

SEATING FURNITURE FOR PUBLIC INTERIOR (CREATING OF NON-DISCRIMINATORY INTERIOR FOR PEOPLE WITH LIMITATIONS AND SENIORS)

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Abstract

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For optimal use and function in the public interior evaluation of seating furniture is important in terms of typology, ergonomics, safety, quality of design, used materials, ecology and other properties. The aim is to adjust the dimensional requirements of the seating furniture for public interior to meet the needs of the current population and reflect the proportional changes in the human body over the last decades.

Due to the ageing of population and growing number of people with movement and physiological limitations (which also include the elderly), it will become, in near future, more topical need to modify the rules related to seating furniture that is used in public space. Particularly, in the term of simple and non-discriminatory sitting down and standing up.

Proposal to change standards is based on the analysis of used values, the results of the current anthropometrical survey and addition of parameters that were processed by using ergonomic software.

In most of the activities related to the seating there is an interaction with the surrounding furniture. Based on this assumption arise the importance of connection between seating furniture and reaching distance of the person sitting on it. Ranges are in the computer simulation divided according to intensity - static, dynamic and comfortable (with the preservation of the natural physiological limitations of joints). The resulting values of simulations can be defined distances suitable for placing objects near seating furniture to ensure the possibility of full utilization.

If the principles are kept and they come from the needs of people with limitations, it is certain that the environment will suit all healthy individuals and at the same time it will be non-discriminatory for a greater proportion of people with physical limitations.

furniture, sitting, non-discriminatory public interior, anthropometry, reach zone, handicap

Not every piece of the seating furniture, out of wide spectrum of typology, is appropriate for public interior. It must meet a wide list of requirements for the design, construction, and use of materials as well as for safety. Sitting is closely connected with human anatomy. Based on this and anthropometrical measurement criteria for appropriate ergonomics and dimension of seating furniture can be established.

Conclusions of the current research are different from the original studies (Grandjean, 1973; Panero and Zelnik, 1979; Dlabal, 1983; Neufert, 2000) because it is a project realized in a long time ago (the latest data from the sixties 20th century). It would be desirable to make the survey at regular time intervals when it is possible to establish (on the basis of the results) the data series and then specify an estimation of the objective trend of the future

development of the population and related changes. Only current users' data processing can ensure the production of appropriate furnishings that will satisfy the majority of population. It is appropriate to note that the users of seating furniture, especially if it is located in the interior, are not only people in optimum physical condition. Public environment must be created for the full availability to all the users and discriminatory barriers must not arise within it.

Sitting in the majority of cases is related to other human activities. Precisely because of the need to tackle the complexity of the session it is not possible to define the seating furniture in isolation but always in coexistence with the surrounding structures. From that assumption we can understand the importance of the context of seating furniture and the distance of a person who sits on it.

The aim of the work is to adjust the dimensional requirements for seating furniture for the interior so as to meet the needs of the current population and to reflect proportional changes of the human body in the last decades. The location of the furniture in the public space brings with it the condition of fitness for a major proportion of the users because there is no possible adjustment to the level of the user in the private interior. The aim is to define the ergonomic criteria that comply with the conditions and this "universal" location. The issue of ergonomics must be dealt with on the basis of the current anthropometric measurement.

Due to the ageing of population and growing number of people with movement and physiological limitations (which also include the elderly), in the near future, more topical need to modify the requirements related to seating furniture that is used in public space will be necessary. Particularly, in the terms of simple and non-discriminatory sitting down and standing up. The issue about elderly people is identical to the issue about people with disabilities and the requirements for seating furniture are not very different as it results from their needs.

The aim is to incorporate those terms and conditions to the requirements of seating furniture for public interior so as the resulting solution is not discriminatory and allows for a full recovery, as well as for persons with disabilities. In most activities related to sitting the interaction with the rest of the furniture and furnishings occurs. It is necessary to take their coherence and the possibility of a full recovery into account. The need for solutions of the distance of the sitting man implies from that. The distance is affected not just by the physical dimensions but also by the physical condition of the user.

METHODS

The analysis of values reported in standards and in the scientific literature was the starting point. It was followed by the processing of the results of

the current anthropological research and these were verified by the critical ergonomic criteria using specialized software. Further questions related to lumbar and head rests were clarified when solving various standardized sizes and their corresponding values of anthropometric measurements. It must be stated that in the literature the origin of dimensions is not determined therefore it is not clear how the reported values were obtained.

