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Physiological effects of Therapeutic Body Wraps in healthy volunteers: An observational study

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ABSTRACT

Introduction: The clinical management of severe anxiety is challenging. Along with specific medication, several nonpharmacological treatments exist, among which the Therapeutic Body Wraps (TBW). While TBW is clinically known to be efficient, the absence of objective physiological measurements raised some debates about its harmlessness.
Aims: This observational study investigated TBW in healthy volunteers.
Methods: Measurements were done in 26 participants, who experienced TBW, which consisted of tightly wrapping the body in one layer of wet cold sheets and several warm blankets. These were compared to 13 participants, who rested in supine position.
Results: Our results showed increase in the trunk skin temperature by the end of TBW similar to rest. Somatosensory perception as assessed with quantitative sensory testing was stable after both TBW and rest. The heart and breath rates decreased both during TBW and rest. It was accompanied by increase in heart rate variability parameters and decrease in salivary cortisol levels.
Discussion: Our data indicate anxiolytic effect of TBW in healthy participants.
Implications for practice: The TBW is harmless and might be used in patients, who are unable to relax by themselves and/or without anxiolytic medication. Further studies are necessary to investigate physiological response to TBW in clinical population.

Introduction

Therapeutic Body Wraps (TBW) is an integrative mind-body approach in adult psychiatric patients to address clinical issues of anxiety through physical containment (Bovier & Brandli, 1979; Ross et al., 1988). This paper is the first and only response to Ross et al. (1988) call for a study of the physiological effects of TBW in healthy subjects. Indeed, Ross and others before him had observational clinical data that confirmed the efficacy of TBW as an anxiolytic in patients. However, the mechanism of this efficacy was unknown. TBW has also been used as an adjunct therapy to treat severe atopic dermatitis (Devillers & Oranje, 2012) and self-injurious behaviors in children and adolescents with autism spectrum disorder (ASD) (Cohen, 2009; Delion et al., 2018). However, lack of experimental data on physiological effects of TBW in both adults and children led to controversy on safety of this technique (Chamak, 2019; Spinney, 2007).

The clinical practice of TBW consists of tightly wrapping the patient's body in wet cold sheets (below 60 °F/15 °C) and then covering by blankets. The head of the patient can either be covered with a wet sheet or not, but face remains uncovered. The patient is comfortably positioned on a bed and two health practitioners take seats on either side of the bed, thus allowing for visual contact and communication. For patients displaying clinical signs of bodily scheme disintegration or sensory integration dysfunction, the physical (sheets) and relational holding (presence and availability of health practitioners) provided by the TBW setting can be completed by a procedure of sensory stimulation. The latter consists of simultaneous and symmetrical manual pressure through the wrap and of naming aloud the patient's consecutive body parts. To mark bodily limits, this procedure of sensory stimulation is concluded by one practitioner softly pressing the patient's head, whereas the other practitioner is gently pushing the feet (Opsommer et al., 2016; Skuza, Bangerter, & Dubois, 2017).

The physiological process of rapid vasoconstriction and vasodilation of subcutaneous capillary vessels during the TBW is believed, in addition to a synesthetic holding action of tight sheets, to confer a better consciousness of the bodily limits and has been suggested to have an

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anxiolytic and sedative action on manic symptomatology (Ross et al., 1988; Silver, 2000).

Previous studies in adults showed significant reduction in the daily intake of anxiolytics by patients that may be interpreted in terms of TBW potential to reduce anxiety in patients (Opsommer et al., 2016; Skuza et al., 2017). It is established that heightened anxiety levels lead to elevated levels of salivary concentration of such biomarkers as cortisol (sC) and alpha-amylase (sAA) (Petrowski, Herold, Joraschky, Wittchen, & Kirschbaum, 2010). Considering that sC is a neuroendocrine indicator of hypothalamic-pituitary-adrenal (HPA) axis activity, which is of particular importance in the context of severe anxiety within the clinical spectrum of psychotic disorders, it is of great interest to study its dynamics during TBW in association with other outcome measures, such as heart rate variability (HRV) and quantitative sensory testing (QST). Indeed, as a sensory integration therapy, TBW aims to correct somatosensory processing dysfunction by exposing the body to sensory stimulation in a structured and repetitive way, which should gradually help the brain to adapt and react to sensations more efficiently.

The aim of this study was to explore the physiological effects of TBW in healthy volunteers and test usefulness of such measures as saliva sample (sC and sAA), HRV and QST to assess the nervous system state following TBW.

Methods

Participants

Healthy volunteers were recruited through an e-mail campaign between 20.11.2018 and 22.06.2020 (Supplementary Fig. 1). Inclusion criteria were: (1) good health status and quality of life (assessed with "European Quality of Life 5 dimensions and 3 lines" (EuroQoL EQ-5D-3L) questionnaire) with no lower-back or lower-limb pain (assessed with "Delphi Definitions of Low Back Pain Prevalence" (DOLBaPP, Form O2) questionnaire (Dionne et al., 2008)), (2) age between 20 and 40 years old and (3) ability to read and speak French. Exclusion criteria were diabetes, endocrine dysfunction, cognitive disorders, pain, neurological or rheumatologic disorders, any medication within the last 10 days and known pregnancy. Anxiety and depression levels were evaluated with "Hospital Anxiety and Depression Scale" (HADS) questionnaire (Zigmond & Snaith, 1983). All participants confirmed not being on any pain medication and signed a written consent form. The study was approved by the local Ethics Committee and complies with the Declaration of Helsinki (World Medical Association, 2001).

The sample size of 26 participants, necessary to evaluate the effect of TBW, was estimated using Lehr's equation (Belle, 2008), based on the previously published data, which tested the effect of relaxation techniques such as massage and touch using sC levels (Rapaport, Schettler, & Breese, 2010). The effect size (−0.29) and standard deviation (0.38) values (Rapaport et al., 2010) were taken from above mentioned studies with conventions accepting 5 % significance level ($p = 0.05$, Type I error) and a power of 80 % (Type II error). Due to difficulties in the recruitment of participants and restrictions during pandemic, the final design of the study was 2:1 with 26 participants in the TBW group and 13 in the rest group serving as a control.

Protocol procedure

Tests of this observational study with pre-post design were conducted in a quiet room with dim light and ambient temperature between 20° and 24 °C between 1 and 4 P.M due to the diurnal course of sC and sAA (35, 36). The TBW was performed on each participant according to the standard practice of TBW in Switzerland (Opsommer et al., 2016; Skuza et al., 2017). All participants had trial TBW test to familiarize with procedure without data collection, which was performed on another day before the main TBW experiment. Within 15 min of their TBW, participants were asked to freely recount their experiences of TBW and questions targeting bodily perceptions were asked. A member of the team took notes in order to later cross-check each participant's subjective experience with the results of the analyses of the physiological variables, in particular in order to obtain additional insight if anomalies were to be detected. In the rest group, participants had rest in the supine position under the blanket for the same duration as TBW. The Fig. 1A presents the protocol procedure. Participants were assessed before and after TBW or rest for QST, sC (nmol/l) and sAA (U/ml) concentrations (Fig. 1A). Breath rate (BR, rpm (respirations per minute)), electrocardiogram (ECG, mV), heart rate (HR, bpm (beats per minute)) as well as trunk and peripheral skin temperatures (ST, °C) were recorded

