Evaluation of patient compliance with the use of scrotal cooling devices

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Objective: To evaluate the compliance of infertile men with the use of scrotal cooling devices. As a secondary objective, sperm parameters, deoxyribonucleic acid fragmentation, and hormone profiles were examined.
Design: This exploratory study on scrotal cooling provided scrotal cooling devices to men with primary infertility and abnormal semen parameters. Feedback on the devices after their use was gathered in the form of a questionnaire, and semen parameters were examined after device use.
Setting: Single center infertility clinic in Toronto, Ontario, Canada.
Patient(s): Patients with primary infertility and abnormal semen parameters were prospectively evaluated before and after scrotal cooling.
Intervention(s): One of two scrotal cooling devices (Underdog or Snowballs) was used, on the basis of patient preference.
Main Outcome Measure(s): Questionnaires were completed by patients on compliance with device use and concerns about and recommendations for improving the cooling devices. Baseline deoxyribonucleic acid fragmentation index, sperm parameters, and hormones were measured at the initial visit (t = 0) and at subsequent visits (t = 4–12 weeks). Statistical comparison of values before and after scrotal cooling was performed.
Result(s): Forty patients were enrolled in the study, and the questionnaire was completed by 65.0% (n = 26). Most respondents (76.9%) used scrotal cooling less than the recommended duration. Respondents believed that the devices were uncomfortable (31.5%), impeded work (21.0%), and lost cooling rapidly (14.3%). Significant increases in sperm motility and vitality (from 25.4 % to 29.0% and from 64.8% to 71.7%, respectively) were demonstrated after scrotal cooling.
Conclusion(s): Most patients were not compliant with the recommended use of the scrotal cooling devices because of issues of comfort, convenience, and concealability. Further work on improving scrotal cooling devices is necessary to enhance their potential as a therapeutic tool for men with abnormal sperm parameters and infertility. (Fertil Steril Rep® 2021;2:289–95. ©2021 by American Society for Reproductive Medicine.)
Key Words: Compliance, male infertility, scrotal cooling, sperm parameters

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Chronic testicular hyperthermia from conditions like cryptorchidism and varicocele has been shown to exert deleterious effects on spermatogenesis in humans and animals (1–3). To support effective sperm production, the testicles in humans require an environment that is 2°C to 4°C cooler than their core temperature (4). An acute and transient rise in scrotal temperature ranging from 0.5°C to 2.2°C has been demonstrated to induce impaired spermatogenesis (5, 6). In fact, lower spermatozoa production, higher degree of deoxyribonucleic acid (DNA) damage, reduction in sperm concentration, reduced progressive motility, and ultimately a reduction in the number of viable pregnancies have been identified in adult mice subjected to scrotal heating (7). An example of a cause of elevations in testicular temperature and infertility is varicoceles, and if varicoceles are surgically corrected, it has been shown to reduce the testicular temperature and improve fertility (3, 8, 9).

Few studies have evaluated the effects of extrinsic scrotal cooling in improving semen parameters and enhancing the potential for fertility (Supplemental Table 1, available

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online) (10–17). Devices for scrotal cooling could conceptually be used to treat conditions associated with chronic elevations in scrotal temperature (like varicoceles) or lower the scrotal temperature in men with normal temperatures. To this day, the optimum scrotal temperature to support spermatogenesis is unknown in humans. The first study on the use of extrinsic devices for scrotal cooling was reported in the *Journal of the American Medical Association* in 1968 and involved 5 normospermic and 7 oligospermic patients who received scrotal cooling for 30 minutes a day for a period of two weeks (10). The mean testicular cooling was 6.9°C. The results revealed a significant increase in sperm count after five weeks for normospermic patients. In addition, the oligospermic group had a rise in sperm count after two weeks (10). Since then, there have been eight reported studies on scrotal cooling in men with abnormal semen parameters; all of these demonstrated improvements in sperm counts but only a limited number of studies conducted statistical analyses (10–17). These eight studies were summarized in a 2013 systematic review (18).

Presently, we have identified several retail products that are purported to treat male infertility by lowering the scrotal temperature. Current products for scrotal cooling include cooling patches (FertilMate), cooling underwear (Snowballs), cooling bolstering supports (Underdog), air stream (Ubreeze), and a topical cooling device (CoolMen) (Fig. 1). There were no publications that we were able to find to support the use of the presently available commercial cooling devices. Of these devices, only two, Snowballs and Underdog, are reusable, commercially available in North America, and portable (no plug-in required). More details of these devices can be found in Supplemental Table 2.

