

**CORE TEMPERATURE AND PERCEPTIONS  
OF AQUATEX HYDROWEAVE™ VEST  
WHILE WEARING A PROTECTIVE BARRIER SUIT**

Project Date: September 1-15, 1999

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**CORE TEMPERATURE AND PERCEPTIONS OF  
AQUATEX HYDROWEAVE™ VEST WHILE WEARING A PROTECTIVE BARRIER SUIT****Introduction:**

Our previous research project revealed that rectal temperatures significantly ( $p \leq 0.01$ ) increased in a linear pattern throughout the trial for all three test conditions (CV: cold activated vest, TV: tap water activated vest, and NV: no vest trials) with the protective barrier suit (PBS). This was expected due to the increase in heat storage resulting from the exercise (intensity, duration) and barrier effect created by the Tyvek® coveralls. The rectal temperatures were not significantly different ( $p \geq 0.05$ ) between trials (NV, TV, and CV) for the first 15 minutes. At 20 minutes, NV was significantly warmer than CV ( $p \leq 0.05$ ) and TV ( $p \leq 0.01$ ). Thereafter (25-30 minutes) TV and CV were similar but significantly different ( $p \leq 0.01$ ) than NV. The lower rectal temperature for the TV in comparison to the CV trial is not unexpected. The colder mean skin temperatures in the CV vest trial causes a vasoconstriction of the skin, thereby retaining the warmer core blood flow centrally and reducing the dissipation of heat to the periphery and surrounding environment.

The purpose of this investigation was to determine the work time to reach core temperature (WTCT) while wearing Tyvek® protective barrier coveralls and either the tap water activated vest or no vest. WTCT was defined as the work time required to increase the core temperature by 2°C (3.6°F). A resting, non-thermally stressed core temperature is usually maintained at 37°C (98.6°F), but can range from 36.6° to 37.4°C. Therefore, the termination of these experimental trials will be from 38.6°C (97.88°F) to 39.4°C (102.9°F) depending on the individuals' resting core temperature.

**EXPERIMENTAL METHODS:**

*Subject Population:* Eight males subjects ages 19-48 years of age were recruited. Male subjects were chosen as requested by company officials because this represents the market that AquaTex Industries plans to introduce their product. All prospective subjects completed a Par-Q Physical Activity Readiness Questionnaire to help screen individuals with potential health problems that posed a risk to the individual during the research testing. If there were no contraindications to exercise or problems associated with

heat and cold they were allowed to participate. Prior to participating in any trials, all subjects read and signed the University approved informed consent.

*Experimental Methods and Study Design:* After the consent form had been signed, the subjects were given an opportunity to familiarize themselves to their experimental treadmill speed and elevation used during the trial. All test trials were separated by at least 24 hours and subjects were reminded to drink at least 500 ml ( $\frac{1}{2}$  liter or 20 ounces) of water one hour prior to the trial to assure a state of euhydration (no dehydration prior to trial). In this experiment, changes in the hydration status and body weight can have profound effects on the thermal responses of the subjects and interpretation of the data.

Prior to all vest trials, the vests were prepared for the experimental procedures as indicated on the AquaTex ["Care and Use"](#) instruction sheet on the web site page (See Appendix). The pre-trial temperature of the tap water activated vest trials (TV) was approximately 20°C ( $\approx$ 68°F). The test vests were given to the subjects after the experimental trials.

In this experimental design, eight subjects participated in trials in which a Tyvek® protective barrier suit (PBS) was worn during the testing sessions. The workload in these trials was maintained at a moderate walking level on the treadmill (3.5 mph, 6% grade incline) until their core temperature rose 2.0°C. Subjects were not allowed to begin the experimental trial unless their resting core temperature was between 36.6°C and 37.4°C. Two randomized trials were performed: NV- no vest, no shirt under the PBS and TV- tap water treated vest under PBS. The trials were randomized to avoid the possibility of creating an "order effect" as influenced by the sequencing of the trials.

