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Determination of Seat Design Prameters Based on Ergonomics

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***Abstract*- Automotive seat design has been always challenge for engineers because design parameters for automotive seats are complex. Three design objectives comfort, safety, and health need to be satisfied simultaneously and measurement of this objectives are difficult because of such factors as user subjectivity, seat geometry, occupant anthropometry and amount of time spent sitting. This paper describes various methods of comfort analysis of off-road car vehicle seat which is based on different criteria like fit parameters related to anthropometric measurements, feel parameters and support parameters defined with respect to seated posture.**

***Keywords:*- Seat design parameters , ergonomic ,Comfort, anthropometric variables.**

I.INTRODUCTION

Seats are one of the most important components of vehicles. An automobile seat consists of a headrest, a backrest, and a cushion and it is built in three parts: a metal armature, foam injected in a matrix, and a dress which covers the foam and armature. These parts are connected to each other by three joints:one for the connection between seat cushion and its surroundings, one for the connection between seat cushion and seat back, and one for the connection between seat back and headrest.

These joints allow adjustment in the seat back angle and head restraint angle by changing this adjustment we try to reach comfort zone of driving. When attempting to specify design characteristics of a comfortable seat, it is important to have in mind a functional definition of comfort as it applies to seating. Comfort zone of driver is decided by fit and feel parameters of driver with support parameters of seat.Current review summarizes research and investigation on how his parameter are affect of ergonomics of driving posture for manufacturing of best comfort seat.

II. LITERATURE REVIEW

1. In Driver Ergonomics in an Off – Road Vehicle:
They discus that It is quite essential for any automobile of its kind to make sure that the driver and passenger within the automobile are quite comfortable within it and that their ride is happily executed and that's the point where drive ergonomics comes into play.

They state that ergonomics-negligence consequences have not any direct effect on the performance of the vehicle but that can be caused to passengers or drivers present in the vehicle, then they suggest some harmful effects of ergonomics negligence.

- Disorder of dorsal muscle and back pain.
- In some instances bad driver ergonomics can also lead to fatal Spondylitis.
- Pain in neck.
- Disorder of muscles, tendons, ligaments associated with the back portion.

They study the detailed analytical report that is concerned with their vehicle and just notify its important aspects. they were designing the ergonomic capacity of an off road vehicle so that they kept the vehicle ergonomic capacity in accordance with the rule that as a prototype of a commercial product, the design intent should be to accommodate drivers of all sizes from the 95th percentile male to the 5th percentile female. They have proposed andincorporated some idea for better enhancement of the driver ergonomic features in an off road vehicle and those points are as follows;

Table 1. Off-road vehicle subpart.

Size Adjustments concerning the driver	Maximum legroom area can be made available to the driver so all the operational features
Position Of Steering	Efficiently and effectively.
Seat	Car seat tilting brackets to give an extra 4-6 inches of legroom for
Visibility of the concerned driver	Longer people.

Base on above data they select ergonomic parameters for the vehicle[1].

2. J. Mark Porter and Diane E. Gyi Published Exploring the optimum posture for driver comfort:

Research paper base on postural angles for driving comfort which is based on theoretical calculations and not observed driving postures. They was conducted an experiment to investigate observed optimum driving postures and positions of the main driving controls for comparison with available data. They developed New guidelines for optimum postural comfort and recommended range of postural angles. They were carefully selected to include a wide range of percentiles in the dimensions important for car work station design.They were instructed to wear clothing and footwear which was comfortable for driving. A highly adjustable driving rig was constructed for the experimental work.

Criteria for its construction were the following;

- The steering wheel and pedals were easily fully adjustable for deciding comfort zone of driver.
- The positions of the controls could be easily measured from a fixed reference point and converted to the standard SAE packaging dimensions. s (Figure 1 and SAE Handbook, 1985).
- Floor, steering wheel and pedals, would be adjustable around the seat. The seat itself was also adjustable in tilt, backrest angle and lumbar support.
- The seats could be replaced quickly and easily as necessary.

