

Driving & Ergonomics

By Tamara Mitchell



A recent study in the U.K. found that 48% of all British drivers suffer from what is now termed Repetitive Driving Injury.¹ Research on business drivers found that 65% reported low back trouble, 43% reported neck trouble, and 40% reported shoulder trouble.² Long term joint, muscle, and spinal injuries can develop because people do not know how to adjust their car seat or the vehicle doesn't allow for proper accommodation of a wide range of body types.¹ If your car seat has limited adjustability, it's even more important to shift your posture and weight frequently and take breaks from driving to stretch. Various types of seat cushions can be added to adapt your car seat to you, which we will discuss later in this article. We discuss all of these factors as well as other environmental and human factors issues involved in driving.

Seating Research and Design

Automobile design is quite a science. As with most research, there is some controversy. The empirical designers look at global measurement data called anthropometry of various human populations or use dummies to simulate drivers, and create designs to fit the majority of the car-buying population targeted for marketing. Other designers that say this approach misses the whole question about what is actually comfortable for individuals. Designing to averages and statistical models with dummies in the driver seat does not necessarily result in something that is comfortable to real humans.³ Pressure measurement data can be used to determine what seats are more comfortable and to distinguish between seat designs.^{3,4} Pressure points in the buttocks and back of the legs, as well as muscle strain in the lower back result when the seat is not adjusted correctly.⁵ The real test is whether the seat is correct for each individual or if the variety of adjustments provide adaptation in the dimensions necessary to provide comfort and safety while driving. The objective of ergonomics research in automobile driver seating is to predict the postures that people will choose as a function of physical human variables as age, gender, height, and weight, and vehicle geometry variables such as steering wheel position, seat height, seat back angle, seat distance, lumbar support, etc.

Recent research at the Biomechanical Design Research Laboratory at Michigan State University has led to replacing the Society of Automotive Engineers (SAE) late 1950's machine used in seat design with a new manikin that has been accepted into practice and design by the SAE.⁶ The Automobile Seat and Package Evaluation and Comparison Tools (ASPECT) program is an ongoing research effort sponsored by auto manufacturers BMW, Ford, Daimler Chrysler, General Motors, P.S.A.-Peugot-Citroen, Toyota, V.W. America, and Volvo as well as seat suppliers Lear, Johnson Controls, and Intier.⁶ The manikin represents a 170 lb. male, 5'8" -5'10" tall.⁶

More recent research has used humans to evaluate automobile seating manufactured based on the ASPECT model.⁷ 86 automobiles including passenger cars, light trucks, and minivans were tested by 68 people ranging in stature from less than the 5% percentile female to over 95% percentile male.⁷ Seat fore-aft position and steering wheel fore-aft position were adjusted and rated according to whether the position was too far, too close, or just right. The seat fore-aft position did not change that much between subjects ranging from about 475 mm to 650 mm with

most subjects falling in the range of 525 mm to 575 mm.⁷ Steering wheel height showed a lot more variability in preference ranging from about 180 mm to 375 mm with subjects approximately evenly distributed throughout this range.⁷ Steering wheel height is actually constrained to a fairly narrow range in current auto manufacturing, and it was suggested that a wider range of height adjustments, telescoping steering wheel, and actual road conditions may produce different results.⁷

There appears to be one company designing automobile seats with the physiology of the driver/passenger in mind along with a solid knowledge of posture, blood circulation, and spinal alignment.⁸ That company is NuBax in Surrey, England and they supply the seat design for the Lotus Elise and Exige models. They are also working with British Airways and a number of other auto manufacturers to incorporate their seating design into automobiles. The technology is applied to office seating as well. ProBax seat design requires no adjustment at all, creating a form that supports the pelvis and spine in a neutral position regardless of body size or shape.⁸

Recent research in England found that 37% of drivers sit leaning forward with the seat adjusted too far forward, the arms and legs bent.¹ 26% sit upright with the arms bent and one hand on the gear shift.¹ Currently in the U.S., most cars have automatic transmissions, but this still may be a common resting place for the right hand if the car has a gear shift beside the driver seat. 19% of drivers were found to recline too far back and low, with the arms and legs straight. 8% of drivers, primarily 25-35 year old men, recline too far back and low with one hand on the wheel and one hand either on the window ledge or hanging completely out the window.¹

