

Original Article

A preliminary investigation of a novel method to manipulate penis length to measure female sexual satisfaction: a single-case experimental design

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Objectives

To investigate a novel methodology and explore whether artificially reducing the depth of penetration during intercourse matters to women.

Study Design and Methods

A study with a single-case experimental design ('*n* of 1'), in which a heterosexual couple act as their own control and the study is then replicated in subsequent couples, was conducted. Thirty-five couples were assessed for eligibility to participate. Twenty-nine couples without any sexual problems were randomized and 12 submitted sufficient data to analyse. As a proxy for reducing penis length, we artificially reduced the depth of penetration by using different sizes of silicone rings around the base of the man's erect penis. The main outcome measures were provided by the female partner on a scale of 0–100 and comprised: degree of (i) overall sexual pleasure; (ii) sexual pleasure from intercourse alone; and (iii) emotional connection to the male partner. The female partner was also asked before the experiment began to rate the degree of positive or negative change that would be personally meaningful for her.

Results

On average, reducing the depth of penetration led to a statistically significant 18% reduction of overall sexual pleasure with an average 15% reduction in length of the penis. The longer the erect penis, the less likely the rings were to have an impact on sexual pleasure. There was a range of individual responses, however, with a minority of women reporting that reducing the depth of penetration was more pleasurable on some occasions.

Conclusions

Size may matter in women in a healthy stable relationship when there is penile shortening. Because of the small number of couples and the inclusion of men with an apparently long penis, our results are preliminary, and we welcome replication in a larger sample with a more diverse range of penile lengths. Our results should not be misinterpreted as meaning that increasing penile length will increase sexual pleasure in women.

Keywords

penile size, sexual pleasure, Peyronie's, single case experimental design, penile shortening, penile length, sexual satisfaction, #Urology

Introduction

Men may worry or be ashamed about the length or girth of their penis. Surveys have found that many men desire a larger penis [1–3]. Of particular interest is that men seem to be more concerned about the size than are their female sexual

partners. For example, a survey of 52 031 heterosexual men and women found that 84% of women reported they were satisfied with their partner's penis size and 14% wanted it to be larger; however, 46% of men wanted their penis to be larger [4]. In three small surveys, 15–21% of women reported that the size of the penis was important during intercourse

[5–7]. Relevant studies of three-dimensional penis models have demonstrated that, aesthetically, women may prefer a slightly larger than average non-erect penis [8] and that penis size is used in combination with body shape and height to determine male sexual attractiveness [9].

Men who have a total prostatectomy [10], androgen suppression [11] or Peyronie's disease [12] may experience penile shortening. Men with Peyronie's disease may also undergo a surgical procedure that reduces the length of the penis [13]. By contrast, some men may develop a clinical preoccupation with and distress regarding their normal penis size, termed body dysmorphic disorder [14–16]. The most common situation is characterized by men who are anxious about their penis size but do not develop body dysmorphic disorder. As a consequence, men with body dysmorphic disorder or small penis anxiety seek help from internet sites that promote non-evidenced based penis enlargement 'solutions' such as, lotions, pills, exercises, or penile extenders [16]. Others might also seek help from private urologists or plastic surgeons, who offer hyaluronic acid or fat injections to increase the girth or suspensory ligament release for an illusory increase in the length of the penis. Cosmetic phalloplasty to enlarge the penis, however, is regarded as experimental, without any adequate outcome measures or evidence of safety [17]. It would therefore be of interest to know whether the length of the penis matters to female sexual partners as much as it does to men. There is, however, a lack of experimental research in regard to how the length of the penis might affect sexual pleasure for women during intercourse. We investigated this question empirically in a single-case experimental design. As a proxy for reducing penis length, we artificially reduced the depth of penetration by manipulating the size of silicone rings around the base of a man's erect penis. Our aim was to determine the feasibility and acceptability of the intervention and explore whether reducing the depth of penetration in couples with a stable relationship would lead to any significant loss of sexual pleasure or emotional closeness in the female partner. We started with the premise that size mostly does not matter to most women [4].

Method

Design

We used a single-case experimental design ('*n* of 1') to test an intervention in one couple and to provide evidence by replication in subsequent couples. In this design, the female partner acts as her own control between randomly allocated phases. These phases include a control phase (A) and three phases with different sizes of penile rings (Phase B, C and D), sitting at the base of the penis, that limit the depth of penetration. We followed the Single-Case Reporting Guideline In Behavioural Interventions (SCRIBE) [18].

Randomization

For each participant there was randomization (i) to the phase (the size of ring) and (ii) to the number of episodes of intercourse within a phase. Randomization was conducted by one of the authors, using a random number generator for both the number of episodes of intercourse (three, four or five) and the sequence of the rings. The male partner was informed by text, email or telephone (whichever was convenient) about which ring to use and the number of times it should be used. Randomisation was to one of the following phases. Participants were then re-randomised to a different phase until each of the 4 phases had been completed:

1. Phase A (control): a very thin, 0.5-cm (0.2") ring, with further randomization to either three, four or five episodes of intercourse. This was designed to not interfere with the depth of penetration but to still feel the same as the other rings.
2. Phase B: a 2.54-cm (1") ring, with further randomization to either three, four or five episodes of intercourse. This represented a 19.4% reduction in penis length from the population data-based mean of 13.1 cm [19].
3. Phase C: a 3.81-cm (1.5") ring, with further randomization to either three, four or five episodes of intercourse. This represents a 29% reduction in penis length [19].
4. Phase D: a 5.03-cm (2") ring, with further randomization to either three, four or five episodes of intercourse. This represents a 38% reduction in penis length [19].

