

Ebola Grand Challenge:

Evaluation of cooling devices

NPPTL physiology team

We tested 6 people on 4 different cooling vest + control session. The following graphs and interpretation are the preliminary analysis of the data collected on these subjects.

Following our previous evaluation of PPE recommended for the Ebola outbreak, we tested six people in hot and humid conditions that mimic many of the places affected by the Ebola outbreak in West Africa. The testing was carried out in an environmental chamber at 32°C and 92% relative humidity. The subjects continuously walked on a treadmill at 3 METs intensity (2.5 mph) to mimic the work intensity of a nurse taking care of patients in a hospital setting. The PPE used over the cooling devices consisted of: medical scrubs, sock and rubber boots, Tychem® QC highly impermeable coverall (Dupont), Médecins Sans Frontières (MSF) custom-made Tyvek hood with integrated splash resistant surgical mask, rubber surgical apron, splash resistant goggles, surgical nitrile inner gloves, heavy duty nitrile outer gloves, duckbill N95 filtering facepiece respirator (Kimberly Clark model 46828), and fluid-resistant surgical cap (Kimberly Clark KCH69240) (Figure 1).

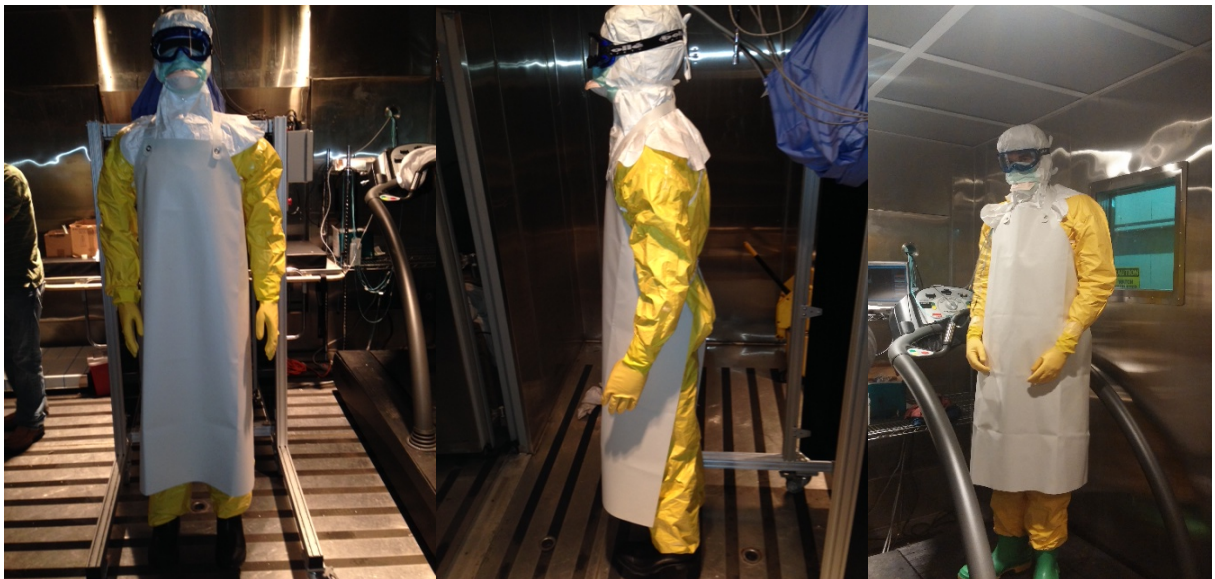


Figure 1. PPE used in the evaluation on a sweating thermal manikin, front and side views; and a participant wearing the PPE.

Four cooling devices were tested in addition to a control session (no cooling) with the PPE described above. The four cooling devices consisted of an upper body vest with different cooling materials (ice, phase change materials or circulating water). The 4 cooling devices were:

- Steele vest (figure 2): The whole vest, ready to use, weighted 6.13lbs (medium size)



- Liquid cooling garment (LCG) (figure 3): The whole vest +unit, ready to use, weighted 15.78lbs (medium size)



- Tech Niche vest (Figure 4): The whole vest, ready to use, weighted 6.15lbs (medium size)



- First Line phasecore28 technology vest (Figure 5): The whole vest, ready to use, weighted 4.96lbs (medium size)



The preliminary analysis of the data shows a slower increase in core temperature with most of the cooling devices compared to the increase during the control session (no cooling).

