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Ergonomic Suitability of Kitchen Furniture Regarding Height Accessibility

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ABSTRACT

It is possible to significantly ease kitchen chores with properly sized and appropriately arranged cupboards. In designing kitchen furniture and the optimal depth and the height of storage capacities, accessibility should be taken into consideration. It is known that the optimal storage zone is between 800 and 1100 mm and that there is reduced visibility and accessibility at the level between 1400 and 1700 mm, which is even more prominent for the elderly. This suggests that wall cabinets are not recommended for the elderly. The aim of this study was to determine to what extent kitchens manufactured by Slovenian furniture manufacturers are suitable for users of different age groups with regard to the accessibility of goods stored in the cupboards. Furthermore, based on the measurement analysis, recommendations are provided for designing kitchen furniture that would meet the needs of the elderly. The study, carried out using a computer simulation model, analyzed the products of three Slovenian kitchen manufacturers. The cross section of accessibility in the wall cabinets was determined for different age groups of men and women. The results show that the efficacy of the volume in wall cabinets higher than 600 mm, in comparison to places where objects are easily reachable, is 30% lower for women, thus indicating the inefficiency of storage space in wall cabinets. In terms of accessibility, existing kitchens are not optimal for the elderly, and a model with a deeper worktop and wall cabinets lowered onto the worktop is proposed. Accessibility in such wall cabinets is increased by up to 70% if the body is moved forward by 30°.

Key words: *furniture, dimensions, ergonomics, anthropometry, kitchen, elderly, design, inclusive design*

Introduction

The importance of anthropometry and ergonomics in the field of furniture design has been confirmed by a many authors. The majority of studies, however, examine the correlation between ergonomics and design for classroom furniture[1] or for the workplace[2–3]. Few studies have focused on the correlation between ergonomics and kitchen furniture design for the elderly. Some authors[4,5,6] have addressed the issues of kitchen design by means of inclusive design, which generally includes the elderly and special needs individuals. The demographics of the developed world are changing; the extended lifespan and reduced birth rate are resulting in an increased proportion of older people within the adult population. This is leading to a reduction in the Potential Support Ratio (PRS), or the number of people aged 15–64 years who can support one person over the age of 65. In 1950, the global PSR was 12:1, in 2000 the PSR was 9:1, while by 2050 it will be 4:1 globally and 2:1 in the developed world.

It has been stated[7] that the elderly have greater difficulty in adjusting to inappropriately high worktops than people under the age of 65. The fact is that kitchen work could be significantly eased with the appropriate design and suitable arrangement of kitchen cupboards. In designing kitchens, the optimal depths and heights of worktops and storage places should also consider accessibility and spinal load.

Some authors[8] state a limit of vertical accessibility of 180 cm. Of course, accessibility of wall cabinets is lower if a person is standing in front of low cupboards on the floor or by the kitchen worktop. Accessibility also depends on the size and the age of the user. The optimal storage zone is between 800 and 1100 mm. Both visibility and accessibility are reduced at heights between 1400 and 1700 mm. At this height, the majority of men and women are able to store light items on the edges of shelves, however,

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accessibility above 1700 mm is considerably reduced for most people. Apart from height, the depth of the cupboards and cabinets plays an important role in accessibility and visibility. Pheasant recommends that the depth of shelves at heights between 800 and 1400 mm should not exceed 600 mm. At heights below 800 mm, the depth of the shelves should be up to 450 mm and at heights above 1400 mm, the depth should be up to 300 mm[9].

Some authors[9] state that a shelf depth of 300 mm and height of up to 1400 mm are suitable for 95% of the elderly. Nevertheless, if there is an obstacle in front of the cupboard, like a worktop, the height should not exceed 1350 mm. Shelves placed below 300 mm[7] are not suitable for people who have problems kneeling or bending. Deep shelves are particularly impractical, and the author suggests that shelves be placed above a height of 500 mm for the elderly.