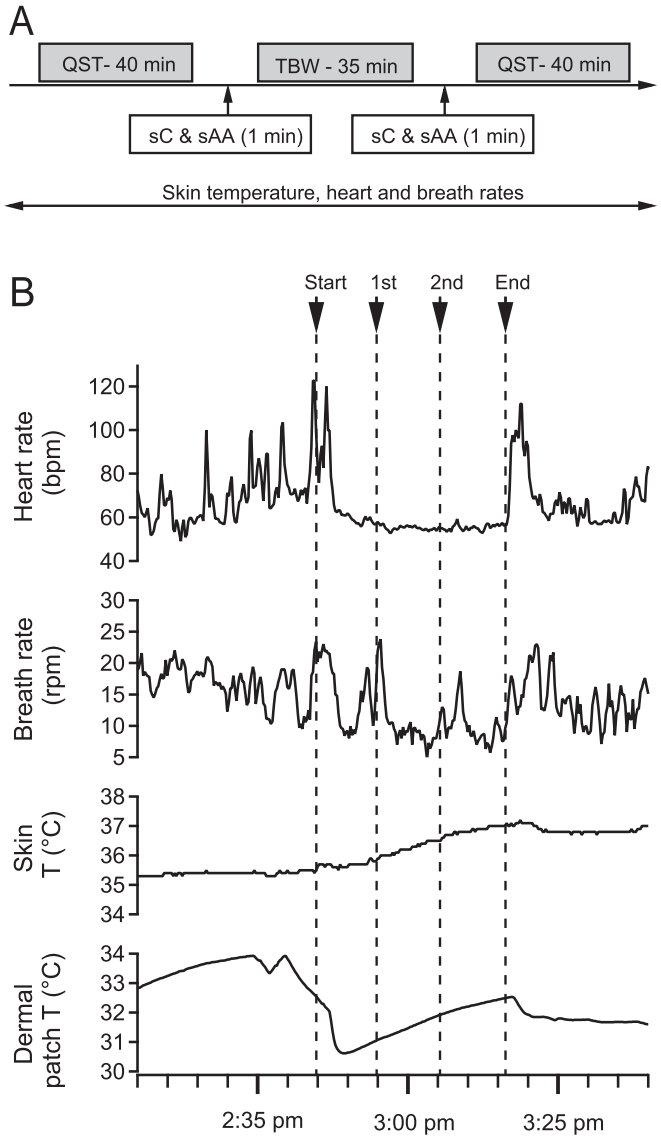

Fig. 1. Experimental protocol for TBW in healthy participants. (***A***) Sequence of the protocol procedure included assessments of the nervous somatosensory system with QST and collecting salivary samples to check sC and sAA concentrations before and after TBW, which lasted approximately 35 min. Physiological data such as heart rate (beats per minute, bpm) and breath rate (respirations per minute, rpm), as well as skin temperature (in degrees Celcius, C°) around the chest and at the periphery (tibialis anterior) were collected throughout the whole procedure. (***B***) Example of physiological recordings during experimental procedure, which was performed in the afternoon (here between 1 and 4 pm) with arrows and dashed lines indicating main events (start and end of the TBW as well as 1st and 2nd peripheral stimulation series). Abbreviations: **QST**, quantitative sensory testing; **TBW**, therapeutic body wraps; **sC**, salivary cortisol; **sAA**, salivary alpha-amylase.

throughout the whole procedure (Fig. 1B).

Physiological parameters

The ECG, HR, BR and ST were recorded using Equivital system (Cambridge, UK), which included: sensor electronic module (SEM), EQ02 Sensor belt and Equivital™ software. Sensory belt contained two ECG electrodes with sampling rate at 250 Hz, expansion based respiratory belt transducer and triaxial accelerometer required by the SEM. Trunk ST was recorded via infrared temperature sensor located in the inner pocket of the SEM, which was placed against the subject's skin. Peripheral ST was recorded via dermal patch (VitalSense® Dermal Patch, Cambridge, UK) positioned on the lower leg part (tibias anterior muscle). These data were sampled every 15 s.

Heart rate variability

The activity of the autonomous nervous system (ANS) in relation to TBW and rest was assessed with HRV analysis (Shaffer & Ginsberg, 2017). For this, we extracted 5 min ECG epochs recorded without artifacts, which included three time periods: before the start of experiment (T0), in the middle of experiment (T1) and within 15 min after experiment (T2). The HRV analysis was done using HRVTool (Vollmer, 2019) in MATLAB® software (R2019B, MathWorks Inc). Analyzed HRV included indices in time and frequency domains, the Poincaré plot and relative HRV (rrHRV), a new geometric measure for HRV, which was based on calculation of relative RR intervals (rr), the difference of consecutive RR intervals weighted by their mean and could be applied even to short RR sequences with artifacts and missing values (Shaffer & Ginsberg, 2017; Vollmer, 2019).

For the time domain, following parameters were analyzed: SDNN (standard deviation of all normal RR intervals, ms); RMSSD (root mean square of successive RR intervals, ms), pNN50 (percentage of successive RR intervals that differ by >50 ms); TRI (triangular index, integral of the density of the RR interval histogram divided by its height) and TINN (triangular interpolation, baseline width of the RR interval histogram).

In the frequency domain, we evaluated vagal modulation via following parameters: the relative power of the low-frequency (LF) spectral component (0.04 to 0.15 Hz, %), associated with activity of the sympathetic nervous system (SNS); relative power of the high-frequency (HF) component (0.15 and 0.4 Hz, %) associated with activity of parasympathetic nervous system (PNS); and LF/HF ratio, reflecting balance between SNS and PNS. Non-linear HRV variables were obtained from the ellipse fitted to the Poincaré plot (the map of points constructed from the RR intervals), from which deviations perpendicular to the identity line were measured: SD1 (standard deviation 1, ms) along the short and SD2 (standard deviation 2, ms) along the long axis. The SD1 index reflects PNS activity; the SD2 - SNS activity and SD1/SD2 ratio – the balance between them (Shaffer & Ginsberg, 2017).

Salivary sC and sAA

The saliva samples were collected using the Salivette device (Sarstedt, Germany) and stored at −18 °C before sending for analysis of sC and sAA concentrations to a third-party laboratory (Clemens Kirschbaum Laboratory, Dresden, Germany).

The latter measured the concentration of alpha-amylase in saliva by an enzyme kinetic method: saliva was processed on a Genesis RSP8/150 liquid handling system (Tecan, Crailsheim, Germany). First, saliva was diluted 1:625 with double-distilled water by the liquid handling system. Twenty microliters of diluted saliva and standard were then transferred into standard transparent 96-well microplates (Roth, Karlsruhe, Germany). Standard was prepared from "Calibrator f.a.s." solution (Roche Diagnostics, Mannheim, Germany) with concentrations of 326, 163, 81.5, 40.75, 20.38, 10.19, and 5.01 U/l alpha-amylase, respectively, and bi-distilled water as zero standard. After that, 80 ml of substrate reagent (*a*-amylase EPS Sys; Roche Diagnostics, Mannheim, Germany) were pipetted into each well using a multichannel pipette. The microplate containing sample and substrate was then warmed to 37 °C by incubation in a water bath for 90 s. Immediately afterward, a first interference measurement was obtained at a wavelength of 405 nm using a standard ELISA reader (Anthos Labtech HT2, Anthos, Krefeld, Germany). The plate was then incubated for another 5 min at 37 °C in the water bath, before a second measurement at 405 nm was taken. Increases in absorbance were calculated for unknowns and standards. Increases of absorbance of diluted samples were transformed to alpha-amylase concentrations using a linear regression calculated for each microplate (Graphpad Prism 4.0c for MacOSX, Graphpad Software, San Diego, CA). The intra and interassay coefficients for amylase were below 5 % and 9 %.

For salivary cortisol analysis samples were frozen and stored at −20 °C until analysis. After thawing, salivettes were centrifuged at 3000 rpm for 5 min, which resulted in a clear supernatant of low viscosity. Salivary concentrations were measured using commercially available chemiluminescence immunoassay with high sensitivity (IBL International, Hamburg, Germany). The intra and interassay coefficients for cortisol were below 5 % and 6 %.

Quantitative sensory testing

The QST was performed according to the German Research Network protocol (DFNS) as described in investigator's brochure. This protocol assesses functions (loss and/or gain) of the somatosensory system based on responses of the participants to the specific stimuli of specific modality and intensity, which include measurements of 13 thermal and mechanical parameters (Rolke et al., 2006). Measurements were done on the paravertebral area between thoracic Th10 and lumbar L3 defined as "lower back". The thermal tests were done using a thermoanalyzer type TSA II (Medoc Ltd., Israel) and included: cold detection threshold (CDT), warm detection threshold (WDT), cold pain threshold (CPT), heat pain threshold (HPT) and thermal sensory limen (TSL) and paradoxical heat sensation (PHS). Tactile detection thresholds (MDT) were determined by von Frey filaments (Optihair2-Set, Marstock Nervtest, Germany) using a modified method of limits. Mechanical pain threshold (MPT) and wind-up ratio (WUR) were analyzed with PinPrick stimulator set (MRC systems, Germany), vibration detection threshold (VDT) with Rydel-Seiffer tuning fork (64 Hz), pressure pain threshold (PPT) with pressure algometer (FDN200; Wagner Instruments, Greenwich, CT, USA) over the latissimus dorsi muscle, mechanical pain sensitivity (MPS) and dynamic mechanical allodynia (DMA) with weighted pinprick stimuli plus three innocuous stimuli (Q-tip, cotton wisp and soft brush). QST values were transformed to z-scores (Rolke et al., 2006) and compared to normative values (Magerl et al., 2010).

