# Anthropometric Consideration of Interior Design of City Buses

*Aleksandar Zunjic* [a] , *Svetozar Sofijanic* [b] and Evica Stojiljkovic [c]

[a] *University of Belgrade*
*Faculty of Mechanical Engineering*
*11000 Belgrade, Serbia*

[b] *Lasta*
*11000 Belgrade, Serbia*

[c] *Univerity of Nis*
*Faculty of Occupational Safety*
*18000 Nis, Serbia*

## ABSTRACT

There are numerous researches that are connected with designing of the bus driver's workplace. However, there is no a study that has been conducted in relation to the designing of the interior of city buses from the anthropometric aspect. It is noticeable the lack of existence of the methodology for collecting the relevant ergonomic data that can be used at the designing stage of buses for public transport of passengers. This article is primarily concerned with solving the problem of selection of relevant anthropometric dimensions that need to be considered when designing the city buses. On the basis of adopted criteria, certain number of relevant anthropometric dimensions is initially selected for designing the interior of buses. In addition, the initial methodological approach has been further improved by creating the new anthropometric dimensions (such is, for example, the comfortable grip height) that should be measured in connection with designing certain elements of the bus interior. These dimensions are named the comfortable anthropometric dimensions. For each new dimension, the measurement method is described. In addition, each dimension is associated with the function that it has in terms of designing and positioning of certain parts of the interior of the bus.

**Keywords**: City Bus, Anthropometry, Comfortable Anthropometric Dimensions

## INTRODUCTION

A number of studies was previously published, regarding the design of the bus driver's workplace from the anthropometric aspect. However, there is no a research that has been conducted in relation to anthropometric designing of the interior of buses for urban transport from the aspect of passengers. To the importance of the need for the aforementioned type of research indicate data that have been recently published in the scientific literature (Albertsson and Falkmer, 2005; Halpern et al., 2005; Palacio et al., 2009, Zunjic et al., 2012), which are related to the injuries of the passengers during the collision and non collision situations involving buses in urban city areas. From the analysis of types of injuries and way of injuring, it can be concluded that one of the causes of injuring was the incompatibility of designed equipment which is integral part of the interior of a bus, with anthropometric characteristics of passengers.

Due to the lack of scientific and technical literature, which deals with the problem of designing of the interior of buses for urban transport of passengers from the ergonomic aspect, most manufacturers of this type of buses were forced to create structural characteristics of individual elements inside the bus alone, often without specific reliance on relevant anthropometric data. So, it is noticeable the lack of existence of the methodology for collecting the relevant ergonomic data that can be used at the design stage of buses for public transport of passengers. In this regard, of particular importance is the determination of proper anthropometric dimensions that should be taken into account when designing the mentioned types of buses.

### Problem

One of the rare documents that treats constructional aspects of the interior of busses is the E/ECE/TRANS/505 recommendation. This recommendation has an international application, and it is used in designing by a number of bus manufacturers. However, the lack of this recommendation is that it does not include all ergonomic aspects to be taken into account when designing the interior of busses from the anthropometric aspect. This article is primarily concerned with solving the problem of selection of relevant anthropometric dimensions that need to be considered when designing the buses for transport of passengers in urban city areas.

## INITIAL METHODOLOGICAL FRAMEWORK

Depending on the problem under consideration, various researchers specify different anthropometric dimensions that should be taken into account for the design of various products (or for different categories of users). In order of selection of anthropometric variables that are relevant for the design of busses, the extensive literature dealing with various problems in the field of anthropometry was taken into account (Dewangan et al. 2008; DOD, 1991; Gordon et al. 2013; Kroemer and Grandjean, 1997; NASA, 1978a; NASA 1978b; Parkinson and Reed, 2010; Pheasant, 2003; Robinette et al., 2002; Roebuck, 1995; Wagner et al., 1996).

Based on analysis of mentioned literature, an initial set of 132 anthropometric dimensions was selected for further analysis. This set of anthropometric variables has been selected on the basis of appreciation of several criteria. First of all, it has been necessary that this initial set includes all body regions. In addition, it is necessary that the set encompasses a wider range of anthropometric dimensions. In this way, the probability for omitting some anthropometric dimension that is of importance for designing is minimized.

Each of the selected dimensions was further analyzed, in terms of its usefulness for designing of some interior part of the bus. In this regard, each of these 132 anthropometric dimensions was also classified as a dimension that is important for designing from the aspect of passengers, as a dimension that is potentially important, as a dimension of little importance or as a dimension of marginal importance. As a result of this analysis, a certain number of relevant anthropometric dimensions is selected for designing the interior of buses, which are intended for the transport of passengers in sitting and standing position.

