

# CLIMATE MITIGATION FOR EQUESTRIAN AT TOKYO 2020(1)

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## Summary

The stable air-conditioning installations generally performed extremely well and kept the air temperature between 22° and 25°C and humidity between 60-80%RH. However, these were often working at maximum capacity.

The provision of the indoor arena ensured that horses were able to train at WBGT below 28°C on days when the WBGT outside exceeded 30°C. The indoor arena was used by a good proportion of competitors. For example, it was used for lunging, riding and for keeping horses out of the heat before official horse inspections as well as for pre-competition warm-up.

Air quality in the barns at EQP, based on PM2.5, PM10 and total particle counts, was extremely good and tended to track outside air quality. From observation it was extremely rare to see horses with nasal discharge or hear horses coughing.

Barn CO<sub>2</sub> measurements at EQP suggest that the number of air changes per hour was lower than required to maintain levels similar to outside even when working at maximum capacity.

The air-conditioning in the temporary stables at SFC were able to maintain a temperature of ~22°C overnight before the cross-country. Humidity was higher, at around 80%RH, than in the stables at EQP. However, for the short duration of occupation this is not considered to represent any risk.

Air quality at SFC was very good in Barn 1 but poorer in Barn 2, which was larger in size and occupancy. The specifications and equipment used for Barn 1 can be considered appropriate for the design and number of horses whilst Barn 2 was just adequate.

Air quality in the indoor arena was excellent and was the same or better than outside.

Individual stalls were of a suitable size. As a result of restriction of access to training areas between 12pm and 3pm the stables were quiet in this period and the majority of horses were observed to be resting.

There was no evidence that horses competing in Dressage were compromised by the thermal environmental conditions during warm-up and or competition.

Two morning and one evening sessions were held for Eventing Dressage. Whilst the 2<sup>nd</sup> morning session was hotter, there was no evidence that scores were related to conditions and thus no evidence of disadvantage to competitors competing in evening *versus* morning sessions.

Conditions during Eventing XC were thermally challenging. WBGT measurements recorded on course (Kestrel HS meter) were between 30 and 34°C. Horses generally finished the cross-country in good condition and rectal temperatures, HR and respiratory rate were not inconsistent with a full distance 4\* or 5\* event in warm conditions.

There was a slight trend for horses to finish with higher rectal temperatures as the morning of XC progressed. There was no clear evidence to suggest that there was any significant effect of order of go, and hence WBGT, on falls, refusals or time penalties.

The end XC cooling area was shielded from the press and public.

There was no evidence to suggest the Eventing Jumping was influenced by thermal environmental conditions.

Thermal environmental conditions were similar for all 4 days of the Jumping competition.

Although conditions became slightly cooler as the evening competitions progressed, examination of faults and time penalties for the Individual and Team Qualifier Jumping rounds showed no evidence of an order of go advantage.

Previous analysis from historic records for nearby stations and estimates of WBGT for 2006-2016 and WBGT onsite measurements in 2017, 2018, 2019 and 2020 indicated that the Paralympic period was usually cooler than the Olympic period. 2021 was atypical with WBGT during warm-up and competition for earlier events often exceeding 33°C. As a result the warm-up for some Paralympic grades was moved into the indoor arena.

Overall, there is no evidence to suggest that any horse and rider combinations in any of the Olympic or Paralympic Equestrian events were disadvantaged by having to warm-up or to warm-up and compete in high WBGT conditions.

### **Recommendations**

The number of air-changes per hour in climate-controlled or air-conditioned barns should be sufficient to maintain CO<sub>2</sub> below 1000ppm.

Ideally low-dust bedding should be provided at FEI events with indoor stabling to maintain air quality. This is also linked to natural ventilation or air changes per hour when mechanical ventilation/air-conditioning is installed as the greater the number of air changes per hour the lower the respirable dust.

Stable air quality should be routinely monitored at FEI competitions with internal/closed stabling.

For Paralympic competition, to avoid exposure of horses and riders to high levels of thermal stress during either warm-up and competition or warm-up only, in climates such as Tokyo scheduling competition for periods of lower and stable WBGT is recommended.

### **Conclusion**

Despite there being some periods of very high thermal stress, there was no evidence that horse welfare was compromised. There were no reported veterinary incidents of heat-related illness. In addition, there was no evidence to suggest that the thermal environmental conditions disadvantaged horses and athletes in the Olympic or Paralympic Equestrian disciplines.

The success of the Tokyo Equestrian disciplines was due to extensive education, excellent facilities, in particular the air-conditioned stables and indoor arena, teamwork by the officials and scheduling of training and competition to avoid the most thermally stressful conditions.

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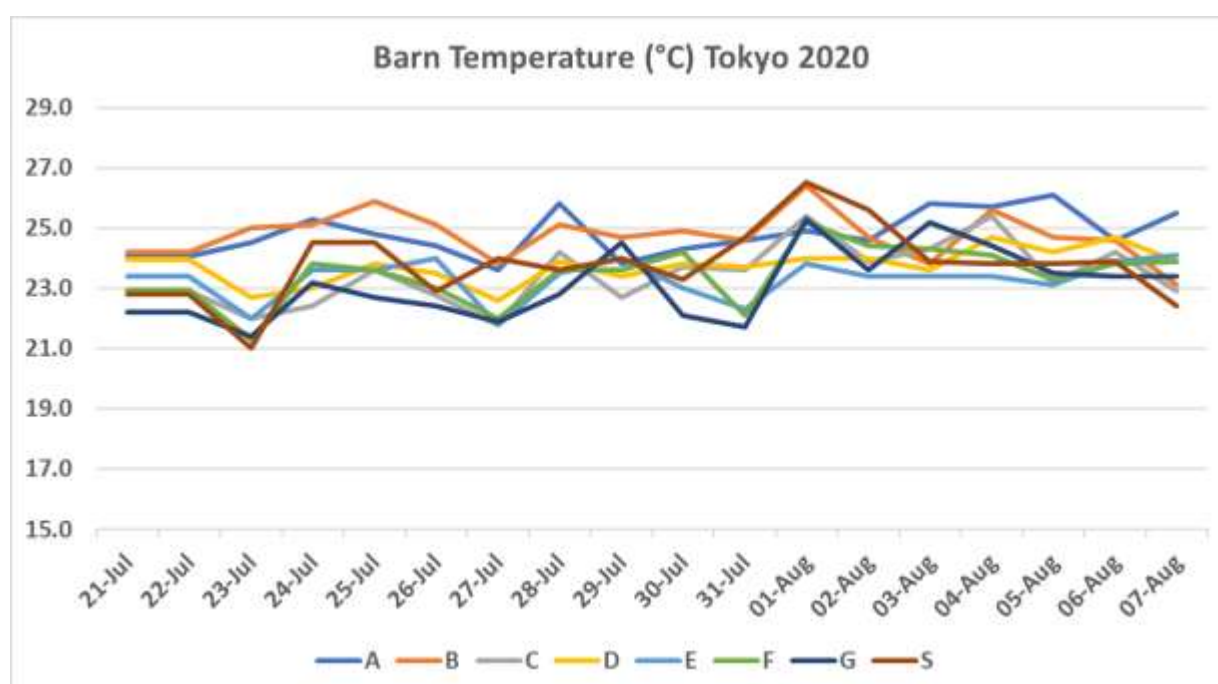
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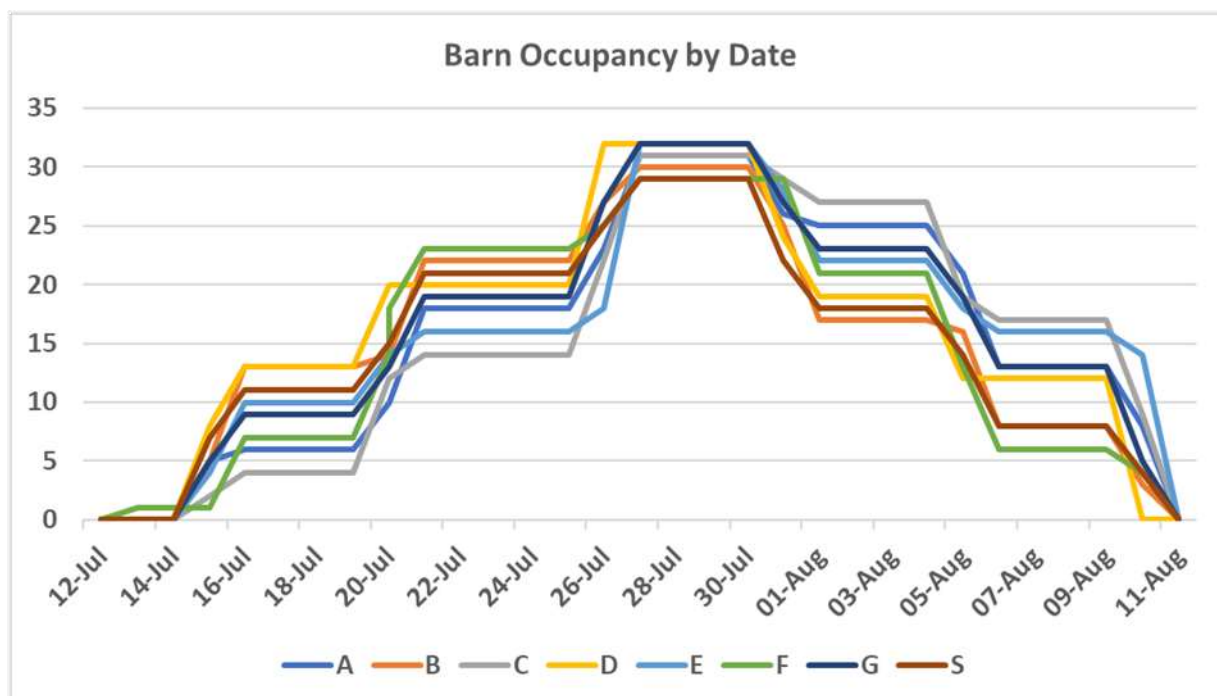
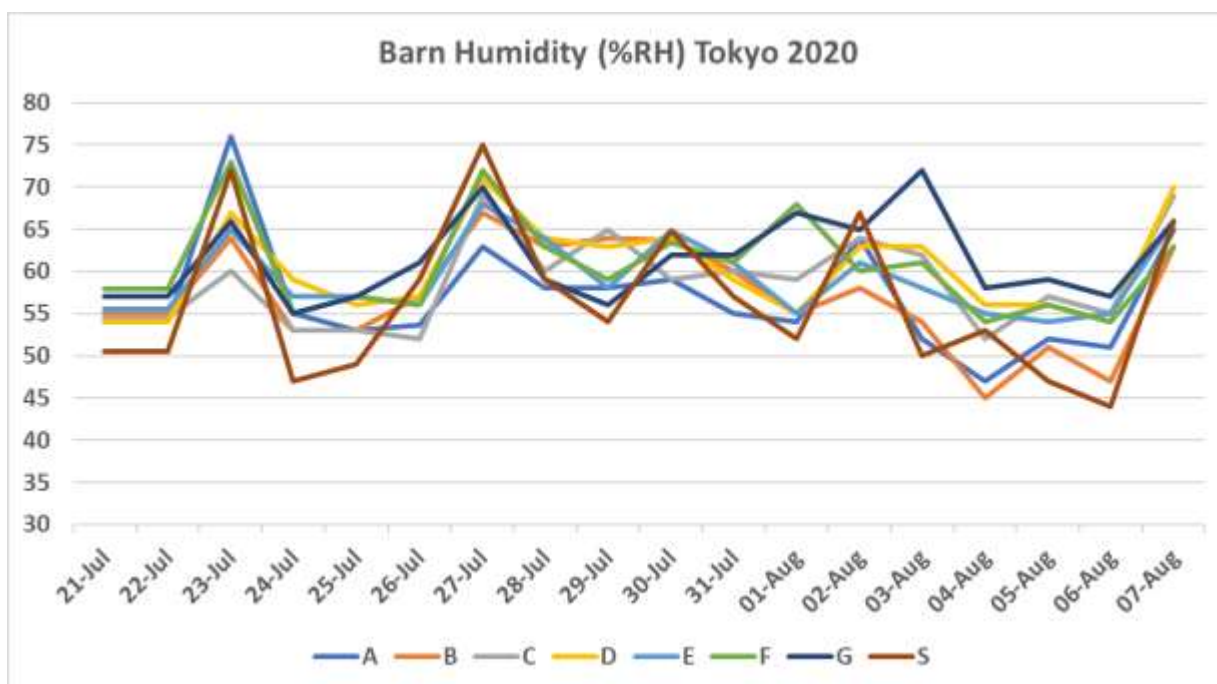
Pages 45-48	Venue photographs
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## THERMAL ENVIRONMENTAL CONDITIONS

