Strategies for Aerosol Mitigation in a Football Competition

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The performance of a ND football helmet for aerosol mitigation was investigated. The helmet used was one which was fitted with both a plastic visor and plastic mouth guard. Tests used were the "hiss" test in which the subject (DTL) hissed while wearing the helmet for 30s, and the "pop" test where a loud vocalization of "pop" was performed again over 30s. In both cases a few drops were observed on the visor, but not a significant amount relative to what is observed on a ClearMask which is closely fitted to the mouth. Thus, as expected, the distance from the guard and visor to the mouth was too great and velocities too low for inertial impaction to result in significant capture. Thus, while a visor and mouth guard will protect the wearer against large drops (and fingers), it will not control the emission of aerosols produced by speech and provides no protection against inhalation.

As an alternative approach, a Port Authority gaiter was investigated in addition to the helmet. It is known from our earlier study that this gaiter is effective in reducing droplet emission (particularly larger droplets) when dry, and even more effective when wet. The difficulty arises that when a loud vocalization of "pop" or a heavy exhalation with pursed lips occurs, liquid on a wet gaiter will be released as a spray of fine droplets. The question is whether the visor and guard are capable of retaining these droplets. This is a possibility since the droplets are only produced under conditions where the velocity is large, and the droplets are somewhat larger than those typically associated with speech, both of which contribute to inertial impaction.

In the test a gaiter, initially dry, was wetted with two squirts of distilled water from a spray bottle (approximately 1.3ml), sufficient to get the gaiter over the mouth wet (but not fully saturated). Four tests were performed, each time the gaiter was rotated or flipped to present an initially dry section. After each of the different breathing/vocalizations the helmet was removed and photographed. The observed behavior was as follows.

Sharp (maximum velocity) exhalation with pursed lips: The resulting image is given below. As can be seen, a very large quantity of droplets were captured after a single breath. The droplet pattern is centered over the upper part of the mouth guard, however it extends upwards into the visor region. Thus, both pieces are required for capture. The spray density and droplet size decreases away from the center of the pattern, consistent with inertial impaction scaling. The exhalation velocity is on the order of 10-20m/s, so droplets of 25μm or greater in size would be expected to be captured.

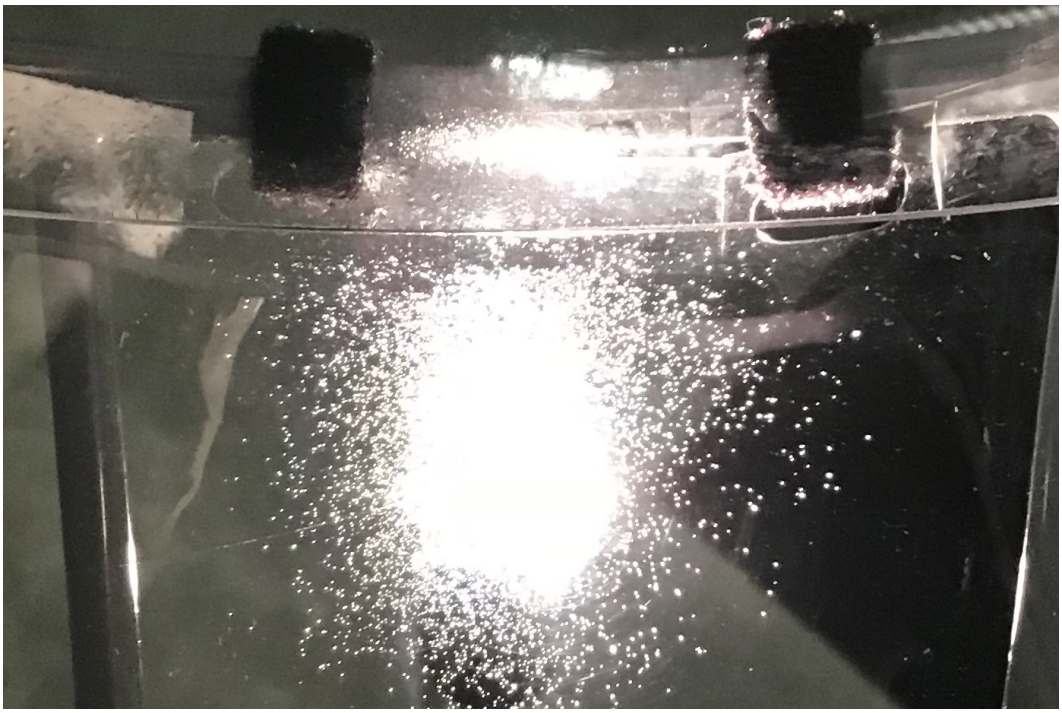

Figure 1. Spray pattern associated with maximum exhalation, pursed lips. A very large quantity of droplets are captured by both the mouth guard and the visor.

Clearing Breath, pursed lips: As seen in figure 2, in this case a somewhat smaller quantity of droplets are observed, however the spray pattern is very similar. Again, although the velocity of the breath is likely somewhat lower than the maximum exhalation it is still sufficient for the droplets produced from the wetted gaiter to be captured.

Clearing Breath, normal mouth width: In this case, while "fog" was observed on the visor (as was the case in the other breathing patterns), no droplets were observed on the visor or mouth guard at all. Based on the earlier laser sheet study, it appears that a clearing breath with mouth held open normally is insufficient to trigger the release of droplets from the surface of the gaiter.

Loud "pop": A loud vocalization of "pop" resulted in the pattern in figure 3. The pattern here was quite similar to that produced by a clearing breath, with droplets spattered on both the mouth guard and the lower part of the visor.

Based on these observations, a possible strategy for controlling emissions and protecting athletes from Covid-19 infection in a game environment is suggested. From the earlier study it is clear that a gaiter provides significant protection against emission of droplets, with the exception of the difficulties of excessive droplet production when sharp exhalations through a wet gaiter are performed. If used in concert with a plastic mouth guard and plastic visor (both would be required to catch the spray), the droplet emissions from a wet gaiter could be contained and the protective benefit could be retained. Because the "hood" is a more comfortable and practical

Figure 2. Spray pattern associated with clearing breath and pursed lips. The number of droplets is less than that for maximum exhalation, however the distribution is similar.

Figure 3. Spray pattern associated with vocalization “pop”. This vocalization produced a spray pattern similar to that of a clearing breath with pursed lips.

geometry, it is recommended that a hood be made from the same material as the Port Authority gaiter. This, coupled with visor and mouth guard, should be effective in mitigation of transmission. While, based on the earlier study, a mask such as the Under Armour sports mask provides even better protection for both "in" and "out", the combination proposed here should be a reasonable compromise if the resistance to air flow of the sports mask is found to be too high.

As always, the primary defense against transmission of the SARS-CoV-2 virus is comprehensive testing: If none of the athletes are infected at the start of the competition, no one will be infected at the end either. Since such testing is never perfect, however, the approach outlined here should at least provide a further reduction in the probability of transmission.