

## Functional limitations associated with housing environmental problems among community-living older people

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### Abstract

This paper describes the functional limitations due to normal aging that are associated with difficulties in older persons housing environments.

Literature review from occupational therapy, medicine and human kinetics was used to study the evolution of abilities with aging, the prevalence of functional limitations in old age and the implications of these limitations in the use of the housing environment. In addition, the functional limitations used in instruments for assessing and analysing accessibility problems in housing and to evaluate housing were analyzed.

Ten functional limitations that may arise with aging and have implications in the use of the housing environment were identified and described. Functional limitations associated with aging are physical, sensory or cognitive impairments. These limitations can be combined to set a specific functional profile of an older person or to establish a generic functional profile of an aging population. Functional profiles can be used to set performance specifications for design or to assess housing environments for community-living older people. Profiles can also be used to adapt the environment to the specific needs of users.

## 1 Introduction

The number of older people is increasing rapidly across populations worldwide. Although most persons over the age of 65 are healthier, more active and mentally better off today than were those of previous cohorts, a large number of people over the age of 75 are living alone with some type of inability to complete at least some activities of daily living [1]. The rate of functional limitations increases with age, ranging from about 20% in adults aged 65 and older to 35% in adults aged 70 and older [2].

Older people may experience difficulties to age in place due to functional limitations. Controlling, from scratch or through adaptations, the characteristics of the housing environment, can reduce the consequences of some of these functional limitations in older people daily life and improve their autonomy, independence, and self-perception of well being [1].

There are currently numerous home safety guidelines for older adults, several documents identify the characteristics that contribute to or can be components of universal housing [3][4][5] and in some European countries new housing is covered by accessibility regulations [6]. However, the universal housing features and most of the accessibility requirements seek to meet the needs of a user with limited mobility, while the problems that older people have in performing activities in the housing environment do not occur exclusively due to accessibility difficulties. There are other housing aspects like noise, heating and ventilation that should be considered [7]. The limited number of studies available on the relationship between housing characteristics and functional limitations associated with aging and the focus on accessibility problems emphasize the need for further research. The aim of this study was twofold: 1) to identify functional limitations due to normal aging that are associated with mismatches between older persons and their housing environments, and 2) to describe problems that older persons with specific functional limitations have in performing activities in the housing environment.

## **2 Material and methods**

Functional limitations used in housing assessment methods [8][9], descriptions of human abilities and the consequences of impairment [10][11] were studied and equivalences between different sources established.

The influence of aging on each functional limitation was assessed through literature review from occupational therapy, medicine and human kinetics. The functional limitations associated with aging that have implications for the use of the housing environment and are sensitive to the adjustment of housing characteristics were selected and integrated into a preliminary list of functional limitations. Where two or more functional limitations had similar implications in the housing environment, these limitations were grouped.

The main changes in abilities associated with normal aging, the evolution and prevalence of functional limitations and the housing environmental problems associated with each functional limitation are described.

## **3 Results**

### **3.1 Cognitive limitation**

Some cognitive abilities are likely to decline with normal aging. Age-associated memory impairment has a prevalence of nearly 20% among elderly people [12]. The short-term memory is particularly affected, which hinders the execution of simultaneous cognitive operations, because the products of early processing are not available when later processing is completed [13]. Older persons also tend to have lower performance on delayed recall and recognition [14]; decline of executive functions, such as decision making, goal setting, planning and judgment [13]; and lower performance on measures of novel problem solving, fluency and mental flexibility [14]. On the other hand, verbal abilities, information, and comprehension tend to show stability [16] and some cognitive functions, such as vocabulary, improve with age [13]. A progressive cognitive impairment can lead to dementia, a

disease that affects up to 25% of people older than 75 years and 40% of people older than 80 years [13].