### **Barn Thermal Environment - EQP**

Daily spot measurements of air temperature ( $^{\circ}\text{C}$ ) and humidity (%RH) taken in each barn (A, B, C, D, E, F, G & S) at the same time as air quality measurements using a calibrated Extech HT30 WBGT meter are shown in the figures below. As these measurements were taken between 13:00 and 15:00h daily, this would correspond to the hottest part of the day. Temperature was maintained between 21 and 25 $^{\circ}\text{C}$  for the majority of the time. Humidity was maintained between 55 and 65%RH for the majority of the time, with spikes in humidity on the 23<sup>rd</sup> and 27<sup>th</sup> July. There was no evidence that occupancy (number of horses per barn) affected the maintenance of barn temperature and humidity.

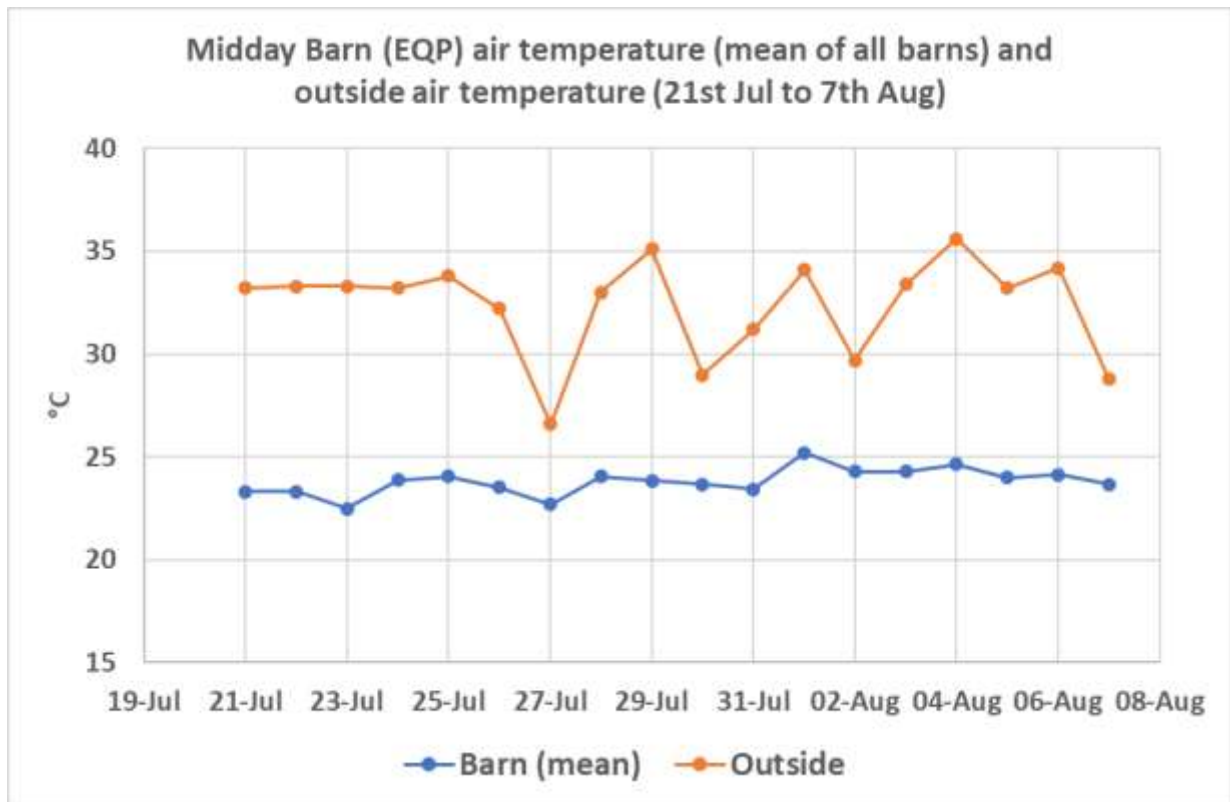




Barns B to G were identical whilst Barns A and S were each of a different size and configuration.

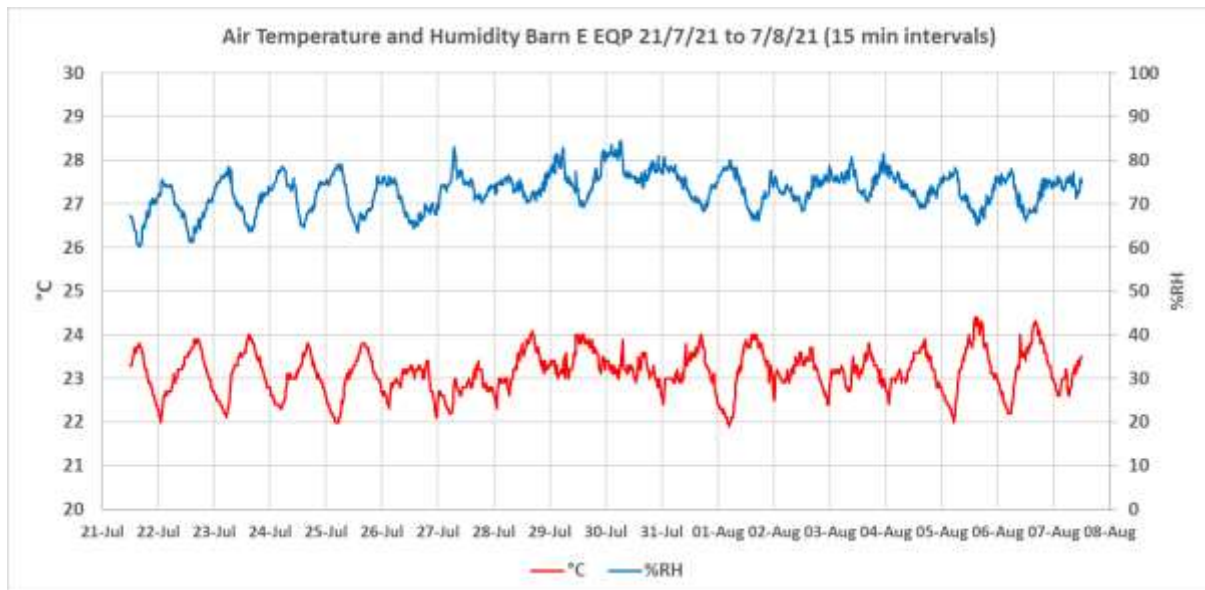
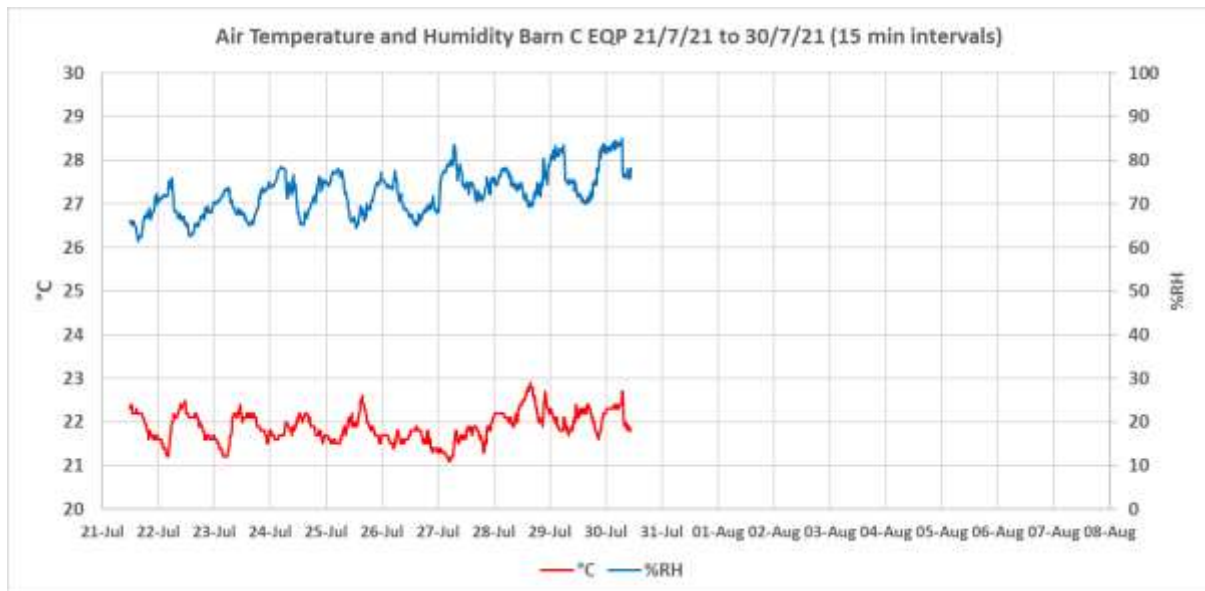
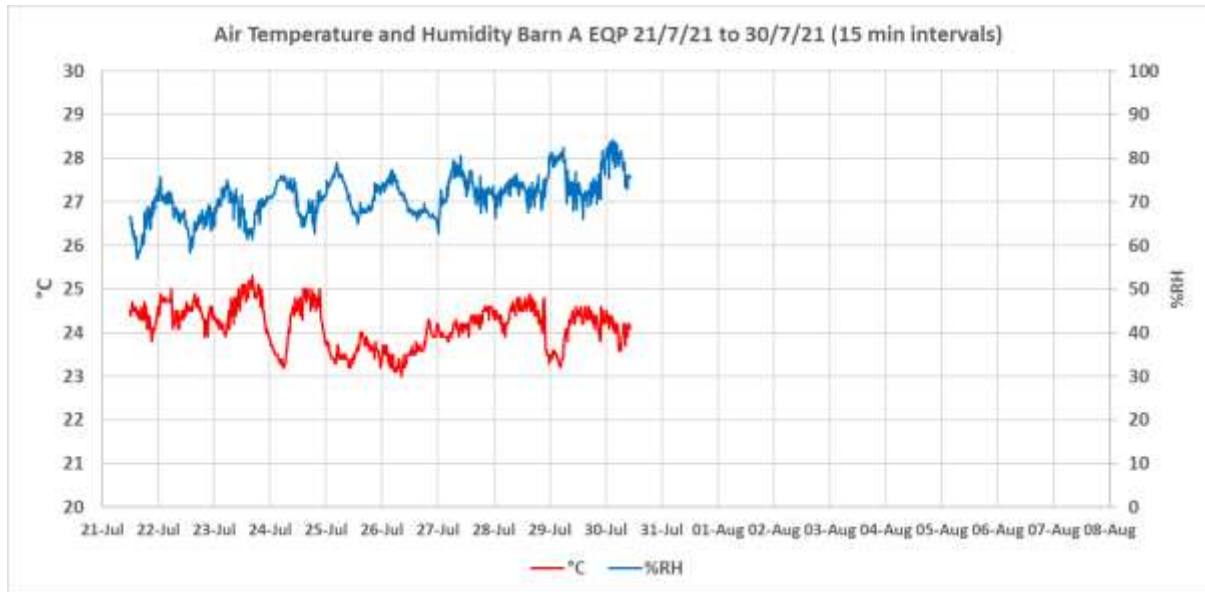
The AC systems in Barns A, B and S occasionally failed to maintain the midday temperature below 25°C. This did not appear to be related to barn occupancy (i.e. total number of horses in each barn by date). This may have been due to the AC units being of insufficient power and/or to differences in barn construction. The latter could explain the issues in Barns A and S (but no barn B). Another possibility could be related to windows being opened more, higher numbers of entry/exits and/or doors being left open. On average, across all barns, there was no indication of a strong influence of outside temperature, suggesting the reason for differences was most likely due to individual barn construction and/or behaviour of people within each barn.





