19 ANTHROPOMETRY IN INTERIOR DESIGN

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19.1 ANTHROPOMETRY: AN ERGONOMIC APPROACH IN DESIGN FOR HUMAN COMPATIBILITY

Experiences of design are in every walk of life, it is everywhere- we breathe it in every breadth. Design is a concept of an object/a process, or a system. It is an aid to human lifestyles. The verb to design indicates the process of developing an object/a process, or a system. Designing is a **c**ontinuous problem-solving process to achieve quality aids to human life. In some cases, the direct construction of an object without an explicit prior plan may also be considered to be a design i.e., artwork and craftwork.

Every day, we use different consumer products, tools, and furniture which are becoming an inevitable part of life to carry out our day-to-day activities and are usually used in or around the home, in a social setting, rather than in a workplace environment with commercial needs. Our lives are woven in such a manner into a plethora of such items that it has made our lives more enjoyable and hassle-free. Our dependency on these products has reached such a level that without these we cannot think a step forward in the direction of our growth. The design of a product or a system must yield maximum comfort, efficiency, and safety to its users and should operate on the premise-of "better design for people" and should cater tothe needs and aspirations of the anticipated users to enhance humanely, enhance productivity, ensures safety, and comfort for effective use. For a designer, designing is a passion, when it performs it thrills but to get the user's positive response it needs to fulfill certain factors i.e., usability, contextual needs, pleasure in use, ease of use, ability to learn product functions, efficiency, comfort, safety, and adaptability and finally the comfort in use, all of which meet the needs and contribute to user satisfaction. Due to technological advancement, the market is flooded with varieties of items for human aid but it is seen quite often that though these items are being designed for human aid, theytire, provide uneasiness and discomfort in using them, and sometimes may create for health hazards and might cause inattentive accidents also. We are reluctant to use those that are being designed for us as an aid to our lifestyle. Many more, almost everywhere these types of situations can be cited. People intentionally have not invited these problems. As users, we expect whatever items of human aid we use, no matter how simple or complex, to perform their expected functions in a safe, reliable, and efficient manner and have comfort in using those products and better performance. Unfortunately, this is not always the case. Sometimes an over-stuffed beautifully designed sofa/bed may not give the anticipated comfort, the users expect. Sometimes people do not want to work in a well-decorated kitchen.

Why does it happen? Probably, the user's natural limitations, aspirations, and needs do not match with the system that has been developed, which is the prime requirement for design success. Users are individuals of any age, gender, or physical condition with varying educational, cultural, and economic backgrounds. A product/tool/furniture/workspace must give maximum comfort, efficiency, and safety to its users, considering differences in human characteristics, performances, and limitations. Designs that satisfy human needs and expectations are not an easy task.

What can be done? The solution lies in the application of the best scientific principles and appropriate technologies that may generate a design, deliver better functions to its users (the prime system component), and ultimately have to feel comfortable while using it to qualify the same to be a good design. This very issue can be addressed by consideration of ergonomics in the design process. The design process that involves the application of human factors and ergonomics principles and knowledge strives to achieve the above goals and, at the same time reduce the risk of product malfunction or failure, potential for accidents and finally contribute to overall product acceptance and utility. Application of Ergonomics knowledge can improve critical features of designed products.

"Ergonomics is defined as the scientific study of the man-machine-working environment relationship and the application of anatomical, physiological, and psychological principles to solve the problems arising from the relationship.

The objective of ergonomics is to make the design fit for the user rather than to make the user adapt him or her to it. The ergonomics of such items are crucial because if it does not fit users, it doesn't meet their needs and lead to the product failing in its purpose. Ergonomics is a unique and wide-ranging discipline that focuses on the nature of human–product interactions, which are viewed from a unified perspective on science, engineering, design, technology, and management of human-compatibility systems. There is substantial and convincing evidence that the human-compatibility can improve critical product features. These features include: ease of use, learning, efficiency, comfort, safety, and adaptability, all of which meet the needs and contribute to consumer satisfaction." (Chakraborti,1997)

The application of ergonomics in design promotes a holistic, human-centered approach that considers physical, cognitive, social, organizational, environmental, and other design-relevant factors. As such, Ergonomics aids designers by raising their awareness of the full scope of knowledge required when designing consumer products and plays an important role in facilitating a better performance of consumer products in general. Ergonomics-based design of products encompasses a wide variety of consumer preferences and accounts for differences in such preferences due to factors such as age, gender, or health issues because users are individuals of any age, gender, or physical condition with varying educational, cultural, and economic backgrounds. The goal of the human-centered design paradigm as applied to design is to improve levels of user satisfaction, and efficiency of use, increase comfort, and assure safety under normal use as well as predictable misuse of the product. Ergonomics involves using information about people to design for comfort, efficiency, and safety.