*Orientation difficulties, tendency to wander away and difficulty in returning home*, can lead to a hazard if the parking space is far from the entrance and the routes are complicated or illogical [8]. *Difficulty in understanding, integrating and processing of information* can cause problems when using automatic doors, complex controls, abstract or illogical signs, complex operable hardware and when lift signals do not indicate the direction of the lift [8]. Slower speed of processing may cause problems dealing with sensitive controls that require precision or intact fine motor control. There are also risks if the person is unable to understand written warnings or significant instructions [10] and during an emergency evacuation. *Forgetfulness and tendency to leave tasks incomplete* can lead to a hazard if an uncompleted task results in a dangerous situation such as the gas supply turned on but not ignited [10]. *Propensity to stumble and slip* can cause falling down stairs, particularly stairs with narrow depth or irregular treads and no handrails, and when the walking surface is irregular or dimly lit [8]. *Slower reaction time* can make the person collide with suspended objects and doors that do not stay in open position or close quickly and strike in poorly marked transparent obstacles such as doors or glass partitions [8]. Persons with cognitive impairment may also not react quickly to stimuli such as a hot burner or a sharp knife [11]. *Difficulty in executing simultaneous cognitive operations*, may lead one to ignore signs that are poorly exposed, lighted or placed [8]; can cause falls when the visual environment distracts the stairway user's attention from the stairs; and cause accidents when crossing vehicular traffic in frequent pathways (e.g., from parking place to the entrance). *Lack of awareness of danger* associated with radiators, sharp knives, open windows, steep staircases, hot burners, electrical equipment, household chemicals, and medicines can cause accidents [11].

### 3.2 Visual limitation

Visual acuity remains constant up to fifty years of age and then steadily declines [17]. Age-related normal changes in vision include: lower ability to distinguish small details; difficulty to accommodate changes of focus (near and/or distance vision); reduced field of vision and depth perception (difficulty to judge distances); lower contrast sensitivity; difficulty to distinguish colours (differentiate between blue and green and yellow and red); loss of sensitivity to colour intensity; decreased speed of adaptation to changing light levels (dark adaptation); lower sensitivity to light (e.g., older persons need more light to read) and increased susceptibility to glare [10][17]. Visual impairment affects about 10% of people aged 65-75, and 20% of those aged 75 and older [17] and there is a higher prevalence of eye diseases such as cataract, age related macular degeneration, glaucoma and retinopathies among older persons.

*Reduced visual acuity, field of vision, depth perception, dark adaptation, and sensitivity to light* can prevent older people from driving an automobile, especially when highway signs are small, roads are poorly lit at night and road signs have text instead of icons [18]. Visual limitations increase the risk of falling, especially when circulation paths are poorly lit, exposed to glare, have steps, and irregular, unstable or not level walking surfaces. *Restriction of the visual field* can cause inability to see objects in the path (e.g., suspended objects), especially in poor lighting conditions and glare. *Loss of visual acuity and contrast sensitivity* can make the edge of patterned carpets, stairs or edges, difficult to detect. *Decline in depth perception* can make patterned surfaces appear as elevations or depressions and cause difficulties in perceiving objects in areas of shadow, low light or excessive brightness. *Glare* increases when windows are exposed to direct sunlight and do not have solar protection devices, when surfaces are highly reflective, and light bulbs are unshielded [17]. *Relying on touch to identify features* can cause accidents on products with sharp points and edges, open fire and flames, hot surfaces or corrosive substances without tactile warning [10]. *Difficulty in obtaining information from the environment causes orientation problems*, especially when there are no tactile or audio signals and in noisy and resonant environments where is difficult to obtain information through hearing and touch.

*Difficulty in identifying objects can prevent from cooking, cleaning, reading, communicating and taking medication because the ability to identify food, detergents, keyboards, displays and medications is limited [11]. Finally, persons with visual limitation have increased susceptibility to accidents, especially when the most frequently used routes involve crossing vehicle traffic [8] or during evacuation procedures [10].*

### **3.3 Auditory limitation**

From 30 years of age auditory sensitivity decreases by 3 dB in the frequency of 1000 Hz and around 10 dB per decade in the frequency of 6000 Hz [20]. The aging of the auditory system can cause trouble hearing in noisy environments, loss of ability to detect higher frequency sounds, discomfort in hearing loud sounds and tinnitus [20][21].

