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UNIVERSAL DESIGN APPROACH TO ANALYSIS OF PHYSICAL ENVIRONMENT FOR USERS WITH MULTIPLE SCLEROSIS

Hülya Soydaş Çakır[1*], Anıl Tosun[2]

[1]Faculty of Engineering and Architecture, Fenerbahçe University, Istanbul, Turkey

[2]Faculty of Health Sciences, Fenerbahçe University, Istanbul, Turkey

[1] ORCID: *0000-0002-4631-510X* , [2] ORCID: *0000-0003-1815-385X*

[1]hulya.soydas@fbu.edu.tr, [2]anil.tosun@fbu.edu.tr

*corresponding author

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***Abstract*:** The concept of Universal Design aims for the utilization of every product and environment for every individual without the need for further adaptation. The frequent occurrence of Multiple Sclerosis (MS) in societies has necessitated a more innovative and exploratory approach to the field of design. Many of the products and built environments encountered by individuals with MS in their daily lives fall short in terms of meeting safety and accessibility needs. It is essential to establish the correct design approach so that users with MS can meet their needs easily and safely without depending on others. In this research, the problems encountered by users with MS in their residences were evaluated within the framework of Universal Design principles, and design recommendations were stated using a sample case in Turkey. Throughout the study, accessibility challenges, mobility, fatigue and balance problems, vision and lighting conditions, climatization and noise sensitivity, and psychological issues were primarily considered. The residence of the sample user with MS was examined in detail, and an in-depth interview was conducted during the research. The difficulties and life routines of the user with MS were observed and identified. Home design solutions associated with Universal Design principles were represented so that the users with MS have safe and accessible housing regarding their physiological and psychological conditions. The highlighted proposals may contribute to architectural design to make modifications for

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comfortable and safe housing in related cases having similar symptoms with MS. Future research can benefit from these findings and proposals to provide innovative approaches, develop policies, and conduct interdisciplinary studies on related design issues.

Keywords: Universal Design, Multiple Sclerosis, MS, home design, accessibility

Introduction

Any item and equipment we utilize in our daily lives and any place we spend time in have to meet the physical standards of safety and health. It should be ensured that all kinds of actions and activities in our daily life are carried out without risk and any danger to ourselves or other individuals. When taking into consideration the liberty of individuals to access all designs under equal and fair conditions, Universal Design Approach acts as a salient guide. This guidance substantiates to be even more important when users of the products range in terms of physical features and age.

Practical studies are carried out to reinforce and adopt the concept of Universal Design and to support it as a guide in daily life. Denizou (2016) conducted a study about the approach of the design team and the use of the regulatory framework to create better homes in Norway and develop dwellings with innovative and functional solutions. Universal Design was taken as a tool and a method in the study to improve housing quality and usability considering the needs of various resident groups. Mattie, Borisoff, Wong & Miller (2016) evaluated user perspectives of existing home access solutions and an experimental device used in their research. Participants were chosen from different age groups with mobility limitations. Their study was held to investigate user needs which were necessary for designers and researchers. An initiative of Rebuilding Ireland and the Centre for Excellence in Universal Design had a call for ideas that demonstrated innovation in the design and delivery of solutions for adaptable and smart homes. One of the solution areas was the adaptation of existing houses to meet the needs of older people, and the winning project was an innovative solution aligned

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with a multi-faceted Universal Design approach. The initiative demonstrated that; by the Universal Design approach, innovative solutions can be found through diverse stakeholder collaboration that enable people of all ages, sizes, abilities, and disabilities to live and thrive in their own homes and communities (Rebuilding Ireland, 2017). Lantz & Fenn (2017) pointed out in their report that it was important to include Universal Design features in any new housing unit considering visitors of all ages and adaptation to changing needs of residents. Cho, MacLachlan, Clarke & Mannan (2016) searched the health and social effects of home environments for participants of all ages with physical or cognitive limitations. They observed that interventions to enhance the accessibility of homes have positive effects on health and social issues. They pointed the future research to be more specific about the types of functional limitations for different accessibility features related to mobility or cognitive impairments.

This study has been carried out to support other research in different disciplines to facilitate the daily lives of users with MS and raise awareness through the Universal Design approach. With the advances in diagnosis, more numbers of persons with MS are identified. Any design realized by adopting the Universal Design concept will serve the safety and needs of MS users. In this study based on the research of the physical environment of a user with MS, design proposals are developed in the residence as a daily living space.

Universal Design and User Characteristics

The concept of Universal Design is basically about enabling the use of design products or environments by all people without any adaptation or specialized design. Mace, Hardie & Place (1991) defines Universal Design as simply designing all products, buildings, and exterior spaces to be usable by all people to the greatest extent possible. The Universal Design approach aims to decrease the amount of negativity a person may encounter during lifetime either because of changes that take place in life or an unexpected disability. Universal Design Approach targets to create environments and products that provide equal use for all individuals regardless of their variable features. Universal Design considers the population as a whole with various human

bodies with different abilities (Pritchard, 2014). Hence, the Universal Design approach is not a trend or a temporary approach but rather the means to ease living and provide user-friendly environments by designing within the framework of this approach.

Universal Design Concept and Approach

The Universal Design concept has historically emerged from the conditions of accessibility. In the 1990s, almost simultaneously, two designers R. Mace and S. Goldsmith who had both used wheelchairs; came up with the idea with a common perspective that it was time to consider designing for everyone. The accessibility concept was quite restricted in a world where variations were burgeoning. Principles regarding Universal Design were elucidated by different experts from North Carolina State University Universal Design Center and confirmed with copyright. The seven basic principles of Universal Design denominated a common understanding of products that everyone could use without the need to make adaptations or form a special design (IHDC, 2019). These principles can be applied to the evaluation of existing designs, the guidance of the design process, and training both designers and users on the features of the more usable product and the environment (The Center for Universal Design, 1997) (Table 1).

