

# Ergonomic Bicycle for Ladies

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**Abstract**— Proper fit is vital for cycling performance, efficiency, comfort and injury prevention. Study reveals that bicycle is generally male favored. It struggles in popularity with females despite the fact that cycling is a good exercise. There is a small but significant difference between male and female anatomy. Due to so, they have different requirements, taste, specifications than the males. This paper emphasizes principal difference between male and female anatomy. It highlights the basic physiological factors, differences of females and their comfort during cycling. Thus, proposing brief study on “The Ergonomic bicycle for Ladies”, taking into account their peculiar anatomy. Here, we are introducing conceptual, new anthropometrically designed seat, frame, handle, tires etc. in bicycle to make it popular for the gender. Hence, an attempt has been made to make cycling more comfortable and popular.

**Keywords**— Anatomy, pelvis, saddle, anthropometry, hip, stem, Ergonomics, comfort, androgynous, silhouette, Dutch type

Posture, Tracking type cycling posture.

## INTRODUCTION

Bicycle is a pedal driven, human- powered vehicle with two wheels attached to a frame, one behind the other. It has evolved significantly in this technological era. Comfort, a combination of physical and psychological factors, is now a dominating issue in design. It is still the best means for transportation. A surprising issue has been observed in case of cycling. All teenagers around eleven years use bicycle. There is no real issue of gender. But as we proceed from eleven to nineteen years and further, female cyclist decrease sharply to almost zero percentage. Particularly in India, a women (age above 23 years above) is hardly seen on bicycle. So concentrating on the phenomenon we are highlighting the proper reasoning behind the problem. Here, evaluating modifications to make bicycle more popular among ladies. Incorporating these points and redesigning bicycle for females. In the article below, we define these aspects one by one.

## DIFFERENCE BETWEEN MALE AND FEMALE ANATOMY

The bicycle available is designed on the basis of human anatomy dominated by the male perception. However, the anatomy of female changes slowly and drastically from twelve years. It is this time that female organ starts to develop. This anatomy is the characteristics of the female which is distinctly different from males. Due to these changes their requirement as per their anthropometry, changes from the males. Hence the designed cycle is less comfortable for the female gender. As a result, cycling is less popular in them, despite the fact that cycling is a good exercise.

The other side of the coin is that the female anatomy can range all the way from the marked characters of female to the androgynous figure (does not strongly show in male and female direction ).

Male and Female anatomy are seldom so different that even a skeleton (or certain parts of it) betrays their sex.

On a vertical axis there is no real difference. Other than height proportion, joints don't move up or down. The variations are almost entirely on the horizontal axis, i.e. in width of certain parts of the body. Below, designates the various differences between male and female anthropometry.

### 1. Hip and Shoulders

Most and foremost is the shoulder, Hips and the hip to shoulder ratio. So as to sustain fetus during pregnancy the women has broader Pelvis bone than men. Secondly, there is development and projection of the mammary gland or the female breast.

These two adjustment effect is seen on the entire female body abdomen. As a result, in women, hip is the broadest part and then the chest. This is shown in the figure:-1.1(a) and Figure:-. 1.1 (b). So, female silhouette is broader at the shoulder, narrow at the waist and broadest at the Thighs, giving an hourglass figure as shown in figure: - 1.1(a) and (b).This projections are seen in the width as well. Their breast and buttock tends to bulge outwards as shown in the figure: - 1.1(a)