Ergonomics has become a business promotion word that we hear so often these days, particularly in the high-tech industry tagged to their products.Businesses all across the world are recognising the value of incorporating great ergonomics into their product designs. Application of ergonomics in the early stage of the design process is proactive i.e., "ergonomics should be incorporated into the design process early on, rather than as an afterthought". Why? Consider the following scenario: suppose whenplanning a kitchen space, the designers discover that the designed space causes physical discomfort and may jeopardize end-user safety while working in the kitchen. That implies the designer essentially lost significant time, money, and resources while designing the unproductive space that will give users comfort. When designing, keep ergonomics (anthropometry, cognitive load while being used by the users, ease of operation, etc) in mind. Application of ergonomics in design establishes user- user-friendliness and compatibility between man and articles for use and his surroundings.

19.2 ANTHROPOMETRY-CONCEPT, DEFINITION, TYPES

19.2.1 Definition

Anthropometry means "measurement of man," or "measurement of humans," comes from the Greek words anthro, a man, and metron, a measure.Anthropometry is a device that provides scientific methods and techniques for taking several measurements to describe the morphology of the human body and the skeleton. It is a branch of physical anthropology that provides the measurements of the human body i.e., linear dimensions and functional capabilities, including weight, volume, range of movements, etc. Anthropometric measurements are non-invasive quantitative measurements of the body. The core elements of anthropometry are height, weight, head circumference, Body Mass Index (BMI), body circumferences to assess for adiposity (waist, hip, and limbs), and skin fold thickness.

Bodily features vary considerably between regional populations,age, gender, and race i.e., different geographical situations and biological environments. Anthropometry is the science that measures the range of sizes of bodies in a population. When designing products, it is important to remember that people come in many sizes and shapes. Anthropometry is the only science that measures the human body accurately and scientifically. Therefore, anthropometry helps in expressing the variations quantitatively in the form and bodily features of various populations.

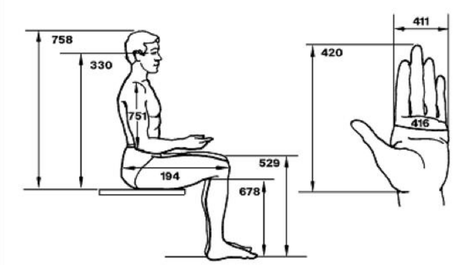
19.2.2 Types of Anthropometric Data

Anthropometry is divided into two types:

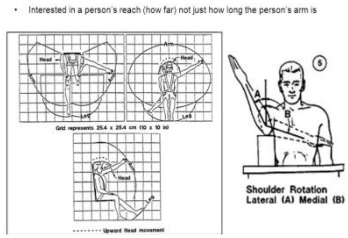
i. **Static (Structural) Anthropometry (Ergonomics):** Human body measurements when the subject is still.

- The measurements when the body iskept in a fixed position, i.e., static, such as height, joint to joint, BMI, Skin folds, etc.
- Data is collected using standardized equipment such as calipers, stadiometers, or anthropometers.
- Design contexts include chair height, door width, personal protective equipment, furniture, tools, etc.
- Design contexts in can openers, car console features, book shelving reach, etc.

Static Measurements



Dynamic



(Source: Google, 2023)

ii. **Dynamic (Functional)Anthropometry:** Human body measurements that are taken when the subject is in motion related to the range and reach of various body movements,e.g. squatting height, overhead reach, and the range of upper body movements.

- The measurements that relate a range or reach of various types of body movements such reach, grip strength, reaction times, etc
- Carrying out a task.

19.3 HISTORICAL PERSPECTIVE OF ANTHROPOMETRY

The history of anthropometry includes its use as an early tool of anthropology, for the identificationand understandingof human physical variations in Paleo-anthropology. One of the valuable scientific methods for studying the evolution of humans through fossil remains in Paleo-anthropology was the application of anthropometric technology. The civilizations of Egypt, Greece, and Rome used mostly anthropometric measurements for cultural needsi.e., artwork to portray beauty, power, and other needed features of the human forms. Duringthe Renaissance artists used anthropometric measurements in their artistic works for human proportion, e.g., the famous artist Leonardo da Vinci obtained measurements of the human body by analyzingcorpses for use in his artistic work. Onthe contrary,to obtain accurate body measurements artists used to rely on live models and historical achieves.

