Air Quality in Stables at an American Thoroughbred Racetrack

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Inhaled particulates are one cause of airway inflammation. We report the first systematic measurements of ambient particulate concentrations in three racing stables. Stable construction, location of stall within a stable, time of day, and season all significantly impact the number and concentration of particulate matter. Particle concentrations are in the range known to result in worsening of airway disease in humans. Authors’ addresses: Department of Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, East Lansing, MI 48824 (May, Derksen, Holcombe, Robinson); Cleveland Equine Clinics, 3340 Webb Rd., Ravenna, OH 44266-9490 (Berthold); e-mail: milleric@cvm.msu.edu. © 2007 AAEP.

1. Introduction

Accumulation of mucoid secretions in the airways of racehorses is associated with reduced racing performance.1 Mucoid accumulations are a consequence of airway inflammation, which can have many causes. Those of interest in racehorses are infection and ambient exposure to particulate matter (dust). Many of the horses in racing stables found to have mild to moderate airway disease do not culture positive for bacteria;2–4 therefore, our focus has turned to the evaluation of exposures to particulate matter.

It is likely that multiple factors acting alone or synergistically cause the severity of inflammation that is responsible for mucus production and accumulation. Of particular relevance to the development of airway inflammation in racehorses is the observation in humans that small increases in ambient fine particulates (<2.5 μm in diameter) are associated with an increase in patients with upper-respiratory infections at hospitals.5

Sources of particulate matter in the racehorse environment include feed and bedding, flooring materials, track footing, road dust, vehicle exhaust, and emissions from adjacent industrial operations. Particle sizes of interest in this study are classified as those <10 (PM10) and <2.5 (PM2.5) μm in diameter. A small percentage of PM10 have the potential to reach the lower airways, but the majority of these particles are deposited in the central airways such as the trachea. The smaller particles represented by PM2.5 penetrate deep within the airways.

The current study is the first to characterize particulate concentrations and numbers of particles in the stables of racehorses as well as the factors that influence their presence.

2. Methods

Description of Stables
Three racing stables at Thistledown racetrack in Cleveland, OH were studied. This racetrack has
stables of different types of design and orientation with respect to prevailing winds and neighboring roads.

Stable 1 was of a new construction and design that allowed for maximal ventilation. Roll-up shutters along the entire length of the stable (both front and back) in combination with the high vaulted ceilings, large sliding doors on both ends (front and back), and open-front stalls (bars and gates) that faced the outdoors virtually eliminated any and all “dead space” in terms of fresh-air exchange. This stable was located immediately adjacent to a busy roadway and a common parking area. Human activity in this stable was limited to the early morning hours.

Stable 2 was of brick construction with little interior air movement. This stable had low ceilings, closed-front stalls, and small, high windows (only in stalls that were on outer walls) that were kept closed. The only source of ventilation was from two sets of large doorways at either end of the stable and one set of smaller doorways in the center front. Any air exchange that would be provided from outside air was impeded by a large manure handling building located immediately outside one end of the stable (blocking any airflow/wind through the large doorways). Stable management attempted to improve ventilation in the summer months by placing large air-moving fans in the end doorways; however, ventilation was difficult to improve within the stalls because of their solid fronts and high partitions. Unlike the other two stables, human activity levels were high for much of the day. This was the only stable in the study that fed from hay nets. This stable was also located immediately adjacent to a busy roadway.

Stable 3 was of identical construction to stable 2 with the exception that it had a high vaulted airspace above the horses, open windows along both lengths of the stable, and nothing to impede of airflow (e.g., buildings) at either end. This stable was located in a secluded area (away from roadways). Human activity in this stable was limited to the early morning hours.

Measurement Techniques

Concentration and number of ambient airborne particles were quantified using two DustTrak monitors and one MetOne HHPC-6 Airborne Particle Counter. One DustTrak was set to measure the concentration (mg/m$^3$ of air) of PM10, and the other was set to measure PM2.5. The particle counter provided the number of particles of 0.5, 0.7, 1.0, 2.0, 5.0, and 10.0 μm. At each location, we measured ambient concentrations for 1 min. The coefficient of variation of a 1-min sample was 6% for PM10 and 14% for PM2.5. Longer measurement periods did not reduce the variability of the measurements.

Experimental Design

We measured ambient particulate concentrations and particle numbers in each of the three racing stables during morning cleanout and feeding, mid-day, and late afternoon three times of year. Because of the time-consuming nature of the measurements, each stable was measured on a separate but consecutive day. Measurements were made in the center front of each stall with the sampler placed at approximately “nostril height” (1 m above ground). This was close to the feed and water buckets, because we assumed that this was where the horse spent most of its time.