Classification of anthropometric dimensions given in the list that follows has been performed in the following way. In the group "of importance" (OI) have been classified the anthropometric dimensions that almost without exception should be included, if we want to achieve a quality design solution for city bus interior. Each dimension from this group of anthropometric dimensions has a specific purpose in connection with designing (positioning) the equipment with an ergonomic point of view. Anthropometric dimensions that should take into account when we want to design the new or a specific design solution with an increased level of comfort and safety are classified in the group "of potential importance" (OPI), and dimensions that should be considered in the case when we want to define a more precise position which is required for accommodation of the equipment, as well as when in the case of certain user population, some of the anthropometric dimensions from the group "of importance" do not adequately reflect the situation for which it is necessary to accommodate the design solution. As well as the group "of importance," this group of anthropometric dimensions certainly should take into consideration when designing the interior of the bus.

The group "of little importance" (OLI) includes anthropometric variables that less accurately reflect a situation or occurrence that should be taken into account when designing, in relation to the dimensions belonging to any of the above-mentioned two groups. Almost each of these dimensions has a more precise alternative, which is contained in the group "of importance" or in the group of dimensions "of potential importance". In the best case, some of the anthropometric dimensions from this group could be used for very specific solutions. The last group "of marginal importance" (OMI) primarily includes anthropometric variables that do not have an impact on the design of the interior of the bus, or their application is almost impossible to predict. Some of the anthropometric dimensions from this group also have a considerably more precise replacement in all three previously mentioned groups. Due to its characteristics and on account of reduced importance for designing the interior of the buses, group of anthropometric sizes "of little importance" and "of marginal importance" in the vast majority of cases can be omitted from consideration when designing the interior of buses for public transport of passengers. The list with the classification marks is given below.

| | |
|---|---|
| • Stature | OI |
| • Waist depth | OPI |
| • Biacromial breadth | OMI |
| • Chest depth | OI |
| • Eye height, sitting | OMI |
| • Abdominal extension depth, sitting | OLI |
| • Thigh clearance | OMI |
| • Foot length | OI |
| • Waist height, sitting (natural identation) | OMI |
| • Wrist height | OMI |
| • Acromial height | OPI |
| • Vertical grip reach | OI |
| • Lateral femoral epicondile height | OLI |
| • Waist height  sitting (omphalion) | OMI |
| • Axilla height | OMI |
| • Elbow-fingertip length | OPI |
| • Bustpoint/thelion-bustpoint/thelion breadth | OMI |
| • Suprasternale height | OMI |
| • Scye depth | OLI |
| • Maximum body breadth | OI |
| • Acromial height, sitting | OPI |
| • Waist height (natural indentation) | OMI |
| • Waist height (omphalion) | OMI |
| • Popliteal height | OI |
| • Wrist height, sitting | OMI |
| • Bispinous bredth | OMI |
| • Buttock depth | OLI |
| • Chest height | OMI |
| • Crotch length (natural identation) | OMI |
| • Cervicale height, sitting | OPI |
| • Crotch length (omphalion) | OMI |
| • Iliocristale height | OMI |
| • Waist back length (natural indentation) | OLI |
| • Neck-bustpoint/thelion length | OMI |
| • Tenth rib heith | OMI |
| • Knee height, sitting | OI |
| • Waist breadth | OMI |
| • Calf height | OMI |
| • Bideltoid breadth | OPI |
| • Cervicale height | OMI |
| • Chest breadth | OMI |
| • Elbow rest height | OI |
| • Shoulder length | OMI |
| • Strap length | OMI |
| • Waist back length (omphalion) | OLI |
| • Waist front length (natural indentation) | OMI |
| • Waist front length (omphalion) | OMI |
| • Interscye II | OLI |
| • Waist (natural indentation) to waist (omphalion) length | OMI |
| • Axillary arm circumference | OMI |
| • Sitting height | OI |
| • Buttock circumference | OMI |