In addition to the daily midday measurements, LogTag devices to record temperature and humidity were placed in the middle of Barns A, C and E. These stored readings every 15 min from 21<sup>st</sup> July 2021. The LogTag's in barns A and C were removed on the 30<sup>th</sup> July to be used in the temporary stables at SFC for cross-country and were not reinstalled. All three barns showed similar conditions, with temperature only varying by ~2°C over 24h and RH by ~15%. Barn C tended to be the coolest and Barn A the warmest.



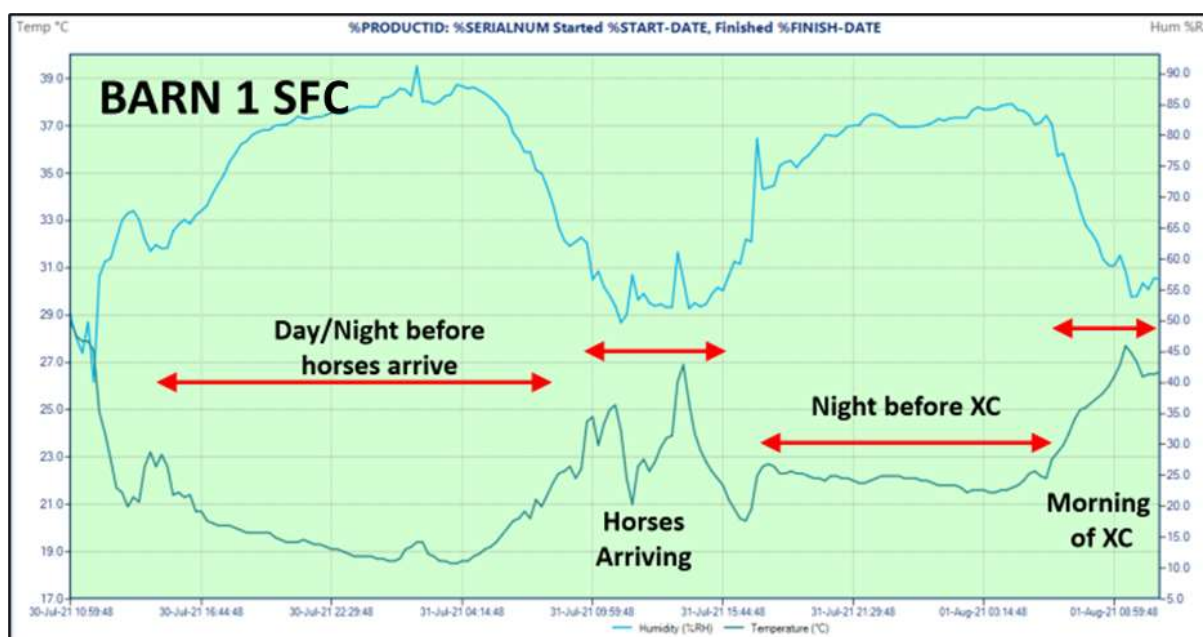


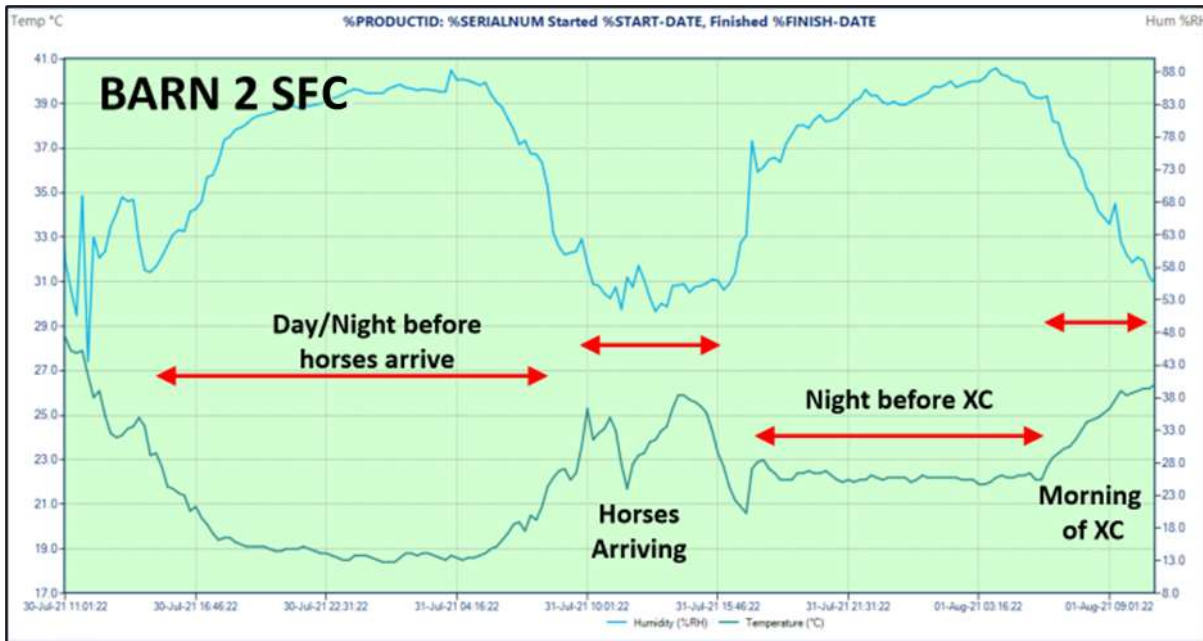


Barn Thermal Environment – SFC



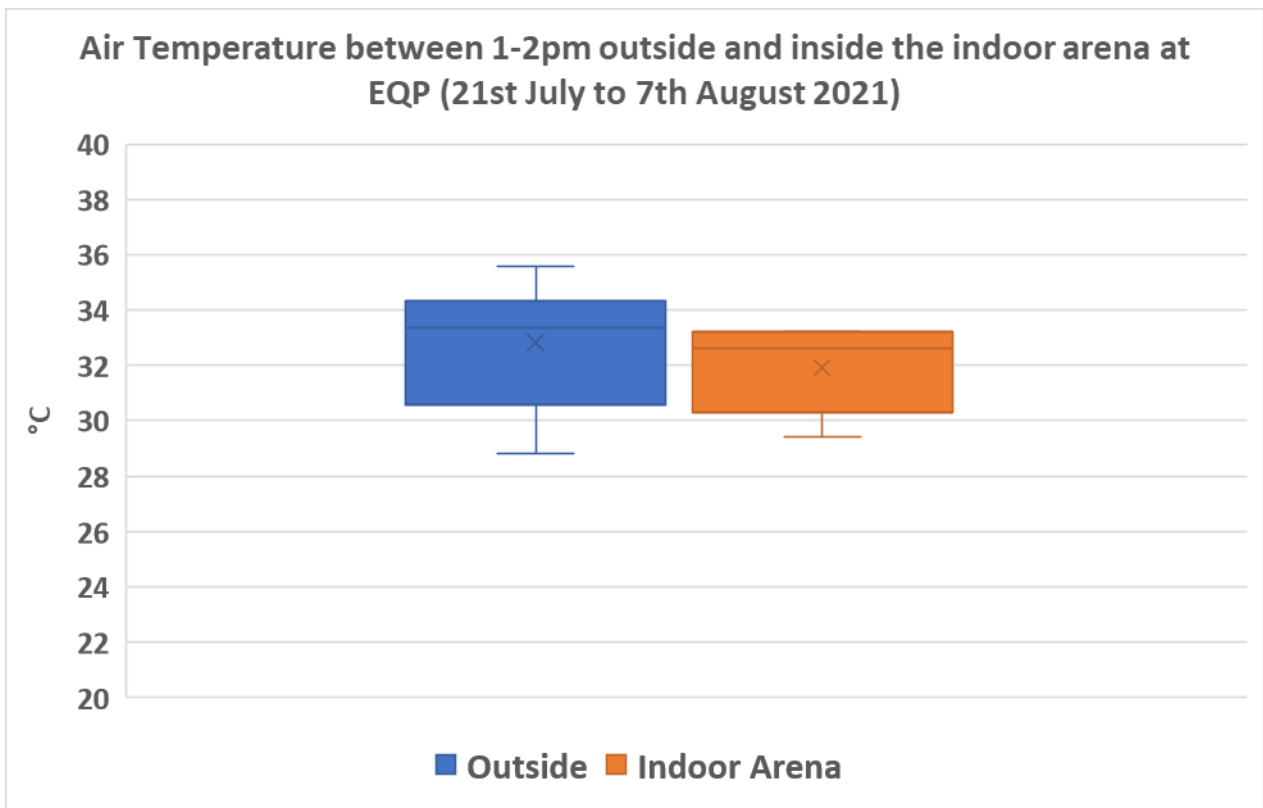
LogTag temperature and humidity loggers were placed in Barn 1 and Barn 2 from ~12:00h on the 30<sup>th</sup> July 2021 until ~11:00h on the 1<sup>st</sup> August 2021 (cross-country day). Conditions in both barns were similar before and during occupation. Overnight prior to cross-country the temperature of both barns was relatively constant around 22°C with a humidity of ~85%RH. This is cooler and more humid than the conditions in the barns at EQP but for this short duration there would likely not be any significant adverse impact on horses.

