SADDLE PRESSURE DISTRIBUTION IN CYCLING: COMPARISON AMONG SADDLES OF DIFFERENT DESIGN AND MATERIALS

Renato Rodano[1], Roberto Squadrone[2], Massimiliano Sacchi[2], Alberto Marzegan[2]
[1]Dipartimento di Bioingegneria, Politecnico di Milano. [2]Centro di Bioingegneria, Politecnico di Milano - Fnd. Don Gnocchi I.R.C.C.S., Milan, Italy

This study compared saddle pressure distribution patterns in a group of experienced cyclists riding their own bicycle mounting different saddle models. Two traditional flat surface saddles incorporating different shock-absorbent materials in the perineal area and two innovative saddles with a hole in the perineal area were evaluated. The T-Scan system was utilised to measure the saddle pressure distribution. Each subject showed an individual pressure distribution pattern when using the same saddle. The use of the different saddles resulted in same significant changes in the saddle pressure amplitude and distribution pattern in all the subjects examined. In general, the flat surfaced saddles showed a more uniform pressure distribution with less pressure on the anterior part and more on the posterior part compared with the saddle with a perineal hole.

KEY WORDS: piezoresistive sensors, pressure distribution, road cycling.

INTRODUCTION: When riding a bicycle, the cyclist distributes his body weight and the inertial forces arising from the movement of his body mass to the pedals, the handlebar and the saddle. In competitive road and mountain bike cycling, about 40% of the body weight loads the saddle, which offers about 200 cm^2 of support to that load. Due to anatomical characteristics of the pelvis, riding position and pedalling action, the load distribution involves same delicate biological tissues, glands and organs (Mellion, 1991). Literature reports that shocks from the rough terrain and vibrations of the saddle cause repeated microtrauma to the perineum, resulting in chafing, perineal folliculitis, furuncles and subcutaneus perineal nodules (Vuong et al, 1988). Serious cyclists may develop pudendal neuropathy characterised by numbness, and tingling the scrotum and penile shaft. Male impotence, probably developing as a complication of pudendal neuropathy, has recently been documented as a saddle related problem in cyclists. In a study conducted on 505 male cyclists British researchers at the Institute of Urology in London (2001) found that regular cycling had an impact on impotence, difficulty achieving orgasm, prostate pain, difficulty urinating and pain as well as pain and numbness in the saddle area. These pathologies had a higher frequency of occurrence in mountain bikers. Frauscher et al (2000) found that 96% of a group of 45 mountain bikers presented pathological abnormalities of the scrotal content compared with 16% of a control group. The scientific results are confirmed by practical experiences reported by athletes and cycling team clinicians. Saddle manufacturers have tried to get around the above described problems using different padding materials or incorporating shock absorbent devices into the saddle itself as well as designing special seats with particular shapes (e.g. a broader rear expansion, a hole in the middle). The rationale of this approach is that an optimal shape and/or the use of shock absorbent materials should help to reduce peak pressures in the anatomical areas most frequently subjected to injury.This study compared saddle pressure distribution patterns in a group of experienced cyclists riding their own bicycle mounting different saddle models. In particular, two traditional flat surface saddles incorporating different shock-absorbent materials in the perineal area and two innovative saddles with a hole in the perineal area were evaluated (Figure 1).

METHODS: The subjects of this study were five experienced road cyclists, (age: 28.7 ± 3.6; height: 179 ± 5 cm; body mass: 67 ± 4.9 kg), usually covering more than 15.000 km/year. At the time of the experiments, all the subjects were free of lower limbs and pelvis dysfunction and injury. The subjects used their own bicycle whose rear wheel was fixed to a magnetic variable-load ergometer. After 10 min of standard warm-up gears ratio was freely chosen by the subjects in order to maintain a pedalling rate at 90-95 rpm with an external load of about 250 watt. The different saddles were randomly mounted on each subject bike. For each subject, in the different saddle conditions the distance from the center of the bottom bracket to the top of the saddle was kept constant. Data of four 20-s trials for each condition were collected.