External cooling devices, which should be safe and relatively inexpensive to use, are currently not extensively studied and used for men with infertility. One of the primary issues is whether most infertile men would actually consistently use the existing devices. There are no present studies published on the compliance with the use of the scrotal cooling devices.

To build a foundation for further research on scrotal cooling, we believed that it was essential to investigate whether or not these devices were feasible for consistent patient use. The objective of our study was to determine the compliance specifically among men with infertility. As a secondary outcome, we examined the effects of scrotal cooling on the semen quality in men referred to our center for primary infertility.

MATERIALS AND METHODS

Study Population

This was a prospective cohort study on men presenting with infertility and abnormal semen parameters to our male infertility clinic at Mount Sinai Hospital from January 1, 2019, to December 31, 2019. Men with infertility (defined as more than one year of unprotected sex without a conception) and with any abnormal semen parameter (as per World Health Organization 2010 reference values [19]) were offered the use of a scrotal cooling device . The abnormal semen parameters included abnormal concentration, count, motility, progressive motility, morphology, and vitality. Patients with obstructive azoospermia were excluded from the study.

Study Design

Eligible and consented patients were advised to select, on the basis of their lifestyles, one of the two scrotal cooling devices described next. In this study, the devices were provided to the patients free of charge. Recommendations were made to use the scrotal cooling a minimum of two hours daily for up to three months. Instructions on how to properly cool the device before use as well as how to position the device for maximal efficiency were provided.

Snowballs. Snowballs provides boxer briefs with slits for placement of gel devices known as SnowWedges. The SnowWedges are placed in the freezer for approximately an hour and then placed in the boxer slits. They are advertised to provide cooling for up to 30 minutes (Fig. 1E and F). This device is available from https://www.snowballsunderwear.com/.

Underdog. Underdog is a device with a wedge-shaped ice pack with insulation to deliver cooling and allows for use while driving or sitting. Each ice pack takes 2–3 hours to freeze and is advertised to last 3–4 hours once frozen (Fig. 1G and H). This device is available from https://underdogfertility.com/.

Outcome Assessment

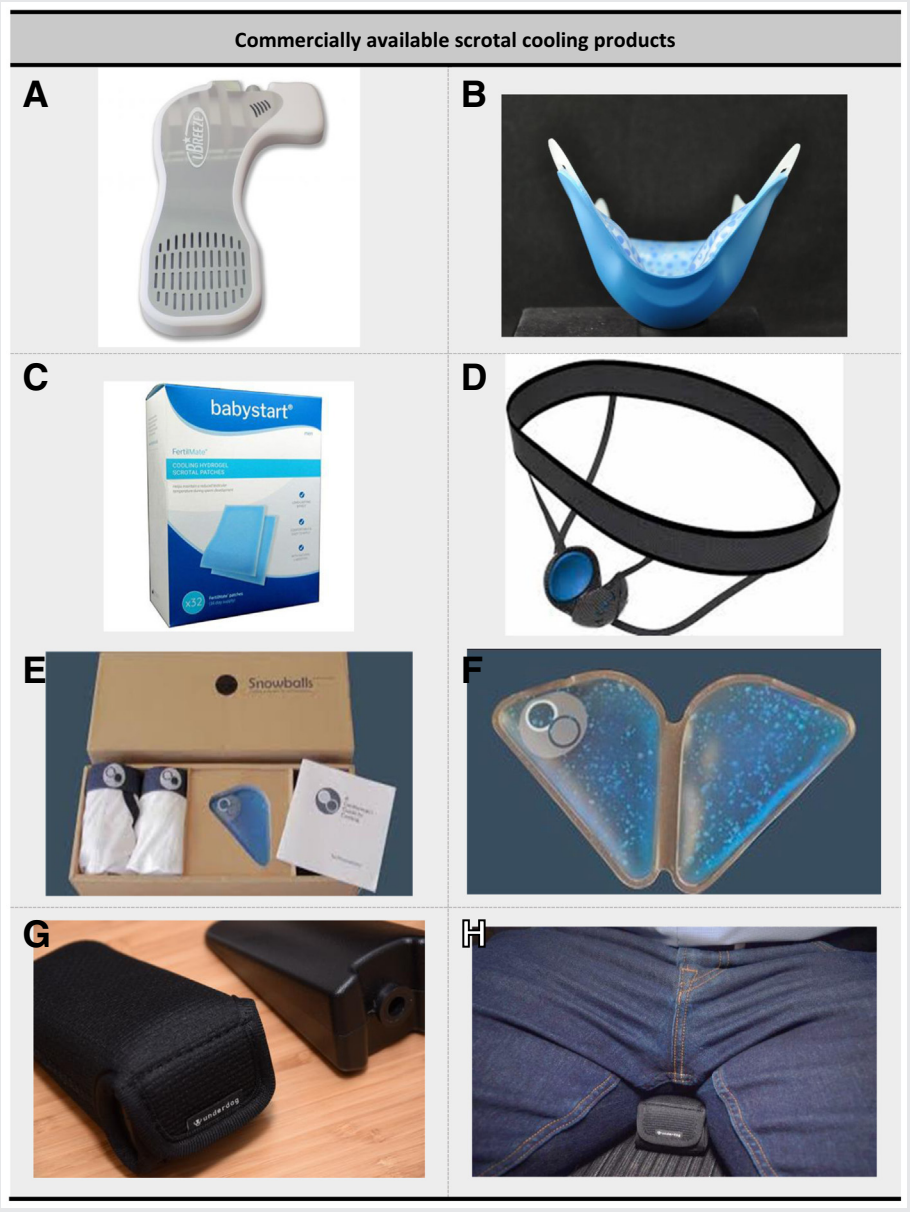
Compliance with device use. Paper-based questionnaires were completed by the patients to obtain information on the frequency and duration of device use (duration of each session the device was used and the number of months the patients used the device), the ease of use of the device, difficulties encountered using the device, and suggestions to improve the device (Table 1).