Table 1. The Seven Principles of Universal Design

No	Principles	Descriptions
1	Equitable use	The design is useful and marketable to people with diverse abilities
2	Flexibility in use	The design accommodates a wide range of individual preferences and abilities
3	Simple and Intuitive use	Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills or current concentration level
4	Perceptible information	The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
5	Tolerance for error	The design minimizes hazards and the adverse consequences of accidental or unintended actions
6	Low physical effort	The design can be used efficiently and comfortably and with minimum fatigue
7	Size and space for approach and use	Appropriate size and space are provided for approach, reach, manipulation, and use regardless of the user's body size, posture, or mobility.

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The products and environmental designs under these seven principles will be appropriate, safe, and user-friendly for a wide variety of user profiles. The demand for designs in accordance with Universal Design principles is inevitable for various permanent or temporary situations we encounter in our daily lives. The need for the Universal Design concept is not only for disadvantageous physical conditions such as congenital or acquired vision, hearing, and limb loss, but also for special conditions such as excessive weight gain, pregnancy, and old age. Every individual should be entitled to the accessibility of these products on equal terms, and this view should be supported in all relevant platforms.

In the guidebook of The Centre for Excellence in Universal Design (CEUD) established by the NDA in January 2007 under the Disability Act 2005 a part of the National Disability Authority (NDA), it is pointed out that there is a 60% chance that a new estate may be occupied by a person with a form of any disability. During their lives, people have changing needs at different stages. Homes built with Universal Design principles can adapt and change with the users. Flexibility and adaptation to changing needs have to be in cost-effective way. Sustainable design for comfort and energy efficiency and smart technologies for easy living become important issues in the design and construction phases (CEUD, 2015).

The Scope of Universal Design for users with MS

Any environment designed in compliance with the product and services for everyone's scope of Universal Design can meet the requirements of different users. However, many projects designed up until now have not been able to meet the requirements of the Universal Design approach. In the case of acquired disabilities, which necessitate compulsory changes in lifestyle, existing designs may fail to be adequate and they may even turn out to be unsafe. This inadequacy unleashes itself in environments that do not conform to the principles of Universal Design. Users who encounter symptoms of MS at some stage of their lives adapt to continue their lives depending on these symptoms. Users with MS need efficient solutions in their living environment for comfort and safety. Pursuing their lives at home, in the workplace, at school, in transportation, and in recreational areas

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without much difficulty and being able to benefit from all design items without any help are becoming more significant for users with MS. When the increasing number of users with MS is taken into consideration, it is essential to prioritize designs and design details while raising awareness for their needs. Many users with MS do not have the opportunity to reside in environments planned according to the Universal Design principles. In such conditions, the Universal Design approach can be utilized for the modification of the existing spaces and products. The most common home modification methods are home adaptation and renovation which requires the assistance of certain devices and technology (Sabata & Lowenstein 2013). The inaccessibility of a house can cause significant costs in long term and various negative health outcomes (Sheppard-Jones et al., 2013).

Living with MS

Multiple Sclerosis (MS) is a Central Nervous System (CNS) disease that affects the immune system, characterized by inflammation, loss of myelinization, and axon damage. Many symptoms associated with CNS damage can occur in persons with MS. Among these symptoms are physical ones such as weakness in arms and legs, sensory problems, loss of balance, fatigue, bladder control problems, double vision, blurriness, and cognitive ones like speech impediment, and memory-concentration-attention disorders which are commonly observed. The severity and the length of these symptoms in the long term may differ from person to person. Some patients experience clinical declines defined as attacks more frequently, while others can have no attacks for a long period of time. In the most common type of MS, attacks are followed by healing periods where neurological symptoms that emerge from the attacks may either decline or disappear completely. MS is commonly observed among young adults. The incidence of MS varies between 2 and 200 in 100,000, depending on geographical features. There are three million persons with MS around the world, nearly 70,000 of whom are in Turkey. MS is observed among females twice more than males and it emerges mostly between the ages 20-40 (Efendi, 2018).

MS causes a loss of independence in the most productive, active, and reproductive stage of life. The living quality of the patient deteriorates, and

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they become dependent as MS causes handicaps in walking, coordination, balance, and vision (Dehghani, Khoramkish & Isfahani, 2019). They have physical symptoms like loss of muscle strength, clumsiness, altered sensation, decreased vision, or reduced perception of the position of the body or limbs in space (Guarnaccia & Booss, 2005). It is known that; environmental and individual factors affect the physical functions and structures of the body, activities, and participation in activities (Karaduman & Özberk, 2011; Hadgkiss, Jelinek, Weiland, Rumbold, Mackinlay, Gutbrod & Gawler, 2012). Fortunately, by redesigning the environment of persons with MS, the restriction in their daily life activities can be reduced. From this perspective, the design of the environment of the user with MS may cause more handicaps than the disease itself. Therefore, the characteristics of the users with MS and their environment should be considered separately. However, while it is much easier to adapt changes to a house so that the patient has more freedom of movement, it is more challenging to make necessary modifications in their environment. The majority of users with MS fail to own a house or they cannot afford necessary home modifications (Kettaneh & Umeasiegbu, 2016). These problems will be solved to a great extent by simply designing homes for residents with the Universal Design approach. On the contrary, although new buildings are designed with this approach, many people around the globe have to reside in houses that are deprived of Universal Design (Lien, Steggell, Slaug, & Iwarsson, 2016).