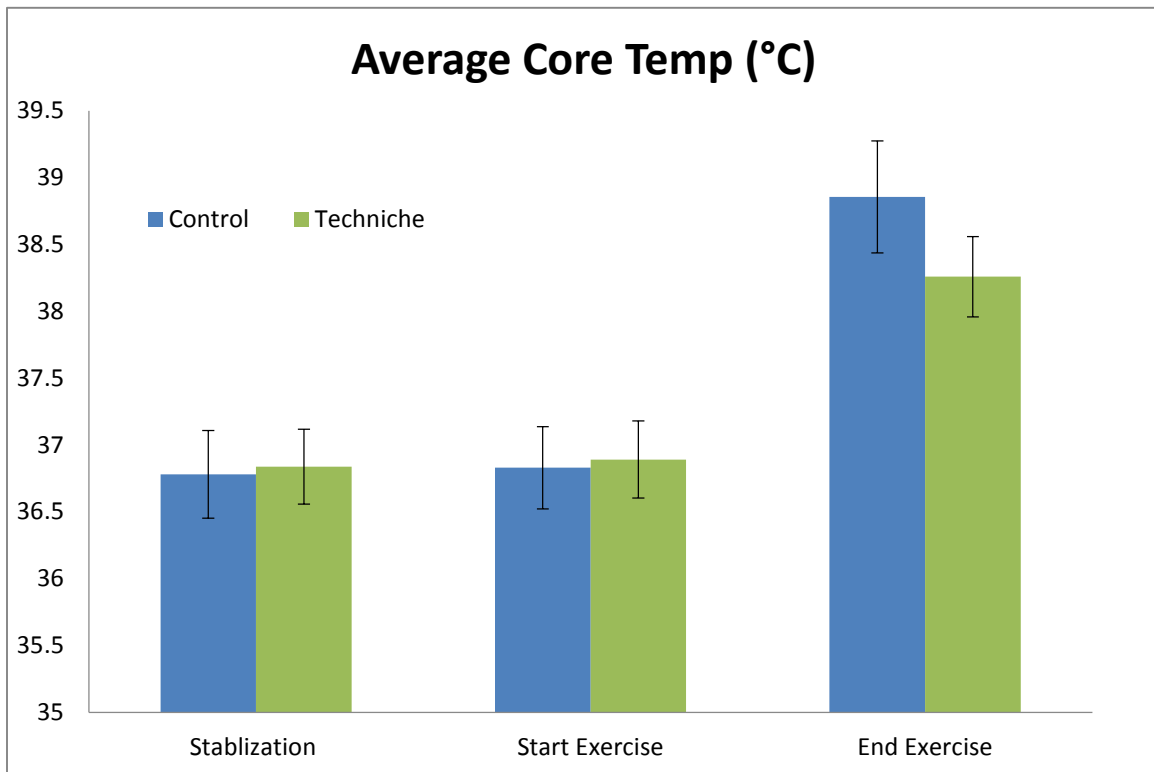


Figure 6. Comparison of core temperature across stages for the Tech Niche cooling and control.

