Thai Journal of Ergonomics: Volume 3 Issue 1 January – June 2020: p. 45-53
วารสารการยศาสตร์ไทย: ปีที่ 3 ฉบับที่ 1 มกราคม – มิถุนายน 2563: หน้า 45-53

บทความปริทัศน์
(Review article)

เทคโนโลยีในผู้สูงอายุที่เกี่ยวข้องกับการหกล้มเพื่อป้องกันการพลัดตกหกล้มในกลุ่มผู้สูงอายุที่ชราในถิ่นที่อยู่อาศัย

Fall-related gerontechnology preventing falls among the elderly for ageing-in-place

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Received: May 26, 2020/ Revised: June 8, 2020/ Accepted: June 25, 2020

บทคัดย่อ: *การชราภาพของประชากรกำลังกลายเป็นสังคมใหญ่ที่สำคัญในหลายๆ ประเทศของโลก การพัฒนาเทคโนโลยีต่าง ๆ จึงนำไปสู่ความสนใจทางด้านความปลอดภัยในสังคมผู้สูงอายุ เนื่องจากอายุที่มากขึ้นทำให้เกิดการเปลี่ยนแปลงทางร่างกายและทางจิตใจ ดังนั้นกิจกรรมพื้นฐานในชีวิตประจำวันจึงอาจก่อให้เกิดอุบัติเหตุของการพลัดตกหกล้มในผู้สูงอายุที่ตัดสินใจใช้ชีวิตในบ้านและไม่ไปอยู่บ้านพักคนชรา การออกแบบทางด้านการยศาสตร์และเทคโนโลยีในผู้สูงอายุเพื่อสร้างโอกาสของการอาศัยอยู่ในบ้านสำหรับวัยชรา จึงสามารถลดความเสี่ยงและอุบัติเหตุในผู้สูงอายุได้ การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาและค้นหาเทคโนโลยีที่มีความเกี่ยวข้องด้านการป้องกันการพลัดตกหกล้ม เพื่อการดำรงชีวิตอย่างอิสระภายในบ้านและเพิ่มความปลอดภัยในผู้สูงอายุ รวมทั้งศึกษาและพิจารณาข้อดีและข้อเสียของเทคโนโลยีที่เกี่ยวข้องกับการพลัดตกหกล้มนี้ได้แก่ การป้องกันการพลัดตกหกล้ม การตรวจจับการพลัดตกหกล้ม และการเฝ้าดูเพื่อป้องกันการพลัดตกหกล้ม อย่างไรก็ตามถึงแม้ว่าเทคโนโลยีในผู้สูงอายุจะแสดงให้เห็นว่าเทคโนโลยีและบริการนั้นสามารถช่วยเหลือผู้สูงอายุได้อย่างมีประสิทธิภาพ แต่ยังมีข้อจำกัดบางประการในแง่ของการยอมรับของผู้ใช้และการใช้งานเทคโนโลยี รวมถึงความชอบส่วนบุคคล นอกจากนี้ในด้านเครื่องตรวจจับการพลัดตกหกล้ม ถึงแม้ว่าเครื่องตรวจจับพื้น เครื่องตรวจจับการสั่นสะเทือน และเครื่องตรวจจับการเคลื่อนไหวจะให้ความเป็นส่วนตัวกับผู้สูงอายุ แต่ปัจจัยอื่น ๆ เช่น ความซับซ้อนในการเก็บรวบรวมชุดข้อมูล ลักษณะที่แตกต่างกันของการพลัดตกหรือหกล้ม และจำนวนชุดข้อมูลที่อาจจะไม่เพียงพอ ควรมีการศึกษาวิจัยเพิ่มเติมเกี่ยวกับสิ่งเหล่านี้ รวมทั้งควรสำรวจความพึงพอใจของผู้ใช้ และสำรวจการใช้เทคโนโลยีช่วยเหลืออื่น ๆ เพื่อช่วยเหลือและบรรเทาภาระความรับผิดชอบของแพทย์ในโรงพยาบาลหรือสถานพยาบาล*