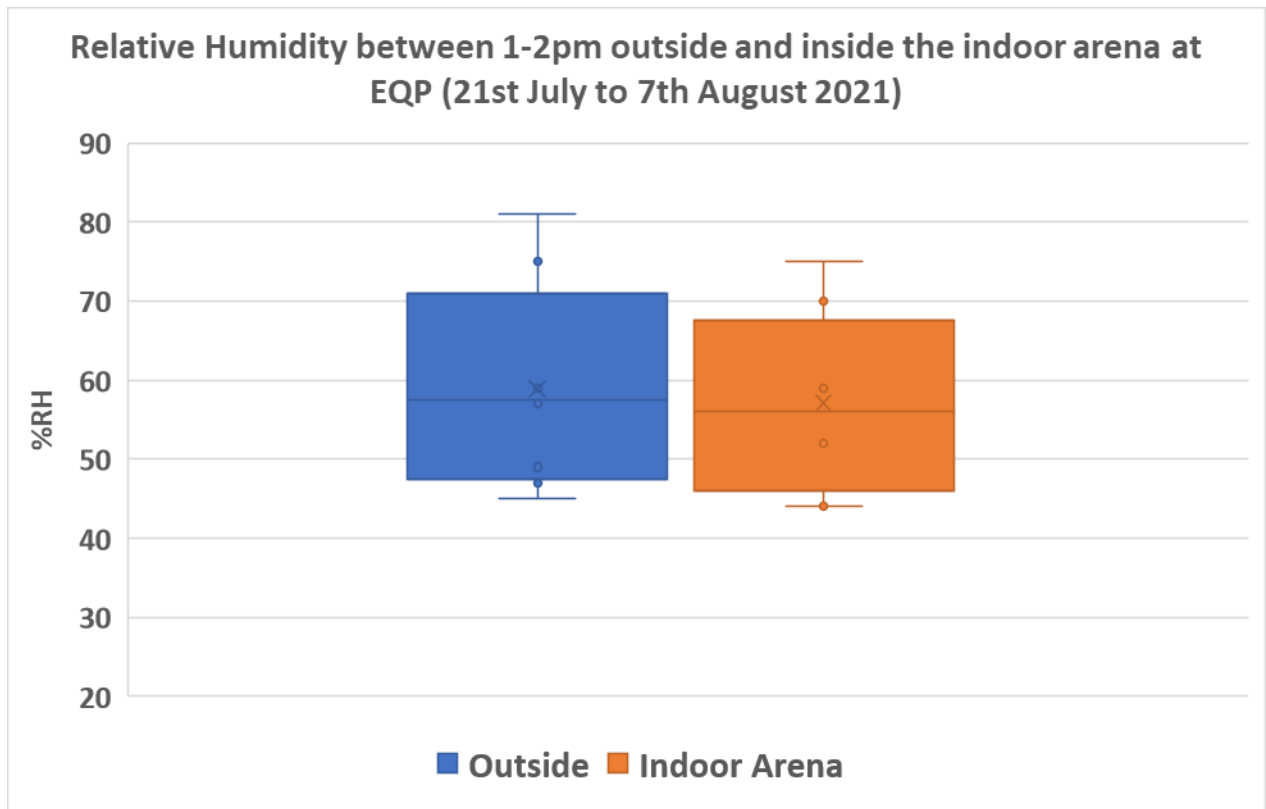




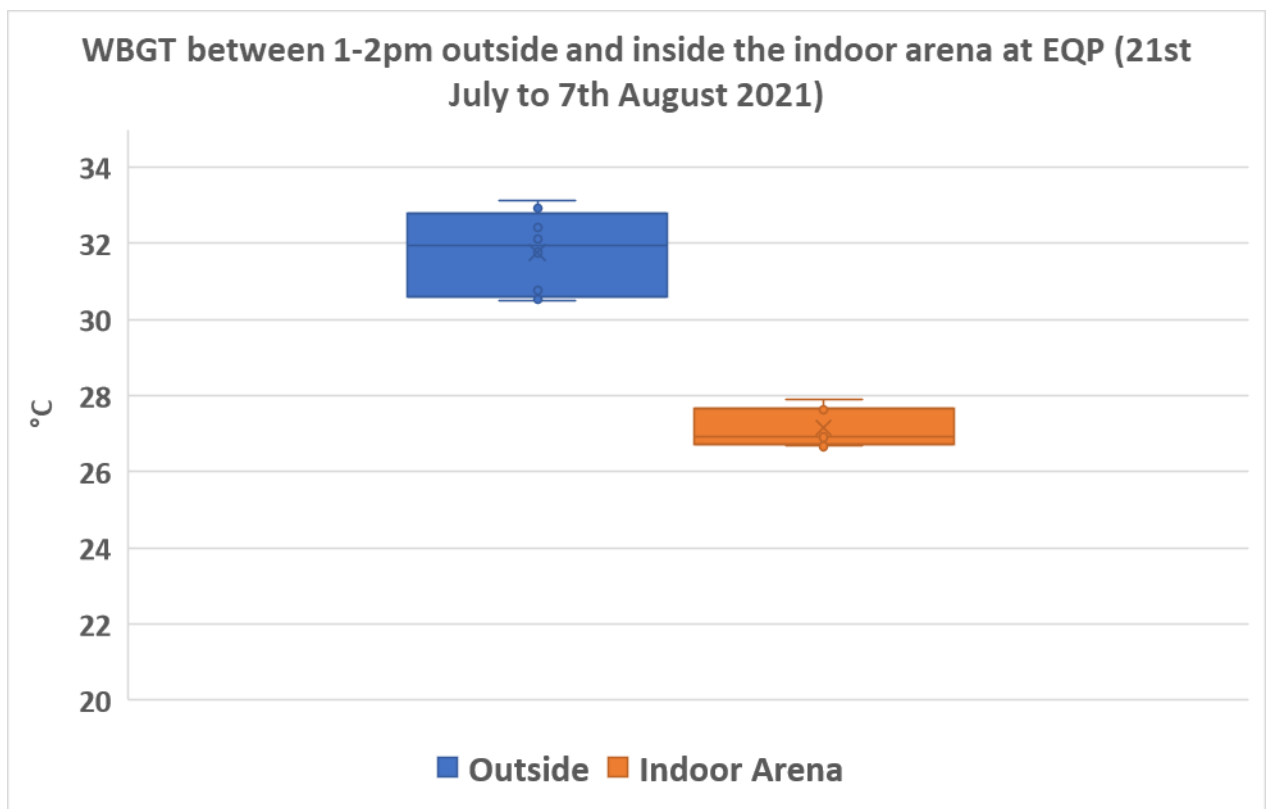
**Indoor Arena – EQP**

Spot measurements of thermal environmental conditions at EQP outside and inside the indoor arena showed very similar temperature and relative humidity.





However, due to the shade provided by the indoor arena, the WBGT Index was always below 28°C.



## AIR QUALITY

### **Barn Air Quality - EQP**

Measurements of air quality (PM2.5, PM10, total particles and CO<sub>2</sub>) were made daily inside each barn at 13:00 to 15:00h when activity was minimal using a Temtop M2000 2nd generation monitor (Temtop, San Jose, CA 95131, USA). Measurements were made from the 21<sup>st</sup> July 2021 to 7<sup>th</sup> August 2021, inclusive. Measurements of outside air quality were also made during the same time period. Barns B, C, D, E, F and G were of the same design. Barn A had a larger overhang whilst Barn S had reduced air-space above the stalls due to the location of accommodation above. On the 21<sup>st</sup>, 22<sup>nd</sup> and 23<sup>rd</sup> August 2021, measurements were taken in the middle of each of the two blocks of stables within each barn. These paired measurements showed a strong correlation between measurements in each block and thereafter only a single reading was taken daily (Top versus Bottom of Barns: PM2.5  $r^2=0.81$ ; PM10  $r^2=0.85$ ; Particles  $r^2=0.87$ ; CO<sub>2</sub>  $r^2=0.62$ ).



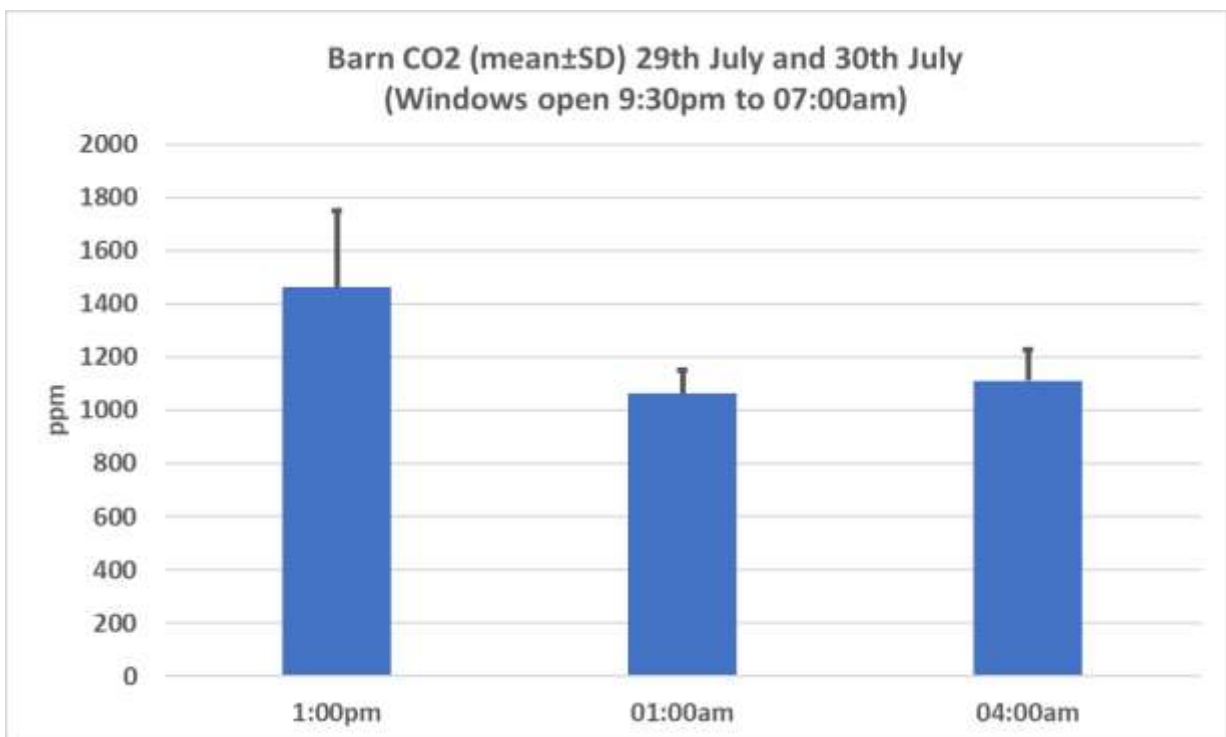
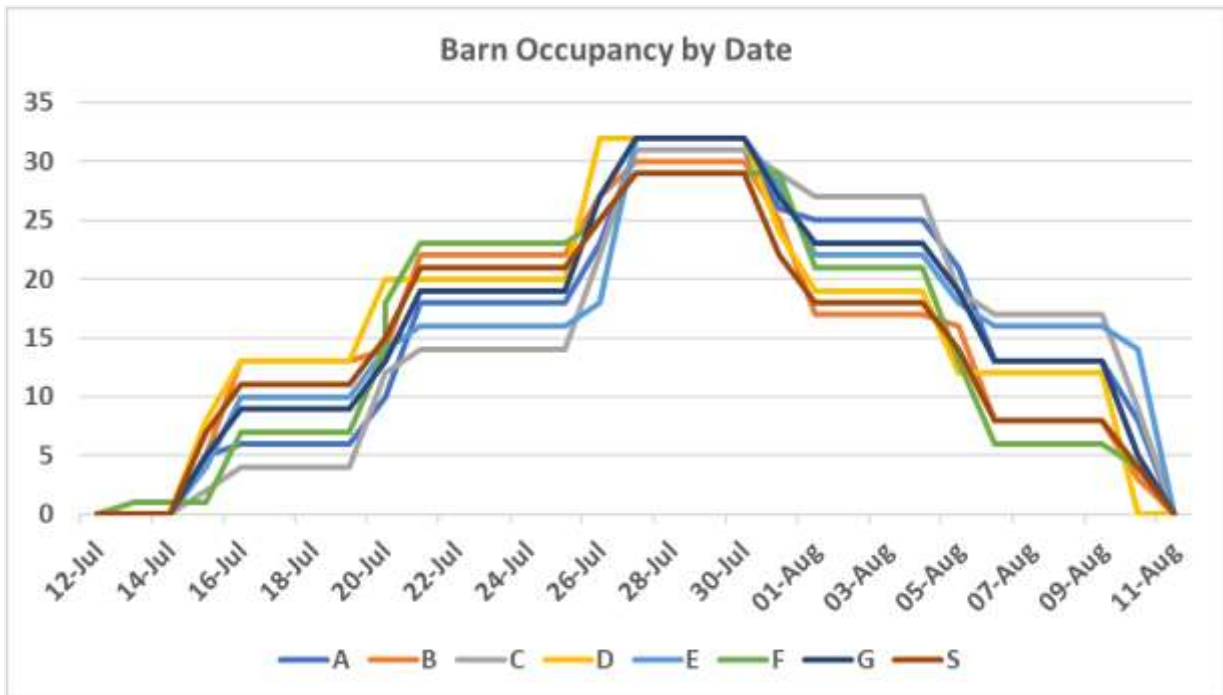
Barn air quality closely followed outside air quality, indicating that air quality within the barns was excellent. CO<sub>2</sub> was higher in all barns for the duration of the games. This indicates that there were insufficient air changes per hour. Outdoor CO<sub>2</sub> is typically around 400ppm but can be higher in urban areas and/or areas of high pollution. The average outdoor CO<sub>2</sub> at EQP during the monitoring period was 584±82ppm. Indoor (barn) CO<sub>2</sub> was considerably higher. Whilst no guidelines exist for CO<sub>2</sub> for horses, for people, indoor CO<sub>2</sub> concentrations of 400 to 1000ppm are considered typical, whilst values of 1000-2000ppm can lead to drowsiness. Values above 2000 and up to 5000ppm are often associated with complaints of headaches, sleepiness, stagnant, stale, stuffy air, poor concentration, loss of attention, increased heart rate and slight nausea. Barn CO<sub>2</sub> showed a similar trend to barn occupancy. It was also confirmed that lack of fresh air intake was the cause of the elevated barn CO<sub>2</sub> by opening windows to allow more fresh air circulation.