The modification of houses that are not designed within the framework of Universal Design principles for the use of persons with MS will provide more independent and satisfying lifestyles to them (Roessler et al., 2013). In a research, it was observed that home modifications have a positive impact on users' lives by decreasing difficulty and increasing safety (Petersson, Lilja, Hammel, & Kottorp, 2008). In another research; enabling activities by changes in the home environment was observed by users as new opportunities to participate outside more often (Thordardottir, Fänge, Chiatti, & Ekstam, 2019). Also, housing adaptations help users to be more active and social through the changes in their physical environment (Pettersson, Löfqvist, & Malmgren Fänge, 2012).

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The symptoms of MS which affect the accessibility, needs, adequacy, mobility, and psychological well-being of a person are still being explored. Decrease in mobility, tremor, coordination problems, and spasticity are among the symptoms which impact the accessibility of a person with MS. Devices such as canes, walkers, or wheelchairs used by people with MS who have difficulty in walking due to reasons such as muscle weakness, muscle stiffness (spasticity) or balance disorders (ataxia) in the lower extremities can become an important problem, especially in narrow spaces. Tremor is a symptom that negatively affects the daily life of people with MS, especially when they reach an object in their upper extremities, where treatments are not very effective.

Fatigue, cognitive impairments, loss of motor skills, and sensory deficits, which are among the most common symptoms in people with MS, may prevent their participation in activities. Especially the modifications in the environmental space minimizing the movement required for activities may be beneficial on fatigue and perceived energy loss.

Vision problems such as double vision (diplopia) in people with MS can become trouble when going up and down stairs. Cognitive dysfunctions, difficulties in problem-solving and organizational complications also affect daily life undesirably (Finlayson, 2013).

Balance deficits are common in people with MS. A person's musculoskeletal and neurological system, motivation, and cognition factors affect balance in daily life, but environmental conditions such as lighting, support surface, and visual distractions can also influence balance strategies (Jackson, Mulcare, Donahoe-Fillmore, Fritz, & Rodgers, 2007). Along with coordination problems, sensory, motor, and vision problems intensify the risk of falling (Kesgin, 2019). In order to reduce fall risk in many cases, proper design of the environment is vital. In a study carried out on persons with MS and their problem of falling, it was found that more than 50% of persons with MS experienced falling and that more than half of them were severely injured. In the study, it was reported that tripping or slipping and then being tired or fatigued were perceived as the most common cause of falling cases (Matsuda et al., 2011).

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Another problem, urinary incontinence which is common among around 70% of people with MS (Kalb & Holland, 2008), creates stress and causes them to rush, making to face further problems if the bathrooms/toilets are not appropriately designed for them. Housing accessibility is an important issue as many injuries can be caused by architectural barriers (Smith, Rayer, Smith, Wang & Zeng, 2012).

Case Study: Analysis of the home environment through a volunteer user with MS

Aim, scope, and method

As users with MS spend most of their time at home, it is essential that their home environments comply with Universal Design principles to ensure they carry out their activities in a healthy and productive manner. This paper analyses the house of a 43-year-old user with MS who was diagnosed 20 years ago and suffered from some of the symptoms to pinpoint the housing problems of persons with MS and to come up with specific solutions. The following results were considered by evaluating the user with primary progressive MS (Demiral, Ergor, Unal, Semin, Akvardar, Kivircik & Alptekin, 2006; Kurtzke, 1983; Küçükdeveci, Yavuzer, Elhan, Sonel & Tennant, 2001; Stucki, Kostanjsek, Ustün & Cieza,2008):

- Body and function (impairment) assessment: Expanded Disability Status Scale (EDSS) 7,
- Activities (disability) assessment: Functional Independent Measure (FIM) Motor Score 45, Cognitive Score 35, Total Score 80,
- Life health (emotional role restriction, mental health, vital and social function) assessment: Short Form 36 (SF36) physical health total score 40, mental health total score 60.

An in-depth interview method was used in this study and spatial analysis has been made in the residence of the user with MS. The following steps have been carried out within the scope of the study:

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1. Design problems and current dimensions of the spaces, products, and built elements have been identified.

2. Design proposals associated with the Universal Design principles were presented.

3. Design ideas for residents have been developed to reduce the difficulties faced by individuals with MS and people living with similar symptoms.

Challenges and suggestions

In order to cater for both the physical and emotional well-being of a user with MS, the criteria of environmental design should be evaluated prudently. This section of the paper classifies the challenges users with MS encounter under basic concepts of design. Suggestions are proposed and exemplified for a safer and easier life at home within the framework of Universal Design.

Accessibility

The user with MS in the case study experiences difficulties in daily life and in-house activities. The user cannot fulfil daily chores and personal care without assistance and especially need help with walking the main reason being the inefficiency of the design of the house to accommodate a wheelchair. The user can use the wheelchair only outside the residence. However, as the entrance of the building is not designed adequately for a wheelchair, the user's daily life is affected negatively (Figure 1). The user with MS finds it difficult to leave the building for activities like shopping, personal care, regular health checks, and many other accomplishments. The entrance door of the building is not easily perceptible to users.

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Figure 1. Building entrance with inadequate design for access

The landing area at the entrance of individual houses should be a minimum of 1500mm x 1500mm and it should be at least 2400mm x 2400mm at the communal entrances to allow different residents to use it simultaneously (NDA, 2019a). The landing area at the entrance of the building has only 1300mm in width for the user with MS. The width of the landing area does not have the ideal dimension. The entrance should be easily perceived and reached by the user, but it is hardly perceivable in the present case. The corridors in the house should have a clear passage distance of a minimum of 1200mm according to the Universal Design approach. For non-public buildings, the recommended optimal width for corridors is 1500mm. The corridor width should be a minimum of 1200mm for wheelchair use (WDU, 2013). The corridor width is measured by only 1130mm in the residence of the user with MS.