ABSTRACT: *Population ageing is becoming a major social in many parts of the world, recent developments in the field of an ageing society thus have led to a renewed interest in safety among the elderly people. Since ageing affects both the physical changes and the psychological changes, the daily basic activities may be concerned regarding fall accident in the elderly who decide to live in their home when they get old called ageing-in-place. The technology of specific design through ergonomics along with gerontechnology which technology and service support the older adults therefore can reduce the risk and accident in the older people. The purpose of this review was to examine the identification of the technology and service that the gerontechnology has developed in independent living for the elderly concerning fall accident. The benefit and drawback of fall-related gerontechnologies which are fall prevention, fall detection and fall monitoring were also represented in this review. However, although the gerontechnology has successfully demonstrated that the technology and service can assist older adult, it has certain limitations in terms of the user acceptance and usability of technology including individual preferences. Regarding fall detectors, although floor detector, vibration detector and motion detector provide the privacy condition as the main concern to elderly, the other factors such as the complication in collecting the fall datasets, the various ways of fall and the number of datasets should be still considered. Additional research should be conducted on these and a survey of user's satisfaction including exploring the use of other types of assistive technology in helping and easing the responsibilities for a medical field at the hospitals or nursing care.*

คำสำคัญ: *เทคโนโลยีในผู้สูงอายุ, การยศาสตร์, ผู้สูงอายุ, ชราในถิ่นที่อยู่อาศัย*
Keywords: *Gerontechnology, Ergonomic, Elderly, Ageing-in-place.*

1. INTRODUCTION

At the present time, the developing country has been moving closer towards an ageing society. As WHO's report [1], the rapid development of demographic trend from younger to older population age structure can assume the encounter regarding health care costs. Ageing affects not only the physical changes which influence the decrease of visual perception, sensory perception, strength, movement control, information processing, and memory but also the psychological changes which are emotional factors namely stress, anxiety, depression, social isolation, and poor relationship leading to the risk of hypertension, stroke cardiovascular disease and others [2, 3] As a consequence of the ageing process, the daily basic activities such as bathing, dressing, cooking and walking may be concerned regarding safety and accident among the elderly who decide to live in their home when they get old.

Although the continuing care retirement communities (CCRCs) provide the housing, health care and other facilities for the older adults, most elderly choose to stay in their home even if that means living alone [4]. Previous studies have reported that the older people prefer to live in their home called age-in-place [5, 6] which is defined as the desire of a person to "remaining living in the community with some level of independence rather than in residential care" [7] because they have a sense of attachment or connection to their home, their environment and their community [8]. Therefore, a primary concern of age in place is safety condition because of the age-related decrease in physical activity and functional fitness among the elderly causing the risk of injury and accident, particularly fall accident. A number of studies have found that the elderly fall once a year in the living room, bedroom and hallway on a flat floor [9-11]. The effect after the fall event may cause a fall fatality among the older people.

Home therefore needs to be designed through ergonomics which is the perspective of interactions between human and others elements in the environment to improve human well-being and performance, along with gerontechnology which technology and service support the older adults to reduce the impairment causing the quality of life. In recent years, there has been an increasing interest in gerontechnology which design of technology, product, service and environments by connecting gerontology, ergonomics and technology for independent living and social participation of the elderly who desire of ageing-in-place in order to enhance the quality of life, good health, comfort and safety [12]. It is to be explored the need for a deeper knowledge of the older population regarding the living situations and possible inconveniences in their daily life at home.

So, the first section of this paper will begin with the situation regarding fall accident in older adult including the consequences and risk factors which are internal and external factors causing the injuries. This review also examines the modification and adaptation of the home environment not only to improve the health and wellbeing outcomes but also to reduce the risk of accident, especially fall risk in older people. However, a major problem with this kind of general modification is individual preferences because the design for some people may be difficult for

another. Therefore, the investigation of gerontechnology will be studied and identified for individual elderly in order to apply reasonably. This review also focuses on the technology which is fall prevention, fall detection and fall monitoring to review the application, usefulness, and condition of the specific design concerning fall accident. Finally, the conclusion gives a brief summary and critique of the findings.

2. FALL ACCIDENT IN THE ELDERLY POPULATION

Since the ageing population is becoming a major concern in many parts of the world, recent developments in the field of an ageing society have led to a renewed interest in safety among the elderly. Fall accident is showed as the most common mechanism of injury in the elderly population. The statistics showed that one third of people who age over 65 and half of people who age over 80 years fall at least once a year in their home [9, 10, 13]. The effects after fall in old people are different in person, from a slight consequence which is a physical injury to a serious consequence which is accidental death. Although more than 52% of older adult who experienced fall accident contribute to hip fracture, the report stated that half of the elderly people who had a hip fracture die from fall in six months [14].

