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Research

The Effect of Reflective Blankets on Reducing Inadvertent Perioperative Hypothermia in Abdominal Surgery Patients: A Randomized Controlled Trial

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A B S T R A C T

Keywords:

inadvertent perioperative hypothermia
reflective blanket
thermal comfort
passive warming

Purpose: This study aimed to evaluate the effect of a reflective blanket on reducing perioperative hypothermia and on thermal comfort and shivering levels in patients undergoing abdominal surgery.

Design: The research is in the design of a randomized controlled clinical trial.

Methods: This randomized controlled trial, conducted between February 2022 and January 2023 in a public hospital, included 105 American Society of Anesthesiologists I and II patients undergoing laparoscopic cholecystectomy or umbilical hernia surgery. Patients were randomized into three groups: active warming (n = 35), reflective blanket (n = 35), and routine care (n = 35). The active warming and reflective blanket groups received 15 minutes of prewarming. Body temperature, shivering, and thermal comfort were assessed. Data were analyzed with SPSS 21.0 (IBM Corp) ($P < .05$).

Findings: There were no statistically significant differences between the groups in terms of demographic and clinical characteristics ($P > .05$). At the end of anesthesia, hypothermia was observed in 71.4% of patients in the control group, 42.9% in the intervention group and 28.6% in the reference group ($P < .05$). Before clinical transfer, hypothermia persisted only in the control group (37.1%) and was not observed in the other two groups ($P < .001$). Shivering was seen only in the control and intervention groups, while it was absent in the reference group ($P < .05$). Thermal comfort scores were similar at baseline, but during the perioperative period, the reference group had the highest and the control group the lowest scores ($P < .01$).

Conclusions: The use of reflective blankets was as effective as active warming in reducing the incidence of inadvertent perioperative hypothermia and shivering and increasing the level of thermal comfort perception in patients and provided superiority over the control group.

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Inadvertent perioperative hypothermia (IPH), defined as a drop in core body temperature below 36 °C, refers to the temperature of the blood and internal organs.^{1,2} It may occur from 1 hour before anesthesia

to the first 24 hours after its administration.³ Various studies have reported IPH incidence rates ranging from 29% to 75%.⁴⁻⁶ High rates of hypothermia are particularly noted in urological, orthopedic, spinal, colorectal, and abdominal surgeries. Despite preventive measures, IPH remains a significant clinical concern. IPH can lead to complications such as myocardial problems, surgical site infections, delayed wound healing, postoperative pain, increased blood loss and transfusion requirements, decreased drug metabolism, and prolonged stay in the recovery unit and hospital.⁷ It also impairs patient comfort due to chills and shivering.⁸ In patients who did not receive warming, shivering rates have been reported to range from 25.9% to 71.4%.^{9,10} Several studies have also emphasized that IPH negatively affects patient recovery and increases health care costs.^{11,12}

Active and passive warming methods are commonly used in the perioperative period. Active warming methods include hot air systems,

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circulating water beds, carbon fiber blankets, radiant heaters, and warmed anesthetic gases or intravenous fluids. Passive methods involve materials such as cotton blankets, surgical drapes, plastic sheets, and reflective blankets.² Studies have shown that even brief prewarming (< 15 minutes) before surgery helps reduce body temperature loss.^{4,13} Prewarming is effective in preventing hypothermia and is more beneficial when combined with intraoperative warming.¹⁴ Although hot air-blowing devices are proven effective, they are costly and may not be practical in all operating rooms.¹⁵

Reflective blankets, introduced in the 1960s, are low-cost passive warming tools originally used to keep accident victims warm in outdoor settings. They do not produce external heat but provide warmth by reflecting the body's own heat back to the skin. By reflecting up to 80% of body heat, they can reduce heat loss from 100 to 40 kcal/h depending on the surface area covered.¹⁶ After adequate prewarming, reflective blankets have been shown to be as effective as hot air-blowing devices in maintaining intraoperative normothermia.¹⁷ However, conflicting results on their effectiveness in reducing IPH have been reported.¹⁸⁻²⁰ These differences may stem from variations in patient groups, sample sizes, and the perioperative phases studied. Many studies lacked prewarming and applied warming only during surgery or in the recovery unit. For example, Koenen et al²⁰ did not use reflective blankets intraoperatively or evaluate the period after recovery unit. Similarly, Tjoarkarfa et al¹⁷ did not assess the postoperative phase in their study. In contrast, this study included warming in all perioperative stages and followed patients up to 24 hours post-anesthesia, making it more comprehensive. The aim of this study is to evaluate the effect of using reflective blankets during the perioperative period on reducing IPH, enhancing thermal comfort perception, and decreasing shivering levels in patients undergoing abdominal surgery.

The following hypotheses were tested within the scope of the study.

H1₁: There is a statistically significant difference in perioperative body temperature among the reflective blanket, hot air-blowing device, and control groups.

H1₂: There is a statistically significant difference in thermal comfort levels among the reflective blanket, hot air-blowing device, and control groups.

H1₃: There is a statistically significant difference in shivering levels among the reflective blanket, hot air-blowing device, and control groups.

Methods

Type, Setting, and Duration of the Research

The study is a randomized, controlled, clinical trial design and was conducted between February 2022 and January 2023 in a public hospital operating room and general surgery clinic. The Consolidated Standards of Reporting Trials (CONSORT) 2025 checklist was used in the reporting of this study. This research was designed according to the CONSORT reporting guidelines.²¹

Description of the Hospital Where the Study Was Conducted

The hospital is a fully equipped center where laparoscopic and open abdominal surgeries are routinely performed. All patients received standard anesthesia with 1 to 2 mg of intravenous midazolam for premedication, followed by fentanyl (1 to 2 mcg/kg), propofol (2 to 2.5 mg/kg), and rocuronium (0.6 to 1 mg/kg) for induction. After endotracheal intubation, patients were connected to volume-controlled mechanical ventilation with standardized settings (ETCO₂ 32 to 36 mmHg, RR 12/min, I:E ratio 1:2, tidal volume 7 to 10 mL/kg).

