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Personalised cutout saddle selection reduces perineal pain and improves cycling comfort in women with vulvar skin conditions

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A B S T R A C T

Perineal pain limits sitting and bicycling comfort in women with chronic vulvar conditions, reducing functional mobility and physical activity. This study evaluated personalised ergonomic saddle solutions to reduce perineal pain and restore cycling ability. Fifty women (age 57 ± 14 years) with lichen sclerosus, lichen planus, or vulvar cancer participated in a pre-post intervention study. In an outpatient living lab setting, participants evaluated four cutout saddle designs, received posture advice, selected a saddle, and tested it at home for 1-3 months. Outcomes included saddle pressure and centre-of-pressure metrics, trunk tilt, bicycling-related symptoms, quality of life, physical activity, user satisfaction, and personal goal achievement. A reference group of 50 healthy volunteers evaluated the saddles in the outpatient setting only. Pre-post cycling impediments (moderate or worse) decreased from 76.0% to 30.4% ($p < 0.001$), with marked reductions in perineal symptoms. Saddle design influenced centre-of-pressure location and variability, particularly in the anteroposterior direction. Seventy percent of participants achieved their personal bicycling goal. No changes were found in overall quality of life or physical activity. To conclude, personalised saddle selection reduces perineal pain and improves cycling ability in women with chronic vulvar conditions.

1. Introduction

Perineal pain and hypersensitivity can severely restrict mobility by making it difficult to sit, walk, or bicycle, especially in women with chronic vulvar conditions, such as lichen sclerosus (LS), lichen planus (LP), or vulvar cancer (Dietz et al., 2025; van de Berg et al., 2023). With rising prevalence of these diseases (Baandrup et al., 2024; Bleeker et al., 2016), more individuals face mobility restrictions that disrupt activities of daily living, limit transport options, and reduce physical activity. Although many ergonomic bicycle saddles are available, it is often impossible for individuals to identify a suitable saddle without dedicated testing sites that aid in effective product–user matching.

Bicycling is a widely accessible and sustainable mode of transport, with proven benefits for cardiovascular health and mental well-being (Chen et al., 2022; Milton et al., 2021; Oja et al., 2011; Zukowska et al., 2022). Physical *inactivity* affects 31% of the world population and is associated with an increased risk of obesity and non-communicable diseases, placing a considerable burden on health systems (Ding et al., 2016; Strain et al., 2024). Therefore, the World Health Organization developed a global action plan on physical activity, linking it to 13 out of 17 Sustainable Development Goals defined by the United Nations (World Health Organization, 2018). In the context of the European Green Deal, a new Urban Mobility Framework was proposed, and a *Pan-European Master Plan for Cycling Promotion* was formulated in 2021 (Monti, 2022), aiming to expedite cycling promotion policy developments at individual member state levels. In short, the goal to make people more active is on global agendas, and promotion of bicycling activities is an often-considered cornerstone in achieving this.

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Saddle design, effective product-user matching, and posture optimisation are key ergonomic factors for improving cycling comfort and accessibility (Ayachi et al., 2015; Husband et al., 2024; Larsen et al., 2018). We developed a living lab intervention to evaluate tailored bicycling solutions for women with chronic vulvar skin conditions. The outpatient setup included a stationary bike, four cutout saddles, and pressure sensors to assess loading patterns and centre-of-pressure variation. Trunk tilt was measured and participants received guidance on bike settings to improve cycling posture. A home-based testing phase was added to establish whether solutions found on the stationary bike remained effective during everyday cycling. The aim is to conduct pre-post comparisons of self-reported bicycling symptoms, quality of life, user satisfaction, and physical activity. We hypothesise that personalised saddle selection and posture changes can reduce perineal pain and improve bicycle use in populations with chronic vulvar skin conditions.

2. Methods

2.1. Study design

A pre-post intervention design with a mixed-methods approach was used, in which quantitative and qualitative data were collected to assess the effectiveness of the living lab in facilitating the participants' search for an individual pain-reducing bicycling solution, shown in Fig. 1. The study consisted of four phases, taking place in outpatient clinic and home settings. The study protocol was approved by the Medical Ethics Review Committee of the Erasmus MC (protocol: MEC-2023-0753, date of approval: 26-03-2024).

Phase I: enrolment and inclusion. Participants received a flyer during standard clinical follow-up moments at our outpatient clinic or viewed an open message at a private Facebook group of the Stichting Lichen Sclerosus patient advocacy group. Enrolments were self-initiated. Participants were adult women experiencing perineal pain and cycling problems because of LS, LP, or vulvar cancer. They also had to be able to read Dutch to understand the content of our questionnaires and have a weight less than 120 kg to meet the safety criteria for use of our stationary bike. In total, 50 participants were included between April – December 2024. Simultaneously, 50 healthy women were recruited as a reference group, consisting mostly of female colleagues from the Erasmus MC. Reference group participants only completed the phase II outpatient clinic test. All recruitment methods linked to our website with contact form. We sent a follow-up mail to respondents, providing the option to use the living lab with or without taking part in the study. Participants who were eligible and who enrolled in the study received an information letter and informed consent form, which was signed during the first meet-up. This letter explained (in Dutch) the aim to reduce cycling symptoms and improve mobility with solutions (saddle designs and cycling posture) to adjust pressure on sensitive regions of the sitting area.