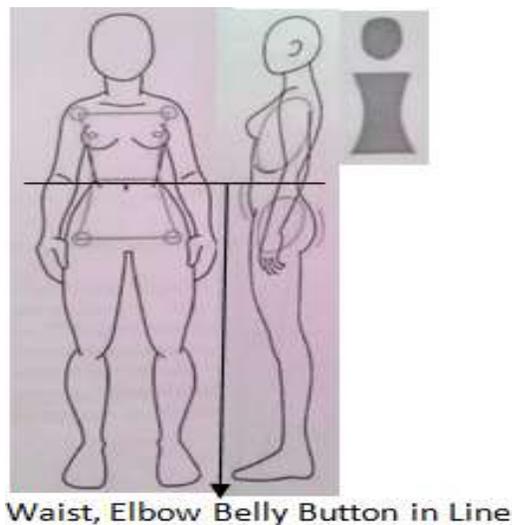


Figure: - 1.1(a) Female body domain

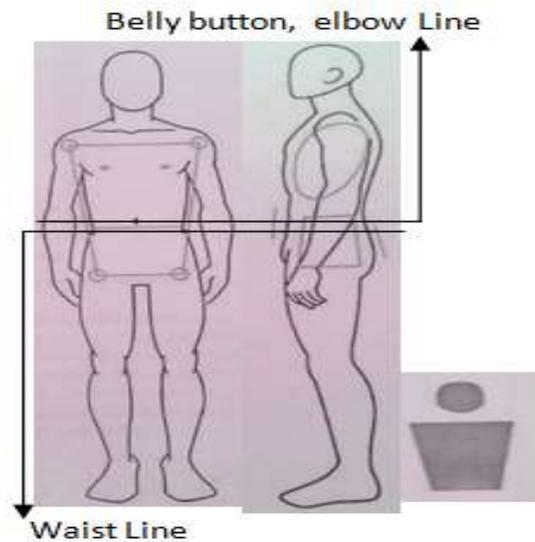


Figure: - 1.1(b) Male body domain

For males, the broadest part is shoulder and its slants linearly, as we descend towards belly. This slant is disturbed by pelvis, giving a trapeze shape. This is shown in figure: - 1.1 (b)

## 2. Joints:-

Figure: - 1.2 shows rough bone structure of male and females. Three noticeable differences are observed.

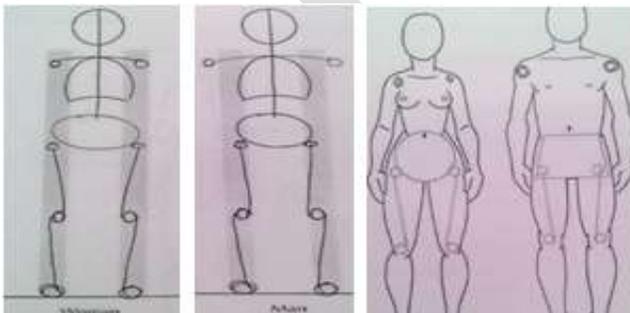


Figure: - 1.2 Bone line of male and female

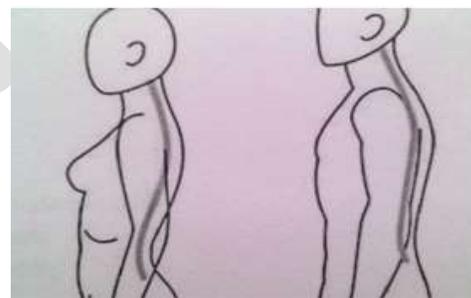


Figure: - 1.3 Vertebra of the male and female

Firstly, the males shoulder joints falls outside the body contour. As such the arms of male hang naturally away from the body. Thus, their natural posture of arm is away from the body. The female arm-sockets are attached inside the body structure shown in figure: - 1.2. The arm, forearm, tends to rest on the body contour. Hence female natural posture of the arm lies near the body unlike males.

Secondly, in males thigh is less tapered as compared to females. This is shown in figure: - 1.2, the right one.

It's the broadened pelvis bone in female makes thigh taper in, much more to join knees. Much inclined foreleg bone is other outcome of female broadened pelvis. The hips joint jut out visibly in the female body.

Thirdly, in males the belly button and elbow are in line but are offset with waist. But in ladies, the belly button, elbow and waist lie in same line. This is shown in the figure:-1.2

### 3. Vertebral column

The women back bone and the male back bone position is shown in figure: -1.3 from figure it's clear that female vertebra is more "S" shaped than males for pelvis support. Hence, their back-bone is more sensitive than males.

