Coll. Antropol. **30** (2006) 4: 853–865
Original scientific paper

Anthropometric Evaluation of the Crèches Children Furniture in Turkey

Önder Barli[1], Reyhan Midilli Sari[2], Derya Elmali[2] and Erkan Aydintan[3]

[1] Faculty of Economics and Administrative Sciences, Ataturk University, Erzurum, Turkey
[2] Department of Architecture, Faculty of Architecture, Karadeniz Technical University, Trabzon, Turkey
[3] Department of Interior Architecture, Faculty of Architecture, Karadeniz Technical University, Trabzon, Turkey

ABSTRACT

The dimensions of the living and working space and buildings, the types of material and different riggings should be designed to conform to the users' anthropometric measures. The first requirement to design on ergonomic system is to measure the human being who will work and live in that system. Because of this, anthropometric measures are the most frequently used ergonomic data during the design process. In this research paper, we attempt to organize a new data base of anthropometric data to use in the design of children's equipment and furniture used in crèches. A starting point for research on the proper dimensions of crèche furniture is to investigate how the dimensions of furniture reflect the body dimensions and the functional needs of the children using furniture. The anthropometric data of 3, 4 and 5 year-old-children in crèches was used. We report the results of the measurements of 18 anthropometric characteristics of children which constitute a set of basic data for the design of functional spaces and furniture.

***Key words**: anthropometry, crèches, design, Turkey*

Introduction

Anthropometrics is a term used to describe the measurements of a »user« or »target« population for which a product is designed. Measurements are reported in terms of the range of body dimensions, of the target population. Having data available on the dimensions of a population takes the guesswork out of furniture and equipment design. With anthropometric measurements to him, the designer can build equipment for a specific age group of children or to conform to a range of sizes of children. In fact, there are already considerable data available, gathered from taking measurements of large numbers of people in standard positions, which provide designers with the exactly information they need.

It is necessary to know the body dimensions of the potential user for the proper design of product. This is important for service sectors such as schools, hotels and banks as well as in the production and manufacturing sectors. On the other hand, it has been found that even small changes in dimension of the work space can have considerable impact on worker productivity and may also impact occupational health and safety. Therefore, the user characteristics and specifically the structural anthropometrics dimensions should be known for design of an effective workstation[1].

During the past decade, research in ergonomics has led to an increased interest in the technology of equipment and furniture design based on the biomechanics of the human body. The debate, building on early work in the field by Branton[2] and Keegan[3], has been especially active in trying to determine guiding principles for the design of furniture in the workplace[4]. The design of furniture is generally not different from that of other industrial products. Thus, the functional uses of the furniture define the design of the final product. The design features that play significant roles in the design of a final product are: aesthetics, economics, functionality and originality. The functionality of furniture is based on its comfort, safety and usefulness. And these qualities of comfort, safety, and usefulness are related to the anthropometric characteristics of the user and the suitability of materials used in furniture design.

When a manufacturer or designer designs a product or products, he must know the body dimensions of the prospective user. Reasons for applying ergonomic design are that accidents (falls, strikes, injures, etc.), reduced productivity, ineffectiveness, and user discomfort may

Received for publication January 10, 2006

arise from incorrect product dimensions that do not match those of the user. Consequently, health problems such as musculoskeletal, visual, and circulatory[5] problems may result from an improperly designed product. Mandal[6] noted the importance of furniture specifically designed to conform to a child's body proportions and recommended different sitting postures for different activities[7]. For example, it has been noted that without proper design, sitting will require greater muscular force and body control to maintain stability and equilibrium. This, in turn, results in greater fatigue and discomfort and these are likely to lead to poor postural habits in the child as well as neck or back complaints[4]. On the other hand, good posture, which leads to improved lung expansion and reduces organ crowding and strain on soft bones, tendons, and muscles[8], can be facilitated by proper ergonomic design. In the same way that industrial accidents and health problems may occur through badly designed equipment, so it[9] may occur in school and crèches due to badly designed furniture such as tables, chairs, beds, TV stands and shoe cupboards. In this respect, many health problems and accidents appear to be increasing throughout the world. For example, eighty percent of the citizens of the U.S.A seek medical attention for back problems some time in their lives[10]. Contrary to what one might assume, back problems are not confined to the adult population. A surprising number of grade school children and adolescents are reported to have regular bouts of back, neck, and headache pain[11,12]. Back and neck pain also have a substantial economic impact. In 1990, direct medical care costs for low back pain exceeded $24 billion, and total costs increase substantially when the indirect costs of disability are included[13]. Given these statistics, the importance of prevention through proper product design is evident[9].

However, surprisingly little interest has been shown in the ergonomic design of crèches. Crèche children are especially prone to suffer the adverse effects of badly designed and ill-fitting furniture owing to the prolonged periods of time they spend seated during crèches. In addition, it is in the crèches during their formative years where children acquire their permanent habits of sitting. For these reasons, public health concerns over the effects of bad posture need to be focused on the design of crèche furniture. However, studies that provide empirical evidence on the extent and the nature of a possible mismatch between crèche furniture and crèche children's bodily dimensions are rare[4].

It is well known that there are serious ergonomic problems among the school-age children of Turkey. These problems have arisen through the non-implementation of the aforementioned design concepts in the schools of Turkey. The absence of reliable ergonomic and anthropometric data of school-age children, which measurements take into account the applications for which the children's furniture and equipment are designed as well as the dimensions of the children, can serve as examples of the national inattentiveness to design principles in crèches.

Crèche furniture from manufacturers is typically not designed to accommodate the dimensions of the individual user. Even among developed countries this problem is quite widespread and is not limited to less developed countries. Instead, for reasons of economy, a one-size--fits-all philosophy has been adopted in the manufacture of children's furniture. Such furniture is less costly to manufacture and easier to sell at a lower price. In addition, this practice reduces inventory problems for manufacturers and crèches. Today most companies base their designs on specifications from the American Furniture Manufacturers Association and the National Standards Board to decide »seat width, belly room, and prohibited combustible materials«. Existing designs have basically been unaltered for years[4].

On the other hand, while it is known that manufacturing and inventory expenses are significant topics, it is also recognized that there are hidden costs associated with products that have not been designed using anthropometric data and according to ergonomic principles. These hidden costs are, of course, the previously mentioned health and safety problems and their attendant costs. At the same time, not surprisingly, observations and measurements indicate that furniture designed to accommodate a specific task and the individual's size is more acceptable to users than standardized styles.