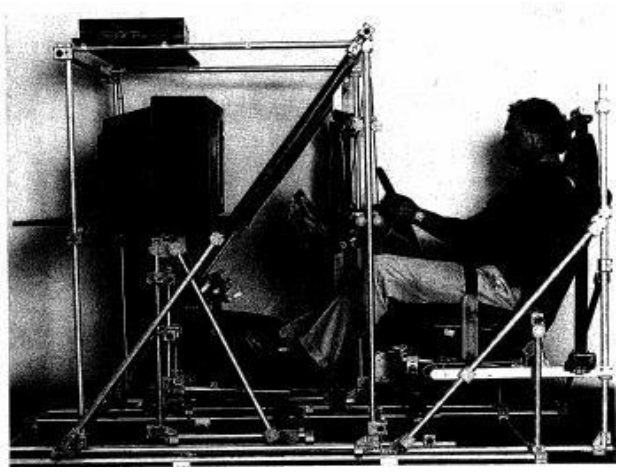

Fig 1. Vehicle seating configuration. (based on SAE Handbook, 1985)

Then the trial for two videos of the 2.5 hour (60 mile) test route in that they test rig, giving a driver's view of the road, with a voice-over of instructions about the route to guide the driver as to when to slow down, change gear etc. Seven experimental seats were also constructed for use with the rig, which were identical in all respects with the exception of foam density. Then they perform some trial and base on that they obtain the optimum height and distance from the seat to the steering wheel, height of the car floor, horizontal distance to the pedals and the tilt of the seat.

A 10-15 minute driving simulation at the rig was then carried out to further confirm that this posture was optimum and then relevant measures regarding the positions of the controls from a fixed reference point were documented, then observed postures were compared with recommendations from the literature Knee angle and foot calf angle were very similar to the theore tical recommendations of Rebiffe (1969) and Grandjean (1980) [2].

Table 2. Comparison of observed postural angles for comfort.

	Rebiffe	Grand jean	Observed Postures	95% confidence Limit
Neck Inclination	20-30	20-25	30-55	29-63
Trunk-Thigh Angle	95-120	100-120	90-115	89-112
Knee Angle	95-135	110-130	99-138	103-136
Arm Flexion	10-45	20-40	19-75	16-74
Elbow Angle	80-120	-	86-164	80-161
Foot-Calf Angle	90-110	90-110	80-113	80-105
Wrist Angle	170-190	-	-	-

3. In Sitting comfort and discomfort and the relationships with objective measures:

Some scientist work together with Faculty of Human Movement Sciences. They discuss concepts of comfort and discomfort in sitting are under debate. They present some idea of comfort and discomfort and the hypothetical associations with underlying factors were indicated then

they study some literature base on that they found measures of an objective parameter and a subjective rating of comfort or discomfort after that they presented model of the different factors under lying sitting discomfort and comfort.

From this model they can be prove that for discomfort the relationships of objective measures with discomfort would be stronger than for comfort, as the link between discomfort objective measures of physical exposure, dose or response is more direct. they gave relationships of objective measures to comfort and discomfort some of the parameter are shown below:

- Posture and movement
- Electromyography swelling
- Pressure distribution load
- Spinal

They conclude that From above parameter:

3.1 Pressure distribution is one of most important parameter and Pressure distribution appears to be the objective measure with the most clear association with the subjective ratings.

3.2 Pressure distribution holds particularly for car seats and they gave statistical relationship between pressure distribution and local discomfort.

3.3 A uniform distribution at the seat pan as well as a high enough level of back pressure at the back rest at a lumbar level appear to be important in this respect and For the other objective variables (posture, movement, muscle activity, spinal load), it is premature to state that measuring these variables would be useful in seat evaluation and design [3].

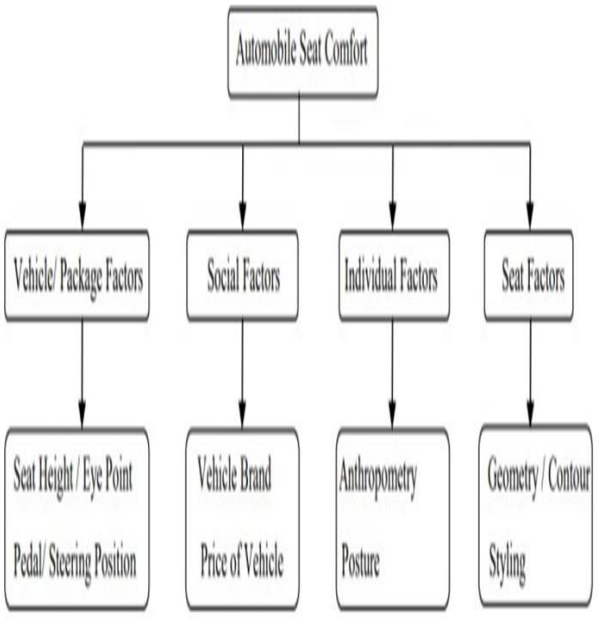

Fig 2. Factor affects seat comfort.