The temperature of the heat chamber was maintained at approximately 31°C ( $\approx$ 80-85°F) and relative humidity between 50-55%. Prior to and after each trial the subjects were weighed nude to the nearest 0.01 kilogram. Throughout the trial, the subjects' core temperature (rectal) were monitored and recorded by a Grant data logger. A rating of perceived exertion (Borg RPE Scale) was obtained every 10 minutes of the PBS trial. Clothing (vest) comfort was determined from visual analog scales which measured the perceptual responses to comfort, temperature, and wetness. A differential synonym Likert type scale was used to determine the skin comfort/discomfort, sweating response, and skin temperature.

## RESULTS/DISCUSSION

### A. Vest Activation

Prior to all vest trials, the vests were prepared for the experimental procedures as indicated on the AquaTex Industries "[Care and Use](#)" instruction sheet on the web site page. The TV vests were activated with tap water 20°C (68°F). This was slightly cooler than the temperature used in the previous AquaTex investigation (-5°C, 9°F).

### B. Physiological Responses

The subject's work time to core temperature (WTCT) in the NV trial was  $57.31 \pm 8.7$  minutes as compared to TV  $68.62 \pm 8.24$  minutes (See [Figure 1](#)). This represents a 16.4% increase in work time prior to reaching trial termination as defined as a 2°C increase in core temperature. On average, the Hydroweave™ Vest prolonged the trial by an average of 11.25 minutes. One subject performed 2 minutes less work, while the remaining subjects demonstrated increases in work time up to 26 minutes. Rectal temperatures for the first 40 minutes of the trial are presented in [Table 1](#). No statistical analyses are provided for core temperatures after 40 minutes due to the elimination of some subjects as they reached their pre-determined core termination temperature. The response of the rectal core temperatures throughout the experimental trials is presented in [Figure 2](#).