### 4. Other Minor differences

Besides these points stated above, there are minor properties that is sensitive to gender. However they are subjected to great variations. These points are discussed one by one as follows:-

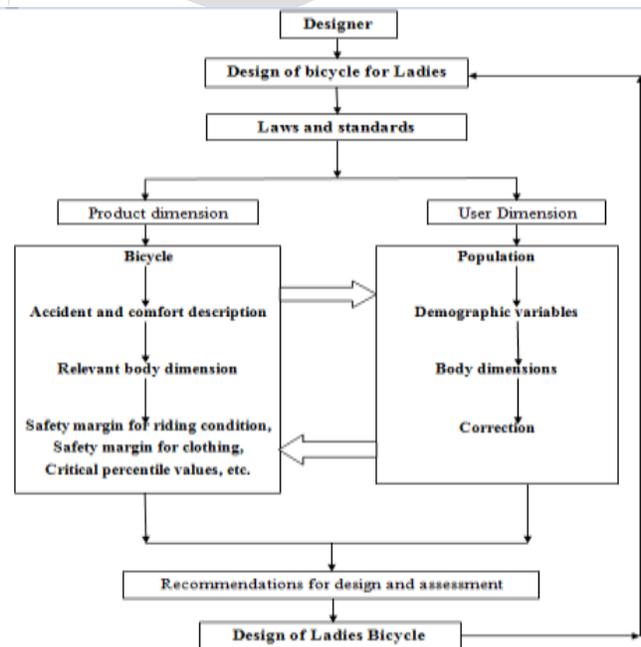
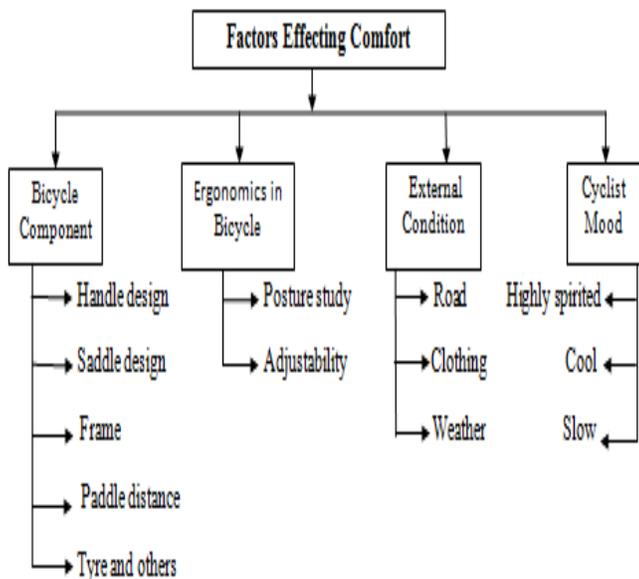
- Women body part soft rounded shapes. She stores more fat under skin as compared to males. The males body are on the other hand harsher and angular
- Palm, hands and sole of the foot are shorter than the males. Palm, hands and sole are half the face as shown in the figure.
- Women generally prefer long hairs.

Chart: - 1.2 is simplified over –view of the design process for ladies bicycle according to Molenbroek. It states the step by step design procedure of the ladies cycle.

Table: - 1.1 states the strategy involved during ladies cycle design. The first stage is the laws and standard specification which is directly picked according to the Steenbekkers and Snyder laws. We have discussed the anthropometric details of women with respect to males in the above section. Now, going for the design specifications, one by one according to the data observed.

Table: - 1.1 Design step of Ergonomic bicycle for ladies.

Chart: - 1.2 Basic principal design of Bicycle for ladies



### DESIGN OF LADY BICYCLE FOR MORE COMFORT

Factors affecting the comfort of the lady rider are delt one by one below. Table:-1.2 The External factors (Road, clothing, weather, etc.) and the cyclist mood (sporty, cool fatigue mood etc.) are taken as constant in our analysis. Here, concentrating on bicycle components and ergonomic factors of female cycling in the current paper.

## 1. Ergonomic design in bicycle for ladies comfort

It is very important to have proper distance between the saddle and handle of a cyclist. This distance varies with individual anthropometric dimensions of ladies. Thus two component of adjustment is being proposed. It is vital for proper fit. They are:-

- (a) Horizontal distance between Saddle and handle.
- (b) Vertical distance between Saddle and handle.