| | |
|---|---|
| • Calf circumference | OMI |
| • Knee height, midpatella | OLI |
| • Chest circumference | OMI |
| • Cest circumference at scye | OMI |
| • Cest circumference below breast | OMI |
| • Buttock-knee length | OI |
| • Elbow circumference | OMI |
| • Knee circumference | OMI |
| • Functional leg length | OPI |
| • Lower thigh circumference | OMI |
| • Neck circumference | OMI |
| • Interscye I | OLI |
| • Neck circumference, base | OMI |
| • Overhead fingertip reach, extended | OMI |
| • Buttock-popliteal length | OI |
| • Scye circumference | OMI |
| • Shoulder circumference | OMI |
| • Radiale-stylion length | OLI |
| • Thigh circumference | OMI |
| • Waist circumference (natural indentation) | OMI |
| • Waist circumference (omphalion) | OMI |
| • Sleeve outseam | OLI |
| • Hip breadth, sitting | OI |
| • Wrist circumference | OMI |
| • Biceps circumference | OMI |
| • Shoulder-elbow length | OLI |
| • Buttock height | OMI |
| • Crotch height | OMI |
| • Forearm-forearm breadth | OI |
| • Forearm circumference, flexed | OMI |
| • Trochanteric height | OMI |
| • Span | OLI |
| • Vertical trunk circumference (ASCC) | OMI |
| • Vertical trunk circumference (USA) | OMI |
| • Forward grip reach, sitting | OI |
| • Waist-hip length | OMI |
| • Crotch length, posterior (natural indentation) | OMI |
| • Crotch length, posterior (omphalion) | OMI |
| • Acromion-radiale length | OLI |
| • Ear length | OMI |
| • Ear length above tragion | OMI |
| • Ear protrusion | OMI |
| • Hip breadth | OLI |
| • Sleeve length, spine-elbow | OMI |
| • Sleeve length, spine-scye | OMI |
| • Sleeve length, spine-wrist | OMI |
| • Vertical grip reach, sitting | OI |
| • Bitragion chin arc | OMI |
| • Bitragion coronal arc | OMI |
| • Bitragion crinion arc | OMI |
| • Bitragion frontal arc | OMI |
| • Wrist-wall length | OLI |
| • Bitragion submandibular arc | OMI |
| • Bitragion subnasale arc | OMI |
| • Bizygomatic breadth | OMI |
| • Hand length | OI |
| • Ear breadth | OMI |
| • Head breadth | OMI |
| • Head circumference | OMI |

| | |
|---|---|
| • Head length | OMI |
| • Interpupillary breadth | OMI |
| • Menton-sellion length | OMI |
| • Ankle circumference | OMI |
| • Ball of foot circumference | OMI |
| • Ball of foot length | OMI |
| • Bimalleolar breadth | OMI |
| • Foot breadth, horizontal | OMI |
| • Hand breadth | OMI |
| • Hand circumference | OMI |
| • Heel breadth | OMI |
| • Lateral malleolus height | OMI |
| • Thumb breadth | OMI |
| • Wrist-center of grip length | OMI |
| • Wrist-index finger length | OMI |
| • Wrist-thumbtip length | OMI |
| • Wrist-wall length, extended | OLI |
| • Gluteal furrow height | OMI |
| • Overhead fingertip reach, sitting | OLI |
| • Midshoulder height, sitting | OMI |
| • Neck height, lateral | OMI |

## FURTHER DEVELOPMENT OF THE METHODOLOGY

Anthropometric dimensions that are presented in the list are dimensions that can be found in the literature. However, only the use of specified dimensions cannot fully provide the comfort and safety of passengers. In this regard, as a result of observation of body positions and behavior of passengers during transport in buses for public transportation, the need for identifying additional anthropometric dimensions has been noticed. Mentioned new anthropometric dimensions were created based on the observation of passengers in standing and sitting positions, in different conditions of transport (when the bus has few passengers, and especially in situations when it was recorded big crowd).

Most of the anthropometric dimensions that are listed above are related to some maximum distance. For example, knowing the dimension overhead grip reach is necessary, but not sufficient if we want to provide adequate passenger comfort during transport. One cannot expect that a passenger holds the hand during the whole transport in the position of maximum reach, and to suppose that he is satisfied with the way of transport. In this regard, first of all, the passengers expect handrails on the positions that are most comfortable to them for grip and holding during an extended period of time.

As a result of the large number of interactions with passengers who use buses for urban transport, conducted interviews, surveys and testing, certain new anthropometric dimensions have been established, which are named comfortable anthropometric dimensions. These anthropometric dimensions have for the aim, first of all, to enable comfortable, and also the safe transporting the passengers, when on the occasion of designing the individual segments of the interior we take these dimensions into consideration. In the group of the comfortable anthropometric dimension belong: universal comfortable grip height, overhead comfortable grip height, below head comfortable grip height, universal comfortable grip length, overhead comfortable grip length, below head comfortable grip length, comfortable grip height (sitting) and comfortable grip length (sitting).

In addition to comfortable anthropometric dimensions, there are also several anthropometric variables that we could not find in the previously reviewed literature. However, their measurement is also important because it contributes to the design of the interior of buses on the principles of safety and comfort. These anthropometric dimensions are: height of forward grip reach (sitting), minimum grip height, lower thoracic height and upper thoracic height.

All these newly formed anthropometric dimensions in accordance with the classification criteria that were applied on the above presented list, also can be classified into two groups. The first group, of importance for designing, includes the following anthropometric dimensions: universal comfortable grip height, overhead comfortable grip height, below head comfortable grip height and height of forward grip reach (sitting). The second group, of potential importance for designing, includes the following anthropometric dimensions: universal comfortable grip length, overhead comfortable grip length, below head comfortable grip length, comfortable grip height (sitting), comfortable grip length (sitting), minimum grip height, lower thoracic height and upper thoracic height.

In the following, all anthropometric measures from groups of importance for designing and of potential importance for designing graphically will be displayed, and brought in connection with the design of a specific part of the bus interior. For the newly formed anthropometric dimensions will be explained further the way of their measurements.