Secondary objective. Semen parameters (using World Health Organization standard testing), DNA fragmentation index (DFI using the sperm chromatin structure assay with flow cytometry), and hormone analyses (total testosterone, follicle-stimulating hormone, and luteinizing hormone) (samples drawn in the morning) were obtained before the use of the cooling devices and after 2–3 months of scrotal cooling (19, 20). All patients in this study were encouraged to use a fertility multivitamin such as FertilPro Men (YAD-TECH, Montreal, Canada). The use of such vitamin supplementation is standard in our fertility clinics. This study was a research ethics board-approved study.

Statistical Analysis

Compliance with and comments about the device use were reported using descriptive statistics only. The DFI, semen parameters, and hormonal markers before and after scrotal cooling were compared using paired t tests. If a patient returned on multiple occasions after the onset of scrotal cooling and was still using his device, the averages of all of the after scrotal cooling semen parameters and hormone values were calculated and compared with the before scrotal cooling values. Statistical significance was considered at $P < .05$.

FIGURE 1



Images of commercially available scrotal cooling devices. (**A**) U Breeze, (**B**) Epiditi cooling cup, (**C**) FertilSmart cooling patch, (**D**) CoolMen, (**E** to **F**) Snowballs underwear—we used this cooling device for half of our cohort, and (**G** to **H**) Underdog cooling device—we used this cooling device for the other half of our cohort.

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This was an exploratory study and no power calculations were performed. The analysis was performed using SPSS Software (SPSS Statistics version 27 for Windows, IBM Corporation, Armonk, NY).

RESULTS

Questionnaire

Our study assessed 40 men aged 18–48 years (mean age ± SD 37.1 ± 6.8 years) with primary infertility. A total of 65% (26/40) completed the questionnaire during the first attended follow-up appointment (Table 1). The results of this questionnaire are available in Table 2. Of the patients who completed the questionnaire, 12 used the Snowballs device and 14 used the Underdog device. Among the respondents, only 26.9% (7/26) of the patients used the device daily. In fact, 30.8% (8/26) used the device two days or less per week. In terms of minutes/hours per session, the most chosen answer was 30–60 minutes per session (34.6%). The duration of time ranged between 30 minutes and greater than four hours,

TABLE 1

The questionnaire provided to the patients.