4. In Comfort Analysis of Passenger Car Vehicle Seat Rajesh kumar U. More and Dr. R. S. Bindu: discuss that the choice of a passenger automobile depends on factors, such as the vehicle type, brand, trend, security, its performance, interior space, interior design, additional equipment offered, etc The manufacturers of automobile seats usually make prototypes for testing the comfort in order to achieve the desired results. It is very costly process and many factor affect on seat comfort. Then they give some function of seat and seat design parameter for achieve that parameters they did an experiment on that then they made a Manikin and place in seat, after that they calculate distance from various angles and position for H Point, cushion/back width, cushion/back length then they fixed sensors on seat for measured distance from manikin and take reading for different seat and plot graph for each seat [4]

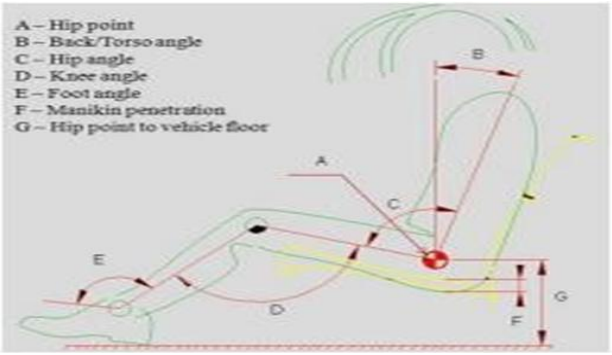

Fig 3. Seat parameters.

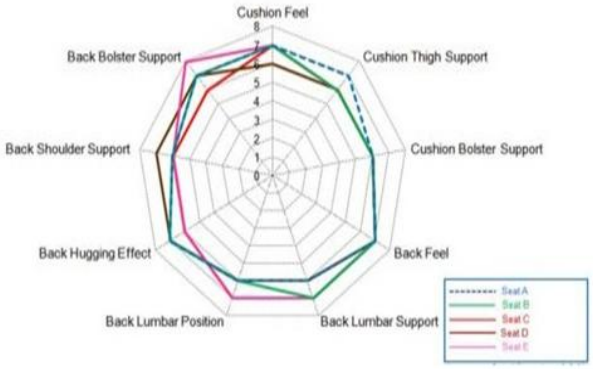

Fig 4. Spider graph.

5. Matthew P. Reed Lawrence W. Schneider Leda L.Ricci published Survey of Auto Seat Design Recommendations for Improved Comfort:
In this report they have identified seat design parameters that have been demonstrated to be or associated with seat comfort and recommends levels for parameters.They divided these parameters in three as fit, feel and support parameters.

5.1 Fit Parameters:
Fit parameters are linear dimensions related to sitter anthropometry.

Parameter	Recommendation
1. Pressure Distribution	
Seat cushion patterns	Peak should be located only in areas of ischial tuberosities. No other local maxima should be found
Backrest Patterns	Peak should be only located in lumbar area. No local maxima should be found in shoulder area
Peak levels	Peak level should be determined by subjective comfort testing wih target population. Large differences in pressure distribution and sensitivity among individual make specifying a quantitative "optimal pressure distribution" difficult.
2. Surface Shear	Surface shear on cushion should be minimized by increasing the cushion angle or contouring the cushion to achieve the same effect
3.Temperature and humidity	The seat covering should allow the heat transfer at least 75 W/m2 by conducting and diffusion of water vapor. Foam should not compressed to more than 80% to allow for maximum vapor diffusion

Table 3. Fit Parameter Recommendations.