It has been observed that a beginning was has been made recently toward the consideration of ergonomic necessities in the design of products such as children's furniture intended for use in crèches. This growing trend is gaining speed especially in European countries like Denmark, Sweden, Germany, France and Switzerland[5]. For Turkey, it is known that, there are serious problems in this respect. It has not been so quick to adapt ergonomic principles in the design of furniture for school-age children. This situation resulted from both lack of anthropometric data as well as design and product problems. As a consequence, there are a lot of ergonomic problems in schools in Turkey and these problems could increase the number of health problems[14–16] in the future.

In light of these problems and in the absence of data, this study was undertaken to meet the urgent need for anthropometric data from Turkey and to examine the possible mismatch between the individual body dimensions of children and the crèche furniture they use.

Methods

Sample and study design

The research area included crèches located in the centre of Trabzon. The potential data set, from which optimum furniture dimensions were to be calculated, included twenty crèches which were active during the years 2001–2002. Measurements were taken in 16 crèches that were randomly selected. The methods used for random selection have been cited in previous publications[15]. Measurements included the depths, breadths and heights of the furniture used in crèches. These measurements were tabulated to compare them with the optimum furniture dimensions calculated according to children's anthropometric dimensions (Table 1).

In order to calculate optimum furniture dimensions, anthropometric measures were taken from a total of 286 children attending crèches (154 male, 132 female) who were 3–5 years of age[19]. A total of 18 different measurements were made while the children were the in sitting and standing positions (Table 2).

The dimensions of existing furniture were measured. From these measurements, optimum values were calculated based on the anthropometric datum previously acquired[19] (Table 2). In calculating the optimum dimensions of the furniture, dynamic or static anthropometric measures, minimum and maximum values, and also the function of the furniture were taken into consideration. All of the furniture was divided in to two groups according to reach and volumetric function based on the main criteria of anthropometric design. The formula for calculating the optimum furniture dimension is as follows:

Maximum values were calculated for volume measurements:

Furniture dimension = X+ SDxZ

Minimum values were calculated for reach measurements:

Furniture dimension = X – SDxZ

Because some anthropometric values of females can be greater than those of values males, suitable male or female values were used in the calculating processes.

It is known that anthropometry tables give measurements of different body parts for men and women, and split into different nationalities, and age groups. Firstly, it is need to be known who you are designing for. The group you are designing for is called the user population. If an office chair is designed, it would be needed to consider dimensions for adults of working age and not those for children or the elderly. You also need to know whether you are designing for all potential users or just the ones of above or below average dimensions. This depends on what it is that you are designing. For instance, if you are designing a doorway using the height, shoulder width, hip width etc., of an average person, and then half the people using the doorway would be taller than the average, and half would be wider. Since the tallest people are not necessarily the widest, more than half the users would have to bend down or turn sideways to get through the doorway. Consequently, in this case you would need to design using dimensions of the widest and tallest people to ensure that everyone could walk through normally[16,20]. At the same time, deciding whether to use the 5th, 50th or 95th percentiles of the potential users' values depend on what you are designing and who you are designing it for.

TABLE 1
FURNITURE DIMENSIONS MEASURED IN CRÉCHES*

Crèches	Table depth	Table breadth	Table height	Chair depth	Chair breadth	Chair height	Bed depth	Bed length	Bed height	Bunk height	W.C. pan depth	W.C. pan Height	W.C. pan breadth	Washbasin depth	Washbasin height	Mirror height	TV height	Coathanger height	Shoe cupboard height
1	485	768	555	225	275	275	962	1,550	390	1,213	–	–	–	250	450	–	1,000	820	905
2	850	1,480	570	235	245	265	540	1,205	255	–	330	320	300	145	540	815	–	1,040	960
3	605	1,305	530	300	300	290	765	1,345	560	–	310	305	280	220	710	–	650	–	600
4	650	1,200	545	305	270	284	605	1,300	350	1,186	320	310	280	130	790	–	–	900	160
5	790	790	510	270	249	275	675	1,165	260	–	440	405	375	187	635	1,200	1,270	870	1,105
6	520	885	520	245	285	270	760	1,220	365	–	280	320	270	190	545	–	1,030	1,150	765
7	695	695	520	295	275	310	700	1,200	480	1,300	–	–	–	240	650	–	1,370	1,140	550
8	595	735	525	270	300	285	535	1,285	150	–	300	295	290	195	485	800	–	1,030	1,000
9	515	1,020	530	285	330	310	670	1,465	195	1,335	310	335	265	200	440	1,100	–	950	1,500
10	690	1,190	525	313	310	255	660	1,200	340	1,200	310	280	250	320	640	950	–	920	445
11	490	1,900	450	–	–	–	650	1,450	430	–	–	–	–	170	525	–	–	1,530	560
12	685	1,990	445	285	315	270	700	1,330	510	1,320	–	–	–	180	590	–	–	–	515
13	600	600	500	240	280	310	765	1,370	260	1,090	–	–	–	170	510	1,010	–	1,160	1,090
14	600	1,100	460	290	270	285	580	1,200	100	–	360	290	280	190	640	1,250	1,150	1,060	240
15	700	1,400	505	265	275	265	660	1,265	200	920	–	–	–	290	760	–	–	900	1,020
16	350	520	500	260	245	270	760	1,375	500	–	345	310	290	160	640	–	630	–	740
Total	16	16	16	15	15	15	16	16	16	8	10	10	10	16	16	7	7	13	16

*All measurements are in millimeters

TABLE 2
MEASUREMENTS (mm) OF ANTHROPOMETRIC CHARACTERISTICS OF THE CHILDREN*

Characteristics in the standing position	Group	X	SD	Characteristics in the sitting position	Group	X	SD
Stature	1	104.13	9.86	Sitting stature	1	78.15	7.63
	2	103.73	6.35		2	77.46	6.803
Max. vertical reach	1	125.77	9.42	Eye height	1	67.17	4.656
	2	124.92	9.14		2	67.15	5.07
Eye height	1	93.30	8.49	Elbow height	1	34.37	3.32
	2	92.84	6.26		2	34.75	3.83
Elbow height	1	60.16	4.72	Hip breadth	1	22.67	2.05
	2	60.01	4.34		2	22.27	1.82
Forward elbow reach	1	29.31	2.66	One calf thickness	1	7.56	1.18
	2	28.60	2.17		2	7.70	1.24
Forward arm reach	1	51.09	4.68	Two calf thickness	1	16.00	2.32
	2	50.28	4.40		2	15.35	2.12
Shoulder breadth	1	26.22	1.80	Buttock-calf depth	1	27.27	2.20
	2	26.06	1.90		2	28.04	2.24
Elbow to elbow breadth	1	27.68	2.19	Buttock-knee depth	1	33.59	3.32
	2	28.84	21.00		2	33.99	2.83
Waist depth	1	13.62	1.45	Sitting height	1	23.52	2.17
	2	13.37	1.42		2	23.73	2.43

*In groups, 1 – male and 2 – female

Measuring procedure

In this research, various dimensions of furniture and equipment used by children used in crèches were measured. The aim of this is to compare existing furniture dimensions with optimum furniture dimensions based on anthropometric data.

