Comparing the Functional Performance of BIOPAC© Respiratory Belt-Transducers With and Without Repair Tape

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Introduction

More than 1100 undergraduate students enroll in the one-semester, five-credit Human Physiology course offered year-round by the University of Wisconsin School of Medicine and Public Health. These students are afforded the opportunity to work in small groups and noninvasively measure physiological variables on members of their group. Furthermore they may then engage in hypothesis testing and inquiry-based activities as they measure physiological responses to various stimuli. BIOPAC© (Goleta, CA) respiration belt-transducers are an excellent means for the collection of human respiratory effort data. However, it recently came to the faculty's attention that some belts were damaged and a crack appeared in the plastic exterior of the transducer's central element. In order to save precious and dwindling monetary funds, teaching assistants had begun the practice of repairing the belts with stiff vinyl tape. The purpose of this technical report is to test whether taping the cracked plastic exterior yields similar data values to that measured by intact unbroken respiration belts.

Methods

Five broken respiratory belts were compared to five intact control respiratory belts (model #SS5LB). All ten belts were tested using three participants. First, the participants attached the respiratory belts as seen in Figure 1. The distance between the ends of the straps was kept consistent for each participant to control for varying tension. Next, the participants were asked to sit calmly for 60 seconds while their resting respiration was recorded. After this data was collected, the participants were given a short break and then asked to hyperventilate for 30 seconds. Each participant was allowed at least two minutes to recover before each next measurement was taken.

Data from the respiratory belts (model #SS5LB in all cases) was collected using a PC compatible computer and a BIOPAC system converter (model MP36E-CE). Using BIOPAC and Microsoft Excel, the average peak-to-peak values (mV) and breaths per minute (BPM) were charted from both taped and intact respiratory belts for the three participants (*see Appendix I*). Data recorded during the calibration period was not included in the analysis.

Figure 1. Recommended setup for BIOPAC respiratory belt. (Image from BIOPAC tutorial)

Results

The number of breaths per minute (BPM) and the depth of breathing (peak-to-peak measured in mV) were measured using the laboratory's BIOPAC respiration belts (#SS5LB). A subsequent Kruskal-Wallis statistical test was used to determine if any significant difference could be detected between intact and taped belts (**Figures 2-6**). There was no significant difference in the measured Breaths-Per-Minute (BPM) and peak-to-peak values recorded for all belts under both regular breathing and hyperventilation conditions (all p-values > 0.05). Despite this conclusion, it should be noted that the BPM and peak-to-peak data collected by the taped belts was on average lower than that from the intact belts (**Figures 2-5**). On average, the percent difference between the peak-to-peak values was 42.48% lower for taped belts under baseline conditions and 11.03% lower for taped belts under hyperventilation. As for the average percent differences between the belts for the BPM measurements, a 31.19% lower difference under baseline conditions and 12.59% lower difference under hyperventilation was found with the taped belts.