Intraoperative monitoring included non-invasive blood pressure, electrocardiography, pulse, and oxygen saturation. Each patient received approximately 1,000 cc of non-warmed isotonic fluid infusion. Neither intravenous fluids nor irrigation solutions were warmed. All

temperature-related procedures were standardized across groups, and no blood transfusions were needed.

Population and Sample

A total of 328 patients who underwent elective abdominal surgery during the study period constituted the study population. To determine the study sample, a sample size calculation was performed. The sample size calculation for the study was performed using the G*Power 3.1.9.7 (Heinrich-Heine-University Düsseldorf) program. A priori power analysis was conducted based on the assumption that repeated measures analysis of variance (ANOVA) would be used in the study. Cohen's (f) standard effect size was employed in the calculation.²² When the effect size was set at 0.25, the α error at 0.05, the β error at 0.20, and the power at 0.80, the required number of participants was determined to be 102 (N = 102). In the post hoc analysis, it was found that the sample size was sufficient. The effect size was calculated as 4.45.

Sampling Criteria

Participants included in the study were those (1) classified as American Society of Anesthesiologists (ASA) I and II, (2) scheduled to receive general anesthesia, (3) with an expected anesthesia duration between 30 and 120 minutes, (4) having a body mass index (BMI) of 18.5 to 35 kg/m², (5) who had no febrile illness in the past 4 weeks, (6) who had not been diagnosed with any psychiatric illness and were not under psychiatric medication, (7) who did not have diabetic neuropathy, (8) who had no central nervous system disease, (9) who had not taken corticosteroids or immunosuppressive drugs within the 4 weeks before surgery, and (10) who voluntarily agreed to participate in the research.

Exclusion Criteria

The exclusion criteria were (1) the development of serious complications after inclusion in the study (such as severe bleeding, shock, altered consciousness, malignant hyperthermia, etc.), and (2) patients who wished to withdraw from the study at any stage were excluded from the research.

A total of 328 patients were evaluated for eligibility; 146 patients were excluded because they did not meet the sampling criteria, 46 patients were excluded because their surgery was expected to last longer than 120 minutes, and 31 patients declined to participate. No patients developed complications or withdrew from the study after inclusion. In this study, 65 laparoscopic cholecystectomy and 40 umbilical hernia patients with an operation time between 30 and 120 minutes, totaling 105 patients, were randomly assigned into three groups. Intervention group (n = 35): patients in this group were warmed using a reflective blanket. Reference group (n = 35): patients in this group received active warming via a hot air blower device. Control group (n = 35): patients in this group underwent passive warming using standard operating room drapes, the hospital's routine method. [Figure 1](#) shows the CONSORT flow diagram.

Randomization

Before randomization, patients were stratified into two separate groups: female and male, to ensure a balanced gender distribution across study arms. Within each gender group, triple block randomization was applied, and patients were randomly assigned to the study groups. The assignment was conducted using sealed envelopes containing cards labeled with the names of the study groups. For every three patients, one block was created and the envelopes were randomly distributed.

The sealed envelope method allowed the researcher to be blinded during the randomization process. However, since the