Depth, height and breadth of the furniture that are frequently used in the children's classrooms and have dominant characteristics were measured. The furniture and equipment that were measured included tables, chairs, beds, bunks, washbasins, toilets, pans, mirrors, TV tables, coat hangers, shoe/toy and equipment cupboards. These measurements were tabulated (see Table 3) along with mean value of each measurement, its standard deviation, and its minimum and maximum values. Thus, measured, empirical values could be compared with calculated optimum values.

Results

Calculations of the depth, height and breadth of the furniture and equipment which are considered to be used rather frequently by children were done. Anthropometric data of children were used when calculating the measurements. Consequently, calculated values and existing furniture measurements were compared in a table and suitability of the optimum measurements with the existing was discussed (Table 4).

TABLE 3
STATISTICS OF EXISTING FURNITURE*

Furniture measurements	X	SD	Min.	Max.
Table depth	614	125	350	850
Table breadth	1,099	437	520	1,990
Table height	512	35	445	570
Chair depth	254	67	300	313
Chair breadth	282	25	245	330
Chair height	281	17	255	310
Bed depth	687	105	535	962
Bed length	1,308	112	1,165	1,550
Bed height	334	138	100	560
Bunk height	1,196	138	920	1,335
W.C. pan depth	331	45	280	440
W.C. pan breadth	288	34	250	375
W.C. pan height	317	35	280	405
Washbasin depth	202	51	130	320
Washbasin height	597	105	440	790
Mirror height	1,018	177	800	1,250
TV height	1,014	286	630	1,370
Coat hanger height	1,036	186	820	1,530
Shoe cupboard height	760	352	160	1,500

*All measurements are in millimeters

TABLE 4
COMPARISON OF MEANS OF CALCULATED OPTIMUM FURNITURE DIMENSIONS WITH THE MEAN VALUES MEASURED*

Furniture	Depth (mm)		Breadth (mm)		Height (mm)	
	X	Calculated	X	Calculated	X	Calculated
Table	614	345	1,099	395	512	490
Chair	254	264	282	267	281	193–285**
Bed	687	626	1,308	1,235+pillow	334	193
Bunk	–	–	–	–	1,196	931
W.C. pan	331	230	288	187	317	193
Washbasin	202	244	–	–	597	515
Mirror	–	–	–	–	1,018	806
TV table	–	–	–	–	1,014	572-TV Height /2
Coat hanger	–	–	–	–	1,036	948
Shoe cupboard	–	–	–	–	760	806

*All measurements are in millimeters

** Minimum and maximum values of chair height

The tables

In sizing tables, two possible sitting positions were considered: sitting facing one another and sitting sideways. Also, the ease of knee and elbow movement must be considered to determine suitable dimensions.

Calculation of table depth (for one person):

The maximum value of forward elbow reach was used in calculating of table depth for one person (Figure 1).

Table depth (for one person) (max. value) =
= Forward elbow reach (X_{male}) + SD × Z

Table depth (for one person) = 29.31 + 2.66 × 1.96

Table depth (for one person) = 34.52 cm = 345 mm

Calculation of table breadth:

The maximum value of buttock-knee depth was used in calculating of table breadth (Figure 2).

Table breadth (max. value) =
= Buttock-knee depth (X_{female}) + SD × Z

Table breadth = 33.99 + 2.83 × 1.96

Table breadth = 39.54 cm = 395 mm x (per person)

Calculation of table height:

The minimum value of sitting height and maximum value of two-calf thickness were used in calculating of table height. The reason of this is to ensure easy acting of knee on horizontal and vertical ways and the connection between elbow and table (Figure 1).

Table height (max. value) = [Sitting height (X_{female}) + SD × Z] + [Two calf thickness (X_{male}) + SD × Z]

Table height (max. value) = (23.73 + 2.43 × 1.96) + (16.00 + 2.32 × 1.96)

Table height (max. value) = 49.04 cm = 490 mm

The chairs

In sizing chairs, sitting height, chair depth and breadth are necessary for a comfortable and healthy sitting.

Calculation of chair depth:

The maximum value of buttock- knee depth was used in calculating of chair depth. Chair depth should be 2:3 of buttock-knee depth[17,21] (Figure 3).

Chair depth (max. value) = [Buttock-knee depth (X_{female}) + SD × Z] × 2:3

Chair depth (max. value) = (33.99 + 2.83 × 1.96) × 2:3

Chair depth (max. value) = 26.36 cm = 264 mm

Calculation of chair breadth:

The maximum value of hip breadth was used in calculating of chair breadth (Figure 4).

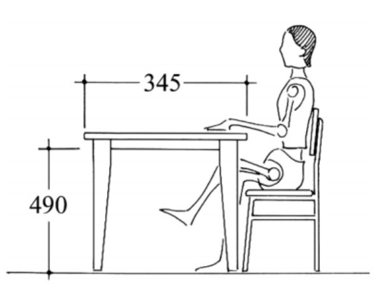

Fig. 1. Table depth and height (mm).

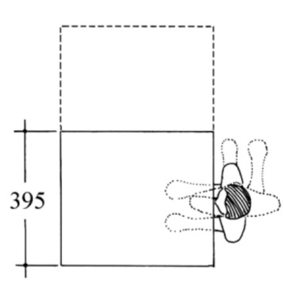

Fig. 2. Table breadth (mm).

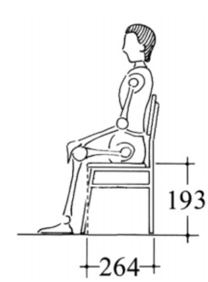

Fig. 3. Chair depth and height (mm).

