Thermoneutral Environment of Hybrid Farm Piglets

Samantha Burnham’04 and Jill Cheeseman

Abstract

Researchers use piglets to examine defects within the brain stem that may be associated with Sudden Infant Death Syndrome (SIDS). These brain abnormalities are often manifested in irregular breathing patterns, and the correlation between breathing patterns and SIDS is being studied extensively. However, other conditions such as temperature can also induce irregular breathing patterns, which can therefore interfere with such research. This study establishes thermoneutral temperatures for piglets of various sizes and ages at which oxygen consumption (VO2) is lowest, thereby minimizing external variables in the analysis of breathing patterns. It was found that the thermoneutral temperature decreased with increasing piglet size. Specific ideal temperatures for various piglet weight groups were generated as a future reference for researchers using piglets to study SIDS.

INTRODUCTION

Understanding the complexities of Sudden Infant Death Syndrome (SIDS), the leading cause of death among children under 1 year of age in the United States, has been the goal of many researchers since the mid 1970’s (Bergman, 1986). A number of hypotheses have been made, including the idea of an association between SIDS and abnormalities in certain areas of the brain stem. The specific region being investigated, the arcuate nucleus region within the rostral ventral medulla (RVM), is involved in control mechanisms of breathing, heart rate, blood pressure, and thermoregulation. Abnormalities within this region, such as decreased numbers of neurotransmitter binding sites, have been found in SIDS victims and are thought to influence the victims’ abilities to respond correctly to normal conditions (hypoxia and hypercapnia for example). SIDS researchers are currently studying the normal responses to these onsets, including gasping or sleep arousal, and comparing them to the responses found in subjects with RVM abnormalities. The breathing patterns of Hybrid Farm piglets both with and without induced brain stem abnormalities are being examined to find imitations of human responses and to help understand this tragic and mysterious syndrome.

Within these studies of brain stem irregularities, other hypotheses are being taken into consideration. Conditions such as hyper- and hypothermia alter breathing patterns, and therefore it is important to regulate temperature conditions during experiments involving brain stem abnormalities. Hyperthermic conditions can potentially cause inhibition of breathing by increased panting or gasping as the piglet’s heat-dissipating system is exceeded (Stanier et al., 1984). During hypothermia metabolism is used to maintain body temperature and as metabolic rate increases in efforts to warm the body, breathing and heart rate increase as well. Metabolic rate can be measured by oxygen consumption (VO2), where greater VO2 values indicate a greater metabolic rate. Due to the effect metabolic rate has on breathing patterns, environmental temperature has become an important factor in the analysis of breathing abnormalities within SIDS studies. When examined at non-controlled temperatures, the piglets used for brain stem studies may not only experience breathing defects from the induced RVM abnormalities, but possibly from being tested at temperatures that cause their metabolic rate to increase. The environmental temperature range at which the piglets require no additional energy to maintain body temperature, referred to as the thermoneutral temperature range, would be the ideal temperature at which to perform SIDS experiments. This temperature range, which would differ for piglets of various sizes and ages, would eliminate any skewed breathing patterns due to overheating or excessive cooling. The thermoneutral zone for piglets of different sizes and ages has not yet been determined but would provide beneficial and important information for future SIDS experiments using piglets.

Our goal was to determine the thermoneutral temperature range for piglets of various ages and
weights. This temperature zone is bordered by an upper and lower critical temperature (Stanier et al., 1984), which we determined for the larger and smaller piglets respectively. With the lower critical temperature established for the smaller piglets, SIDS researchers will know the minimum temperature at which that sized piglet reaches minimal VO2, or lowest metabolic rate, while insuring the maintenance of body warmth during this sensitive developmental stage. For larger piglets, the upper critical temperature will give the researchers the maximum temperature at which the piglets reach lowest VO2 without overheating the piglets (who can more easily self-regulate body temperature).