The word "anthropometry" was devised by Georges Cuvier, a French naturalist during (1769–1832).Later, it was used by physical anthropologists in their studies of variability among human races and for comparing humans to other primates. In 1883, Alphonse Bertillon who was a French police officer and biometrics researcher applied the anthropological technique of anthropometry to law enforcement, creating an identification system based on physical measurements. "Moreover, physical anthropologists developed anthropometry asa method for studying evolution in both living and extinct populations. Such anthropometric measurementsparticularly have been used historically to associate physical propertieswith racial, cultural, and psychological attributes. Anthropomorphic measurements, especially involve the size of the human body (e.g., stature height, weight, surface area, and volume), structure (e.g., sitting and standing height, elbow height, shoulder and hip width, arm/leg length, and neck circumference), body composition (e.g., fatness of the body, water content, and lean body mass) of humans, etc.

In the eighteenth century for military, slavery, and other productive purposes stature height was most used as an anthropometric measurement of human health until the twentieth century when environmental and social conditions were correlated with human anthropometric measurements. While physical anthropologists continue to use anthropometric measurements in the study of human evolution through the comparison of novel fossil remains to archived specimens and forensics, the current applications of anthropometric measurements have extended to:

- Industrial design
- Interior design and architecture (e.g., vehicle seating and cockpits)
- Clothing (e.g., military uniforms)
- Ergonomics (e.g., seating)
- Nutrition
- Designing for people with special needs i.e., aging, obesity, sports science, diabetes, etc.

In these anthropometric data is precious to the success of various products and observing the changes that occur in response to various lifestyle, genetic, and ethnic factors.

19.4 APPLICATION OF ANTHROPOMETRIC DATA IN DESIGN AND PRINCIPLES

To make the design human-centredthe designers need to ensure that the products they design are the right size for the users and comfortable to use. Designers need to consider how users will interact with the products or services. Designers have access to data and drawings, which state measurements of human beings of all ages and sizes. The use and misuse of anthropometric data in designing is an important consideration.

There are a variety of anthropometric assessments that may be used to study the range of body sizes and body types found within human populations. Some of the basic anthropometric characteristics studied by researchers include height, weight, fatness, cranial circumference, and limb length. Anthropometric data sets can vary significantly between populations. Particularly in the PPE, customized furniture/tools/equipment the variance in these data sets impacts the size ranges of products for users. Based on the context for which the measurements are required, the use of basic measurements may be different.

The use of anthropometrics in building design aims to ensure that every person is as 'comfortable as possible'. In practical terms,it means that the dimensions must be appropriate e.g., ceilings high enough, doorways/hallways wide/high enough, and so on.People with mobility issues wheelchair users,children old peopleand so on may have specific space requirements. In particular, good accessibility and easy manoeuvrability around the building i.e., in hallways, doorways stairs, lifts, ramps, other features, etc. must be considered when designing.

Anthropometry has an impact on space requirements for furniture and fittings in interior design. For example, a bathroom must have enough space to comfortably fit a bath and sink, considering the special requirements, if any. Following are the basic anthropometric measurements that are required for use in architecture /product/tool/furniture designing(IS: Ergonomics Anthropometric Terminology, 1991)

"According to IS:1991, the basic Anthropometric Measurements are:

i. **Standing Posture**

- **Body Height:**Vertical length from the floor to the top of the head. The subject stands erect with heels together and looks straight ahead.
- **Eye Height:**Vertical length from the floor to the inner corner of the eye. The subject stands erect and looks straight ahead.
- **Shoulder Height:**Vertical distance from the floor to the uppermost point on the lateral edge of the shoulder (acromion) with the subject standing erect'.
- **Elbow Height:**Vertical distance from the floor to the depression at the elbow between the bones of the upper arm and forearm. The subject stands erect with his arms hanging naturally, at his sides'.
- **Knuckle Height:**Vertical distance from the floor to the point where the middle finger of the righthand meets the palm. The subject stands erect with his palm flat against the side of his thigh'.
- **Maximum Body Depth:**Maximum horizontal distance between the vertical planespassing through the most anterior and posterior points on the trunk'.
- **Maximum Body Breadth:**Maximum breadth of the body, including arms with the subject standing erect with his arms tightly pressed against the body with dorsiflexion of the palms'.
- **Hip Breadth:**Maximum horizontal distance across the hips. The subject stands erect with his heels together.