Statistical analysis

Statistical analysis was performed using SPSS (IBM SPSS Statistics 23.0. IBM, Armonk, NY, USA). Data were reported as means and standard deviations (SD), unless otherwise stated. The differences in demographic and questionnaires data between groups were tested using Welch *t*-test. All variables' values were tested for normality with Shapiro–Wilk test. For normally distributed data, repeated measures within and between subject ANOVA was conducted to compare main effects of group (TBW, Rest) and time during experiment (before (T0), during (T1) and after (T2)) as independent variables as well as their interaction effects on every measurement outcome values (dependent variables). The equality of variances was tested using Leven's test and post-hoc pair-wise comparisons were done by multiple comparison Bonferroni test. Data were reported as F (df independent variable, df error) = [F-value], p = [*p*-value], η_p^2 = [Partial Eta squared]. *P* value < 0.05 was considered as statistically significant. For non-normally distributed variables, Friedman test was used to compare main effects of time during experiment in each group with 3 repeated measures (T0, T1, T2 or before, 5 min after and 15 min after the experiment) and Wilcoxon Signed-Rank test with 2 measures (T0 and T2). The values between the groups for measured time points were compared by Mann-Whitney test. Data were reported as test

statistics and *p*-values of corresponding tests.

Results

Outcomes of the participants' self-administered questionnaires

Table 1 shows that both groups had similar outcomes of self-administrated questionnaires (HADS, EuroQoL). The global health level (EQ. 5D VAS), mean healthy utility EQ. 5D index and the results of HADS questionnaire were within the normative range for both groups (Perneger, Combescure, & Courvoisier, 2010) (Zigmond & Snaith, 1983).

Physiological parameters

Because all values of the physiological parameters had normal distribution (Shapiro-Wilk test, $p > 0.05$), repeated measures two-way ANOVA was conducted to compare main effect of group (TBW and Rest) and time (T0, T1 and T2) as well as their interaction effects on BR, HR, trunk and peripheral ST (Table 2).

The main group effect on BR was not statistically significant, but main time effect was and yielded an effect size of $\eta_p^2 = 0.199$, indicating that 19.9 % of variance in BR values was explained by time during experiment. Multiple post-hoc comparisons with Bonferroni test showed statistically significant decrease in BR in both groups during experiment (T1) when compared to before (T0) values (Mean $\text{difference}_{T1\text{-}T0}$ = -2.513, $p = 0.002$). There was no interaction between time and group effects.

The main group effect on HR was not statistically significant. The main time effect was statistically significant and yielded an effect size of $\eta_p^2 = 0.319$, indicating that 31.9 % of variance in HR values was explained by time during experiment. Multiple post-hoc comparisons with Bonferroni test showed statistically significant decrease in HR in both groups during experiment (T1) when compared to before (T0) values (Mean $\text{difference}_{T1\text{-}T0}$ = -6.865, $p < 0.001$). There was no interaction between time and group effects.

The main group effect on trunk ST was not statistically significant. The main time effect was statistically significant and yielded an effect size of $\eta_p^2 = 0.740$, indicating that 74 % of variance in trunk ST values was explained by time during experiment. Multiple post-hoc comparisons with Bonferroni test showed statistically significant increase in ST during (T1, mean $\text{difference}_{T1\text{-}T0} = 1.033$, $p < 0.001$) and after TBW or rest (T2, mean $\text{difference}_{T2\text{-}T0} = 1.592$, $p < 0.001$) when compared to values at T0. There was no interaction between time and group effects.

Table 1
Outcomes of the participants' self-administered questionnaires.

Characteristic	Group		Welch *t*-test			
	TBW	Rest				
Number (female, male)	26 (19,7)	13 (9,4)	F	df1	df2	Sig. *p*-value
Age, years Mean (SD)	26.8 (4.9)	31.6 (5.1)	7.82	1	23.55	0.010
EQ. 5D VAS Mean (SD)	88.3 (7.4)	84.7 (11)	1.09	1	17.64	0.309
EQ. 5D 3 L index Mean (SD)	0.93 (0.12)	0.88 (0.16)	1.44	1	19.29	0.244
HADS Mean (SD)						
Anxiety	5.15 (2.44)	5.15 (2.82)	0.00	1	21.25	1.000
Depression	1.50 (1.80)	2.60 (2.70)	1.70	1	17.49	0.209

Abbreviations: TBW: Therapeutic body wrap. EQ-5D: EuroQol EQ-5D-3L questionnaire. VAS: Visual Analog Scale. HADS: Hospital Anxiety And Depression Scale. SD: Standard Deviation. Welch's unequal variances *t*-test: *F*- Test statistic, df1, df2-degrees of freedom.

The main effect analysis showed that group and time had statistically significant effect on peripheral ST (group effect size: $\eta_p^2 = 0.195$; time effect size: $\eta_p^2 = 0.126$), indicating that 19.5 % of variance in peripheral ST values was explained by type of group and 12.6 % by time during experiment. Multiple post-hoc comparisons with Bonferroni test showed that: 1) in the TBW group peripheral ST mean value was lower than in the rest group and this difference was statistically significant (Mean $\text{difference}_{TBW\text{-}Rest} = -1.047$, $p = 0.008$) and 2) there was statistically significant increase in peripheral ST in rest group between T0 and T2 (Mean $\text{difference}_{T2\text{-}T0} = 0.522$, $p = 0.024$).

Heart rate variability

All measured HRV parameters were within the normative values for both groups. (Nunan, Sandercock, & Brodie, 2010) Most of HRV parameters' values were normally distributed (Shapiro-Wilk test, $p > 0.05$), except RMSSD, SD1, SD1/SD2 and LF/HF. Therefore, repeated measures two-way ANOVA was conducted to compare main effect of group (TBW and rest) and time (T0, T1 and T2) as well as their interaction effects on following HRV parameters: SDNN, pNN50%, TRI index, TINN, SD2, LF, HF, rrHRV (Table 3). This analysis showed that main time and group effects on SDNN, TRI index, TINN, SD2, HF were not statistically significant and there was no interaction between these effects.

The main group effect on pNN50 was not statistically significant, but main time effect was and yielded an effect size of $\eta_p^2 = 0.222$, indicating that 22.2 % of variance in pNN50 values was explained by time during experiment. Multiple post-hoc comparisons with Bonferroni test showed statistically significant increase in pNN50 at T1 when compared to T0 (Mean $\text{difference}_{T1\text{-}T0} = 9.03$, $p = 0.001$) and T2 (Mean $\text{difference}_{T1\text{-}T2} = 10.01$, $p = 0.017$). There was no interaction between time and group effects.

The main group effect on LF was not statistically significant. The time effect was statistically significant and yielded an effect size of $\eta_p^2 = 0.127$, indicating that 12.7 % of variance in LF values was explained by time during experiment. However, multiple post-hoc comparisons with Bonferroni test were not anymore significant ($p > 0.05$). There was no interaction between time and group effects.

The main group effect on rrHRV was not statistically significant. The main time effect was statistically significant and yielded an effect size of $\eta_p^2 = 0.186$, indicating that 18.6 % of variance in rrHRV values was explained by time during experiment. Multiple post-hoc comparisons with Bonferroni test showed statistically significant increase in rrHRV at T1 when compared to T0 (Mean $\text{difference}_{T1\text{-}T0} = 1.03$, $p = 0.033$) and T2 (Mean $\text{difference}_{T1\text{-}T2} = 1.23$, $p = 0.027$) values. There was no interaction between time and group effects.