Also, many researchers presented that elderly men were reported the higher rate of fall fatality although elderly women tended to fall more often than elderly men. Buzink, et al. [15] claimed that risk factors causing fall in the elderly were internal factors which are sex, personal characteristic, behavior and physical fitness and external factor which is the environmental factor. Similarly, the others found that the causes of fall accidents which are falls, slips and trips were brought about by the risk behavior and unsafe conditions from the daily activity [16]. Regarding internal factors, Pereira [14] explained that the internal factors related to both the physical health due to the changes of anthropometry such as the loss of height, visual function, bone and muscle weakness and the mental health disorders such as anxiety, depression and cognitive impairment.

The research also found that the decrease of physical fitness, difficulty of movement, previous falls, Parkinson illness, arthritis and the use of some drugs can result in a fall accident. By contrast, external factors were stairs, floor covering, furniture style, bathroom design, and lighting characteristics including other factors such as shoes, slippers and flip-flops which influence the falling event were also included as external factors [16]. Previous study has shown that most accidents of fall occurred in the bedroom and bathroom because they not only feel comfortable and familiar with their environment but also spend the majority of their time in there [4]. Along with this growth in older adults, however, there is increasing concern about accidental falls at home. This section has analysed the causes of fall accident and has indicated that internal and external factors are the influences causing the risk. The chapter that follows moves on to consider the possible home adaptation and modification through the improvement of environmental

factors including gerontechnology application to promote the quality of life for elderly people who decide to live as the ageing-in-place.

3. A DESIGN FOR ELDERLY PEOPLE DECREASING THE FALLS

Firstly, the environmental factor which is the lighting influences the older people who have a decrease in visual acuity, dark adaptation and perception. The study of Pinto [17] suggested that poor conditions can design by installing more lights and arranging the appropriate position. Secondly, the furniture design that looks a slippery surface, slope and uneven floors can result in the risk of an accident. These can develop by rebuilding the structural design. However, the findings of the current study do not support the previous research because some design that suits one person may be unsuitable for another. As a result, gerontechnology is the technology and service which design in individualize solutions for providing each elderly person to improve the ease of use, safety and security in order to live independently and to promote ageing-in-place.

With regard to fall detection and fall prevention concerns, the severity of the injury depends on the response time and the rescue time. The statement was confirmed by Rahman [18] who presented that both the response and rescue time were the factor to mitigate the medical outcome of falls in the elderly. It is therefore important to not only consider the measures how to minimise the chance of elderly falls but also apply the assistance technology to detect or monitor the fall accident to help the patient as fast as possible. In recent years, a number of researchers have innovated fall-related gerontechnology to prevent falls, detect falls and monitor falls among the elderly to ensure that older people can live independently and promotes safety in their home [4]. So, the next part of this paper will demonstrate each type of fall-related gerontechnologies to determine a comparison across numerous experimental studies

3.1 Fall preventing gerontechnology

Fall-related gerontechnology was developed to prevent fall event by implementing the training application such as videogames to build elderly strength and improve balance [19]. This finding corroborates the ideas of Doyle, et al. [20] and Williams, et al. [21] findings which showed that twice a week playing a game can promote their body balance leading to decreasing the fall accident in the elderly. Also, the touch-screen application which is the exercise video for improving fall management can help to build the muscle strength and body balance among the elderly [4]. In addition, a wireless sensor which is wearable fall prevention sensor is used commonly to detect the fall in elderly patients with chronic diseases and stroke diseases [18]. This sensor which has a small size and light-weighted is mounted on the thigh or foot and the alarm is activated when a leg changes the angle to smaller than 45 degrees from the horizontal. However, no previous study has investigated this type of sensor in a home for the elderly as it is only used in hospitals and nursing care [22, 23]. On the other hand, Pereira [4] reviewed the literature from the period and demonstrated that non-wearable fall prevention sensor which is installed around the bed and

chairs is applied in older people who live in their home. It will detect the motion when the older people move out of the bed or get up from the chairs. In the middle of the night, an infrared sensor which is used to detect the elderly's movement will switch on automatically the light avoiding any accident from the darkness.

3.2 Fall detecting gerontechnology

This type of fall detection technology such as floor sensor has been designed to detect the fall after the fall accident in order to decrease the rescue time. As was mentioned in the previous section, the long waiting time after fall, the severe consequence of injury. There are two types of fall detector. On the one hand, wearable sensors which perform to prevent the fall event carry out through the attaching on the body and request for help from detecting the fall like a fall prevention technology [4]. There are some arguments in the attaching location of sensors. Some researchers examined that sensors should mount on only the upper body [24, 25] while the others represented that the most common location was the upper body along with lower body [26, 27].