- **Total Arm Span:**Maximum horizontal distance across the tips of extended middle fingers with subject standing erect and arms stretched on sides'.
- **Forward Arm Reach:**Horizontal distance from the posterior surface of the right shoulder to the tip of the extended middle finger. The subject stands erect with heels, buttocks, and shoulders against the wall and right arm -and hands extended forward horizontally to their maximum length'.
- **Elbow to Wrist:**Distance between the tip of the elbow and the outside projection of the distal end of the ulna. The subject stands erect with his arms by the side of the body.
- **Elbow to Finger Tip:**Distance between the tip of the elbow and the tip of the extended middle finger. The subject stands erect with his arms by the side of his body.

ii. Sitting Posture

- **Sitting Height:**'Vertical distance from the sitting surface to the top of the head. The subject sits erect and looks straight ahead with his knees and ankles forming right angles.
- **Eye Height:** 'Vertical distance from the sitting surface to the inner corner of the eye. The subject sits erect and looks straight ahead.
- **Shoulder Height: '**Vertical distance from the sitting surface to the uppermost point on the lateral edge of the shoulder with the subject sitting erect'.
- **Elbow Height:** 'Vertical distance from the sitting surface to the bottom of the right elbow. The subject sits erect with his upper arm vertical at his side and his forearm at a right angle to the upper arm'
- **Knee Height:** 'Vertical distance from the floor to the uppermost point of the knee (top of muscle mass near the lower end of the femur). The subject sits erect with knees and ankles at right angles.
- **Thigh Height:** 'Vertical distance from the floor to the top of the thigh at its intersection with the abdomen. The subject sits erect with his knees and ankles at right angles.
- **Buttock Knee Length:**'Horizontal distance from the most posterior point on the buttocks to the most anterior point on the knee. The subject sits erect with his knees and ankles at a right angle.
- **Buttock Popliteal Length:** 'Horizontal distance from the plane of the most posterior point on the buttocks to the back of the lower leg at the knee. The subject sits erect with his knees and ankles at right angles.
- **Popliteal Height:** 'Vertical distance from the floor to the underside of the thigh immediately behind the knee. The subject sits erect with his knees and ankles at right angles and the bottom of his thighs and the back of his knees barely touching the sitting surface'.
- **Buttock-leg Length:** 'Horizontal distance from the most posterior point on the buttocks to the base of the heel. The subject sits erect with his legs as forward as possible on a horizontal surface'.

- **Hip Breadth:** 'Maximum horizontal distance across the hips. The subject sits erect with his knees and ankles right at angles and lands his knees and heels together.
- **Shoulder to Shoulder Breadth:** 'Maximum horizontal distance across the deltoid muscles. The subject sits erect with his upper arms touching his sides and his forearms extended horizontally'.
- **Elbow to Elbow Breadth:** 'Maximum horizontal distance across the lateral surface of the elbows. The subject sits erect with his upper arms vertical and touching his sides and his forearms extended horizontally'.
- **Forearm-Hand Length:** 'Horizontal distance from the tip of the right elbow to the tip of the middle finger. The subject sits erect with his upper arm vertical at his side and his forearm, hand, and fingers extended horizontally.
- **Foot Length:** 'Horizontal distance from the back of the heel to the tip of the longest toe. The subject stands with his weight equally distributed on both feet.
- **Foot Breadth:** 'Maximum horizontal distance across the foot at right angles to the long axes.
- **Hand Length:**'Distance from end of small wrist bone at the base of the thumb to the tip ofthe middle finger of the right hand, when the palm is up with fingers, extended and together'.
- **Hand Breadth (AtThumb): '**Maximum breadth across the plane (at right angles to the long axis of the hand) at the knuckle of the thumb of the right hand with the fingers extended and the thumb lying alongside and the plane of the hand'.
- **Hand Breadth (AtMetacarpal):'**Maximum breadth across the ends of metacarpal bones (where the fingers join the palm) of the index and little fingers of the right hand held straight and stiff with the finger together'.
- **Hand Thickness:**'Maximum distance between the dorsal and palmier surfaces of the knuckle of the middle finger where it joins the palm of the right hand when the fingers are extended'.
- **Index Finger Length:** 'Distance from the tip of the second finger to the proximal skin furrow of the joint between proximal phalange and metacarpal.
- **Index Finger Breadth:**'Maximum distance between the media! and lateral of the second finger in the region of the joint between the medial and proximal phalanges.
- **Waist Height (TrochantericHeight):** 'Vertical height of the waist (trochanteric protuberation) that is, from the hip bones to floor'. (IS:1991)"

19.5 APPLICATION OF ANTHROPOMETRY IN INTERIOR DESIGN

Ergonomics is the science of making any space or environment safer and more comfortable for the end users through design, using anthropometric data. In ergonomics, anthropometric data plays a major role in designing interiors and helps make spaces a good fit between people and what they interact with**.**The use of context-specific anthropometric data that considers the size and mobility of the human body allowsthe designer to design equipment/tools/space/furniture that utilizes and enhances human usability. Anthropometry **supports** ergonomics and deals with human body measurements**.** Anthropometric studies can be made relating to a specific population and different age groups. Anthropometry has a significant impact on the design of buildings, influencing a wide range of businesses, processes, services, and products. When it comes to establishing the proportions and overall design of a structure, considering the comfort in use and usability, human body dimensions and limitations are crucial and the buildings should adapt to the human body rather than the other way around. The use of anthropometric datawhen designing joinery or cabinetry, furniture, circulation spaces, workspaces, accessibility, overall design of spaces, etc.by interior designers will help not only make working easy but also more efficient in terms of relative comfort.