## Anthropometric dimensions of importance for designing the bus

*Stature*
This basic dimension of the human body determines vertical clearance required for accommodation of passengers that are in standing position (Figure 1, dimension 1).

*Chest depth*
It determines clearance between seat backs and obstructions. It is also important for determining the number of people who can at the same time stand in a passage or pass each other along the passage, and for the planning the total number of passengers who can be accommodated in a bus (Figure 1, dimension 2).

*Foot length*
It is important for predicting the necessary space for the accommodation of the feet of the person sitting if an obstacle is located in front of the passenger (e.g. panel), then for determining the width of the passage in the bus, and for determining the length of the stair (Figure 1, dimension 3).

*Vertical grip reach*
This dimension is important for determining the maximum height on which the handrail can be positioned (Figure 1 (2), dimension 4).

*Universal comfortable grip height*
This dimension defines the most comfortable position on which should provide the handrail along the vertical axis, so as to ensure conditions for transportation of passengers with the minimal fatigue of the hand, as well as parts of the body that are associated with this posture, while maintaining the necessary stability at the same time. If the measurement is conducted under laboratory conditions, before measuring a subject receives instructions to imagine that is located in a bus for public transportation of passengers and to put the hand (in which he/she holds the cylinder that simulates the handrail) into the position for which he/she considers that is the most appropriate in terms of minimum fatigue over a longer period and maintaining the stability. Then measure the distance from the floor to the knuckle (Figure 1 (3), dimension 5).

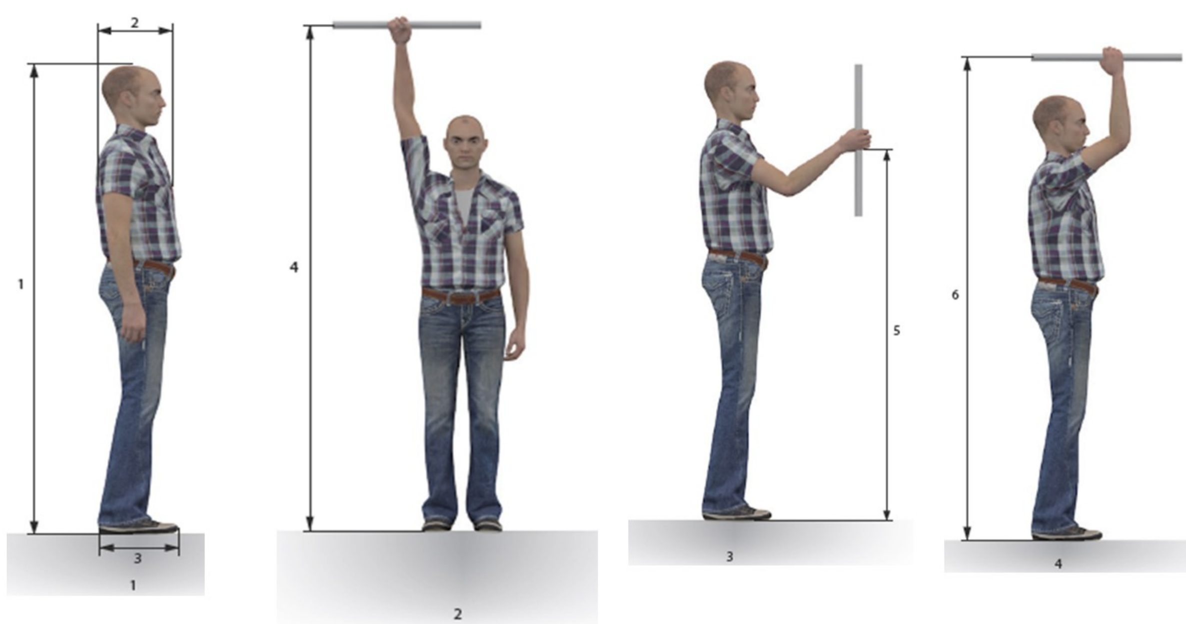

Figure 1. Anthropometric dimensions of importance for designing the bus.

*Overhead comfortable grip height*

This dimension defines the most comfortable position on which should provide the handrail above the top of the head, so as to ensure conditions for transportation of passengers with the minimal fatigue of the hand (as well as parts of the body that are associated with this posture), while maintaining the necessary stability at the same time. It appreciates the fact that there are certain reasons for positioning the handrails above the head. If the measurement is conducted under laboratory conditions, before measuring a subject receives instructions to imagine that is located in a bus for public transportation of passengers and to put the hand (in which he/she holds the cylinder that simulates the handrail) into the position above the top of the head for which he/she considers that is the most appropriate (in terms of minimum fatigue over a longer period and maintaining the stability). Then measure the distance from the floor to the center of the cylinder that holds in hand (Figure 1 (4), dimension 6).