Friedman test was conducted to compare main effect of time (T0, T1 and T2) on RMSSD, SD1, SD1/SD2 and LF/HF in each group (TBW and rest). It showed statistically significant change for RMSSD, SD1 in TBW group and SD1/SD2 in both groups (Table 3). Pair-wise comparison with Wilcoxon signed-rank test showed significant increase ($Z = 3.2$, $p = 0.001$) in RMSSD and SD1 at T1 when compared to T0 in TBW group. There was significant increase in SD1/SD2 in both groups at T1 when compared to T0 (TBW: $Z = 3.1$, $p = 0.002$; Rest: $Z = 2.3$, $p = 0.019$) and T2 (TBW: $Z = -2.6$, $p = 0.009$; Rest: Z = -2.4, p = 0.019).

Salivary sC and sAA

Changes in sC and sAA are shown on the Fig. 2.

Mean values of sC in the TBW group ($N = 26$) were following: 3.35 (1.67) nmol/l - before TBW; 2.02 (0.81) nmol/l - 5 min after TBW and 1.68 (0.75) nmol/l - 15 min after TBW. Mean values of sC in the rest group ($N = 13$) were: 2.44 (1.04) nmol/l - before rest; 1.64 (0.51) nmol/l - 5 min after rest and 1.44 (0.57) nmol/l - 15 min after rest.

The sC values had non-normal distribution (Shapiro-Wilk test, $p < 0.05$) in both groups. There was no statistically significant difference in sC between the groups (before: $U = 119$, $p = 0.141$; 5 min after: $U = 125$,

Table 2
Physiological parameters before, during and after TBW and rest.

	Group		Physiological parameter			
			BR (rpm) Mean (SD)	HR (bpm) Mean (SD)	Trunk ST (°C) Mean (SD)	Peripheral ST (°C) Mean (SD)
Mean value measured over 5 min time window	T0	TBW (N = 26)	17.62 (2.37)	69.58 (12.88)	35.43 (0.96)	33.11 (1.29)
		Rest (*N* = 13)	17.08 (2.99)	64.15 (13.07)	35.44 (0.79)	32.98* (1.26)
	T1	TBW (N = 26)	14.42 (3.23)	60.69 (9.51)	36.48 (0.70)	32.29 (1.14)
		Rest (N = 13)	15.27 (2.14)	59.31 (11.28)	36.45 (1.05)	34.09* (0.75)
	T2	TBW (N = 26)	15.27 (3.86)	67.04 (7.89)	36.96 (0.81)	32.83 (0.89)
		Rest (N = 13)	14.42 (3.65)	65.00 (11.99)	36.96 (0.81)	34.30* (0.89)
Two-way ANOVA: F = F-Ratio *p* = *p*-value η_p^2 = Partial Eta Squared	Time (T0 vs T1 vs T2)		**F (df_{IV} = 2,df_{error} = 72) =8.922 *P* < 0.001 η_p^2 = 0.199**	**F (df_{IV} = 2,df_{error} = 74) =17.336 *P* < 0.001 η_p^2 = 0.319**	**F (df_{IV} = 2,df_{error} = 74) =105.184 *P* < 0.001 η_p^2 = 0.740**	**F (df_{IV} = 2,df_{error} = 66) =4.749 *P* = 0.012 η_p^2 = 0.126**
	Group (TBW vs Rest)		F (df_{IV} = 1,df_{error} = 36) =0.060 *P* = 0.808 η_p^2 = 0.002	F (df_{IV} = 1,df_{error} = 37) =0.747 *P* = 0.393 η_p^2 = 0.020	F (df_{IV} = 1,df_{error} = 37) =0.000 *P* = 0.987 η_p^2 = 0.000	**F (df_{IV} = 1,df_{error} = 33) =7.978 *P* = 0.008 η_p^2 = 0.195**
	Time × Group		F (df_{IV} = 2,df_{error} = 72) =0.041 *P* = 0.841 η_p^2 = 0.001	F (df_{IV} = 2,df_{error} = 74) =1.453 *P* = 0.240 η_p^2 = 0.038	F (df_{IV} = 2,df_{error} = 74) =0.052 *P* = 0.950 η_p^2 = 0.001	**F (df_{IV} = 2,df_{error} = 66) =17.406 *P* < 0.001 η_p^2 = 0.345**

Abbreviations: TBW: Therapeutic body wrap. N: number of participants concerned by the values. SD: standard deviation. BR: Breath rate. Rpm: respirations per minute. HR: heart rate. Bpm: beats per minute. ST: skin temperature. * = number of participants is 9 and not 13. T0: time before Therapeutic Body Wrap or rest. T1: time during Therapeutic Body Wrap or rest. T2: time after Therapeutic Body Wrap or rest. df_{IV} = df-independent variable. df_{error} = df-error. Bold values are statistically significant ($p < 0.05$).

$p = 0.201$; 15 min after: U = 138, 0.373, Mann-Whitney test). The main time effect was statistically significant in both groups (TBW: $X_r^2 = 40.69$ (2, $N = 26$), $p = 0.000$; Rest: $X_r^2 = 9.85$ (2, $N = 13$), $p = 0.007$). Pair-wise comparison with Wilcoxon signed-rank test showed significant decrease in sC between all three time points in both TBW (before TBW – 5 min after TBW: Z = -3.9, p = 0.000; 5–15 min after TBW: Z = -3.7, p = 0.000; before TBW – 15 min after TBW: Z = -4.3, p = 0.000) and rest (before rest – 5 min after rest: Z = -2.7, p = 0.007; 5–15 min after rest: Z = -2.2, $p = 0.028$; before rest – 15 min after rest: Z = -2.7, p = 0.007) groups (Fig. 2A).

Mean values of sAA in the TBW group ($N = 26$) were following: 202.00 (193.54) U/ml - before TBW; 282.75 (178.07) U/ml - 5 min after TBW and 197.98 (129.69) U/ml - 15 min after TBW. Mean values of sAA in the rest group ($N = 13$) were: 154.91 (113.15) U/ml - before rest; 123.80 (100.36) U/ml - 5 min after rest and 105.28 (107.43) U/ml - 15 min after rest.

The sAA values had non-normal distribution (Shapiro-Wilk test, $p < 0.05$) in both groups. There was statistically significant difference in sAA between the groups at 5 min (U = 67, $p = 0.003$, Mann-Whitney test) and 15 min (U = 75, $p = 0.005$) after TBW/rest, but not before the experiment start (U = 144, $p = 0.465$). The main time effect was statistically significant in both groups (TBW: $X_r^2 = 21.77$ (2, $N = 26$), $p = 0.000$; rest: $X_r^2 = 10.31$ (2, $N = 13$), $p = 0.006$). Pair-wise comparison with Wilcoxon signed-rank test showed significant increase in sAA 5 min after TBW when compared to before TBW (Z = 3.1, $p = 0.002$) and 15 min after TBW (Z = -3.5, $p = 0.001$). In the rest group, there was significant decrease in sAA values 15 min after rest when compared to before the start of the experiment (Z = -3.0, p = 0.002) (Fig. 2B).

Quantitative sensory testing

Part of the QST parameters' values, such as CDT, CPT, HPT, MPT, MPS and WUR, were normally distributed (Shapiro-Wilk test, $p > 0.05$) and part not (WDT, TSL, PPT, MDT, VDT). There was no statistically significant difference neither in time (Two-way repeated measures ANOVA or Wilcoxon Signed-Rank test, p > 0.05) nor between the groups (Two-way repeated measures ANOVA or Mann-Whitney p > 0.05) in any of the QST parameters (Table 4).

Discussion

Main findings

In this study, we investigated physiological reaction of the body to TBW in healthy individuals by comparing it to those having rest for the same period. First, we found that the trunk ST raised to an average of 37C° by the end of TBW. These values were like in the rest group. Concurrently, peripheral ST decreased by about 1° right after wrapping, but then recovered to initial values by the end of TBW. Participants described the cold phase as lasting about 1 min, after which they have experienced progressive warmth. These results showed that upon exposure to wet cold tissue, all participants had normal initial physiological response in peripheral skin vasoconstriction, which retarded heat loss and maintained core temperature (Castellani & Young, 2016).