Parameter	Recommendation(mm)	
	Should not be less than	Should not be more than
1. Cushion Width		
Actual width at H-Point	432	-
Clearance at H-Point	500	-
Width at front of cushion	500	-
2. Cushion Length		
Forward of H- point on thigh line	-	305
3. Backrest width		
At waist(220 mm above H-point)	360	-
At chest (318 mm above H-point)	456	-
Height of side bolsters above H-point	-	288
4. Backrest Height	410	550

5.2 Feel Parameters:
Feel parameters affect local comfort and are related to stimuli detected primarily in the skin and subcutaneous tissues.

Table 4. Recommendations for Feel Parameters.

5.3 Support Parameters:
Support parameters are intended to influence the posture of the sitter and are related to body segment angles [5].

Table 5. Recommendations for Support Parameters.

Parameter	Recommendation
1. Lumbar support (fixed)	
Vertical Position	Locate apex 200-250 mm above depressed seat surface, or 105-155 mm above H-point along back line
Prominence	Support should protrude 20 mm in front of backrest plane for seat heights above about 240 mm. support should be nearly flat for lower seat heights.
Radius	The 20 mm support should have depressed-contour,
2.Lumbar support(Adjustable)	
Vertical position	Apex should be adjustable between 100 and 200 mm above H-point along back line.
Prominence	Between 0 and 50 mm
Radius	It should be adjustable between 250-400 mm. if only a prominence adjustment is provided, higher prominence should be achieved with smaller radii.
3.Knee angle	Angle should be less than 135 degrees
4.Trunk/thigh angle	Angle should be larger than 90 degree and close to 135 degree.
5.Trunk angle	Angle should be between 10-30 degree.

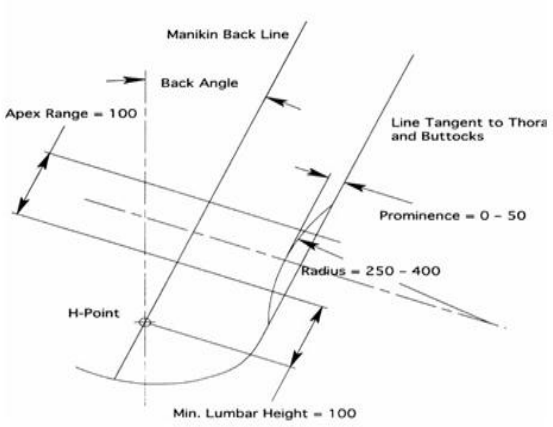

Fig 5. Schematic illustration of lumbar support recommendations.

6. In Ergonomics for Passenger Cars:
Clemens Marek, Ford Werke Koln & Karl Siebertz study Categories of human performance limits which are Anthropometry, Biomechanics, Physiology, Psychology. They study some International Standards from SAE papers which represent the largest collection of standards defined for vehicle development. Some SEA paper gives great idea of human posture by representing it in simple figure are given below;

- J826 describes two representations of the human inside the vehicle.
- J941 shows the definition of the eyellipse, the theoretical position of the driver's eyes.

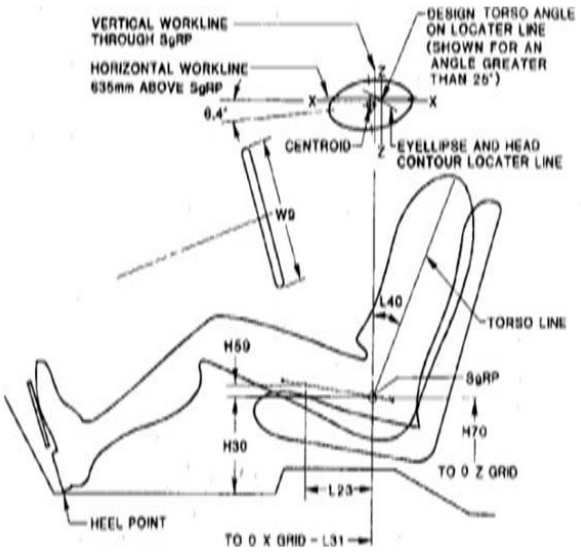

Fig 6. Positioning of the SAE eyelids.