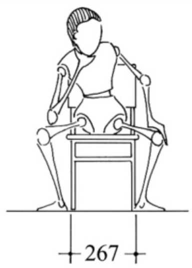

Fig. 4. Chair breadth (mm).

Chair breadth (max. value) = Hip breadth (X_{male}) + SD × Z

Chair breadth (max. value) = 22.67 + 2.05 × 1.96

Chair breadth (max. value) = 26.69 cm = 267 mm

Calculation of Chair height:

The minimum value of sitting height was used in calculating chair height. Because feet must touch to ground and calf must be rest while sitting (Figure 3).

Chair Height (min. value) = Sitting height (X_{male}) – SD × Z

Chair height (min. value) = 23.52 – 2.17 × 1.96

Chair height (min. value) = 19.27 cm = 193 mm

Chair height (max. value) = Sitting height (X_{female})+ SD × Z

Chair height (max. value) = 23.73 + 2.43 × 1.96

Chair height (max. value) = 28.49 cm = 285 mm

Actually, chairs have to be adjusted between minimum and maximum values. If adjustable chairs aren't used, then the minimum height calculation is preferred. For many purposes, the 5th percentile female chair seat height represents the best compromise for a fixed seat height. The seat height should be low enough to avoid excessive pressure on the underside of the thigh[18,22]. If the seating surface is too high, the underside of the thigh becomes compressed causing discomfort and restriction in blood circulation. To compensate for this, a sitting person usually moves his buttocks forward on the chair seat. This can result in a slumped, kyphotic posture due to lack of back support[4,19,23].

The beds and bunks

Calculation of bed depth:

The maximum value of buttock-knee depth was used in calculating of bed depth (Figure 5).

Bed breadth (max. value) =
= 2 × [Buttock-knee depth (X_{female}) + SD × Z] – [Waist depth (X_{male}) + SD × Z]

Bed breadth (max. value) = 2 × (33.99 + 2.83 × 1.96) – (13.62 + 1.45 × 1.96)

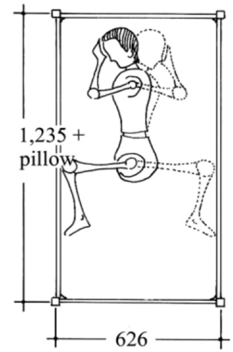

Fig. 5. Bed/bunk breadth and depth (mm).

Bed breadth (max. value) = 62.61 cm = 626 mm

Calculation of bed breadth:

The maximum value of stature was used in calculating of bed length (Figure 5).

Bed length (max. value) = Stature (X_{male}) + SD × Z + (pillow)

Bed length (max. value) = 104.13 + 9.86 × 1.96 + (pillow)

Bed length (max. value) = 123.46 cm = 1,235 mm +pillow

Calculation of Bed Height:

The minimum value of sitting height was used in calculating of bed height (Figure 6).

Bed height (min.value) = Sitting height (X_{male}) – SD × Z

Bed height (min. value) = 23.52 – 2.17 × 1.96

Bed height (min. value) = 19.27 cm = 193 mm

Calculation of Bunk height:

The maximum value of sitting stature was used in calculating of bunk height (Figure 6).

Bunk height (max. value) = Sitting stature (X_{male}) + SD × Z

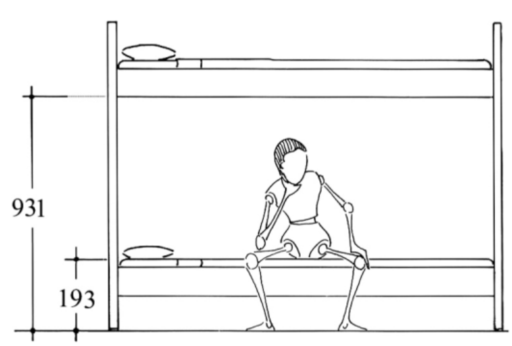

Fig. 6. Bed/bunk height (mm).

Bunk height (max. value) = 78.15 + 7.63 × 1.96

Bunk height (max. value) = 93.11 cm = 931 mm

The W.C. pans

Calculation of W.C. pan depth:

The minimum value of buttock-calf depth was used in calculating of W.C. pan depth (Figure 7).

W.C. pan depth (min. value) = Buttock-calf depth (X_{male}) – SD × Z

W.C. pan depth (min. value) = 27.27 – 2.20 × 1.96

W.C. pan depth (min. value) = 22.96 cm = 230 mm

Calculation of W.C. pan breadth:

The minimum value of hip breadth was used in calculating of W.C. pan breadth (Figure 8).

W.C. pan breadth (min. value) = Hip breadth (X_{female}) – SD × Z

W.C. pan breadth (min. value) = 22.27 – 1.82 × 1.96

W.C. pan breadth (min. value) = 18.70 cm = 187 mm

Calculation of W.C. pan height:

The minimum value of sitting height was used in calculating of W.C. pan height (Figure 7).

W.C. pan height (min. value) = Sitting height (X_{male}) – SD × Z

W.C. pan height (min. value) = 23.52 – 2.17 × 1.96

W.C. pan height (min. value) = 19.27 cm = 193 mm

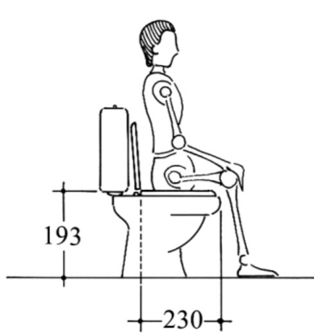

Fig. 7. W.C. pan height, depth (mm).

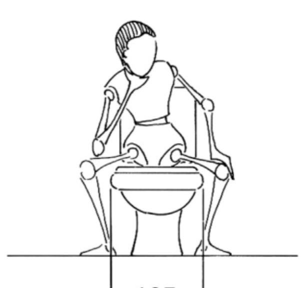

Fig. 8. W.C. pan breadth (mm).

The washbasins

Calculation of distance of tap to person (Depth of the Washbasin):

Tap distance from the person is necessary in tap dimensions. The minimum value of forward elbow reach was used in calculating of distance of tap to the person for reaching out for water easily (Figure 9).

Distance of tap to person (min. value) = Forward elbow reach (X_{female}) – SD × Z

Distance of tap to person (min. value) = 28.60 – 2.17 × 1.96

Distance of tap to person (min. value) = 24.35 cm = 244 mm

Calculation of washbasin height:

The minimum value of elbow height in standing position was used in calculating of washbasin height (Figure 9).