Question no.	Questions	Answers
1 (a)	How often did you use your device?	a) Daily b) 5 days/week c) 3–4 days/week d) 1–2 days/week e) Rarely
1 (b)	During a day, how long did you use your device?	a) <30 minutes b) 30–60 minutes c) 1–2 hours d) 2–4 hours e) >4 hours
1 (c)	How many weeks did you use your cooling device for?	a) <4 weeks b) 4–12 weeks c) >12 weeks d) No response
2	How easy was it to use your cooling device?	a) Not easy b) Relatively easy c) Very easy d) No response
3	What bothered you about your cooling device, if anything?	Free Text
4	How would you improve the cooling device?	Free Text

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with the latter occurring in only two patients. Of the 21 patients who answered the question, 12/21 (57.1%) found the devices to be very easy to use and the remaining 9/21 patients suggested the devices were relatively easy to use. For the ease of use of the devices, among the 19 patients who answered the question, the most common written response was that the devices were uncomfortable (31.6%). The second most written response was that the cooling devices were not "work-friendly" (21.1%). The third most common answer was matched between "hindrance of privacy" (15.8%) and the rapid loss of optimal cooling with the devices (15.8%). The most common suggestions for improving the devices from 13 respondents were to make the cooling devices more comfortable (38.5%) and to sustain a longer and more consistent cooling effect (30.7%).

Semen Parameters

A total of 22 patients completed a semen analysis at baseline, at 4 weeks, and between 4 and 12 weeks. Sperm motility demonstrated a statistically significant increase after a short 4–12-week trial of scrotal cooling (Table 3). The percentage of motile sperm rose from a mean (±SD) of 25.39% (±20.39%) before cooling to 31.24% (±20.32%) ($P = .017$) after approximately four weeks of cooling. This was sustained in the 4–12-week period of repeated measurements; 25.39% (±20.39%) before cooling vs. 29.00% (±15.95%) ($P = .009$). The mean progressive motility increased from 14.46% (±10.64%) before cooling to 23.01% (± 18.01%) ($P = .154$) at approximately four weeks, but this change did not achieve statistical significance. The mean (±SD) sperm concentration increased from 12.12 × 10^6/mL (±19.26 × 10^6/mL) before cooling to 16.14 × 10^6/mL (±27.01 × 10^6/mL) at approximately four weeks ($P = .363$), but this change did not reach statistical significance. The mean semen volume was not affected by scrotal cooling; 3.62 mL (±3.32 mL) before cooling vs. 3.46 mL (±2.13 mL) at approximately four weeks ($P = .941$).

Vitality and DNA Fragmentation Index

The vitality was found to reach a statistically significant increase when comparing the before and after values. The mean vitality before scrotal cooling was 64.80% (±18.52%) and 70.87% (±14.78%) after approximately 4 weeks ($P = .045$). The mean DFI decreased from 23.50% (±14.40%) before cooling to 17.68% (±14.72%) after 4–12 weeks ($P = .679$), but only 11 patients had the two DFI tests performed.

Hormone Profile

We measured hormone profiles before and after scrotal cooling; 10 patients completed two sets of hormone data. Paired *t* tests showed no statistically significant change in levels of follicle-stimulating hormone ($P = .542$), luteinizing hormone ($P = .999$), total testosterone ($P = .431$), or estradiol ($P = .862$). The prolactin level was statistically significantly lower after cooling: 9.21 ng/mL (±3.41 mL) before vs. 12.45 ng/mL (±3.65 ng/mL) after approximately 4 weeks ($P = .035$).

DISCUSSION

In our study, we found that most patients (approximately 77%) were not compliant with the recommended duration and consistency of use of scrotal cooling despite being specifically provided with information on how to use the devices. Only seven of the patients in the study used the scrotal cooling devices on a daily basis. The reasons for the low compliance with the device usage described by our patients in the questionnaire included discomfort using the device, privacy issues, that the devices were not "work-friendly", and that they only cooled the scrotum for a short period of time. Although we did document improvements in semen parameters with the use of the cooling device, this study was not primarily designed to identify changes in semen parameters with the cooling devices. These improvements occurred despite a poor overall compliance with the use of the devices.

There was a series of studies that suggested that application of cooling devices to the scrotum had a positive impact on semen parameters (10–17). Potentially, the cooling devices could be counteracting the effects of chronic heat stress on the testis, or perhaps a lower-than-normal temperature is more supportive of spermatogenesis. Chronic scrotal heat stress, such as in varicoceles, has in addition been associated with sperm damage, putatively by increasing reactive oxygen species (ROS) and decreasing protective heat shock proteins (21–23). The disproportionately elevated levels of ROS then increase markers of inflammation and promote a state of apoptosis within developing germ cells, testicular tissue, and ejaculated spermatozoa (24). This state of "oxidative stress" perpetuates itself as the ROS can then affect nearby normal spermatozoa, furthering sperm DNA damage (25, 26). To counter these changes seen with scrotal

TABLE 2

The questionnaire results.