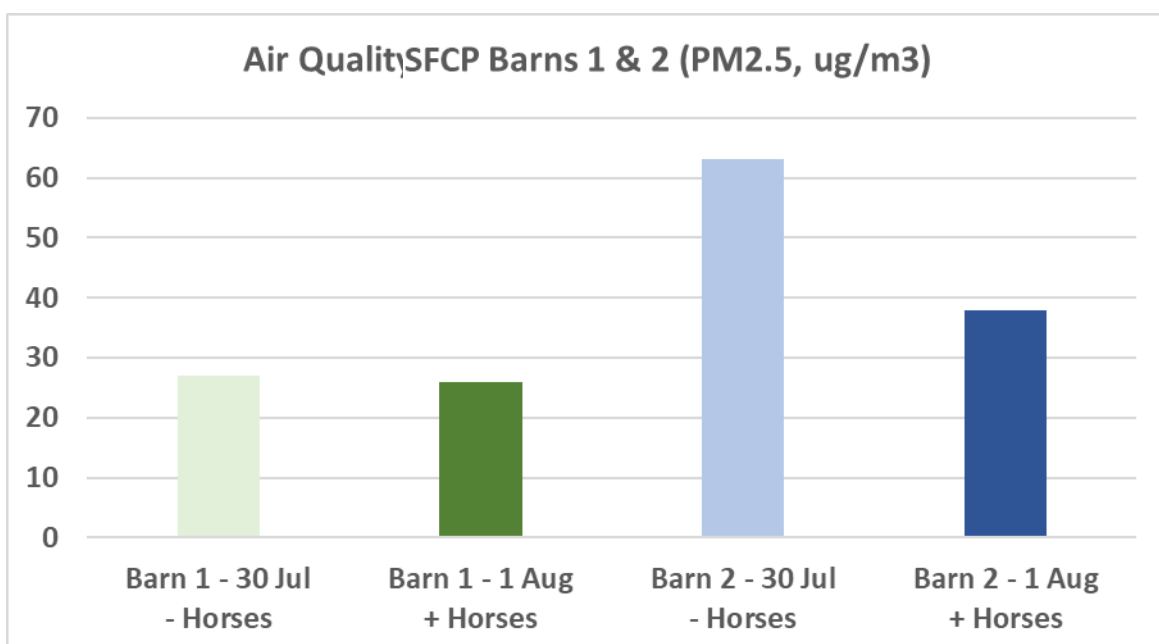


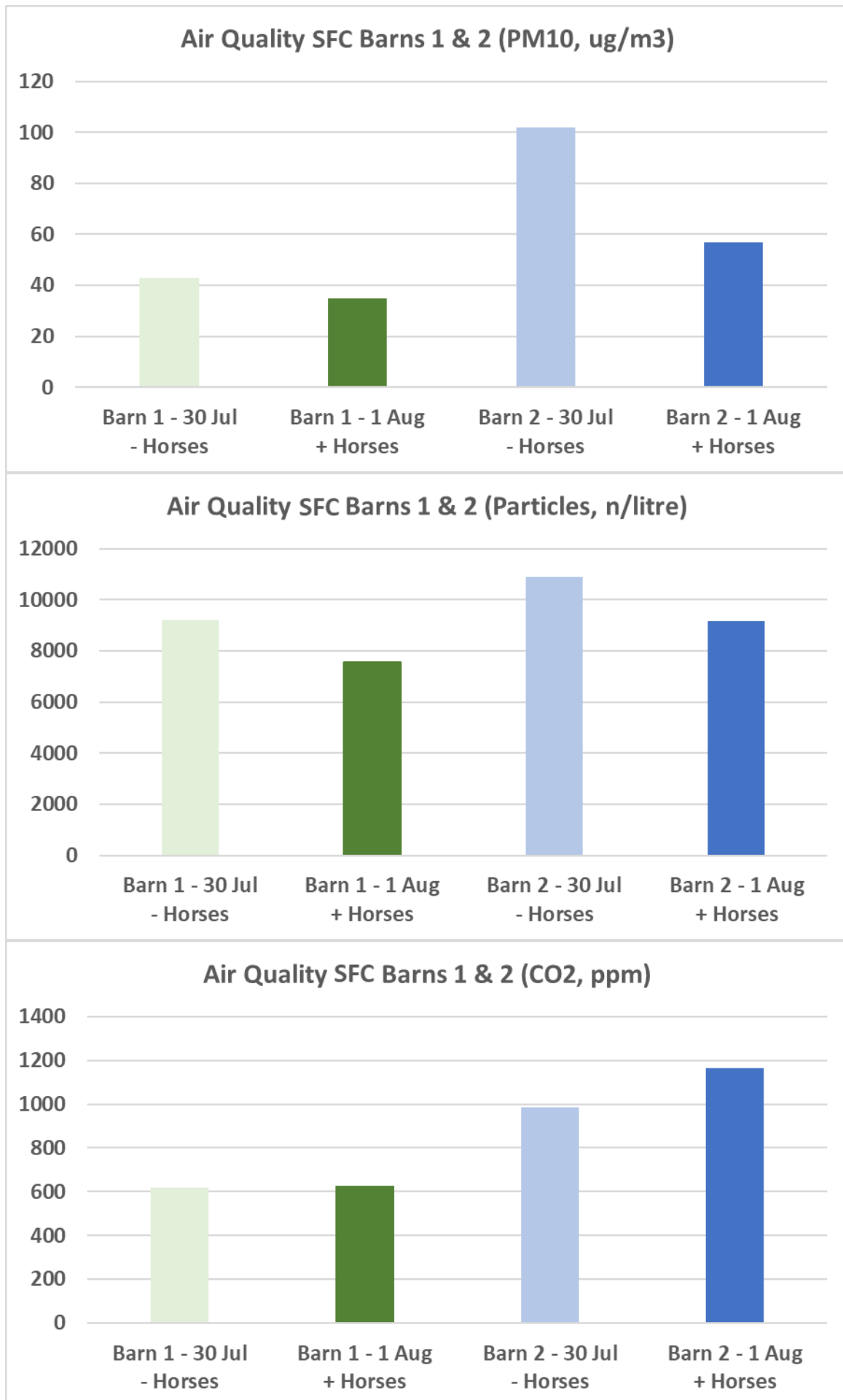




## Barn Air Quality - SFC

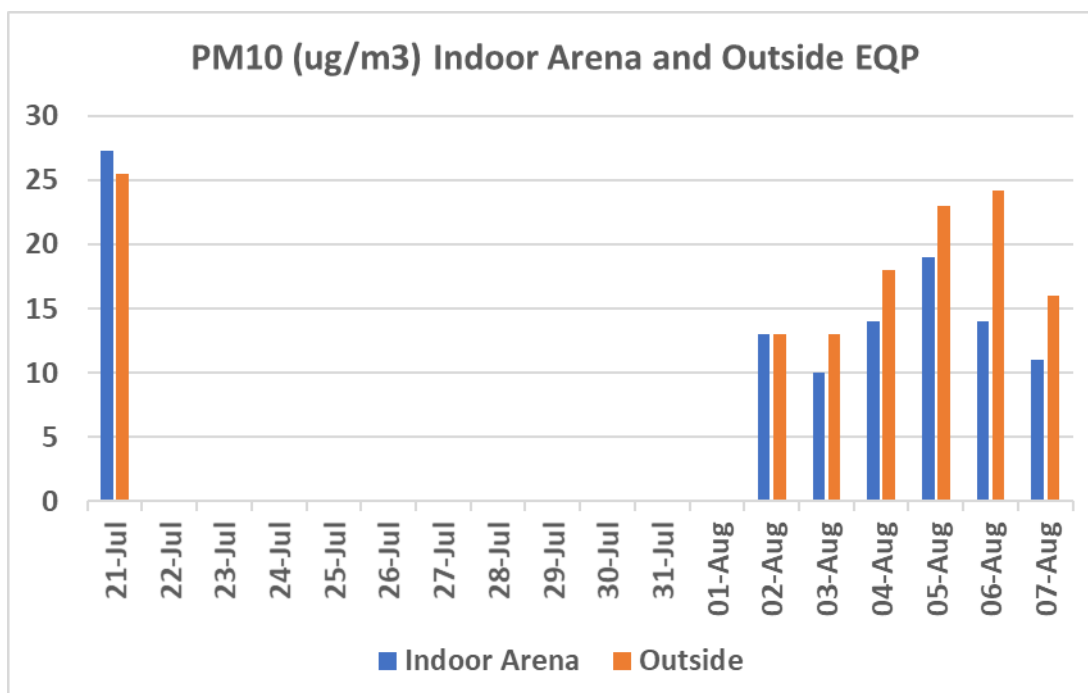
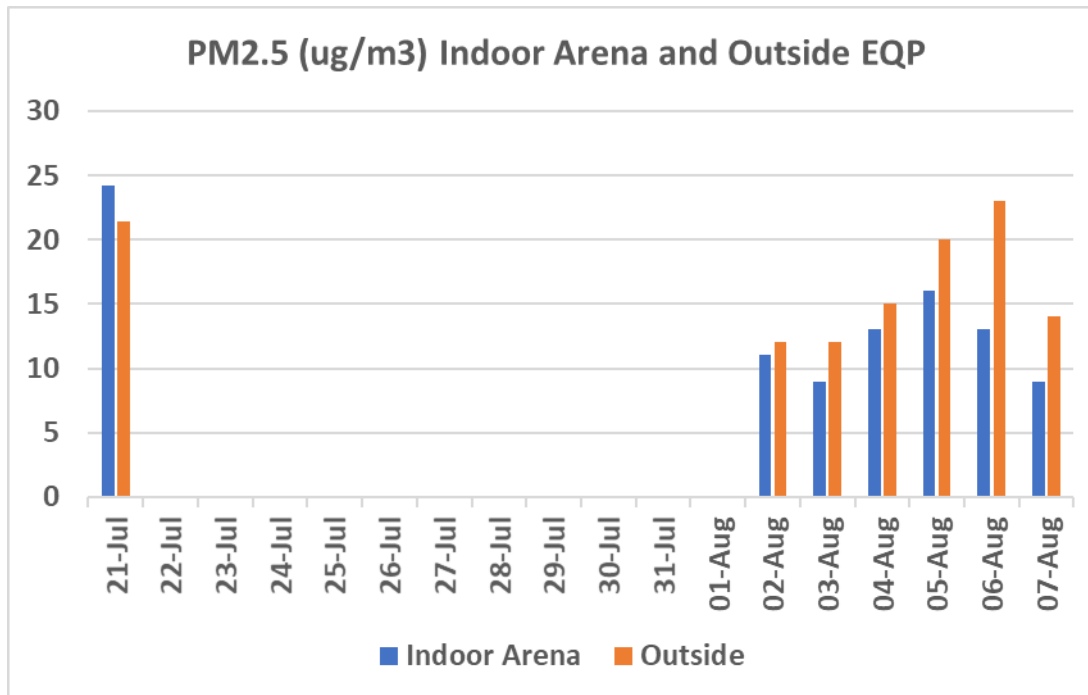
Spot measurements were made at 11:00h on the 30<sup>th</sup> July 2021 before horses arrived and at 05:00h on the 1<sup>st</sup> August 2021 when horses had been stabled overnight. Air quality at SFC was better in Barn 1, which was slightly smaller than Barn 2. Compared with EQP Barns, air quality at SFC was poorer with respect to PM2.5 and PM10 (EQP mean for all barns for whole period: PM2.5 21±8 ug/m<sup>3</sup>; PM10 25±11 ug/m<sup>3</sup>), similar for total particles (7908±2459 particles/litre). Barn 1 had low CO<sub>2</sub> compared with EQP (1228±290ppm) whilst Barn 2 was similar.