Washbasin height (min. value) = Elbow height (X_{female}) – SD × Z

Washbasin height (min. value) = 60.01 – 4.34 × 1.96

Washbasin height (min. value) = 51.50 cm = 515 mm

The mirrors

Calculation of mirror height:

Centre point height of mirror must be known for mirror height. The minimum value of eye height in standing position was used in calculating of mirror height (Figure 9).

Centre point of mirror (min. value) = Eye height (X_{female}) – SDxZ

Centre point of mirror (min. value) = 92.84 – 6.26 × 1.96

Centre point of mirror (min. value) = 80.57 cm = 806 mm

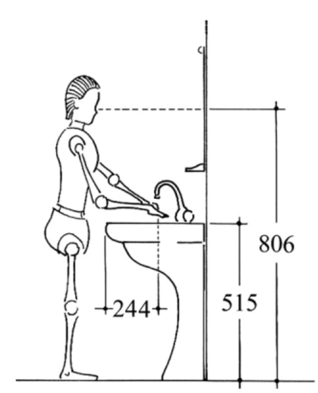

Fig. 9. Washbasin / mirror height and distance of tap to person (mm).

The TV tables

The most important measurement in the design of TV table is the eye height in the sitting position for getting a perfect view. This height was accepted to be the centre point of the TV height and the table height was calculated according to this situation.

Calculation of centre point of tv height:

The minimum value of eye height in sitting position was used in calculating of centre point height of TV (Figure 10).

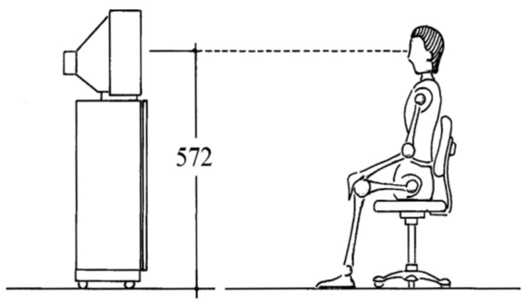

Fig. 10. Centre point of TV height (mm).

Centre point of TV height (min. value) = Sitting eye height (X_{female}) – SD × Z

Centre point of TV height (min. value) = 67.15 – 5.07 × 1.96

Centre point of TV height (min. value) = 57.21 cm = 572 mm

Calculation of TV Table Height:

Centre point height of TV value was used in calculating of TV table height (Figure 10).

TV table height (min. value) = Centre point of TV height – TV height/2

TV table height (min. value) = 572 mm – TV height/2

The coat hangers

Calculation of coat hanger height:

In calculating of coat hanger height, arm is considered to make 45° with the coat hanger while using it. According to this, the formula below was used to calculate the minimum value of coat hanger (Figure 11 and 12).

Coat hanger height (min. value) = Shoulder height (min. value) + Y (Forward arm reach/v2)

First step:

$\sqrt{2}Y$ = Forward arm reach

Y = Forward arm reach/$\sqrt{2}$

Forward arm reach (min. value) = Forward arm reach (X_{female}) – SD × Z

Forward arm reach (min. value) = 50.28 – 4.40 × 1.96

Forward arm reach (min. value) = 41.66 cm = 417 mm

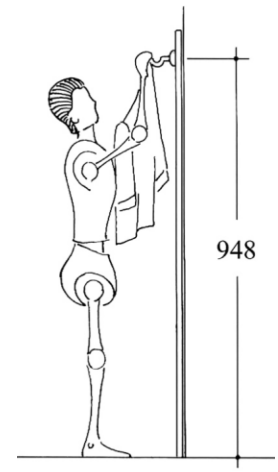

Fig. 11. Calculating coat hanger height (mm).

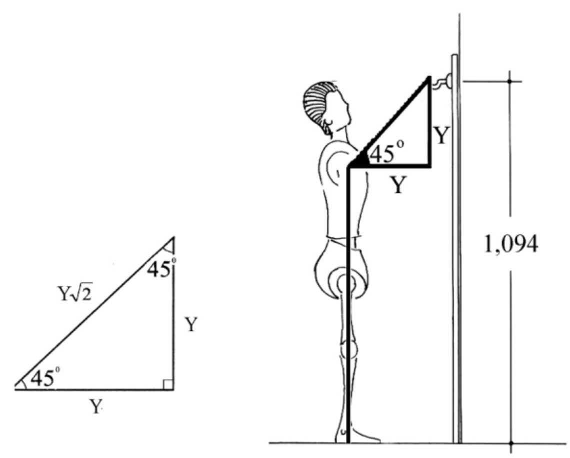

Fig. 12. Coat hanger height (mm).

Y = Forward arm reach/$\sqrt{2}$ = 41.66/$\sqrt{2}$ = 29.46 cm = 295 mm

Second step:

Shoulder height (min. value) = [Maximum vertical reach (min. value) – SD × Z] – [Forward arm reach (min. value) SD × Z]

Shoulder height (min. value) = (124.92 – 9.14 × 1.96) – (50.28 – 4.40 × 1.96)

Shoulder height (min. value) = 65.35 cm = 654 mm

Third step:

Coat hanger height (min. value) = Shoulder height (min value) + Y

Coat hanger height (min. value) = 65.35 + 29.46

Coat hanger height (min. value) = 94.81 cm = 948 mm

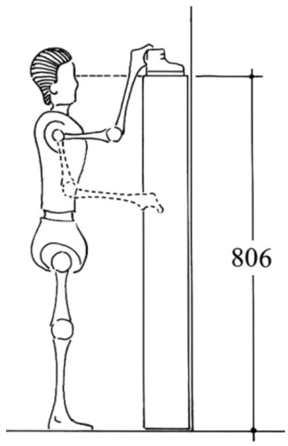

Fig. 13. Shoe, toy and equipment cupboard height (mm).

The toy, shoe and equipment cupboards

Cupboard height is important in designing of shoe, toy and equipment cupboard. The minimum value of eye height in standing position is used in calculating of cupboard height (Figure 13).
Because of the bending forward will take a short time while using toy and equipment cupboard, minimum shelf height wasn't calculated.

