On the use of self-reported anthropometric measurements in ergonomics

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Introduction:
After the Second World War, social sciences have seen the emergence of cognitivism. This new paradigm has affected not only ergonomics but all other social and human sciences. In this context, cognitive ergonomics emerged in the seventies of the last century (Lee, 2001). At about the time, affective ergonomics appeared influenced by the occurrence of the humanism school (Jordan, 1997). Not far from these two movements, some features of the spiritual movement have emerged in ergonomic studies (see for example James, et al. 2011). These new developments were behind the growth of qualitative methodology in ergonomics which was behind the appearance of self-reported studies. The great advantage of self-reports is that they give the researchers qualitative data that can be used in qualitative research, specifically phenomenology (Wertz, 1983; Sheth, et al. 2009). That, in turn paved the way to the growth of self-reported anthropometry.

Anthropometry has been in use for many years. Before the middle of the last century, anthropometric data were mainly used in anthropology for the scientific study of humans, and the creation and validation of racial typologies. Also, it has been used in health sciences for the determination of healthy or strong physique. However, after the development of ergonomics in the second half of the last century, anthropometry has become one of its most important pillars (Rodriguez-Anez, 2001).

As far as ergonomics is concerned, design, which is a systematic series of steps that ergonomists use in creating equipment, instruments, workplaces, products and processes, can be divided into two types: traditional and modern design (Molenbroek & de Bruin, 2005).

1) Conventional designs, include:

- Design as Procrustes: a design called after the former Greek mythology, where the user is fitted in force to the product.
- Design for Ego: here, the designer only looks to his own size and assumes his designs will fit everyone else.
- Design for more types: a design where the product is manufactured in several types to fit the variation of users. An example is shoe design that consists of small, medium and large sizes to fit the requirements of customers.
- Design for the average: this is only acceptable when one is using the workplace for a very short duration, such as the design of work surface height in a bank, based on customers’ elbow height.
- Design for the extremes: this is usually directed to the 5th percentile (Design for the Small) or the 95th percentile (Design for the Tall), such as the design of a kitchen shelf
for the smallest person's arm reach, or the design of a doorpost height for the largest person's stature.

2) New designs, include:

• Design for adjustability: a design that is usually carried out from the 5th percentile to the 95th percentile, such as the design of adjustable height chairs based on popliteal height.
• Design for all: this is sometimes called universal design or inclusive design which aims to produce equipment, instruments, workplaces, products, processes and environments that are inherently accessible to all (normal people, people with disabilities and older people).

Ergonomic designs whether conventional or new, are to a great extent dependent on anthropometric measurements that can either be directly measured or self-reported. Direct measurements are often taken using anthropometric instruments such as anthropometers, calipers, tapes, scales etc. On the other hand, self-reported measurements are taken using self-reported methods such as interviews, questionnaires, inventories etc.

This study aims to answer the following questions:

1. What is self-reported anthropometry?
2. How valid is self-reported anthropometry?
3. How is self-reported anthropometry used in ergonomic design?

Method: To achieve the aims of this study, the descriptive method of mainly surveys, was used as follows:

First, a literature survey was conducted, using a variety of keywords (anthropometry, self-reported anthropometry, validity, ergonomic design). This search is conducted as follows: Initially, an electronic search in the following data bases: Ergonomics Abstracts, Scopus, and Science Direct, is conducted using key words self-reports and self-report anthropometry. In addition, manual searches are carried out in journals such as The American Journal of Clinical Nutrition, Applied Ergonomics, Ergonomics, and International Journal of Industrial Ergonomics etc.

Second, a questionnaire survey was administered on a sample of students. The sample was composed of (60) students who were randomly chosen from College of Arts at Bahrain University. They were (38) males and (22) females at the age range of (21) to (28) years with an SD of (2.03). The questionnaire that was written in Arabic, consisted of two sections: the instructions and questions sections. The Questions section consisted of the subsequent questions: How tall are you without shoes? How much do you weigh without clothes or shoes? What is your right and left hand grip? What is your chest circumference? And what is your waist circumference?
Third, an anthropometric survey was carried out on the above-mentioned sample. Five body measurements were taken (body height, body weight, hand (right and left) grip, and chest and waist circumferences). Body measurements were taken with the following instruments:

- A Harpenden standard anthropometer (Holtain Ltd., UK) to take the body height to the nearest millimeter.
- A portable Seca weighing scale (Hangzhou, China) to take the body weight to the nearest 50 gms.
- A tailor (cloth) meter to take the body circumferences to the nearest millimeter. The measurement was taken horizontally at midpoint between the costal margin and iliac crest in the mid axillary line. The subject standing with relaxed arms hanging at sides and the measurement was taken approximately from the armpit at the level of 4th costosternal joint and just superior to the level of nipple.
- A squeeze dynamometer (Model 78010 Lafayette Instrument Co.) to take the hand grip to the nearest kg. Students were standing at relaxed arms hanging at sides.