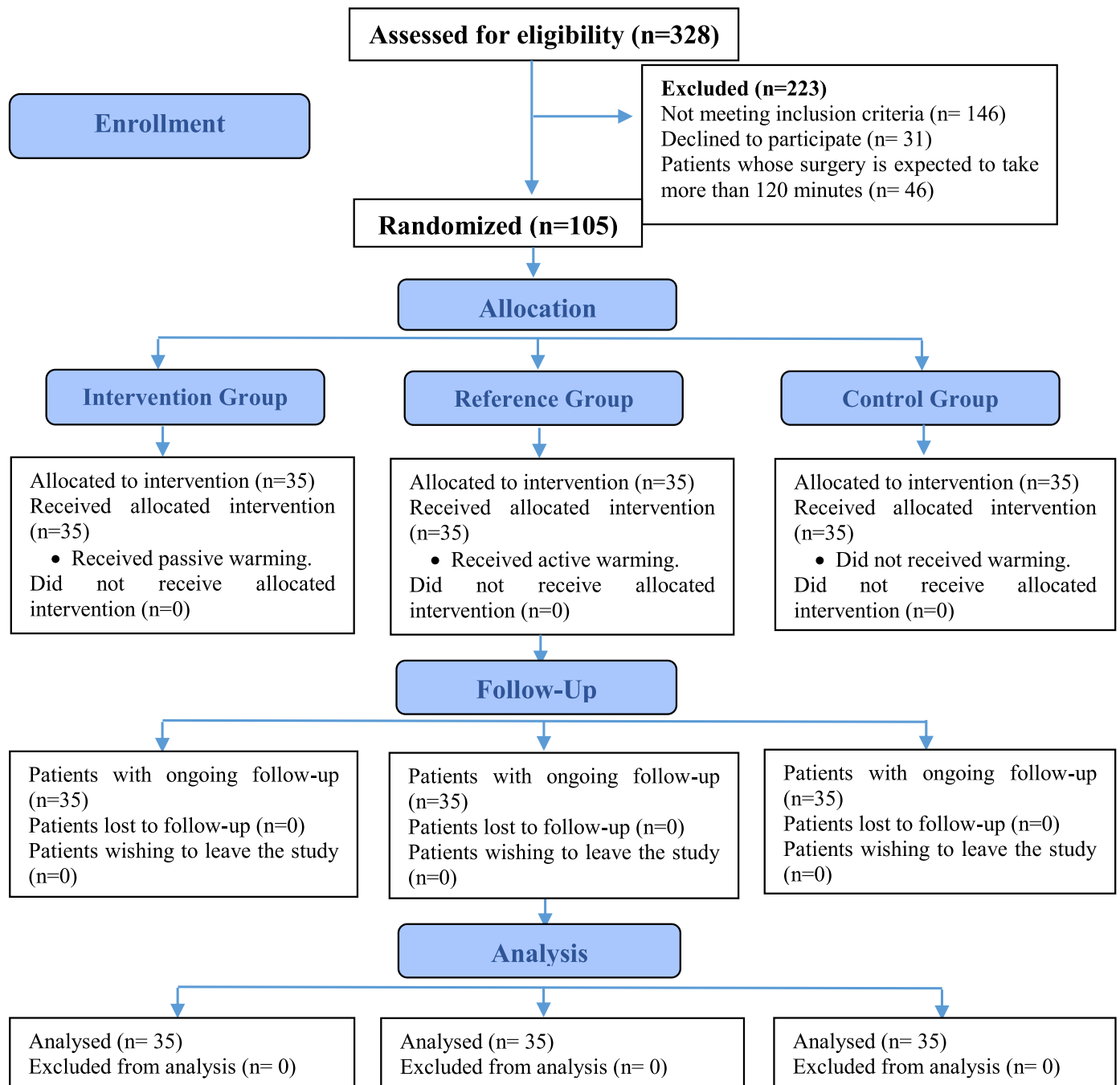


Figure 1. CONSORT flow diagram. CONSORT, Consolidated Standards of Reporting Trials. This figure is available in color online at www.jopan.org.

researcher personally administered the warming procedures to patients in the intervention and reference groups, blinding could not be maintained afterward. Vital signs were recorded by nurses in the clinic and technicians in the operating room. While the clinic nurses were blinded because they were unaware of the applied warming methods, the patients and operating room technicians could not be blinded as they directly observed the procedures.

Ethical Aspects of the Research

For the study, ethics committee approval was obtained from the Hasan Kalyoncu University Faculty of Health Sciences Non-Interventional Research Ethics Committee (Decision no: 2021/041, Decision date December 6, 2021). Written permission was obtained

from the institution where the study was conducted (February 18, 2022 13:58-E75384813-000-864). The study was registered on ClinicalTrials.gov (NCT05702320). Patients who agreed to participate in the study were informed about the study, and written informed consent was obtained. The Declaration of Helsinki was followed at all stages of the research.

Medical Equipment Used in the Research

Body Temperature Measurement Device

Body temperature was measured using a tympanic thermometer (Braun ThermoScan 7 IRT 6520). The most accurate method for core temperature measurement is through the pulmonary artery¹; however,

due to its invasive nature and infeasibility throughout all perioperative stages, the tympanic membrane method was preferred in this study for its practicality. In patients under general anesthesia, the use of a tympanic thermometer is considered appropriate as it provides a non-invasive, continuous method for measuring temperature closest to core body temperature and allows for rapid application without interfering with the surgical field.³ Other vital signs were recorded manually in the clinic and with a monitor in the operating room.

Passive Warming Device (Intervention Group)

For passive warming, single-use reflective blankets (160 to 210 cm) with one side in gold color were used.

Active Warming Device (Reference Group)

For active warming, the Mistral-Air Plus Warming Unit and its corresponding single-use full-body and half-body blankets were used.

Data Collection Tools

Patient Characteristics Form

The Patient Characteristics Form included questions designed to identify patients' demographic and clinical characteristics, such as age, gender, presence of chronic disease, BMI, type of surgical intervention, ASA score, and preoperative fasting duration.

Thermal Comfort Perception Assessment Form

In this form, developed by the researchers based on the literature,^{23,24} a rating scale from 0 to 100 is used. "0" indicates extremely unbearable cold, "50" represents an ideal temperature (neither hot nor cold), and "100" indicates extremely unbearable heat. Patients were asked to rate their current level of thermal comfort on this scale.

Shivering Level Assessment Form

In this form, shivering levels were assessed observationally based on literature^{25,26} as follows: 0 (none), 1 (mild; neck, thorax), 2 (moderate; neck, thorax, upper extremities), and 3 (severe; trunk, upper and lower extremities).

Implementation of the Research

Data were collected in four phases:

Phase 1 (Preoperative Period)

In all groups, body temperature, vital signs, thermal comfort, and shivering levels were measured upon entry to the operating room unit and just before entering the operating room.

Phase 2 (Intraoperative Period)

In all groups, body temperature and vital signs were recorded every 15 minutes.

Phase 3 (Recovery Unit Period)

Body temperature, vital signs, thermal comfort, and shivering levels were measured every 15 minutes.

Phase 4 (Postoperative Clinical Period)

Body temperature and vital signs were recorded every 15 minutes during the first 2 hours, and at the 4th, 8th, and 24th hours. Thermal comfort was assessed every 15 minutes during the first 2

hours and at the 4th and 8th hours. Shivering levels were assessed only during the first 2 hours.

Clinical data were collected by nurses, and intraoperative data by anesthesia technicians. Warming procedures for the reference and intervention groups were performed by the researcher. Before the study, staff were trained on the study protocol and tympanic thermometer use. For each measurement, the thermometer probe was cleaned and covered, the auricle was positioned, and the device was inserted into the ear canal until a signal sounded. Three consecutive measurements were taken, and the average was recorded. Core body temperature below 36 °C was defined as hypothermia.^{1,2}

Warming Procedures for Research Groups

Intervention Group

Patients, wearing only a surgical gown, were covered from the neck down with a reflective blanket, with the reflective side facing inward, 15 minutes before surgery. After warming, they were immediately transferred to the operating room and remained covered with the blanket until positioned on the operating table. An operating room drape was applied to the lower extremities, followed by the reflective blanket and sterile drapes. The researcher left the operating room after completing the application. In the recovery unit, patients were again covered with the reflective blanket as in the preoperative period. Additional drapes were provided upon patient request and recorded.

Reference Group

Before surgery, patients wearing only a surgical gown were warmed for 15 minutes with a full-body blanket (43 °C) from the hot air-blowing device. Afterward, they were transferred to the operating room on the same blanket. Once positioned, a half-body blanket was applied to the lower extremities, and warming continued at 43 °C during anesthesia, with body temperature monitored tympanically. Sterile covers were applied per hospital protocol. The device and hose were positioned at the foot of the bed to avoid interfering with the surgical team. The researcher exited after initiating warming. In the recovery unit, full-body warming resumed.