Similarly, the British Standard Institution recommendations (BSI, 4467/1969) suggest that for the elderly, shelves in a wardrobe should not exceed a height of 1600 mm. In the case of wall cabinets placed above an extended worktop, the height should not exceed 1400 mm. In addition, shelves in the low cupboards should not be placed below 300 mm. The European Standard EN 1116, in effect in Slovenia as SIST EN 1116, contains coordinating sizes for kitchen furniture and kitchen appliances, but does not focus specifically on dimensions adjusted for the older population. The height of the shelves in low cupboards can be lowered to 35 mm if casseroles with a handle[7] are stored there, as the actual height of the grip is above the level of the shelf, thus avoiding low bending.

The elderly have greater problems in reaching objects than younger people[10], due to the occurrence of arthritis and other conditions that restrict joint movement. Also, elderly users have reduced muscular strength and joint mobility due to the ageing process. To the greatest possible extent, the majority of items should be stored between the knuckle and shoulder heights so that elderly users are not subjected to bending and overreaching demands[11]. Differences in vertical accessibility in the standing position for persons of different gender and age are shown in Table 1. The table shows that accessibility between the young and the elderly differs by an average for 170 mm for males and 147 mm for females. The difference until the age of 80 is considerably smaller, namely, 120 mm for males and 80 mm for females.

An article[8] described the functional limitations of the elderly in Mexico State. Objects in wall cabinets in their kitchens could be reached without difficulty or assistance by 26.67% of females involved in the research, with assistance by 56.67%, while 16.67% of females could not reach the objects. In the low cupboards, 12.9% of females did not have problems reaching the objects, 35.48% of females were able to reach the objects with assistance, whereas 35.48% of females found the objects in the low cupboards almost unreachable. Accessibility of food in the refrigerator is better, since 87.1% of females did not have any problems, 9.68% required assistance and for 3.23% of females, the food was almost unreachable. In their article[11] recommended that in designing for reach, it is better to use a lower percentile (5th percentile) in order to accommodate as large a share of the population as possible. The great differences in heights between males and females and the differences between races make it virtually impossible to determine the optimal dimensions for cupboards, as their size is closely related to the size of people. A 900 mm high worktop is too low for about half of the females and almost all males, which is why work in the kitchen is often related to pain. Nevertheless, a higher worktop means that wall cabinets should be placed higher, making the upper shelves even more difficult to reach, especially for the elderly. Furthermore, it is necessary to consider that the height of the elderly is getting smaller over time. Height already begins to decrease at the age of 40[10] and becomes more apparent between the ages of 70 and 80. A comparison of heights among 19-year-old British males and 65-year-old males and the group of 65 and 80-year olds showed a difference of 55 mm. The difference within the same age groups with females was 40 mm. Similar conclusions were reached by Kothiyal et al.[11]. They indicated that both elderly males and females were significantly heavier (α=0.05) than the younger group and that elderly males and females were significantly shorter (α=0.05) than the younger group. Therefore, the height of the worktop for the elderly should be lower than for young people.

The objective of this study was to determine the extent to which kitchen furniture manufactured by the Slovenian furniture producers is suitable for users of different age groups and the accessibility of objects in the wall ca-

TABLE 1
Anthropometric evaluation of vertical accessibility in a standing position for British adults (Pheasant, 2006)

Age	Male			Female		
	5th %ile	50th %ile	95th %ile	5th %ile	50th %ile	95th %ile
19–45	1950	2085	2220	1805	1915	2030
45–65	1910	2035	2160	1775	1890	2000
65–80	1840	1965	2090	1725	1835	1950
Elderly	1770	1915	2060	1640	1770	1900

binets. Furthermore, basic principles upon which kitchen furniture should be designed to meet the needs of the elderly are proposed based on the measurement analysis, so as to enable maximal productivity with minimal time and energy consumption without harmful consequences for health.

The main objective of every company is effective and efficient business. There is a general economic principle: to achieve maximum results with minimum resources. We believe that the Slovene manufacturers of kitchen furniture could find a niche market on the basis of these research results[12]. We assume that mass-produced standardized kitchen furniture on the market is not ergonomically optimal. We believe that the accessibility of objects stored in wall cabinets is problematic, and therefore the optimal kitchen furniture for a young and healthy person cannot be identical to the optimal equipment for an elderly person over the age of 60. The research was exclusively focused on the accessibility for a model person and not on joint load, muscle strength and activity or lever measurements, since the stiff positions of the model person employed were not always ergonomic.