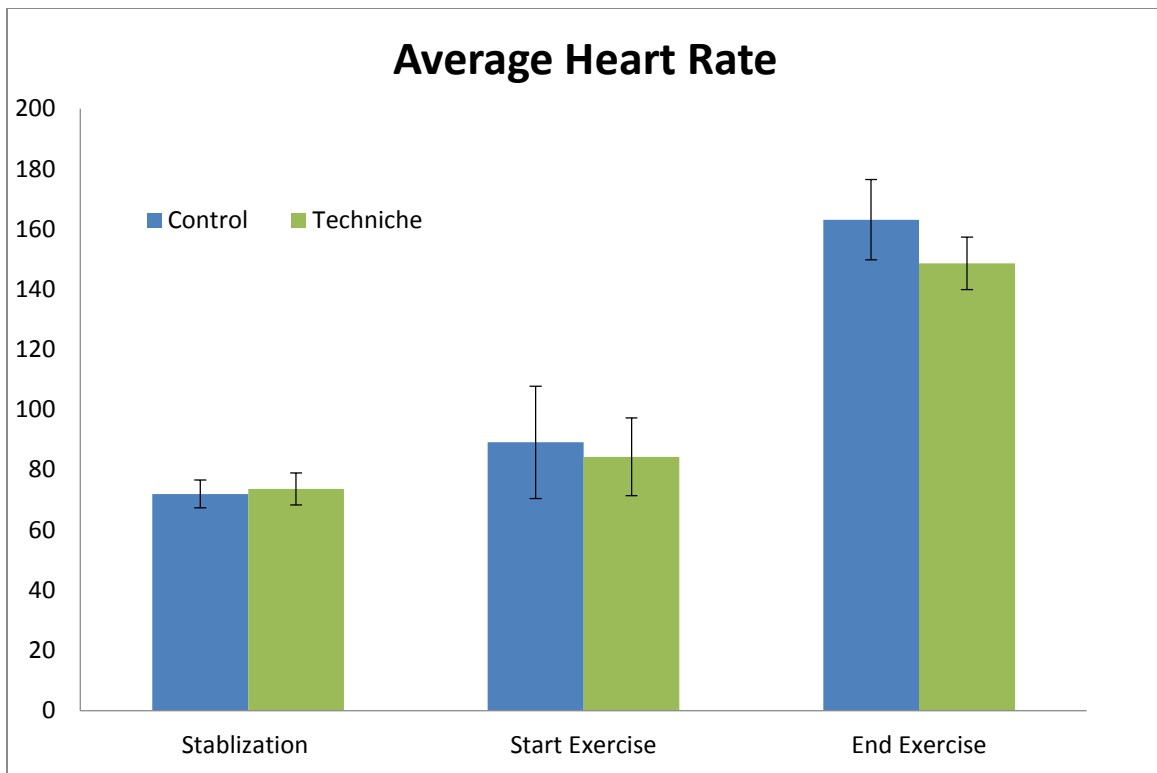


Figure 7. Comparison of HR across stages for the Tech Niche cooling and control.

Sweat rate in kilograms (kg) was calculated from pre-post nude weight.

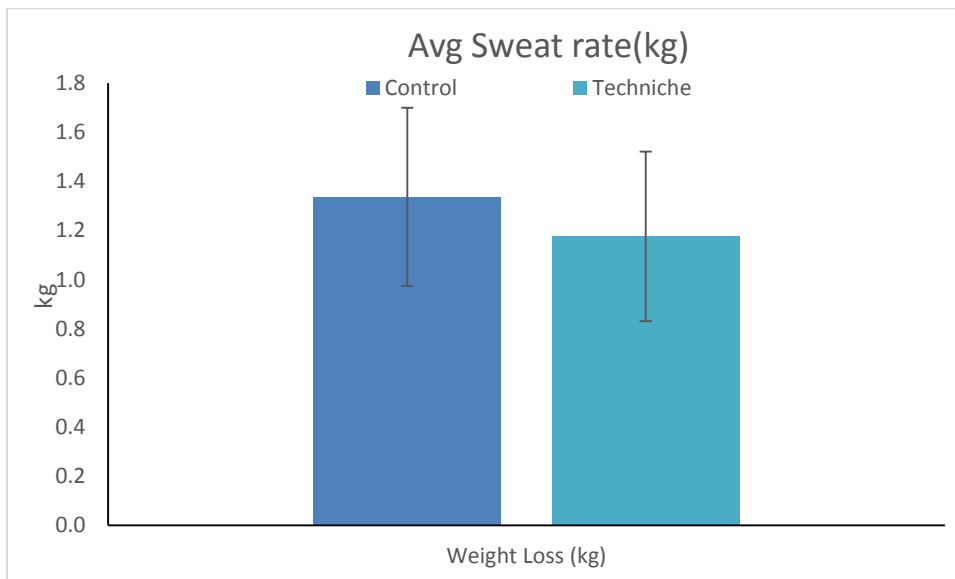


Figure 8. Comparison of sweat rate for the Tech Niche cooling and control.

We also collected subjective perception feedback and a questionnaire from the 6 participants. The measurements were rated following the scales next to the graphs:

How does your body temperature feel now?