The sensor location has been examined by many researchers. For example, Kangas, et al. [25] carried out the research to investigate the best location by setting the sensors on the head, waist, and wrist and found the head and waist as the appropriate location. This finding is in agreement with Gjoreski, et al. [26] findings which showed the waist as the best location when compared to the ankle and thigh of body. In contrast, the study of Bagnasco, et al. [24] argued the previous research by setting sensors on the waist, chest, and wrist and found the chest as the best location. However, although the findings were a different result from the experiments [24, 25, 26] over half of those concluded that the best location was the core body which is the chest or waist when compared to the peripheral body because it is near the center of mass of human body.

In term of non-wearable sensors, several studies have found that there are different characteristics of non-wearable sensors which are floor detector, vibration sensors and motion sensors [19, 28]. The floor detector is placed on the floor, under the carpet or tiles to recognize human presences, walking movement, walking speed including the lying of human on the floor. If detecting the fall accident, it will call for help. This detector also performs the tuning on the light to provide the safety surrounding for the elderly when the feet hit the floor during the night. According to Litvak [28], the vibration sensor is placed in the smart restroom to detect the fall event as well. However, although this sensor can recognize the vibration of the fall between object and human which the accuracy and specificity of 95%, fall detectors need to be accurate and reliable to ensure that the system quality can perform and analyze the fall accident effectively.

In addition, the classification of the fall pattern is difficult to detect because of the individual characteristics and different ways of fall. So, to perform effectively of the sensor system, the collecting datasets from the subjects should have an adequate amount to evaluate the different event of falls. In term of a motion sensor, the research of Rahman [18] examined a passive infrared

sensor which is applied to detect the human motion. This sensor is located in various places such as the wall, the mirror and the door in the smart restroom to send the visitor restroom data to the cloud server. The sensor system will notify the operator who engages in this system when detecting as no motion in the restroom.

3.3 Fall monitoring gerontechnology

The Lab for Advanced Sensing, Computing & Control (ASCC) at Oklahoma State University studied the robot monitor which assesses the interaction with a human through talking. It will request for help after no response from human [4]. So far, however, there has been little discussion about the robot monitor because it is at the prototype stage. No previous study has investigated the deep application and the impact of this robot on the older adult. In case of real-time monitoring, video monitor which consist of a camera is used commonly to monitor the older people's activity [4]. The cameras are set around the house, especially in the bathroom which is the dangerous room occurring the fall accident, to observe and monitor the older people promoting the safety system totally. The captured photos or videos from the system which will be sent in real-time are stored and reported to their family members or caregivers to observe the daily activities of older adult. In addition, several studies have presented that the combination of camera and wearable detector also is used in the present time because of the reliable of the camera which can monitor the elderly thoroughly [29-31]. However, this has been unable to demonstrate video camera acceptance among older adults because the privacy condition was still concerned in the elderly.

4. CONCLUSION

The purpose of this review was to focus on the identification of the technology and service that the gerontechnology has developed in independent living for the elderly concerning fall accident. The benefit and drawback of fall-related gerontechnologies which are fall prevention, fall detection and fall monitoring were also represented in some aspect whereas this paper cannot provide a comprehensive review of the aspect of users in the positive and negative experiences due to practical constraints. Therefore, a user's satisfaction can be surveyed further to collect the feedback to develop the obstacles.

Moreover, a number of important limitations regarding fall detectors need to be discussed. Firstly, although wearable sensors have many preferences namely flexible, comprehensive, simple and private including the accuracy when it is attached near the center of mass, the limitations which are the user acceptance and usability of technology should be concerned [32]. Secondly, these fall detectors; floor detector, vibration detector and motion detector provide the privacy condition as the main concern to the older adults because it only detects the fall, the other factors such as the complication in collecting the fall datasets, the various ways of fall and the

number of datasets should be considered. Lastly, regarding the individual preferences, since some designs that are acceptable for one individual may be unfavorably arranged to another.

To apply the suitable type of this technology in order to perform effectively, the context of individual such as the physical fitness, mental health and preferences including the context in the house such as interior design and installed location, should be proposed and adapted to their home. In term of the perception of usefulness and ease of use, the research found that these did not affect among the older people who desire to age-in-place, hence the marketing strategists and gerontechnology advertisement should be emphasized the value of the existing gerontechnology in the elderly to approach the target [4].

Finally, further experimental research is needed to estimate a survey of user's satisfaction with the technologies and services [33]. This suggestion and recommendation should be included from both the elderly and their family or caregivers to assess the long-term effects of fall-related gerontechnology. In addition, Further research might explore the use of other types of assistive technology in helping and easing the responsibilities for a medical field of nurses and caregivers at the hospitals or nursing care as well.

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