Although, in real life, penile shortening may occur at 2–3 cm (Phase B), we wanted to test the methodology to the limit in Phase D to determine the depth of penetration that might matter to women.

Blinding

The male partner was blind to ratings made by the female partner. The female partner was asked to try to be blind to the size of ring used during intercourse.

Bias

Blinding was tested by asking if the female partner 'saw' the size of the ring being used and whether she could guess when a change in the size of the ring occurred. After the second episode of intercourse and thereafter, we asked her whether she believed there was a change in the depth of penetration by her partner compared to the previous episode of intercourse. We asked if she believed it was shallower, the same, or deeper. However, it was emphasized that the purpose of the experiment was not to get this correct. The randomization of the phase and number of episodes of intercourse within a phase meant there was less likelihood of guessing the size of the ring, and less interaction with moderators (e.g. menstrual cycle, use of alcohol, holiday or

life events randomly spread across phases). We also checked whether the female participant or her partner altered their normal sexual behaviour because of the experiment or because their partner was using a penile ring (0 = not at all to 4 extremely). This was also asked of the male partner to ensure consistency and validity of the answers provided.

Participants

Participants were recruited by an internal advertisement to staff and students at King's College London. Participants had to be heterosexual couples that were: (i) in a stable relationship (defined as 6 months or more) and (ii) having regular intercourse (defined as on average twice a week or more). The exclusion criteria included age <18 years and any current sexual dysfunction in either partner or worries about penis size. Men were screened with the International Index of Erectile Function Questionnaire and were required to score >25 [20], and women were screened with the Female Sexual Function Index [21] and were required to score >26.55 [22]. Additional exclusion criteria were: any current emotional disorder in either partner (screened in both partners using the Hospital Anxiety and Depression Questionnaire [23]; any significant disagreements on sexual issues or inability to discuss intimacy; and, in men, a micro-penis (defined as the bottom 2.5% of the population or a penis <6 cm when flaccid) [19].

Participant Characteristics

Thirty-five heterosexual couples, who were originally assessed for eligibility, were recruited between March 2017 and April 2019. Of these, 29 were randomized. Twelve couples submitted sufficient data for analysis (see Consort Diagram Fig. S1). The median interquartile range (IQR) age of the female partners was 26 (24, 26) years and for the male partners it was 26 (25, 28) years. All participants were heterosexual. Participants in the sample were classified as 81% White, 9% Asian, 9% Mixed and 1% Other. The sample comprised 51% students, and 46% employed and 3% unemployed participants. A total of 89% of the participants identified as single and 11% as married. The self-reported median (IQR) erect penis length of the male partners was 17 (18, 16) cm, which was on the 95th percentile according to the penis length nomogram [19]. This is clearly at the higher end of the nomogram, with the 50th percentile of the general population being at 13 cm [19]. Thus, in our sample, Ring B represents a 15% reduction in length compared to the control, Ring C a 23% reduction and Ring D a 30% reduction. The median (IQR) number of episodes of intercourse in the experiment was 16 (15, 17).

Context

The study was conducted wherever a couple made love.

Intervention

We used silicone penile 'ComeClose protector rings' (see Fig. 1). These were modified from the standard 2.54-cm (1") ring used therapeutically for women with dyspareunia (e.g. due to the man's penis making contact with the woman's cervix, or in women with post-surgical scars and/or adhesions caused by endometriosis). Couples were asked not to alter their normal lovemaking apart from limiting their use of the woman-on-top position (in both directions) if possible, to limit any likelihood of a penile fracture.

Procedure

After consent, couples were given instructions on how to measure the length and girth of the male partner's erect penis using standardized instructions of 'bone to tip' and a flexible tape measure as part of a sexual episode. Instructions were also provided when consent was obtained, and a YouTube video [24] highlighting the correct technique was provided. The girth of the penis determined the inner circumference of the rings provided (either 13.7, 14.2 or 15.8 cm). The penile rings were all 11.5 cm in diameter, with three different girth sizes (Fig. 1). Only the male partner was informed which depth of ring to use, and how often to use it. The male partner was asked as far as possible to hide from the female what ring was being used. However, if the women saw the ring, the data were not deemed to be nullified.

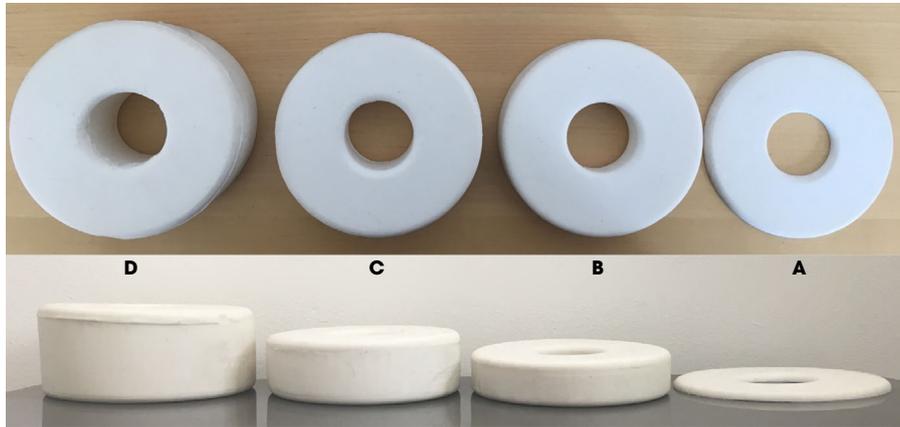
Measures

The study outcomes were determined by the female partner's ratings on a visual analogue scale, which was labelled 0–100, and were as listed below.