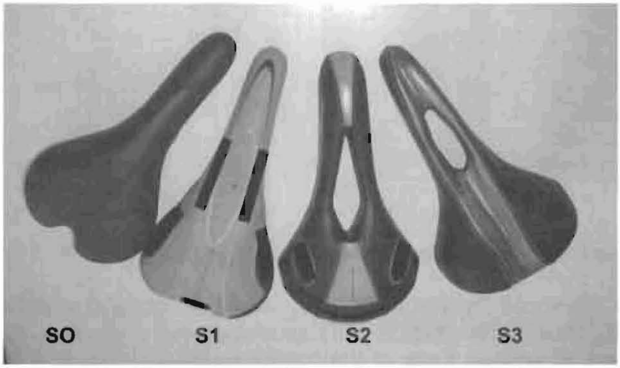

Figure 1. The saddles analysed. From left to right: S0, S1 (flat surface saddles), S2 and S3 saddles with a "hole" in the perineal area.

Figure 2. T-Scan transducer.

The T-Scan system was utilised to measure the saddle pressure distribution. The system uses a thin (0.1 mm thick) and flexible mat of piezoresistive sensitive areas (Figure 2) that allows the recording of the loads exerted on its surface (the single resistance is proportional to the perpendicular force exerted on each transducer). In this study a matrix of 12 x 11 piezoresistive sensitive areas was used with a sampling rate of 50 Hz. Equilibration was performed by applying an even pressure to the whole surface of the sensing pad through an inflatable rubber diaphragm (placed between the sensor and weight) and calculating the weight factor to be attributed to each sensor in order to obtain a homogeneous pressure distribution. An in-house software program named SELLE (Matlab 5.0 for Windows) was used for data processing, parameters computing and graphic representation. In particular, the program provided for: 1) numerical cut off of the transducers not involved in the measurement; 2) spatial oversampling of the matrix (from 11 x 16 to 110 x 160); 3) pressure normalization; 4) graphic representation of the pressure distribution through chromatic maps; 5) load distribution among the anterior, posterior left, posterior right areas of the saddle and the corresponding centres of pressure (COP); 6) asymmetry index between posterior left and right loads. All parameters extracted were averaged across the four trials to determine the individual means. Due to the small number of subjects non-parametric tests were employed.

RESULTS AND DISCUSSION: The first finding of this study was that each subject showed an individual pressure distribution pattern when using the same saddle. This is well illustrated in Figure 3 where the pressure maps of the five subjects using the same saddle are displayed. In considering this result it should be observed that, setting aside the interindividual anatomical differences, the saddle pressure distribution may be heavily influenced by the posture assumed by the cyclist on the bike. Body posture affects pelvis rotation influencing the part of the body's areas effectively in contact with the saddle and, consequently, the pressure distribution. The second main finding was that the use of the different saddles resulted in same significant changes in the saddle pressure amplitude and distribution pattern in all the subjects examined. For the four saddles analysed, in Figure 4 the mean COP coordinates of the loads acting on the three portions in which the saddle was divided are illustrated. Despite the presentation of data as an average masks the individuality of each subject and potentially washes out important information, same significant group trends could be individuated. It can be easily recognised that the two flat saddles S0 and S1 originated more symmetric triangles than S2 and S3.

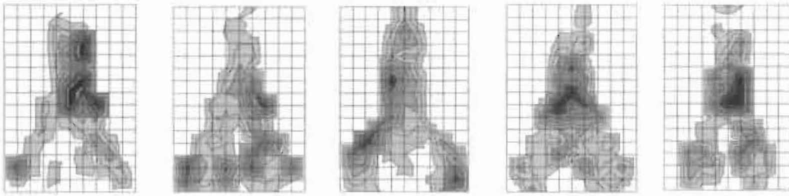

Figure 3. Pressure distribution maps of the 5 subjects when using the saddle S0.

The anterior COP was more advanced for the saddles S2 and S3, meaning a potential stronger compression of the pudendal nerves that, in this region approach each other. At the same time, S2 and S3 showed a reduced base of the triangles (line connecting the two posterior COP). This characteristic may be related to a load mostly sustained by muscles and perineum than by the ischiatic bones in contrast to what happens using S0 and S1. This condition may be potentially considered dangerous for subjects riding S2 and S3.

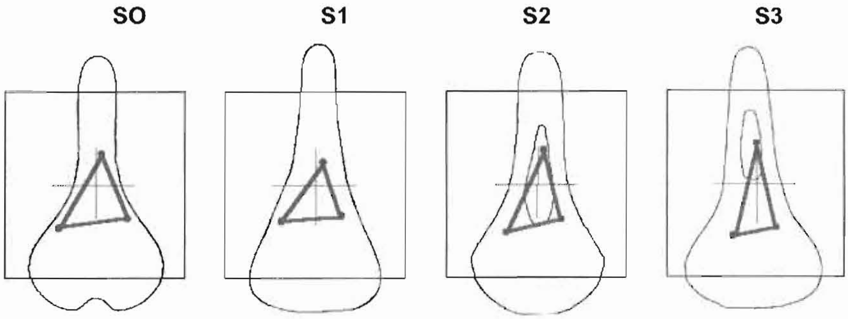

Figure 4. Graphic representation of the mean centres of pressure (COP) coordinates for the whole subject group.