4	Very Hot
3	Hot
2	Warm
1	Slightly Warm
0	Neutral (No feeling of heat or cold)
-1	Slightly Cool
-2	Cool
-3	Cold
-4	Very Cold

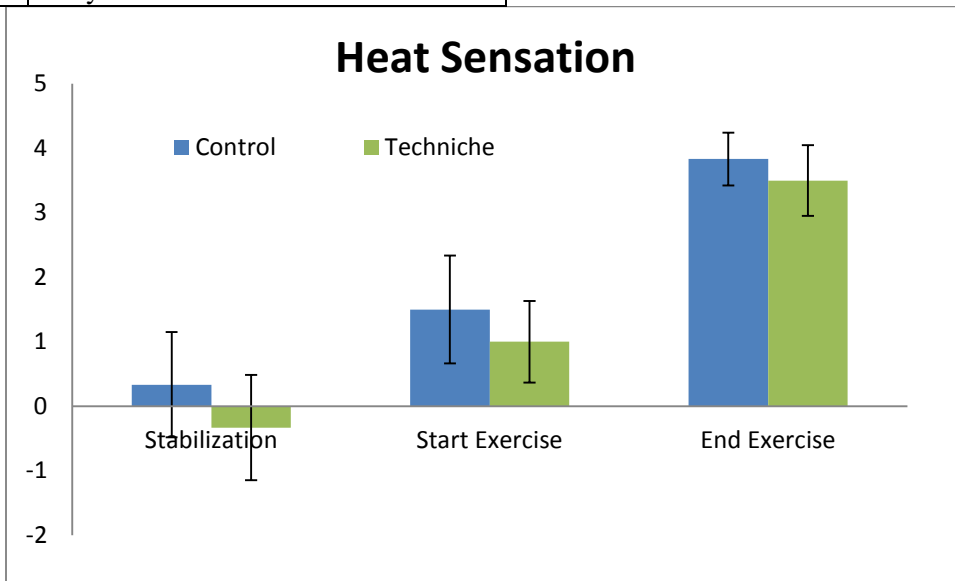


Figure 9. Comparison of heat sensation across stages for the Tech Niche cooling and control.

How comfortable are you with the body temperature you feel now?

1	Not Uncomfortable (Comfortable)
2	Slightly Uncomfortable
3	Uncomfortable
4	Very Uncomfortable

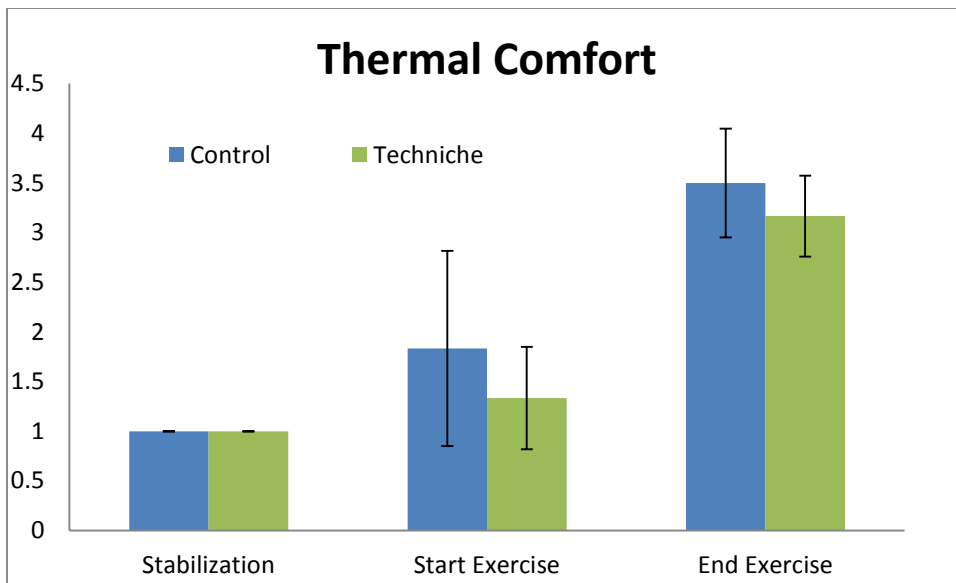


Figure 10. Comparison of thermal comfort across stages for the Tech Niche cooling and control.

How hard (exertion) do you feel now?