Material and Methods

The research was carried out using a computer simulation model. 3D modelling technology is already being integrated into the design of other products[2]. A similar research was also carried out by[13]. Three standardized kitchen furniture manufacturers were included in this study. One typical kitchen set was selected from each manufacturer and the 3D CAD program (MegaCAD, manufacturer MegaTECH and Megatischler manufacturer Planles, version 2009) was used to design the kitchen furniture as life-size furniture. In the study, the focus was on the accessibility of objects in the wall cabinets.

Accessibility was tested using a person designed in three sizes. The data for British males and females of three age groups[9] (19–25 years, 26–45 years and 45–65 years old) was used in determining sizes. These data were used due to the lack of data for average Slovenes, as there is only basic data available and these do not differ significantly from the anthropological dimensions of the British. Therefore the chosen data are sufficiently relevant for this study. The model person was placed into the kitchen designs and we detected height accessibility in the wall cabinets (Figure 1). The model was placed beside the worktop so that the end of the foot was 30 mm from the line of the low cupboard base. Mainly the accessibility was analyzed by joint recruitment problem and not by muscle recruitment like in case of solving the problem in the model used inresearch[14].

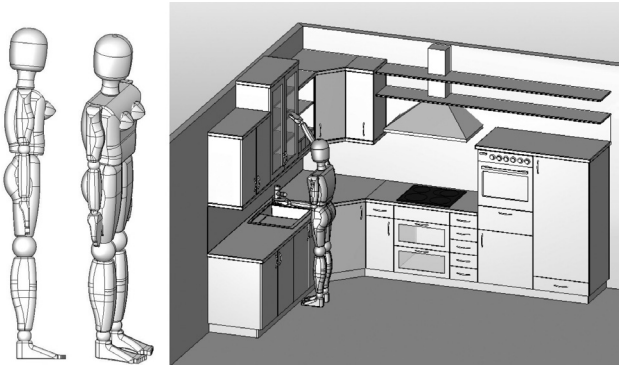

Fig. 1. 3D model of a person and the kitchen furniture.

Results

Using the computer simulation model of a person and the kitchen furniture, we observed the intersection of accessibility in wall cabinets for different male and female age groups in the three selected kitchens. In Figures 2, 3, 4 and 5, the area of accessibility is hatched. In Tables 2, 3, 4 and 5, the calculation of accessibility is presented as a percentage.

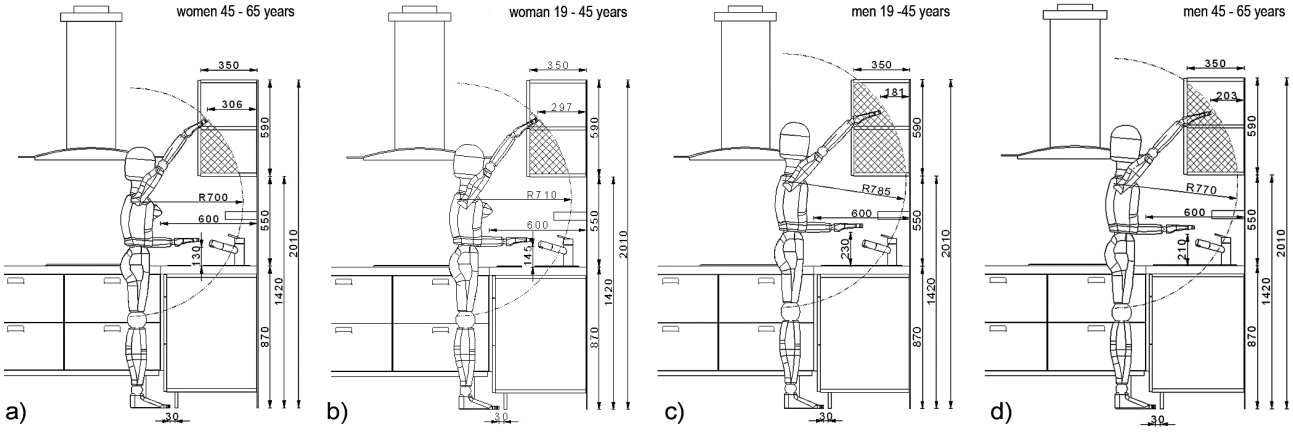

Fig. 2. Placement of the female and male model, ages 19–65 in kitchen I.