The warming procedures were performed in accordance with the standard sterile protocols of the operating room. The approval of the surgical and anesthesia teams was obtained before application, and coordination with the teams was ensured to maintain patient safety and surgical field sterility. The placement and use of the warming equipment were carefully managed so as not to interfere with the surgical procedures or compromise sterile requirements. Transfer to the clinic in the intervention and reference groups took place when the body temperature exceeded 36 °C and other criteria were met.

Control Group

Patients in this group received routine hospital care without researcher-applied warming. Per hospital protocol, no active warming was performed preoperatively or intraoperatively; passive warming was provided with operating room covers. Postoperatively, patients were warmed with blankets in the recovery unit and a cotton blanket in the clinic. Patients in this group were transferred from the recovery unit to the clinic according to the hospital protocol.

In the clinic, all patients were covered with a single cotton blanket, with routine treatment and nursing care provided as per standard practice.

Table 1
Descriptive Characteristics and Comparison of Groups (N = 105)

Introductory Features	Groups				Test	P
	Intervention (n = 35) n (%)	Reference (n = 35) n (%)	Control (n = 35) n (%)	Total n (%)		
Gender						
Female	20 (57.1)	18 (51.4)	19(54.3)	57(54.3)	0.230*	.891
Male	15 (42.9)	17(48.6)	16(45.7)	48(45.7)		
Chronic disease status						
Yes	8 (22.9)	5 (14.3)	9 (25.7)	22 (21.0)	1.495*	.474
No	27 (77.1)	30 (85.7)	26 (74.3)	83 (79.0)		
Surgical intervention						
Laparoscopic cholecystectomy	23 (65.7)	20 (57.1)	22 (62.9)	65 (61.9)	0.565*	.754
Umbilical hernia	12 (34.3)	15 (42.9)	13 (37.1)	40 (38.1)		
ASA score						
ASA I	25 (71.4)	24 (68.6)	25 (71.4)	74 (70.5)	0.092*	.955
ASA II	10 (28.6)	11 (31.4)	10 (28.6)	31 (29.5)		
	Mean ± SD (min-max)	Mean ± SD (min-max)	Mean ± SD (min-max)	Mean ± SD (min-max)	Test	P
Age	46.51 ± 9.97 (24-68)	49.29 ± 10.24 (22.59-33.17)	47.91 ± 10.91 (26-65)	247.90 ± 10.34 (22.82-31.61)	0.624†	.538
BMI	26.39 ± 1.89 (22.53-31.23)	27.08 ± 2.73 (22.59-33.17)	26.77 ± 2.26 (23.34-30.42)	26.75 ± 2.29 (22.82-31.61)	0.795†	.454
Preoperative fasting period (min)	647.29 ± 97.77 (540-905)	619.94 ± 69.12 (534-820)	633.37 ± 83.63 (545-910)	633.53 ± 13.68 (539-878)	0.920†	.402
Preoperative period	24.17 ± 0.36	24.25 ± 0.35	24.31 ± 0.31		1.588†	.209
Patient room temperature (°C)						
Operating room temperature (°C)	20.43 ± 1.01	20.58 ± 1.81	20.45 ± 0.89		0.125†	.882
Recovery unit temperature (°C)	24.10 ± 0.40	24.27 ± 0.36	24.27 ± 0.35		2.400†	.096
Postoperative clinic	24.16 ± 0.39	24.29 ± 0.32	24.31 ± 0.31		2.029†	.137
Patient room temperature (°C)						

ASA, American Society of Anesthesiologists; min-max, minimum-maximum values; Mean ± SD, Mean ± standard deviation; BMI, body mass index; ANOVA, analysis of variance. * χ^2 .

† ANOVA test.

Statistical Analysis of the Data

Statistical analyses were conducted using SPSS for Windows 21.0 (IBM Corp). Normal distribution was assessed through skewness, kurtosis (within ± 1.96), and Q-Q plots. Parametric tests were used for continuous variables. Independent samples *t* test was applied for two-group comparisons, and one-way ANOVA was used for comparisons among three groups, followed by the Tukey test when significant differences were found. Repeated measures ANOVA was used for within-group comparisons over time. Hypothermia trends across time points were analyzed with the Cochran Q test, and McNemar test was used for pairwise comparisons when needed. Categorical variables were evaluated using the χ^2 test. Statistical significance was set at *P* less than .05. Effect sizes were calculated using Cohen's *d*, categorized as small (0.20 to 0.49), medium (0.50 to 0.79), and large (≥ 0.80).^{22,27}

Results

The study groups were found to be statistically similar in terms of age, gender, chronic disease status, type of surgical intervention, ASA score, BMI, preoperative fasting period, clinical and operating room temperature (*P* > .05) (Table 1).

The differences between the groups in mean body temperature before entering the operating room, intraoperative period, recovery unit, and postoperative period were statistically significant (*P* < .05) (before entering the operating room, *P* = .001; intraoperative period, *P* = .011, *P* = .009, *P* = .002, *P* = .000, *P* = .010, *P* = .004; recovery unit and postoperative period, *P* = .000). The mean of the reference group was higher than the other groups, while the mean of the intervention group was higher than the control group. The reference and intervention groups had high levels of effect size compared to the control group (Table 2).

As shown in Figure 2, all patients were normothermic during the preoperative period and the first 30 minutes of the intraoperative period. At the end of anesthesia, the incidence of hypothermia was highest in the control group at 71.4%, while it was 42.9% in the intervention group and 28.6% in the reference group. A similar trend continued upon transfer to the recovery unit, with hypothermia observed in 74.3% of the control group, 40% of the intervention group, and 22.9% of the reference group. During transfer to the clinic, all patients in the intervention and reference groups had reached normothermia, whereas 37.1% of the control group remained hypothermic. During clinical admission, 31.4% of control group patients remained hypothermic, and only 2.9% remained hypothermic at the 90th minute. All patients in the intervention and reference groups remained normothermic throughout the postoperative clinical period (Figure 2).

No shivering was observed in any patient in the reference group. In the control group, mild shivering was detected in 14.3% of the patients when they were taken to the recovery unit, in 9.1% at the 15th minute in the recovery unit, and in 5.7% when they were taken to their beds in the clinic. In the intervention group, only 2.9% of the patients had mild shivering when they were admitted to the recovery unit.