*Auditory limitations* affect the ability to hear spoken announcements, warnings and alarms if they are not loud or intelligible enough, or if frequencies are too high to detect [10]. They can also cause difficulty in hearing routine alerts (e.g., doorbells, telephones, alarm clocks and timers), television and radio and in understanding face-to-face conversations, especially when background noise is present or inadequate lighting hampers lip-reading or sign language viewing.

### **3.4 Handling limitation**

Hand function remains stable until the age of 65 years, after which it diminishes slowly. Older people experience largest declines (greater than 50%) in hand-force steadiness, speed of hand-arm movements, and vibration sense. After the age of 75 years, age differences become more apparent in hand strength, performance time, and range of motion. Persons over the age of 70 have average declines in wrist flexion (12%) and wrist extension (41%), and these declines double during the following decade. A person with 90 years of age may have wrist range-of-motion values of approximately 60% of those of 30-year-old adults. The rate of fingernail growth and blood flow in the hands also diminishes with aging [22].

*The reduction of fingernail growth* can cause difficulties in fine grip and in manipulating small objects. *Reduced sensitivity to local heat sources or slower reflexes* can cause burns to the hands, namely hot water scalding and stove burns, and cuts from a knife or another sharp object [10][11][22]. *Reduced hand function* can cause difficulty in bathing, eating, cooking and doing the laundry [18]; in adjusting too large or small controls that require rotation of the wrist, strength, complex manoeuvres or precision; and in carrying objects. It also increases the risk of accidents on stairs and bathrooms due to difficulty grasping handrails and grab bars [8].

### **3.5 Arm reach limitation**

The ability to reach with the arms can be constrained by lack of strength in upper limbs (vide 3.8), lower balance (vide 3.9) and decreased range of motion. Flexibility declines 20% to 30% with aging, spine flexibility reduces 15% per decade after the age of 30 years and people with 70 to 84 years of age have an average capacity of spine extension 50% lower than young adults [18]. The strength and range of motion of the shoulder also decrease with aging [23].

*Arm reach limitation* causes difficulties in cleaning baths and toilets, making beds and changing light bulbs, reaching controls and objects placed too high, low or deep; causes trouble circulating, especially when doors require physical effort to manoeuvre (e.g., heavy doors); and can cause problems using the bathroom, when support bars or accessories are difficult to reach.

### **3.6 Difficulty in bending and kneeling**

Causes of age-related bending and kneeling difficulty include: aging associated spine mobility and strength reduction (vide 3.6), poor balance (vide 3.9), lower limbs strength decline (vide 3.8 and 3.10), reduced motion range of the hip [18] and arthritis, namely osteoarthritis of the knee, which affects 40% of people over 70 years [24].

*Reduced ability to bend and kneel* causes difficulty in reaching controls and objects placed too low or deep, using low working surfaces and appliances, getting in and out of bed, on and off the toilet, and in and out of the tub or the shower [11], especially when there are no grab bars in the bath, shower or toilet or grab bars are inadequately positioned. Persons with problems bending and kneeling also have difficulty in passing over obstacles and using steps and stairs [8].

### **3.7 Strength and endurance limitation**

The decline in strength with aging is strongly affected by loss of muscle mass (reduction of 20% to 40% in sedentary adults) and to a lesser extent to changes in muscle fiber characteristics, in muscle blood flow and in the nervous system. In sedentary older adults muscle strength declines about 1% per year beginning in the 50s, with steeper declines, approximately 3% per year, after 70 years of age. Muscles in upper extremities tend to change less with age than muscles of lower limbs. The decline in muscle power (product of force produced and movement speed) with age is greater than the decline in muscle strength, for power declines at a 10% greater rate per decade than does strength [18]. Endurance, or the ability to continually repeat physical activity without muscle fatigue, is affected by maximal aerobic capacity ( $VO_2\text{max}$ ) decline with aging.  $VO_2\text{max}$  declines by about 10% per decade from 25-30 years in sedentary adults [25], with a steeper decline from 70/75 years of age [26].