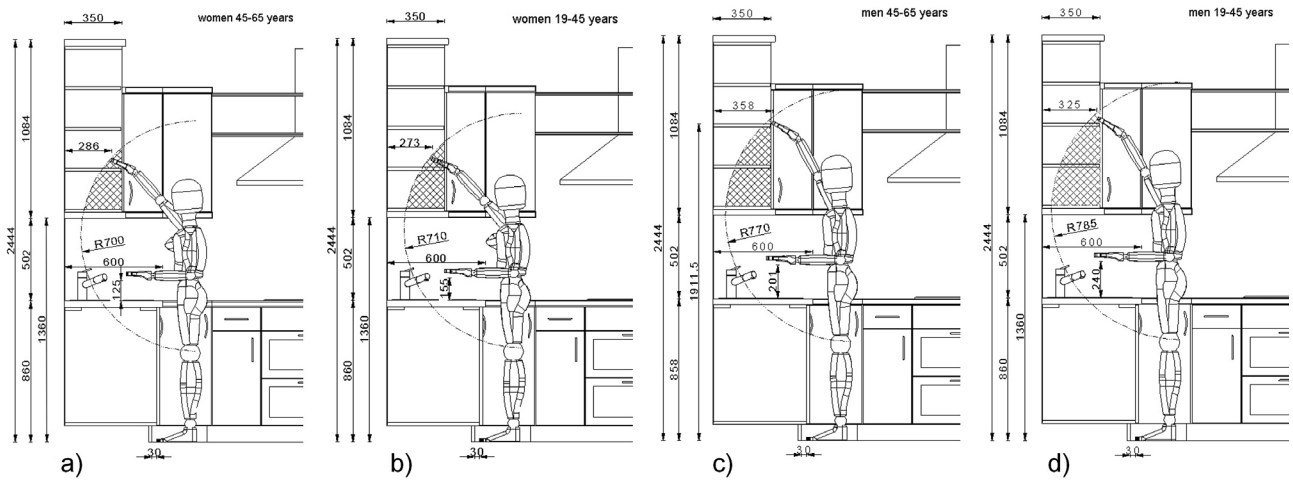

Fig. 3.Placement of the female and male model, ages 19–65 in kitchen II.