Thermal comfort perception scores showed statistically significant differences between the groups at several time points (*P* < .05). Before entering the operating room (*P* = .001), the reference group had the highest comfort scores, followed by the intervention and control groups. This trend continued in the recovery unit (*P* = .001) and during clinical transfer (*P* = .001). Throughout the postoperative period at the time of being taken to bed (*P* = .001), the 15th minute (*P* = .001), and the 30th minute (*P* = .010), the reference group consistently maintained higher comfort scores than both the intervention and control groups. The intervention group also exhibited significantly higher scores than the control

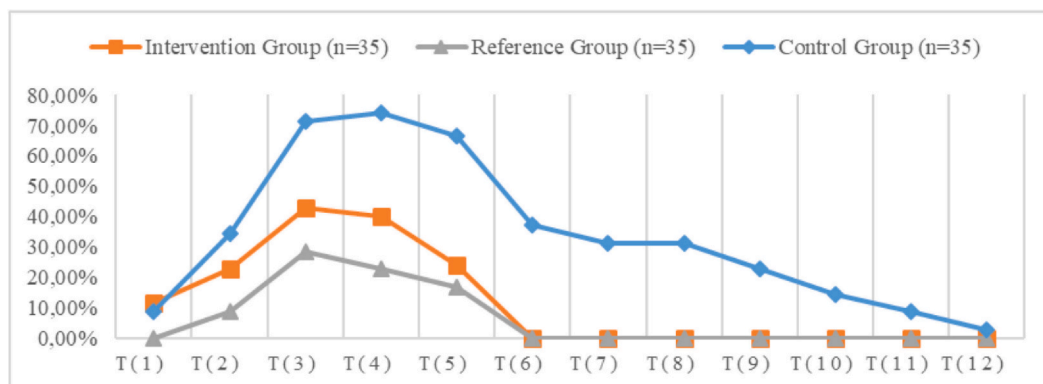
Table 2
Comparing Body Temperature Score Averages in Terms of Groups (N = 105)

Assessment Time		Groups			P*	Multiple Comparison†	Cohen d	
		Intervention ⁽¹⁾	Reference ⁽²⁾	Control ⁽³⁾				
		Mean ± SD	Mean ± SD	Mean ± SD				
Preoperative period	Wearing an operating gown in the clinic	37.09 ± 0.27	37.18 ± 0.19	37.08 ± 0.28	.165			
	When you come to the operating room unit	37.05 ± 0.28	37.13 ± 0.23	37.01 ± 0.28	.151			
Intraoperative period	Before entering the operating room	37.11 ± 0.27	37.16 ± 0.21	36.94 ± 0.29	.001	3 < 1, 3 < 2	0.86, 0.60	
	During the entrance to the operating room	37.06 ± 0.33	37.13 ± 0.21	36.91 ± 0.30	.006	3 < 2	0.84	
	0th minute (start of anesthesia induction)	36.93 ± 0.33	37.03 ± 0.21	36.83 ± 0.29	.011	3 < 2	0.78	
	15th minute	36.69 ± 0.31	36.79 ± 0.27	36.58 ± 0.25	.009	3 < 2	0.80	
	30th minute	36.43 ± 0.40	36.56 ± 0.26	36.30 ± 0.22	.002	3 < 2	1.07	
	45th minute	36.21 ± 0.42	36.38 ± 0.24	36.03 ± 0.31	.001	3 < 1, 3 < 2	1.26, 0.48	
	60th minute	36.06 ± 0.38	36.28 ± 0.27	35.79 ± 0.32	.001	3 < 1, 3 < 2, 1 < 2	1.65, 0.76, 0.66	
	75th minute	35.93 ± 0.40	36.03 ± 0.32	35.66 ± 0.37	.010	3 < 2	1.06	
	90th minute	35.92 ± 0.28	36.19 ± 0.46	35.40 ± 0.14	.004	3 < 1, 3 < 2	2.32, 2.34	
	End of anesthesia	36.02 ± 0.42	36.17 ± 0.36	35.68 ± 0.36	.001	3 < 1, 3 < 2	1.36, 0.86	
	Recovery unit	0th minute (when taken to the unit)	36.08 ± 0.40	36.20 ± 0.31	35.76 ± 0.33	.001	3 < 1, 3 < 2	1.37, 0.87
		15th minute	36.19 ± 0.37	36.30 ± 0.30	35.85 ± 0.31	.001	3 < 1, 3 < 2	1.47, 0.99
During the transfer to the clinic		36.33 ± 0.29	36.39 ± 0.24	36.03 ± 0.27	.001	3 < 1, 3 < 2	1.40, 1.07	
Postoperative period clinic	0th minute (when taken to bed)	36.30 ± 0.30	36.39 ± 0.24	36.02 ± 0.30	.001	3 < 1, 3 < 2	1.36, 0.93	
	15th minute	36.30 ± 0.29	36.42 ± 0.22	36.07 ± 0.29	.001	3 < 1, 3 < 2	1.35, 0.79	
	30th minute	36.40 ± 0.26	36.53 ± 0.19	36.17 ± 0.23	.001	3 < 1, 3 < 2, 1 < 2	1.70, 0.93, 0.57	
	45th minute	36.48 ± 0.29	36.62 ± 0.18	36.24 ± 0.23	.001	3 < 1, 3 < 2, 1 < 2	1.84, 0.91, 0.58	
	60th minute	36.53 ± 0.23	36.67 ± 0.16	36.32 ± 0.24	.001	3 < 1, 3 < 2, 1 < 2	1.71, 0.89, 0.70	
	90th minute	36.58 ± 0.20	36.79 ± 0.14	36.38 ± 0.25	.001	3 < 1, 3 < 2, 1 < 2	2.02, 0.88, 1.21	
	120th minute	36.70 ± 0.17	36.85 ± 0.16	36.49 ± 0.22	.001	3 < 1, 3 < 2, 1 < 2	1.87, 1.06, 0.90	
	4th hour	36.76 ± 0.13	36.92 ± 0.14	36.65 ± 0.20	.001	3 < 1, 3 < 2, 1 < 2	1.56, 0.65, 1.18	
	8th hour	36.89 ± 0.18	37.01 ± 0.13	36.78 ± 0.19	.001	3 < 1, 3 < 2, 1 < 2	1.41, 0.59, 0.76	
	24th hour	37.13 ± 0.17	37.20 ± 0.12	37.09 ± 0.19	.032	3 < 2	0.69	

Mean ± SD, Mean ± standard deviation; ANOVA, analysis of variance. Bold values indicates significant values ($p < .05$).