Second, the QST evaluation of somatosensory pathways showed no significant changes in both thermal and mechanical parameters in healthy individuals after TBW as in rest group. Therefore, our findings do not confirm any detectable hypothermia and somatosensory changes associated with TBW in healthy subjects. Yet, it could be different in some psychiatric conditions, where thermal and pain regulation/perception may be altered. For example, bipolar or borderline personality disorders are often accompanied by thermal discomfort even at ambient temperature (Murphy, Frei, & Papolos, 2014), ASD was associated with higher thresholds for light touch detection and mechanical pain (Fründt et al., 2017; Vaughan, McGlone, Poole, & Moore, 2020) and schizophrenia was associated with increased CPT and HPT thresholds (Boettger, Grossmann, & Bär, 2013). However, QST necessitates a high degree of subject's self-awareness, therefore, could be problematic to use in certain psychiatric pathologies. Thus, an evaluation with more objective methods is necessary.

Third, we evaluated the response of HPA-axis and ANS to TBW. Our findings showed significant decrease in sC and sAA 15 min after both TBW and rest. However, in contrast to the rest group where at 5 min after experiment there was decrease in sC, sAA levels increased in TBW

Table 3
Heart rate variability parameters before, during and after TBW and rest.

	Group		HRV parameter										
			SDNN (ms) Mean (SD)	RMSSD (ms) Mean (SD)	pNN50 (%) Mean (SD)	TRI index Mean (SD)	TINN (ms) Mean (SD)	SD1 (ms) Mean (SD)	SD2 (ms) Mean (SD)	SD1/SD2 Mean (SD)	LF (%) Mean (SD)	HF (%) Mean (SD)	LF/HF Mean (SD)	rrHRV Mean (SD)
Mean value measured over 5 min time window	T0	TBW (N = 18)	76.71 (40.74)	54.06 (36.34)	24.98 (18.59)	13.51 (4.04)	195.33 (71.44)	38.23 (25.68)	100.77 (52.94)	0.37 (0.12)	50.41 (9.81)	51.63 (10.92)	1.11 (0.50)	5.25 (1.99)
		Rest (N = 13)	71.20 (25.62)	51.65 (27.41)	26.36 (20.80)	15.47 (5.75)	244.62 (104.03)	36.52 (19.36)	92.75 (33.00)	0.38 (0.15)	47.47 (8.39)	52.52 (8.38)	0.95 (0.29)	5.35 (2.32)
	T1	TBW (N = 18)	75.35 (37.11)	76.18 (60.12)	37.96 (28.01)	15.98 (8.03)	262.17 (154.41)	53.86 (42.49)	89.22 (36.71)	0.57 (0.26)	46.22 (8.79)	54.29 (9.13)	0.91 (0.35)	6.95 (4.21)
		Rest (N = 13)	66.18 (40.29)	59.44 (39.26)	31.44 (24.74)	13.52 (6.96)	211.69 (120.43)	42.03 (27.77)	82.78 (50.71)	0.53 (0.18)	44.89 (8.90)	55.11 (8.9)	0.86 (0.29)	5.71 (3.03)
	T2	TBW (N = 18)	70.56 (30.96)	54.94 (28.85)	28.37 (19.91)	13.84 (4.91)	209.55 (78.07)	38.85 (20.39)	90.86 (38.72)	0.42 (0.11)	49.99 (10.12)	50.56 (10.04)	1.08 (0.42)	5.59 (2.43)
		Rest (N = 13)	62.63 (23.03)	42.52 (20.03)	21.00 (17.02)	14.05 (4.75)	223.15 (85.13)	30.06 (14.14)	82.52 (30.10)	0.37 (0.12)	50.19 (6.43)	49.81 (6.43)	1.04 (0.27)	4.60 (1.99)
Two-way ANOVA: F = F-Ratio $p = p$-value η_p^2 = Partial Eta Squared	Time: T0 vs T1 vs T2 ANOVA: F ($df_{IV} = 2$, $df_{error} = 58$)		$F = 1.039$ $P = 0.360$ $\eta_p^2 = 0.035$	Friedman: TBW: $\mathbf{X_r^2 = 7.19\ (2, N = 18)}$ $\mathbf{P = 0.027}$ Rest: $X_r^2 = 2.46\ (2, N = 13)$ $P = 0.292$	$\mathbf{F = 8.295}$ $\mathbf{P = 0.001}$ $\mathbf{\eta_p^2 = 0.222}$	$F = 0.263$ $P = 0.770$ $\eta_p^2 = 0.009$	$F = 0.439$ $P = 0.647$ $\eta_p^2 = 0.015$	Friedman: TBW: $\mathbf{X_r^2 = 7.19\ (2, N = 18)}$ $\mathbf{P = 0.026}$ Rest: $X_r^2 = 2.86\ (2, N = 13)$ $P = 0.239$	$F = 1.472$ $P = 0.238$ $\eta_p^2 = 0.048$	Friedman: TBW: $\mathbf{X_r^2 = 7.86\ (2, N = 18)}$ $\mathbf{P = 0.020}$ Rest: $\mathbf{X_r^2 = 11.89\ (2, N = 13)}$ $\mathbf{P = 0.003}$	$\mathbf{F = 3.651}$ $\mathbf{P = 0.033}$ $\mathbf{\eta_p^2 = 0.127}$	$F = 2.004$ $P = 0.146$ $\eta_p^2 = 0.077$	Friedman: TBW: $X_r^2 = 2.07\ (2, N = 14)$ $P = 0.355$ Rest: $X_r^2 = 2.92\ (2, N = 13)$ $P = 0.232$	$\mathbf{F = 6.620}$ $\mathbf{P = 0.003}$ $\mathbf{\eta_p^2 = 0.186}$
	Group: TBW vs Rest ANOVA: F ($df_{IV} = 1$, $df_{error} = 29$)		$F = 0.474$ $P = 0.497$ $\eta_p^2 = 0.016$	Mann-Whitney: T0: $U = 128$ $P = 0.952$ T1: $U = 110$ $P = 0.352$ T2: $U = 88$ $P = 0.180$	$F = 0.321$ $P = 0.575$ $\eta_p^2 = 0.011$	$F = 0.003$ $P = 0.955$ $\eta_p^2 = 0.000$	$F = 0.022$ $P = 0.882$ $\eta_p^2 = 0.001$	Mann-Whitney: T0: $U = 128$ $P = 0.952$ T1: $U = 110$ $P = 0.352$ T2: $U = 88$ $P = 0.180$	$F = 0.352$ $P = 0.557$ $\eta_p^2 = 0.012$	Mann-Whitney: T0: $U = 122$ $P = 0.779$ T1: $U = 125$ $P = 0.696$ T2: $U = 95.5$ $P = 0.289$	$F = 0.243$ $P = 0.626$ $\eta_p^2 = 0.010$	$F = 0.018$ $P = 0.896$ $\eta_p^2 = 0.001$	Mann-Whitney: T0: $U = 114$ $P = 0.920$ T1: $U = 109$ $P = 0.459$ T2: $U = 108$ $P = 0.952$	$F = 0.572$ $P = 0.456$ $\eta_p^2 = 0.019$
	Time × Group ANOVA: F ($df_{IV} = 2$, $df_{error} = 58$)		$F = 0.066$ $P = 0.936$ $\eta_p^2 = 0.002$	–	$F = 1.586$ $P = 0.214$ $\eta_p^2 = 0.052$	$F = 1.930$ $P = 0.154$ $\eta_p^2 = 0.062$	$F = 2.323$ $P = 0.107$ $\eta_p^2 = 0.074$	–	$F = 0.011$ $P = 0.989$ $\eta_p^2 = 0.000$	–	$F = 0.404$ $P = 0.670$ $\eta_p^2 = 0.016$	$F = 0.084$ $P = 0.920$ $\eta_p^2 = 0.003$	–	$F = 1.947$ $P = 0.152$ $\eta_p^2 = 0.063$

Abbreviations: TBW: Therapeutic body wrap. HRV: Heart rate variability. SDNN: Standard deviation of the NN intervals, which represent normal (without artifacts and arrhythmic beats) RR intervals of the ECG. RMSSD: Root mean square of successive RR intervals. pNN50: Percentage of successive RR intervals that differ by >50 ms. TRI index: Integral of the density of the RR interval histogram divided by its height. TINN: Baseline width of the RR interval histogram. rrHRV: relative RR heart rate variability. SD1: Poincaré plot standard deviation perpendicular the line of identity. SD2: Poincaré plot standard deviation along the line of identity. LF: Relative power of the low-frequency band (0.04 to 0.15 Hz). HF: Relative power of the high-frequency band (0.15 to 0.4 Hz). N: number of participants concerned by the values. SD: standard deviation. T0: time before Therapeutic Body Wrap or rest. T1: time during Therapeutic Body Wrap or rest. T2: time after Therapeutic Body Wrap or rest. df_{IV} = df-independent variable. df_{error} = df-error. Bold values are statistically significant ($p < 0.05$).