METHODS

Twenty-six piglets between the ages of 1 and 16 days of age were studied in a whole-body plethysmograph. Each piglet was chosen from the litter the morning of the experiment, and once the experiment had been completed, was returned to its siblings and mother sow to maintain a more natural and comfortable environment.

Equipment Preparation

Prior to each experiment the plethysmograph was equilibrated for 45 minutes to allow stabilization of water bath temperatures, box pressures, and gas concentrations. Using a computer program, the continual recording of all plethysmograph conditions was made. Calibrations for the O2 Analyzer, CO2 Analyzer, and box pressure were tested once the 45 minutes was complete. The piglets were tube fed piglet formula, and a rectal probe, the only invasive instrument used, returned to its siblings and mother sow to maintain a more natural and comfortable environment.

Table 1. Group Pig Temperatures

<table>
<thead>
<tr>
<th>Group #</th>
<th>Weight Range (kg)</th>
<th>Temperature Range (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5 - 2.0</td>
<td>26.5,27.5,28,29.5,30</td>
</tr>
<tr>
<td>2</td>
<td>2.1 - 2.5</td>
<td>26.5,27.5,28,29.5,30</td>
</tr>
<tr>
<td>3</td>
<td>2.6 - 3.0</td>
<td>25,26.5,27.5,28,28.5</td>
</tr>
<tr>
<td>4</td>
<td>3.1 - 4.0</td>
<td>23.2,24.5,25,25,26.5</td>
</tr>
</tbody>
</table>

*Began use of table with piglet NTE14071801
Experimental Protocol

Each piglet was monitored at each water bath temperature until approximately 10 minutes of constant oxygen consumption was achieved. The temperature of the water bath was then changed and the same procedure was repeated at a different temperature. The overall temperature range at which we tested the piglet’s lowest oxygen consumption was chosen based upon previous experiments and ranged from 23.0°C to 29.5°C. Four weight groups were then established, and with just a few initial experiments, specific ranges composed of six temperatures were then assigned to each group (see Table 1). Additional piglets of similar size and age were tested at similar ranges, allowing for comparisons between the four weight groups. The order at which these temperatures were administered was randomized with the use of six shuffled playing cards, each representing a temperature that was selected randomly to create a non-bias protocol for each experiment. Data intermissions occurred naturally while waiting for the water bath to change temperatures, and the piglet was not removed from the plethysmograph until data was collected at all six temperatures.

Calculations and Analysis

The data from five of the studied piglets were eliminated during the compilation of results and data analysis. These experiments experienced malfunctions and inaccurate readings from the O2 Analyzer, and therefore were not included in any of the calculations. The data from the remaining 21 pigs were then analyzed after being divided according to weight group. To calculate the temperature for lowest VO2 from each group, the data was arranged in two ways: (1) the VO2 was averaged at each water bath temperature within each weight group (Figures 1-4), and (2) the temperatures at which the lowest VO2 for each animal was found were averaged within each weight group (Figure 5). These two methods depict not only the relation between water bath temperature and mean VO2 for each individual weight group, but also a comparison of lowest VO2 temperatures between each weight group.

Table 2. Piglet Weight Groups and Mean Age

<table>
<thead>
<tr>
<th>Group #</th>
<th>Mean Weight (kg)</th>
<th>Mean Age (days)</th>
<th>Temperature of Mean Lowest Oxygen Consumption (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.7</td>
<td>3.8</td>
<td>29.13</td>
</tr>
<tr>
<td>2</td>
<td>2.3</td>
<td>4.5</td>
<td>28.78</td>
</tr>
<tr>
<td>3</td>
<td>2.8</td>
<td>8.2</td>
<td>26.13</td>
</tr>
<tr>
<td>4</td>
<td>3.5</td>
<td>12.5</td>
<td>24.55</td>
</tr>
</tbody>
</table>

Figure 5. The water bath temperature (°C), found by averaging the lowest oxygen consumption (VO2) for each piglet, is depicted according to weight group. The smaller piglets found in Group 1 display the smallest mean VO2 at higher water bath temperatures while in the plethysmograph, whereas the larger piglets found in Group 4 consumed the smallest mean VO2 at lower water bath temperatures. This trend indicates the need for smaller piglets to be placed in warmer environments in order to achieve lowest VO2 values and closer proximity to the piglets’ thermoneutral zone.