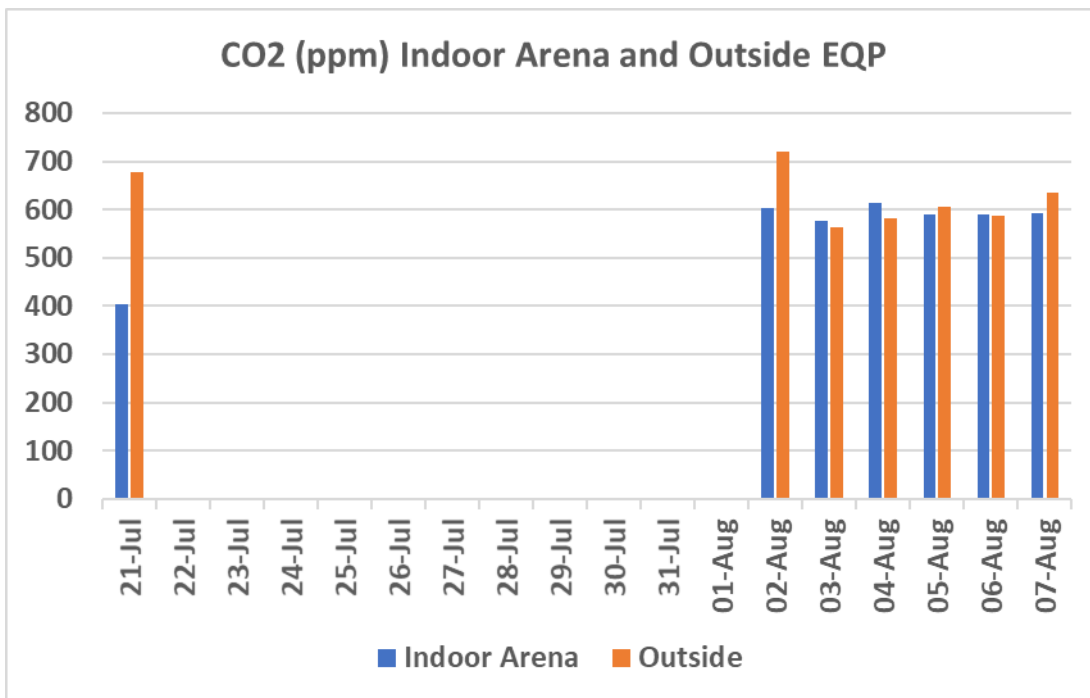
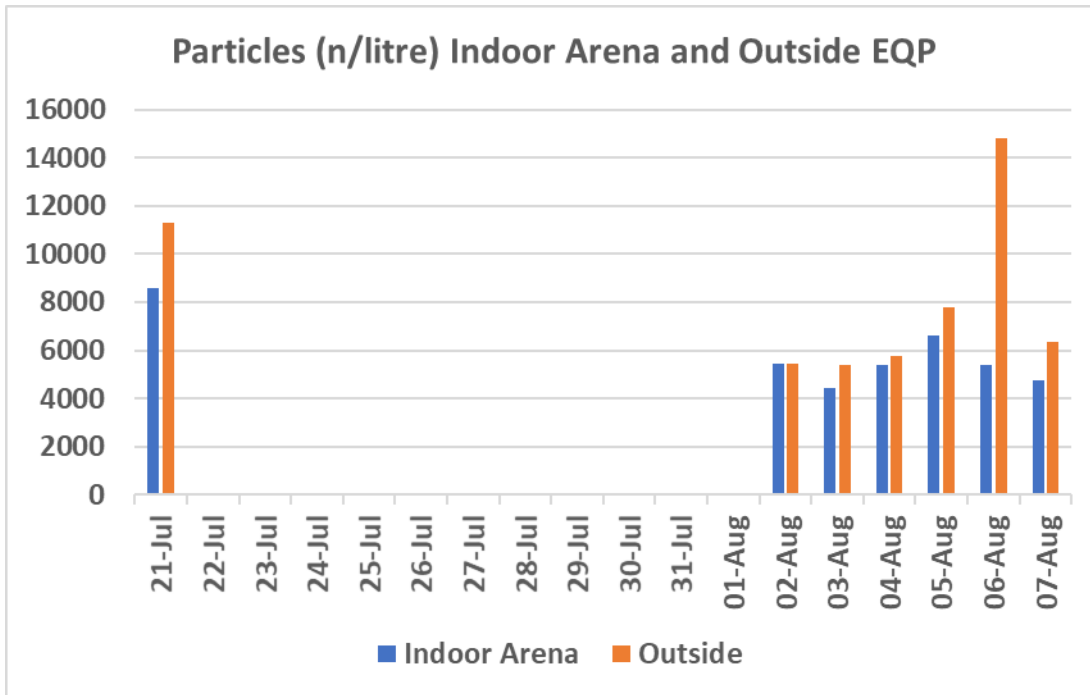




### Air Quality – Indoor Arena

Air Quality in the indoor arena was monitored initially and then in the last week of the games when it was used more. Air quality followed the same trend as outside and was usually similar or better than outside conditions. There was a slight “musty” smell in the indoor arena which may have been due to growth of mould or bacteria within the surface material although no tests of the hygienic quality of the footing were performed. Given the very good ventilation of the indoor arena, evidenced by the similarity between indoor and outside CO<sub>2</sub>, it’s considered unlikely that any mould or bacterial growth would have negatively impacted air quality.

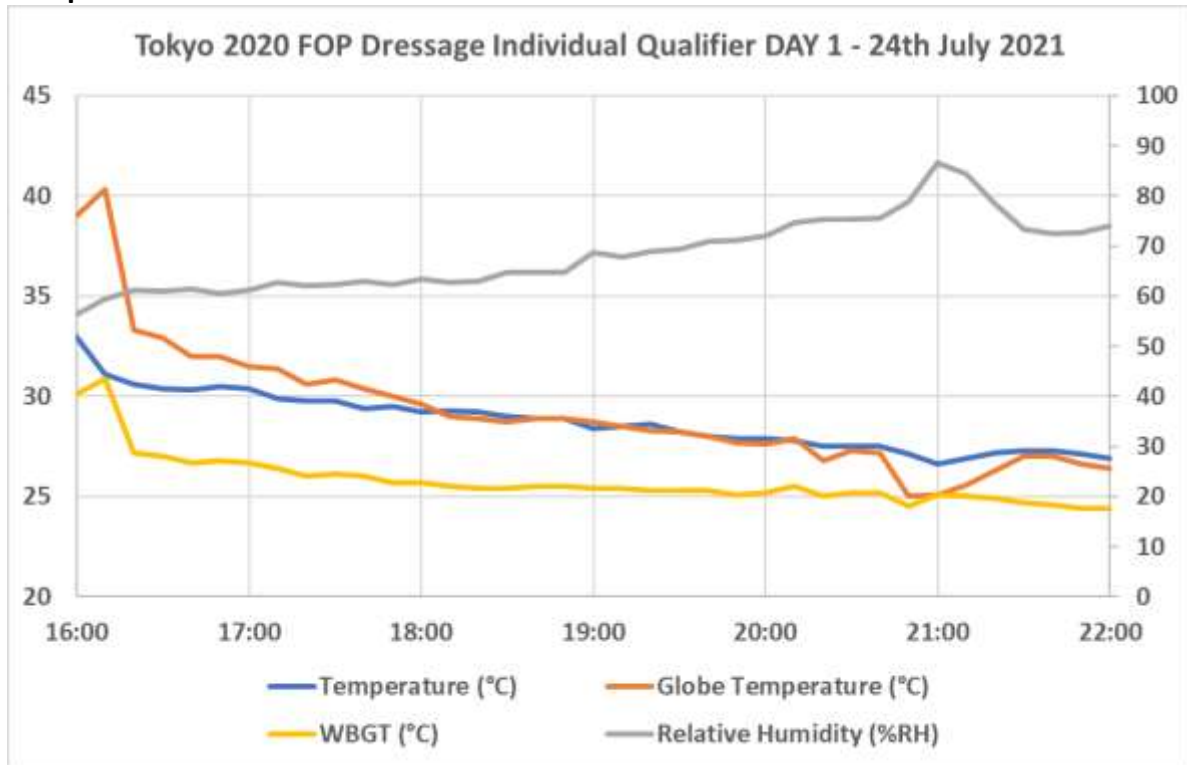




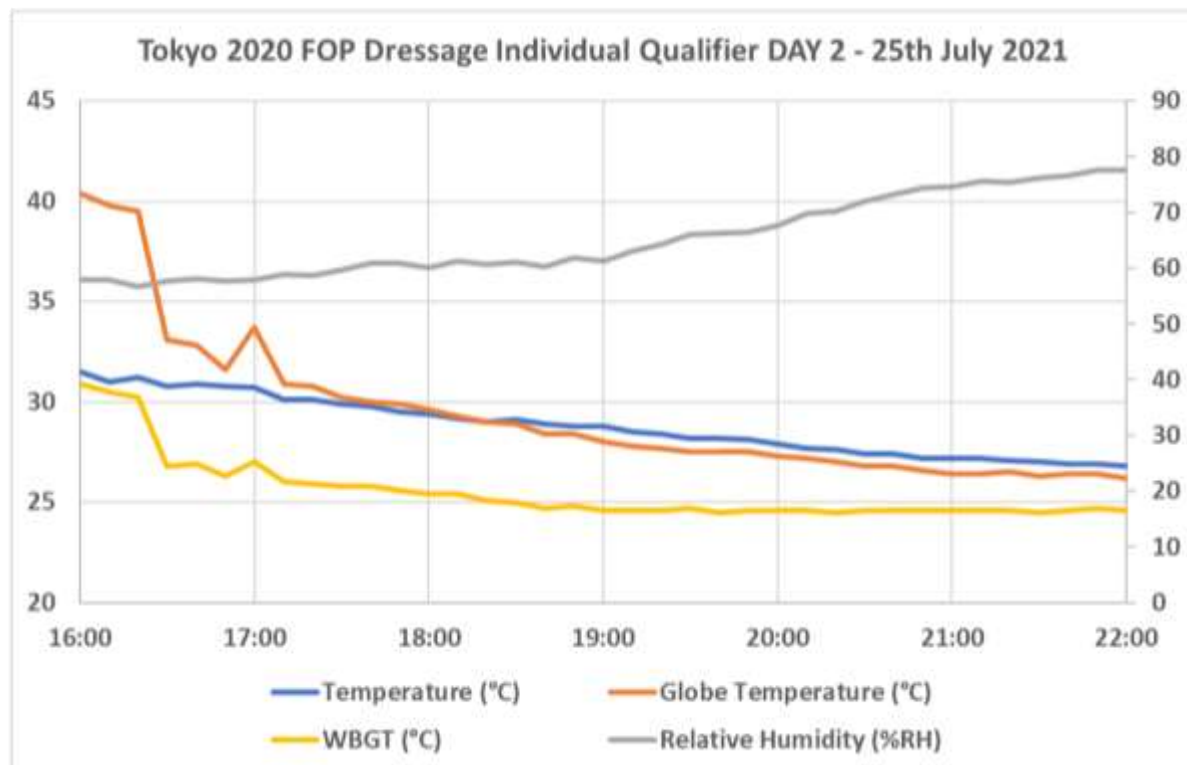
## THERMAL ENVIRONMENTAL CONDITIONS IN COMPETITION