The optimal interior door clear opening width should be a minimum of 850mm (NDA, 2019b). The clear opening widths of the inner doors have various dimensions in the residence of the user with MS. The kitchen door has a 760mm clear opening width. The living room has a double wing door and the clear opening widths are 900mm and 420mm. The clear opening width of the bedroom door is only 770mm. The other two rooms have doors with 810mm clear opening widths. The door of the bathroom has a 710mm opening width. Door handles should be designed 800 to 1000mm above floor

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level, preferably at 900mm height. The height of the door handles is measured at 1020mm in this case study. When the location of the door is decided in a project, it should be designed in line with the optimal door opening (NDA, 2019b). The clear width of the entrance door of the house should be 1000mm (CEUD, 2015). The clear width of the entrance door is 900mm in the residence of the user with MS which means it is 100mm less than the optimum requirement of 1000mm.

Designing inward-opening doors minimize the risks that will be formed by the wings that open to the corridors and halls. Doors need to be designed such that it is easy to open and close them. Designs can be generated without doors in some spaces like open kitchens and living rooms where it is possible. In this case study, the user has a small kitchen with 2830mm x 3280mm dimensions and a living room close to it. The living room has a 4320mm width and 6000mm length with a 2130mm x 2300mm extra balcony.

Thresholds in the house also cause major problems for the user with MS. With the Universal Design Approach, the use of thresholds indoors should be avoided as much as possible. The balcony door has a 60mm height frame on the floor level which makes access difficult for the user with MS. There are level differences between the rooms and corridor by 80mm to 120mm in the case study. If there are level differences between rooms, door threshold ramps can be designed as a solution. Door threshold ramps can easily be facilitated in existing homes between rooms (DLF, 2020).

For users with MS, floor coverings of the house should be smooth and anti-slip. The user with MS has difficulty with slippery wet floor coverings in the bathroom. The floor covering should not cause fatigue while walking. Contrasting colours of flooring and walls will also make the perception of the ground easier. Carpeting should have a low profile and a firm pad. It is also better to use non-slip low-pile carpets for the floor covering. High pile carpets will make both walking and using the wheelchair difficult. In this case study, the user has a high pile of carpets in the bedroom and living room. Non-carpet flooring is also a solution but as the user with MS in the case study has suggested it is not preferable because of issues like the contribution of carpeting to heating in winter, aesthetic concerns, perceiving

the warm space, and circulation of dust. Possible solutions to be appropriate to these situations could be underfloor heating systems or wooden covering to create a warm effect.

Among the conclusions reached by a group of multidisciplinary experts involving an architect and physiotherapist by evaluating surveys, interviews, and observations regarding home accessibility; the size of a room, objects, and materials used have an important effect on accessibility. The most inaccessible rooms were the bathrooms and bedrooms of the houses as concluded (Sukkay, 2016).

Bathroom

In a research carried out among users with MS, the most modified and change needing spaces at home were the bathrooms (Bishop et al., 2015). They are complex spaces as they comprise many different activities in terms of accessibility and they need to be designed in line with the individual demand of the user with MS. Bathrooms are one of the places where accidents occur when the wet floor becomes slippery. Considering the movement restrictions of the user with MS, the risk increases even more. For users with MS getting on and especially off the toilet is seriously difficult and requires some modifications or adaptive equipment (Gackle, 2012).

The universal bathroom should support individualization and personalization by design flexibility and diversity (Mullick, 2011). Users with MS usually have major troubles in bathrooms. Bathrooms should be easily accessible and truly safe by design. Users with MS should easily perform bathroom activities preferably on their own. In the case study, the user has difficulty using the toilet and carrying out independent bathroom activities (Figure 2). The bathrooms should have a minimum manoeuvring space of 1500mm turn diameter for the wheelchair (CMHC, 2018). In the case study, the bathroom has 1770mm in width and 2440mm in length including the shower unit. The wheelchair can not be used effectively in the bathroom. The toilet seat is 450mm above the floor level and can not be accessed easily. A wall-mounted toilet seat can be installed at a level convenient for the user with MS (Schwarz, 2017). The raised toilet seat will make it easier to sit down and get up. Grab bars by the toilet can be used to push off (National MS Society,

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2019). There are no grab bars to assist the user with MS in the bathroom. Grab bars are essential to get up from the toilet and to maintain balance.

Figure 2. The bathroom having difficulty to access and use

Grab bars can be used also outside the shower. Grab bars should be tubular with a diameter of 32mm-35mm and a clearance of 50mm-60mm to the wall. (NDA, 2019c). It will be comfortable and safe to use a no-threshold shower. Even a low-threshold shower causes trouble while using as it was in our case study (Figure 3). The user with MS cannot reach the shower without the additional help of family members because of the 60mm height of the shower unit above the floor. Floor-level showers will be preferred for easy access and comfortable use. Shower screens should be removed for showers; stylish shower curtains can be used instead (Harmon, 2016; National MS Society, 2019). The user with MS has trouble with the current shower screens and prefers not to use them. The shower unit has a 780mm width and 1290mm length in the case study. The shower cabins should have a minimum size of 9500mm x 9500mm or 7600mm x 1500mm for effective use (WDU, 2013).

Figure 3. The shower threshold causing trouble for the user with MS

A bench in the shower will help to sit easily which could provide more balance than a shower chair. If the width of the space is not adequate, a strong and balanced shower chair can be favoured. The seating unit should be 430mm to 485mm above the bathroom floor (WDU, 2013). The shower controls should be located at a maximum height of 1200mm to reach easily (CMHC, 2018). Simple and intuitive use of the shower should be maintained. An adjustable and handheld shower will help to control water flow. Lever-operated taps and mixers can be used for easy operation. These kinds of faucets can be controlled with the underarm or elbow easily. Sensor-activated faucets also enable hands-free operation for easy use (Adelson, 2004). Mirrors above the hand-wash units should extend 1600mm to 1800mm above floor level and can be tilted forwards to be viewed easily by the users (NDA, 2019c).