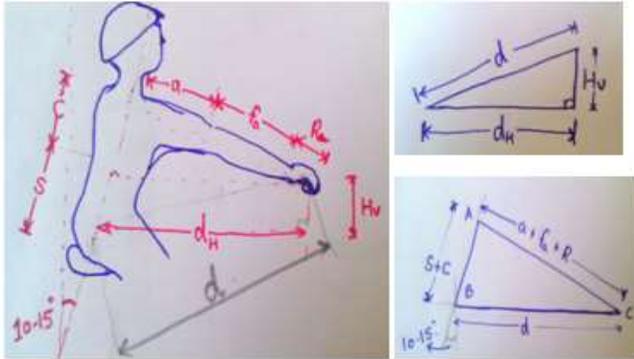


Figure:-1.4 Male favored posture while cycling

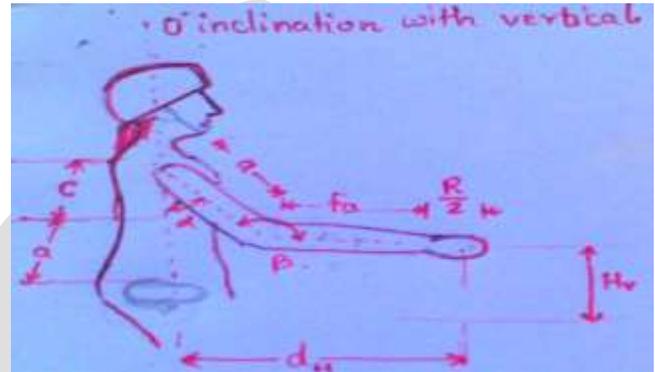


Figure:-1.5 Female favored posture while cycling

Figure:-1.4 and Figure: -1.5 clearly describes the favored posture by different gender while cycling. For the females, the body is erect and arms are closer to the body.

From the figure:-1.5 by simple geometry we have

(a) Horizontal distance between Saddle and handle:-

$$d_H = a \sin \alpha + F_a + R/2$$

(b) Vertical distance between Saddle and handle:-

$$H_v = c + a - a \cos \alpha$$

Set of 20 female data s been taken as stated in the graph below. On their taste and favoring, we have designed the bicycle handle bar. Design stated is based on the ergonomic posture stated above. They are:-

1. Distance between Saddle and handle bar- horizontally = 575mm
2. Distance between Saddle and handle bar- vertically = 195 mm
3. Horizontal distance of adjustable Handle Bar rod = 375mm
4. Handle rod diameter = 30mm
5. Handle rod adjustability –

- a). Angular adjustability
- b). Horizontal adjustability
- c). Vertical adjustability through stem.

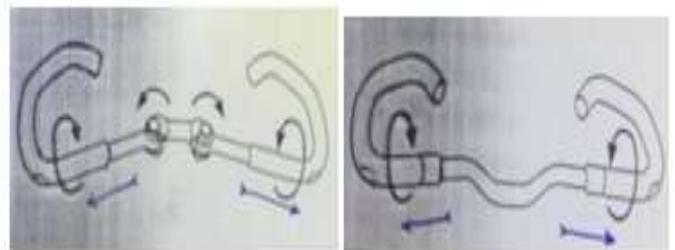


Figure:-1.6 Proposed adjustment

6. Wrist angle =  $170^{\circ}$

7. Bend angle =  $0^{\circ}$ .

**Instrument Used for measurement**



Figure: - 1.7(a)