Phase II: outpatient clinic test. During the first visit, participants completed three questionnaires (GO-Bicycling2, EQ-5D-5L, SQUASH), aimed at measuring self-reported bicycling problems, quality of life, and habitual physical activity, respectively. A personal bicycling goal was formulated by each participant, ranging from practical cycling for errands to recreational rides of 40 km through nature. After this, participants were asked to test four saddles for 5 min on a stationary bicycle. Through the information letter, participants were asked to wear clothes that they would normally wear when cycling. The saddle order was randomised to evenly distribute the effect of test duration on saddle experience, i.e., pain may increase over time. In line with Royal Dutch Touring Club (ANWB) guidelines, saddle height was initially set at hip level and adjusted so the leg maintained a slight knee flexion at the bottom of the pedal stroke. When pedals were horizontal, the front knee was approximately above the pedal axis. Saddles were installed approximately horizontally. Saddle-handlebar distance was adapted to allow relaxed shoulders and slight elbow flexion. Settings could subsequently be adjusted based on participant preferences. The effects of bicycling posture on perineal loads were briefly discussed. A side-view photograph was taken to enable posture evaluations. During the experiment, participants were asked to keep gear settings and rotation frequency constant. To assess differences in saddle pressure, a saddle cover with pressure sensors was used. After each 5-min session, a saddle evaluation form was completed. After the four sessions, participants were asked which saddle was perceived to be most comfortable, and whether they wished to test this saddle on their own bikes at home.

Phase III: home environment test. Saddles were used in the home environment for 1–3 months, with duration influenced by experienced pain levels, scheduled hospital visits, and seasonal conditions affecting bicycle use. Participants were asked to update a diary on bicycle uses and experiences, aiming to establish whether sufficient testing occurred, and to validate personal bicycling goal achievement. They were also asked to send a second side-view picture to enable the comparison of trunk tilt at home and on the stationary bike.

Phase IV: return visit. A concluding visit to the outpatient clinic was scheduled to retrieve the saddle and complete a second series of questionnaires (GO-Bicycling2, EQ-5D-5L, SQUASH), enabling pre-post comparisons of self-reported outcomes. Participants were asked whether their personal bicycling solution was considered helpful, and whether it allowed them to achieve their personal goal.

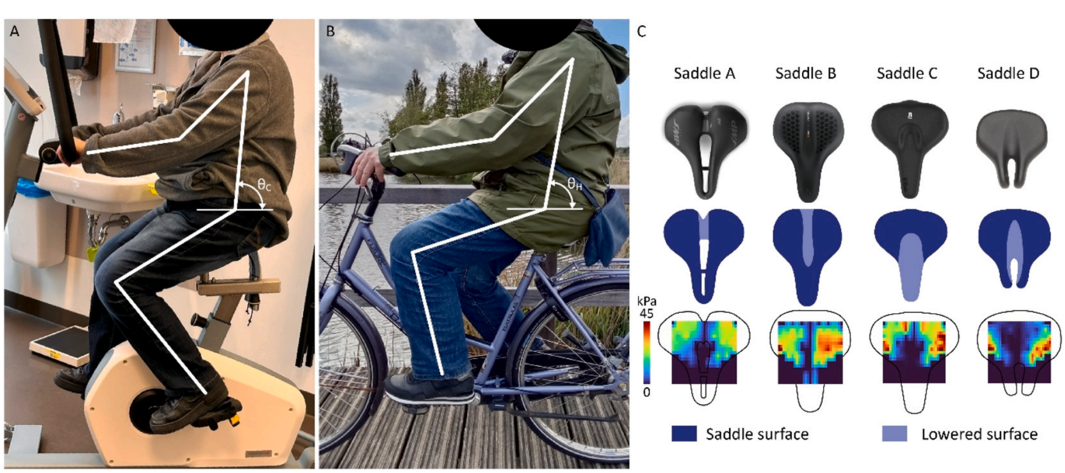

Fig. 1. Photos to illustrate the experimental set-up in the outpatient clinic (A), and home environment (B). Trunk tilt was determined in the clinic (θ_C) and at home (θ_H) based on these photos. Saddles with cutouts and lowered zones were tested (C), and saddle pressure was measured during steady-state bike use.