Measurements within each stable were taken only in those areas occupied by our trainers (Fig. 1). A sampling “grid” was developed for each stable, which allowed for measurements to be taken at approximately equidistant points (stalls and aisles) throughout the stables. Stable 1 had 34 stalls occupied by one trainer, which allowed for 204 measurements on each sampling day; this resulted in a total of 612 measurements over the 3 mo of sampling. Multiple trainers occupied stables 2 and 3, and our trainers occupied 30 and 20 stalls, respectively. The occupied stall/aisle configuration allowed for 144 and 31 sets of measurements, respectively, to be taken each sampling day; this resulted in a total of 432 and 279 sets of measurement.
ments, respectively, over the 3 months of sampling in stables 2 and 3.

Data Analysis

We prepared descriptive maps showing the regional particulate concentrations in each barn at each measurement period to identify “hot spots.” Repeated measures analysis of variance (ANOVA) procedures were used to determine the effect of season, stable, location within stable, and time of day on particulate concentration and counts. We divided each stable into regions based either on inner and outer stalls and aisles or based on the “hot spots” in our maps, and we ran ANOVA for each stable to determine if there were regional pockets of high particulate concentrations.

3. Results

There were highly significant (p < 0.0001) differences in average concentrations of PM10 and PM2.5 between stables. Stable 2, which was the most enclosed and the busiest, consistently had the highest concentrations of both PM10 and PM2.5. Stable 1, with the open sides and outwardly facing stalls, had the lowest concentrations. Concentrations in stable 3 ranged between the other two depending on the time of day. Within each stable, there were regions that had significantly (p < 0.027) higher particle concentrations (Fig. 1). These were generally regions that would be expected to have the least ventilation.

Particle concentrations were significantly (p < 0.0001) affected by month. The highest concentrations occurred in September, and the lowest counts occurred in July after a period of damp weather. November particle concentrations were similar to September.

Concentrations of PM10 and PM2.5 changed significantly (p < 0.0001) throughout the day. Concentrations were highest in the morning during cleanout and generally decreased by midday. Although concentrations were lowest in the late afternoon, these values were not significantly different from midday. There was one exception to this general trend. Concentrations of fine particles (PM2.5) did not decrease by midday. Because of their size, these particles remained suspended. Also, concentrations of PM2.5 were greatest in the two stables located close to the road. Particle numbers (0.5, 0.7, 1.0, 2.0, and 5.0 μm in diameter) followed the same trend as the PM10 and PM2.5 concentrations. They showed significant differences throughout the day (p < 0.0001) with peak values occurring during the morning sampling session, and no significant differences between the midday and evening sampling sessions were noted.

The average PM10 and PM2.5 concentrations ranged between 0.078 and 4.090 mg/m³ and 0.030 and 1.170 mg/m³, respectively. Peak concentrations ranged from 0.124 to 12.800 mg/m³ and 0.052 to 4.16 mg/m³, respectively.

4. Discussion

These are the first measurements of indoor air quality (real-time particle concentration and number values) in American racing stables. The newly constructed stable with roll-up (open-air) sides and vaulted ceilings had significantly lower concentrations and numbers of large particles (<10 μm in diameter) throughout the day than the older brick-style building with low ceilings, closed windows, and hay fed from hay nets rather than the floor. Stables located along busy roadways experienced significantly higher concentrations of small (<2.5 μm in diameter) particles in the early morning hours during high traffic times than the stable that was more secluded. Particle concentrations and numbers increased from July to September and then decreased slightly during November. These observations are consistent with weather patterns, ventilation status (e.g., doors open versus closed), and number of horses in the stables (fewer horses in the stables in November). As would be expected, season, time of day (activity level), and stable construction/orientation affect both concentrations and numbers of particles.

In humans and laboratory animals, inhalation of PM10 typically results in a neutrophil influx into the lung and up-regulation of pro-inflammatory cytokines. The pathogenesis of PM10 damage has been related to their metal content, which leads to oxidative stress. PM2.5, because of their large surface area per unit mass, provide a large capacity to generate free radicals and are inherently more toxic than coarse particles. Exposing rats to PM2.5 in concentrations observed at Thistledown has been shown to compromise the ability of the lung to handle streptococcal infections. Compounds such as endotoxin attached to the particle surface also may be responsible for particle-induced injury or may prime the airway for particle-induced inflammation. Increases in PM2.5 are consistently associated with increased morbidity and mortality from respiratory disease, whereas increases in PM10 tend to be linked to short-term transient worsening of disease. These first systematic measurements of real-time particulate concentrations in racing stables have shown that particle concentrations consistently vary between stables, within regions of the stable, by season, by time of day, and by location of the stable with regard to neighboring roads. Particle sizes and concentrations are in the ranges known to cause airway disease in people and laboratory animals. Our measurements represent “background” concentrations rather than “breathing zone” concentrations, where the apparatus would be affixed at the nostril (halter noseband) of the horse. Breathing-zone exposures will be significantly higher, because these take into consideration both background particulate exposures and the additional exposures generated by eating, walking in the stall, rolling, etc.
Phase two of our project includes such measurements.

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References and Footnotes


*DustTrack*, TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126-3996.

*MetOneHHPC-6 Airborne Particle Counter, Hach Ultra, 481 California Avenue, Grants Pass, OR 97526.*