Help or Hindrance?
A Case Study of Pragmatic Anthropometry

David HITCHCOCK[1], Chris DIDIO[2] and Tina REES[2]

[1]David Hitchcock Ltd, 45 Dennis Street, Hugglescote, Leicestershire LE67 2FP.
[2]Arriva Trains Wales, St Mary's House, 47 Penarth Road, Cardiff CF10 5DJ

Abstract. Arriva Trains Wales has endeavored to use the anthropometric information from a rail industry specific assessment tool to pragmatically appraise their train cabs and control musculoskeletal disorder (MSD) risks to its drivers. This paper offers thoughts on the merits and shortcomings of using anthropometric data in such an application and its value in communicating key issues to decision makers. It challenges the ergonomics profession to consider the communication and application of what is a cornerstone of the discipline.

Keywords. Anthropometry, Cab, Communication, Musculoskeletal

1. Introduction

Anecdotally, poor cab fit has been reported to be a primary source of musculoskeletal risk to train drivers because of the difficulties they may have in attaining and maintaining healthy working postures. In 2013, as a response to this, the Railway Safety and Standards Board introduced the 'MSD risk Assessment for Train drivers (MAT) tool'. This ergonomics-based tool takes a holistic view, considering factors such as task activities, driver movements, forces applied and vibration characteristics. This is consistent with MSD assessments (Prado-Lu, 2004).

It is important to state that the validity and usefulness of the MAT tool is not in question as far as this paper is concerned – its holistic approach provides a strong evidence base on which to identify and weigh up the MSD risks. Rather the focus of the paper is on the element which is perhaps the most prominent - the anthropometry sections which compare a number of static body measurements with the equipment provision within the cab.

2. People Know About Anthropometry

The practicing ergonomist will no doubt be familiar with the emphasis that clients can place on anthropometry. As ergonomics has become more widely known, it is anthropometry that is seemingly a common area of knowledge with designers, albeit with differing levels of detail and understanding.

Is the design the correct height? Do the sizes enable a neutral working posture? What sizes of people does the design need to accommodate to achieve compliance? In our experience these are regular questions, typically considered at least as, if not more, important than issues such as usability, task design and psychosocial factors which may also contribute to MSD risks.

This presents a potential problem, worthy of exploration. While it is accepted that good fit between the user and their workplace is important, the question must be asked if this emphasis is beneficial or possibly misleading. For example the Display Screen Equipment Regulations (HSE, 2002) do **not** demand the anthropometric aspects of cashpoint machines to facilitate good operating posture by all users (or the typical 5th-

95th percentile range) because the low frequency of use does not present an MSD risk.

3. Are the Measurements Accurate?

A fundamental starting point to explore the usefulness of anthropometric data is the reliability of the measurements. In this case study, for example, there is plenty of scope for error when measuring the work area. Train cabs are typically relatively confined spaces which make measuring awkward. Differing degrees of wear and tear within cabs of the same type can lead to inconsistencies. For example seat cushion rigidity, depressions from use and the like can present varying measurements for important features such as seat pan width and height of lumber support. Other key measurements such as leg clearance may vary because of the subjective determination of driver posture. The positions which the measurer has to adopt in order to collect the measurements using a tape measure and the often poor lighting conditions in which they need to read the measurement can also influence accuracy:

Figure 1: Examples of Measurement Difficulties.

Efforts, of course, are made to account for these potential sources of inaccuracy. For example, three measurements are taken by the same competent person for each dimension and the average then calculated. Even so, as an example, the differences between individual measurers and/or cabs were found to vary by up to 80mm over a 1m length for zone of convenient reach. While this might be easy to address in a laboratory setting, with the many constraints (e.g. time, availability, circumstances) of site work, practical improvements are unlikely or unrealistic.

While perhaps less of a problem, as Kroemer (1998) described, the subsequent measurement of drivers may also be compromised for similar reasons and constraints, using basic anthropometry measuring equipment.

The issue of measurement accuracy is not unique to the example of this case study. Krakower (1937) in his historical paper stated the objects of anthropometry to be: "*(1) to measure as exactly as possible the structure and activities of the human body, and (2) to measure the factors of the environment with which changes in man's structure and activities are associated*.". This paper suggest that the real problem arises when, despite being aware of the potential margins of error, the resulting data begins to be recognised as the definitive measurement without consideration of any caveats. A very small difference of, for example, 5mm can give the client the impression of a 'Pass' or 'Fail' for a particular dimension – without considering the context or any extraneous factors. This may be exacerbated by the fact that cabs, even of the same type, can vary by such margins as a result of, for example, wear and tear within the acceptable life

cycle of equipment (e.g. seat cushion depression).