Current anthropometric measurement (from 2009 to 2012) was carried out in the framework of the project of the NIS "Furniture Information System for the Support of the Research, Development, Innovation and Quality of Furniture" with the support of the Ministry of Industry in the Czech Republic. The project was designed at the Department of Furniture, Design and Habitation of Mendel University in Brno. 375 subjects were measured (182 men and 193 women). To help clarify the results of measurement, the statistics has been developed. The statistics shows the ideal distribution of body proportions measured. On its basis the interval of the usual dimensions between the 25th–75th percentile in the so-called middle figures was established and it is further used for the comparison. Dimensions are measured according to ČSN EN ISO 7250-1: 2010 Basic human body measurements for technological design. Body measurement definitions and landmarks.

Methodology and working methods in dealing with the dimensions of seating furniture with the help of ergonomic software Tecnomatix Jack

The solution comes from functional dimensions analysis referred to in the literature and standard. It is followed by a graphical and statistical processing of the results of the current anthropometric measurement and verification of the critical ergonomic criteria in the software Tecnomatix Classic Jack (the building of the models of the environment – the definition of environment, inserting the figure and an object needed to perform the analysis; the change of the default model men/women according to the results of anthropometric survey → real appreciation of the dimensions of furniture; the adjustment of the model to the desired position using the features of human control and adjust joint; the hands, back and feet analysis using posture analysis) and evaluation and interpretation of results of analyses carried out.

Generating of reach zone – Tecnomatix Jack simulates the movement of the point of the human model which is limited by real physiological range of joints and creates a network model of reach area. Implications of computer animation are divided according to the intensity of the movement of the other parts of the body into the static, dynamic and comfortable reach.

DISCUSSION AND RESULTS

Ergonomics of seating furniture on the basis of the final values of anthropometric measurement

As for chairs and sofas, we should also add the dimensional allowances for rest session and the change of the inclination of the seat cushion and backrest angles for comfort seating.

Lumbar backrest

For the height determination of lumbar support graphical modelling was used, because there is no corresponding anthropometric characteristic, through which it would be measured. Definition of each figure is built on the basis of measured anthropometric characteristics, body height and body weight. Setting of lumbar support above the seat is defined as distance of top curvature of lumbar support from seat, which is in graphic processing expressed by the distance of lumbar vertebra (top of lumbar lordosis – curvature) from the sitting plane.

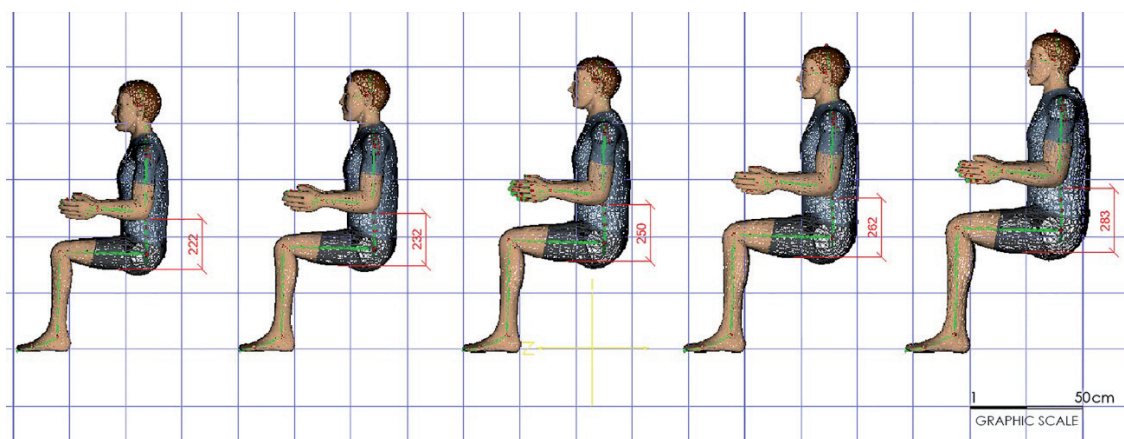
Interval of average values for further use in solving ergonomic seating was set to interval corresponding values for the figures of 25th and 75th percentile, i.e. after rounding the recommended lumbar support height above seat is 230–260 mm.