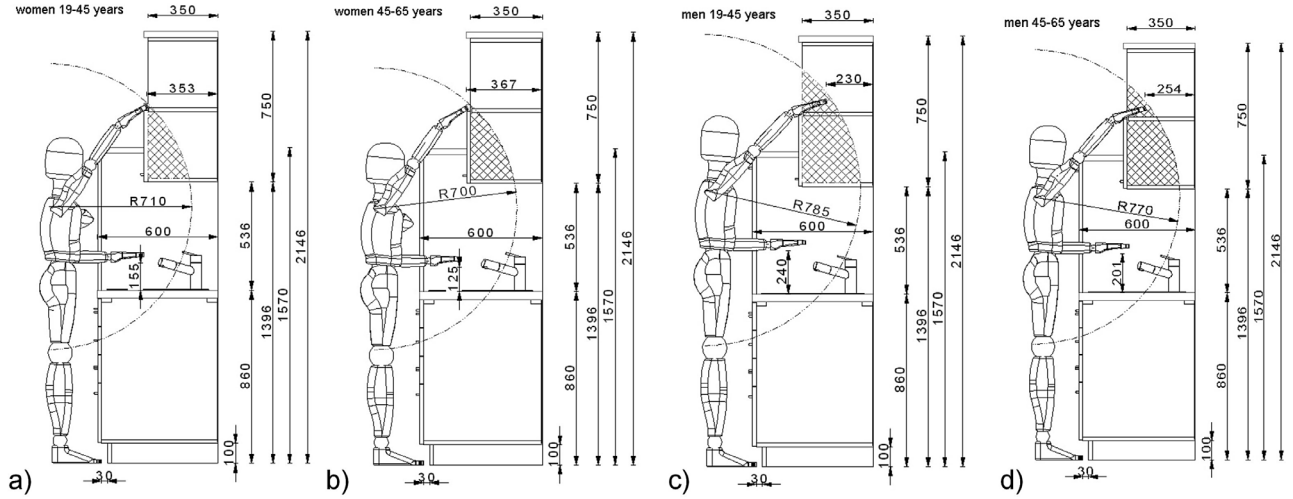

Fig. 4. Placement of the female and male model, ages 19–65 in kitchen III.

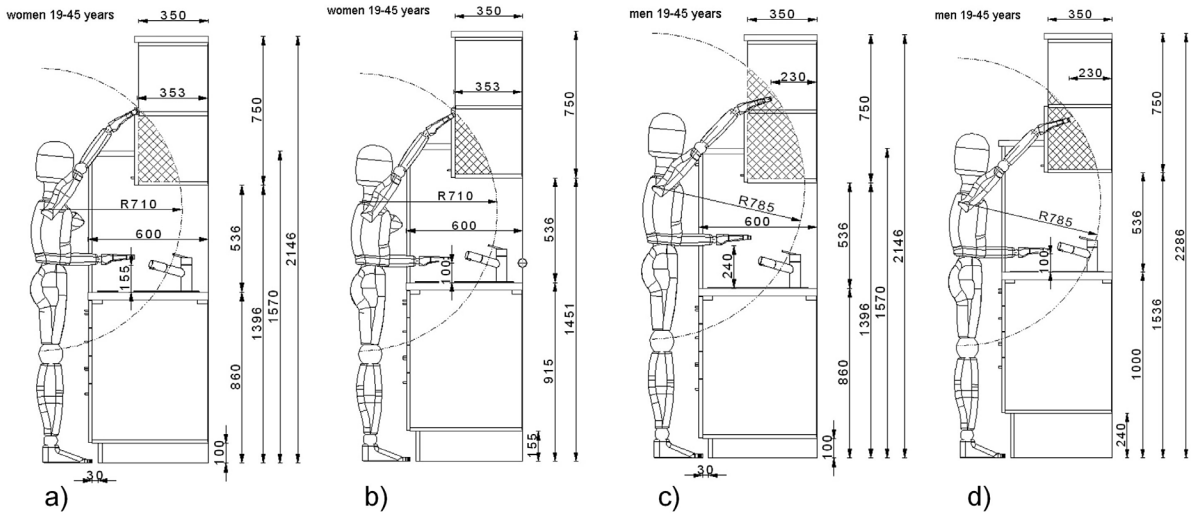

Fig. 5. Height accessibility for females and males, ages 19–45 in kitchen III (a, c), where the height of the worktop meets ergonomic requirements (b, d).

TABLE 2
Accessibility in wall cabinets in kitchen I

50 %ile	Area of accessibility (dm²)	Total area (dm²)	Accessibility (%)
Female, 19–45 years	5.8	19.1	30.4
Female, 45–65 years	5.4	19.1	28.3
Male, 19–45 years	12.8	19.1	67.0
Male, 45–65 years	11.1	19.1	58.1

TABLE 3
Accessibility in wall cabinets in kitchen II

50 %ile	Area of accessibility (dm²)	Total area (dm²)	Accessibility (%)
Female, 19–45 years	5.9	33.6	17.5
Female, 45–65 years	5.4	33.6	15.8
Male, 19–45 years	12.8	33.6	33.9
Male, 45–65 years	11.1	33.6	28.9

TABLE 4
Accessibility in wall cabinets in kitchen III

50 %ile	Area of accessibility (dm²)	Total area (dm²)	Accessibility (%)
Female, 19–45 years	4.9	21.7	22.6
Female, 45–65 years	4.7	21.7	21.7
Male, 19–45 years	11.0	21.7	50.7
Male, 45–65 years	9.4	21.7	43.3