Kitchen

Kitchens are spaces to be considered in terms of access and use of persons with MS. Designing countertops with the Universal Design approach that can be removed without the need for plumbing system modification provides many advantages. For wheelchair use, space can be created under the countertop when it is essential. The cabinets under the sink can be removed. Dishwashers can be raised to reach easily. There must be enough space for movement in the kitchen and easy access to the oven and the refrigerator. Kitchens with work surfaces on three sides should have a minimum 2400mm diameter clear space for manoeuvring. Oven controls should be positioned between 750mm and 1050 above floor level according to the Universal Design approach (NDA, 2019d). Countertops can be lowered for wheelchair users. In the case study, the height of the counter is 890mm above the floor and it is difficult for the user with MS to reach it. Storage cabinets should be accessed and operated easily by the user. Easy reach zone is nearly between 3800-4100mm and 1300-1320mm for wheelchair use (Harmon, 2016). The kitchen of the case study is not easily accessible regarding the dinner table, counters, and storage cabinets (Figure 4). Kitchens should have a clear space 1100mm wide between all units (NDA, 2019d). There is only a 1050mm distance between the main counter and the dining table to pass through in the case study. The height of the storage cabinet at the corner of the

kitchen is 1400mm above the floor and is difficult to use. The shelf height that can be reached by wheelchair should be a minimum of 38mm and a maximum of 1220 mm (WDU, 2013).

Figure 4. The kitchen of the user with MS

Under-cabinet lights can be installed for better lighting and safety. Most frequently used appliances such as toasters, blenders, or others can be placed on the countertop instead of stored in a cabinet (Schwarz, 2017).

Bedroom

The bed should be positioned far from the walls to allow mobility around it. There should be no objects placed around the bed that may restrict movement. There should be a 1500mm radius area around the bed when using a wheelchair (WDU, 2013). Bedrooms should be easily accessible. In the case study, the commode in the bedroom makes it difficult to enter the room through the door and access the bed (Figure 5). The dimensions of the commode are 550mm x 900mm with a height of 850mm. Adequate transition gaps should be provided especially for individuals using wheelchairs. The bed should be higher than standard so that the individual sits down and gets up easily. In this case study, the height of the bed above the floor is 510mm and the user with MS has difficulty using it. A portable handrail can be used for rising from the bed (Blaustone, 2007). Wall-mounted swing-arm lamps can be installed on the two sides of the bed to use effectively. Bedroom closets should be organized for easy access by making shelves and clothing rods low enough to reach (Schwarz, 2017). Sliding cabinet doors can be designed to operate them easily and gain much space in the room. Dress hanger sticks in the wardrobe should be at a maximum of 1200mm height above the floor for

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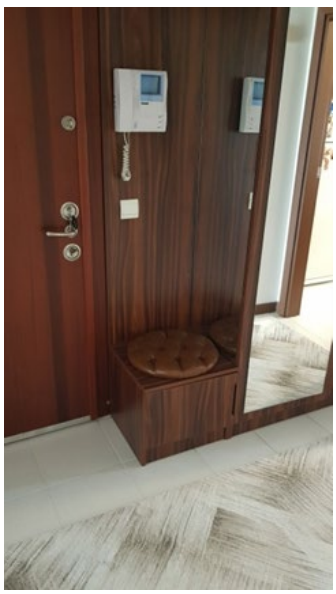
wheelchair use. The depth inside the wardrobe should be a maximum of 530mm for accessibility (WDU, 2013).

Figure 5. The bedroom having difficult access by the user with MS

Fatigue and Balance

Corridors should be planned as short and safe as possible due to loss of balance and fatigue (Halper, 2005). The length of the corridor in the sample case is 4260mm. There must be enough space for the wheelchair to turn around when necessary. The user in the case study prefers some pit stops around the house due to fatigue and to solve this problem a sitting unit has been added to the entrance hall later for this purpose (Figure 6).

Figure 6. The entrance hall and the sitting unit



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The user with MS in the case study utilizes a suction balance grab bar to get support and maintain balance. In terms of easy and practical use so that this equipment is not required, specially designed handrails can be used along the corridor and especially in the access routes to wet spaces such as kitchens and bathrooms. Considering that the user does not prefer handrails for aesthetic purposes, holding elements that will provide functional support with up-to-date and stylish designs can be provided. In wet areas, materials like stainless chrome can be used and in corridors and rooms, adjustable handrails made of wood could be installed to create a warm effect. All the mirrors and pictures in the house should be firmly fixed onto the walls for safety. Design products should not contain any sharp and dangerous edges.

Vision and Lighting

Adequate and appropriate lighting is extremely important for users with MS to eliminate vision difficulties. It is essential to avoid the glossary on surfaces. Colour contrast can be used between surfaces and walls, stair treads, and risers for easy recognition of their junction and to prevent vision problems (The Center for Universal Design, 2006). The walls and doors of the house can be in contrasting colours to maintain visual clarity. In the case study, the user with MS cannot stand and look at white light as it disturbs the user's pupils and makes the eyes tired. Furniture and home textile of plain colours with no patterns will provide a comforting effect and on the contrary, complex patterns, dark and warm colours will not support the feeling of spaciousness and will make perception difficult.

For users with MS choosing the correct lighting will improve safety and help to reduce certain types of fatigue (Harmon, 2016). Light switches should be easy to operate for users with MS. Rocker-style light switches will be suitable as they require less hand pressure or pressure-sensitive switches can be used. Dimmer switches allow to adjust the intensity of lights for personal use (Schwarz, 2017). Light switches can be lowered for accessible use. Remote control switches are better solutions as the user can control the lights easily from any distance. Remotes can also have motion and light sensors or can be controlled by applications on smartphones. Electrical sockets can be raised for easy access. The user with MS in the case study usually feels

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uncomfortable with direct lighting in the house. The user feels more comfortable using indirect lighting instead of hanging fixtures from above and mostly prefers to use floor lamps.