4. **Is the Anthropometry Representative?**

The next fundamental question must be to ask whether what is being measured is actually representative of the issue. For example, in order to compare the workplace provision with the anthropometry data, it is often necessary to directly compare against the standardised static anthropometry postures such as those shown in Figure 2:

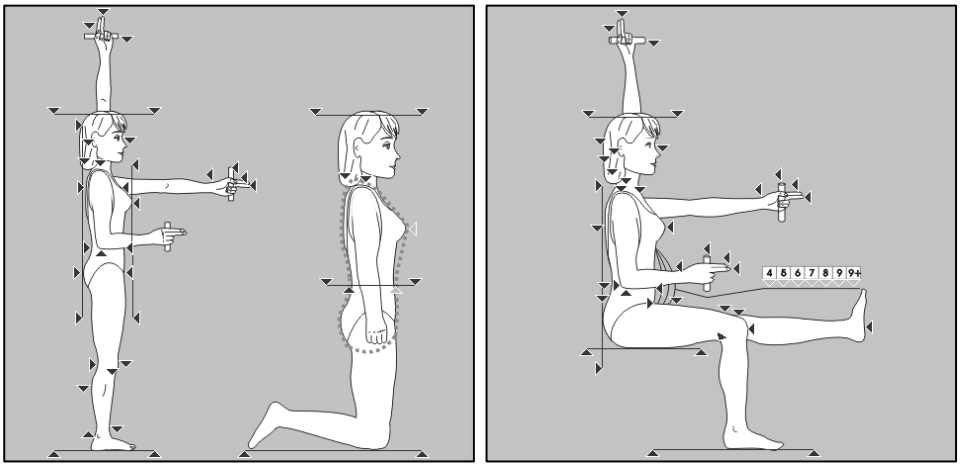

Figure 2: Example Standardised Static Anthropometry Postures © Open Ergonomics.

Not all operating postures reflect these textbook ones; therefore, direct comparison is not necessarily applicable. In the 'safe' hands of the trained ergonomist, such comparisons may be handled appropriately; perhaps not so by those with less understanding of the application of human body size data. Again, this can lead to compromised decisions regarding workplace suitability. It has long been recognised that even minor changes in workplace dimensions can have major impact on a person's performance and safety (Das and Grady, 1983). It is essential then that any review of existing provision and the need for any changes must be based on the correct and meaningful application of the anthropometry data in context.

In this case study, not all train drivers adopt seated driving postures that look like the seated posture in the picture on the right-hand side Figure 2. Some recline, some lean forward. Some compromise their posture because the cab design itself gives them no choice – they can't reach or they can't fit without doing so. In some cases the posture adopted is one of personal preference. The MAT tool endeavours to account for this, but the potential problem lies, again, in the way that the client or non-ergonomist interprets the anthropometry output.

5. **Is the Data Valid?**

In the teaching and training of anthropometry, the need to use the correct data source for the application is usually emphasised. Gender, age, origin, data collection date are common considerations. Perhaps even more fundamental when it comes to practical anthropometry is to determine whether or not the data are appropriate or realistic at all. For example, in train cabs there are controls which are pretty much unique to the industry, for which – at best – there is only limited available data. This raises the question of the data's validity. For example, in a cab, the Driver's Safety Device (DSD) foot pedal requires a force to depress it in the first place and then a force to hold

it down throughout a journey. As such, it doesn't operate like a car's accelerator, brake or clutch pedals for which data are available. So what data should be used to determine whether or not the force requirements are within the drivers' capabilities? Dare it be suggested that in such circumstances a 'best, educated guess' may be necessary on occasion? This may not be a new dilemma for the experienced ergonomist, but again the decisions may not be easy for the client to understand and, again, this may lead to confusion or misinterpretation of results.

