The Boot.

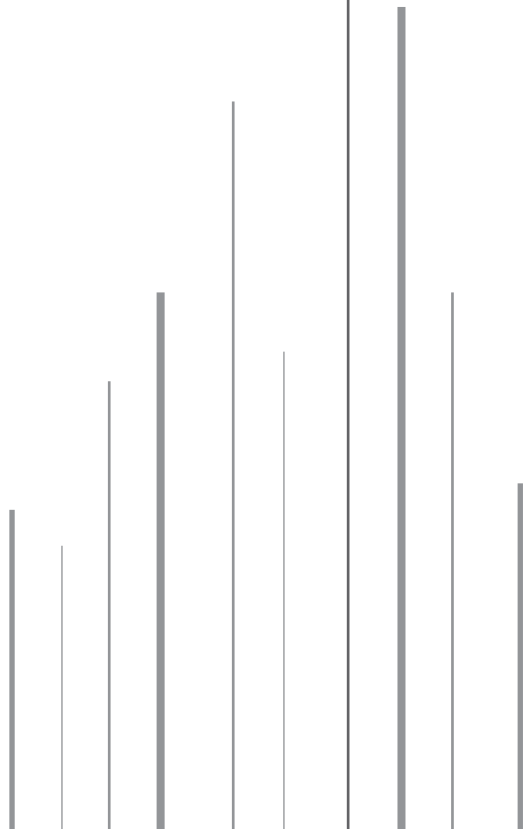
An Ergonomic Investigation.

Tom Becker.

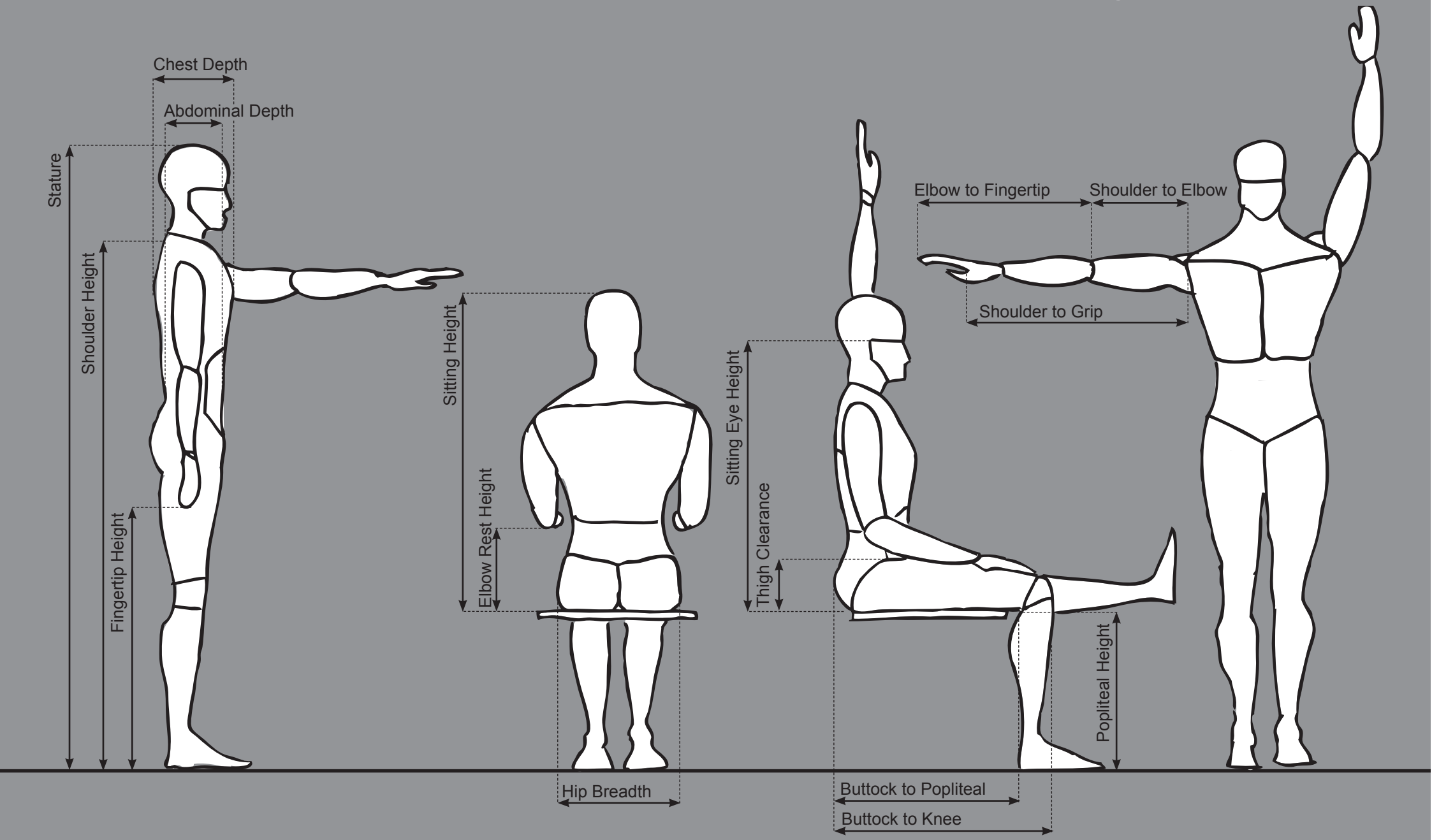
The Boot.