* ANOVA test.

† Tukey test.



T (1)= Intraoperative period 30th minute. T (2)= Intraoperative period 45th minute. T (3)= End of anesthesia, T (4)= Recovery unit 0th minute. T (5)= Recovery unit 15th minute. T (6)= During the transfer from the recovery unit to the clinic. T (7)= 0th minute (When taken to bed). T (8)= 15th minutes in the clinic. T (9)= 30th minute in the clinic. T (10)= 45th minute in the clinic. T (11)= 60th minute in the clinic. T (12)= 90th minute in the clinic.

Figure 2. Distribution of hypothermia development status in groups according to the time of assessment (N = 105). This figure is available in color online at www.jopan.org.

group at these times. No significant difference was found between the groups at the 45th minute ($P = .371$). These results indicate that both active and passive warming improved patients' thermal comfort compared to the control group, with the active warming method (reference group) providing the greatest effect (Table 3).

In the study, the proportion of patients who requested one more blanket in addition to the one they were wearing after being admitted to the recovery unit in the control group was 28.6%, while the proportion of patients who requested two blankets was 22.9%. No patients in the intervention or reference group requested additional blankets.

Discussion

The most important finding of this study, conducted to reduce intraoperative hypothermia, enhance thermal comfort, and decrease shivering levels, is that the reflective blanket was as effective as active warming in reducing hypothermia incidence and improving thermal comfort. This finding adds valuable insight to the literature, as it shows that reflective blankets can serve as a low-cost, practical alternative to active warming devices, particularly in clinical environments where such devices are unavailable or where financial limitations exist. Moreover, the significantly lower incidence of

Table 3
Comparison of Thermal Comfort Perception Level Score Averages in Terms of Groups (N = 105)

Assessment Time	Groups			P*	Multiple Comparison†	Cohen d
	Intervention ⁽¹⁾	Reference ⁽²⁾	Control ⁽³⁾			
	Mean ± SD	Mean ± SD	Mean ± SD			
When you come to the operating room unit	47.43 ± 4.09	48.86 ± 2.73	48.43 ± 3.59	.223		
Before entering the operating room	60.80 ± 3.23	67.29 ± 2.38	47.63 ± 3.69	.001	3 < 1, 3 < 2, 1 < 2	6.33, 3.79, 2.28
Prewarming start	48.37 ± 3.37	49.43 ± 1.61		.099‡		
End of prewarming	60.80 ± 3.23	67.29 ± 2.38		.001 ‡		2.28
0th minute (when taken to the unit)	49.14 ± 2.26	49.86 ± 1.48	42.86 ± 5.33	.001	3 < 1, 3 < 2	1.78, 1.53
15th minute	51.36 ± 2.43	58.04 ± 3.04	46.52 ± 3.85	.001	3 < 1, 3 < 2, 1 < 2	3.32, 1.50, 2.42
During the transfer to the clinic	53.17 ± 3.03	59.83 ± 1.87	48.71 ± 2.53	.001	3 < 1, 3 < 2, 1 < 2	4.99, 1.59, 2.64
0th minute (when taken to bed)	51.00 ± 2.03	53.86 ± 3.85	47.57 ± 3.51	.001	3 < 1, 3 < 2, 1 < 2	1.70, 1.19, 0.92
15th minute	50.29 ± 1.18	51.86 ± 2.45	48.80 ± 2.56	.001	3 < 1, 3 < 2, 1 < 2	1.22, 0.74, 0.81
30th minute	50.00 ± 0.00	50.43 ± 1.42	49.57 ± 1.42	.010	3 < 2	0.60
45th minute	50.00 ± 0.00	50.00 ± 0.00	49.86 ± 0.85	.371		

Mean ± SD, mean ± standard deviation; ANOVA, analysis of variance. Bold values indicates significant values ($p < .05$).

* ANOVA test.

† Tukey test.

‡ Independent groups *t* test.

shivering in the intervention group using reflective blankets compared to the control group further underscores its positive effect on patient comfort. In this study, all three hypotheses tested (H1₁, H1₂, and H1₃) were confirmed, demonstrating that reflective blankets are an effective passive warming method during perioperative period.

Reflective blankets offer a low-cost, portable, and energy-independent passive warming option compared to active warming devices in the perioperative period. Due to their ease of use, they can provide continuous thermal protection from the preoperative stage through intraoperative and postoperative periods. Additionally, their ability to be used during patient transfers offers a significant advantage in reducing heat loss. By reflecting the patient's own body heat back, the reflective surface reduces heat loss and enhances thermal comfort. The literature also reports that with adequate prewarming, reflective blankets can be as effective as forced-air warming devices in maintaining intraoperative normothermia.¹⁷

The absence of differences between the groups in Table 1 allowed for a more reliable evaluation of the effects of the warming methods. This indicates that the results were attributable to the applied methods and is considered important for providing comparable data to the literature.

In studies evaluating the effectiveness of warming methods, achieving homogeneity in baseline characteristics across groups is critically important to ensure that the observed outcomes can be attributed solely to the interventions applied. Similarity between groups minimizes the influence of potential confounding variables and strengthens internal validity.^{2,28} This is frequently emphasized in the literature and is recognized as a key design element that enhances the reliability of randomized controlled trials.²⁹ In this study as well, the similarity of the groups enabled a direct comparison of the effects of reflective blankets and active warming methods, generating data that can contribute to the existing body of literature.