6. **How is the Anthropometry Communicated?**

Having suggested just three aspects which offer the potential for problems arising from blindly relying too much on the anthropometry, the authors offer the opinion that in and of themselves they may not offer significant difficulties…if they are handled by a competent practitioner. Problems can arise when those with less familiarity or understanding of the data are presented with the outputs as a fait accompli. Arguably, in the same way that many projects, reports and surveys are communicated to decision makers, only headline findings may be considered. This is a fact of life, especially for what businesses might consider issues of less priority. As heart wrenching as this might be to ergonomists, anthropometry is probably often one such lower priority. According to Olds (2004), "*Since 1985, there has been declining interest in anthropometry.*" This is a somewhat contentious view, especially if taken out of context, but it is used in this paper simply to raise the question about how others see one of the building blocks of the ergonomics discipline. The ergonomist recognises the purposes and limitations of anthropometry, particularly as an early instrument in the design process, rather than a definitive retrospective benchmarking standard. Such an understanding cannot be presumed among non-ergonomists.

7. **Are We Bothered?**

If there is a concern about how others interpret the outputs of anthropometric design or evaluation, the authors propose the pragmatic solution lies with those giving the message rather than those receiving it.

Over recent years, there seems to have been an increasing tendency to present complex MSD findings using a 'traffic-light' system (e.g. Manual Handling Assessment Charts [HSE, 2014]). This form of simplified presentation makes it quick and easy for those looking to assess the extent of risks and prioritise the implementation of control measures. The downside is that a common response in reviewing the results is that RED is considered bad or unacceptable, AMBER might be acceptable but could be improved and GREEN is good or no problem.

The version of the MAT tool used at the time of this case study adopted a similar approach. In terms of the anthropometry feedback, a GREEN was used to convey that the cab fit for a given dimension should be suitable for those between 5%ile female – 95%ile male. RED meant it did not provide for such a range. Plenty of support data and explanation is also provided in the tool to show what range is actually covered, what the physical shortfalls are, what might be done to address them and so on.

However, the key problem can be that the interpretation – particularly by those with a particular bias, such as someone seeking compensation for an alleged injury– is that GREEN represents a 'pass', and 'RED' is a fail.

Which is where the question posed in the title of this paper comes into focus. Does the anthropometry become a 'Help or Hindrance?' It is clearly a help to the practitioner; informing them of the design and provision issues – given the caveats and

understanding factors already discussed. It can be a hindrance to others who don't have the necessary experience or background to consider which dimensions are important in a particular case (a RED rating for a low risk dimension or particular size of individual may not be remotely problematic). It can throw people off the scent, highlighting a low priority anthropometry issue instead of other more active risk factors.

More detailed presentation of findings using 'busy' presentations of applied anthropometry data overlayed on line drawings and plans appear to present a similar conflict for the unfamiliar. A well rendered drawing can be so impressive that the key data to be considered may be lost by those responsible for the descison making.

Yet, the ergonomist knows just how important anthropometry is! So, what to do?

The authors believe that research into the communication of anthropometry data to those outside of the ergonomics discipline should be conducted. As an example, a very common question regarding cab fit is '*what are the tallest and shortest drivers that a particular cab will fit?*' Aware of the variability between and within idividuals, such a question can strike fear into the heart of the design ergonomist, although Haslegrave (1986) reported that stature and weight are two body dimensions which are related to the general characteristics of body dimensions. Could we develop such a simple communication with confidence? It may not be possible of course, because as reported in the same publication, at the extremes of the populations there is considerable variation in body dimensions and proportions.

Of course, if the issue was simple to resolve the solution would probably be already to hand for such a core aspect of the ergonomics discipline. It is nevertheless, surely a challenge worth facing?

References

Das, B. & Grady, M. (1983). Industrial Workplace Design: An Application of Engineering Anthropometry. Ergonomics: 26:5: 433-447.

Haslegrave, C.M. (1986). Characterizing the Anthropometric Extremes of the Population. Ergonomics: 29:2: 281-301.

HSE. (2014). Manual Handling Assessment Charts (the MAC tool).

HSE. (2002). Work with display screen equipment: Health and Safety (Display Screen Equipment) Regulations 1992 as amended by the Health and Safety (Miscellaneous Amendments) Regulations 2002.

Krakower, H. (1937). Anthropometry, Research Quarterly. American Physical Education Association: 8:3: 85-95.

Kroemer, K.H. (1989). Engineering Anthropometry. Ergonomics: 32:7: 767–784.

Olds, T. (2004). The Rise and Fall of Anthropometry. Journal of Sports Sciences. 22:4: 319-320.

Open Ergonomics. (2008). Peoplesize Professional.

Prado-Lu, J.L.D. (2004). Risk Factors to Musculoskeletal Disorders and Anthropometric Measurements of Filipino Manufacturing Workers. International Journal of Occupational Safety and Ergonomics: 10:4: 349-359.