Head rest

There is no descriptive variable in the set of characteristics of anthropometric measurements, which corresponds precisely to the location of lateral head supports. Because the fulcrum placed at eye level next to the head of seated user allows comfortable support and also provides in backward direction sufficient support for the neck, as approximate retaining quantity for determining height of side / headrest, characteristic eye level while seated can be used. Current anthropometric measurement determines an average interval of seated eye height from 761 to 821 mm. At the same height the middle part of lateral headrest should be

I: Comparison of results of the current anthropometric measurement with recommended dimensions for chairs (in mm)

Dimension	Dlabal (1983)	Panero, Zelnik (1979)	Neufert (2000)	Grandjean (1973)	Current anthropometric measurement; (interval between 25. and 75. percentile)
Seat Width ← Hip Breadth	380	406–432	450	435	379–423
Armrest spacing ← Elbow to Elbow Breadth	min 450	457–508	-	-	543–681
Seat Depth ← Buttock-Popliteal Length	380	394–406	450–500	435	468–511
Lumbar Backrest ← Lumbar Height	180	279	-	140	-
Seat Height above the floor ← Popliteal Height	420	406–432	450	370–400	400–440
Height of Armrests ← Elbow Rest Height	200–250	203–254	-	260	225–257
Angle of Tilt of Seat Surface	0–3°	0–5°	-	6°	-
Angle of Backrest	95°	105°	-	101–108°	-
Backrest Height	700–1020	787–838	900	-	-



1: Determination of height of lumbar support for the figure value 5. and 25. percentile average, 75. and 95. percentile according to the current anthropometric measurements (modelled in Tecnomatix Jack; dimensions in mm)

II: Height of the center of lumbar backrest from seat surface (in mm)

	5. percentile	25. percentile	X	75. percentile	95. percentile
Unisex	222	232	250	262	283

placed, which allows a comfortable head support in rest seating. Because higher backrest doesn't prevent use by any person of smaller stature, the minimum height of the top edge of the back seat may come out from average measured value, i.e. minimum height of top edge of back-rest at high resting seat should be 790 mm.

Recommended dimensions of seating furniture according to current anthropometric criteria

To determine requirements, normal sized intervals were considered, i.e. value intervals 25.–75. percentile of current anthropometric measurements. In case of seat, minimum value can be regarded as 75. percentile measured width of seat i.e. 420 mm. Size can be deduced from the upper limit of usual interval dimensions primarily because that even when the width of the seat is greater, it does not cause improper seating. With seats without armrests it is also preferable to increase the minimum value to 380 mm in order to improve the seating comfort.

The distance of armrests is a dimension corresponding to the distance of the elbows, but also the width of the sitters hips; dependence is here manifested especially in the course of standing up and sitting down. Proposed value 540 mm

corresponds to the 25. percentile of measured elbow distance; is derived from the lower limit intervals of normal range dimensions, because too much distance between armrests prevents their use by smaller users. Simultaneously it doesn't limit users with greater width of the seat, because it corresponds to the maximum measured values for the characteristic width of the seat.

About armrests—their height above the seating area is also problematic. For proper function of the armrests when seated upright is needed their minimum height 220 mm (equivalent to approximately 25. percentile value, i.e. the lower limit interval of normal size); maximum height of 260 mm (corresponding to approximately 75. percentile of measured values).

Seat depth—proposed range values from 400 to 490 mm corresponds to reduction of measured lengths interval of usual size.

Seat height – desired interval from 420 to 480 mm.

Recommended values of registered height of the lumbar support is the result of graphical modelling. The angle of inclination of seat to the floor and the angle of the backrest to the seat were not measured and reported normal values were found to be satisfactory.

Due to the increasing level of the population and persons with limitations (disabilities and seniors –

III: *Recommended dimensions for chairs according characteristics of current users (in mm). Suggestions for adjustment of the standard ČSN 91 0620.*

Dimension	Chair without armrests	Chair with armrests
Seat width	min. 380	min 420
Armrest spacing	-	min 540
Seat depth	400–490	min 400
Backrest – lumbar support	230–260	
Seat height above the floor	420–480	
Height of armrests	-	220–260
Angle of tilt of seat surface	not measured (0–5°)	
Angle of backrest	not measured (max. 110°)	

IV: *Recommended dimensions for armchairs and sofas according characteristics of current users (in mm). Suggestions for adjustment of the standard ČSN 91 0611.*