After study of SAE paper they gave Knowledge about the Human Body in that they gives relationship of strength to age and muscle to time then elaborate concept of Electromyography with its process are as follows,

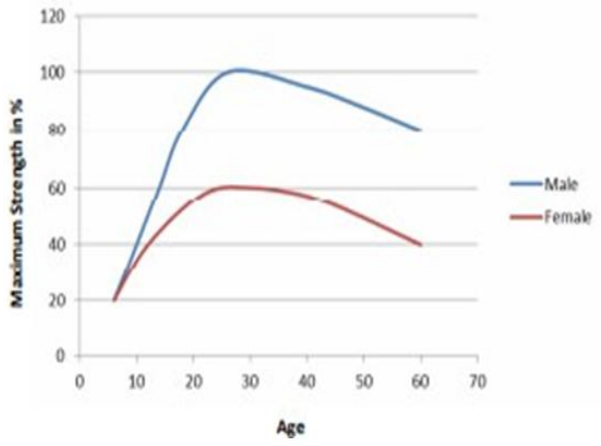

Fig 7. The relationship between of age related to % maximum strength for males and females.

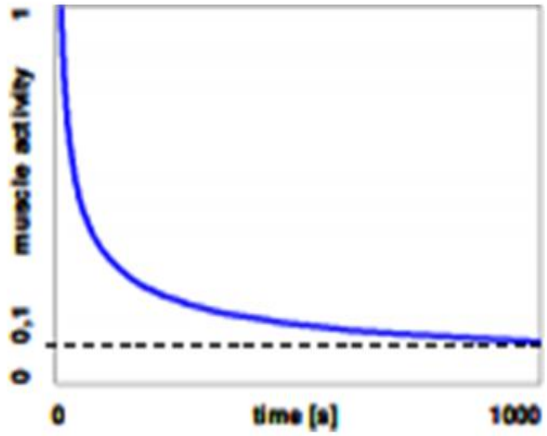

Fig 8. Muscle fatigue. The maximum muscle force can only be generated for a short time, due to metabolic constraints.

Then they discuss on Physiology in that they state how human body age affect Vision of surrounding with some basic examples of traffic, signals, Reading of board etc. In Layout of the driver's environment, they study interior packaging system and conclude some result on Pedal angle, leg space, backrest with proper reason [6].

7. Matthew P. Reed, Miriam A. Manary, Carol A. C. Flannagan, and Lawrence W. Schneider published Effects of Vehicle:
Interior Geometry and Anthropometric Variables on Auto mobile Driving Posture is an understanding of the individual and interactive effects of seat height, steering wheel position, and seat cushion angle on all of the major posture characteristics of interest for vehicle interior design. They conducted this study in three phases, every time with different participants and different set of conditions. They specified and measured, the seat and control layout, termed the vehicle package, by using standard reference points and dimension definitions which were documented in Society of Automotive Engineers (SAE).

They had used three package and seat variables which were manipulated independently. These variables were selected based on the findings of several studies of driving posture conducted at the University of Michigan Transportation Research. They used a typical midsize sedan seat that has minimal contouring or bolstering for phase 1 and 2. Then the Dodge Neon seat used for Phase 3 testing.

They instructed the participant to operate the pedals and steering wheel and to continue to adjust until a "normal,comfortable driving posture" was obtained. In Phase 1, they allowed participants to choose any hand position on the steering wheel. In Phases 2 and 3, participants were instructed to place their hands on the steering wheel at the 10 o'clock and 2 o'clock positions.

After the participant obtained a comfortable driving posture, the experimenter recorded body landmark locations using the sonic digitizer probe.

They used Data from Phases 1 and 2 for Conditions 1 through 10, representing five steering wheel positions at two seat cushion angles, were extracted for initial analysis. However, they found no case where the interaction between seat cushion angle and steering wheel position significant.

Table 6. Effects of Steering Wheel Position and Seat Cushion Angle: Configurations 1–10 in Phases 1 and 2.

Variable	Normalized sterring wheel position (-100 to +100 mm)	Seat cushion angle
HipX (mm)	89.6	-6.0
Hip-to-eye-angle	3.1	0.59
Lumbar flexion	n.s.	2.0
Cervical flexion	n.s.	n.s.
Elbow angle	-26.5	n.s.
Knee angle	16.3	-3.6

The author reached to the conclusion that;

- They came to know that the effects of steering wheel position and seat cushion angle on posture do not depend on the seat geometry.
- They found no significant effects of seat height on lumbar flexion, cervical flexion, or hip-to-eye angle.
- Seat height, steering wheel position, and seat cushion angle have effects on driving posture that are largely independent of body size and gender[7].