Calculation of shoe, toy and equipment cupboard height:

Cupboard height (min. value) = Eye height (X_{female}) – SD × Z

Cupboard height (min. value) = 92.84 – 6.26 × 1.96

Cupboard height (min. value) = 80.57 cm = 806 mm

Findings

Anthropometric measurements are necessary to form the data base which is required for the proper sizing of furniture to match the sizes of its intended users. In this study, we have formed such a data base by collecting the anthropometric data of children (aged 3–5 years) who attend crèches. Using the anthropometric data, the theoretical optimum measurements of furniture frequently used by the children were calculated. These theoretical optimum dimensions were compared to the measurements of furniture actually in use in crèches (Table 4). It can be seen that that the suitability of some types of furniture for use in crèches is questionable. For instance, the mean measured table heights (614 mm) are more than two standard deviations away from the calculated optimal height. Similarly, the mean table breadth (1099 mm) is almost two standard deviations greater than the theoretical optimum breadth (395 mm). However, the mean measured height of the table (512 mm) is easily within one standard deviation of the calculated optimal height (490 mm). Taken together, these data and calculations suggest that manufacturers of children's furniture are getting the height right but that they need to scale down the width and depth of the table dimensions to match the requirements of 3–5 year olds.

The bulleted items shown below summarize the findings of Table 4 in which the mean dimensions of existing créche furniture are compared to the calculated optimum measurements (Figure 14, 15 and 16):

- Table: The height of the existing table is over the optimum measure (512>490 mm) The depth does not provide adequate distance for two children to eat mutually in comfort. (614<345 × 2 mm). Existing table breadths are too wide for two people and too narrow for three people (1,099>395 × 2 mm).
- Chair: While there is no significant difference between the sitting depth of the available chairs and the calculated value (254<264 mm), the sitting breadth is greater on average than the calculated one (282>267 mm). Additionally, while the mean measured height of chairs is over the calculated minimum value (281>193 mm), it is close to the maximum value (281<285 mm).
- Bed: The mean depth (687>62 mm), height (334>193 mm) and breadth (1,308<1,235 mm) of the existing beds are over the calculated optimum values.
- Bunk: The mean height of bunks (1,196>931 mm) and the mean dimensions of W.C. pans (depth: 331>230 mm, breadth: 288>187 mm, height: 317<193 mm) are greater than the calculated optimum measures. The mean depth of washbasins (202<244 mm) is less than the optimum calculated value, while the mean height (597>515 mm) is greater.

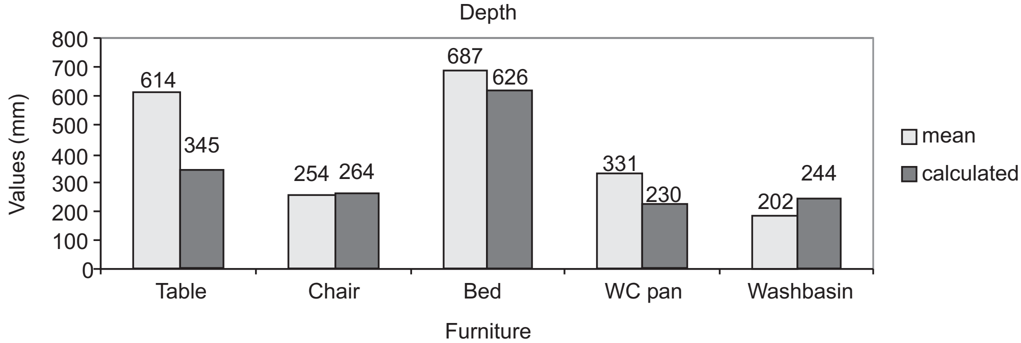

Fig. 14. Comparison of depths of existing furniture measurements and calculated measurements.

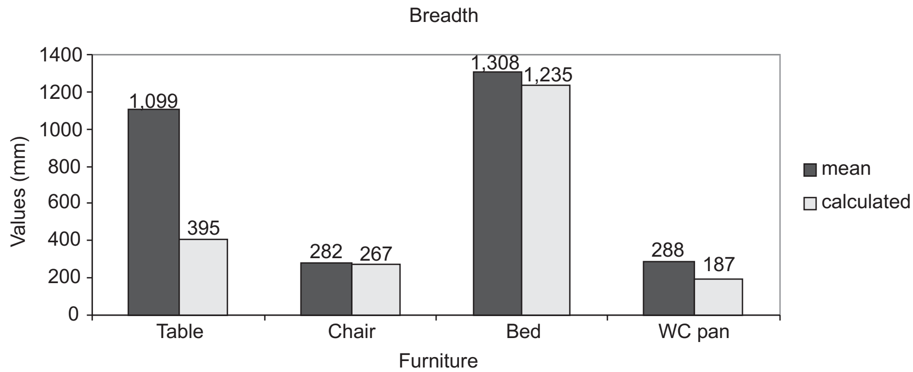

Fig. 15. Comparison of breadths of existing furniture measurements and calculated measurements.

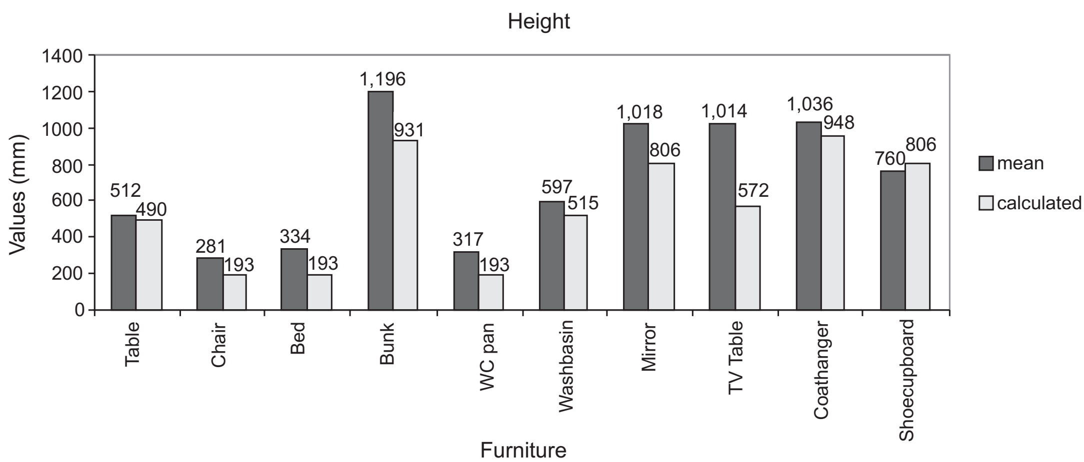

Fig. 16. Comparison of heights of existing furniture measurements and calculated measurements.