Dimension	Formal furniture	Resting furniture – low backrest	Resting furniture – high backrest
Height of the front edge of the seat	min 420		
Seat width	min 380		
Height of the center of lumbar backrest from seat surface	230–260		
Backrest Height	min. 450	min. 510	min 790
Height of Armrests	max 220		
Seat depth	min 450		
Angle of tilt of seat surface	5–10°		5–10 (15)°
Angle of backrest of seat surface	max 95°	95–105°	95–105(110)°
Seat width for one person – armchair	min 530		
Seat width for one person – sofas	min 560		
Inner distance between armrests	min 620		

those percentage representation in population is still growing) the suitable height of seat relaxation furniture is at least 420 mm, as well as with seats. Increase of minimal seat height under load has its justification in particular reason to facilitate getting up. The height of back seat was solved only for enabling the resting of one's head against a high chair (height 800 mm). Other values correspond approximately to leaning on the shoulderblades (community chair) and resting one's arms (low resting chair).

Determining the height of the lumbar support is result of graphical modelling; recommended height of lumbar support above the seat is 230–260 mm.

For relaxing sitting, especially with increasing distance of armrest from body height of armrests is being reduced; similarly as in chairs, the maximum height of armrests is set at 220 mm (value corresponding to approximately the 25. percentile, i.e. lower limit interval of normal dimensions for elbow height).

Depth of seat is slightly increasing in comparison to the chairs in order to maintain dimensional allowances for user comfort while sitting. Seat angle toward horizontal plane, which is greater than 10° carries a risk of "slipping" and subsequently difficult standing up and it is not suitable as resting furniture, it can be used in exceptional cases, but no more than 15°. Large gradient angle of backrest reclines causes excessive backward bend while seating, which is not always desirable and difficult subsequent standing up. The upper limit of recommended angle is 105°, and 110° for exceptional cases. Especially for furniture in public interior is suitable to choose

gradient angles of seat and backrest from the first part of the interval, because it ensures comfortable seating and standing up for a greater percentage of users.

Increasing of the width of seat shows the measured values of seat widths and dimensional allowances required to ensure seating comfort. Minimal value of the width of the seat for one person is 530 mm. For reason of not always desired contact with the sitters on multisite sofas, the recommended width for one person sitting on multisite sofas is increased to 560 mm.

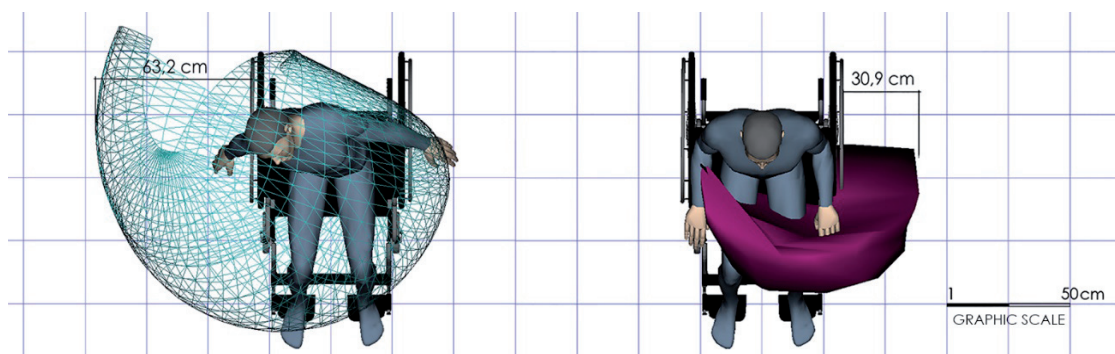
The same reasoning is solved by a proposal to change the size of the internal distance between the armrests, which is maintained in addition to the value of the proposed distance armrests on chairs.

Reach zone

The seating has to be seen as a set of activities in relation with the environment. Only in a small number of cases, sitting should be considered as a separate activity session (rest sitting in a chair), while most are affected with seating continuous activities (working at office desk, dining, leaning for surrounding objects even in case of relax seating). Value of real distance range is quite variable, depending not only on the physical dimensional parameters of the individual, but also his/her physical condition.

According to the intensity of body movement ranges are divided into static, dynamic and comfortable.

- static reach characterizes the maximum distance reach without moving the body



2: Generating outreach distances to side with tilting and comfortable range using Tecnomatix Jack (graphic scale: 1 segment = 25 cm)

V: Distance values for static, dynamic and comfortable reach; generated in Tecnomatix Jack (in mm)

	reach forward	reach to the side – from the edge wheelchair	reach to the side – from the axis of the body	upper reach
anthropometric measurement	733	515	865	-
Tecnomatix Jack – static reach	731	523	873	1307
Tecnomatix Jack – dynamic reach	bending forward 1002	with tilt 632	with tilt 982	
Tecnomatix Jack – comfortable reach	646	309	659	691

- dynamic reach in comparison to the static is expanded by the value of reach distance when connected with other parts of the body
- comfortable reach is generated because of the high rate of repetition of movement with minimal load on the body without overloading the body and without tilting.