2.2. Materials

A stationary bike and ergometer (Motion Cycle 900 MED ALL-IN, emotion fitness GmbH, Hochspeyer, Germany) was used together with a smart saddle cover with pressure mapping sensors (gebioMized, Muenster, Germany). The saddle cover contained 64 sensors, capturing pressure data with a sampling frequency of 200 Hz. The sensing area had a length of 18.0 cm and width of 15.3 cm. Four saddles were selected based on discussions on personal experiences and success rates with four experienced and independent bike fitters. They included.

- Saddle A: SMP Tour e-city gel (Selle SMP, Padua, Italy), size: 26 × 22 cm (length x width).
- Saddle B: Enjoy CS-plus-24 (Enjoy & Meerens, Lelystad, Netherlands), size: 27 × 24 cm (length x width).
- Saddle C: SQlab 621 M-D LINE Active City (SQlab GmbH, Taufkirchen, Germany), size: 27 × 22 cm (length x width).
- Saddle D: ISM Metro (ISM, Dirkslands, Netherlands), size: 23 × 21 cm (length x width).

The use of a saddle cover contributed to a partially single-blinded study design, ensuring that participants evaluated pressure and contact sensation, rather than saddle appearance.

2.3. Data collection and processing

Key performance metrics. Summary statistics are provided on living lab participation rates within and outside of the study context. In addition, the lab effectiveness is determined using the personal goal achievement rate.

Saddle pressure. To compare the impact of saddle type on perineal load, a saddle pressure distribution was determined in participant subgroups. A 30-s window of steady-state cycling was selected from the pressure data of each participant. These data were averaged over time and spatially interpolated with a moving average with a 3x3 window to obtain pressure heatmaps per condition. Pressure values were summarized by maximum values, and as a median with interquartile range (IQR) to capture dynamic pressure variations. Centre-of-pressure (CoP) samples were summarized spatially using two-dimensional kernel density estimation, visualising CoP occupancy. For each saddle, participant-specific mean CoP locations and standard deviations (SD) in the mediolateral (ML) and anteroposterior (AP) directions were computed, and group-level summaries were obtained as the mean of participant means and the mean of participant SDs.

Cycling posture. A simple posture analysis was done using side-view photographs on the stationary bike and on the participant's bike at home. All photos were processed with face redaction. The main metric collected was trunk tilt, which was determined based on a midline drawn between the hip and shoulder joints, see Fig. 1. The trunk tilt angle was determined and compared for the study component in the clinic (θ_C) and at home (θ_H). Photos made in the home setting were discarded from the analysis if participants did not hold the steering wheel with at least one hand, or if the view angle was inadequate (not in side-view) for determining trunk tilt.

Questionnaire outcome metrics. To evaluate pre-post intervention changes on cycling problems, one problem-specific questionnaire (GO-Bicycling 2) and two validated questionnaires (EQ-5D-5L, SQUASH) were used.

- GO-Bicycling2: Participant characteristics, medical background, bicycle use, and bicycling symptoms were collected with this problem-specific questionnaire (Dietz et al., 2025). Lesions were categorized by location: near pubic bone, left or right of the introitus, between the vulva and anus, near the sitting bones, or no reported problem area. Perceived bicycling inhibition was registered, along with symptom types including pain, irritation, numbness, and itching. Post-cycling symptoms were also assessed, including cracks, redness, and swelling – symptoms requiring visual inspection. All scores were expressed with a Likert scale, using the levels no, slight, moderate, and severe.
- EQ-5D-5L: Quality of life was computed by combining patient-reported outcomes on mobility (MO), self-care (SC), usual activities (UA), pain/discomfort (PD), and anxiety/depression (AD). Factors had five levels: no problems, slight problems, moderate problems, severe problems, and extreme problems. A single index, $I_{QoL} \leq 1$, was computed using the constraint tobit model with Dutch tariffs (Versteegh et al., 2016), using Eq. (1):

$$I_{QoL} = 1 - c_0 - \beta_i^{MO} - \beta_i^{SC} - \beta_i^{UA} - \beta_i^{PD} - \beta_i^{AD} \quad (1)$$

Here, $c_0 = 0.047$, is a constant penalty used for all health states except 1-1-1-1-1, and the beta values are level i-dependent penalties for the five factors. In addition, a patient-reported health index, I_H, was determined using a 100-point visual analogue scale (VAS). Here, 0 and 100 present the worst and best imaginable health possible.
- SQUASH: Habitual physical activity on an average week was computed as the cumulative duration of activities in the domains of commuting, leisure, household, and work or school (Wendel-Vos et al., 2003). The percentage of participants adhering to Dutch physical activity guidelines was calculated (Weggemans et al., 2018). According to Dutch guidelines, a person should engage in 150 min/week of moderately intense physical activity and should perform two bone and muscle strengthening activities per week. Household activities and activities at work were excluded, as they were considered of low intensity (Gal et al., 2019). Activities of at least moderate intensity required a metabolic equivalent of task (MET) score of 3.0 or higher.
- *Saddle evaluation form*: After testing on the stationary bike, a brief saddle evaluation form was completed. Participants were asked to rate comfort and stability of the saddle with VAS scores, ranging from 0 to 10. Here, 10 was the most comfortable or stable. In addition, bicycling problems (itching, pain, irritation, numbness) and problem locations (near pubic bone, left/right of the labia, between the vulva and anus, near the sitting bones, no problem locations) were reported.