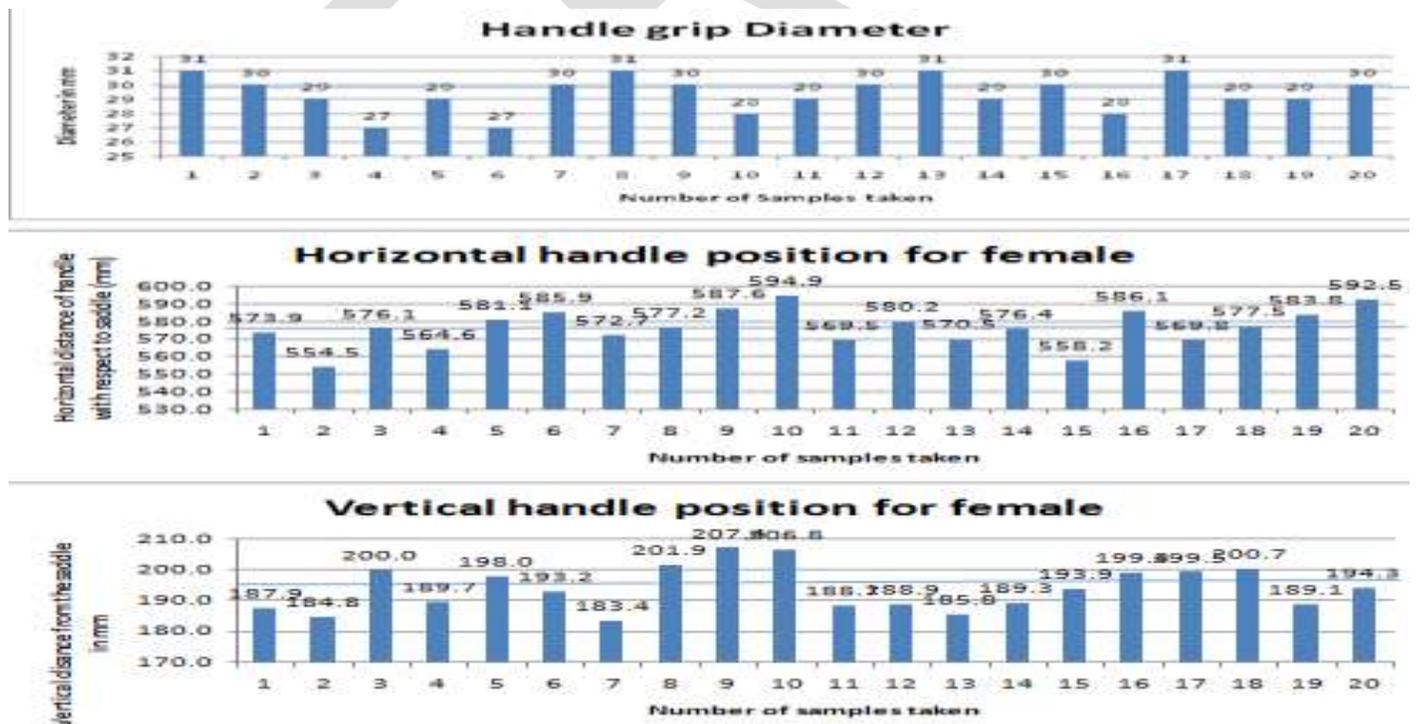
Figure: - 1.7(b)



Figure: - 1.8

The design stated above, clearly depicts the peculiar dimensions of handle bar distinct from market available. Also there is clear difference between the handle choices of ladies with respect to males. The posture comfort clearly depicts the “City” type posture. However, handlebar is subjected to stem change as shown in figure: - 1.8. The four butterfly screw and nuts adjust various handle grips as shown in figure 1.8. Prototype handle bar adjusts various sets of adjustable handle grip. It can simply be done by unscrewing the butterfly nut, de-attaching former bar and attaching the next handle bar grip to screw the four nuts.

The figure: - 1.7(a) and figure: - 1.7 (b) shows the measuring angle bar, for the dimensioning the posture angle and grip width. Figure:-1.7(a) is the part of figure: - 1.7 (b). It is intentionally tapered for grip diameter measurement. The table 4.1 and 4.2 are recorded using these measuring instruments and prototype. Set of 20 samples of the data has been taken using these instruments which is shown in the Graph: -1.3 below.



Graph: - 1.3

## 2. Bicycle components design favoring the females

### Designing of saddle

#### 1. Saddle Inclination:-



Figure:-1.9 Saddle with nose and saddle without nose

The saddle tilt that is “too nose up” will put additional pressure on the front soft tissues part. This usually causes a slouched posture on the bike.

A saddle that is too “nose down” will result in slide forward on the saddle and make you sit on the wrong part of the saddle. The sit bones will no longer provide adequate support and more weight will be placed on the hands, causing numbness and hand pain.