A study done on the benefits of sunlight indicates that sunlight intake and vitamin D3 play a positive role in reducing the symptoms of MS (Mayne, Spanier, Rellan, Williams & Hayes, 2011). The psychological benefits of sunlight on users with MS also guide and inspire designers. Wide-span windows, balconies, skylights, and terrace designs that receive as much natural light as possible will make a positive contribution. Using the balcony in the house for the maximum intake of sunlight may seem like a feasible idea but the threshold at the entrance of the balcony challenges accessibility. It is highly advantageous that the user's house faces east, south, and west facades, which allows all rooms to receive direct sunlight. The patient prefers the curtains to stay open but finds it difficult to manage them. In order to solve this problem, curtain systems can be remotely controlled by a smart curtain motor or by smartphone applications/voice assistants like Google Home or Amazon Alexa (Smith, Martinez, Marlowe, C. & Claypool, 2019).

Climatization

As temperature, humidity and ventilation affect comfort levels and feelings; users with MS are usually sensitive to heat and warm spaces (Harmon, 2016). Using cool colours for the perception of low temperature will comfort users with MS. The user in this case study does not favour the use of air conditioning unless it is too hot. A climatization system that can be controlled and managed easily would provide a lot of benefits for the users of the house.

Noise sensitivity

Unpleasant noises usually disturb users with MS in their environment. The user in this case study is also getting stressed by the noise of neighbours frequently. The walls of the house can be soundproofed to eliminate such noise problems (Harmon, 2016). Double-glazed windows and well-sealed doors will help to reduce noise. Room placement of the building far from

noise sources in the designing stage can help to reduce the impact of noise in rooms with the most sensitivity to noise such as bedrooms and study rooms (Urban Land Institute, 2015).

In this study, design recommendations were presented in the housing example of the user with MS which was examined as a case study considering the difficulties experienced by individuals with MS in their houses. The summary of the design items for the users with MS discussed in the study under the title of Universal Design principles is presented in Table 2, Table 3 and Table 4.

Table 2. Home design proposals for accessibility items

Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Building Entrance	Equitable Use	Poorly accessible building entrance with slope and threshold	Designing a common accessible entrance with appropriate dimensions for everyone's use
Building Entrance Door	Simple and Intuitive Use	Poorly perceived building entrance door	Designing a distinctive and perceivable entrance door for easy detection with less effort
Corridors	Size and Space for Approach and Use	Width is under 1200mm in the main corridor	Moving any furniture out of the corridor, stabling mirrors and pictures on walls properly
Inner doors	Size and Space for Approach and Use	Unaccessible inner doors by narrow clear width for wheelchair	Providing inner doors with 8500mm effective clear width

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Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Thresholds	Tolerance for Error	Trouble causing thresholds in rooms, corridor, hall and entrances.	Floor covering with the same level with appropriate material for each space
Floor covering	Low Physical Effort	Carpets make it difficult to move	Low-pile carpets or non-carpet floors
	Tolerance for Error	Hazardous ceramic floor covering	Reducing glare and slip on floor surfaces by using non-glare and anti-slip floor covering

Table 3. Home design proposals for basic rooms

a)Bathroom

Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Tabs	Low Physical Effort	Centerset lavatory tabs	Lever operated tabs
Faucets	Flexibility in Use	Manuel operated faucets	Sensor-activated faucets
Shower	Low Physical Effort	Difficult to use with a low-threshold and shower screen	Designing a floor-level shower unit with a light shower curtain
	Flexibility in Use	Wall-mounted shower	Adjustable and handheld shower
	Equitable Use	Unstable shower chair	Comfortable and stable shower bench
Toilet	Tolerance for Error	Difficult to use the toilet independently	Installing grab bars for toilet and shower
	Equitable Use	Not easy to use lower toilet seat	Installing wall-mounted toilet at a convenient level

b)Kitchen

Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Counter	Size and Space for Approach and Use	Inaccessible counter for wheelchair	Redesigning / removing cabinets under the countertop
Cabinets	Size and Space for Approach and Use	Difficult to reach for storage	Designing at the appropriate level for easy use
	Tolerance for Error	Low vision within the storage space of cabinets	Installing under-cabinet lights for better vision and safety
Household appliances	Size and Space for Approach and Use	Difficult to access for using	Designing enough space in the kitchen, keeping most used appliances closer and accessible.
	Low Physical Effort	Difficult to use the doors of the closet opening to the main space	Installing sliding doors in order to operate with less effort in a larger space
Commode	Size and Space for Approach and Use	Minimizing the space and making access difficult by inappropriate position	Designing the commode with the appropriate size and position

c)Bedroom

Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Bed	Low Physical Effort	Difficult to sit and raise	Raising bed for easy use, using a portable handrail
	Tolerance for Error	Poor vision in the bedroom, difficulty moving and acting in darkness	Wall-mounted lamps can be installed to be used when the user needs
Closet	Size and Space for Approach and Use	Difficult to reach shelves and clothes individually	Designing shelves and clothing rows easily accessible with the appropriate level.
	Low Physical Effort	Difficult to use the doors of the closet opening to the main space	Installing sliding doors in order to operate with less effort in a larger space
Commode	Size and Space for Approach and Use	Minimizing the space and making access difficult by inappropriate position	Designing the commode with the appropriate size and position