1. Degree of sexual pleasure overall. The woman was asked 'How much sexual pleasure did you experience overall (e.g. including foreplay, use of vibrator, intercourse etc.) on a scale between 0 and 100, where 0 is the least pleasure and 100 the most pleasure you have ever had.' She was asked to enter a whole number between 0 and 100.
2. Degree of sexual pleasure from intercourse alone. The woman was asked 'How much sexual pleasure did you experience from intercourse alone on a scale between 0 and 100, where 0 is the least pleasure and 100 the most pleasure you have ever had'.
3. Degree of emotional connection. The woman was asked 'How emotionally connected did you feel to your partner on a scale between 0 and 100, where 0 is the least emotional connection and 100 the most emotional connection you have ever had'.

Lastly, the female partner was asked to rate whether there was any discomfort or unwelcome symptoms. She was asked to rate these measures as soon as possible after intercourse

Fig. 1 Penile rings. Top picture shows a vertical view of the penile rings. The hole in the middle allows the erect penis to fit through. The bottom picture is a horizontal view of the penile rings. Rings are shown largest to smallest (left to right: D to A). The rings restrict penetration by 5.03 cm (2") for Phase D, 3.81 cm (1.5") for Phase C, 2.54 cm (1") for Phase B and 0.5 cm for Phase A (control), respectively.



(within 24 h). All participants were requested to enter their anonymized data directly into a web-based survey programme. Prior to the experiment, the female partner was asked to rate the degree of change (positive or negative) that would be significant for her in sexual pleasure, emotional connectedness and discomfort; for example, an increase or decrease of her rating from 65/100 to 45/100 would be a 20-point change. The male partner was asked to confirm the size of the ring he used and if there were any problems wearing the ring. We estimated that if each phase consisted of an average of four episodes of intercourse, then there would be a total of 16 episodes for the duration of the study.

Procedural Fidelity

It was not possible to evaluate the procedural fidelity or to observe whether the couple used the penile rings in the correct manner.

Analysis

Prior to starting the experiment, the female partner had determined the change that would be meaningful for her (either positive or negative) for each visual analogue scale (sexual pleasure overall, sexual pleasure from intercourse alone and emotional connection). Meaningfulness was determined by adding or subtracting the individual scores from the median of the control Phase (A). All data are graphed according to each couple and each of the phases is analysed visually, as is customary for single-case designs [25]. Visual inspection examines change graphed within and across phases, with attention to changes in level, variability and overlap between Phases A and B, C or D. We drew a line for the median of all the scores within each phase to assist the visual analysis. We counted the number of episodes showing a meaningfully positive, negative or neutral change in phases

B, C and D by comparing them to the median value of the control phase (for each phase separately, i.e. A/B, A/C and A/D) to find the difference between the two. Results were reported in percentages (Table 1). We did not compare B/D (which was the same reduction in depth of penetration) as our focus was on comparing a reduction against normal, and further analyses risked a Type 1 statistical error. To combine cases for overall estimates of the rings, we conducted hierarchical (mixed) linear modelling on the ratings [26,27] in order to determine if the differences in pleasure ratings shared variance according to phase or number of episodes of intercourse within a phase. This adjusts for random effects of participants and takes into account the individual as well as the overall effect. Penis length was used as a covariate for the model not including an interaction. We also fitted exploratory models with an interaction between penis length and ring size in which we estimated whether any impact of ring size was dependent on penis length. This was analysed with a likelihood ratio (chi-squared) test (as opposed to a regular chi-squared test for differences in proportions).

Ethics

The study was approved by the Psychiatry, Nursing and Midwifery Research Ethics Subcommittee of King's College London (Reference: HR-16/17-2018). There was no deviation from the study protocol. Enrolment occurred between March 2017 and April 2019. The trial was registered at ClinicalTrials.gov (NCT04052217). We had not registered the study before enrolment of participants as we had believed that we were conducting a study that was exploring a model of disease rather than a clinical intervention that would be of potential benefit. The authors confirm that all ongoing and related trials for this intervention will be registered prospectively.

Table 1 Number of episodes of intercourse showing either a meaningful positive or negative or a neutral change based on the difference between phases (Ring A/B, A/C and A/D) for all the domains (shown as a histogram in Figs S4–S6).