Anthropometry reflects the true need for space requirements.Human dimensions and capabilities are paramount in determining a building's dimensions and overall design. The underlying principle of the use of anthropometrics is that building designs should adapt to suit the human body, rather than people having to adapt to suit the buildings.The use of anthropometrics in building design aims to ensure that whoever is using the space is as comfortable as possible. In practical terms, this means that the dimensions must be appropriate, ceilings/doorwayhigh enough, doorways/hallways wide enough, and so on. In recent times, it has come to have particular significance for workplace design, and the relationship between desks, chairs, keyboards, and computer display.It is important to consider the specific purpose and requirements of end users and the space that is being designed i.e.,older people, children, people with mobility issues, wheelchair users and so on may have specific requirements. In particular, good accessibility and easy manoeuvrability around the building must be considered when designing.

Anthropometry may also impact on requirements of space for furniture and fittings/control points. For example, a bathroom must have enough space to comfortably fit a bath and sink; a bedroom must have enough space to comfortably fit an average-sized bed; an office building must have enough space to fit desks, air-conditioning units, communal areas, meeting rooms, placement of switches should be in easy reach by the inmates and so on.

19.5.1 Ergonomic Considerations in Workspaces: Constraints and Criteria

In the modern era, where individuals spend a significant portion of their lives in workspaces, the importance of designing ergonomic environments cannot be overstated. Ergonomics, the science of fitting workplace conditions and job demands to the capabilities of the working population, plays a crucial role in promoting health, well-being, and productivity.

Constraints in Ergonomic Design

- **Physical Constraints:** Physical constraints involve the limitations imposed by the human body's structure and function. These constraints may include factors such as body size, range of motion, and physical strength. To address these constraints, furniture, and equipment must be designed to accommodate diverse body types and ensure ease of movement.According to Pheasant and Haslegrave (2006), incorporating adjustable furniture and providing options for varied postures can help mitigate physical constraints in ergonomic design.

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- **Psychosocial Constraints:** Psychosocial constraints encompass the psychological and social aspects of the workplace environment. Factors like job stress, workload, and interpersonal relationships can impact employees' well-being and performance, especially in organizational settings. Designing workspaces that consider these psychosocial factors is crucial for creating a conducive and supportive environment.The work of Karasek (1979) on the Job Demand-Control model highlights the significance of balancing job demands and control to reduce psychosocial constraints in workspaces.

Criteria for Ergonomic Design

- **User-Centered Design:** The fundamental criterion in ergonomic workspace designUser-centered design. This implies actively involving end-users in the design process to ensure that their needs, preferences, and limitations are considered. By incorporating feedback from the actual users, designers can create spaces that are tailored to the diverse needs of the workforce.Tronstad (2001) emphasizes the importance of involving users in the design process to enhance user satisfaction and overall workspace functionality.
- **Anthropometrics and Biomechanics:** Anthropometrics and biomechanics involve the study of human body measurements and movement. Designing workspaces based on accurate anthropometric data ensures that furniture and equipment accommodate a wide range of body sizes and shapes. Biomechanical considerations focus on optimizing body mechanics to prevent musculoskeletal disorders and fatigue. A. Hedge (2008) underscores the significance of applying anthropometric and biomechanical principles to design workspaces that support the natural movements of the human body.
- **Environmental Ergonomics:** Environmental ergonomics involves creating a workspace that optimizes lighting, temperature, noise levels, and air quality. These environmental factors significantly impact employee comfort, health, and productivity. Adequate lighting, for example, reduces eye strain and enhances visibility, while proper ventilation contributes to a healthier indoor environment.According to Hedge and Dorsey (2017), attention to environmental ergonomics is essential for creating workspaces that promote overall well-being and performance.