According to Table 2, significant differences were observed in mean body temperatures between the groups. While body temperatures were similar across groups during the preoperative period, these differences became more pronounced during the later stages of the intraoperative period and in the postoperative phase. The reference group (active warming device) consistently achieved the highest body temperature values throughout the entire process, while the intervention group (reflective blanket) demonstrated better temperature maintenance compared to the control group.

In particular, the more stable body temperatures observed in the reference and intervention groups during the intraoperative and postoperative periods indicate that these warming methods are

effective in reducing hypothermia and maintaining normothermia. These findings suggest that reflective blankets may serve as a viable alternative to active warming methods and align with similar results reported in the literature.

When the current literature is reviewed, it is reported that the use of a reflective blanket combined with adequate prewarming can be an effective method for maintaining body temperature during the perioperative period.¹⁷ In the present study, more successful outcomes were achieved through prewarming and extensive coverage of the body surface. However, Koenen et al²⁰ reported that reflective blankets may not fully maintain normothermia throughout all perioperative stages. Furthermore, as emphasized by Rauch et al³⁰ and Simegn et al,⁷ considering the risk of increased perioperative complications due to IPH, the findings of this study demonstrate that the reflective blanket offers a valuable contribution as a low-cost and practical option to mitigate this risk. In clinical practice, especially in settings where active warming devices are unavailable or their use is limited, the reflective blanket combined with prewarming may serve as an effective alternative. We recommend the use of this method to support normothermia and enhance patient comfort.

When examining Figure 2, it is evident that normothermia was maintained across all groups during the preoperative period; however, as the intraoperative and postoperative phases progressed, distinct differences emerged in the ability to maintain body temperature between the groups. Among these differences, it is noteworthy that the intervention group using the reflective blanket preserved body temperature more effectively than the control group. In particular, the continuity provided by the reflective blanket during patient transfers and in the early postoperative period offered a significant advantage in minimizing heat loss. The effectiveness of combining prewarming with extensive body surface coverage, as emphasized in the literature, is further supported by these findings.¹⁷ In clinical practice, especially in settings where active warming devices are limited, the reflective blanket can be safely recommended as an option to support normothermia and enhance patient comfort.

When Table 3 is examined, significant differences in thermal comfort perception levels between the groups are evident. In the preoperative period, particularly before entering the operating room and after prewarming, the reference group (active warming device) recorded the highest thermal comfort scores. The intervention group (reflective blanket) also achieved higher thermal comfort scores compared to the control group. This difference was

maintained during both the intraoperative and early postoperative periods, with the reference and intervention groups demonstrating significantly higher patient comfort levels compared to the control group. These findings indicate that both active and passive warming methods, especially when combined with prewarming, are effective in enhancing patients' thermal comfort, and that reflective blankets can serve as a clinically valuable alternative in this regard.

When reviewing the current literature on this topic, it is reported that the use of reflective blankets in combination with adequate prewarming is effective not only in maintaining body temperature but also in enhancing patients' thermal comfort perception.¹⁷ Similarly, in our study, the use of reflective blankets with prewarming and continuous application throughout the perioperative period resulted in significantly higher thermal comfort scores compared to the control group (Table 3). This finding is also supported by Palmer et al,¹⁶ who reported that the use of reflective blankets during preoperative waiting and in the postoperative period improved patients' thermal comfort. On the other hand, Koenen et al²⁰ reported that reflective blankets may not fully maintain normothermia and the associated thermal comfort at all perioperative stages. However, in our study, these limitations were largely addressed by covering a wide body surface area and applying prewarming, leading to more consistent results. Furthermore, Rauch et al³⁰ and Simegn et al⁷ emphasized that IPH increases the risk of perioperative complications and negatively affects patient comfort. Therefore, the findings of this study suggest that the reflective blanket, being a low-cost and energy-independent option, could serve as a valuable tool to enhance patient comfort in clinical practice. In clinical settings, especially where active warming devices are unavailable or impractical, the use of reflective blankets with prewarming can improve patient satisfaction and comfort. We recommend that practitioners use reflective blankets continuously from the prewarming stage and ensure wide body surface coverage to achieve optimal results in terms of thermal comfort.

The findings of this study indicate that when used with appropriate prewarming, reflective blankets are an effective method for maintaining body temperature, reducing hypothermia, and enhancing thermal comfort during the perioperative period. Due to their low cost, portability, and independence from energy sources, reflective blankets offer a valuable alternative to active warming devices, particularly in resource-limited health care settings. For future research, we recommend further investigation into their effectiveness across different surgical types, larger patient populations, and varying prewarming durations and body surface coverage ratios. Additionally, exploring the potential influence of patient characteristics (age, BMI, and comorbidities) and surgical duration on the effectiveness of reflective blankets would be beneficial. Moreover, assessing long-term outcomes, including patient satisfaction, postoperative complications, and cost-effectiveness analyses, would provide stronger evidence to support their clinical implementation.

Limitations of the Research

In this study, body temperature was measured using a tympanic thermometer, which is practical and reliable but less precise than pulmonary artery measurements, thereby limiting the full evaluation of the effects of prewarming. Additionally, the inability to standardize the amount of fluids administered to patients and intraoperative blood loss is another limitation of the study. Anesthetic drug doses, fluid and irrigation volumes were administered according to standard protocols; however, the use of unheated fluids may have influenced body temperature. The lack of control over ambient conditions (temperature and humidity), the single-center study design, and the fact that the interventions were conducted by the researcher also limit the generalizability of the findings.

Nevertheless, the scarcity of studies on reflective blankets in the literature adds particular value to these results.

Conclusion

This study demonstrated that reflective blankets may be effective in reducing IPH and positively influencing thermal comfort and shivering levels during the perioperative period, similar to active warming methods. Particularly in surgical settings where the use of hot air-blowing devices may be limited, reflective blankets can be considered a low-cost and practical alternative. The findings may contribute to the broader clinical adoption of reflective blankets. However, further large-scale studies are needed to validate these results across different surgical types and patient populations.

CRedit authorship contribution statement

Aynur Koyuncu: Supervision. **Ayla Yava:** Writing – review & editing. **Ali Güzel:** Investigation, Formal analysis, Conceptualization, Funding acquisition, Data curation.