	Ring A/B (n = 43)			Ring A/C (n = 45)			Ring A/D (n = 39)		
	Negative, n (%)	Neutral, n (%)	Positive, n (%)	Negative, n (%)	Neutral, n (%)	Positive, n (%)	Negative, n (%)	Neutral, n (%)	Positive, n (%)
Sexual pleasure overall	12 (28)	30 (70)	1 (2)	20 (45)	24 (53)	1 (2)	19 (49)	19 (49)	1 (2)
Intercourse alone	14 (33)	22 (55)	7 (16)	19 (42)	20 (45)	6 (13)	26 (66)	10 (26)	3 (8)
Emotional connection	16 (37)	21 (49)	6 (14)	15 (33)	26 (58)	4 (9)	21 (54)	12 (31)	6 (15)

Results

Sequence

The demands of the experiment were a challenge to couples, with 19 out of 29 couples dropping out after consenting (see Consort diagram in Fig. S1). Ten couples were lost to follow-up despite several emails. There was no significant difference between the couples who participated and those who dropped out in terms of their age, scores on the International Index of Erectile Function, the Female Sexual Function Index or the Hospital Anxiety and Depression questionnaire, or frequency of intercourse. There was no difference in the girth of penis size between those who participated and those who dropped out, but those who dropped out had a longer penis size (median [IQR] length 17 (16, 18) cm vs 16 (15, 16) cm; $P = 0.004$).

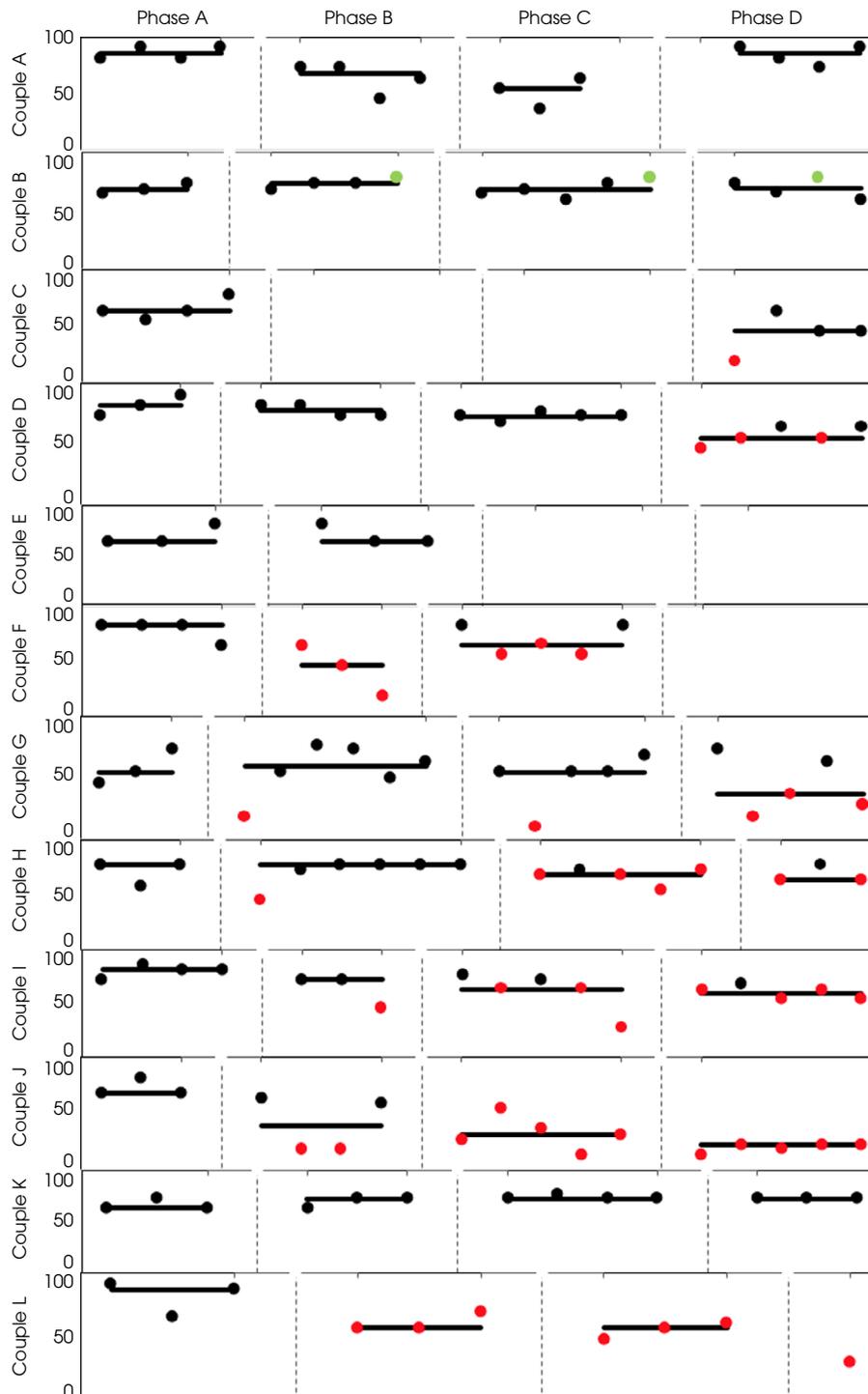
Of the couples that dropped out, two completed Phase A (control) and at least one other phase to compare against. One couple (L) completed only one episode of intercourse in Phase D. The actual order of phases for each couple is shown in Table S1. The median (IQR) number of days taken for each couple to complete the experiment was 183 (146, 247) and the median (IQR) number of episodes of intercourse was 17 (15, 17). Before the experiment began, the female partner had determined the importance of each domain (rated on a scale between 0 and 4) and the change that would be meaningful for her (either positive or negative) between 0 and 100 on the visual analogue scale. Table S2 shows the median ratings of the importance and personally meaningful change for each domain. There was no significant difference in the median for the personally meaningful positive or negative change for sexual pleasure overall, sexual pleasure from intercourse alone and emotional connection (Table S2).