Question	Snowballs (12 patients) No. (%)	Underdog (14 patients) No. (%)	Total (26 patients) No. (%)
1. (a) How often did you use your device?	Daily: 3 (25%) 5–6 days/week: 4 (33.3%) 3–4 days/week: 2 (16.7%) 1–2 days/week: 2 (16.7%) No response: 1 (8.3%)	Daily: 4 (28.6%) 5–6 days/week: 2 (14.3%) 3–4 days/week: 0 (0%) 1–2 days/week: 6 (42.9%) No response: 2 (14.3%)	Daily: 7 (26.9%) 5–6 days/week: 6 (23.1%) 3–4 days/week: 2 (7.7%) 1–2 days/week: 8 (30.8%) No response: 3 (11.5%)
1. (b) During a day, how long did you use your device?	<30 Minutes: 0 (0%) 30–60 Minutes: 5 (41.7%) 1–2 Hours: 5 (41.7%) 2–4 Hours: 1 (8.3%) >4 Hours: 0 (0%) No response: 1 (8.3%)	<30 Minutes: 0 (0%) 30–60 Minutes: 4 (28.6%) 1–2 Hours: 0 (0%) 2–4 Hours: 3 (21.4%) >4 Hours: 2 (14.3%) No response: 5 (35.7%)	<30 Minutes: 0 (0%) 30–60 Minutes: 9 (34.6%) 1–2 Hours: 5 (19.2%) 2–4 Hours: 4 (15.4%) >4 Hours: 2 (7.7%) No response: 6 (23.1%)
1. (c) How many weeks did you use your cooling device for?	<4 weeks: 0 (0%) 4–12 weeks: 10 (83.3%) >12 Weeks: 1 (8.3%) No response: 1 (8.3%)	<4 weeks: 0 (0%) 4–12 weeks: 1 (7.14%) >12 Weeks: 9 (64.3%) No response: 4 (28.6%)	<4 weeks: 0 (0%) 4–12 weeks: 11 (42.3%) >12 Weeks: 10 (38.5%) No response: 5 (19.2%)
2. How easy was it to use your cooling device?	Not easy: 0 (0%) Relatively easy: 7 (58.3%) Very easy: 4 (33.3%) No response: 1 (8.3%)	Not easy: 0 (0%) Relatively easy: 2 (14.3%) Very easy: 8 (57.1%) No response: 4 (28.6%)	Not easy: 0 (0%) Relatively easy: 9 (34.6%) Very easy: 12 (46.2%) No response: 5 (19.2%)
3. What bothered you about your cooling device, if anything?	Uncomfortable: 4 (33.3%) Not "Work-friendly": 2 (16.7%) Lacked privacy: 2 (16.7%) Loss of cooling: 2 (16.7%) Other: 1 (8.3%) No answer: 1 (8.3%)	Uncomfortable: 2 (14.3%) Not "Work-friendly": 2 (14.3%) Lacked privacy: 1 (7.14%) Loss of cooling: 1 (7.14%) Other: 2 (14.3%) No answer: 6 (42.9%)	Uncomfortable: 6 (23.1%) Not "Work-friendly": 4 (15.4%) Lacked privacy: 3 (11.5%) Loss of cooling: 3 (11.5%) Other: 3 (11.5%) No answer: 7 (26.9%)
4. How would you improve the cooling device?	Improve device comfort: 4 (33.3%) Improve device cooling: 2 (16.7%) Other: 3 (25.0%) No answer: 3 (25.0%)	Improve device comfort: 1 (7.14%) Improve device cooling: 2 (14.3%) Other: 1 (7.14%) No answer: 10 (71.4%)	Improve device comfort: 5 (19.2%) Improve device cooling: 4 (15.4%) Other: 4 (15.4%) No answer: 13 (50.0%)

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TABLE 3

Descriptive means, medians, and *P* values for semen parameters, DNA, and hormone profile.