When standing, the lower back (lumbar region) has a concave curve that results in even pressure on the spinal discs. Sitting straightens out this natural curve and results in uneven pressure on the spinal discs.^{5,9} This flattening of the lumbar region leads to a posture that is prone to shoulder, neck, and back muscle tension, misaligned vertebrae, and a rounding of the lower back.¹⁰ In this position, the discs of the spine are less prepared to handle the vibrations from your truck or car.⁵

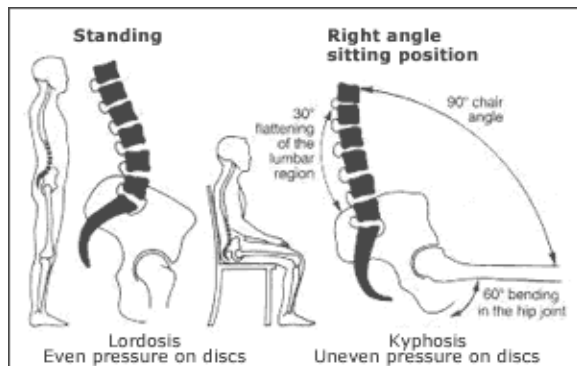


Illustration courtesy of Reference 9

Research has found that myoelectrical activity of the muscles and disc pressure are both reduced when the back is supported.^{11, 12} Both muscle activity and disc pressure *decrease* the most when the backrest is *reclined*.^{11, 12} Lumbar support *in combination* with reclining the seat back has a significant effect on myoelectric activity of all of the back muscles. When lumbar support exceeded 7cm (approx. 2 ¾ inches), it increased muscle tension when the seat was inclined. The lowest recorded activity was with lumbar support of 5 cm (approx. 2 inches).¹³

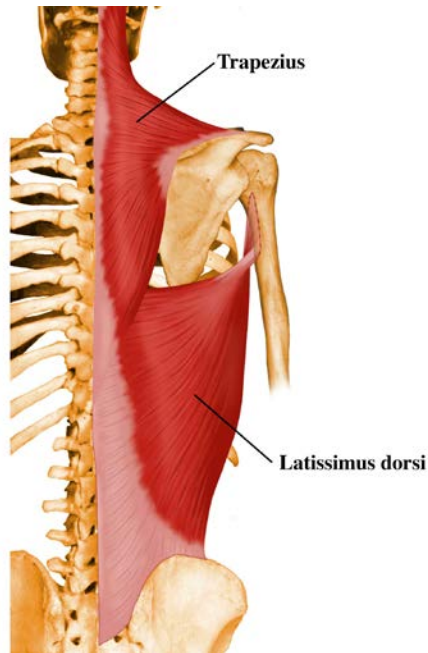


Image courtesy of Reference 14

Research measuring the electromyographic activity of the latissimus dorsi muscle during a simulated 1-hour driving task, found that reclining the seat back angle 10 degrees (100 degree incline) resulted in the least muscle activity in both male and female drivers who participated in a one hour driving session.¹⁵ This study also looked at a seat angle of 0 degrees and inclined upwards (front edge up) 10 degrees, finding that the 10 degree seat position resulted in a high risk of fatigue setting in with time.¹⁵ Other research has found that the seat fabric itself plays a part in the fatigue of various muscle groups.¹⁶ In the case of woven or wool seat fabric, friction helps to keep the driver in place, while vinyl or leather is slippery and results in increased muscle activity of the abdomen and lower leg.¹⁶

Tilting the seat pan forward to increase the thigh-to-torso angle reduces fluid accumulation (edema) in the lower leg, enhances leg mobility, reduces risk of varicose veins, and facilitates rising from the seat.^{5,8,10,17} This increases lumbar lordosis to some extent to correct for the kyphosis (flattening of the lumbar region) induced in the upright sitting position, though slopes of over 5 or 6 degrees are generally not well-accepted.¹⁷ In fact, a semi-standing position with the seat pan tilted forward to 45-55 degrees and a hip angle of 45 degrees, rather than 90 degrees, has been suggested as the optimum balanced posture for the low back.^{9,10} It would be anticipated that as in the seat back angle research, vinyl and leather fabrics would be more slippery than woven fabrics and would result in more fatigue. Many cars seats do not provide adjustability of the seat pan to allow forward tilting at all.

