

# Product Fit and Sizing

## Sustainable Product Evaluation, Engineering, and Design

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Sandra Alemany, and Karen Bredenkamp



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# About the Authors



**Kathleen M. Robinette** is a research consultant specializing in anthropometry, biostatistics, and fit and sizing for product development and assessment. She has more than 45 years' experience, spearheading the development, management, and transitioning of new technologies in the field of engineering anthropometry and led the field in the development of 3D automated human scanning and modeling for product design and evaluation. She planned, organized, negotiated, and directed the first successful 3D whole body human measurement survey (CAESAR), which produced more than

4,000 whole body models which continue to be used around the world today. She is a fellow of the Air Force Research Laboratory from which she retired after 30 years of service and is an honorary fellow of the Human Factors and Ergonomics Society. She was professor and head of the Department of Design, Housing, and Merchandising at Oklahoma State University 2012–2015 and she established and directed the Human Factors department for Magic Leap Inc. 2015–2017 implementing fit mapping into the product development process. Kathleen has a Ph.D. in Biostatistics and Epidemiology from the University of Cincinnati, an M.S. in Mathematics/Statistics from Wright State University, and a B.A. in Anthropology from Wright State University.



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**Sandra Alemany** is a research scientist at the Instituto de Biomecánica de Valencia (IBV) and founded the Anthropometry Research Group in 2015. She led large-scale anthropometry surveys in Europe using 3D scanning technology and has experience in applying anthropometry to improve wearable fit including footwear, electronic devices, orthotics, insoles, and clothing. Recent developments include a 4D body scanner in movement and the development of two mobile applications to generate 3D body shapes from photographs. She is an expert advisor on European Standardization Committees of Anthropometry and Size System of Clothing and an expert reviewer of R&D projects for the European Commission. She is currently serving as co-chair for the Anthropometry Technical Committee for the International Ergonomics Association. She received her Ph.D. from the University Polytechnic of Valencia in 2023 with research about fit and clothing size prediction from anthropometry.



**Karen Bredenkamp** currently heads up the Human Factors team at Magic Leap Inc. Karen has more than 20 years' industry experience in anthropometry survey design, data collection, analysis, and implementation in wearable product and workstation design, as well as wearable product fit research as part of the product selection or development processes. Between 2000 and 2016, Karen was employed at Ergonomics Technology, a division of the Armaments Corporation of South Africa (ARMSCOR), where she had a core role in the establishment of the 3D whole-body and foot anthropometry databases for the ethnically diverse and unique South African National Defence Force (SANDF) population. Her activities furthermore involved providing anthropometry and fit inputs and evaluation support for product design as well as purchasing of SANDF clothing, footwear, protective wearable products, workstations, and occupant environments. Karen is currently serving as co-chair for the Anthropometry Technical Committee for the International Ergonomics Association. She has an M.Sc. in Biomedical Engineering from the University of Cape Town and a B.Eng. in Mechanical Engineering from Stellenbosch University, South Africa.

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# Preface

Nearly everyone has experienced fit problems with some wearable product and, as a result, few people have confidence in buying something without trying it on. Even if we have the option of trying it on, we may not find any size that fits well. We may have to shop in a department that doesn't have the type of items we need, such as a tall woman forced to shop in menswear or a small person forced to shop in childrenswear department. Being small doesn't mean you want to wear girly pink frilly knickers!

This is also a big problem for retailers who must decide how many of each size to buy and stock for good sales with minimal waste. For online shopping, fit problems result in returns with extra shipping costs. Shipping costs have gotten to be so high that some online apparel companies have been offering to refund a large part of the cost of the product rather than paying for the return shipping! Fit is not only a problem for fashion apparel but even more difficult for protective equipment or special wearables, such as helmets, eyeglasses, continuous positive airway pressure (CPAP) masks, and nitrile gloves, which we may purchase only once or infrequently. This problem exists with larger cost implications for organizations, such as hospitals, fire departments, law enforcement agencies, or the military, having to acquire sizes in large quantities.

Why, after hundreds of years of collecting body measurements, decades of three-dimensional (3D) human scanning and biomechanical modeling, and numerous textbooks on engineering anthropometry, are we still having problems with fit? The reason is a lack of fit data and no guidebook that explains how to get it. There is no database of fit test results and no resource that tells us reliably what product proportioning will fit a given body. The proportioning and sizing for fit success varies depending upon the design, the materials, the target population, the intended function of the product, the style, the other products with which it must interface, and more.

This book describes the process needed to design and assess wearable products effectively and select the best sizes for any population or any individual. We refer to it as the Sustainable Product Evaluation, Engineering, and Design (SPEED) process. The secret to good fit and product functionality is to measure, validate, and document early and throughout the development of the product, who we fit, how well we fit them, and how they relate to our intended wearer population. With this information, it is possible to make informed decisions about the design, the adjustment mechanisms (such as the type and number of pads, elastic straps, lacing, and belts), the number and assortment of sizes, and more to best accommodate your target market with the least amount of sizes and cost.

The authors, with 125 years of combined experience, have put together this textbook to capture and document the best methods and to help others learn from their experience. This is the book we wish we had had, first when we were just starting out in the business, then to use as a quick reference for procedures we only use

occasionally, and finally to use a textbook for our students and for co-workers who were carrying on our work.

We have spent more than three years pulling all the materials together and testing our processes and descriptions to ensure they work well for all types of products and industries. We have even used the draft of the book when explaining processes to our current customers and are sure we will continue to use it after it is published. We hope it will prove to be useful to anyone who wants to create well-designed and well-fitting products.