Procedures: Initially, (Sunday, February 22, 2015) students were informed about the research aim and were asked if they were willing to participate in this research. Then, they were asked to answer the questionnaire. After a month elapsed (Sunday, March 29, 2015) students were asked to visit the physical education lab for anthropometric measurements. Male students were measured by one of the two researchers (M.M.), however, females were measured by the female researcher (M.A.). All measurements were taken in the first half of the day, while students were standing as naturally as possible. Body height, body weight, and chest and waist circumferences were taken once. However, hand grip was taken twice. The measurements mean was recorded.

Statistical Analysis: Statistical analysis was carried out using SPSS version 16.0 for Windows.

Results and discussion:

1) What is self-reported anthropometry?

Self-reported study, is any study where participants are asked to supply information about their body (anthropometric measurements), affect (feelings and attitudes), cognition (beliefs) and soul (faith and devotion). According to researchers, the use of self-reported studies for gathering information relating to a particular construct, is very prevalent in social sciences (Schwarz, 1999; Vazire, 2006; Kagan, 2007) and in ergonomic studies (Juul-Kristensen & Jensen, 2005; Hagberg, et al. 2002; Zungu and Ndaba, 2009; Camille-peres, et al. 2009). The major reason for which self-reported studies has spread is that people can convey a vast amount of information about themselves through words spoken and expressing their actions (McCrae & Costa, 1999). Self-reports –in terms of construct clarity– can either be direct or indirect. Direct self-reported studies are the studies where people are asked to report directly on their own personalities. However, indirect self-reports are studies where researchers usually and deliberately obscure the construct being measured (Paulhus & Vazire, 2007). Howard (1994)
asserts that self-report is generally a suitable methodology for the study of human characteristics. When collecting data from participants, several researchers such as Harre (1974) and Kelly (1955), argue that researchers should ask a participant for his/ her own views but not an informant (someone who knows the person), unless there are convincing reasons not to do so.

Self-reported anthropometry is a type of self-reported study where anthropometric measurements are not directly measured but gained through participants' responses. Participants are frequently interviewed to report anthropometric measurements, such as how tall they are without shoes, and how much they weigh without clothes or shoes. Interviews can be mail, face-to-face, telephone or Internet interviews. It is to note that up to the 1970s, mail and face-to-face interviews were the main modes of data collection (Lyberg and Kasprzyk, 1991). However, with the proliferation of the telephone among individuals all over the world, telephone interview become very popular (Dillman, 2000). With the spread of the Internet in the nineties of the last century, internet interviews became also popular (Couper, 2011). Regardless of the interview mode, participants are asked to report their demographic information (including anthropometric measurements such as height and weight). Self-reported anthropometry enables a large number of individuals to be sampled at relatively minimal cost, time, and resources.

2) How valid is self-reported anthropometry?

Validity is described as the correlation between the anthropometric measurements taken through self-reports and the measurements taken through direct measurements. The higher the correlation coefficient, the more valid the self-reported measurements are. Both questionnaire and anthropometric survey results are depicted in Tables (1) and (2).

Table 1, Mean values, SD values, R, 95 % CI and T test of measured and self-reported variables, (N= 38).

<table>
<thead>
<tr>
<th>Body Measurements (Males)</th>
<th>self-report data</th>
<th>measured data</th>
<th>R</th>
<th>95% CI of the difference</th>
<th>T test</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>SD</td>
<td>X</td>
<td>SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body height (mm)</td>
<td>1739.7</td>
<td>43.65</td>
<td>1728.2</td>
<td>52.4</td>
<td>0.86</td>
<td>2.84</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>74.3</td>
<td>7.4</td>
<td>75.8</td>
<td>6.7</td>
<td>0.96</td>
<td>0.87</td>
</tr>
<tr>
<td>Master Hand grip (kg)</td>
<td>32.9</td>
<td>3.77</td>
<td>30.9</td>
<td>2.93</td>
<td>0.74</td>
<td>1.09</td>
</tr>
<tr>
<td>Chest circumference (mm)</td>
<td>75.05</td>
<td>4.57</td>
<td>73.2</td>
<td>5.57</td>
<td>0.88</td>
<td>0.90</td>
</tr>
<tr>
<td>Waist circumference (mm)</td>
<td>76.63</td>
<td>3.45</td>
<td>79.21</td>
<td>3.32</td>
<td>0.72</td>
<td>-3.40</td>
</tr>
</tbody>
</table>

Table 2, Mean values, SD values, R, 95 % CI and T test of measured and self-reported variables, (N= 22).