Noise is an important environmental factor in the automobile cabin as it is a source of stress, ability to hear approaching emergency vehicle sirens, inability to communicate or listen to music or the radio, and causes fatigue on long drives. Research has found that the use of viscoelastic material is effective in reducing cabin noise, particularly when applied to the roof.¹⁸ Using 1.4mm viscoelastic panel material, noise was reduced by about 6.8% or 4.3 dB.¹⁸ Sound-damping glass composed of 3 layers was very effective in reducing noise in the cabin at all frequencies, but especially at higher frequencies; from 10 dB at lower frequencies to almost 40dB at higher frequencies.¹⁸ Noise in the rear passenger's position is higher than that of the driver and

noise at waist level is lower than at head level, so it's likely that shorter drivers experience less noise than taller drivers where the head is higher in the cabin.¹⁸

Noise can be reduced by reflection (bouncing the sound back toward the source and away from the cabin, and/or absorption (dissipating the sound wave energy with absorbing materials).¹⁹ Most of the traditional materials used have not been environmentally friendly nor sustainable. At the end of the automobile's life, these materials end up in a landfill...an increasingly expensive option.¹⁹ Research has been conducted to determine the effectiveness of using renewable, low-cost, biodegradable fibers such as kenaf, jute, cotton, and flax in creating sound-absorbing materials in blends with polypropylene and polyester.¹⁹ At all frequencies, use of an underpad and floor covering significantly reduced noise. Unfortunately, the cotton underpad used in the research was not as thick as the polyurethane underpad, so it was not possible to compare the effectiveness of the two materials, but it was expected from the results obtained from the floor covering materials that cotton is likely as effective as polyurethane.¹⁹ It's nearly impossible to find reference to the materials used in soundproofing today's automobile, but a law taking effect in 2004 required auto manufacturers to greatly increase the recyclable products used in vehicles with a target rate of 95% recyclability by 2015, so we should expect that these materials will be used to a large extent in most vehicles today.^{20, 21, 22}

Recommendations

Driver's seat adjustments

Many people give little thought to adjusting the seat or are even unaware of all the possible adjustments that can be made.¹² The recommendations on the website Ergonomics Simplified²³ are excellent. Make these adjustments before driving when the car is stationary.

If you are used to sitting bolt upright, this change to a slightly reclining position will feel somewhat strange and uncomfortable at first, but if you make all the other seat adjustments accompanying this change, you will soon find that your body is much more relaxed in this posture. If you find you are not comfortable after making the suggested adjustments, you should explore the supplemental products at the end of this article, or even decide if it's time to buy a different car that suits you better.

Some cars allow for programming dashboard buttons for the unique seat for each driver of the vehicle. This is a great time saver when switching drivers and assures that the correct adjustments are set each time that person is driving.

- Start by adjusting the seat position completely wrong. Push the seat all the way back, as low to the floor as possible, and reclined back 30-40 degrees.²³
- Bring the seat back up to a reclined position of 100-110 degrees.^{1,12,23}
- Raise the seat height up until your hips are level with your knees and you can see the road and the instruments well.^{12,23}
- Scoot the seat forward so you can completely depress all the foot pedals without having your back come away from the backrest.²³
- Tilt the seat cushion forward until it evenly supports your entire thigh without pressure on any particular point and without pressing on the backs of your knees.