2.4. Data analyses

Data were processed in MATLAB R2024a (Mathworks, Natick, MA, USA), and in SPSS Statistics 28.0.1.0 (IBM, Armonk, NY, USA), and checked for normality using the Shapiro-Wilk test before further analysis. The pressure and posture data were analysed with Mann-Whitney U tests. If normality assumptions were violated, the Wilcoxon signed-rank test or McNemar test was performed when data were paired (before-after comparison), and the Mann-Whitney U test or χ^2-test was performed with independent data (participant-reference group comparison). If normality assumptions were met, paired (pressure, trunk tilt, numerical questionnaire results) or independent (participant characteristics) sample t-tests were used. To account for per-hypothesis multiple testing, a Bonferroni correction was applied, setting the significance threshold at $\alpha = 0.05/m = 0.005$, when testing against complaints ($m = 11$) in the GO-Bicycling2 questionnaire. Effects of saddle on CoP location and variability were evaluated using a linear mixed-effects model with saddle as a fixed effect and participant as a random effect. Post-hoc pairwise comparisons were performed for outcomes showing a significant saddle effect.

3. Results

3.1. Living lab participation and user characteristics

Characteristics of living lab users are summarized in Table 1. An additional 35 women used the living lab without taking part in the study. They either did not wish to participate, or they had perineal pain with a different medical origin. The total number of living lab users (including the reference group) between April-December 2024 was 135, or 15/month. The average time a saddle was tested at home was 72 ± 36 days. The mean age of participants in the intervention group was 57 ± 14 years. In our reference group, the age of participants was 49 ± 12 ($p < 0.001$). Other reference group characteristics can be found in Supplementary Table S1. In the intervention group, the following bike types were used by participants at home: city bike (42%, n = 21), electric bike (54%, n = 27), mountain bike (2%, n = 1), and urban bike (2%, n = 1). The following saddles were used (before switching saddles): traditional saddle (68%, n = 34), cutout saddle (14%, n = 7), noseless saddle - 'rokzadel' (6%, n = 3), sports saddle (2%, n = 1), and other (10%, n = 5, mixed types often in-between traditional and sports saddles).

3.2. Comparing saddles: pressure distributions

To compare the four saddles tested, median pressure heatmaps of the participant group are shown in Fig. 2. The total median [IQR] pressure across the loaded part of the saddle surface was 21.0 [12.4-27.9] kPa, 22.2 [9.6-31.1] kPa, 21.5 [11.1-30.6] kPa, and 14.3 [4.6-24.4] kPa for saddle types A (n = 22), B (n = 18), C (n = 19), and D (n = 20), respectively. Saddle type D had the lowest median pressure ($p < 0.001$), while no differences were observed among the other three saddle types. Maximum pressures on these four saddle types were 82.9 kPa, 71.6 kPa, 71.8 kPa, and 105.3 kPa, respectively.

The CoP positions (Fig. 2, origin in the left bottom corner) were 76.9 ± 6.7 mm, 76.3 ± 9.5 mm, 74.8 ± 6.6 mm, and 76.4 ± 15.5 mm in the ML direction and 139.3 ± 5.7 mm, 125.4 ± 9.9 mm, 133.5 ± 7.0 mm, and 115.9 ± 13.8 mm in the AP direction for saddles A, B, C, and D, respectively. The linear mixed effects model indicated differences in the AP direction ($p < 0.001$) and in the absolute size of variability (mean of participant SDs) for the AP and ML directions (both $p < 0.001$). No differences were found in the CoP ML positions. In post-hoc comparisons, all saddles significantly differed from each other in CoP AP positions (all $p < 0.001$). For both ML and AP absolute size of variability, only saddle D differed from the other saddle types (all $p < 0.001$). Kernel density maps and CoP positions of the reference group can be found in Supplement S2.

Participants could choose one saddle to take home for phase III of the experiment. Four participants were not satisfied with any of the saddles and automatically did not meet their personal bicycling goal. Saddles A, B, C, and D were chosen by 23, 7, 7, and 9 participants, respectively.

Table 1
Characteristics of participants in the intervention group (showing mean ± S.D.), and summary of medical conditions and treatment history.