TABLE 5
Accessibility at the height of the worktop THAT meets ergonomic requirements in kitchen III

50 %ile	Area of accessibility (dm²)	Total area (dm²)	Accessibility (%)
Female, 19–45 years	3.6	21.7	16.6
Male, 19–45 years	7.1	21.7	32.7

In kitchens I and III, accessibility is considerably better than in kitchen II as the wall cabinets in kitchens I and III are situated much lower (590 mm, 750 mm) than in kitchen II (1084 mm). Height accessibility also depends on the distance of the wall cabinet's lower edge from the floor. This dimension depends on the height of the worktop and the height of the interspace between the worktop and the bottom of the wall cabinet. The interspace is 550 mm in kitchen I, 502 mm in kitchen II and 536 mm in kitchen III. The height of the space between the worktop and the bottom of the wall cabinet depends on the high cupboards if the top of the high cupboard is intended to be at the same level as the top of the wall cabinet. Nevertheless, it is desirable that the height of the interspace is larger so that the wall cabinets do not obscure the view on the workspace, while on the other hand, the height should not be too high due to accessibility of the objects in the wall cabinets.

Figures 2, 3 and 4 show that the height accessibility is lower for the elderly than for young people as a result of decreasing height in the elderly. If illnesses restricting joint movement are also taken into consideration, height accessibility would be even lower. Also, it should also be noted that if the worktop is placed at a higher level, the wall cabinets are also moved higher, which will, again, reduce accessibility. If we consider the recommendation of[6] that the recommended height of the worktop is from 80–100 mm measured under the curved elbow, we can see that the worktop in all three kitchens is too low for both males and females.

Figure 5 shows accessibility with the height of the worktop as found in kitchen III, and the height accessibility if we adapt the height of the worktop to the height of the users, namely to 50% of males and females (Table 5). If the height of the worktop is adapted to the height of the user, the difference in height accessibility between males and females is decreased, although males are on average taller than females (Table 6).

TABLE 6
Difference in accessibility concerning the height of the worktop and gender

50 %ile	Accessibility at the height of the worktop as in kitchen III (%)	Accessibility at the height of the worktop that meets the ergonomic requirements (%)	Difference (%)
Female, 19–45 years	22.6	16.6	6
Male, 19–45 years	50.7	32.7	18
Difference in accessibility between man and women	28.1	16.1	

Discussion

Figures 2, 3 and 4 show that accessibility is higher for males than for females, which is logical due to differences in their body heights. On the other hand, accessibility in the wall cabinets also depends on the height of the cupboards under the worktop and the distance from the lower edge of the wall cabinet from the floor. If the height of the worktop is adapted to the height of the user, the wall cabinets are placed higher and the difference in height accessibility is no longer as prominent (Table 6).

This study has shown that in wall cabinets higher than 600 mm, the efficiency of the volume where objects are easily accessible is less than 30% for females. The percentage is even smaller if the height of the worktop is 100 mm under the curved elbow, meaning the space in the wall cabinets is used inefficiently, especially if the wall cabinets are higher.

The results coincide with the results of a study[9] that found that accessibility is reduced at heights between 1400 and 1700 mm. Since the lower edge of wall cabinets is usually above 1400 mm, this means that wall cabinets are problematic in terms of comfortable accessibility. It is evident in the figures showing a 3D model of a person that accessibility on the lower shelf is satisfactory, whereas the objects stored on the second shelf are difficult to reach.

The optimal storage zone is between 800 mm and 1100 mm[8], thus in the area of the worktop which is without cabinets, as in standard kitchen furniture the cupboards are positioned under the worktops and above as wall cabinets. The solution to this problem is high cupboards or cabinets placed on a deeper worktop. Figure 6 shows accessibility in a cabinet placed on the worktop with a body inclination of 30° and 55°.

Since the cupboards under the worktop are deeper, the volume of these cupboards is 48% greater, meaning that by increasing the depth of these cupboards, the storage space has increased. Nevertheless, considering that the elderly commonly have problems with bending and kneeling, shelves placed below 300 mm should be avoided, and deep shelves are especially impractical[7]. A better solution would be cupboards with drawers that can be fully pulled out.