- Mirror: The mean height of mirrors (1,018>806 mm) is over the calculated optimum measure.
- TV table**:** The mean height of TV tables (1,014>572 mm) is almost twofold greater than the calculated optimum value.
- Shoe cupboard: The mean height of the shoe cupboards (760<806 mm) is less than the calculated optimum value.
- Coat hanger: The mean height of coat hangers (1,036> 948 mm) is over the calculated optimum value.

Discussion

The deviations between the existing and calculated optimum furniture measurements were written as percentages (see Table 5). Thus, the relative strength of the differences between the existing furniture dimensions and those of the optimum calculated values can be evaluated.

This study of the dimensions of current accessories used by children attending crèches revealed that the greatest deviation between these measured dimensions and the optimal calculated dimensions are those along the vertical or height coordinate while the smallest deviation occurred along a horizontal coordinate called »breadth« (Table 5). A one by one comparison of mean measured values against calculated optimal values show that the highest deviation (i) occur in all three dimensions of the W.C. pan, depth, the breadth, the height with deviations of 44%, 54% and 64% respectively; (ii) that deviations in the heights of chairs and beds are large (46% and 73%, respectively); and that (iii) the smallest deviations are found in the depth, the breadth and the maximum height of chair (4%, 6% and 1% respectively), the breadth of beds (6%), the heights of coat hangers and shoe cupboards (9% and 6% respectively).

- Table: It is observed that the existing table height is 22 mm less than the ideal measure. This case may cause a child to experience difficulties while moving, sitting at the table and standing up. Additionally, the breadth of table does not make it possible for two people to interact with each other in an activity that requires both people to participate.
- Chair: It is observed that the mean measured chair height is 88 mm greater than the desired value, which is the optimal calculated value. This large difference may cause trouble for most children, making it difficult for them to get into chairs and awkward to get out. The current chair depth is almost same with the ideal depth of chair (10 mm) and no ergonomic problems are

TABLE 5
THE DEVIATION RATIOS AND DIRECTIONS OF EXISTING FURNITURE MEASUREMENTS FROM CALCULATED OPTIMUM VALUES

Furniture	Depth (mm)		Breadth (mm)		Height (mm)	
	(+) Deviation	(–) Deviation	(+) Deviation	(–) Deviation	(+) Deviation	(–) Deviation
Table	–	11%	–	–	5%	–
Chair	–	4%	6%	–	46%**	1%***
Bed	10%	–	–	6%	73%	–
Bunk	–	–	–	–	29%	–
W.C. Pan	44%	–	54%	–	64%	–
Washbasin	–	17%	–	–	16%	–
Mirror	–	–	–	–	26%	–
Coat hanger	–	–	–	–	9%	–
Shoe cupboard	–	–	–	–	–	6%
TV Table*	–	–	–	–	–	–

* Because of the height of TV table is changeable according to the dimension of selected TV, the standard deviation of it wasn't calculated.
** The deviation ratio between the existing chair height and ideal min. chair height
*** The deviation ratio between the existing chair height and ideal max. chair height

expected here. It is seen that the mean breadths of chair are about 15 mm wider than the ideal measure. No ergonomic or functional problems are expected as a result of this small difference.

- Bed: It is not expected that a bed will be uncomfortable for its user if the existing mean bed depth (width) is 61 mm larger than the calculated ideal width.. However, that the mean bed length is 77 mm less than the optimal calculated value and that its height is 141 mm greater than the optimal height value suggest the possibility of ergonomic discomfort for the user or, especially in the case of height, the possibility that the user will have difficulty getting in and out of bed.
- Bunk: It is clearly a dangerous situation for children that the mean measured bunk height is 265 mm higher than the ideal. The danger arises from potential for children to fall out of bed while sleeping or falling while trying to climb into bed.
- WC Pan: In all three dimensions, the WC pan is not ergonomically designed to meet the needs of its users. The average WC pan in current use is 124 mm higher, 101 mm larger and 101 mm deeper than the ideal calculated values. It doesn't take much imagination to see the functional problems these differences will cause: inability to use the toilet properly or the possibility that the child will slip into the WC pan.
- Washbasin: The current average washbasin depth is 42 mm less than the ideal. This may cause difficulties for children their washing hands. Clearly children will have trouble using the average washbasin as it is 82 mm higher than the optimal calculated height.
- Mirror: The mean existing mirror height is 212 mm higher than the ideal calculated measure. Therefore, young children cannot use most mirrors currently in use. It is considered that this case makes discomfort (and corrupts the functionality of furniture).
- TV Table: It was determined that the mean height of existing TV tables is higher than the calculated ideal measure by nearly a factor of 2. This large difference in height between real and ideal suggests that children watching television will be forced to sit in uncomfortable positions possibly causing pain in the neck muscles, eye fatigue, and poor posture.
- Coat hanger: It was determined that the average existing coat hanger height is 88 mm higher than the calculated ideal height. This height difference suggests that most young children will find it difficult or impossible to use the coat hanger.
- Shoe cupboard: It was determined that the mean existent shoe cupboard height is 46 mm less than the calculated ideal height. However, this height, because it is less rather than greater than the ideal value, is still accessible for easy use by young children. Thus, it is expected that the differences (mean measured vs. ideal) will not cause discomfort or lack of use.

The data in this study indicate a substantial degree of mismatch between the furniture measure in crèches and the optimum crèche furniture available to them. Most children are using furniture that are too high, too deep or too breadth (wide-extensive). For instance, according to the calculated ideal measures, some differences considered to cause problems for the comfortable use were detected at the depth and the height of table; at the height of chair; at the length and the height of bunk/bed, at the depth and the height of washbasin; at the depth, the breadth and the height of WC pan; at the heights of mirror, TV table and coat hanger. The positive findings are that chair and bed depth and shoe cupboard were not problem for any student.

While the findings of this study are suggestive, they are based only on data from a convenience sample in a single school district. There may also be systematic variations in body dimensions, based on ethnic/racial characteristics of the students that were not captured in this study. Finally, our definition of mismatch focused on only a few furniture dimensions, such as height, depth and breadth may make to the fit to body dimensions.