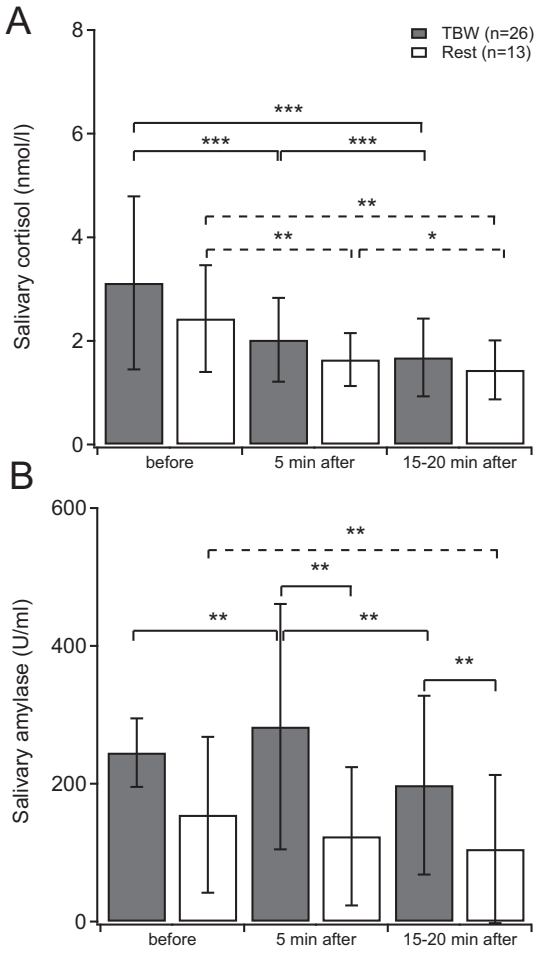

Fig. 2. Salivary cortisol and alpha-amylase concentrations in TBW and rest groups. (***A)*** Salivary cortisol measured before, 5 min and 15-20 min after TBW (grey bars) and rest (white bars). (***B)*** Salivary alpha amylase measured at the same time points as in (***A)***. Abbreviations: **TBW**, therapeutic body wraps; **n**, number of participants. Dashed lines indicating statistical tests done for the rest group and continuous lines for TBW group. Significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

group. This was probably related to the fact that participants had to stand up right after the TBW to unwrap from wet tissue, while participants in rest group remained in bed throughout the whole experiment. These data confirmed our hypothesis that TBW in healthy individuals have similar effect to other relaxation therapies, such as massage and touch (Rapaport et al., 2010), where it was also demonstrated that repeated sessions had positive cumulative effect, which persisted for several days, and profoundly depended on the frequency of sessions (Rapaport, Schettler, & Bresee, 2012). It would be interesting to test if series of TBW could have cumulative effect, especially in patients with psychotic disorders.

We also noted, that during both TBW and rest, participants were able to relax, and some fell asleep. It was accompanied by decrease in HR and BR as well as changes in HRV parameters. Analysis of HRV during TBW and rest showed significant increase in RMSSD, pNN50, SD1, SD1/SD2 ratio and rrHRV, which indicated dynamic shift towards PNS axis of the ANS (Hoshi, Pastre, Vanderlei, & Godoy, 2013) and might have been associated with non-rapid eye movement (NREM) sleep state in the participants (Ahn, 2020; Khairandish & Shapiro, 2013). Indeed, during debriefing after TBW, some participants reported experience of short sleep and/or felt calm and safe that they said resulted from being in the TBW. This echoes reports by several patients, who found themselves too agitated and described their time within TBW as a welcomed parenthesis in their daily anxiety-filled existence (Skuza et al., 2017). Similar benefit was reported by parents of ASD children treated with TBW (Chamak, 2020). Therefore, it would be interesting to investigate if TBW could optimize the ANS variables in the clinical populations with high levels of anxiety-bound psychomotor agitation, which negatively affect their ability to rest.

To our knowledge, this is the first study that evaluated physiological effects of TBW by using quantitative assessments. Our results showed usefulness of such measures as sC and HRV, which were sensitive to detect changes related to TBW. We showed that TBW was accompanied by progressive warming of the body and decreased stress levels in healthy participants. These data did not support theoretical speculations about hypothermia and heart attacks during TBW, which caused critical attitudes towards TBW (Spinney, 2007).

Limitations

The results obtained in this study are subject to biases and confounding factors and should be interpreted with caution. Recruitment difficulties caused by COVID-19 pandemic and imposed regulations, did not allow us to have equal number of participants in groups, which could affect statistical significance of certain parameters. Larger samples and tests should be applied to investigate the effects of TBW in the future studies.

Implications for practice

Although conducted with healthy participants, this study provides several novel and relevant insights for psychiatric nurses. Our results brought several complementary elements towards an objective confirmation of TBW's harmlessness in healthy individuals. Beyond harmlessness, TBW also appear to have a direct impact on two mechanisms underlying anxiety in humans, namely, HPA axis activity and cardio-autonomic response, which potentially represents several advantages over current psychopharmacological treatments such as benzodiazepines. Therefore, nurses may want to use TBWs both as a harmless and potentially effective nondrug anxiolytic technique and as a relational setting that creates a privileged space and time for care, which can hardly be offered by the activity of dispensing a drug. Thus, our data may encourage the use of TBW in the nursing clinic concerned with providing an anchor in scientific evidence and reinforce the value of psychiatric nursing as potentially as curative as is sometimes acknowledged about anxiolytic psychopharmacology, whose ability to decrease HPA axis activity is well documented (Tafet, 2020), yet without the notorious and increasingly feared side effects of benzodiazepines, among them addiction (Smith, 1990). Furthermore, research shows that when medication is offered alone without other forms of therapy, the rate of initial refusal and that of early termination of treatment by the patient is up to more than three times higher compared to treatment plans that combine non-drug interventions with medication (Swift, Greenberg, Tompkins, & Parkin, 2017). Also, most importantly for clinical nurses, TBW can be perceived by the patient as a means to enhance their action in their illness control, as reported by Skuza et al., 2017(Skuza et al., 2017), which could be creatively used by nurses as part of a medication discontinuation strategy while still providing anxiolytic protection. Finally, the use of TBW as a specific anxiolytic nursing intervention could contribute to reinforce the specific/own professional role of nurses by placing the patient and their resources and the therapeutic interaction with the nurse at the center, not the substance.

Based on these data, which are in line with clinical observations, TBW might be used in patients, who are unable to have rest by themselves and/or without anxiolytic medication. However, TBW should be first explored in these different psychiatric conditions by comparing single to multiple TBW interventions and to other standard interventions in this clinical domain. Therefore, further studies are necessary to

Table 4
Quantitative sensory testing parameters (z-scores) before and after TBW and rest.

