

**AN EXPLORATORY STUDY ON SOFT COMPUTING  
ASSISTED PRODUCT DESIGN FOR INDIAN  
CHILDREN USING ANTHROPOMETRIC DATA**

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# An exploratory study on soft computing assisted product design for Indian children using anthropometric data

by

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*Dedicated to Hari, Guru & Vaishnav*

## CERTIFICATE

This is certified that the work contained in this thesis titled “**An exploratory study on soft computing assisted product design for Indian children using anthropometric data**” is submitted by **Mr Jitesh Kumar Khatri** to the Indian Institute of Technology Delhi for the award of the degree of **Doctor of Philosophy** has been carried out under my supervision.

Mr. Jitesh Kumar Khatri has fulfilled the requirements for the submission of this thesis, which to our knowledge has reached the requisite standard. This research work has not been submitted any other University/ Institute for the award of any degree.

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Now at the completion of this course, reflecting back my life immediately reminds me that my situation is somewhat similar to honeybee. As honeybee goes from flower to flower for collecting nectars and pollens then processes and deposits as honey. Similarly I kept collecting nectar like information, suggestions, and guidance from various sources such as thesis advisor, committee members, and colleagues etc. and keep experimentally processing it and depositing as results, which has now taken the shape of a thesis. The quality of honey depends on the source of nectars as well as the type of honeybee; same is true for this thesis as well. Therefore it is a great privilege for me to take this opportunity to thank those who have helped me directly or indirectly to shape this work in a full-fledged thesis.

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## ABSTRACT

Designers often use complex information to synthesize design concepts (Cross, 1994; Earl et al., 2004). User's anthropometric data is one such type of data that a product designer needs to consider during the product ideation process. However, the anthropometric data required to design the different kinds of products for different age groups are not readily available, especially for developing countries like India. Also, hand ergonomic consideration in children's products design has often not received sufficient attention which impacts their performance (Valikhani et al., 2016). For ease of use of children's products like tiffin boxes, water bottles, cricket bats, jam bottles etc. the design process will require hand anthropometric parameters like hand length, hand width, grip strength, and pinch strength. To the best of my knowledge, the literature lacks any such anthropometry data for Indian children. Therefore, anthropometric data was collected from 2461 Indian children between 6-17 years on 9 anthropometric dimensions. The anthropometric data was collected by visiting 71 schools in National Capital Region and students participated on voluntary basis. Hand dynamometer, pinch gauge, measuring tape, weighing machine were used for measurements and the data including palm impression was recorded on a calibrated information collection sheet. As expected, the comparisons among genders within same country showed significant difference on all measured parameters. Comparison with other countries within same age and gender groups showed Indian anthropometric dimensions significantly different as compared to countries like USA, Sweden, and Saudi Arabia. This significant difference in dimensions indicates that using available anthropometric dimensions from other countries for product development in India could lead to inappropriate sized products.

Moreover, while designing products, the creative designers use anthropometric data tables that they often struggle to use. Therefore, the study has developed a design assistance system intending to assist product designers in designing children's products. The design assistance system uses soft computing techniques based on the children's anthropometric data collected as part of this thesis work. The developed design assistance system was then used by 30 designers. It was observed that the soft computing-based design assistance system was found to be much useful to the designers. The system helped save time and made the design thinking process more efficient.