Ergonomic considerations in workspaces are essential for ensuring the health, comfort, and productivity of employees. By addressing physical and psychosocial constraints and adhering to criteria such as user-centered design, anthropometrics, biomechanics, and environmental ergonomics, organizations can create work environments that contribute to the overall well-being of their workforce. As research in ergonomics continues to evolve, considering the following factorsin workspace design will become increasingly critical for fostering a thriving and sustainable work culture:

i. **Age:** It is an important factor in body size.Full growth, concerning body dimensions, peaks in the late teens and early twenties for males and usually a few years earlier for females.

ii. **Gender:** Anthropometric data are different for different genders.

iii. **Ethnicity:** 'Statistics of body height vary according to the national groups, race and genes.The variation in stature is quite significant, ranging from 160.5cm, for the Vietnamese to a high of 179.9cm for the Belgian'.

19.5.2 Designing for Inclusivity and Accessibility

In today's diverse and dynamic world, designing spaces, products, and services that are inclusive and accessible to all, is not just a moral imperative but a necessary strategy. This section explores the principles and practices of designing for inclusivity and accessibility, emphasizing the importance of creating environments that cater to the diverse needs of individuals regardless of their abilities or characteristics.

i. **Principles of Inclusive Design:** Inclusive design goes beyond compliance with accessibility standards.It strives to create products and environments that are usable by as many people as possible, regardless of their age, ability, or background. In inclusive design, designers incorporate a variety of perspectives and backgrounds to create a design that is welcoming to everyone. The principles of inclusive design, as proposed by the Inclusive Design Research Centre (IDRC), involve recognizing diversity, involving users, and considering the broadest range of abilities from the outset.According to Clarkson et al. (2003), inclusive design is an ongoing process that requires collaboration with end-users and a commitment to understanding and addressing the diverse needs of the target audience. For inclusive designthe following considerations are essential:

- Flexible so different people can use them in different ways.
- Convenient so everyone can use them without too much effort or separation.
- Accommodating for all people, regardless of their age, gender, mobility, ethnicity, or circumstances.
- Welcoming with no disabling barriers that might exclude some people.

ii. **Universal Design and Accessibility Standards:**Universal design is a key concept in creating inclusive environments. It involves designing products and spaces that are usable by all people to the greatest extent possible without the need for adaptation. Accessibility standards, such as the Web Content Accessibility Guidelines (WCAG) for digital content or the Americans with Disabilities Act (ADA) for physical spaces, provide specific criteria and benchmarks for ensuring inclusivity.The work of Story et al., (2019) emphasizes the importance of incorporating universal design principles and adhering to accessibility standards to create environments that are accessible to individuals with various disabilities.

iii. **User-Centered Design in Accessibility:**User-centered design (UCD) plays a pivotal role in ensuring inclusivity and accessibility. By actively involving end-users throughout the design process, designers can gain insights into the specific needs and challenges faced by diverse individuals. This approach facilitates the creation of products and environments that are not only accessible but also responsive to the preferences and requirements of the users.As stated by Henry et al.,(2018), the iterative nature of user-centered design allows for continuous refinement, ensuring that the final product is both inclusive and user-friendly.

iv. **Tectechnological Innovations for Accessibility:**Advancements in technology offer significant opportunities for enhancing accessibility. From screen readers and voice recognition software to adaptive technologies for mobility assistance, technology can play a transformative role in creating inclusive designs. Integrating these innovations into the design process ensures that products and spaces are not just accessible but also leverage technology to enhance user experiences.Research by Lazar and Jaeger (2011) highlights the importance of considering the role of technology in promoting accessibility and ensuring that technological solutions are integrated seamlessly into the design.

19.6 CHALLENGES AND FUTURE DIRECTIONS

While progress has been made in promoting inclusivity and accessibility, challenges persist. Limited awareness, budget constraints, and the evolving nature of technology pose ongoing challenges to designers. However, recognizing these challenges is a crucial step toward addressing them. Future directions in designing for inclusivity involve continued research, increased awareness, and the incorporation of emerging technologies to create environments that are universally accessible.

Designing for inclusivity and accessibility is a multifaceted endeavour that requires a commitment to diversity, adherence to universal design principles, and active collaboration with end-users. By embracing these principles, designers can contribute to the creation of environments that not only comply with accessibility standards but also foster a sense of inclusivity and dignity for individuals of all abilities and backgrounds.

19.6.1 Ergonomics and Comfort: The Relationship Between Anthropometry And Ergonomics, Ergonomic Furniture And Equipment Design

Ergonomics, the science of designing work environments to optimize human performance and well-being, is closely intertwined with the study of anthropometry—the measurement of the human body. Understanding human body dimensions contributes to the creation of comfortable and efficient workspaces.