The more critical behaviour of the saddle S2 and S3 is confirmed analysing the percentage areas classified by pressure ranges ($p<25$ g/cm^2, $25<p<50$ g/cm^2, and $p>50$ g/cm^2) with this two saddles showing a wider area with $p>50$ g/cm^2 (figure 5). These high-pressure areas were mainly located on the anterior part on the edges of the hole. Indeed, significant differences ($p<0.05$) were found among the four selected saddles in the posterior–anterior percentage load distribution (Figure 6). The flat surfaced saddles showed less pressure on the anterior part and more on the posterior part compared with the saddle with a perineal hole. The portion of load acting on the posterior portion of the saddle mainly involves the muscles and the ischiatic bones, while the anterior portion solicits the perineum, the bilateral pudendal nerve and the vessels of blood supply to penis. Assuming that these latter biological components are more sensitive to high pressures than the muscles and bones, a lower portion of the total load on the anterior part of the saddle, could be identified as a positive characteristic.

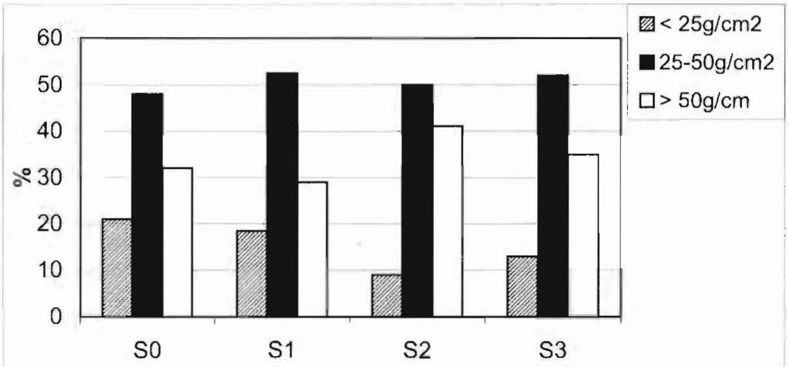

Figure 5. Average percentage areas classified by pressure ranges in the four saddles.

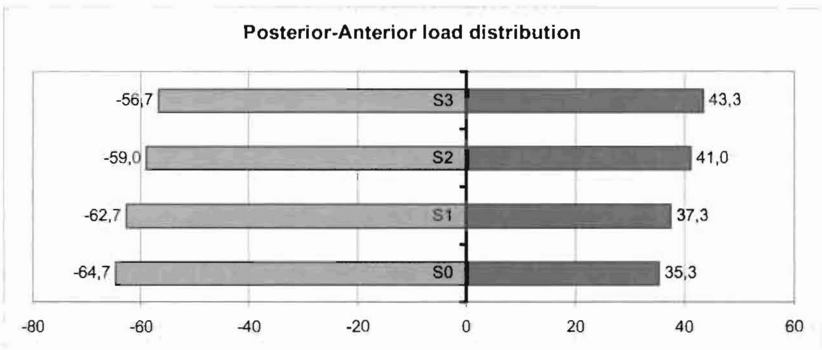

Figure 6. Average posterior (green) – anterior (red) percentage load distribution on the saddle.

CONCLUSIONS: Each athlete showed an individual pattern of pressure distribution. The model of saddle used significantly influences this pattern. In general, the flat surfaced saddles showed a more uniform pressure distribution with less pressure on the anterior part and more on the posterior part compared with the saddle with a perineal hole. However, the number of trials and subjects used limits the generalization of the findings of this study.

REFERENCES:

Frauscher F, Klauser A, Hobisch A, Pallwein L, Stenzl A, Subclinical microtraumatisation of the scrotal contents in extreme mountain biking. *Lancet.* **356**(9239), 1414, 2000 Oct 21.

Mellion MB. Common cycling injuries: menagement and prevention. Sports Medicine, 1991: 11: 52-70.

Vuong PN, Camuzard P, Schoonaert MF, Perineal nodular indirations ("accessory testicles") in cyclists: fine needle aspiration and pathological findings in two cases. *Acta Cytol.* 1988; **32,** 86-90.

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