## सार

डिजाइनर अक्सर डिजाइन अवधारणाओं को संश्लेषित करने के लिए जटिल जानकारी का उपयोग करते हैं (क्रॉस, 1994; अर्ल एट अल, 2004)। उपयोगकर्ता का एंथ्रोपोमेट्रिक डेटा एक ऐसा डेटा है जिस पर उत्पाद डिजाइनर को उत्पाद डिजाइन अवधारणाओं को संश्लेषित करने की प्रक्रिया के दौरान विचार करने की आवश्यकता होती है। हालांकि, विभिन्न आयु समूहों के लिए विभिन्न प्रकार के उत्पाद डिजाइन करने के लिए आवश्यक एंथ्रोपोमेट्रिक डेटा आसानी से उपलब्ध नहीं होते हैं, खासकर के लिए भारत जैसे विकासशील देश। इसके अलावा, बच्चों के उत्पादों के डिजाइन में हाथ के एर्गोनोमिक पर अक्सर पर्याप्त ध्यान नहीं दिया गया है जो उनके प्रदर्शन को प्रभावित करता है (वलिखानी एट अल, 2016)। बच्चों के उत्पादों जैसे टिफिन बॉक्स, पानी की बोतल, क्रिकेट के बल्ले, जैम की बोतल आदि के उपयोग में आसानी के लिए डिजाइन प्रक्रिया में हाथ की लंबाई, हाथ की चौड़ाई, पकड़ ताकत और चुटकी ताकत जैसे हस्त एंथ्रोपोमेट्री डेटा की आवश्यकता होती है। लेखक को भारतीय बच्चों के लिए कोई हस्त एंथ्रोपोमेट्री डेटा प्रकाशित साहित्य में नहीं मिला। इस प्रकार, इस थीसिस ने सबसे पहले 6-17 वर्ष के 2461 भारतीय बच्चों से 9 मानवमितीय आयामों की डेटा एकत्र किया है। एंथ्रोपोमेट्रिक डेटा राष्ट्रीय राजधानी क्षेत्र के 71 स्कूलों में जाकर एकत्र किया गया और छात्रों ने स्वेच्छा से भाग लिया। हैंड डायनेमोमीटर, पिंच गेज, मापने वाला टेप, वजन मशीन का उपयोग माप के लिए किया गया और हथेली के डेटा को कैलिब्रेटेड संग्रह पत्रक पर दर्ज किया गया। जैसा कि अपेक्षित है, एक ही देश में लिंग के बीच तुलना से पता चला है सभी मापा मापदंडों में महत्वपूर्ण अंतर है। अन्य देशों के साथ भारतीय मानवशास्त्रीय आयामों की समान उम्र और लिंग समूहों की तुलना में अमेरिका, स्वीडन और सऊदी अरब जैसे देशों के मानवशास्त्रीय आयामों में महत्वपूर्ण अंतर पाया गया। मानवशास्त्रीय आयामों में यह महत्वपूर्ण अंतर यह इंगित करता है कि भारतीय उपयोगकर्ताओं के उत्पाद विकास के लिए अन्य देशों से उपलब्ध मानवशास्त्रीय आयामों का उपयोग करने से अनुपयुक्त आकार के उत्पादों तैयार हो सकते हैं।

इसके अलावा, लेखक ने देखा कि उत्पादों को डिजाइन करते समय, रचनात्मक डिजाइनर एंथ्रोपोमेट्रिक डेटा की तालिकाओं का उपयोग करते हैं जिसमें वे अक्सर संघर्ष करते हैं। इसलिए, इस थीसिस ने बच्चों के उत्पादों को डिजाइन करने में उत्पाद डिजाइनरों की सहायता करने के उद्देश्य से एक डिजाइन सहायता प्रणाली विकसित किया। डिजाइन सहायता प्रणाली इस थीसिस कार्य के हिस्से के रूप में एकत्र किए गए बच्चों के एंथ्रोपोमेट्रिक डेटा पर आधारित सॉफ्ट कंप्यूटिंग तकनीकों का उपयोग करती है। तब विकसित डिजाइन सहायता प्रणाली का उपयोग 30 डिजाइनर द्वारा किया गया। यह देखा गया कि सॉफ्ट कंप्यूटिंग-आधारित डिजाइन सहायता प्रणाली को डिजाइनरों के लिए बहुत उपयोगी पाया गया। इस प्रणाली ने समय बचाने में मदद की और डिजाइन थिंकिंग प्रक्रिया को अधिक कुशल बनाया।

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