Figure 1: Work Time to Core Temperature

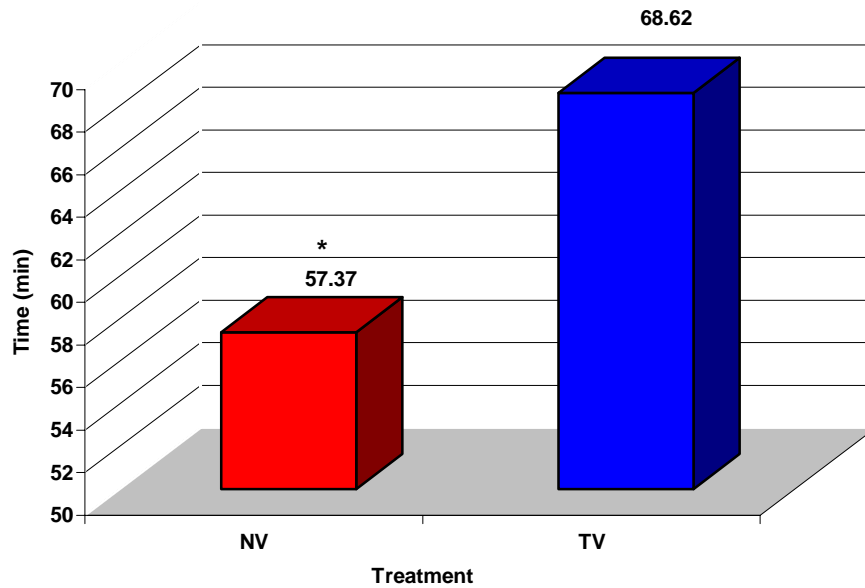


Figure 2: Core Temperature

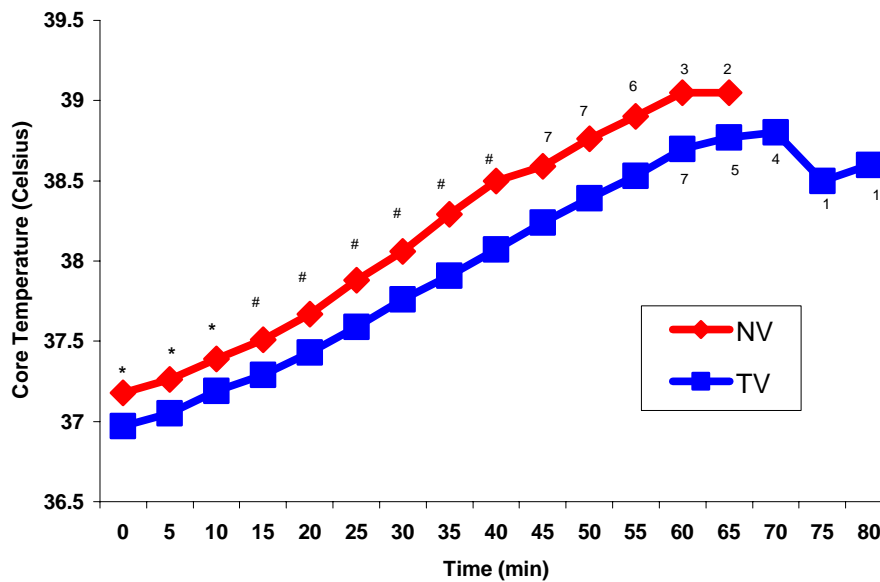


Figure Legend:

\* Significant difference between trials at the  $p \geq 0.05$  level.

# Significant difference between trials at the  $p \geq 0.01$  level.

Numbers above the data points represents the number of subjects remaining in that experimental trial.

**Table 1: Rectal Core Temperatures During the Initial 40 Minutes of PBS Trial**

	Time (min)								
	0	5	10	15	20	25	30	35	40
<b>NV</b>	37.17	37.26	37.38	37.51	37.66	37.87	38.06	38.29	38.50
<b>TV</b>	36.96*	37.05*	37.19*	37.28#	37.42#	37.59#	37.75#	37.90#	38.06#

\* Significant difference ( $p \geq 0.05$ ) between trials.

# Significant difference ( $p \geq 0.01$ ) between trials.

Data and statistics are not provided after 40 minutes because of the elimination of subjects due to WTCT.

Body weight was significantly reduced pre to post trials, but no statistical difference was observed between the NV and TV trial for either the pre or post nude weigh-ins (See [Figure 3](#)). This non-significance in body weight is interesting when one considers that the subjects during the TV trial performed longer (mean 11.25 minutes), thereby increasing the amount of heat stored.

The heart rate during the TV trial was significantly lower ( $p \geq 0.05$ , 20-30 minutes;  $p \geq 0.01$ , 35-40 minutes) as compared to the NV test condition (See [Table 2](#)). No statistical analyses are provided for trials after 40 minutes when some subjects ceased to participate after reaching their pre-determined termination core temperature. Heart rates throughout the experimental trials are presented in [Figure 4](#).

**Table 2: Heart Rates (bpm) During the Initial 40 Minutes of PBS Trial**

	Time (min)								
	0	5	10	15	20	25	30	35	0
<b>NV</b>	95.25	112.50	121.50	126.12	133.75	140.37	146.37	53.50	157.37
<b>TV</b>	96.62	107.00	113.75	119.25	124.00*	130.12*	136.12*	141.00#	145.50#

\* Significant difference ( $p \geq 0.05$ ) between trials.

# Significant difference ( $p \geq 0.01$ ) between trials.

Data and statistics are not provided after 40 minutes because of elimination of subjects due to WTCT.