Outcomes

As is customary in single-case experimental designs, the first step was visual analysis. Figure 2 shows that size impacted changes in some participants when considering sexual pleasure overall. For two participants (A, K), size did not matter. There was a significant negative step change for only the deeper rings in two participants (D, H), and consistent negative change in at least two rings in four participants (F, I, J, L). There was no clear pattern in three participants (B, C, G) and none with any consistent positive change with increasing ring size across all rings.

In Fig. S2, the size of the ring did not matter for sexual intercourse alone for two participants (B, E). There was a significant negative step change for only the deepest ring in two participants (C, D), and consistent negative change across all rings in four participants (A, F, I, J). There was no clear

Fig. 2 Visual analysis for sexual pleasure overall in the female partners, showing the median line (red dots represent a personally significant deterioration compared to Phase A; black dots represent no personally significant difference from normal; green dots represent a personally significant improvement).



pattern in four participants (G, H, L) and a consistent positive change across all rings in one participant (K).

The rings had the least impact on emotional closeness. Visual analysis of Fig. S3 reveals there was a significant negative step

change for the deepest ring in two participants (C, D), no persistent impact in three participants (B, F, L) and fairly consistent negative change across all rings in one participant (J), with no clear pattern in five participants (A, E, G, H, I)

and a fairly consistent positive change across all rings in one participant (K). The median values for each phase used for Figs 2, S2 and S3 are shown in Table S3.

Table S4 shows the actual difference in median scores between phases (A/B, A/C, A/D), which was used to determine a personally meaningful positive or negative change. This was then used to calculate the percentage of episodes of intercourse showing either a personally meaningful positive or negative change (see Table 1 and Figs S3–S5). This showed a trend for the number of negative experiences to increase for each increase in ring size. There was significant variation as, for example, restricting the depth of penetration by 2.54-cm (1"), comparing Phase A with B, showed that for pleasure from intercourse alone 33% of all episodes of intercourse were rated as significantly worse, 51% were rated as no different and 16% were rated as significantly more pleasurable (Table 1, Fig. S5)

Tables S5–S10 provided the predicted means and 95% CIs of the mean from the linear mixed modelling. For all the participants combined, there was a negative and statistically significant relationship between size of ring and sexual pleasure overall ($P < 0.001$ [Fig. 3]). Contrasts across adjacent levels were due to difference between Phase A and B (15-point reduction, 95% CI 7.9, 22). This represents an 18% reduction from the initial overall sexual pleasure with a 15% reduction in the length of the penis. Smaller differences between phases B and C and between phases C and D were not significant at this sample size.

The analysis was repeated with the penis length used as a covariate (15-point reduction, 95% CI 7.7, 21.0). There was a strong association between penis length and overall sexual pleasure. This was explored further by adding an interaction between penis length and ring size, with the caveat that the sample size was small to be considering interaction effects.

Fig. 3 Estimated marginal means (and 95% CI) for the effect of ring size on sexual pleasure overall (rated 0–100).

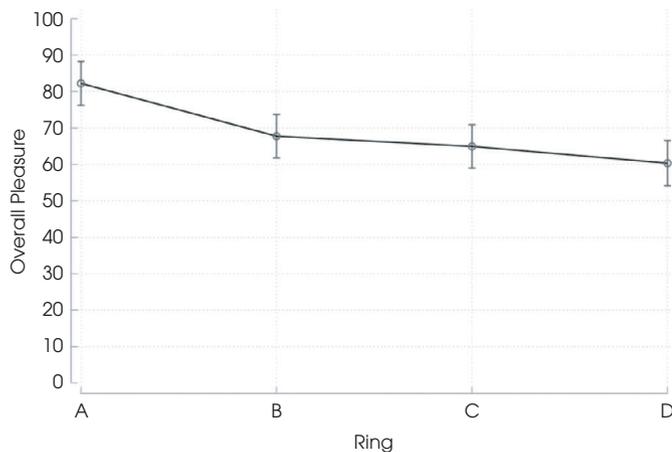


Figure 4 (data in Tables S5 and S8) shows that, for the control ring (Phase A), there was no relationship between sexual pleasure overall and penis size ($P > 0.05$). However, there was a strong relationship for Rings B, C and D in which the longer the penis, the less likely the rings were to have an impact on sexual pleasure overall, with each unit increase in penis length increasing pleasure ratings by 8.5–9 points ($P < 0.003$).

A similar pattern was shown for pleasure from sexual intercourse alone, although the association was slightly weaker, from 5.8 to 8.5 ($P = 0.06$ [Fig. S7 and Tables S6 and S9]). Another similar pattern is shown for emotional connection, with increases in length by each cm increasing emotional connection by 9–11 points ($P < 0.003$ [Fig. S8 and Tables S7 and S10]). In summary, the pattern of results was the same for all three outcomes. The longer the penis, the less impact of restricting the depth of penetration on sexual pleasure and emotional connection.