If manufacturers are going to continue to produce and sell traditionally designed furniture, schools need to be encouraged to at least provide as much variety in furniture sizes as possible to accommodate the variety of student sizes. In this particular study, crèche furniture simply turned out to be too large for many 3, 4 and 5 year old children. Given the low priority generally assigned to the comfort and functional needs of students, it would not be surprising if school furniture in other school districts show a similar mismatch with students' overall body height. However, it is also important that health professionals working in schools be aware that full accommodation of students' needs would require ergonomically redesigned classroom furniture[4].

It is known that there are a lot of ergonomic problems in the schools in Turkey and this could increase effectiveness and health problems. Thus, the set of anthropometrical data obtained should be used for the design or adaptation of interior design and furnishing as well as the design of places for variable actions such as sleeping, studying, playing, eating and etc. In this context, this study is putting forward the optimum-optimal measurements of crèche furniture according to the anthropome - trical characteristics of crèche children in Trabzon, Turkey. And it is accepted that the continuity of this kind of studies is necessary for the researches as well as the producers and everyone relating with this concept.

This kind of studies would also put forward the differences between the optimum furniture measurements of children living in different regions in Turkey and the other countries. On the other hand, one of the increasing problems is childhood obesity around the world. The prevalence of overweight and obesity in adults and children is increasing in high-income countries[20,24], and is also rapidly emerging as significant health problem in less-developed countries[21,22,25,26]. It is appears that the increasing problem will affect furniture sizes. Consequently, because of the optimum furniture measurements were based on the data that taken from the children and those will change by the time, this kind of study would be repeated in every decade.

Acknowledgements

We thank all of the children who participated in this study. In addition, we thank all managers and employees of the schools for their support of this study.

REFERENCES

1. DAS, B., J. W. KOZEY, Applied Ergonomics, 30 (1999) 385. — 2. BRANTON, P., Ergonomics, 12 (1969) 316. — 3. KEEGAN, J. J., Bone Joint Surg., 35 (1953) 589. — 4. PARCELS, C., M. STOMMEL, R. P. HUBBARD, Journal of Adolescent Health, 24 (1999) 265. — 5. KAYIS, B., A. F. OZOK, Applied Ergonomics, 22 (1991) 49. — 6. MANDAL, A., Human Factors, 24 (1982) 257. — 7. HARPER, K., D. MALLIN, N. MARCUS: Ergonomic Evaluation of the Kinder Zeat Child Seat in a Preschool Setting. Project Report. (Cornell University, New York, 2002). — 8. CHAFIN, D., G. ANDERSON, Occupational biomechanics. (New York, Wiley, 1991). — 9. PRADO-LEON, L. R., R. AVILA-CHAURAND, E. L. GONZALEZ-MUNOZ, Applied Ergonomics, 32 (2001) 339. — 10. MULRY, R., Professional Safety, 27 (1992) 24. — 11. SALMINEN, J., Acta Paediatrica Scand., 315 (1984) 1. — 12. NIEMI, S. M., S. LEVOSKA, K. E. REKOLA, J. Adolesc. Health, 20 (1997) 238. — 13. LAHAD, A., A. MALTER, A. BERG, J. A. M. A., 272 (1994) 1286. — 14. OZOK, A. F.: An Anthropometric Research on Turkish Industrial Employees. (Tübitak, Ankara, 1981) — 15. KAYIS, B.: Determination of the dimensional measurement of the primary school children. (Tübitak, Ankara, 1986). — 16. KARAKAS, S., P. OKYAY, O. ONEN, F. ERGIN, E. BESER, Inonu University The journal of The Faculty of Medicine, 2 (2004) 73. — 17. YADAV, R., V. K. TEWARI, N. PRASAD, Applied Ergonomics, 28 (1997) 69. — 18. BOLSTAD, G., B. BENUM, A. ROKNE, Applied Ergonomics, 32 (2001) 239. — 19. BARLI, Ö., D. ELMALI, R. MIDILLI, E. AYDINTAN, S. ÜSTÜN, A. SAGSÖZ, S. ÖZGEN, T. GEDIK, Coll. Antropol., 29 (2005) 45. — 20. HEDGE, A., DEA325pdfs/ AnthroDesign.pdf, Accessed 18.02.2006. Available from: URL: http:// ergo.human.cornell.edu/studentdownloads/ — 21. NEUFERT, E.: The Main Knowledge of Construction Design. (Guven Pub., Istanbul, 1983). — 22. PHEASANT, S.: Bodyspace, Anthropometry, Ergonomics and Design. (Taylor and Francis, London, 1988). — 23. KIRVESOJA, H., S. VAKYRYNEN, A. HAKIKIOK, Applied Ergonomics, 31 (2000) 109. — 24. MOKDAD, A. H., M. K. SERDULA, W. H. DIETZ, J. Am. Med. Assoc., 282 (1991) 1519. — 25. WORLD HEALTH ORGANIZATION (WHO): Obesity, preventing and managing the global epidemic. (Geneva, Switzerland, 1998). — 26. FREEDMAN, D. S., S. R. SRINIVASON, R. A. VALDEZ, D. F. WILLIAMSON, G. S. BERENSON, Paediatrics, 99 (1997) 420.

Ö. Barli

Faculty of Economics and Administrative Sciences, Ataturk University, 25240 Erzurum, Turkey
e-mail: barli@atauni.edu.tr

ANTROPOMETRIJSKA PROCJENA NAMJEŠTAJA U DJEČIJEM VRTIĆU U TURSKOJ

S A Ž E T A K

Dimenzije stambenih prostora u zgradama, kao i odabir materijala različitog namještaja trebao bi biti u skladu sa antropometrijskim mjerama ljudi koji koriste taj prostoru. Za dizajn ergonomski povoljnog sistema potrebne su antropometrijske mjere ljudi. Upravo su zbog toga antropometrijske mjere najčešće korišteni ergonomski podaci tijekom dizajniranja. U ovim istraživanjima pokušano je prema antropometrijskim podacima organizirati novu bazu podataka za dizajn namještaja kojeg će koristiti djeca u vrtićima. Početna istraživanja bazirala su se na mjerenju dimenzija namještaja u dječjem vrtiću te ispitivanju kako trenutni namještaj utječe na tjelesne dimenzije i funkcionalne potrebe dječje populacije. U istraživanjima su upotrijebljeni antropometrijski podaci za 3 4 i 5 godišnju djecu. Prema rezultatima mjerenja 18 antropometrijskih karakteristika u djece, napravljena je baza podataka za dizajniranje funkcionalnog prostora i namještaja.