Semen parameters	Before cooling value Mean	Before cooling value SD	First after cooling value (approx. 4 weeks) Mean	First after cooling value (approx. 4 weeks) SD	Average after cooling values (4–12 weeks) Mean	Average after cooling values (4–12 weeks) SD	First after cooling (*P* value) Sig. ($P<0.05$)	Average after cooling (*P* value) Sig. ($P<0.05$)
Volume (mL)	3.62	3.32	3.46	2.13	3.55	1.57	.941	.801
Concentration ($\times 10^6$/mL)	12.12	19.26	16.14	27.01	15.60	23.72	.363	.395
Count ($\times 10^6$/ejaculate)	38.88	25.7	40.21	50.47	44.05	60.93	.341	.352
Motility (%)	25.39	20.39	31.24	20.32	29.00	15.95	.017[a]	.009[a]
Progressive motility (%)	14.46	10.64	23.01	18.01	21.35	13.93	.154	.168
Morphology (%)	2.09	2.36	2.80	3.54	2.72	3.34	.157	.266
Teratospermia Index	2.28	0.34	2.26	0.27	2.27	0.22	.989	.741
Vitality (% alive)	64.80	18.52	70.87	14.78	71.67	14.62	.045[a]	.032[a]
DNA profile								
Fragmentation index (%)	23.50	14.40	16.99	14.93	17.68	14.72	.679	.945
Hormone profile								
FSH (IU/mL)	7.36	5.56	5.93	3.96			.542	
LH (IU/L)	6.32	2.59	6.00	2.67			.999	
Total testosterone (nmol/L)	14.53	8.44	17.11	8.11			.431	
SHBG (nmol/L)	34.58	17.37	38.50	27.11			Not done	
Estradiol (pg/mL)	109.96	43.24	133.92	64.32			.862	
Prolactin (ng/mL)	9.21	3.41	12.45	3.65			.035[a]	

Note: For the semen parameters, there are two *P* values (one for the paired *t* test between before cooling and the first "after value" and one for the paired *t* test between before cooling and the "average after values" when multiple subsequent testing was conducted by the patient [4–12 weeks]). *P* values were not obtained for SHBG because hormone profiles were rarely done for these values. DNA = deoxyribonucleic acid; FSH = follicle-stimulating hormone; LH = luteinizing hormone; SHBG = sex hormone-binding globulin; Sig. = significance.

[a] Significantly different from before cooling values, $P<.05$.

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heat stress, there is evidence that scrotal cooling either by removing the source of heat (reducing environmental heat exposures, treating varicoceles) or by extrinsic cooling improves semen parameters (8, 9) (Supplemental Table 1).

If the use of an inexpensive and extrinsic (noninvasive and nonmedical) cooling device is a potential means to improve semen parameters, why has this area not been more extensively studied? There could be many reasons, but our study, on highly motivated couples, found that compliance with device use was poor. The patients cited a variety of reasons for poor adherence, including discomfort, privacy issues, and a short effective cooling period. These significant concerns with the devices provided by the patients likely explain the low compliance observed in our study. If a device is not discrete or comfortable or is hard to use, patients may find it difficult to use the device for a long period of time throughout the day. These complaints regarding compatibility with lifestyle mirror other concerns brought up by patients when studying adherence to medical devices (27). In addition to improving these parameters, there are other areas of potential improvement for scrotal cooling devices that could increase compliance. Increasing engagement and allowing the user to have explicit feedback such as an indicator to confirm the device is working can have a positive impact on user satisfaction (27). This could be further accentuated in the case of scrotal cooling by the device being able to provide information during and after use (i.e., the duration of use of the device daily). Additionally, the esthetics of a device can have a role in a patient's compliance with device use and on their clinical condition (28).

The advantage of this study was that it reflected how patients actually use scrotal cooling devices and indicated how compliant men would be with the use of the two presently available cooling devices. This study indicates that further studies on the role of scrotal cooling in male fertility would be facilitated by the design of devices to improve compliance with use.

This study has limitations on the basis of our inability to directly assess device use. When looking at patient compliance with the devices, there is a potential for recall bias because these results were on the basis of questionnaire data. Additionally, we could not directly assess if the devices were applied correctly by the patients. Our study was not designed to test the effects of scrotal cooling on semen parameters of fertility. Future dedicated studies would be necessary to address this question.

CONCLUSION

Extrinsic scrotal cooling may represent a new and innovative approach to managing infertility. By lowering the temperature, it may allow for a noninvasive and potentially inexpensive method of improving fertility outcomes. Commercial devices are available that try to achieve this outcome; however, they have a number of limitations as identified in our study, which indicates a need for further device innovation. Before recommending cooling devices for men with infertility, more work developing pragmatic cooling devices that will be easy for men to use is imperative.

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