Anthropometry serves as the foundation of ergonomic design by providing data on the variations in human body size and shape. Ergonomics, in turn, applies this knowledge to design products, tools, and environments that accommodate the diverse characteristics of the human body. This relationship is particularly crucial in addressing issues related to discomfort, fatigue, and musculoskeletal disorders that may arise from poorly designed workspaces.According to Pheasant and Haslegrave (2006), anthropometric data guides ergonomic interventions, ensuring that designs account for the range of body sizes and shapes within a population.Anthropometric data allows for the customization of products and workspaces to suit individual needs. User-centered design, a key principle in ergonomics, involves incorporating the preferences and dimensions of end-users into the design process. By utilizing anthropometric data, designers can create ergonomic solutions that not only adhere to general standards but also address the specific requirements of diverse user populations.As highlighted by Salvendy (2012), user-centered design ensures that ergonomic solutions are tailored to the unique characteristics and comfort preferences of individuals.

The relationship between anthropometry and ergonomics is integral to the creation of comfortable and efficient workspaces. By leveraging anthropometric data, designers can develop ergonomic solutions that address the diverse dimensions of the human body, promoting comfort, reducing the risk of musculoskeletal issues, and enhancing overall well-being. As technology and research continue to advance, the collaboration between anthropometry and ergonomics will play a pivotal role in shaping the future of user-centric design.

Incorporating anthropometric principles into furniture and workspace design is essential for promoting comfort and productivity. Ergonomic chairs, desks, and workstations are designed based on average body dimensions to provide optimal support and reduce the risk of musculoskeletal issues. Adjustability features, such as chair height and desk tilt, accommodate variations in anthropometry, allowing individuals to personalize their work environments.Hedge (2008) emphasizes the importance of ergonomic furniture in creating comfortable workspaces that minimize discomfort and fatigue.

The growing integration of wearable technology into daily life introduces new challenges and opportunities for ergonomic design. Anthropometric data becomes crucial in creating wearables that fit comfortably and securely on various body parts. Whether it's a smartwatch, fitness tracker, or augmented reality device, understanding anthropometric dimensions ensures that these technologies enhance rather than hinder user comfort and experience.Research by Lee and Salvendy (2009) underscores the significance of anthropometry in the design of wearable devices, emphasizing the need for a user-centered approach.

While anthropometry provides valuable insights, challenges remain in accommodating the increasing diversity of body shapes, sizes, and abilities. Future directions in the relationship between anthropometry and ergonomics involve the amalgamation of advanced technologies, such as 3D scanning and virtual reality, to capture more detailed and personalized anthropometric data. This approach holds the potential to further refine ergonomic designs, ensuring an even closer match to individual needs

19.6.2 Anthropometric Guidelines and Standards

Anthropometric Guidelines/Principles

Anthropometric data is used to help design products to meet ergonomic needs. When designing, the designer must always keep in mind the person for whom the product is designed for people using, the products will differ in age, size, shape, and weight. Adults and children come in different shapes and sizes. In the application of available anthropometric data to the design of physical equipment, facilities, tools, furniture, and interior space, the designer must be careful in selecting the appropriate data. Generally, wide ranges of data may be available but the designer should use only those data which correspond to the population who will use the design in question. The ergonomic guideline/design principles are important to be considered, based on the contextual needs of the design. The goal of applying the principles of anthropometrics to the workplace is to enhance human performance, control fatigue and prevent accidents. Those are:

i. **The Principle of Designing Products for Individuals of Extreme Size:**It is sometimes necessary to design certain aspects of physical facilities to accommodate the relevant anthropometric characteristics at one extreme or the other, e.g., in designing the height of the doors, the criterion may be to accommodate large individuals i.e., 95 percentile, or 99 percentile. This implies that such a height would also accommodate all those smaller in size. Thus, a minimum dimension, or other aspect, of a facility should be based on an upper percentile value of the relevant anthropometric characteristics of the population, such as the 90th, 95th, and 99th percentiles. Similarly,the maximum dimensions of the facility should be based on a lower percentile value of the relevant feature of the people, such as the 1st, 5th, or 10th percentile, e.g., for the location of a control device/display

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panel on a machine within the easy reach of the operator, the designer should use 95th and 5th percentile values. This principle is based on the logical assumption thatif those with short arm reach could reach a control, persons with longer arm reach could also do so.

ii. **The Principle of Designing for Adjustable Range:** Certain features of equipment or facilities should be designed as adjustable to accommodate people of varying sizes. Under this category the height of chairs for telephone operators or typists, kitchen centres, seats for loom and sewing machines, etc. are examples. Under this principle, predictive equations may be developed which may be applied based on the requirements of people and requirement of the activity needs. This principle implies that the design of products with a certain size range can be changed according to the operation of everyone who has a variety of body sizes. The size of this design can be changed or flexible according to the requests of each individual.

iii. **The Principle of Designing Products for the Average:** This principle applies to the design of products/tools/machines/spaceformed based on people who have an average size, e.g., classroomchairs, furniture in public places, seats in vehicles (bus/car), etc.