Figure 3: BODY WEIGHT LOSS

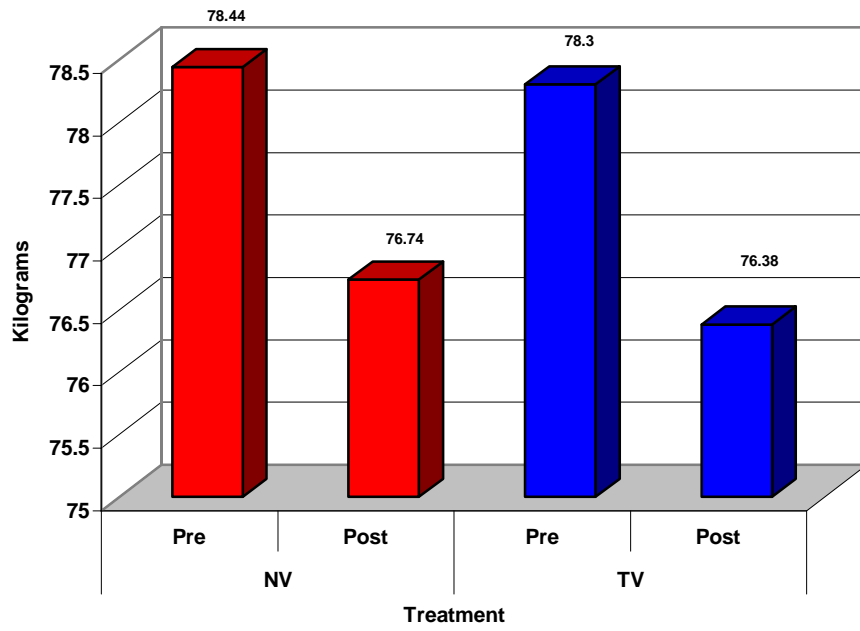
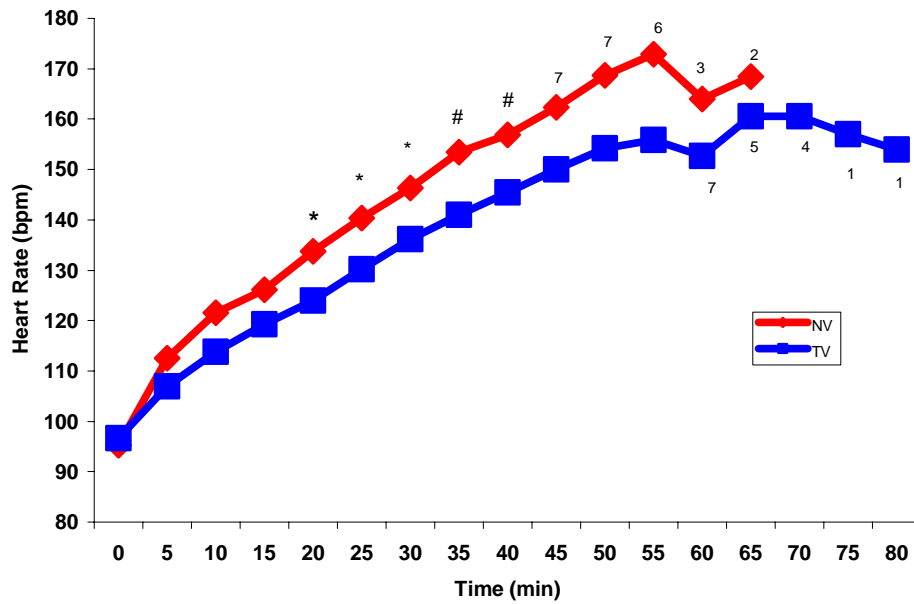


Figure 4: Heart Rate Response



Subject's perceived the TV work trial to be less stressful at all comparable time periods after 10 minutes (See [Table 3](#)). This difference in perception of physical exertion was significantly greater at 30 minutes ( $p \geq 0.05$ ) and 40 minutes ( $p \geq 0.01$ ). No statistical analyses were performed on the data after 40 minutes, as subjects were eliminated from the testing procedures after this time as they reached their pre-determined termination core temperature. The ratings of perceived exertion taken every 10 minutes throughout the trials are presented in [Figure 5](#).

**Table 3: Borg Rating of Perceived Exertion During Initial 40 Minutes of PBS Trial**

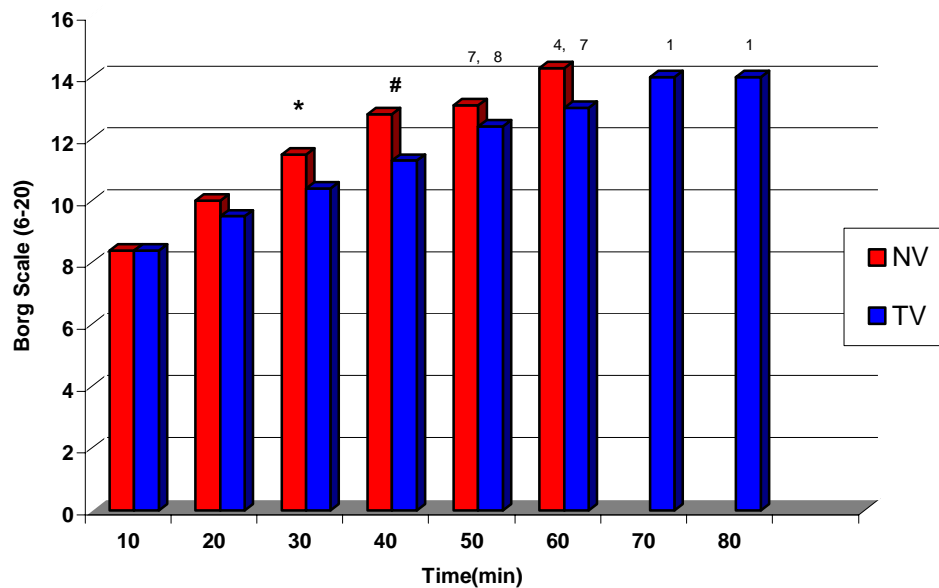
	Time (min)			
	10	20	30	40
<b>NV</b>	8.37	10.00	11.50	12.75
<b>TV</b>	8.37	9.50	10.37*	11.25#