Number of participants	50	
Age (mean ± S.D.)	57 ± 14 years	
Weight (mean ± S.D.)	77 ± 15 kg	
Height (mean ± S.D.)	168 ± 6 cm	
BMI (mean ± S.D.)	27.2 ± 5.4	
Medical conditions		
• Lichen sclerosus (LS)	44[a] (88%)	
• Lichen planus (LP)	1 (2%)	
• Vulvar cancer (VC)	8[a] (16%)	
Treatments	Past (>6 months)	Recent
• Topical therapy	38 (76%)	34 (68%)
• Surgery	9 (18%)	2 (4%)
• Radiation	0 (0%)	0 (0%)
• Medication	1 (2%)	2 (4%)
• None	2 (4%)	2 (4%)

[a] Three women with VC also had LS and four women with LS also had other conditions: vulvodynia, herpes, anal symptoms, or eczema.

3.3. Comparing posture: trunk tilt

Mean trunk tilt was derived by analysing side view photos of participants in the intervention group, see Fig. 1. Included were 48 photos taken in the clinic (phase II), and 35 photos taken at home (phase III), resulting in median [IQR] trunk tilt angles $\theta_C = 91°$ [88°-95°] and $\theta_H = 93°$ [89°-97°], respectively ($p = 0.27$). A similar posture was found in both test settings, in which participants sit up straight, with a minor inclination forward.

3.4. Bicycling symptoms in reference and intervention groups

The prevalence of symptoms reported in phase II by our reference and intervention groups are shown in Fig. 3A and B, respectively. In the reference group, 8% (n = 4) of the participants reported experiencing symptoms at any level. In the intervention group, this was the case for 98% (n = 49) of the participants.

3.5. Pre-post comparison of self-reported outcomes

Differences in bicycling symptoms were compared before (Fig. 3B) and after (Fig. 3C) the intervention. Most symptoms were found to be reduced after the intervention. This is illustrated in Table 2 by the percentages of participants with moderate/severe symptoms. Moderate or worse symptoms left/right of the introitus were reduced from 90.0% to 41.3% ($p < 0.001$). The intervention was not helpful in reducing complaints at the location of the sitting bones (22.0% vs. 19.6%, $p = 0.774$). Table 2 furthermore presents outcomes of the EQ-5D-5L and SQUASH questionnaires. No differences were seen in overall health and quality of life indices or in physical activity patterns, before and after the intervention. Moderate or worse PD scores (pain/discomfort) were 43.5% (before) and 21.7% (after), respectively ($p = 0.013$).

The living lab addresses pain relief but offers no treatment of underlying medical conditions. Fig. 3 shows that symptoms may be mitigated but not taken away fully. Quotes from participants (translated from Dutch) can be found in Supplement S3 (online), providing qualitative insights of outcomes realised.

3.6. Living lab effectiveness

In the GO-Bicycling2 questionnaire, participants were asked whether they felt that their vulvar condition impeded bicycling. Fig. 4 shows a pre-post comparison of this impediment. A moderate or worse bicycling impediment was indicated by 76.0% before the intervention, and by 30.4% afterwards ($p < 0.001$). During the return visit (phase IV), 70% (35/50) of participants reported that they found the saddle comfortable to use, and 70% (35/50) indicated that their self-defined (phase II) cycling goal for saddle use in the home environment was achieved.

4. Discussion

We present the first results on the effectiveness of a patient-in-charge living lab, realised to mitigate perineal pain during bicycling. The lab was open to women with LS, LP, or vulvar cancer. Our findings demonstrate that perineal symptoms adjacent to the introitus can be effectively and immediately reduced with relatively simple and accessible solutions, such as saddles with cutouts. Most participants reported satisfaction with the intervention and achieved their personal cycling goals, indicating meaningful individual-level benefits.

In related work, the *effect of bicycling on perineal pain* was studied mostly in the context of (endurance) sports. This is typically the context in which saddle design is evaluated and optimised (Larsen et al., 2018).