Illustration courtesy of Reference 23

- Bring the steering wheel down and toward you to minimize reach. Your arms should be in a relaxed position and not reaching out to the steering wheel. If you have to reach out with the steering wheel adjusted as close to you as possible, try to adjust the seat back angle and forward/back seat distance to reduce the reach. Arm angles of over 100 degrees have been shown to reduce the strain on the trapezius muscles.²⁴



Illustration courtesy of Reference 23

- Hold the steering wheel with both hands at the 9 o'clock and 3 o'clock positions, lower that often recommended so that the arms are not reaching up.

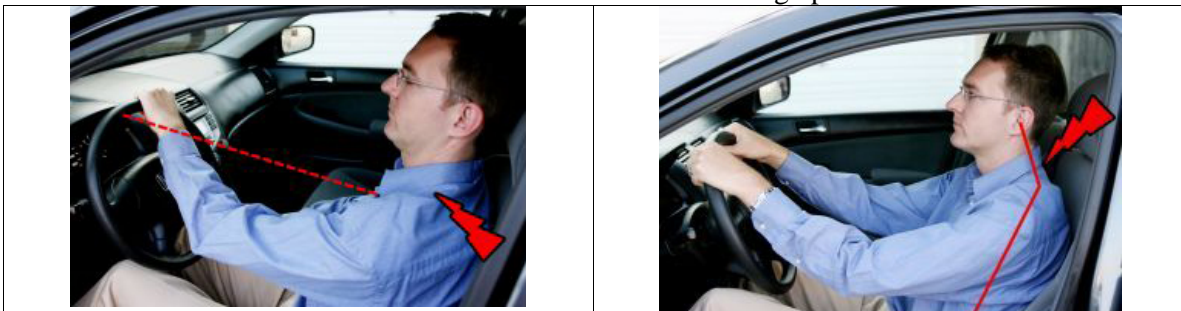


Illustration courtesy of Reference 23

- Adjust your head rest. The top of the headrest should be as high as the top of your head and no lower than 2.5 inches below the top of your head.²⁵ Make sure it is locked into position at the correct height. The head rest should be as close the back of your head as possible and no farther than 2.5 inches away.²⁵ If your head rest tilts, this can help with this adjustment.²⁵ Try not to lift your head to look forward as this will cause neck muscle fatigue over time. Continuous upper back and neck muscle tension can be caused by postures that require holding the head up, especially if vibration is present.⁵ If you have to hold your head away up or away from the headrest, your seat may be reclined too far back.
- Adjust the seatbelt and the mirrors. If you start to slouch, your mirrors will not be in the correct position and will serve as a reminder of proper posture including holding the head forward.²³ You should be able to use your mirrors with a quick glance, without requiring you to crane your neck.
- The back rest should support your entire back from your hips up to shoulder height. Some people have flatter backs than others. If your car or truck has an adjustment for lumbar support and if your lower back is not supported by the seat back, increase the lumbar support until it fits your back with no pressure points or gaps.² If your car doesn't have an adjustable lumbar support, you can purchase a lumbar cushion or just use a rolled up towel to give you more lower back support.⁵

Cruise control

Holding the foot pedal down over a long period of time may cause stiffness and spasm in the legs and low back.⁵ Make sure you can press the pedals without moving your low back off the back of the seat.⁵ Use cruise control when you are driving long distances to take the static tension off your foot, but only if road conditions are dry. (Your car may actually accelerate if you hydroplane while in cruise control, and if your foot is not near the pedals, your reaction time is slowed even more.)²⁶

Vibration

The frequency of road vibration when driving or riding in a car is often in the body's frequency range of 3-5 Hz. This increases the risk of injury.⁵ Whole-body vibration requires constant back muscle activity, causing the muscles to tire and decreasing the support the muscles can give to the spine.⁵ Keep your car's suspension system in good operating condition to make sure road vibration is dampened.⁵ Adding padding to the seat may help dampen vibration also.⁵

Breaks, stretching and exercise

Making minor adjustments to your seat position, modifying the recline of the seat back, shifting weight slightly from left to right hip are things that can relieve constant pressure while driving.^{2,5,12} It is important to listen to your body while driving.² If possible, stop driving every hour and stretch for 5 minutes.⁵

Prolonged sitting in any situation increases the risk of venous thromboembolism. Thromboembolism is the formation of a blood clot in a blood vessel that breaks loose and is carried by the blood to plug another blood vessel.²⁷ Thromboembolism is an important cause of disease and death among adults.²⁷

Remove stuff from your pockets

This is true, particularly for men, who tend to carry wallet, keys, or other things in their back pants pockets. This compression can reduce circulation and press on nerves or other soft tissues when sitting in the car or anywhere else.