Filipiová (2002) is also dealing with this issue in her publication and the value of outreach distances stated in its materials Disabilities Association of the Czech Republic (1991) and also construction activity of European Commission (1995). However, it should be noted that none of them does mention origin of data, and in most cases neither the exact characteristics of the starting points of the measured distance.

CONCLUSION

In terms of the required non-discriminatory furnishing of public space, it is not possible to base the approach only on the requirements of a fully fit healthy population when placing seating into the

public interior. Rather, it is necessary to fully adapt the environment for unlimited usability also for disabled people.

The principles of seating in the public interior to create a non-discriminatory space are:

Selecting the appropriate type of seating dimensionally compliant for majority of population, while also allowing ease of use for people with limitations

- a sufficient seat width and distance between armrests
- sufficient height seating surfaces without excessive inclination (ease of getting up and down)
- fixed armrests for stable support
- without wheels and risks of underrun (safety aspect)

Locating solitaires, so as to maintain sufficiently wide communication zones, allowing comfortable use outside facilities within the outreach distances

- maintaining the distance range for comfortable reaching of control elements and items of common use

SUMMARY

Differences between the existing regulations (based on outdated data and used without reflections of changes in population in the last decades) and the current characteristics of the populations, the constituent part of the work became data processing for adjustment of standards for chairs, armchairs and sofas. Based on the detected values were proposed ideas for their changes so that they are in compliance with the current requirements for seating furniture. Sources which the work refers to the way of unsatisfied existing regulations were also processed using specialized ergonomic software and are valid for seating furniture placed not only in the public interior.

On the basis of the necessity of creating non-discriminatory interiors we need reflect requirements of people with limitations, which include an increasing number of seniors too. Public interior must be available and full utilization adapted also for people walking with difficulty, wheelchair users and blind people.

During the research was found problem with anthropometric points determination and their measurement for lumbar support. Lumbar backrest characteristic is a result of ergonomics software simulation based on other current measured anthropometric characteristics. Setting of lumbar support above the seat is defined as the distance of top curvature of the lumbar support from seat, which is in graphic processing expressed by the distance of lumbar vertebrae (top of lumbar lordosis-curvature) from the plane sitting. Tecnomatix Jack simulates the movement of the point of the human model which is limited by real physiological range of joints.

The resulting values for outreach distances corresponding with the intensity of body movement. According to its extent we can determine the suitability of the location of objects in the sitting area.

If the principles of needs of handicapped persons remain, then the environment will be suitable for all healthy persons and will not discriminate for most people with physical handicap.

REFERENCES

- DLABAL, S. a kol., 1983: *Nábytek, člověk, bydlení*. Praha: ČS středisko výstavby a architektury, 178 s.
- FILIPIOVÁ, D., 2002: *Projektujeme bez bariér*. Praha: Ministerstvo práce a sociálních věcí, 101 s. ISBN 80-865-5218-7.
- GRANDJEAN, E., 1973: *Wohnpsychologie: Grundlagen gesunden Wohnens*. Zürich: Verlag für Architektur Artmenis, 371 s. ISBN 37-608-8026-6.
- KOLEKTIV, 1995: *Evropská příručka pro přístupné prostředí vytvářené výstavbou*. Praha: ABF, 133 s. ISBN 80-901608-2-4.
- NEUFERT, E., 2000: *Navrhování staveb: Příručka pro stavební odborníky, stavebníky, vyučující i studenty*. 2. české vyd., Praha: Consultinvest, 618 s. ISBN 80-901486-6-2.
- PANERO, J. and ZELNIK, M., 1979: *Human dimension: A source book of design reference standards*. 2. vyd.

- London: Architectural Press, 618 s. ISBN 08-513-9457-4.
- ČSN 91 0620, 1982: *Nábytek. Židle. Funkční rozměry a způsoby měření*. Praha: Český normalizační institut.
- ČSN 91 0611, 1988: *Nábytek. Křesla a pohovky. Základní rozměry*. Praha: Český normalizační institut.

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