The saddle on a road bike should be either level, for a more upright rider, or slightly nose down— just a few degrees down from horizontal —for a more forward riding position. On a time taking trial cycling, the saddle should be more nose down as the pelvis is rotated more forward at the front of the bike. A seat post with adjustable angles allows you to find that ideal tilt. Many posts have saddle clamps with notches that often leave you with the choice of being either too nose up or too nose down.

The inclination of the seat must be in range 5 deg., nose down as per handle design. The inclined normal reactions of the body will apply more weight component on the pedal. On the other hand higher inclination will cause more force exertion on the arm. Thus a balanced inclination is must.

#### 2. Saddle Height:-

Secondly, but most important is the saddle height. It determines the cycling height of rider. It should neither be too large nor too low. Also the height should favor all the positioning of the leg for paddling as well as the hand for proper handling. All such conditions is addressed one after the other.



Figure: - 1.10

### Position Too High or Too low:-

The saddle that is too high will take rider's weight off the pedals and exert more weight on the saddle. It will also cause rider hips to rock, causing side to side movement and chafing.

The saddle too low will cause jamming of the leg, causing ineffective cycling force to peddle force.

### Position Too Far Back or Too Front:-

The position too front will cause more folding and cramped feeling. But weight component will be on the pedal, causing forceful cycling.

Moving the seat forward so that the knees are over the pedal axis, changing the pedaling angle, usually, improves saddle comfort.

### 3. Shape of the saddle:-

The conventional seat used is flat rake like structure. It fails to confer the buttock ache for long ride. Figure below gives the detailed new modification seen in seat. The front round section is replaced by flat gel nose. Several engraving is provided to have better buttock contact causing less irritation. Hole at the centre or at end in provided for better air circulation at the buttock.



Figure: - 1.11 Types of modern designed comfortable saddle seat.

### 4. Anatomically favored lady cyclist posture on cycle:-



Figure: - 1.12 (a)

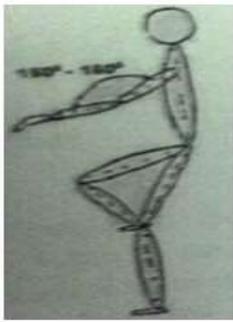
Figure: - 1.12 (b)



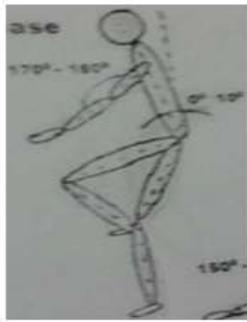
Figure - 1.12 (c)

Posture of lady cyclist: - a. Dutch type position (most popular) b. Tracking position for ladies c. Front view position of handle reach.

Considering these factors in mind proposing the general postural structure of women during cycling, shown in figure:-1.12. As stated above, we can now clearly see the difference of Posture favored during cycling. The male backbone is inclined to about 10 deg. and arm of almost straight. Female arm are close to the body and inclined  $150^{\circ}$  to  $160^{\circ}$ . This is shown in the figure:-1.12(a) figure:- 1.12 (b) and the difference is shown in the figure: - 1.13.



Female posture



Male Posture



Figure: - 1.14



Figure: - 1.15

Figure: - 1.13

### Handle design

After posture study shown in the figure above only two types of handlebar is proposed here. Firstly, most popular, the “Classic Bike Handle Bar”, in Figure: - 1.14 upper and Figure:-1.12(a). Secondly, less popular “City Bike Handle bar” Figure:- 1.6 bottom and Figure:-1.12(b).

### Frame design

The conventional frame of the bicycle as shown in the figure:-1.15. Particularly for the ladies, this frame is most suitable. It makes easy a climb and decent on the cycle. Woman clothing such as “sari” and skirts makes easy access in the frame. Beside these it makes easy control at the start and stop.

### Paddle distance

The paddle distance is another critical factor. The paddling distance should be such that at the top the angle of the leg should be more than  $68^{\circ}$ . At the bottom position it should be greater than  $170^{\circ}$ . This posture is shown in the figure:-1.13.

### Tyre and others

- The choice of broad and streamline tiers are left by the rider for its nature of use. Out of four grades of tire size, she can choose any one.
- Chin cover in must.
- Material more popular is carbon fiber other than steel

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