Table 4. Home design proposals for physiological/psychological items

a) Fatigue and Balance

Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Handrail	Tolerance for Error	Using vacuum suction cups hand tool	Designing adjustable and decorative handrails
Circulation	Size and Space for Approach and Use	Difficult to use the wheelchair in corridors and rooms	Designing corridors and rooms with clear dimensions for wheelchair use
Mirrors and pictures	Tolerance for Error	Poorly and inappropriate installation on walls	Fixing all mirrors, pictures, and paints properly on walls in order not to be fallen or become hazardous
Floors	Low Physical Effort	Difficult to move on the floor covering materials	Installing easily walkable and drivable floor coverings

b) Vision and Lighting

Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Glazing	Tolerance for Error	Undesired glazing on the floor and wall coverings	Designing with unshiny and non-reflective surfaces and materials
Colours	Tolerance for Error	Less perceivable similar colours in the house	Designing with colour contrasts between walls, floors, and doors for easy perception
Furniture	Equitable Use	Feeling uncomfortable and unhappy with the furniture	Using plain textures, and light-coloured textiles avoiding patterns, stripes, checks, and complexity. Designing with less furniture according to need and space.
Curtain systems	Low Physical Effort	Manuel operating	Remote control, Voice assistant
Lighting armatures	Equitable Use	Direct lighting	Indirect lighting
Switches & sockets	Low Physical Effort	Difficult to operate light switches	Remote control, motion / light sensor switches, using smartphone applications

Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Remotes	Equitable Use	Difficult to use electrical sockets	Raising electrical sockets for easy access
	Perceptible information	Difficult to operate and perceive	Using remotes with clearly marked buttons

c) Climatization

Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Temperature	Flexibility in Use	Disturbed by hot weather and humidity	Installing an auto-controlled climatization system
Colouring	Equitable Use	Affected uncomfortably by warm and dark colours in the house	Designing surfaces and furniture with cool colours for the perception of low temperature

d) Noise sensitivity

Design item	Universal Design Principle	Current situation (Case Study)	Design proposal
Walls	Equitable Use	Disturbed by the noise of neighbors	Designing with soundproofed wall systems
Outside noise	Equitable Use	High volume of noise coming from outside	Installing noise-insulated glass and sound-insulated window products, changing the most silence-requiring rooms with others to reduce the impact of outside noise

Findings and Discussion

Home design proposals listed in Table 2, Table 3, and Table 4 are formed by analyzing the sample resident of the user with MS but can be adaptable to the living environments of other people having similar symptoms and difficulties. The proposals are listed on the tables under the headings of accessibility items, basic rooms, and physiological/psychological items.

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In Table 2, there are accessibility items including building entrance, building entrance door, corridors, inner doors, thresholds, and floor covering. Design proposals are associated with the appropriate Universal Design principle for each item. For the entrance of the building "equitable use" is the common request. An entrance has to be accessed easily by everyone (Maisel, Smith & Steinfeld, 2008). The building entrance door is closely related to simple and intuitive use. It should be both easily accessible and perceivable.

Inner corridors and doors of the house should be compatible with the Universal Design principle of "size and space for approach and use" (Roessler et al., 2013). The corridor width is under 1200mm in this case and it is difficult to use the wheelchair. Any furniture should be avoided in the corridors and any items on the walls such as paintings and mirrors should be stabled. The inner doors have to be designed with the appropriate clear opening width, especially for the use of the wheelchair. In the case study, the inner doors except the living room door have narrow clear widths for access. Thresholds are trouble-causing items in the house for a person with MS or other people having similar symptoms. The floor level should be the same for each space by covering it with the appropriate material. There should be "tolerance for error" as one of the Universal Design principals. Easily perceivable door threshold ramps can be used for safety (DLF, 2020). Floor coverings should be also related to the principles of "tolerance for error" and "low physical effort". Floor coverings should be designed to reduce falling and slipping. They should allow a person to walk or use a wheelchair easily. Low-pile carpets, non-glare, and anti-slip floor coverings should be preferred.

Home design proposals for the basic rooms are summarized in Table 3. Bathrooms, kitchens, and bedrooms usually need modifications for users with various disabilities. Tabs and showers should be designed to ensure "low physical effort" as a Universal Design principle. A floor-level shower unit can be used easily with a suitable shower curtain. Lever-operated tabs can be used with less effort. Sensor-activated faucets and an adjustable shower will help the user as they are related to the Universal Design principle of "flexibility in use". Grab bars can avoid the danger of falling and assist the user in bathroom activities enabling "tolerance for error". The user can use

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the toilet and the shower independently with the help of installed grab bars (Davies & Lopez, 2005). A raised toilet seat and a stable shower bench will be effective for the user with MS regarding "equitable use".

The kitchen should be easily accessible for the user (NDA, 2019c). "Size and space for approach and use" is one of the most important principles in this space. The counter is inaccessible for the wheelchair, so redesigning or moving the cabinets under the countertop will help the user to reach it. Cabinets also should be designed at the appropriate level for easy use. Most used household appliances should be reached easily by storing them closer on the counter. For "tolerance for error" it will be better to install under-cabinet lights for better vision and safety.

User with MS mostly spends high physical effort during bedroom activities. By enabling the "low physical effort" principle some design solutions can be activated. The bed can be raised to prevent difficulty to use it. Portable handrails can be used to assist the user. Installed wall-mounted lamps will help to reduce poor vision preventing mistakes and hazards related to the principle of "tolerance for error". The closet should be also easily accessible to reach shelves and clothes. Shelves and clothing rows can be designed at an appropriate level to reach. The commode should be positioned properly to enable easy access. It can be minimized in size considering the inefficient size of the bedroom.