Keep items in easy reach

Sunglasses, tissue, cell phone, driving directions, mints, etc. should all be kept close to the driver's seat so you don't have to reach. Reaching is awkward and is especially hazardous while driving!

Many people use their car as an office. Almost all activities involved in this practice put strain on the body by twisting, leaning forward, and other awkward postures.² It is preferable for you to park and go to a café or other more suitable location that enables you to sit in a neutral position to work.² If you must use your car as an office, please use the following tips:

- Move to the passenger seat, especially if you are using a laptop computer. Never reach from the driver's seat over to the passenger's seat to use a laptop or to do paperwork.²
- Try to set up your work in the passenger's seat so that you have proper posture, can work comfortably, and avoid hunching over or slouching.²
- Store your work and laptop in the trunk of the car, not in the back seat or on the passenger's seat. This ensures that you do not twist and turn to lift your things and it also makes you get out of the car, stand up, and walk around.²

Dashboard human factors

It's amazing that, with the amount of money and effort expended to provide a comfortable seat, auto manufacturers still manage to get the window controls and dashboard features very wrong. Luxury automobiles are not exempt from these design flaws. Information provided to the driver needs to be intuitive and placed directly in front of the driver to avoid distraction from the task of driving. Since many cars are manufactured for both countries that have the driver seat on the left and the right, it's cheaper to locate panels in the center of the dash rather than reconfiguring controls for each driver position.²⁸ For a review of some of the worst human factors offenses, refer to the Funky Ergonomics Awards.²⁸

Noise

Noise within the automobile cabin can be stressful, reduce the ability to converse with others or listen to music/radio, and can even potentially cause hearing damage over time.²⁹ On longer commutes and road trips, a noisy automobile interior can be extremely tiring.²⁹ Sources of automobile cabin noise are engine noise, road noise, vibration noise from car/truck body components, tires, water noise when it's raining, and air noise as at higher speeds.²⁹ More expensive automobiles tend to have better soundproofing in the doors, floor, ceiling, and firewall, because quieter interiors are equated with quality in the consumer's mind. There are after-market products that can be added to the car or truck and most of these significantly reduce cabin noise, though they can require hours of labor to install, including removal of door panels, seats, headliner, etc.^{30,31} These come in the form of mats or spray-in products.³¹ There are some tires which are supposed to be quieter than others on the road, too.²⁹

Shopping for a new car

When purchasing a new car, it's important to spend enough time test-driving the car to really make a good judgment about its comfort. One design authority advises 30 minutes of test-driving to make sure you'll be happy with the comfort of your car many miles down the road.¹² Obviously, while ergonomics is not the only factor in deciding what car to buy, driver comfort and avoiding injury from your car or truck should rank fairly high and is often overlooked.

Ergonomic fit checklist

Print out several copies of this checklist when you go to test drive cars. Fill out one for each car.
<http://drivingergonomics.lboro.ac.uk/downloads/Car%20selection%20checklist.pdf>²

Noise

You may want to refer to ratings done on cars, SUV's, and minivans and take this into consideration when you are shopping for a replacement vehicle:
<http://www.noisehelp.com/car-noise.html>.³²