Bios

We tested blindness in the female partner and found that the number of times their prediction was correct or false did not significantly differ from chance (58%). However, in 40% of the episodes of intercourse, the female partner saw the size of the ring and this may have biased the ratings. In addition, it was reported that in 30% of the episodes, the male partner reported that they changed their behaviour either 'very much' or 'extremely' during intercourse because of the experiment.

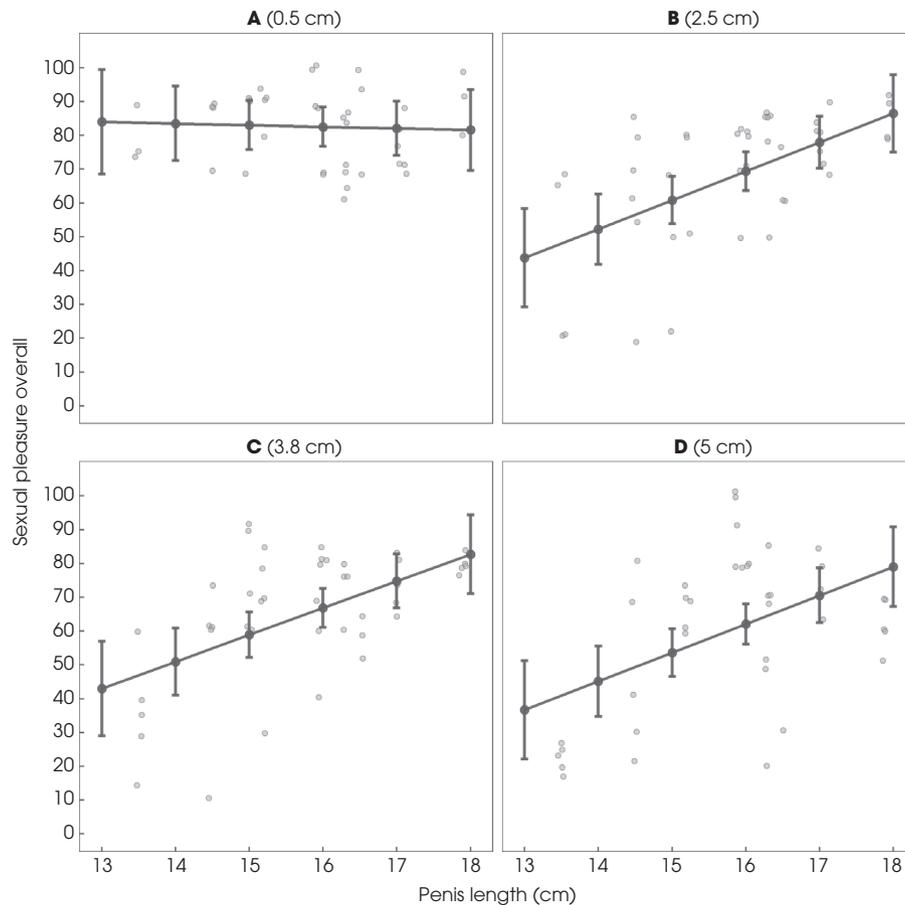
Adverse Events

Some minor adverse experiences were reported by the couples who did not drop out. Throughout the study, women felt minor discomfort in 5% of the episodes of intercourse in Phase A, in 11% of the episodes in Phase B, 4% in Phase C and 17% in Phase D. The main symptoms reported were in Phase D by three women (A, C, D). One reported some soreness and pain due to the penis ring rubbing against the pelvic bone, inner thighs and clitoris, one said there was less lubrication and one had slight discomfort as the ring caused the penis to enter at the wrong angle. There was no attrition in these couples, but there was a reduction in pleasure from intercourse alone.

Discussion

This is the first experimental study to investigate the functional effect of reducing depth of penetration in couples without any emotional or sexual problems. The study provides proof of concept for a novel methodology for investigation of penile shortening. The penile rings were acceptable except the largest, Ring D, was causing minor side effects in three women. There were 10 dropouts where we

Fig. 4 Estimated marginal means (and 95% CI) for the effect of the interaction between penis length and ring size on sexual pleasure overall (rated 0–100).



could not obtain information on the reasons for discontinuing. It is possible that some decided not to participate after being sent the rings. Nine discontinued the intervention for various reasons that were unrelated to the experiment (e.g. pregnancy, need for surgery). No reason was given in two couples. It is possible that participating in the experiment contributed to discontinuing the experiment. Only two couples stated that the experiment interrupted their sexual life. Future studies should show a prospective couple the rings at consent and explore any obstacles before randomization.

We started with the premise that depth of penetration would not matter to most women. However, we found in our participants that reducing the depth of penetration by an average 15% with Ring B (2.54-cm [1"] reduction) led to an 18% reduction of overall sexual pleasure. Furthermore, the longer the penis, the less the rings had an impact. Length may therefore matter *on average* if there is penile shortening. Our male participants reported that they were on the 95th percentile on the nomogram. If this is true, then size may matter more if penile shortening occurs in men who have a

smaller size on the nomogram. There is some indication of this in Fig. 4 as the longer the penis, the less impact of restricting the depth of penetration on sexual pleasure overall.