Figure 6. The age of each piglet (21 piglets total) is graphed in relation to its corresponding weight. The linear regression line indicates a linear correlation between the piglets’ sizes and weights. While the piglets age increases, the weight of the piglet will also increase. This enables not only the comparison between VO2 and weight, but also between VO2 and age.
RESULTS

Several correlations were found from this experiment: a connection between the piglet’s VO2 and water temperature, between the piglet’s size and water temperature of lowest mean VO2, and, as expected, between the piglet’s age and weight. The minimum oxygen consumption for the smallest piglets composing Group 1 (1.5-2kg) was found in high temperature ranges near 29°C and 30°C (Fig. 1). A similar trend was found in Group 2 (2.1-2.5kg), where lowest oxygen consumption levels occurred at high temperatures of 29°C-30°C as well (Fig. 2). The lowest VO2 for Group 3 (2.6-3kg) declined to 25°C-26°C, as seen in Fig. 3. For the largest animals tested, Group 4 (3.1-4kg), the lowest oxygen consumption level was at 24°C (Fig. 4). Averaging the VO2 at each water temperature within the weight groups derived these values. When using the mean temperature at which the lowest VO2 was found for each weight group, Group 1 had a lowest mean VO2 at 29.13°C, Group 2 at 28.78°C, Group 3 at 26.13°C, and Group 4 had the lowest mean VO2 at 24.55°C (Fig. 5). These values illustrate the connection between piglet size and temperature of lowest VO2. The relationship between the piglets’ age and weight group is shown in Fig. 6, and depicts increasing weight with advancing age. Consequently, both age and weight can be used to compare VO2 values and as categories in future experiments.

DISCUSSION

Our data suggests a relationship between a piglet’s size and its thermoneutral temperature (at which no additional energy is exerted to maintain body temperature). Cumulatively, a common trend within the data indicates that smaller piglets require increased temperatures to reduce their oxygen consumption, and as the size of the piglet increases its thermoneutral zone declines in environmental temperature (Fig. 5, Table 2). The thermoneutral temperatures discovered were 29.13°C, 28.80°C, 26.17°C, and 24.55°C in order from smallest piglet size to largest, respectfully. Because of the linear correlation between piglet age and weight, a similar relationship is depicted between a piglet’s age and thermoneutral temperature (Fig. 7). This shows that very young piglets of smaller size require additional environmental heat in order to maintain low oxygen consumption. However, since an average VO2 was correlated to an average weight per piglet, this method can not project an exact temperature of minimal VO2 for each piglet in every weight group. A degree of error is inherent in averages, thus these values are projected estimates of which temperature will most likely yield the lowest oxygen consumption for a piglet in a particular weight group. The weight ranges that separate Groups 1-4 provide guidelines by which researchers may approximate a piglet’s environmental temperature.

By using low oxygen consumption as our indicator for low metabolic rate, we were able to determine the ideal environmental temperature at which to examine piglets. The breathing and heart rate changes caused by the excitatory response of increased metabolic rate has the potential to alter results found in studies involving breathing patterns. Future experiments may use the thermoneutral temperatures established in this study to eliminate the interference of temperature-related breathing abnormalities.

Hypotheses regarding the cause for SIDS still contain many questions with unknown answers. Any progress towards the prevention of this tragic syndrome will benefit hundreds of families around the world who have lost or will lose a child to SIDS. The known thermoneutral temperature of piglets will help researchers elucidate possible causes of Sudden Infant Death Syndrome with more confidence.
REFERENCES


RELATED WORKS


ACKNOWLEDGEMENTS

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