

Physiological Effects of Exercising at Different Intensities Wearing TNT or Double-layer Cotton Facemasks Compared to Not Wearing a Mask

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Purpose: We compared the physiological differences between exercising wearing a TNT or a double-layer cotton (DLC) facemask (FM) and not wearing a mask (NM).

Methods: Sixteen volunteers underwent 4 sets (S) of 2 sequential bouts (B) based on ventilatory threshold (VT) work rate: 80% of VT1 and VT2 for B1 and B2, respectively. FMs were used as follows: S1: NM, S2: TNT or DLC, S3: DLC or TNT and S4: NM (Figure 1). Oxygen and carbon dioxide output, heart rate, tidal volume (VT), breath frequency (Bf), minute ventilation (VE), end tidal (ETCO2) and mixed-expired (PECO2) CO2 pressure, oxygen saturation (SpO2), duty cycle (Ti/TTOT), rate of perceived effort, subjective thermal perception and FM microclimate temperature were monitored throughout exercise. Figure 2 shoe masking preparation.

Results: Table 1 shows the effect sizes (ES [95%CI]) for facemasking comparison. Compared to NM, FM increased Ti/TTOT (B1=1.11[0.58-1.61] and 1.53[0.81-2.18]; B2=1.27[0.63-1.84] and 1.93[0.97-2.68]) and decreased Bf (B1=0.59[0.23-0.94] and 1.43[0.79-2.07], B2=0.39[0.05-0.71] and 1.33[0.71-1.94]). Only B1 VT increased (0.33[0.09-0.56] and 0.62[0.18-1.05]) enough to avoid a VE reduction with TNT but not with DLC (B1=0.52[0.23-0.79]; B2=0.84[0.44-1.22]). Both FMs reduced SpO2 in B1 (0.56 [0.07-1.03] and 0.69 [0.09-1.28]) but only DLC did in B2 (0.66 [0.11-1.13]). Both ETCO2 (B1=0.23[0.05-0.4] and 0.71[0.38-1.02]; B2=0.56[0.2-0.9] and 1.20[0.65-1.68]) and PECO2 (B1=0.74[0.38-1.08] 1.71[1.03-2.37], B2=0.94[0.45-1.38] and 1.78[0.97-2.42]) increased with FMs. Figure show all cardiopulmonary comparisons between NM, TNT and DLC

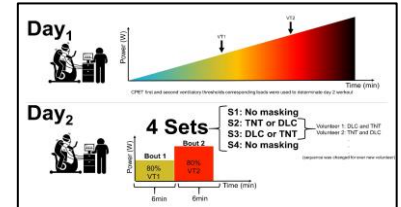


Figure 1-First- and second-day exercise and masking protocol



Figure 2- Masking preparation procedures

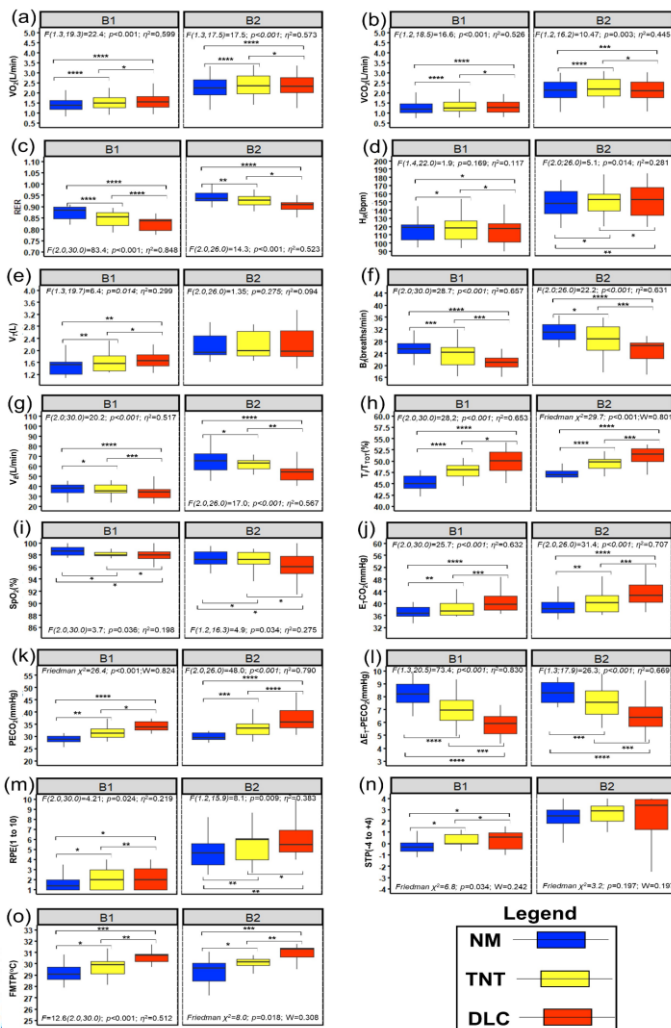


Figure 3-Physiological parameter comparisons between facemasks. Boxplots represent the minimum, maximum, median, first quartile and third quartile in the data set, and the horizontal line reflects the mean of the respective group. Outliers are not represented. Star symbols represent the p values for post hoc pairwise comparisons: (*), (**), (***) and (****) for $p > 0.05$, $p < 0.05$, $p < 0.01$ and $p < 0.001$, respectively. VO2: Oxygen output, VCO2: Carbon dioxide output, HR: Heart rate, VT: Tidal volume, Bf: Breathing frequency, VE: Minute ventilation, Ti/TTOT: Duty cycle, ETCO2: End tidal CO2 pressure, PECO2: Mixed-expired CO2 pressure, $\Delta ET-PECO_2$, Difference between ETCO2 and PECO2, RPE: Rate of perceived effort, SpO2= Oxygen saturation.