<table>
<thead>
<tr>
<th>Body Measurements (Females)</th>
<th>self-report data</th>
<th>measured data</th>
<th>R</th>
<th>95% CI of the difference</th>
<th>T test</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>SD</td>
<td>X</td>
<td>SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body height (mm)</td>
<td>1693</td>
<td>53.7</td>
<td>1672</td>
<td>55.7</td>
<td>0.91</td>
<td>-31.5</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>62.9</td>
<td>2.96</td>
<td>61.8</td>
<td>2.27</td>
<td>0.60</td>
<td>0.014</td>
</tr>
<tr>
<td>Master Hand grip (kg)</td>
<td>20.7</td>
<td>2.84</td>
<td>18.9</td>
<td>2.36</td>
<td>0.73</td>
<td>1.11</td>
</tr>
<tr>
<td>Chest circumference (mm)</td>
<td>79.27</td>
<td>1.66</td>
<td>77.68</td>
<td>4.61</td>
<td>0.30</td>
<td>-0.36</td>
</tr>
<tr>
<td>Waist circumference (mm)</td>
<td>79.59</td>
<td>4.71</td>
<td>80.22</td>
<td>4.88</td>
<td>0.47</td>
<td>-2.82</td>
</tr>
</tbody>
</table>

R= Pearson Correlation
It is seen that both self-reported and measured body dimensions are positively correlated indicating that self-reported anthropometry is valid and accurate. These results are in agreement with results of many other studies that have shown they are of a good validity, and can be used in scientific research (Buckle, 1985; Rees, and Cooper, 1993; Revicki, et al. 1994). Furthermore, Burton, et al., (2010) confirmed the effectiveness of self-reported anthropometry. There are several studies showing that self-reports have many positive aspects including that they are easy to interpret, inexpensive, relatively quick to collect a lot of data, and efficient in obtaining data from a large number of participants, even at one time (Kline, 1993; Paulhus and Vazire 2007). On the other hand, some authors believe they are less valid. Participants may exaggerate their problems in order to make their situation seem worse, or they may under-report them to suggest they are very good. In addition, participants may not remember the information required of them in the study (Van der Beek, and Fring-Dresen, 1998; David, 2005; Connor Gorber, et al. 2007).

It seems that the validity issues of self-reported anthropometry aren’t related to the nature of this type of anthropometry, but to how anthropometric measurements are taken. Stock, et al. (2005) believe that low measured validity may often be due to the poor formulation of questions, which limits the ability of the study population to accurately report their exposures.

To increase validity of self-report anthropometry, one can take advantage of the guidance provided by the researchers to increase validity of self-reported studies in general. In this regard, the instrument, the respondent and the researcher’s variables are taken into account as follows:

**Instrument variables:**

- **Instrument instructions:** Every data collection instrument such as questionnaire, interview, etc. should contain very clear instructions. Short instructions help the respondent make sense of the instrument and make it seem less confused. They also help put the respondent in the proper frame of mind for answering the questions. In these instructions, the aim of research should be clearly stated. In addition, the respondents should be told exactly what is wanted from them. According to Biemer and Lyberg, (2003) good data collection instrument instruction helps increase validity of self-reports.

- **Questions:** The formulation of questions and answers can have a major effect on the responses obtained and ultimately on the conclusions drawn from the research. First, questions and statements are to be kept as short as possible in order to increase the respondent’s comprehension (Holbrook et al. 2006). Second, grammatical complexities should be kept to the minimum (Dornyei, 2003). Third, questions should have specific rather that general terms (White et al. 2005).

- **Sensitivity issues:** When participants are asked questions they see as invading their privacy, they most probably produce inaccurate answers (Tourangeau, 1984). Therefore, the researcher ought to assure the respondents that the information they provide is confidential.
• Social desirability issues: According to Holtgraves (2004, p. 161) social desirability refers to a tendency to respond in self-reports in a manner that makes the respondent look good rather than to respond in an accurate and truthful manner. To reduce the effects of social desirability, indirect questions are asked. Besides, questions are worded as naturally as possible (Klassen, et al. 1976).
• Validity and reliability issues: Key indicators of the quality of a measuring instrument are the reliability and validity of the measures. Using instruments that are valid and reliable is a crucial component of research quality (Kitis, et al. 2009).

