dwellings of 40 homebound older adults over an 11-month period between June 2000 and April 2001 in Manhattan found that dim lights affected negatively with recognition of objects on the floor. For instance, the assessors tripped several times on shoes, stacked magazines, carpet edges, and pet toys. Additionally, dim lighting can lead to older adults experiencing increased postural sway. As older eyes adjust slowly to different light levels, lighting experts suggest uniform lighting between adjacent rooms (Bakker, lofel & Lachs, 2004, pp. 17-27).

Nightlights and/or movement-activated lights to illuminate passageways should be installed. However, over half of the 40 participants (58%) in a pilot study measured light levels in the apartments

in New York City did not use a nightlight or switch on a light during the night. Several old buildings did not provide accessible outlets in bathrooms while many wished to use nightlights. The obstacles to nightlight usage should be further investigated for safety goals (Bakker et al., 2004, pp. 17-27). It should be advised again that lighting must be adequate. The pathway that is obstacle free should have lighting function to and from the bathroom and if a person frequently needs the bathroom, this part of the house should be focused specifically (Rogers et al., 2004, pp. 29-39). A night light, lighted toggle switch, chemically-luminous doorknob cover, or motion-sensitive light can promote more visual ability when one goes to bathroom at night (Pastalan & Schwarz, 2013).

Good vision is key for encouraging healthy aging in house settings. From the study of indoor lighting in relation to activities of daily living with 114 healthy Norwegians, despite indoor lighting is very low, the 75-year-old participants living at home were satisfied, happy, and healthy. However, they relatively did not realize how light levels can have an impact on their vision and their future capabiblity of their daily and instrumental activities in life. Both older people and their healthcare providers in the primary healthcare settings need to learn on utilization of indoor lighting to promote healthy aging at house environment (Eilertsen, Horgen, Kvikstad & Falkenberg, 2016, pp. 199-213).

5.6 Design considerations

In the arena of interior, the interests of relationship between physiologists and designers can overlap by the biomechanism of the human body and functioning. Recent research suggested that a standard room design similar to that commonly found in a local area might be less stressful than a designed room with added structure (e.g., beams, columns). This was indicated in a study by blood pressure and pulse rate, both of which measured arousal. Appling new design approach into traditional living spaces may create more tension to older people than to participants in college years. Taking traditional thoughts into account when designing may help in promoting the well-being and reducing stress for older adults. The article review in the design of environments for the elderly proposed that most older persons wished for homelike residence which is non-institutional style. Families can play a part in their senior members' lives by using mixed-use housing that provides residential accommodations for families at all ages, from new ones with young children through families with teenagers and the elderly, along with residences with nursing home. The built environment exerts emotional, psychological, and physiological effects on its residents and visitors. Thus, aparting from having a healing impact and supporting life satisfaction, good design can also promote the functional capabilities and physical activities for people who live in an institutional setting because of their sickness, weakness, or handicap (Crews, 2005, pp. 103-109).

6. Discussion

Defining and moderating environmental threats can be useful to prevent fall. For those with records of fall or with fall risk factors, assessing settings at home by a healthcare expert with follow-up for any required alterations can be interference action that would work. Intervention programs can cover actions such as assessments at home for potential risks by professionals, alterations or itigation of hazards detected, application of safety tools including bathroom grab bars and lighting fix ("Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons," 2011, pp. 148-157).

It is speculated that budget spent for house safety for older people may be more cost – saving than treating those older people who fall. A study suggests that for those aged 75 and older, the medical

expense reduction is likely to go far beyond a dollar-for-dollar return. House alterations may decrease chance of falls for longer than two years. Investing in home modification brings cost-saving benefit in medial perspective. This does not even cover other expenses including the psychic costs of falls to the elderly and loved ones, the market value of formal and informal post-acute care given to those who fall as well as any dynamic cost savings. Nonetheless, underlying issue is that safety and accessibility may be privately undersupported if the medical cost savings increase to public programs like Medicare and Medicaid, and do not flow through to reductions in out-of-pocket medical costs for the elderly. It is recommended that the future study could focus on analyzing cost–benefit and the long term effects (Eriksen, Greenhalgh-Stanley & Engelhardt, 2015, pp. 14-24).

7. Conclusions and future directions

Fall problems happen commonly which can bring severe health issues as well as social and psychological impacts for older people. All parties including older adults, their families, and the healthcare professionals are most worried about possible injuries from falls. Therefore, one of the key public health objectives is to minimize fall risks in older adults. Also, preventing fall is important because it can help sustain wellness of older people and prolonging their ability to live with less dependence on others at their own residences. Strategies to prevent fall once implemented effectively, rates of injuries from falls, emergency cases, hospital admissions as well as nursing home occupancy will be decreased for those senior persons in the community. To lessen fall chance is to ensure that possible threats, house modifications and helping tools are enforced as they are all important contributors to prevent falls. Time should be invested for evaluating home settings as well as making needed alterations in order to significantly minimize threats for older adults. Additionally, to incorporate ergonomics especially in the bathroom design to prevent or reduce fall risks, there should be collaboration of many parties including safety experts, design professionals, engineers as well as healthcare or homecare persons. Ultimately, this can promote sustainable quality of life in terms of safety and well-being of older people who wish to live independently in their own homes (Rogers et al., 2004, pp. 29-39).

Finally, future studies could look deeper on reviewing the epidemiological evidence about cognition in connection with falls. Cognitive damage could be representative for vaious possible factors related to falls. This includes behavioral problems, less in-depth knowledge about impacts of taking risky activity, lack of mobility as well as challenge in performing actions that need divided attention (e.g., executive function). Further study in this area about older persons who have cognitive impairment which may link directly or indirectly with falls can additionally determine the underlying contributing factors and momentum that may be helpful to make fall prevention interference (Muir, Gopaul & Montero Odasso, 2012, pp. 299-308).

8. Conflicts of interest

None to declare.

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