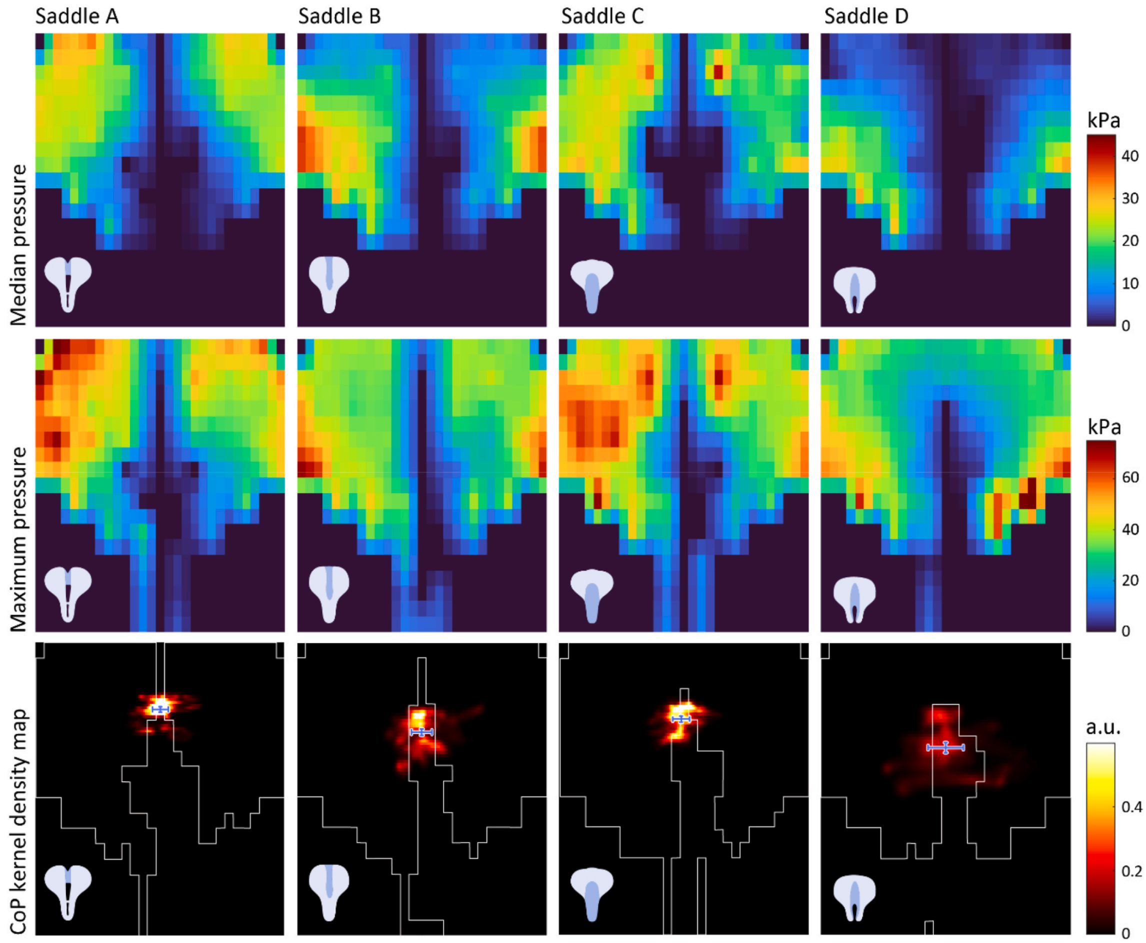

Fig. 2. Median and maximum saddle pressure in kPa over time, demonstrating a clear pressure drop along the saddle midline. The bottom row shows centre of pressure (CoP) kernel density maps placed on top of outlines derived from the maximum pressure maps. Blue bidirectional error bars are centred at the group mean CoP position (mean of participant means) and indicate within-participant CoP variability (mean of participant standard deviations). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

It is well known that seat (dis)comfort is strongly dependent on use context and activities, i.e., static versus dynamic (Hiemstra-van Mastrigt et al., 2017). Prolonged and intense pressure on the perineal region during sportive cycling can cause sores, pudendal nerve entrapment, genital numbness, and sexual dysfunction (Bury et al., 2021). Among others, pain and discomfort may be influenced by an improper bike fit, incorrect saddle design, saddle height or angle, and lack of breaks during long rides (Vicari et al., 2023).

In turn, the *effect of perineal pain on bicycling* inhibition was described for vulvodynia (Young and Miller, 2019) and studied for vulvar cancer and LS/LP. In a questionnaire study among 603 participants with LS or LP, 47.7% experienced moderate or worse bicycling impediment (Dietz et al., 2025). Among women treated for vulvar cancer, this was 40.3% (van de Berg et al., 2023). In our study, 76.0% of participants experienced moderate or worse bicycling impediment at baseline, a rate substantially higher than previously reported. After the intervention, this figure reduced to 30.4%. This suggests that participants who enrolled for our study had a relatively high baseline symptom burden.

Saddle loading during cycling reflects static and dynamic support. Pressure-mapping systems often report CoP as an indicator of dynamic load patterns, though its relation to perceived comfort remains unclear (Potter et al., 2008; Verma et al., 2016). The four saddles tested in this work differed substantially in terms of pressure regions and CoP occupancy, see Fig. 2. For all saddles, pressures were reduced at the saddle midline. As expected, the mean ML CoP position was close to the saddle midline. The mean AP CoP position differed for all saddles, with saddles A and C resulting in a higher load at the back, and saddles B and D in a higher load at the front of the saddle. Pressure appeared more focused for saddle D (lower median pressure, higher maximum pressure). Some participants considered this saddle too wide at the nose, creating friction with the thighs. This could explain the higher-pressure concentrations near the nose, as well as the CoP variability differences compared with the other saddles.