	Group		QST parameter											
			CDT Mean (SD)	WDT Mean (SD)	TSL Mean (SD)	PHS Mean (SD)	CPT Mean (SD)	HPT Mean (SD)	PPT Mean (SD)	MPT Mean (SD)	MPS Mean (SD)	DMA Mean (SD)	WUR Mean (SD)	MDT Mean (SD)	VDT Mean (SD)
z-score	T0	TBW (N = 26)	−0.686 (1.128)	−0.135 (1.004)	−0.757 (1.013)	0	0.650 (0.956)	1.148 (1.094)	−1.441 (0.826)	0.571 (0.831)	0.882 (1.730)	0	−0.479 (1.207)	−0.654 (0.588)	−2.295 (1.985)
		Rest (N = 13)	−0.284 (0.609)	−0.117 (0.955)	−0.563 (0.399)	0	0.381 (0.749)	0.907 (0.833)	−1.276 (0.705)	0.256 (0.706)	0.255 (0.705)	0	−0.478 (1.478)	−0.433 (0.723)	−1.827 (1.344)
	T2	TBW (N = 26)	−0.760 (1.075)	−0.591 (0.978)	−0.598 (1.168	0	0.558 (1.041)	0.968 (1.004)	−1.626 (1.064)	0.414 (0.759)	0.508 (1.615)	0	−0.132 (1.278)	−0.558 (0.716)	−2.683 (1.694)
		Rest (N = 13)	−0.637 (1.086)	−0.564 (0.693)	−0.760 (0.703)	0	0.719 (0.839)	0.953 (0.688)	−1.435 (1.019)	0.624 (1.722)	0.624 (1.722)	0	−0.472 (1.281)	−0.315 (0.759)	−2.155 (1.757)
Two-way ANOVA: F-Ratio = F (df_{IV} = 1, df_{error} = 37) p = p-value η_p^2 = Partial Eta Squared	Time: T0 vs T2		F = 1.281 P = 0.256 η_p^2 = 0.033	Wilcoxon Signed-Rank: TBW: Z = -1.54 P = 0.124 Rest: Z = -1.76 P = 0.077	Wilcoxon Signed-Rank: TBW: Z = -0.65 P = 0.515 Rest: Z = -1.29 P = 0.197	– – –	F = 0.117 P = 0.734 η_p^2 = 0.003	F = 1.884 P = 0.178 η_p^2 = 0.048	Wilcoxon Signed-Rank: TBW: Z = -1.54 P = 0.121 Rest: Z = -0.78 P = 0.435	F = 0.271 P = 0.606 η_p^2 = 0.007	F = 0.000 P = 0.989 η_p^2 = 0.000	– – –	F = 0.772 P = 0.385 η_p^2 = 0.020	Wilcoxon Signed-Rank: TBW: Z = -0.58 P = 0.561 Rest: Z = -0.13 P = 0.896	Wilcoxon Signed-Rank: TBW: Z = -1.75 P = 0.080 Rest: Z = -1.15 P = 0.250
	Group: TBW vs Rest		F = 0.783 P = 0.382 η_p^2 = 0.021	Mann-Whitney: T0: U = 168 P = 0.124 T2: U = 153 P = 0.645	Mann-Whitney: T0: U = 149 P = 0.562 T2: U = 159 P = 0.779	– – –	F = 0.616 P = 0.438 η_p^2 = 0.016	F = 0.639 P = 0.429 η_p^2 = 0.017	Mann-Whitney: T0: U = 139 P = 0.379 T2: U = 147 P = 0.529	F = 0.038 P = 0.847 η_p^2 = 0.001	F = 0.272 P = 0.605 η_p^2 = 0.007	– – –	F = 0.188 P = 0.667 η_p^2 = 0.005	Mann-Whitney: T0: U = 137 P = 0.347 T2: U = 143 P = 0.441	Mann-Whitney: T0: U = 145 P = 0.484 T2: U = 143 P = 0.441
	Time × Group		F = 0.549 P = 0.463 η_p^2 = 0.015	–	–	– – –	F = 0.064 P = 0.802 η_p^2 = 0.002	F = 0.001 P = 0.974 η_p^2 = 0.000	–	F = 1.680 P = 0.203 η_p^2 = 0.043	F = 3.133 P = 0.085 η_p^2 = 0.078	– – –	F = 0.721 P = 0.401 η_p^2 = 0.019	–	–

Abbreviations: QST: quantitative sensory testing. CDT: cold detection threshold. WDT: warm detection threshold. TSL: thermal sensory limen. PHS: paradoxical heat sensation. CPT: cold pain threshold. HPT: heat pain threshold. PPT: pressure pain threshold. MPT: mechanical pain threshold. MPS: mechanical pain sensitivity. DMA: dynamic mechanical allodynia. WUR: wind up ratio. MDT: mechanical detection threshold. VDT: vibration detection threshold. Normative range: $-1.96 <$ z-score $< +1.96$. N: number of participants concerned by the values. SD: standard deviation. TBW: Therapeutic Body Wrap. T0: time before Therapeutic Body Wrap or Rest. T2: time after Therapeutic Body Wrap or Rest. df_{IV} = df-independent variable. df_{error} = df-error. U: test statistic for the Mann Whitney Test. Z: critical value for the Wilcoxon Signed-Rank Test.

investigate physiological response to TBW in clinical populations.

Abbreviations

TBW	Therapeutic Body Wraps
ASD	autism spectrum disorder
sC	salivary cortisol
sAA	salivary alpha-amylase
HPA	hypothalamic-pituitary-adrenal
HRV	heart rate variability
rrHRV	relative hear rate variability
QST	quantitative sensory testing
EuroQoL EQ-5D-3L	European Quality of Life 5 dimensions and 3 lines
DOLBaPP	Delphi Definitions of Low Back Pain Prevalence
HADS	Hospital Anxiety and Depression Scale
BR	breath rate
Rpm	respirations per minute
ECG	electrocardiogram
HR	heart rate
Bpm	beats per minute
ST	skin temperature
SEM	sensor electronic module
ANS	autonomous nervous system
SDNN	standard deviation of normal RR intervals
RMSSD	root mean square of successive RR intervals
pNN50	percentage of successive RR intervals that differ by >50 ms
TRI	triangular index
TINN	triangular interpolation
LF	low frequency
SNS	sympathetic nervous system
HF	high frequency
PNS	parasympathetic nervous system
SD	standard deviation
CDT	cold detection threshold
WDT	warm detection threshold
CPT	cold pain threshold
HPT	heat pain threshold
TSL	thermal sensory limen
PHS	paradoxical heat sensation
MDT	mechanical detection threshold
MPT	mechanical pain threshold
WUR	wind-up ratio
VDT	vibration detection threshold
PPT	pressure pain threshold
MPS	mechanical pain sensitivity
DMA	dynamic mechanical allodynia
NREM	non-rapid eye movement

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CRediT authorship contribution statement

Natalya Korogod (NKO), Krzysztof Skuza (KSK), Gilles Bangerter (GBA) and Emmanuelle Opsommer (EOP) contributed to the conception or design of the study, data analysis, and interpretation of data, writing, and checking the article for important intellectual content. NKO, KSK and GBA performed experiments.

Ethical statement

The study was approved by the local Ethics Committee (ID 2018-01615).

Author disclosure statement

All authors have nothing to disclose.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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References

Ahn, J. (2020). *Heart Rate Variability Assessment Using the Poincare Plot Parameters During Sleep*.

Belle, G.v. (2008). Sample size. In G. M. Fitzmaurice, I. M. Johnstone, G. Molenberghs, D. W. Scottt, A. F. M. Smith, R. S. Tsay, S. Weisberg, & C. N. A. C. D. J. Balding (Eds.), *Statistical rules of thumb* (2nd ed., pp. 27–64). John Wiley&Sons, Inc.

Boettger, M. K., Grossmann, D., & Bär, K. J. (2013). Increased cold and heat pain thresholds influence the thermal grill illusion in schizophrenia. *European Journal of Pain, 17*(2), 200–209. https://doi.org/10.1002/j.1532-2149.2012.00188.x

Bovier, P., & Brandli, H. (1979). L'enveloppement humide: Une tentative d'approche de la psychose. *L'Information Psychiatrique, 55*(7), 771–782.

Castellani, J. W., & Young, A. J. (2016). Human physiological responses to cold exposure: Acute responses and acclimatization to prolonged exposure. *Autonomic Neuroscience, 196*, 63–74. https://doi.org/10.1016/j.autneu.2016.02.009

Chamak, B. (2019). Lobbying by association: The case of autism and the controversy over packing therapy in France. *Social Science & Medicine, 230*, 256–263. https://doi.org/10.1016/j.socscimed.2019.04.027

Chamak, B. (2020). Packing: Quand des parents témoignent. *Neuropsychiatrie de l'Enfance et de l'Adolescence, 68*(7), 339–346. https://doi.org/10.1016/j.neurenf.2020.08.001

Cohen, D., & N. L. P. D. D. L. J. C. K. A. C. A. G. J. M. M. A. D. N.. (2009). Investigating the use of packing therapy in adolescents with catatonia: A retrospective study. *Clinical Neuropsychiatry, 6*(1), 29–34.