An Ergonomic Investigation.

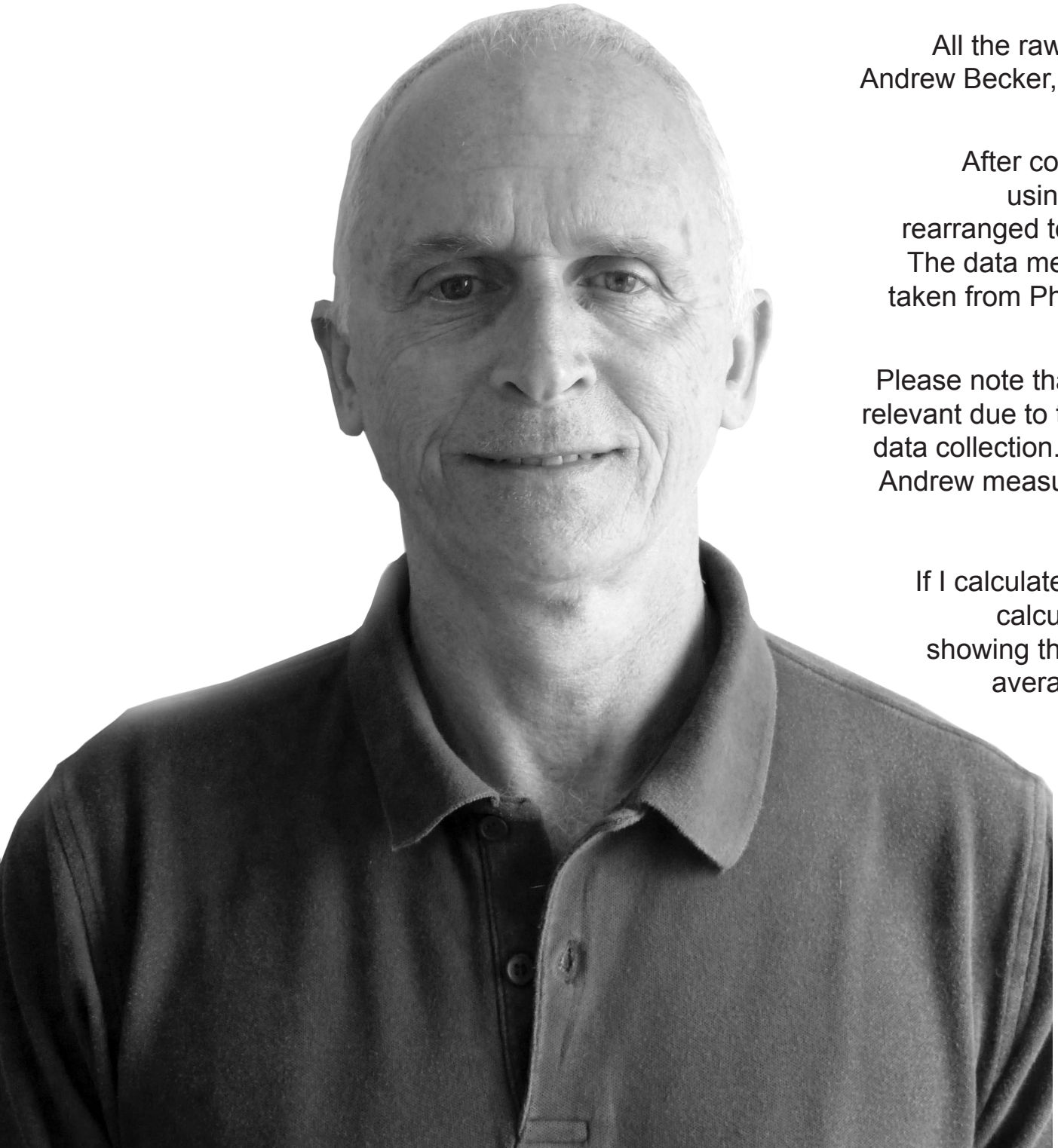
With thanks to Mic Porter and Andrew Becker.