No effects on overall quality of life or habitual physical activity could be demonstrated. This may be due to sample size, or due to the need for lifestyle changes that typically require longer follow-up to detect. Participants in the intervention (and reference) group self-enrolled and likely had an above-average affinity with bicycling. Many continued cycling despite experiencing pain, which complicated the before-after analysis of habitual physical activity and bicycle use, as values were high at both time points. For quality of life, the validated EQ-5D-5L questionnaire did show an effect on reported pain, but not on mobility. The EQ-5D-5L specifically assesses mobility problems using the terminology ‘walking’, rather than broader forms of mobility including cycling. As a result, this measure may not fully capture functional improvements related to bicycling, limiting its sensitivity to change in this context.

A limitation of our study is that most participants had LS, as expected based on disease prevalence. This predominance limits generalizability to those with LP or vulvar cancer and precludes meaningful subgroup analyses. The saddle test period was variable (1–3 months) to provide more equal test opportunities, given that strict cycling regimens were

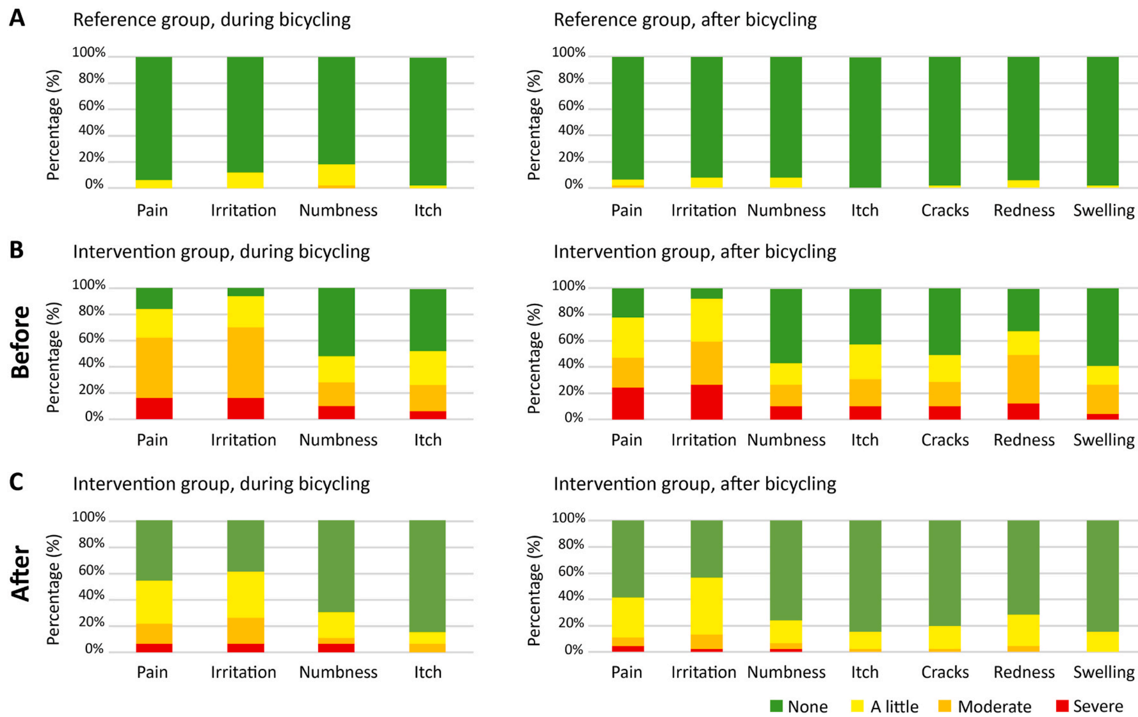

Fig. 3. Comparison of the frequency and severity of symptoms, experienced by participants in our reference group (A) and intervention group (B, C). For the intervention group, symptoms are shown before (B, phase II) and after (C, phase IV) participation. Symptoms were experienced during (left) and after (right) bicycling.

Table 2
Before-after comparison of self-reported outcomes of the EQ-5D-5L and SQUASH. The percentages in the GO-Bicycling2 section indicate the prevalence of moderate or worse symptoms.

	Before	After	p-values
GO-Bicycling2			
Location of symptoms:			
• Pubic bone	40.0%	17.4%	0.008
• Left/right of introitus	90.0%	41.3%	<0.001
• Between introitus and anus or around anus	36.0%	13.0%	0.007
• Sitting bones	22.0%	19.6%	0.774
Symptoms during bicycling[a]:			
• Pain	62.0%	23.9%	<0.001
• Irritation	70.0%	26.1%	<0.001
• Numbness	28.0%	10.9%	0.065
• Itch	26.0%	6.5%	0.021
Symptoms after bicycling[a]:			
• Pain	46.0%	10.9%	<0.001
• Irritation	58.0%	13.0%	<0.001
• Numbness	26.0%	6.5%	0.039
• Itch	30.0%	2.2%	<0.001
• Cracks	28.0%	2.2%	<0.001
• Redness	48.0%	4.3%	<0.001
• Swelling	26.0%	0%	<0.001
EQ-5D-5L			
• I_H	77.86 ± 10.92	79.24 ± 11.61	0.652
• I_{QoL}	0.805 ± 0.128	0.815 ± 0.161	0.451
• Pain/discomfort	43.5%	21.7%	0.013
SQUASH			
• Physical activity, guideline adherence	51.0%	54.3%	0.648
• Weekly bicycle use	79.6%	91.3%	0.070
• Cycling (total), min/week	171.1 ± 179.7	254.5 ± 349.1	0.064

[a] Percentage of participants indicating moderate or severe symptoms.