8. Mr. Rakesh Patel1, Prof. S. M. Gaikwad2 In Ergonomics and Packaging feasibility study of driver Seat, Steering and Cluster using CATIA V5-R25 and RAMSIS:

Discus that within available package constraints, analyze the comfort for the driver position of a target vehicle and propose the changes required for a most optimal comfortable position. They study some property of comfort of seat and base on that they design seat and some added features have resulted in increased cost and used in only a limited number of seating environment. They study some research paper of body posture and summary of recommendations for body segment angles in the automotive environment.

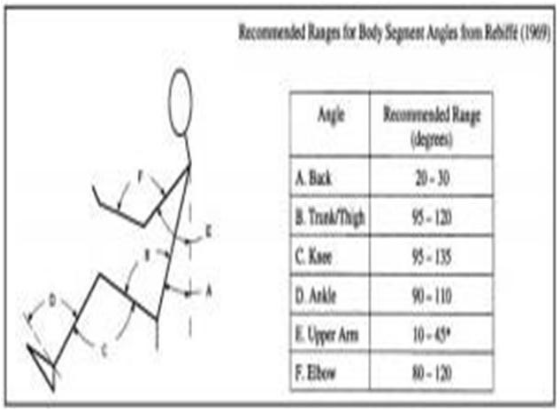

Fig 9. Rebiffe recommended angles for Body segment.

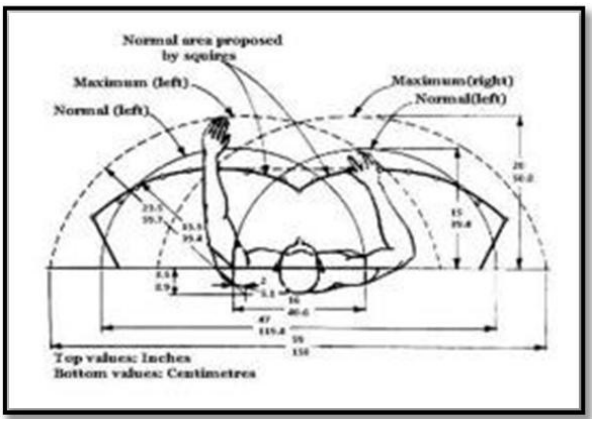

Fig 10. Hand reach of human operator.

After study of angles and body posture they did Ergonomics study on mini truck in that they did analysis on RAMSIS software for different different position and pillar obscuration and upper and lower visibility. After getting the data from styling and initial engineering position of driver seat, they got optimized comfortable position of driver seat, steering position and instrumental cluster in addition, a-pillar obstruction visibility of driver for upper and lower side and hand reach position of driver is properly set [8].

Fig 11. RAMSIS discomfort assessment analysis of driver at existing location.

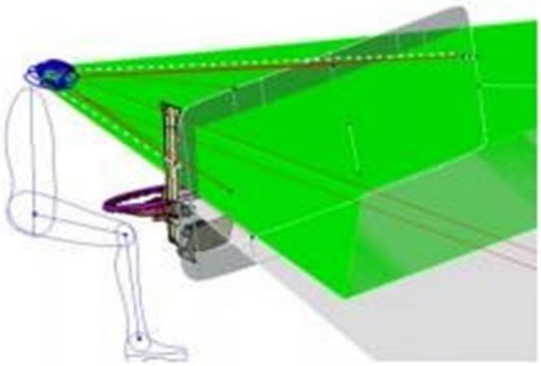

Fig 12. Visibility zone.

III. CONCLUSION

Ergonomics-negligence consequences have not any effect on the performance of the vehicle but that can be affect on passengers or drivers present in the vehicle. It can not define body postural for all drivers but can set some range for body joints angles. Best Comfort zone of driver is base on Posture and movement of body and we can arrange it by changing environmental conditions of cars.

Best comfort zone can achieve by arranging seat parameters. Automobile seat has some main design parameter to arrange driver ergonomics, This design parameters are divided into three categories are fit, feel and Support parameters. Human performance limits are base on Anthropometry, Biomechanics, Physiology, Psychology. Seat height, steering wheel position, and seat cushion angle have effects on driving posture that are largely independent of body size and gender. Large differences in torso posture between participants are not well predicted by anthropometric differences.

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