The Subject: Measurements.



Measurement	Raw Data	Percentile	Calculation
Weight (kg)	76.3	29th	(76.3-83.5)/13.0= -0.553
Stature (mm)	1780	66th	(1775-1745)/69= 0.434
Shoulder Height (mm)	1480	74th	(1475-1435)/65= 0.615
Sitting Height (mm)	936	29th	(931-951)/35= -0.571
Fingertip to Floor (mm)	692	76th	(687-660)/38= 0.710
Sitting Eye Height (mm)	794	43rd	(789-795)/34= -0.176
Elbow Resting Height (mm)	235	30th	(230-245)/30= -0.5
Thigh Clearance (mm)	157	29th	(152-160)/15= -0.533
Popliteal Height (mm)	464	69th	(459-445)/28= 0.5
Buttock to Knee (mm)	615	69th	(610-595)/30= 0.5
Buttock to Popletial (mm)	501	51st	(496-495)/32= 0.031
Hip Breadth (mm)	372	51st	(367-355)/29= 0.034
Abdominal Depth (mm)	245	29th	(240-255)/28= -0.535
Chest Depth (mm)	256	68th	(251-240)/23= 0.478
Shoulder to Elbow (mm)	360	40th	(355-365)/20= -0.25
Elbow to Fingertip (mm)	476	42nd	(471-475)/21= -0.19
Shoulder to Grip (mm)	660	37th	(655-665)/32= -0.312
Body Mass Index Score	24.2	Normal	$76.3/(1775/1000)^2= 24.2$