The published documents on architectural standards are established specifications and procedures designed to ensure the reliability of materials/products/methods/ services related to architecture.

19.6.3 Anthropometric Standards

The uses of anthropometric standards are:

- Assisting thedevelopment of building programs and establishing preliminary space allocations.
- Analyzing the specific client needs and quantifying them.
- Studying the general and specific functional relationships.
- I am assisting inthe processing of preliminary architectural designs.

19.6.4 Future Trends in Anthropometry: Advances in Anthropometric Research and Data Collection

Anthropometric design is one of the most important disciplines within the area of ergonomicapproaches. Products and working tools can be used safely, comfortably, and in a healthymanner with the correct anthropometry layout. As in today's modern tailored production, animmediate and direct adaptation of individual dimensions and proportions cannot realisticallybe realized; data that can describe the diversity of human body dimensions and be used toadapt the general size of a technical device and that device's adaptability to human bodydimensions is needed. The main objective here is to design these products in a way that can beused effectively and in a healthy and fatigue-free manner. In the case of highly developedproducts, a design that focuses on comfort can play a major role. "Anthropometry is the scientific measurement and statistical analysis of data about human physical characteristics and the application (engineering anthropometry) of this data in the design and evaluation of system, equipment, manufactured products, human-made environments, and facilities." The most important objective of anthropometry is the standardization of data procurement and, consequently, the reproducibility of the results (Martinand Knussmann, 1988)".For the measurement of anthropometric data, intensive knowledge about the construction andbiomechanical function of the human body is an absolute prerequisite. "Since the 1920s, it has been accepted that the measurement of the human body must be carried out with the help of defined measuring points and distances, using the skeletal bone structure as a reference (Martin,1974)". Mechanical measurement tools were created because of this definition and these tools have hardly changed at all in the last 80 years". It is only in the last ten years that thedevelopment of contact-free body scanners has enabled the measurement of soft body parts toenhance and supplement the traditional procurement of data using the skeletal point method.

A further essential prerequisite for the quality of anthropometric data is the selection of arandom sample that exactly matches the objective of the study or survey. A particular bodymeasurement (like arm length, for instance) can only be correctly applied if the random samplealso matches the future end-user of a product.In recent years, significant advancements in anthropometric research and data collectiontechniques have emerged, shaping the way we understand and apply human dimensions indiverse disciplines.Advances in anthropometric data collection and analysis may lead to more personalized interiordesign solutions. Designers could use detailed individual anthropometric data to create spacesthat cater to the specific needs and preferences of individuals, enhancing comfort andfunctionality.The increasing availability of big data and advancements in machine learning may enabledesigners to analyze vast amounts of anthropometric data quickly. This could lead to moreaccurate predictions and trends, helping designers make informed decisions in creatinginclusive and accessible spaces.As a part of the anthropometric study, the three major human body parameters are measured.They are Size (e.g., height, weight, surface area, and volume), Structure (e.g., sitting vs. Standingheight, shoulder and hip width, arm/leg length, and neck circumference), and Composition (e.g.,percentage of body fat, water content, and lean body mass).

Certain special tools with high accuracy are used to obtain anthropometric data. They are as follows:

- **i. Stadiometers:** They are used to measure the height of the human body.
- **ii. Anthropometers:** They are used to measure the length and circumference of body segments.
- **iii. Bicondylar calipers:** They are used to measure the diameter of the bone.
- **iv. Skinfold calipers:** They are used to measure skin thickness and subcutaneous fat.
- **v. Scales:** They are used to measure the weight of the body.

A new anthropometric measurement alternative to BMI Body mass index (BMI) is a simple metric used to assess overall body fat and is a marker of relative weight. However, BMI does not distinguish between adipose and lean tissue and is not a proven predictor of cardiovascular events (Yusuf et al., 2005) or mortality (Romero et al., 2006) in some large cohorts. The body shape index (ABSI) and the body roundness index (BRI) are new indices that can be calculated easily using waist circumference (WC), Body Mass Index (BMI), and height (Calderon et al., 2021; Haraguchi et al., 2019).

End of Chapter Exercise

1. Collect anthropometric data of housewives for workplace arrangement by using relevant statistical analysis (Mean, SD, Coefficient of variance, and 5th and 95th percentiles.
2. Collect anthropometric data of the Indian population relevant to furniture designing.

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