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Declaration of Competing Interest

None to report.

Appendix A. Supplementary Materials

Supplementary material associated with this article can be found in the online version at [doi:10.1016/j.jopan.2025.08.024](https://doi.org/10.1016/j.jopan.2025.08.024).

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Appendix A. Supplementary Materials

Section/Topic	No	CONSORT 2025 Checklist Item Description*	Reported on Page No.
Title and abstract			
Title and structured abstract	1a	Identification as a randomized trial	1
	1b	Structured summary of the trial design, methods, results, and conclusions	1
Open science			
Trial registration	2	Name of trial registry, identifying number (with URL), and date of registration	5
Protocol and statistical analysis plan	3	Where the trial protocol and statistical analysis plan can be accessed	17
Data sharing	4	Where and how the individual deidentified participant data (including data dictionary), statistical code, and any other materials can be accessed	17
Funding and conflicts of interest	5a	Sources of funding and other support (eg, supply of drugs), and role of funders in the design, conduct, analysis, and reporting of the trial	17
	5b	Financial and other conflicts of interest of the manuscript authors	17
Introduction			
Background and rationale	6	Scientific background and rationale	2, 3
Objectives	7	Specific objectives related to benefits and harms	3
Methods			
Patient and public involvement	8	Details of patient or public involvement in the design, conduct, and reporting of the trial	3-5
Trial design	9	Description of trial design, including type of trial (eg, parallel group, and crossover), allocation ratio, and framework (eg, superiority, equivalence, non-inferiority, and exploratory)	5-7
Changes to trial protocol	10	Important changes to the trial after it commenced, including any outcomes or analyses that were not prespecified, with reason	"n/a" No unforeseen consequences have developed since the study began. There have been no significant changes.
Trial setting	11	Settings (eg, community and hospital) and locations (eg, countries and sites) where the trial was conducted	3
Eligibility criteria	12a	Eligibility criteria for participants	4
	12b	If applicable, eligibility criteria for sites and for individuals delivering the interventions (eg, surgeons and physiotherapists)	"n/a"
Intervention and comparator	13	Intervention and comparator with sufficient details to allow replication. If relevant, where additional materials describing the intervention and comparator (eg, intervention manual) can be accessed	6, 7
Outcomes	14	Prespecified primary and secondary outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, and time to event), method of aggregation (eg, median and proportion), and time point for each outcome	6,7
Harms	15	How harms were defined and assessed (eg, systematically and non-systematically)	"n/a" No harmful situations were detected.
Sample size	16a	How sample size was determined, including all assumptions supporting the sample size calculation	3, 4
	16b	Explanation of any interim analyses and stopping guidelines	"n/a"
Randomization			4, 5
Sequence generation	17a	Who generated the random allocation sequence and the method used	4, 5
	17b	Type of randomisation and details of any restriction (eg, stratification, blocking, and block size)	4, 5
Allocation concealment mechanism	18	Mechanism used to implement the random allocation sequence (eg, central computer/telephone; sequentially numbered, opaque, and sealed containers), describing any steps to conceal the sequence until interventions were assigned	Reported on page no. 4, 5
Implementation	19	Whether the personnel who enrolled and those who assigned participants to the interventions had access to the random allocation sequence	5
Blinding	20a	Who was blinded after assignment to interventions (eg, participants, care providers, outcome assessors, and data analysts)	5
	20b	If blinded, how blinding was achieved and description of the similarity of interventions	"n/a" The researcher personally administered the warming procedures to patients in the intervention and reference groups, blinding could not be maintained. Vital signs were recorded by nurses in the clinic and technicians in the operating room. While the clinic nurses were blinded because they were unaware of the applied warming methods, the patients and operating room technicians could not be blinded as they directly observed the procedures.

Statistical methods	21a	Statistical methods used to compare groups for primary and secondary outcomes, including harms	8
	21b	Definition of who is included in each analysis (eg, all randomized participants), and in which group	8
	21c	How missing data were handled in the analysis	"n/a" There is no missing data in the study.
	21d	Methods for any additional analyses (eg, subgroup and sensitivity analyses), distinguishing prespecified from post hoc	8
Results			
Participant flow, including flow diagram	22a	For each group, the number of participants who were randomly assigned, received intended intervention, and were analyzed for the primary outcome	8
	22b	For each group, losses and exclusions after randomization, together with reasons	"n/a" There were no withdrawals from the study after randomization
Recruitment	23a	Dates defining the periods of recruitment and follow-up for outcomes of benefits and harms	3
	23b	If relevant, why the trial ended or was stopped	"n/a"
Intervention and comparator delivery	24a	Intervention and comparator as they were actually administered (eg, where appropriate, who delivered the intervention/comparator, how participants adhered, whether they were delivered as intended [fidelity])	6, 7
	24b	Concomitant care received during the trial for each group	6, 7
Baseline data	25	A table showing baseline demographic and clinical characteristics for each group	9
Numbers analyzed, outcomes, and estimation	26	For each primary and secondary outcome, by group: <ul style="list-style-type: none"> ● the number of participants included in the analysis ● the number of participants with available data at the outcome time point ● result for each group, and the estimated effect size and its precision (such as 95% confidence interval) ● for binary outcomes, presentation of both absolute and relative effect size 	9-12
Harms	27	All harms or unintended events in each group	"n/a" No harm or unexpected events occurred in any group.
Ancillary analyses	28	Any other analyses performed, including subgroup and sensitivity analyses, distinguishing prespecified from post hoc	8
Discussion			
Interpretation	29	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	13-16
Limitations	30	Trial limitations, addressing sources of potential bias, imprecision, generalizability, and, if relevant, multiplicity of analyses	16

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*We strongly recommend reading this statement in conjunction with the CONSORT 2025 Explanation and Elaboration and/or the CONSORT 2025 Expanded Checklist for important clarifications on all the items. We also recommend reading relevant CONSORT extensions. See www.consort-spirit.org.

CONSORT, Consolidated Standards of Reporting Trials.