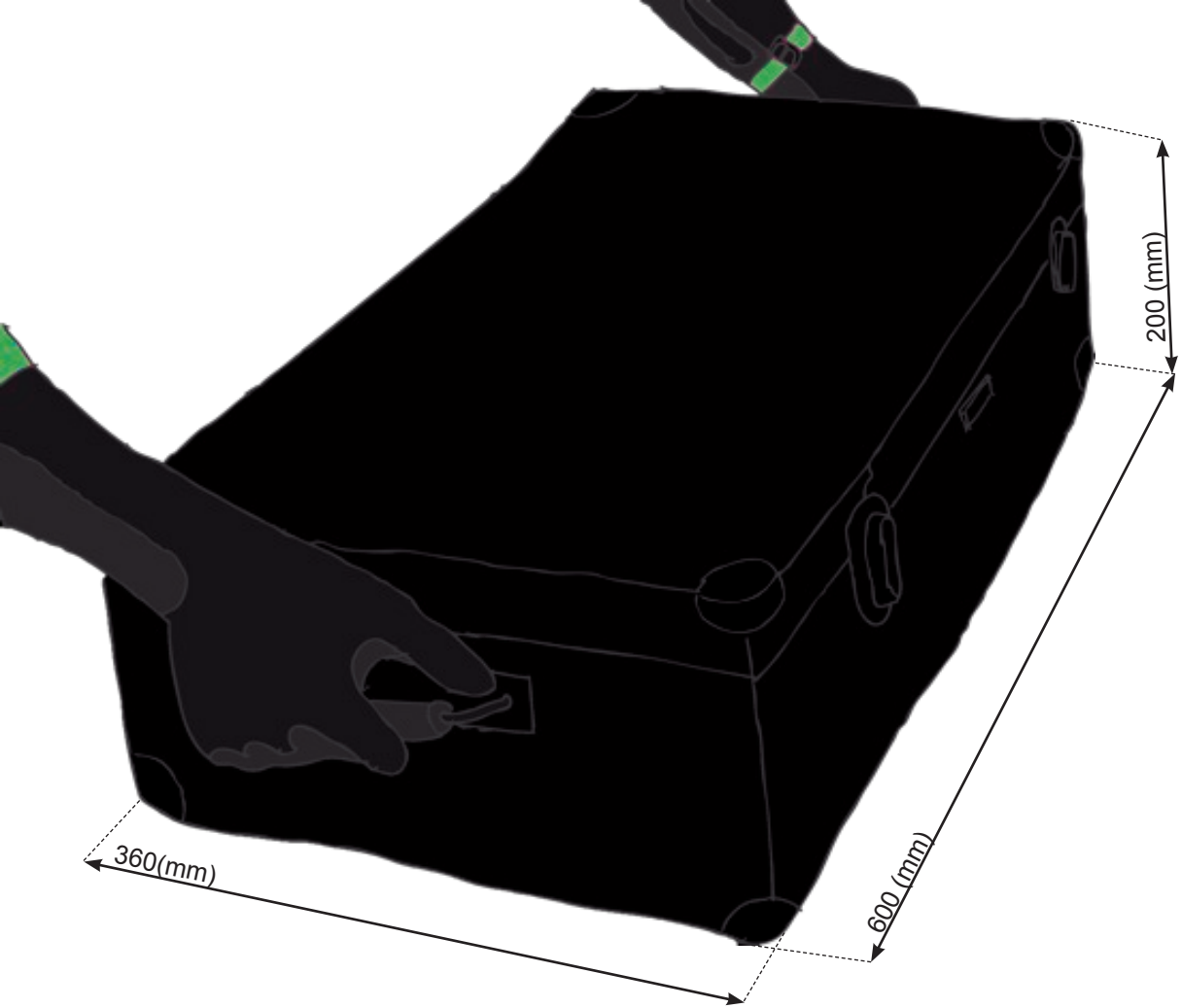


All the raw data was collected by myself from my subject Andrew Becker, who gave his full consent before taking part in the investigation.

After collating the raw data I calculated the percentiles using the fundamental formula $Xp=M\pm Z(s)$, which I rearranged to give me a more basic formula of $Z=(Xp-M)/s$. The data mean and standard deviation for the formula was taken from Pheasant (1986) except the weight figures which were calculated by M. Porter.

Please note that 5mm was removed from the raw data where relevant due to the clothing Andrew was wearing at the time of data collection. The stature was measured with no shoes and Andrew measured his weight for me after having his morning shower.

If I calculate the mean of the percentiles resulting from my calculations we find an average percentile of 48.9th showing that Andy, my subject is fairly anthropometrically average. He has a Body Mass Index Score of 24.2, which (although not definitive) shows him to be in fairly good health. Generally I believe that Andy (although at the age of 61) was in good physical condition to take part in my investigation, especially considering his healthy and active lifestyle of dog walking, football coaching and football playing.



The object to be removed from the boot was a flight case, with some books and a few ornaments inside.

It was of sturdy construction and had strong handles, which were big enough (120 mm x 60 mm) for the subjects hands (114 mm). This meant that Andy had a firm grip on the load at all times and was unlikely to drop it. The “gripping” part of the handle was made of a smooth plastic material, however this was not an issue as Andy could get a good ‘power grasp’ (Kroemer) on the box.

The catches on the front of the box kept the lid firmly on, which ensured that nothing would interfere with the load, and it would not slip out. The secure lid meant that the case could be held in any direction and the load would not spill out. This was good considering that the contents of the box were unstable and could shift about inside the case.

The weight of the case was 13 kg. However it was not of even distribution and had much more weight towards the back right hand side of the box, making not only it’s size, but also the uneven distribution of the weight a problem.

The car used is one that Andy is very familiar with, as it is his own Volkswagen Golf Cabriolet. The cabriolet model is rather different from the other Golf models as it has a much more ‘saloon’ style boot. The top and face of the boot lift away, giving less access than the more popular ‘hatchback’ style.

The boot space is a rather odd shape, as it is much deeper (800 mm) but lower (630 mm) than most boot spaces, as when the roof folds back it needs to take up some of the space that would otherwise be given over to the boot.

The combination of the ‘back’ of the boot lifting upwards and presenting itself parallel with the floor, with the large but low floor space of the boot proves to be an awkward boot to unload.

Another awkward part of the boot of this particular car is the location of the catch on the boot. It sits centrally and protrudes, meaning that unloading any soft load can be problematic, as the item often becomes caught on this catch.

The problem could quite easily be solved by relocating the catches to the two bottom corners of the boot opening. If one catch was placed in each of these corners, the boot would prove much easier to unload and would be much more secure.

The Environment: Details.