*Below head comfortable grip height*

This dimension defines the most comfortable position on which should provide the handrail below the head, so as to ensure conditions for transportation of passengers with the minimal fatigue of the hand (as well as parts of the body that are associated with this posture), while maintaining the necessary stability at the same time. It appreciates the fact that there are certain reasons for positioning the handrails below the level of the head. If the measurement is conducted under laboratory conditions, before measuring a subject receives instructions to imagine that is located in a bus for public transportation of passengers and to put the hand (in which he/she holds the cylinder that simulates the handrail) into the position below the level of the chin for which he/she considers that is the most appropriate (in terms of minimum fatigue over a longer period and maintaining the stability). Then measure the distance from the floor to the center of the cylinder that holds in hand (Figure 2 (5), dimension 7).

Note. If the subject during determination of the universal comfortable grip height positions the hand above the head, then it is not necessary to measure additionally the dimension overhead comfortable grip height, because these two dimensions in this case coincide. However, if the subject during determination of the universal comfortable grip height positions the hand below the level of the head, then it is not necessary to measure additionally the dimension below head comfortable grip height, because these two dimensions in this case coincide.

*Maximum body breadth*

This dimension is important for determining the width of the bus doors, width of an aisle in the bus and planning the total number of passengers that can be accommodated in the bus (Figure 2 (6), dimension 8).

*Popliteal height*

This dimension definines the maximum acceptable height of the seat pan (Figure 2 (7), dimension 9).

*Knee height, sitting*

This dimension determines the position of the knee that does not need to be reached by the backrest of the chair in front of a passenger (Figure 2 (7), dimension 10).

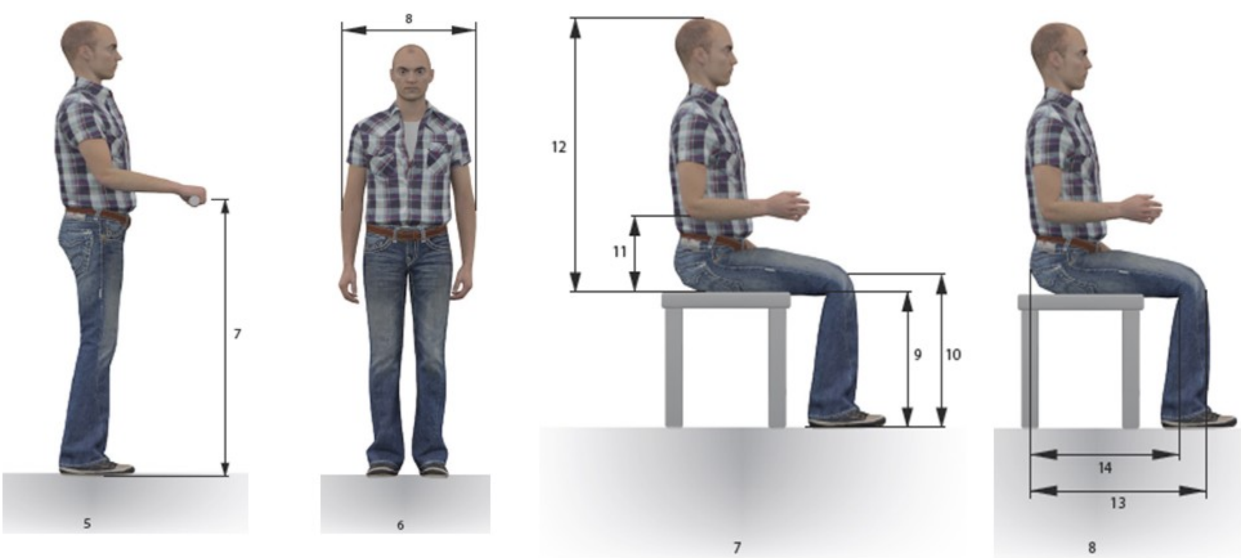

Figure 2. Anthropometric dimensions of importance for designing the bus (continuation 1).

*Elbow rest height*
Represent the vertical distance from the seat surface to the top of the arm rest for the sitting position of a passenger (Figure 2 (7), dimension 11).

*Sitting height*
It determines the minimum distance from the surface for seating, which is necessary for the accommodation of passengers. At the level of this dimension (i.e. the level of the head, for sitting position of a passenger) should not place hard or sharp objects that could endanger passengers in contact with them, in case of change of acceleration of the bus (Figure 2 (7), dimension 12).

*Buttock-knee length*
It determines the horizontal clearance from the front surface of the seat back rest to accommodate the upper leg length of the passenger (Figure 2 (8), dimension 13).

*Buttock-popliteal length*
This dimension defines the maximum acceptable seat pan depth (Figure 2 (8), dimension 14).

*Hip breadth, sitting*
It is used to determine the minimum width of the seat (Figure 3 (9), dimension 15).

*Forearm-forearm breadth*
It is primarily used for determining the width to which armrests of the chair should be set (Figure 3 (9), dimension 16).