With cabinets placed on the deeper worktop, additional storage space with good accessibility has been acquired. Accessibility is increased by 70% if the body is inclined forward by 30° in comparison with kitchen I with wall cabinets, and by 91% if the body is inclined by 55°.

Accommodation for the elderly should take their physical and emotional characteristics into consideration. Muscle strength decreases by 40–50% between the ages of 40 and 807. The changes in muscle function are even more apparent after the age of 70. Besides this, the majority of the elderly cannot actively carry out plantar flexion in their ankle (tiptoeing), which results in even lower height accessibility. In comparison with young people, the area of comfortable accessibility is decreased for the elderly due to their reduced musculoskeletal abilities. That is why it is even more important for the elderly to have ergonomically designed equipment, which considers anthropometry and enables comfortable accessibility. It is even more important for the elderly than for young people to have kitchen furniture that is especially designed to meet their needs. We believe that the cabinets placed on the worktops are undoubtedly a better solution for the elderly than wall cabinets, since the accessibility in the wall cabinets is even lower for the elderly than for people up to the age of 45.

Conclusions

The kitchen furniture produced by the Slovene manufacturers is not suitable for the elderly unless it is designed without wall cabinets, though in this case the volume of storage space is reduced. This study has shown that the efficiency of volume, where objects are comfortably accessed in the wall cabinets higher than 600 mm, is lower than 30% for females, indicating that the storage space in the wall cabinets is used inefficiently. The study conclusions are as follows:

Objects stored in the wall cabinets higher than 600 mm are accessed with difficulty and therefore a version of the kitchen furniture with deeper worktops and cabinets positioned on the worktops is recommended if the room size enables such a solution. This version of the furniture

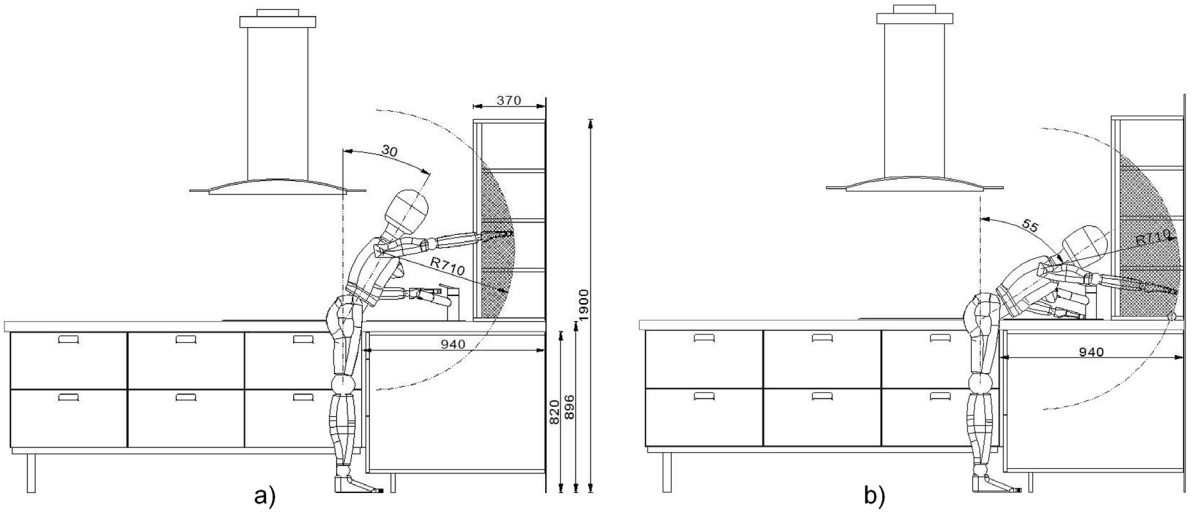

Fig. 6. Placement of the female model, ages 19–45 in kitchen I, with a body inclination of 30° and 55°.

is especially recommended for the elderly, who have greater problems with height accessibility.