Physiological and psychological items in home design proposals are considered in relation to the Universal Design principles (Table 4). Some proposals are suggested for the "equitable use" of the design items (Bishop, Roessler, Rumrill, Sheppard-Jones, Frain, Waletich, & Umeasiegbu, 2013). This principle is about making privacy, safety, and security issues equal for all users and providing the same means of use for all users (Null, 2014). The user with MS is unpleased with the current furniture. The user prefers less furniture in their residence. Light-coloured textiles without patterns, stripes, checks, and complexity, and plain textures will help the user with MS to feel calm and comfortable. Indirect lighting in the house will improve safety by reducing glare and make the user with MS feel peaceful. Surfaces and furniture can be designed with cool colours for the perception of low

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temperatures. Electrical sockets can be raised for easy access making them suitable for other users as well.

The noise of the neighbours and the high volume of voice coming from outside usually disturb the user with MS. Soundproofed wall systems, noise-insulated glass installations, and sound-insulated windows will help to reduce such problems. The most silence-requiring rooms should be designed far away from noise sources (Urban Land Institute, 2015).

The user with MS does not feel comfortable because of the hot weather and humidity (Halper, 2005). Installation of an auto-controlled climatization system will be related to the Universal Design principle of "flexibility in use" providing choice in methods of use. It is difficult to operate and perceive remotes by the user with MS. The "perceptible information" principle is related to providing compatibility with a variety of techniques and devices used by people with sensory limitations. Clearly marked buttons will help the user with MS in perceiving remotes (LaRocca & Kalb, 2005).

The "tolerance for error" principle is related to arranging elements to minimize hazards and errors. Design proposals in competence with this principle can be listed as; designing adjustable and decorative handrails, fixing all mirrors, pictures, and paints properly on walls in order not to be fallen or become hazardous, designing with unshiny and non-reflective surfaces and materials, designing with colour contrasts between walls, floors, and doors for easy perception. Minimizing physical effort and repetitive actions, and using reasonable operating forces will be related to the Universal Design principle of "low physical effort" in design proposals (Shammas, Zentek, Haaren, Schlesinger, Hey & Rashid, 2014; Story, 1998). Installing easily walkable and drivable floor coverings, remote control or voice assistant curtain systems, remote control or motion/light sensor switches, using smartphone applications for lighting, and voice-controlled intelligent personal assistants will help the user with MS in physical energy efficiency and fatigue (Pradhan, Mehta & Findlater, 2018).

Reaching all components comfortably by either a seated or standing user, and providing adequate space for the use of assistive devices and personal assistance will be included in the "size and space for approach and use"

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principle (Steinfield, Zimmerman & Tomasic, 2019). The user with MS has difficulty using the wheelchair in the residence. Designing corridors and rooms with clear dimensions for the wheelchair will be appropriate for the user.

Conclusion

Challenges specific to users with MS make their daily life difficult to cope with. They should be provided with equal and fair access to urban life, transportation, health, education, social life, and recreation. Architects and designers may contribute to the well-being of society with the Universal Design approach. Solutions and design ideas should all emerge from the idea that living standards should be distributed fairly and equally to all humans with disabilities and health problems that may come from birth or be encountered later in life. In this study, the daily life of a volunteer user with MS at home has been analyzed, and recommendations have been made to overcome the challenges through the Universal Design approach. All individuals, regardless of their abilities and physical features will be able to utilize products and spaces designed conforming to the principles of the Universal Design approach without any difficulty. The approach aims to ensure easy access to all available products, services, and environments for every individual. The Universal Design approach should be considered from the very beginning of the design process and reflected in the project. Any intervention and revision after the design process turns out to be less effective, more costly; and requires additional time and labour. Design criteria reflecting all kinds of difficulties, physiological and psychological changes, personal abilities, and the differences that may be encountered in life will provide important support for a safer and healthier life in society. Universal Design is the key to promoting useful and accessible suggestions and solutions for all different abilities. The Universal Design approach will be important for providing easy and reliable access to all kinds of designs in life in terms of increasing the frequency of users with MS in societies.

The Universal Design concept utilized in all physical environments will make a great contribution to eliminate or minimize the effects of physiological and

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psychological changes that individuals experience with MS. The adoption and implementation of the concept from the design process will minimize the modification or adaptation of existing buildings.

The accessibility of the house is essential for the person with MS to socialize with others. In cases where safe and comfortable outdoor access is not available, the individual may move away from social life and enter a depressive mood. Persons with MS can lead an active social life without being isolated when provided with access to buildings, the convenience of movement spaces, and an adequate physical environment inside the house. They are the most natural needs and rights of the users to adapt to their changing conditions with MS without having to change their residences or leave their social lives. Buildings designed with the Universal Design approach will prove to be more cost-effective and user-friendly in the long term without needing further adaptations that may arise in the future. As the accessibility of existing buildings and residences increases, the size of the adaptations that may be needed will decrease considerably. Spreading design criteria determined with the Universal Design approach both in relevant sectors and the society will allow more accessible and usable products and services. Transforming these criteria into standards will contribute to creating healthier, more equitable, accessible spaces and environments. Design suggestions considered in the example case in this study can also be used for people with symptoms similar to the user with MS. Since the main idea of Universal Design is designing for everyone, all living environments and houses have to be built in accordance with Universal Design principles in order to provide fair, safe and comfortable living conditions.

It is crucial that the physical environments of the users with MS should be arranged within the framework of the Universal Design approach in accordance with the unique findings of MS and the changes in the individuals' living conditions. Various design proposals have been suggested in this study to facilitate the life of users with MS and it is aimed to reduce gaps in the related literature and highlight that users with MS can carry out their own activities more comfortably, live in a safe environment, and socialize better when they have adequate living environment. This research

revealed that the Universal Design approach has an inclusive role in order to realize optimal physical environmental conditions of the users with MS. The findings and proposals may contribute to further research on the physical environments of users having similar symptoms to MS. The study will support future research on spatial design ideas for a wide variety of users, including new technologies, inventions, and policies.

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