*Height of forward grip reach, sitting*
This anthropometric dimension defines the position along the vertical direction which match the forward grip reach (sitting). It is used for determination of the maximum distance from the floor at which the handrail can be placed in front of the passenger (usually it is the position regarding the handrail which is placed on the top of the backrest of the chair in front of a passenger). Measures the vertical distance from the floor to the center of the cylinder which person holds in hand (Figure 3 (10), dimension 17).

*Forward grip reach, sitting*
It used for determining the maximal distance from the back to the position at which it can be positioned the handrail in front of the passenger in a sitting position (Figure 3 (10), dimension 18).

*Vertical grip reach, sitting*
This dimension is used to define the maximum height on which the handrail can be positioned, so that a passenger can grip it as needed from a sitting position (Figure 3 (11), dimension 19).

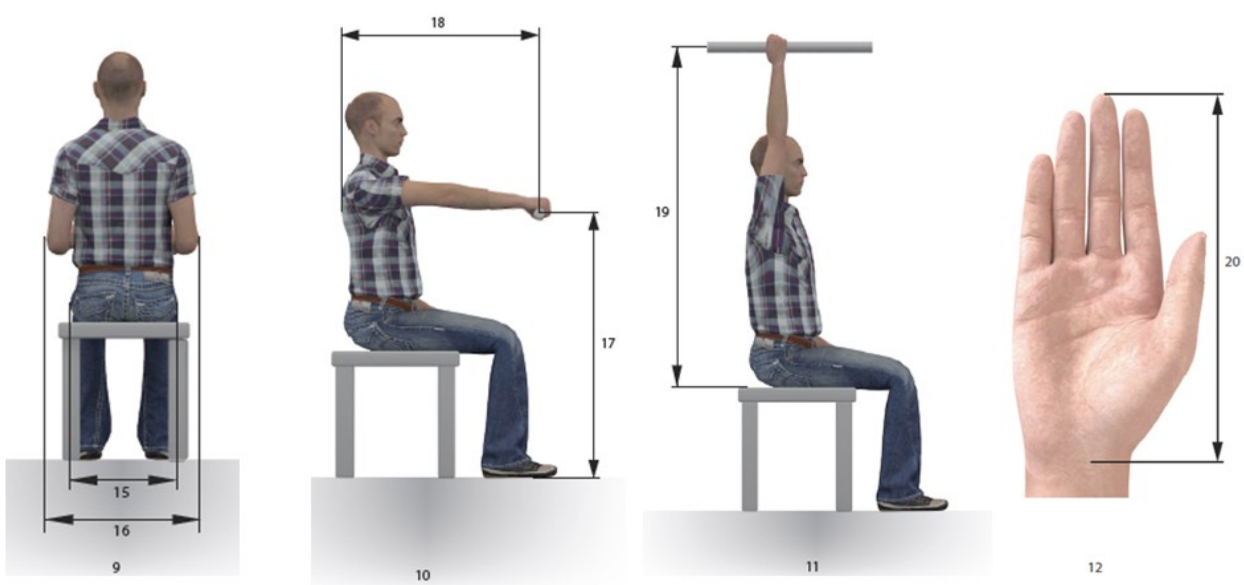

Figure 3. Anthropometric dimensions of importance for designing the bus (continuation 2).

*Hand length*
This dimension can be used when determines the diameter of handrails (Figure 3 (12), dimension 20).

## Anthropometric dimensions of potential importance for designing the bus

*Waist depth*
For some people (obese), this body dimension may represent the maximum physical dimension in the sagittal plane (in depth). In that case, it can be used for determining the width of a passage in the bus, planning the space for seating and the maximum number of people that can be accommodated in the bus (Figure 4 (13), dimension 21).

*Minimum grip height*
This anthropometric dimension defines the lowest position where it is possible to position the handrail, which the passenger can reach from a standing position. Before measurement, a subject receives the instruction to stand upright with the hands beside the trunk. Than measure the distance from the floor to the center of the cylinder that holds in hand (Figure 4 (13), dimension 22).

*Acromial height*
This anthropometric dimension can be used for planing the highest point where it is necessary to provide the handrail, if it is expected achievement of the necessary comfort of passengers, during holding the handrail (Figure 4 (13), dimension 23).

*Universal comfortable grip length*
This anthropometric dimension represents the second coordinate (length) that is related to the body position which is determined by the dimension universal comfortable grip height. It can be used for planning the necessary distance of a passenger to the handrail, which allows the passenger comfort while maintaining the stability. Subject receives the instruction to take the same position as for determining the dimension universal comfortable grip height, but it is necessary that a subject his back lean against a flat surface (wall). Then measure the distance from the back (flat surface) to the center of the cylinder that the subject holds in hand (or knuckle, depending on the orientation of the cylinder in the hand), (Figure 4 (14), dimension 24).