Toxicity

Most people love that “new car” smell, but that odor is actually caused by the off-gassing of many different synthetics and the release of chemicals used in vehicles, from plastics (PVC) to fire-proofing (BFR).^{33,34,35} Most certainly this is a “human factor” in selecting an automobile. In general the chemicals found in the cabin air of vehicles lead to thyroid problems, decreased fertility, problems with almost all internal organs, blood, and memory impairment.³³ Luckily, most auto manufacturers have been working hard to reduce the materials that off-gas in the passenger cabin of vehicles. Honda appears to be the front runner in eliminating toxic materials from their automobiles.³⁵ VW, Mitsubishi, and Ford are the most improved and they making great strides to improve the indoor air quality of their vehicles.³⁵ Daimler AG (Mercedes Benz) and Volvo have actually declining air quality of their vehicles, with Daimler showing a 30% *increase* in toxicity from 2009-2010 to newer models in 2011-2012.³⁵ We urge you to refer to the report produced by The Ecology Center, which tested 204 vehicle models in 2011-2012.³⁵ http://www.healthystuff.org/documents/2012_Cars.pdf Please refer to the HealthyStuff.org website in future years to obtain reports on more recent years.³⁵

General Safety

The nonprofit Insurance Institute for Highway Safety provides an annual list of Top Picks based on crash test data for several key criteria and based on size and class of vehicle.³⁶ Overall, larger heavier vehicles fare better in crashes, so comparison of Top Pick cars across classes of vehicles does not indicate that a mini-sized car rated highly is equally as safe as a luxury car rated highly.³⁶ http://www.iihs.org/ratings/tsp_current.aspx

RESOURCES:

Be aware that buying pads and cushions containing new foams and plastics is generally not good for overall health. These products often contain formaldehyde, polyvinyl chloride and other materials that outgas carcinogens into the closed compartment of the automobile, especially when exposed to the heat of the sun. If your car does come with the required adjustments, finding or making your own “props” to adjust your seating position with such nontoxic materials as towels and organic or wool cotton batting can be a better choice for your overall health. The following products are new technologies that go beyond what is available with normal adaptation by shaping and padding existing seats. Many more options are shown on our website.
<https://insider.sri.com/services/ehs/ergo/pchair.html#car>



Dr. Riter Shiatsu Back Custom Massager Lumbar Support Cushion

Has 96 pressure nodes that massage the muscles and improve the flow of energy, along with lumbar support. Unobstructed air circulation. Nontoxic, washable, with no glues. \$49.99

<http://www.comfortchannel.com/prod.itml/icOid/1821>



Pictures courtesy of Supracor

Supracor Stimulite Honeycomb Cushioning

Stimulite is an exciting new technology developed in San Jose, CA. The technology is used in products from insoles to horse saddle pads, and from seat cushions and mattresses to aerospace applications. The cells contour to your body shape and flex with movement, absorbing shock and tissue trauma while the honeycomb walls circulate air and evaporate moisture. The material is antifungal, antibacterial, washable, and 100% recyclable (thermoplastic). The seat cushions are highly recommended for use in wheelchairs, with a wide variety of models available. Also, lumbar support and sheets of the material are available to use in your car.

www.supracor.com

Many Stimulite products available at discount on:

www.allegromedical.com

Lumbar support: **\$84.55**

All products (including seat cushion) available at:

store.supracore.com

Car seat: **\$150.00**

With lumbar support: **\$225.00**



Mabis Seat Mate Sloping Coccyx Cushion

Coccyx cushions

If you experience intense shooting pains down one or both legs while seated, many car and truck seats can make driving unbearable due to pressure on the tailbone and the sciatic nerve that runs down both legs. Coccyx cushions can help take the pressure off the tailbone. Some are sloped forward to help open the hip angle as well as take pressure off the tailbone. If that is not needed, flat coccyx cushions are available, too. (Avoid donut-shaped cushions. They are not designed to relieve pressure on the coccyx.) Again, making a cushion to fit your needs is not a difficult task and you can customize the foam, shape, and fabric to suit yourself. Stay with woven fabrics to increase the friction and reduce muscle fatigue.



Bamboo, Cotton, or Wool batting:

The Bamboo Fabric Store.

http://www.bamboofabricstore.com/index.php?main_page=index&cPath=13

Near Sea Naturals.

<http://www.nearseanaturals.com/browse.php?category=42>

Organic Cotton, Bamboo, or Hemp fabrics/upholstery:

Green Sage Store.

<http://www.greensage.com/fabricstr.html>

Near Sea Naturals.

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