### DRESSAGE

Competition time: 17:00-22:00

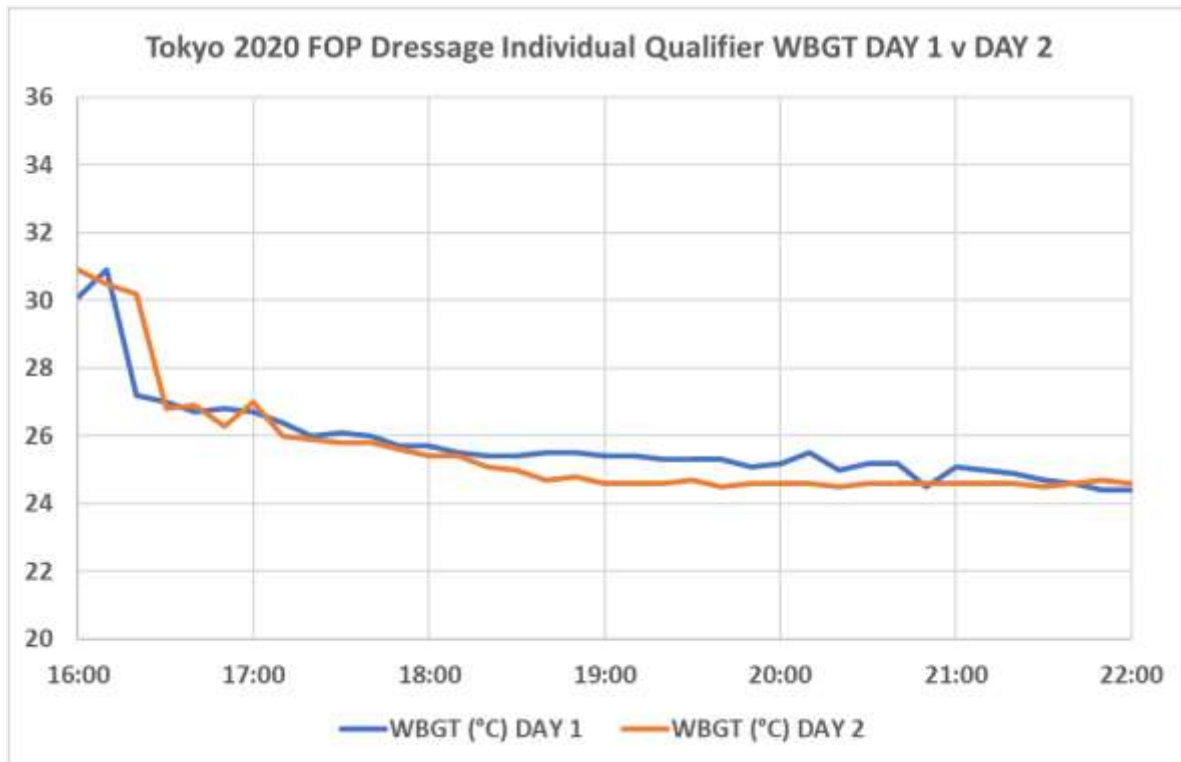


Competition time: 17:00-22:00

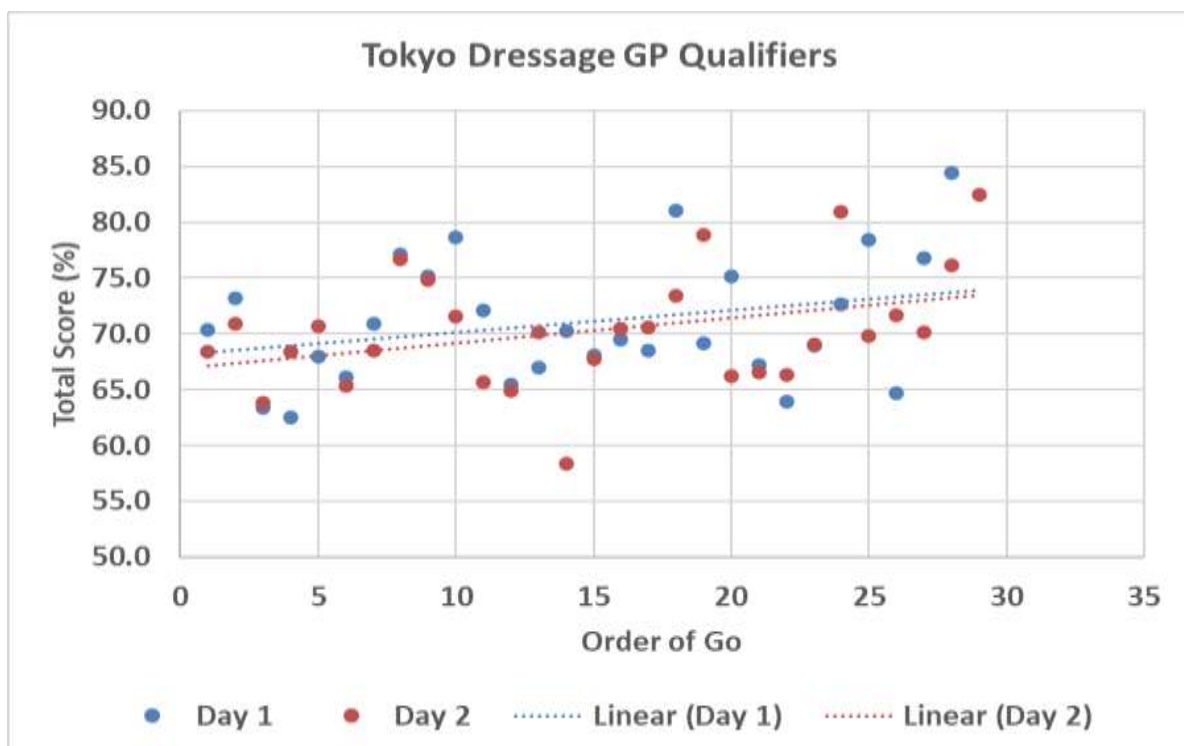




No apparent climate advantage to going early or late. No advantage to going on Day1 or Day 2 (Competition time 17:00 to 22:00).

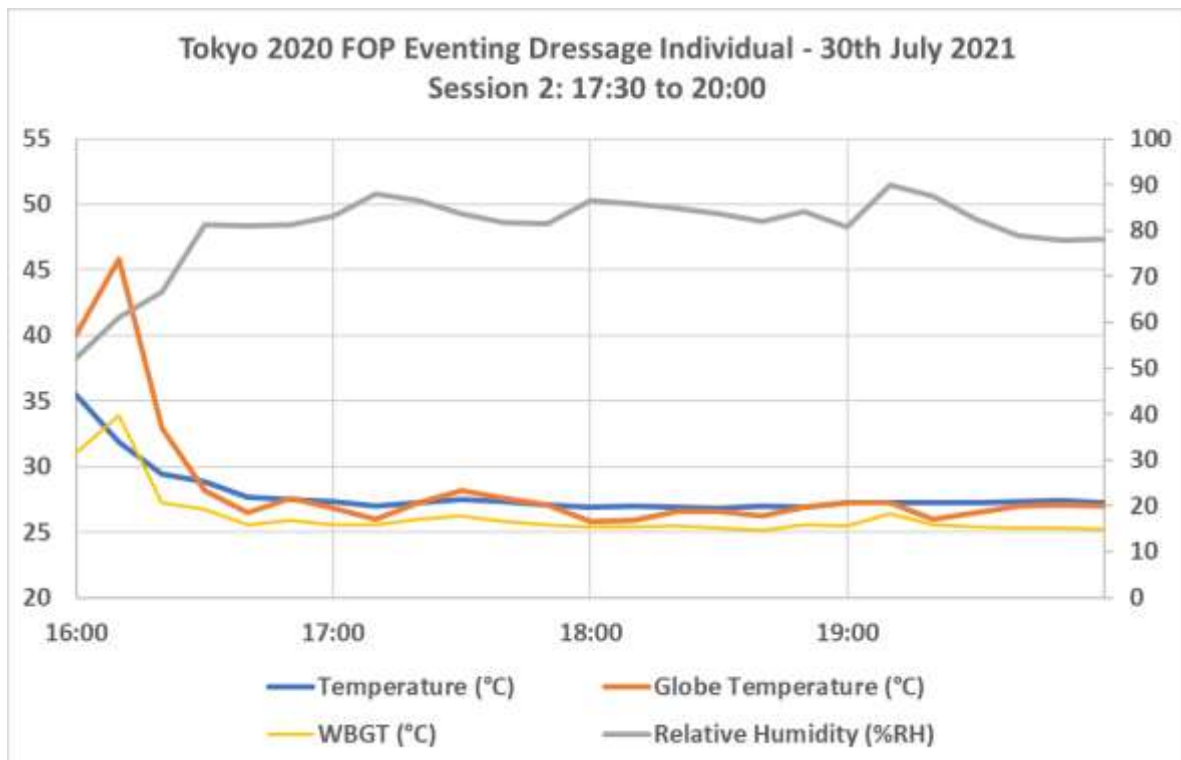
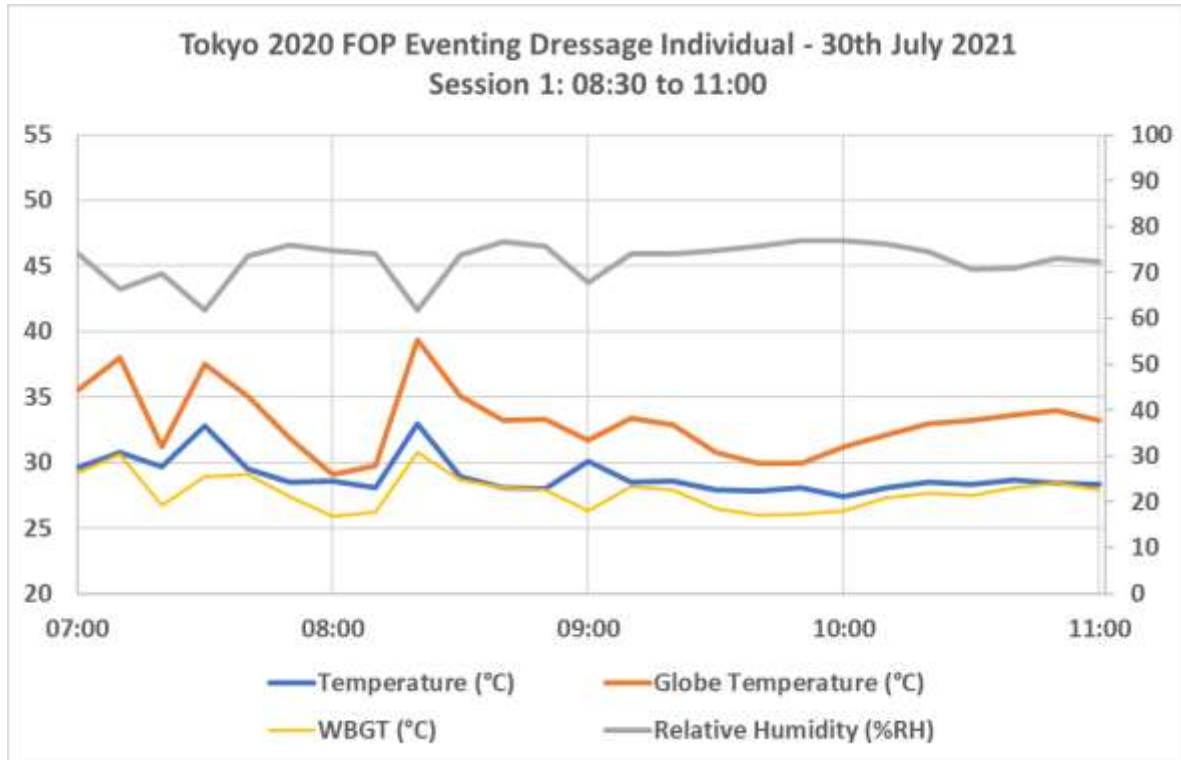