\* Significant difference ( $p \geq 0.05$ ) between trials.

# Significant difference ( $p \geq 0.01$ ) between trials.

Data and statistics are not provided after 40 minutes because of subjects eliminated due to WTCT.

**Figure 5: Rating of Perceived Exertion**





### C. Comfort Perceptions

There was a tendency ( $p=0.083$ ) for subjects to perceive less discomfort during the TV trial as compared to the NV trial condition. The comfort/discomfort rating is based on a scale in which "0" represents comfort and "10" represents discomfort. The subject's perceived comfort/discomfort rating is presented in [Figure 6](#).

The subjects perceived significantly ( $p\geq 0.05$ ) less moisture/wetness during the TV trials as compared to the NV experimental condition. This might be attributed to a wicking effect of the Hydroweave™t or the vest providing a barrier that kept the PBS from "sticking" to the wet skin. The subject's perceived wetness is presented in [Figure 7](#).

No significant difference was reported by the subjects for perceived differences in the temperature within the PBS. Previous investigations using similar experimental protocols have demonstrated that the temperature and humidity rises quickly while wearing a PBS. It is not uncommon to observe relative humidity within the suit of 97-99% and temperatures of 37-38°C experimental trial.

The subjects perceived the last 0.5°C increase in termination core temperature as stressful in both TV and NV trials. This perceived stress was not influenced by the vest nor the difference in trial duration (longer trials for TV).

Figure 6: PERCEIVED DISCOMFORT

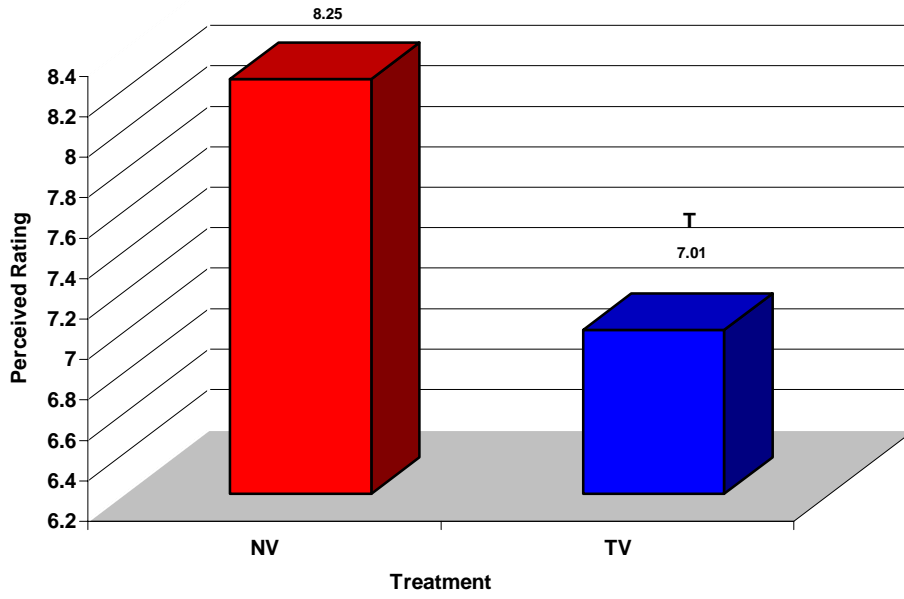


Figure 7: PERCEIVED MOISTURE WITHIN PBS