Discussion/Conclusion

The Kruskal-Wallis statistical test determined that repairing the cracked, plastic exterior of the transducer with a single layer of stiff vinyl tape is an effective method to repair the respiratory belts (Figure 7). Despite there being no significant difference between the taped and intact belts, the taped belts recorded lower absolute values on average. Therefore it is recommended that students use either taped or intact belts *consistently* throughout their studies in future physiology labs.
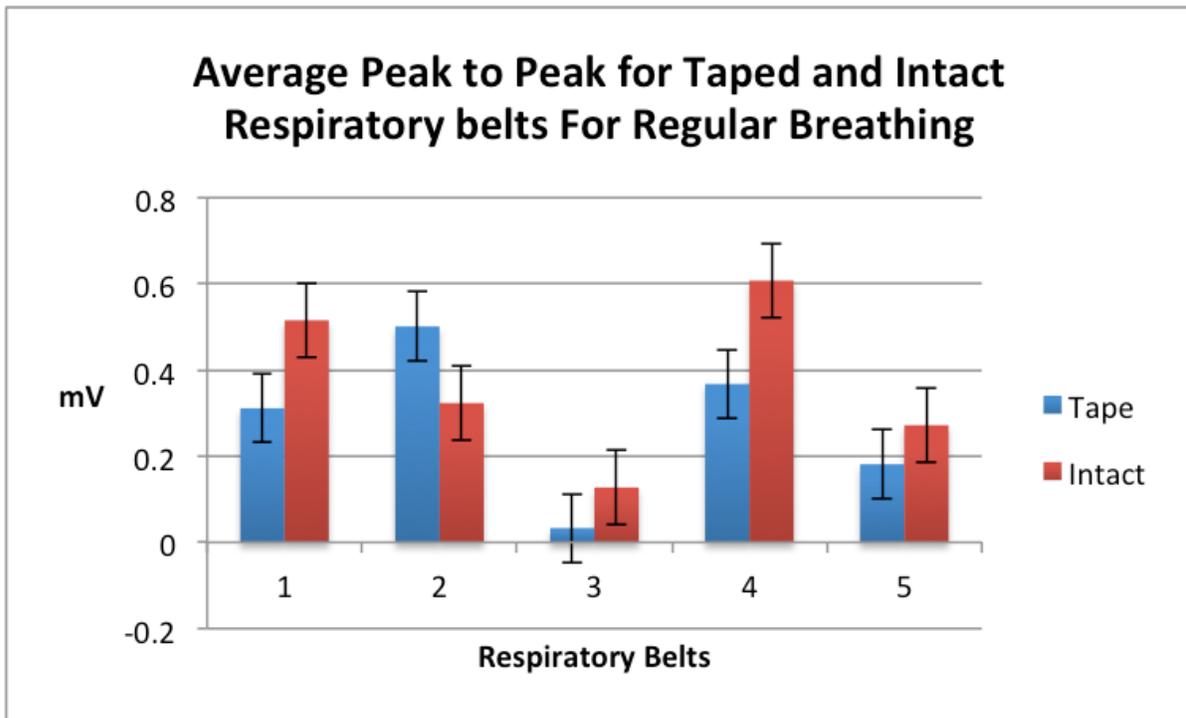
Figure 2. Measurements of range of force (mV) on the taped and intact respiratory belts. There was no significant difference between the data collected from taped vs intact belts under regular breathing conditions (p-value = 0.4647).
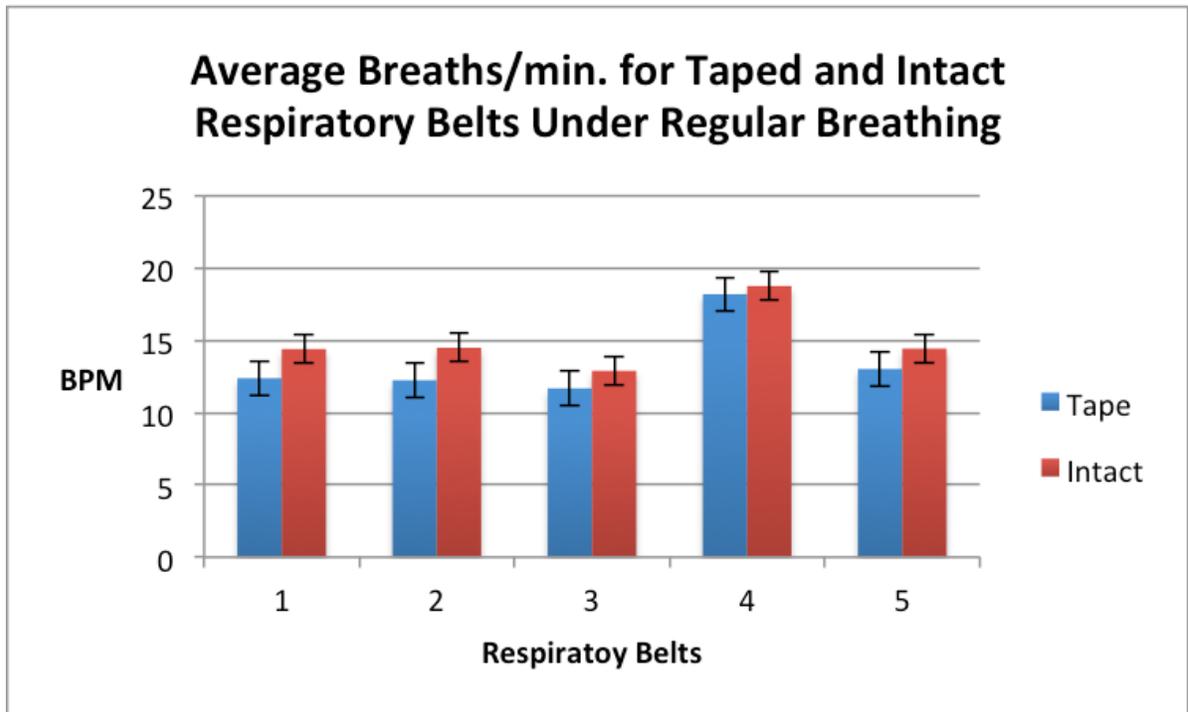