The results should not be misinterpreted as meaning that increasing penile length will increase sexual pleasure in female partners. They are also not generalizable to men who are not in a sexual relationship and fear being rejected as there are other determinants in such scenarios other than penis length. Similar findings were found for sexual intercourse alone, with a greater diversity of individual responses compared to sexual pleasure overall. The association with penis length had less of an impact on ratings for 'sexual intercourse alone' than 'sexual pleasure overall' or 'emotional connection'. However, all three dimensions are in the same direction. The dimension of 'Sexual intercourse alone' may be a slightly weaker association as there was more diversity of individual responses for a positive and negative impact. For example, 16% of episodes were rated as having a positive impact for Rings A/B compared to 2% of episodes for 'sexual pleasure overall'. This was also the case for Rings A/D, where 66% of episodes had a negative impact for 'sexual

intercourse alone' compared to 49% in 'sexual pleasure overall'. Of note is that none of the women had dyspareunia (which is a clinical indication for the penile rings). Future studies require a qualitative component to capture the women's reflections on why reducing the depth of penetration increased sexual satisfaction and whether this was stimulating a different location in the vagina. In many ways, capturing this diversity is a strength of a single-case experimental study, which is designed to answer a different research question for a within-subject comparison ('Is this intervention better than a control intervention for this person?') which can then be replicated across similar cases. This is in contrast to a randomized controlled trial for a between-group design ('Is this intervention better *on average* in this group than a comparison in a control group?').

A strength of the present study is that we have demonstrated proof of concept for investigating whether depth of penetration is important for sexual pleasure in sexually active couples. This is relevant to men who experience penile shortening. The single-case experimental design, where a participant is their own control, is the greatest strength of the study which highlights that sometimes reducing the depth of penetration led to enhanced sexual pleasure. However, the study needs to be replicated with various improvements, for example, increasing the number of participants and with greater variation in penile length. This would allow us to be more confident about generalizing the results to other couples. We had 10 dropouts, where it was not possible to determine the reasons for dropping out or whether this dropout rate could be reduced in future studies. There were no differences in the dropouts other than they had longer penile length which meant that our participants were more representative and that it is difficult to interpret the self-measurements.

We acknowledge that sexual pleasure may depend on different variables and contexts. Investigators in future studies might wish to involve participants in the design before the study commences. We report that, on average, reducing the depth of penetration made a statistically significant 18% reduction in the subjective ratings of overall sexual pleasure, associated with an average 15% perceived reduction in penis length. These figures are accurate based on the relative change in ratings provided by participants, but what is experienced as pleasure and its intensity will of course vary from person to person and is not quantified in any absolute or universal sense.

Ideally, a single-case experimental design requires a slightly larger number of observations within each phase and repeating of the phases to improve the internal validity of the experiment. This would reduce the potential risk of other variables significantly influencing each episode of intercourse. However, there was no significant variability in the data

within each phase. The study was a challenge to our participants and a greater number of episodes of intercourse would probably have led to increased dropouts. It would also be impossible to standardize the context for each episode of intercourse (for example, only on a lazy Sunday afternoon after a nice meal) and would be unnecessary if there are more measures within each phase. Our study focused on altering the depth of penetration, whereas girth may be more relevant for some women [6]. However, we could not find a technical solution to reducing the girth of an erect penis. Furthermore, penile shortening in Peyronie's disease or surgical procedures affects length rather than girth. However, it might be possible to replicate the study with different sizes of a penile sleeve to enhance either the length or girth. We were focused on the function of the erect penis rather than aesthetics of the non-erect penis, which could be partly used by some women to judge a new partner according to what they perceive as healthy and attractive [28]. We included couples who were in secure and stable relationships and this may have influenced the results. The results may have been different for couples in a new relationship. Our participants may have been used to being sexually active in a particular way. The addition of a penile ring may have changed the pattern of intercourse and sexual pleasure either in a negative way if it was stressful or in more positive way if they were open to novelty. However, in a single-case experimental design there is always a control phase to compare the intervention against.

There was an assumption of no carry-over effect from one phase to another. However, it is possible that there was some autocorrelation from one phase to another (that is statistical dependency, whereby scores on timepoint at $t + 1$ depend partially on scores at time t). In addition, increasing the number of episodes of intercourse within each phase could have led to improvements in sexual pleasure.

There was potential bias in the ratings of pleasure. The blinding was partially successful as it was not possible to prevent the female seeing the size of the penile ring in 40% of the episodes of intercourse. The measurements of penis size were self-reported, and these are likely to be biased towards overestimation. This may have been biased across all participants so that the analysis of the impact of restricting the depth of penetration by penis length on sexual pleasure still stands.

Submission of these data was by both men and women, and future studies could be better controlled by asking the female partners to measure and submit the data on erect penis length while using a penile ring. Other reasons for the bias could be measurement error or a self-selection bias for men who had a larger than average penis size. Measurement errors have been previously found even between clinicians who have received training for such procedures [29], suggesting that this would be the most plausible explanation

for the size overestimation. This limited our analysis as we were unable to determine the effect of a very limited depth of penetration with a full range of penis sizes. We depended on those who volunteered for the study and our sample may not be representative of the general population. Those who volunteered may have been more self-confident. A study reducing penile length might affect their confidence or penile hardness during sexual intercourse and thus might influence the performance, which can influence the sexual pleasure of their partner. Future studies should systematically enquire whether a ring reduced penile hardness or confidence in the men as this may have had an impact on the ratings of female sexual pleasure. We also did not measure the frequency of orgasm in our study. This may be a moderator in female sexual satisfaction, and this should be added in future studies.