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

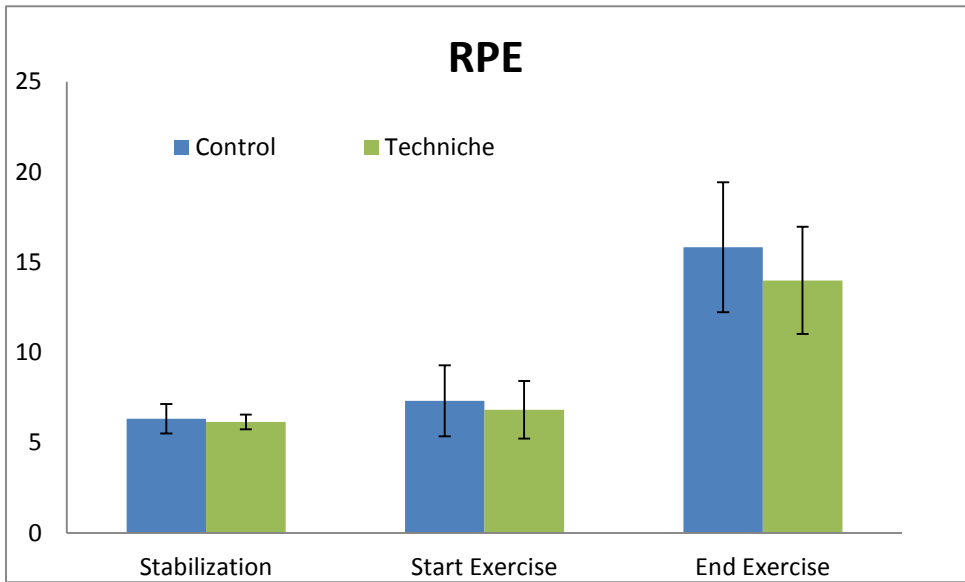


Figure 11. Comparison of RPE across stages for the Tech Niche cooling and control.

How comfortable are you breathing now?

1	No discomfort (Comfortable)
2	Slightly discomfort
3	Moderate discomfort
4	Moderate – High discomfort
5	High discomfort
6	Extremely discomfort
7	Intolerable discomfort

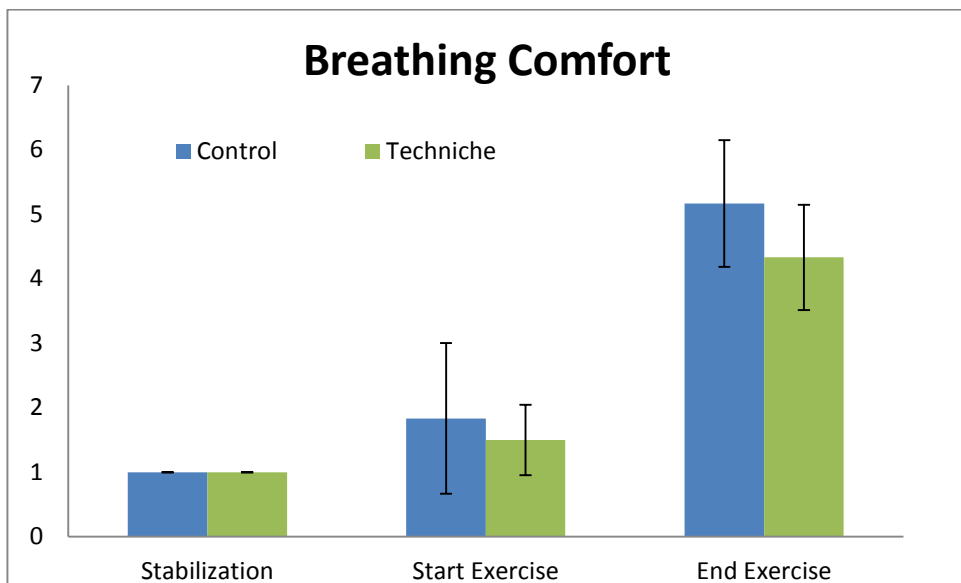


Figure 12. Comparison of breathing comfort across stages for the Tech Niche cooling and control.

How sweaty do you feel now?