*The decline in strength* with aging causes difficulty in sitting and rising from low surfaces (vide 3.7) and in sustain physical effort like carrying objects (especially when there is no elevator, the objects are heavy or have to be elevated), pushing or pulling heavy doors that do not stay in open position and do not have automatic opening, and using controls and operable equipment that require manoeuvre force. The reduction of muscle strength and power with aging also hinders locomotion and increases the risk of falls (vide 3.9). *Persons with strength and endurance limitation* may feel fatigued when using steps, stairs, ramps and routes with steep gradients; when walking over unstable surfaces (e.g., loose gravel, sand); using long routes (e.g., parking space or passenger loading zones far from entrance) with insufficient or inadequate seating places; performing household chores in a standing position, and using appliances or storage units with insufficient manoeuvring area [8].

### **3.8 Balance, coordination and behavioural speed reduction**

Aging is associated with a decrease in balance after 60 years of age [26], faulty postural alignment, changes in coordination ability, and slowing of reaction and movement time. Older persons are slower (especially when executing complex movements), take longer to reach peak velocity, are less smooth in their movements, and take longer to learn new tasks. They also have increasing difficulty to keep attention focused on the task at hand and dividing their attention between tasks that must be carried out simultaneously, particularly complex tasks [18].

*Poor balance* affects mobility (vide 3.10), causes difficulty sitting and rising from a low seat (vide 3.7), carrying objects, entering and exiting from vehicles, and increases the risk of falls and fractures. There is an increased risk of falling when there are no grab bars in the bathroom or the grab bars are inadequately positioned; when using stairs, routes with steps or steep gradients, particularly if they do not have handrails; when objects are difficult to reach; when using irregular, unstable, not level, poorly lit and slippery walking surfaces or when there are loose cables or small mats on the floor [8]. *Coordination decline* causes difficulty in using doors with complicated opening procedures, sensitive

controls or controls that require precision [8]. *Slower reaction and movement time* reduces the number of tasks that can be accomplished in a day and discourages from active involvement in community activities due to societal pressure to hurry [18].

### **3.9 Mobility limitation and dependence on walking aids**

The main age-associated changes in gait are slower walking speed, decreased step length and reduced step high [1][18][27][28][29]. Healthy older persons walk at a preferred speed that is in average 20% slower than younger adults speed and when walking at fast speed the two groups have a 17% difference in gait velocity [18]. From the age of 70 years old, preferred walking speed decreases with a rate of 12% to 16% per decade and rapid gait speed decreases 20% per decade [28]. Increased time in double support, fatter foot-floor pattern, increased stride width and a more careful reception of body weight in the lower limbs, also characterize the cautious gait of older persons [18]. When changing walking direction, older adults show more insecurity and rigidity [29] and have lower mobility in the trunk, upper limbs, head and neck. Older persons gait also shows a reduced arm swing and less synchronization between the upper and lower extremities. When walking at preferred speed older persons need to do more aerobic effort than younger adults, because the walking requires 48% of  $VO_2max$  in older adults and only 32% of  $VO_2max$  in younger untrained adults [28]. Prevalence of gait disorders is high (35.0%) in community-residing older adults (70 to 99 years of age, mean age 77.4) and increases with age, ranging from 24% in adults aged 70 to 74 to 46% in adults aged 85 and older [30].

*Mobility limitations* cause difficulties walking long, crooked, inclined, or uneven pathways; using stairs; carrying items; and reaching high or low objects. Older persons with limited mobility may have difficulty raising or lowering themselves from seats and getting in and out the bathtub or the shower. They also have increased risk of scalding because they cannot move quickly or without assistance [11] and are more vulnerable during emergency evacuations [10]. *Walking aids and wheelchair users* have difficulty circulating between levels without a lift or a ramp; negotiating narrow doorways and corridors, high thresholds and steps; using irregular or unstable walking surfaces and poorly drained paths and roadways. Since they operate controls, equipment and hardware from a sitting position, these objects should not be placed too high or low. Operating controls and performing activities from a sitting position requires additional manoeuvring space at parking spaces, seating places, balconies, doors, circulation paths and bathrooms, particularly if the wheelchair user needs assistance in transfers.