Respondent’s responsibilities:

• Willingness to participate: The willingness to answer self-reports is important to increase validity. The more willing the respondent to answer, the greater the validity of self-report studies will be. Knowing that there are factors working to increase the respondent’s willingness to answer (age, gender, educational level, socio-economic status etc.), it is necessary to take them into account (Fujimori and Uchitomi, 2009).
• Construction of the instrument: A poorly constructed and or administrated instrument can switch off the respondent’s willingness to convey the required information. Therefore, instrument validity will be threatened (Clancy & Wachsler, 1971).

Researcher considerations:

• Training and skills: Researcher training and possessing the skills to build self-report instruments, plays a major role in increasing the validity of the self-reported studies. The more the researcher is trained and possesses the necessary skills, the more valid are the results of self-reports (Wicker, 2008; St. Peter, et al. 2012).
• Ethical issues: Attention to ethical issues in an objective helps to increase validity of self-reported studies (Lucca and Moura, 2010). Despite the fact that there are many ethical issues, the most important are:
  ❖ Privacy: Self-reported studies must respect the privacy and psychological wellbeing of all participants, who have the right to expect that any information they provide will be treated confidentially, and is used only for the purposes of scientific research.
  ❖ Consent: Researchers need to protect participants’ right to take out some or all of the data from the study. In addition, the participants are to agree or not on the inclusion of the information they provide in scientific research.
  ❖ Risk of harm: Researchers ought to protect participants from psychological harm during all investigations. If the risk of harm is to be part of the investigations, it must not be greater than that in ordinary life.
  ❖ Debriefing and support: Socially sensitive topics can cause distress to the participants. For this, researchers must provide the necessary help and support to eliminate it (Salah El-Din & Sugiura, 2013).
How self-reported anthropometry is used in ergonomic design? Considering Molenbroek & de Bruin’s (2005) taxonomy of designs, it is suggested to use self-reported anthropometry at least in the subsequent two types of design:

Design for adjustable ranges: From an ergonomic point of view, designing for an adjustable range is optimum strategy in the work place. Since many workstations must accommodate an array of workers, adjustability gives the designer the mechanism by which to fit the workstation to a wide range of individuals. A good example is office chairs that have height adjustments. It is customary for design adjustments to accommodate individuals from the 5th percentile (Female) to 95th percentiles (Male). However, large ranges are recommended if the design cost is not excessive (Kantowitz and Sorkin, 1983). Its underlying premise is that it should enable rather than exclude different users (Gym, et al. 2000). The fact that each person is different, makes it essential that ergonomic work places are fully adjustable, so they can be customized to suit each individual, and their changing needs. Full adjustability is also important to provide the variation of postures that are so important to the human body.

Design for all: According to researchers (Mace, et al. 1991; Molenbroek, and de Bruin, 2005), design for all or universal design, is a process intended to promote the development of products or environments that can be used effectively by all without adaptation or stigmatization. Besides, it means to exclude as few individuals as possible. To achieve this aim, two important factors are urgently needed: a universal designer and a large amount of data. The universal designer should be considerate, open-minded and creative. However, the large amount of data should be able to fulfill the needs of the universal design. In these circumstances, self-reported data may be very convenient. This new paradigm in ergonomics needs new instruments and methods for the fact that traditional measured anthropometry for example may not be able to satisfy the requirements of universal design especially its two principles: “equitable use” and “flexibility in use”. Equitable use is about making the design useful and marketable to people with diverse abilities. On the other hand, flexibility in use is about producing a design that accommodates a wide range of individual preferences and abilities.

Conclusion: This paper discussed the use of self-reported anthropometry in ergonomic designs. Researchers have been worrying about the use of self-reports as they suffer from decreased validity. It has been shown that self-reported anthropometric studies can be more valid if data collection instruments are tightly designed, and both the respondent and researchers are highly trained and motivated. After ergonomists established the use of qualitative methods in ergonomics research, why not to encourage researchers to use self-reported anthropometry in ergonomic designs?

Keywords: self-report study, self-reported anthropometry, validity, ergonomic design.

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Wicker, T.L. (2008). Self-report of nursing leadership practice after completion of training. A PhD. Dissertation Submitted to the Faculty of the College of Nursing, the Graduate College, The University of Arizona, USA.