*Overhead comfortable grip length*
This anthropometric dimension represents the second coordinate (length) that is related to the body position which is determined by the dimension overhead comfortable grip height. It can be used for planning the necessary distance of a passenger to the handrail, which allows the passenger comfort while maintaining the stability. Subject receives the instruction to take the same position as for determining the dimension overhead comfortable grip height, but it is necessary that a subject his back lean against a flat surface (wall). Then measure the distance from the back (flat surface) to the center of the cylinder that the subject holds in hand (Figure 4 (15), dimension 25).

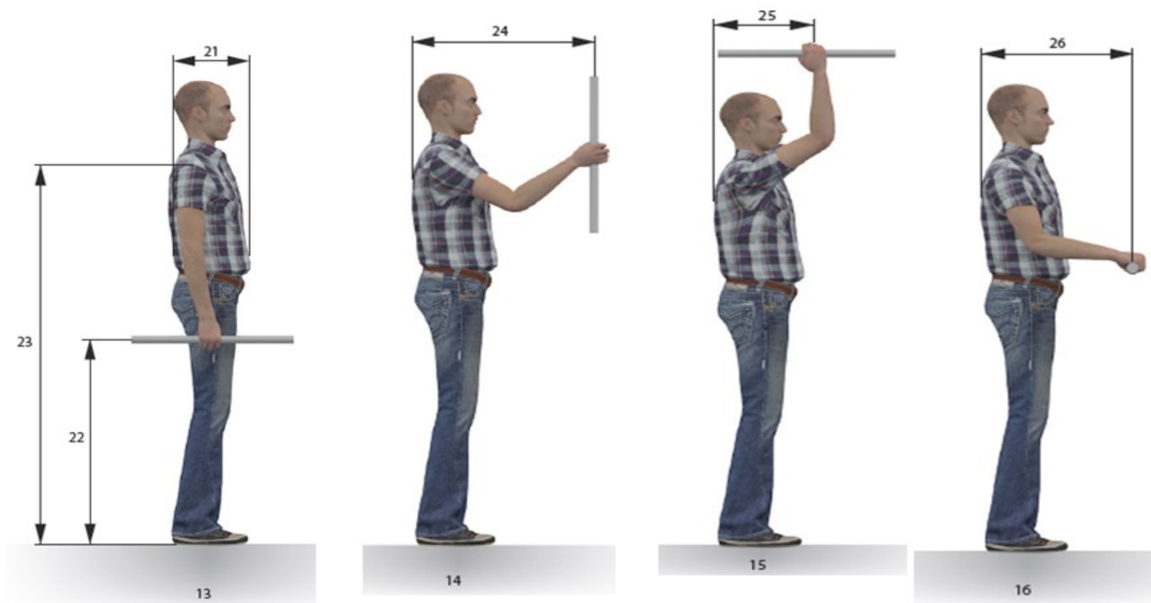

Figure 4. Anthropometric dimensions of potential importance for designing the bus.

*Below head comfortable grip length*

This anthropometric dimension represents the second coordinate (length) that is related to the body position which is determined by the dimension below head comfortable grip height. It can be used for planning the necessary distance of a passenger to the handrail, which allows the passenger comfort while maintaining the stability. Subject receives the instruction to take the same position as for determining the dimension below head comfortable grip height, but it is necessary that a subject his back lean against a flat surface (wall). Then measure the distance from the back (flat surface) to the center of the cylinder that the subject holds in hand (Figure 4 (16), dimension 26).

*Elbow-fingertip length*

This length can be used as a basis for determining the length of the armrests, if it is planned that the chair has this type of support (Figure 5 (17), dimension 27).

*Acromial height, sitting*

This anthropometric dimension can be used for planning the location of accommodation of the handrail that should be mounted frontally, and which a passenger uses from the sitting position during the driving. The satisfactory effects can be achieved if the handrail that is in front of a passenger is located between acromial height and elbow rest height (Figure 5 (17), dimension 28).

*Cervicale height, sitting*

This dimension can be used for planning the position of the head restraint of improved versions of chairs in buses for public transportation, as well as for their dimensioning (together with the dimension of sitting height), (Figure 5 (18), dimension 29).

*Bideltoid breadth*

It represents one of two basic anthropometric dimensions for determining the width of the backrest of the chair (Figure 5 (18), dimension 30).

*Functional leg length*

This anthropometric dimension can be used for planning the legroom of passengers seated (this is related to the luxury, very comfortable bus variants, whose appearance can be expected in the future), (Figure 5 (19), dimension 31).

*Comfortable grip height, sitting*

This dimension defines the most comfortable position on which should provide the handrail in front of a passenger in the sitting position, so as to ensure conditions for transportation of passengers with the minimal fatigue of the hand. If the measurement is conducted under laboratory conditions, before measuring a subject receives instructions to imagine that is located in a bus for public transportation of passengers and to put the hand (in which he/she holds the cylinder that simulates the handrail) into the position in front, for which he/she considers that is the most appropriate in terms of minimum fatigue over a longer period. Then measure the distance from the floor to the center of the cylinder that holds in hand (Figure 5 (20), dimension 32).