Figure 3. Measurements of breathing rate on the taped and intact respiratory belts. There was no significant difference between the data collected from the taped vs intact belts under regular breathing conditions (p-value = 0.1172).
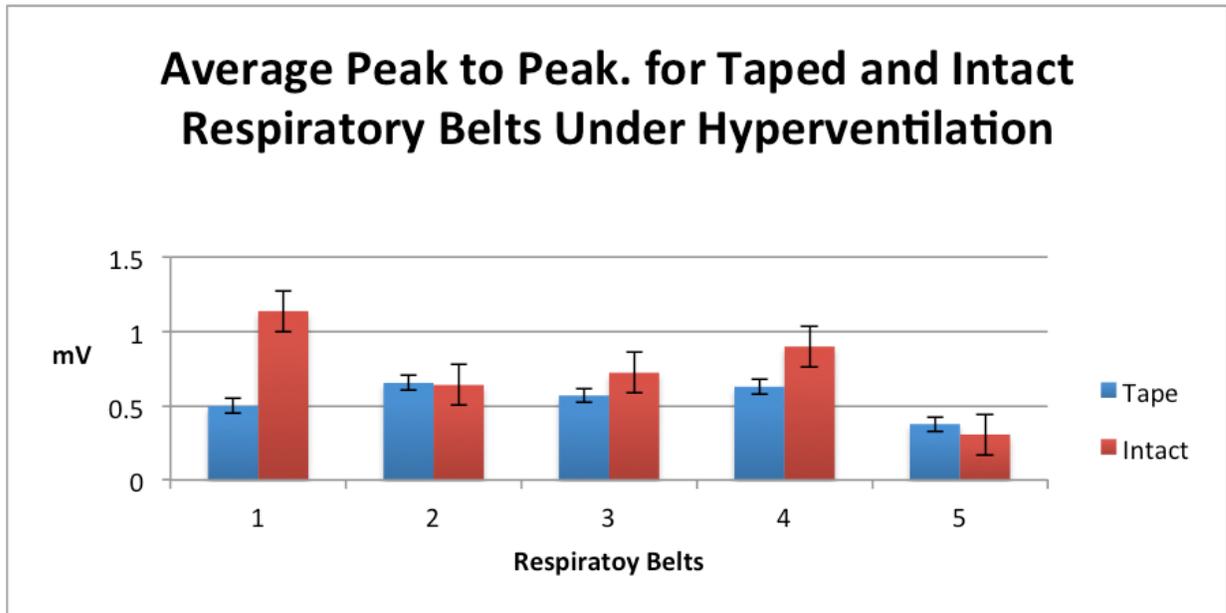

Figure 4. Measurements of range of force (mV) on the taped and intact respiratory belts. There was no significant difference between the data collected from the taped vs intact belts under hyperventilation (p-value = 0.1745).
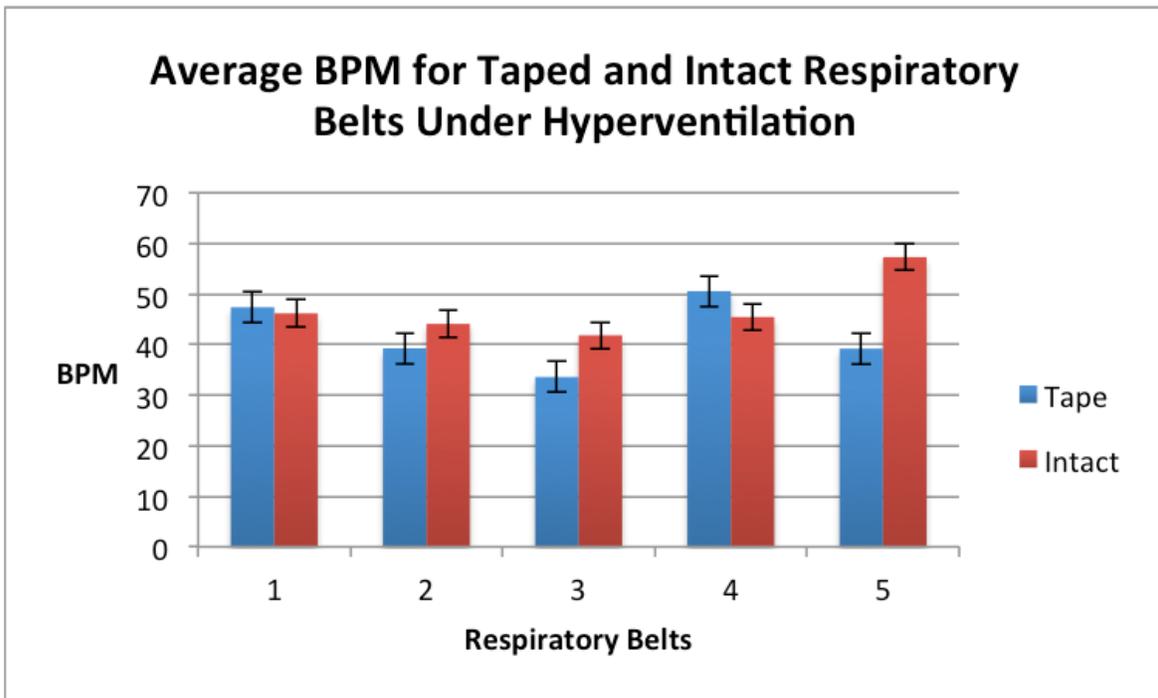
Figure 5. Measurements of breathing rate on the taped and intact respiratory belts. There was no significant difference between the data collected from the taped vs intact belts under regular breathing conditions (p-value = 0.3472).