Cupboards placed under the worktop should have drawers that allow for a better view of the displayed objects, easier loading and emptying without having to remove other objects, better efficacy of volume and loading and emptying without the need for bending.

Ideally, it would be possible to adapt all serially produced kitchen furniture to individual needs and requirements. Therefore, kitchen furniture systems for the elderly should allow for adjustments to worktop height.

REFERENCES

1. DOMLJAN D, GRBAC I, HAĐINA J, Coll Antropol, 32 (2008) 257. — 2. MIJOVIĆ B, UJEVIĆ D, BAKSA S, Coll Antropol, 25 (2001) 639. — 3. MIJOVIĆ B, LONČAR R, Sigurnost, 50 (2008) 9. — 4. HROVATIN J, Ergonomics in the kitchen – Theory and practice, International symposium Wood is good – Furniture, human, design, (2002) 51. — 5. TRAJKOVIĆ J, PREKRAT S, Furniture for mobility-impaired persons, International symposium Wood is good –Furniture, human, design, (2002) 111. — 6. PISSAREVA E, JIVKOV V, Kitchen furniture design for people with physical disabilities, International symposium Wood is good – new materials, quality and design of products, (2009) 85. — 7. KIRVESOJA H, VÄYRYNEN S, HÄIKIO, Applied Ergonomics, 31 (2000) 109. — 8 PENNATHUR A, DOWLING W, Int J Ind Ergonom, 32 (2000) 39. — 9. PHEASANT S, HSDRLGRAVE CM, Bodyspace, Antropometry, Ergonomics and the Design of Work. Third edition. (London, Taylor and Francis 2006) 332. — 10. PANERO J, ZELNIK M, Antropološke mere i enterier. (Novi Dani, Beograd, 1979). — 11. KOTHIYAL K, TETTEY S, Int J Occup Saf Ergo, 7 (2001) 15. — 12. OBLAK L, JELAČIČ D, MOTIK D, GRLADINOVIĆ T. Wood Res, 53 (2008) 105. — 13. SMARDZEWSKI J, Drvna Industrija, 60 (2009) 15. — 14. DE ZEE M, DALASTRA M, CATTANEO MP, RASMUSSEN J, SVENSSON P, MELSEN B, J Biomech, 40 (2007) 1192.

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ERGONOMSKA PODOBNOST ODREĐENA DIMENZIJOM VISINE KUHINJSKOG NAMJEŠTAJA

SAŽETAK

Pravilnim dimenzioniranjem i na odgovarajući način postavljenim namještajem za pohranu moguće je olakšati poslove u kuhinji. Karakteristične dimenzije odnose se na optimalnu dubinu i visinu u skladu s dohvatom. Poznato je da je optimalna zona za pohranu između 800 i 1100mm, te da je smanjena vidljivost i dostupnost na razini između 1400 i 1700mm. Sa starošću populacije ova se razina smanjuje. To znači da se ovješeni ormarići ne preporučuju za starije osobe. Cilj ovog istraživanja bio je utvrditi u kojoj su mjeri kuhinjski viseći ormarići slovenskih proizvođača namještaja dostupni, a time i upotrebljivi za korisnike različitih dobnih skupina te ukazati na kriterije za dizajniranje kuhinjskog namještaja koji će zadovoljiti potrebe starijih osoba. Analiza je izvršena na temelju modela izvedenog računalnom simulacijom. U istraživanje su bila uključena tri slovenska proizvođača kuhinja. Bila je analizirana pristupačnost po bočnom presjeku zidnih ormarića za različite dobne skupine muškaraca i žena. Dokazana je učinkovitost upotrebe volumena zidnih ormarića visine 600mm u kojima su predmeti dostupni bez napora. U odnosu na muškarce, kod žena je utvrđena smanjena dostupnost korištenja ormarića za 30%. Postojeće kuhinje u smislu dostupnosti nisu optimalne za starije osobe. Veća učinkovitost uporabe može se postići s povećanjem dubine radne ploče i spuštanjem zidnih ormarića na radnu ploču. Inklinacijom tijela naprijed za 30°, dostupnost se povećava do 70%.