1	Dry
2	Slightly Moist
3	Moist
4	Wet
5	Soaked

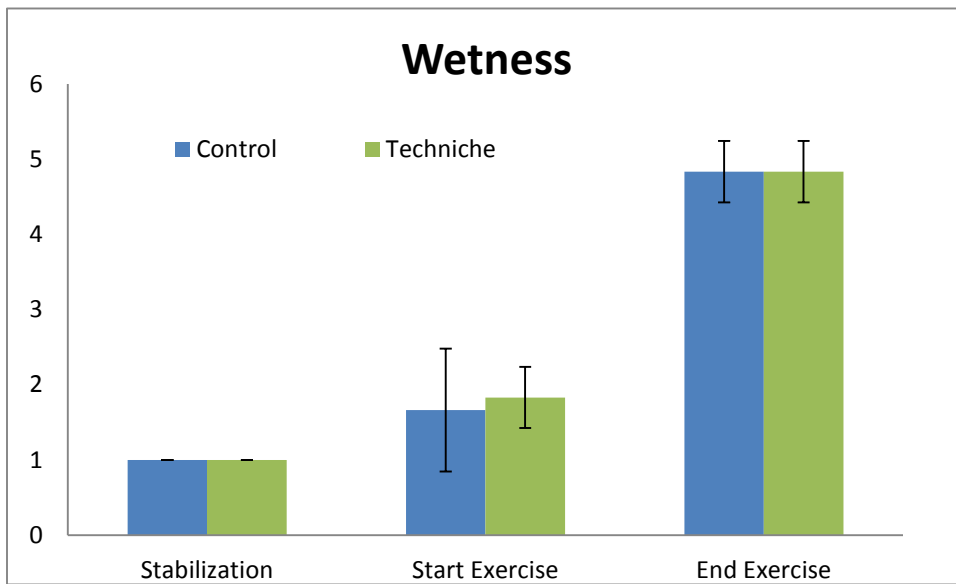


Figure 13. Comparison of wetness across stages for the Tech Niche cooling and control.

Key:

PCS: Personal Cooling System

Q1. How easy did you don/doff the PPE? (Scale: 1-7; 1: Very Easy, 7: Very Difficult)

Q2. How easy did you don/doff the PCS? (Scale: 1-7; 1: Very Easy, 7: Very Difficult)

Q3. If any, identify PPE or PCS component limiting donning/doffing.

Q4. How heavy was the PPE (and PCS) when performing the work? (Scale: 1-5; 1: Very Light, 5: Extremely Heavy)

Q5. How did the PPE (and PCS) fit? (Scale: 1-5; 1: Very Tight, 5: Very Loose)

Q6. How much did the PPE (and PCS) restrict your freedom of movement when performing the work? (Scale: 1-5; 1: No Interference, 5: Extreme Interference)

Q7. How would you rate overall wearing comfort of the PPE (and PCS)? (Scale: 1-5; 1: Comfortable, 5: Extremely Uncomfortable)

Q8. If any, identify PPE or PCS component limiting fit, movement, or wearing comfort.