Tape (+)	Ave. mV	Ave. P-P mV	St. Deviation	Avg. BPM	Ave. mV	Ave. P-P mV	St. Deviation	Avg. BPM
1 (yellow)	-0.00069	0.31136	0.10423	12.38659	0.0098	0.49793	0.17537	47.36843
2 (yellow)	0.00131	0.50137	0.18313	12.24463	0.00843	0.65251	0.21162	39.2295
3 (white)	-0.01419	0.033355	0.11818	11.68381	0.0123	0.56841	0.19501	33.57348
4 (blue)	-0.00891	0.36772	0.13733	18.19279	0.006	0.62723	0.21136	50.55442
5 (green)	-0.00675	0.18145	0.06795	13.02821	0.00233	0.37618	0.12029	39.17415
No Tape (-)								
1	-0.02297	0.51558	0.19779	14.40681	-0.00177	1.13557	0.37147	46.16451
2	0.00683	0.3234	0.11835	14.49266	-0.0018	0.63933	0.21755	44.0785
3	-0.0107	0.12745	0.12745	12.90013	-0.00762	0.72161	-0.00762	41.82209
4	-0.0181	0.6076	0.205	18.76348	-0.02028	0.89769	0.31398	45.43498
5	-0.00397	0.27198	0.10494	14.43877	-0.00924	0.30559	0.10125	57.27684

Figure 6. Raw data collected for each belt under baseline and hyperventilation conditions.

Figure 7. Respiration belt repaired with vinyl tape.

Appendix I
Protocol for Data Collection/Analysis

1. Open up **Biopac 4.0 Student**
2. Select *"Create/Record a new experiment"* and select OK
3. Go to **MP36** and *"Set Up Channels"*
4. For CH1 select "*Respiration"* in the Preset box (then close that tab)
   a. Data may be skewed if Biopac is receiving input from multiple channels
5. Collect respiration data by pressing "*Start"* and "*Stop"*
6. Go to "***Display***" at the top and select "*Autoscale Horizontal"* so you can see the entire waveform
   a. You can also adjust the scale on the right side by double-clicking on it
7. Go to top tab labeled "***Analysis***"
   a. Select "*Find rate"*
   b. Under the "*Signal Parameters"* tab, the following areas should be selected:
      i. Positive (Peak detect)
      ii. Remove baseline (window 25ms)
   c. The "*Auto threshold detect*" should NOT be checked
   d. The "*Transform entire wave*" box should automatically be checked at the bottom
   e. Click on the "*Output*" tab on top in this box
      i. Function should be "*Rate (BPM)"*
      ii. Output reset events should automatically be checked
   f. Press OK
8. Repeat steps 7-12 but select "*Peak to Peak*" rather than "*Rate (BPM)"* under the "*Output*" tab
9. Now you will see 3 segments of analysis
   a. On the left you will see *"Respiration", "Rate"* and *"Peak to peak"*
10. Highlight data you want to analyze
11. In the analysis bar, you can analyze the following…
    a. **Time:** Select "*CH1, Respiration*" and "*Delta T*" in order to analyze a given amount of time (there is a calibration segment of the rate/BPM analysis so you should look at data after that period of time)
    b. **BPM**: In another dropdown menu, select "*CH2, Rate*" and "*Mean*" to find the average BPM across the selected data
    c. **Peak to Peak**: In another dropdown, select "*CH3, Peak to peak*" and "*Mean*" to analyze the average amplitude of the chest excursion in mV
    d. **Standard Deviation**: In another dropdown, select "*CH 1,Respiration*" and "*Stddev*" to analyze the extent of deviation as a whole
    e. **Mean mV:** In another dropdown, select "*CH 1,Respiration*" and "*Mean*" for the mean of mV across the selected data