### **3.10 Respiratory limitations and allergies**

Age-related changes in the respiratory system include lower mobility of the chest wall and loss of the elastic recoil of the lungs, leading to increase the effort involved in breathing, particularly at high rates of breathing. A decrease in alveolar surface area of about 15% from age 20 to 70 causes an increase in anatomical dead space and less surface area for gas exchange. Dilatation of the air spaces in the lungs makes them collapse more easily and causes obstruction to airflow. Lung volumes and maximal flows also change with age as a consequence of the loss of elastic recoil and increased chest wall stiffness [18]. Respiratory muscle strength decreases with age and can impair effective cough, which is important for airway clearance. Older adults have decreased sensation of difficulty in breathing and of shortness of breath, making them more vulnerable to ventilatory failure during high demand states (i.e., heart failure, pneumonia, etc.). The airways receptors undergo functional changes with age, being less likely to respond to drugs. These changes may predispose older individuals to increased risk for respiratory diseases and make them more vulnerable to pulmonary diseases [30]. Data from prevalence surveys estimate that up to about one quarter of adults aged 40 years and older may have airflow limitation, with the prevalence increasing steeply with age [32]. In addition, studies indicate a

prevalence of olfactory impairment of 9.7% to 17.3% in those aged 60-69 years [33] and of 62.5% in persons with 80 to 97 years [34].

*Difficulty in detecting odours* may cause trouble smelling those that are warnings of danger, like smoke, leaking gas, airborne pollutants and toxins [11]. Older persons and people with airflow limitation are particularly susceptible to indoor air pollution, a situation that is exacerbated by the increased length of stay inside the house. Therefore it is necessary to pay careful attention to the air quality by limiting the entry of external contaminants and selecting anti-allergic interior materials, materials with low emission, and materials with low retention of pollutants. Limiting production, facilitating cleaning and extraction of contaminants from housing interior, and taking special care during the application of materials that emit pollutants or during the removal of existing materials that contain contaminants, also help to reduce the level of indoor pollution. *Older persons with intense airflow limitation* have difficulty dressing and bathing independently and feel fatigue while performing simple activities like walking. *Allergies* also limit individual activities due to the need to avoid contact with allergens.

## 4 Discussion

The study combines knowledge from different fields to establish functional limitations associated with aging and to promote an understanding of how the housing environment can prevent a person with specific functional limitations from performing activities. The description of housing environmental problems associated with changes in specific abilities helps to understand the role that housing plays as an extra-personal element that influences the functioning and well being of older people.

The variability of the aging population justifies considering specific functional limitations associated with aging to characterize older persons. Older adults are a heterogeneous group: individuals age at different rates, the rate of decline is not the same across multiple tasks, systematic practice can contribute to maintain some capabilities, and individuals can develop compensatory strategies to cope with losses. Heterogeneity can be increased by pathological conditions and by interaction between aging, pathology and complications due to disease [18]. This makes generalizations across populations difficult and emphasizes the need to consider specific functional limitations.

The identification of functional limitations that may arise with aging can be used to set a specific functional profile of an elderly person or to establish a generic functional profile of an aging population based on epidemiologic information. However, the heterogeneity of the older persons group, the spectrum of functional change in late life, the lack of current epidemiologic data and the wide variation of estimates according to the definition and method used, make accurate identification of generic profiles difficult. Where not enough epidemiologic knowledge about a population is available, the generic functional profile of an older person could include the 10 functional limitations, whereas the major threat of maintaining normal housing in later life are dementia related disorders and severe loss of vision [7].

Functional limitations associated with aging can be used to set performance specifications for design or to assess housing environments for community-living older people and to propose a housing program suitable for seniors.

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