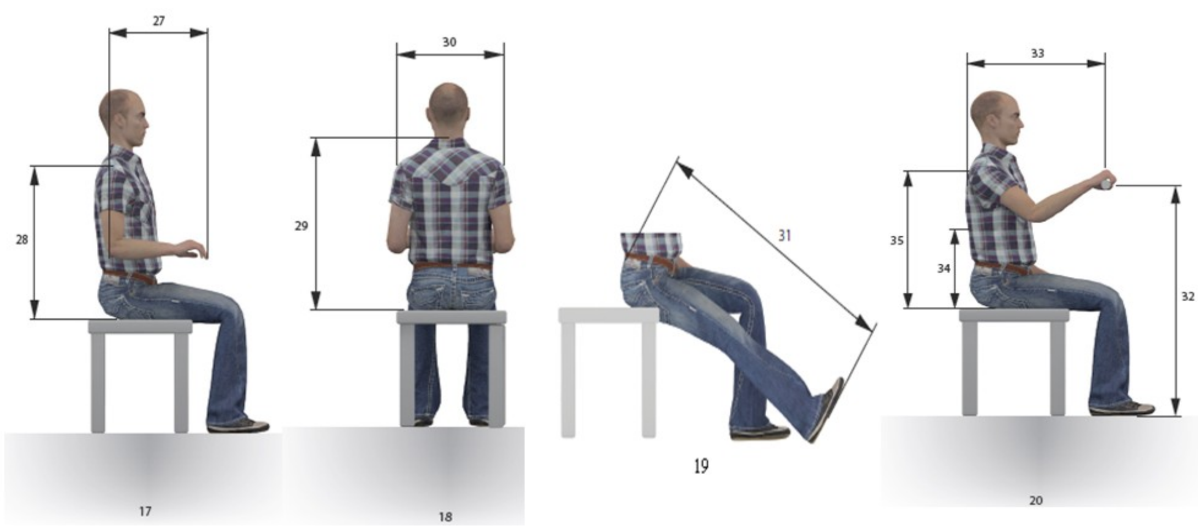

Figure 5. Anthropometric dimensions of potential importance for designing the bus (continuation1).

*Comfortable grip length, sitting*
This anthropometric dimension represents the second coordinate (length) that is related to the body position which is determined by the dimension comfortable grip height, sitting. It can be used for planning the necessary distance from the back of a passenger to the handrail, which is mounted in front of him. Subject receives the instruction to take the same position as for determining the dimension comfortable grip height (sitting), but it is necessary that a subject his back lean against a flat surface (vertical backrest). Then measure the distance from the back (flat surface) to the center of the cylinder that the subject holds in hand (Figure 5 (20), dimension 33).

*Lower thoracic height*
This anthropometric dimension defines the beginning of the thoracic region (along the vertical axis). It can be used for designing the backrest of the chair in accordance with the shape of the spine. Subject receives the instruction to take the neutral sitting position (with the back in upright position). Then measure the distance from the seat to the starting point of the thoracic region of the back (at the level of the diaphragm), (Figure 5 (20), dimension 34).

*Upper thoracic height*
This anthropometric dimension defines the end of the thoracic region. In a pair with the lower thoracic height, it can be used for designing the backrest of the chair in accordance with the shape of the spine. Subject receives the instruction to take the neutral sitting position (with the back in upright position). Then measure the distance from the seat to the ending point of the thoracic region of the back (inferior surface of second right posterior rib), (Figure 5 (20), dimension 35).

## CONCLUSIONS

In the framework of this study, a total of 35 anthropometric dimensions which should be taken into consideration in order to design certain segments of the interior of city buses has been identified. Those 35 dimensions have been classified into two groups. The first group consists of 20 anthropometric dimensions that are of particular importance for designing the interior of the bus. This is the minimum number of anthropometric dimensions that designers of buses need to take into consideration. The second group consists of 15 anthropometric dimensions of potential importance for the design of buses, in the sense of finding some specific solutions, new or more comprehensive design solutions. Certainly, all 35 dimensions are recommended for use. If the measurement includes the larger number of relevant dimensions, the probability of success of the design solution is greater. However, this approach may require additional effort and time consumption.

In the group of 35 recommended dimensions, there are eight new dimensions, which have been named comfortable anthropometric dimensions. In contrast to the functional (dynamic) dimensions that are primarily used for determination of certain maximum distances, or for determining of dimensions of the body while performing certain working activities, comfortable anthropometric dimensions are intended for defining distances regarding the locations of certain parts of the body in positions that are most appropriate for a passenger, in terms of comfort and minimum fatigue over a longer period. Besides the comfortable anthropometric dimensions, additionally have been introduced four anthropometric dimensions, which can contribute to the more precise determination of relevant distances, and which can serve for designing of the bus equipment.

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