On the day the lift was performed, there was a covering of cloud, although there had been a period of hot sunshine a few days before. This ensured a dry and ‘grippy’ surface for the already ‘grippy’ trainers that Andy was wearing on the day. The surface he was standing on at the time of the lift was a mixture of tarmac road and granite pavement, both surfaces of which are intended to be hard wearing and ‘grippy’.

There were no obstructions in the path of the lift or carry, both surfaces were free from cracks, bulges or slopes, however there was a small step up the kurb (122 mm) that Andrew had to negotiate in order to complete the lift. The temperature on the day (although not measured) was warm, but not uncomfortable. Similarly the humidity was not unbearably high and the light was plenty, but was diffused by the cloud, making visibility good. Although the lift was undertaken at the roadside, the road was of quiet, residential nature and so noise (and pollution) levels were low and were of no impact to the lift.

This photograph shows the load in the car before the lift began. Note how low the boot of the car is and how the boot lid protrudes and could obstruct the lift.

In this image Andy is starting the lift. He has to reach into the boot quite a long way, stooping very low to do so. He is making sure he has a secure and strong grip on the handles before beginning the lift.

Once he has a secure grasp of the handles he drags the load towards himself, without actually lifting. This ensures that when he begins the lift he does not need to do it from such an awkward, bent over position.

Now that the load has been dragged to the more accessible rear of the boot Andy begins to lift the load up 230 mm, allowing it to rest upon the lip of the boot.

When the load is resting on the lip of the boot he slides it towards him, allowing himself to straighten up, giving him more power and control over the load. However it is at this stage that the catch of the boot could cause problems for any ‘soft’ load.

Here Andy has begun to lift the load off the lip of the boot. He has to step back and watch his head as he straightens up, as the boot lid is at perfect ‘head banging’ height.

In this photograph Andy is still straightening up as he steps back with the load. He will only feel he has full control over the slightly unsteady load once he has fully straightened up.

Andy has now fully straightened himself up, giving him full control over the load. He has almost locked his arms, and is resting the load against his thighs, to disperse the weight a little more. Although this can obviously infringe waking movement.

In this photograph Andy has rotated and has decided to ‘side step’ the small kurb, keeping one foot firmly placed at the ground at all times.

Now that he is standing safely on the pavement Andy now begins to put the load down.

With his feet at shoulder width apart he bends slightly at the waist, lowering the centre of gravity of the load, giving it more stability.

He also bends his knees as he lowers the load. His arms now taking quite a lot of strain as he now has to hold the load in front of himself slightly in order to safely put the load down.

Now that Andrew has finished the lift he straightens up, with a slightly smug look on his face.

Insert the colour band and numerical score for each of the risk factors in the boxes below, referring to your assessment, using the tool.

Risk factors	Colour band (G, A, R or P)			Numerical score		
	Lift	Carry	Team	Lift	Carry	Team
Load weight and lift/carry frequency	G	G		0	0	
Hand distance from the lower back	A	A		3	3	
Vertical lift region	G	G		0	0	
Trunk twisting/sideways bending Asymmetrical trunk/load (carrying)	A	G		1	0	
Postural constraints	A	G		1	0	
Grip on the load	G	G		0	0	
Floor surface	G	G		0	0	
Other environmental factors	G	G		0	0	
Carry distance		G			0	
Obstacles en route (carrying only)		A			1	
Communication and co-ordination (team handling only)						
Other risk factors, eg individual factors, psychosocial factors etc (see website - address on page 12)		TOTAL SCORE:		5	4	

The lift went very well, with no injury to Andrew caused at all. Generally there were very few problems with the lift, as Andy knows how to lift and how best to work with heavy loads in the boot of that car.

The boot lid could have caused an issue, due to its protruding nature, however Andy navigated his head around it and was also very careful when it came to the kurb.

The most dangerous and awkward part of the lift was at the beginning, leaning in to the boot to slide the load towards a more accessible location. At this point Andy's upper arms were angled away from body and his trunk was bent forward, which would have proved dangerous had he tried to actually lift the load from this point, however he only slid the load towards himself.

On the left you can see part of the Health and Safety Executive's manual handling assessment chart which I used to assess the risk of the lift and carry.

An Introduction to Ergonomical Techniques for Postural and Manual Handling Evaluation, Assessment and Regulation	M. Porter
Manual Handling Assessment Charts	HSE
Getting Started with Anthropometics	M. Porter
Bodyspace : anthropometry, ergonomics and design	S.Pheasant
Introduction to Environmental Factors	M. Poter
Fitting the task to the human : a textbook of occupational ergonomics	K.Kroemer