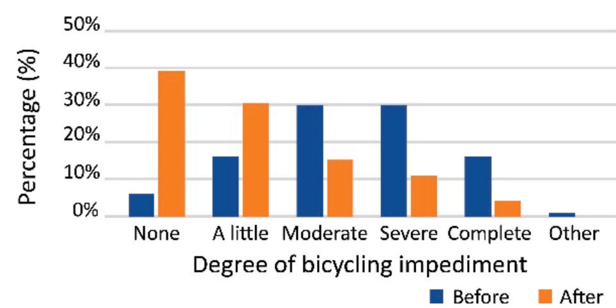

Fig. 4. Comparison of the degree of bicycling impediment caused by the vulvar skin condition, as reported before and after the intervention. The category 'other' refers to bicycling impediments that are not related to the vulvar skin condition.

not feasible for patients experiencing pain and that weather conditions across seasons affected everyday bicycle use. As a result, weekly bicycle use varied considerably among participants (see Table 2). Another limitation was the logistical inability in our hospital to test saddles on the participant's own bike. In our outpatient clinic we gave advice on cycling posture, but we had limited control on bike settings at home. Adding to this is the absence of posture data at home from before the study. This means that we were unable to quantify posture adjustments resulting from our advice. Nevertheless, our posture analysis shows similarity in trunk tilt in the lab and home settings. Trunk tilt directly affects the proportion of weight carried by the saddle and handlebars and alters the region of skin contact with the saddle. Bike fitting is effective in pain mitigation in sports, in particular for the groin and back (Dias Scoz et al., 2025), and results can likely improve further at a (sports) physical therapist or a bike fitter, where posture can be adequately attuned. Here, it must be considered that the types of complaints of utility or recreational cyclists (our participants) differ from those of sportive cyclists. The distribution and magnitude of forces on the saddle is different and higher for the utility cyclist. For sport-oriented cyclists, the starting point is the most efficient bike posture causing as little complaints as possible. For our participants, existing complaints are leading in finding the best position and saddle.

The characteristics of our reference group do not perfectly align with those of the intervention group, e.g., the difference in mean age was 8 years. Underlying the sample difference was the choice to recruit reference group participants among hospital staff members, whereas many intervention group participants were above the retirement age. The reference group was included to provide contextual baseline information on cycling symptoms in healthy women. Fig. 3 shows that moderate or severe symptoms are nearly absent in this group and very common in the intervention group. It is unlikely that closer matching of the reference group would have altered this qualitative insight.

To conclude, perineal pain experienced while riding a bike can be effectively mitigated for patients with vulvar skin conditions by means of saddles with cutouts. We have demonstrated strong reductions in self-reported pain, irritation, itch, cracks, redness, and swelling. All in all, seven-out-of-ten participants were satisfied with the solution found, and as many were able to achieve their personal bicycling goal. Clinicians who encounter patients with these problems are encouraged to reach out to a local (sports) physical therapist or bike fitter to establish a resource-efficient referral option that benefits these women.

CRediT authorship contribution statement

Nick J. van de Berg: Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Eva M. Barnhoorn:** Writing – review & editing, Writing – original draft, Software, Project administration, Investigation, Formal analysis, Data curation. **Frederieke C. de Smid:** Writing – review & editing, Visualization, Software, Project administration, Investigation, Formal analysis, Data curation. **Renée J. Dietz:** Writing – review & editing, Investigation, Data curation. **Rob H. Overdijk:** Writing – review & editing, Data curation. **Ramon G.V. Smolders:** Writing – review & editing, Methodology. **Marianne Maliepaard:** Writing – review & editing, Validation, Project administration, Data curation. **Heleen J. van Beekhuizen:** Writing – review & editing, Methodology, Conceptualization. **Helena C. van Doorn:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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We intentionally placed minimal emphasis on saddle brands, as our study includes only four out of countless available options. We have no financial affiliations with the industry and aim to remain an independent entity that can easily switch to other saddle types when deemed useful for future clinical or research purposes.

During the preparation of this work the author(s) used ChatGPT to assist with language polishing and stylistic refinement. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Appendix A. Supplementary data

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