Despite the narrow range of size in men and small sample size, we were able to demonstrate an association between the length of the penis as a moderator and effect on sexual pleasure. Restricting the depth of penetration by 2.54 cm (1"), on average, led to reduced pleasure but further restriction in depth of penetration did not lead to a significant further loss of pleasure. This may be a Type 2 error, and increasing the number of couples and observations may have led to significant differences between Phases B, C and D.

Our primary aim in this first study was to maximize blinding, and in a pilot, we found that no ring was more likely to be guessed correctly than the presence of a silicone ring. We therefore used a very thin silicone ring that would not interfere in the depth of penetration. However, we do not know whether the control penile ring was interfering in the ratings and replication would benefit from a phase without a ring. Future studies may better focus on rings that limit the depth by 1.27 cm (0.5") and 2.54 cm (1"; Phase B in this study) as this is more consistent with real-life shortening, and the smaller rings may be less likely to cause discomfort or a change in behaviour. Another improvement will be a more representative range of penis sizes.

Our results suggest that, on average, the effect of restricting the depth of penetration was relevant for men even at the top of the range of penile length. Replication of the study will need a more diverse range of penile lengths, including those in the lower quartile. However, the effect is likely to be more pronounced in men in the lower range and this would strengthen the conclusions. We did not ask about the effect on sexual pleasure in the men in reducing their depth of penetration and how this altered their self-confidence and behaviour, and this may be important in replication of the study. The study was also conducted in heterosexual partners and would require replication in homosexual partners.

Lastly, a congenital micro-penis, is defined anatomically as beyond two standard deviations below the mean (13.1 cm),

which is <6 cm in flaccid length [19,30]. The methodology described may be important in future studies to help define a micro-penis in functional terms. For example, at what length does a reduction in depth of penetration lead to meaningful reduction in sexual pleasure in most women?

In conclusion, based on experimentally reducing depth of penetration, our results are consistent with the experience that size may matter for sexual pleasure in some women in a healthy relationship when there is penile shortening. The caveat is that our sample appeared to comprise men with a long penis and analysis suggests the longer the penis, the less impact of restricting the depth of penetration on sexual pleasure.

In a minority of women, shortening may increase sexual pleasure. On average there is a significant reduction in sexual pleasure with reduced depth of penetration which is moderated by the penis length. Our results should not be misinterpreted as meaning that increasing penile length in a normal man will increase sexual pleasure in his female partner. Finally, single-case experimental designs are under-utilized in medical and psychological research and can make a significant contribution to the research cycle.

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Disclosure of Interests

The researchers purchased the penile rings from Yorlon Ltd. Ms Melissa Foks had an interest in Yorlon Ltd, which no longer exists. All other authors have nothing to disclose.

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Abbreviations: IQR, interquartile range.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Fig. S1. Consort diagram for flow of recruitment.

Fig. S2. Visual analysis for sexual pleasure from intercourse alone in the female partners showing the median line (red dots represent a personally meaningful deterioration compared to Phase A).

Fig. S3. Visual analysis for emotional connection in the female partners with a median line.

Fig. S4. Histogram of the number of episodes showing either a personally meaningful positive, neutral or negative change for sexual pleasure overall between phases (A/B, A/C, A/D).

Fig. S5. Histogram of the number of episodes showing either a personally meaningful positive, neutral or negative change for sexual pleasure from intercourse alone between phases (A/B, A/C, A/D).

Fig. S6. Histogram of the number of episodes showing either a personally meaningful positive, neutral or negative change for emotional connection between phases (A/B, A/C, A/D).

Fig. S7. Figure 4. Estimated marginal means (and 95% CI) for the effect of the interaction between penis length and ring type on sexual pleasure from intercourse alone (rated 0–100).

Fig. S8. Estimated marginal means (and 95% CI) for the effect of the interaction between penis length and ring type on emotional connection (rated 0–100).

Table S1. Order of randomization for each couple and the number of episodes of intercourse for each ring.

Table S2. Median self-reported ratings of the importance and personally meaningful change for each domain.

Table S3. Median values for each phase (Ring A, B, C and D) and domain (i) sexual pleasure overall, (ii) sexual pleasure from intercourse alone and (iii) emotional connection) with the positive and negative change reported as significant by the female partners (*personally significant negative changes, +personally significant positive changes; shown in Figs S2–S4).

Table S4. Difference in median scores between phases (Ring A/B, A/C and A/D) and domain (i) sexual pleasure overall,

(ii) sexual pleasure from intercourse alone and (iii) emotional connection alongside the positive and negative change reported as significant by the female partners (*personally significant negative changes, +personally significant positive changes; Fig. S6–S8).

Table S5. Comparison of association of sexual pleasure overall and penis length (i.e. slope of relationship) at each ring size (see Fig. 3).

Table S6. Comparison of association of pleasure from intercourse alone and penis length (i.e. slope of relationship) at each ring size.

Table S7. Comparison of association of emotional connection and penis length (i.e. slope of relationship) at each ring size.

Table S8. Comparison of sexual pleasure overall slopes against each other to examine the interaction between ring size and penis length (see Fig. 4).

Table S9. Comparison of pleasure from intercourse alone slopes against each other to examine the interaction between ring size and penis length (see Fig. S7).

Table S10. Comparison of emotional connection slopes against each other to examine the interaction between ring size and penis length (see Fig. 8).