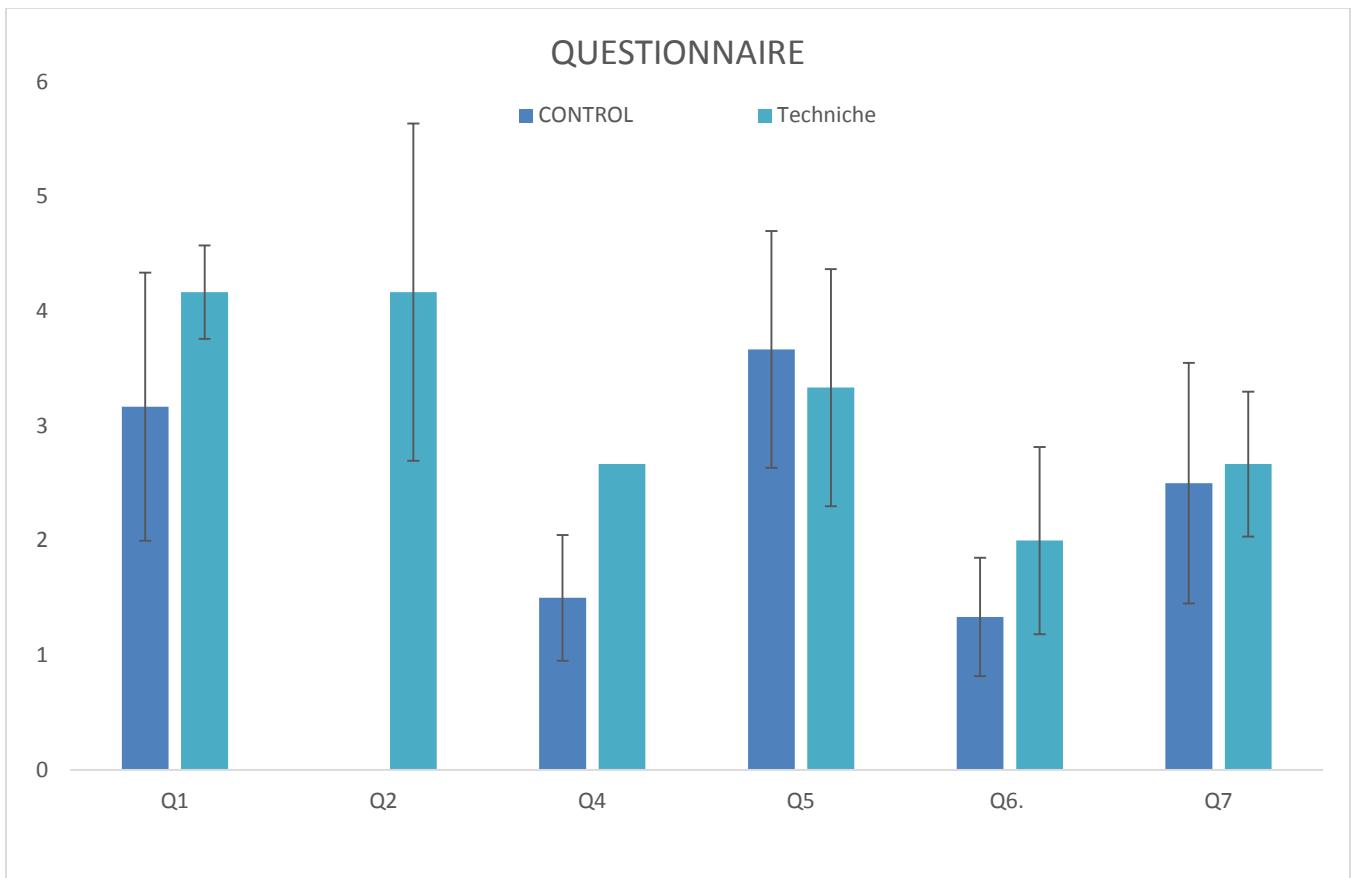


Figure 14. Comparison of the responses to the questions explained above for the four cooling conditions and control.

Control question 3 and 8 (individual feedback)

Q3	PPE: N/A PCS: N/A
Q8	PPE: N/A PCS: N/A
Q3	PPE: Mask, made breathing difficult. PCS: N/A
Q8	PPE: N/A PCS: N/A
Q3	PPE: Mask definitely has to come off first. PCS: N/A
Q8	PPE: Once the mask got wet ~40 min, it made breathing very difficult. PCS: N/A
Q3	PPE: N/A PCS: N/A
Q8	PPE/PCS: No system, just equipment, still extremely hot.
Q3	PPE: None that I am familiar with at this point. PCS: N/A
Q8	PPE: When the mask gets wet, it collapses on mouth & makes breathing difficult, head gear limits field of vision. PCS: N/A
Q3	PPE: Goggles interfered slightly when donning system. PCS: N/A
Q8	PPE: Gloves became uncomfortable near end of test due to sweat collection. PCS: N/A.

Tech Niche questions 3 and 8 (individual feedback)

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- Q3 PPE: N/A PCS: N/A
- Q8 PPE: N/A PCS: N/A
- Q3 PPE: N/A PCS: N/A
- Q8 PPE: N/A PCS: N/A
- Q3 PPE: N/A PCS: N/A
- Q8 PPE: N/A PCS: Jacket was short which reduced the surface area of the cooling effect.
- Q3 PPE: N/A PCS: The corners of the ice packs would get caught in the mesh casing.
- Q8 PPE: N/A PCS: N/A
- Q3 PPE: N/A. PCS: Need to fold the cooling packs to insert them.
- Q8 PPE: Weight on the bridge of the nose can limit ability to breath at times. PCS: Not unbearably heavy, but feels cumbersome late in the test.
- Q3 PPE: None. PCS: Chill packets caught on inner mesh when trying to put packets in, and zipper was difficult to zip up.
- Q8 PPE: None. PCS: Cooling System did not seem to keep me noticeably chilled over the duration of the test, but had full range of motion while wearing the vest.