Table 1- Effect size values with 95%CI for pairwise comparisons between masking

| Variables | Hedges' g effect size (95%CI) | | |
|---------------------------------------|-------------------------------|------------------|------------------|
| | NM vs. TNT | TNT vs. DLC | NM vs. DLC |
| B1 | | | |
| VO ₂ (L/min) | 0.26[0.16-0.4] | 0.05[0.08-0.19] | 0.34[0.19-0.49] |
| VCO ₂ (L/min) | 0.28[0.16-0.4] | 0.04[-0.1-0.19] | 0.24[0.12-0.36] |
| RER | 0.83[0.46-1.2] | 0.70[0.34-1.04] | 1.60[0.98-2.21] |
| H _R (bpm) | 0.30[-0.08-0.66] | 0.25[-0.12-0.6] | 0.06[-0.18-0.29] |
| V _T (L) | 0.33[0.09-0.56] | 0.33[-0.12-0.76] | 0.62[0.18-1.05] |
| B _f (breaths/min) | 0.59[0.23-0.94] | 0.87[0.32-1.4] | 1.43[0.79-2.07] |
| V _E (L/min) | 0.10[-0.03-0.22] | 0.43[0.15-0.71] | 0.52[0.23-0.79] |
| Ti/TTOT (%) | 1.11[0.58-1.61] | 0.63[0.1-1.12] | 1.53[0.81-2.18] |
| SpO ₂ (%) | 0.56[0.07-1.03] | 0.21[-0.41-0.81] | 0.69[0.09-1.28] |
| E _T CO ₂ (mmHg) | 0.23[0.05-0.4] | 0.50[0.2-0.79] | 0.71[0.38-1.02] |
| PECO ₂ (mmHg) | 0.74[0.38-1.08] | 0.97[0.46-1.46] | 1.71[1.03-2.37] |
| $\Delta ET-PECO_2$ | 1.21[0.72-1.69] | 1.03[0.43-1.6] | 2.44[1.48-3.38] |
| RPE | 0.33[0.03-0.61] | 0.12[-0.18-0.42] | 0.45[0.07-0.81] |
| FM (°C) | 0.66[0.19-1.09] | 0.67[0.16-1.16] | 1.16[0.45-1.84] |
| STP | 0.17[-0.04-0.38] | 0.03[-0.23-0.29] | 0.20[-0.03-0.43] |
| B2 | | | |
| VO ₂ (L/min) | 0.26[0.15-0.37] | 0.02[-0.11-0.16] | 0.24[0.07-0.41] |
| VCO ₂ (L/min) | 0.18[0.11-0.26] | 0.11[-0.01-0.22] | 0.07[-0.02-0.17] |
| RER | 0.61[0.11-1.1] | 0.80[0.2-1.37] | 1.48[0.61-2.31] |
| H _R (bpm) | 0.15[0.03-0.26] | 0.02[-0.11-0.16] | 0.17[0.03-0.3] |
| V _T (L) | 0.11[-0.04-0.27] | 0.07[-0.17-0.31] | 0.17[-0.11-0.45] |
| B _f (breaths/min) | 0.39[0.05-0.71] | 0.87[0.45-1.27] | 1.33[0.71-1.94] |
| V _E (L/min) | 0.19[0-0.38] | 0.68[0.3-1.05] | 0.84[0.44-1.22] |
| Ti/TTOT (%) | 1.27[0.63-1.84] | 0.75[0.25-1.22] | 1.93[0.97-2.68] |
| SpO ₂ (%) | 0.11[-0.19-0.41] | 0.58[0.06-1.03] | 0.66[0.11-1.13] |
| ETCO ₂ (mmHg) | 0.56[0.2-0.9] | 0.67[0.3-1.01] | 1.20[0.65-1.68] |
| PECO ₂ (mmHg) | 0.94[0.45-1.38] | 0.92[0.48-1.34] | 1.78[0.97-2.42] |
| $\Delta ET-PECO_2$ | 0.77[0.32-1.19] | 0.66[0.29-1.1] | 1.45[0.69-2.12] |
| RPE | 0.45[0.08-0.81] | 0.46[0.14-0.77] | 0.87[0.26-1.44] |
| FM (°C) | 0.87[0.19-1.47] | 0.61[0.02-1.14] | 1.15[0.44-1.83] |
| STP | 0.14[-0.04-0.3] | 0.00[-0.17-0.17] | 0.12[-0.03-0.27] |

Conclusion

Ventilatory adaptations imposed during FM exercising influenced blood-lung gas exchange. Larger ESs were seen with DLC. No adverse changes to human health were observed.