Delion, P., Labreuche, J., Deplanque, D., Cohen, D., Duhamel, A., Lallié, C., Ravary, M., Goeb, J.-L., Medjkane, F., Xavier, J., & Therapeutic Body Wrap Study G.. (2018). Therapeutic body wraps (TBW) for treatment of severe injurious behaviour in children with autism spectrum disorder (ASD): A 3-month randomized controlled feasibility study. *PLoS One, 13*(6), Article e0198726. https://doi.org/10.1371/journal.pone.0198726

Devillers, A. C., & Oranje, A. P. (2012). Wet-wrap treatment in children with atopic dermatitis: A practical guideline. *Pediatric Dermatology, 29*(1), 24–27. https://doi.org/10.1111/j.1525-1470.2011.01691.x

Dionne, C. E., Dunn, K. M., Croft, P. R., Nachemson, A. L., Buchbinder, R., Walker, B. F., Wyatt, M., Cassidy, J. D., Rossignol, M., Leboeuf-Yde, C., Hartvigsen, J., Leino-Arjas, P., Latza, U., Reis, S., Gil Del Real, M. T., Kovacs, F. M., Oberg, B., Cedraschi, C., Bouter, L. M., … Von Korff, M. (2008). A consensus approach toward the standardization of back pain definitions for use in prevalence studies. *Spine (Phila Pa 1976), 33*(1), 95–103. https://doi.org/10.1097/BRS.0b013e31815e7f94

Fründt, O., Grashorn, W., Schöttle, D., Peiker, I., David, N., Engel, A. K., Forkmann, K., Wrobel, N., Münchau, A., & Bingel, U. (2017). Quantitative sensory testing in adults with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 47*(4), 1183–1192. https://doi.org/10.1007/s10803-017-3041-4

Hoshi, R. A., Pastre, C. M., Vanderlei, L. C. M., & Godoy, M. F. (2013). Poincaré plot indexes of heart rate variability: Relationships with other nonlinear variables. *Autonomic Neuroscience, 177*(2), 271–274. https://doi.org/10.1016/j.autneu.2013.05.004

Khairandish, A., & Shapiro, C. M. (2013). Peripheral nervous system and sleep. In C. A. Kushida (Ed.), *Encyclopedia of sleep* (pp. 494–502). Academic Press. https://doi.org/10.1016/B978-0-12-378610-4.00105-4.

Magerl, W., Krumova, E. K., Baron, R., Tölle, T., Treede, R. D., & Maier, C. (2010). Reference data for quantitative sensory testing (QST): Refined stratification for age and a novel method for statistical comparison of group data. *Pain, 151*(3), 598–605. https://doi.org/10.1016/j.pain.2010.07.026

Murphy, P. J., Frei, M. G., & Papolos, D. (2014). Alterations in skin temperature and sleep in the fear of harm phenotype of pediatric bipolar disorder. *Journal of Clinical Medicine, 3*(3), 959–971. https://doi.org/10.3390/jcm3030959

Nunan, D., Sandercock, G. R., & Brodie, D. A. (2010). A quantitative systematic review of normal values for short-term heart rate variability in healthy adults. *Pacing and Clinical Electrophysiology, 33*(11), 1407–1417. https://doi.org/10.1111/j.1540-8159.2010.02841.x

Opsommer, E., Dubois, J., Bangerter, G., Panchaud, R., Martin, D., & Skuza, K. (2016). Therapeutic body wraps in Swiss public adult acute inpatient wards. A retrospective descriptive cohort study. *Journal of Psychiatric and Mental Health Nursing, 23*, 207–216.

Perneger, T. V., Combescure, C., & Courvoisier, D. S. (2010). General population reference values for the french version of the EuroQol EQ-5D health utility

instrument. *Value in Health, 13*(5), 631–635. https://doi.org/10.1111/j.1524-4733.2010.00727.x

Petrowski, K., Herold, U., Joraschky, P., Wittchen, H. U., & Kirschbaum, C. (2010). A striking pattern of cortisol non-responsiveness to psychosocial stress in patients with panic disorder with concurrent normal cortisol awakening responses. *Psychoneuroendocrinology, 35*(3), 414–421. https://doi.org/10.1016/j.psyneuen.2009.08.003

Rapaport, M. H., Schettler, P., & Breese, C. (2010). A preliminary study of the effects of a single session of Swedish massage on hypothalamic-pituitary-adrenal and immune function in normal individuals. *Journal of Alternative and Complementary Medicine, 16*(10), 1079–1088. https://doi.org/10.1089/acm.2009.0634

Rapaport, M. H., Schettler, P., & Bresee, C. (2012). A preliminary study of the effects of repeated massage on hypothalamic-pituitary-adrenal and immune function in healthy individuals: A study of mechanisms of action and dosage. *Journal of Alternative and Complementary Medicine, 18*(8), 789–797. https://doi.org/10.1089/acm.2011.0071

Rolke, R., Baron, R., Maier, C., Tölle, T. R., Treede, D. R., Beyer, A., Binder, A., Birbaumer, N., Birklein, F., Bötefür, I. C., Braune, S., Flor, H., Huge, V., Klug, R., Landwehrmeyer, G. B., Magerl, W., Maihöfner, C., Rolko, C., Schaub, C., … Wasserka, B. (2006). Quantitative sensory testing in the german research network on neuropathic pain (DFNS): Standardized protocol and reference values. *Pain, 123*(3), 231–243. https://doi.org/10.1016/j.pain.2006.01.041

Rolke, R., Magerl, W., Campbell, K. A., Schalber, C., Caspari, S., Birklein, F., & Treede, R. D. (2006). Quantitative sensory testing: A comprehensive protocol for clinical trials. *European Journal of Pain, 10*(1), 77–88. https://doi.org/10.1016/j.ejpain.2005.02.003

Ross, D. R., Lewin, R., Gold, K., Ghuman, H. S., Rosenblum, B., Salzberg, S., & Brooks, A. M. (1988). The psychiatric uses of cold wet sheet packs. *The American Journal of Psychiatry, 145*(2), 242–245.

Shaffer, F., & Ginsberg, J. P. (2017). An overview of heart rate variability metrics and norms. *Frontiers in Public Health, 5*, 258. https://doi.org/10.3389/fpubh.2017.00258

Silver, A.-L. (2000). The 2000 Frieda fromm-reichmann lecture. The current relevance of fromm-Reichmann's works. *Psychiatry, 63*(4), 308–322.

Skuza, K., Bangerter, G., & Dubois, J. (2017). 'It's the first time I feel as one'. Patients' experience of therapeutic body wraps in swiss public adult inpatient psychiatric wards. *Archives of Psychiatric Nursing, 31*, 359–364.

Smith, D. E. L. M. J. (1990). Benzodiazepine dependency discontinuation: Focus on the chemical dependency detoxification setting and benzodiazepine-polydrug abuse. *Journal of Psychiatric Research: Supplement, 2*(24), 145–156.

Spinney, L. (2007). Therapy for autistic children causes outcry in France. *Lancet, 370*(9588), 645–646. https://doi.org/10.1016/s0140-6736(07)61322-1

Swift, J. K., Greenberg, R. P., Tompkins, K. A., & Parkin, S. R. (2017). Treatment refusal and premature termination in psychotherapy, pharmacotherapy, and their combination: A meta-analysis of head-to-head comparisons. *Psychotherapy (Chicago, Ill.), 54*(1), 47–57. https://doi.org/10.1037/pst0000104

Tafet, G. E. N. C. B. (2020). Pharmacological treatment of anxiety disorders: The role of the HPA Axis. *Front. Psychiatry Frontiers in Psychiatry, 11*.

Vaughan, S., McGlone, F., Poole, H., & Moore, D. J. (2020). A quantitative sensory testing approach to pain in autism spectrum disorders. *Journal of Autism and Developmental Disorders, 50*(5), 1607–1620. https://doi.org/10.1007/s10803-019-03918-0

Vollmer, M. (2019). *HRVTool – An Open-source Matlab Toolbox for Analyzing Heart Rate Variability. 2019*. Computing in Cardiology (CinC).

World Medical Association. (2001). World medical association declaration of Helsinki. Ethical principles for medical research involving human subjects. *Bulletin of the World Health Organization, 79*(4), 373–374. https://apps.who.int/iris/handle/10665/268312.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica, 67*(6), 361–370. https://doi.org/10.1111/j.1600-0447.1983.tb09716.x