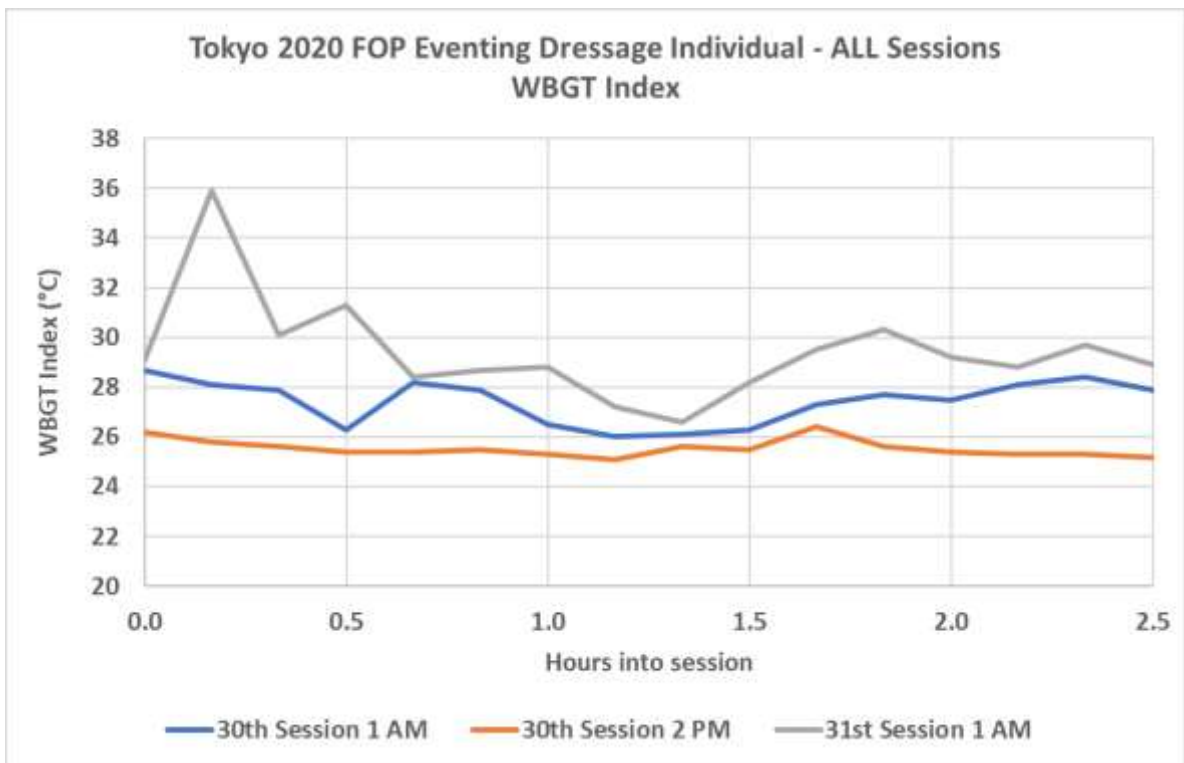
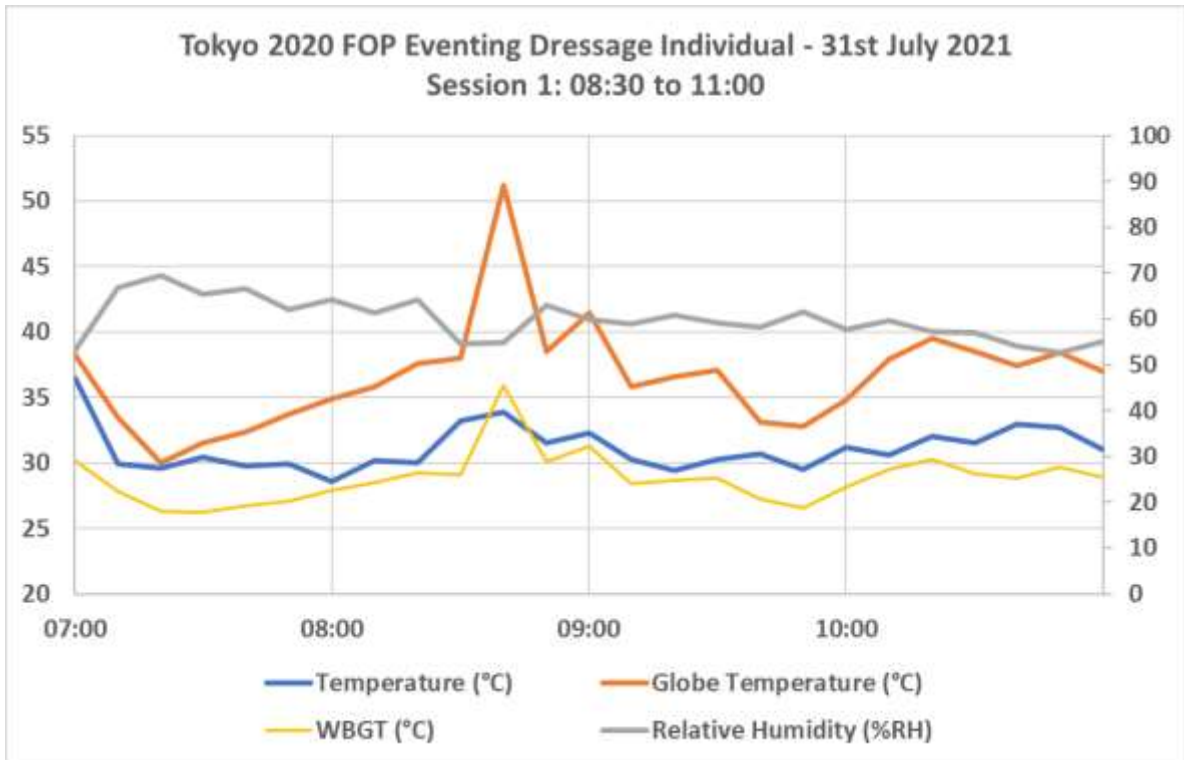
There was a weak but consistent trend for score to increase by 0.2% per order of go from start to finish of each qualifier session. This could be normal drift in marking by judges or a minor effect of the environmental cooling during the sessions. The WBGT and trends were very similar on each day. A small benefit of a later order of go is apparent but an effect of environmental conditions cannot be confirmed or rejected as conditions were similar on each day. Due to technical issues there are no FOP recordings for 27<sup>th</sup> July (GP Special Individual and Team) and 28<sup>th</sup> July (GP Freestyle to Music).



EVENTING

EVENTING – DRESSAGE





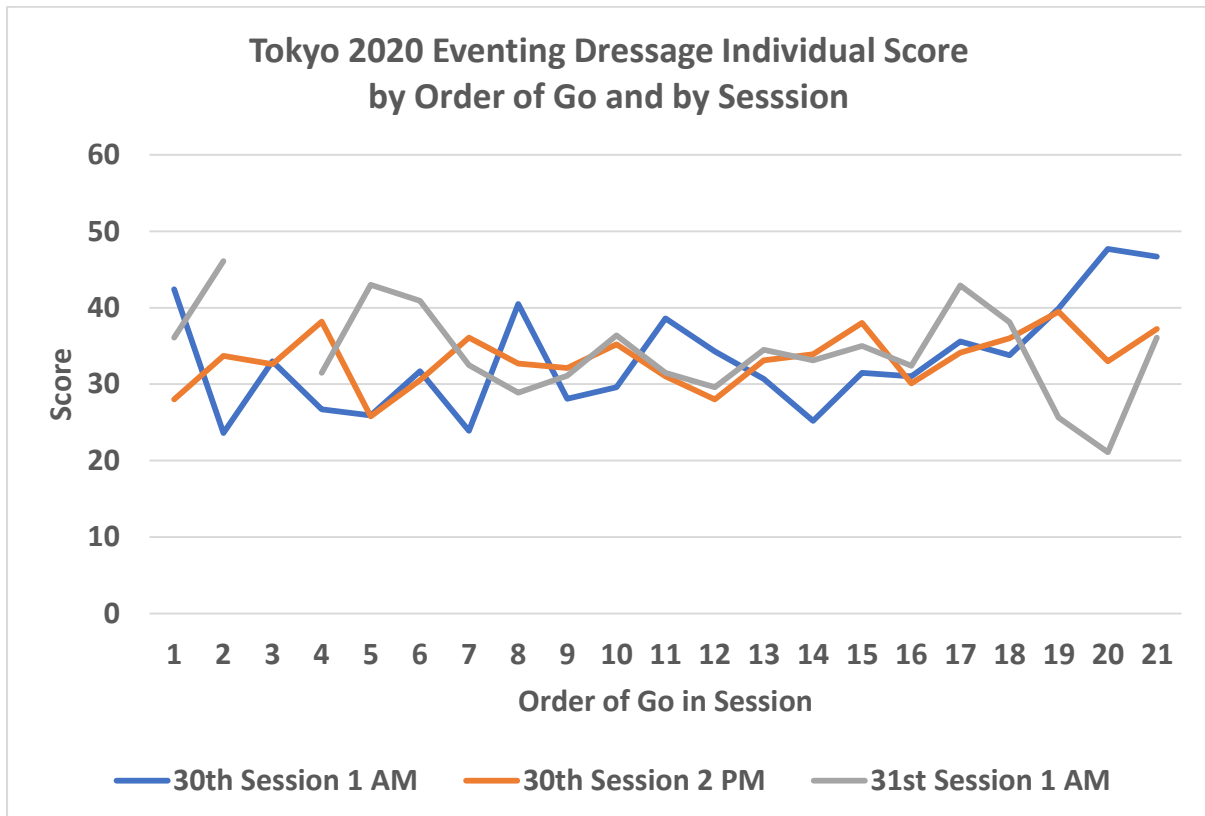
Eventing Individual Dressage - WBGT Index (°C) ALL Sessions			
	30th Session 1 AM	30th Session 2 PM	31st Session 1 AM
<b>Median</b>	27.8	25.5	29.0
<b>Mean</b>	27.4	25.5	29.4
<b>Min</b>	26.0	25.1	26.6
<b>Max</b>	28.7	26.4	35.9
<b>Range</b>	2.7	1.3	9.3

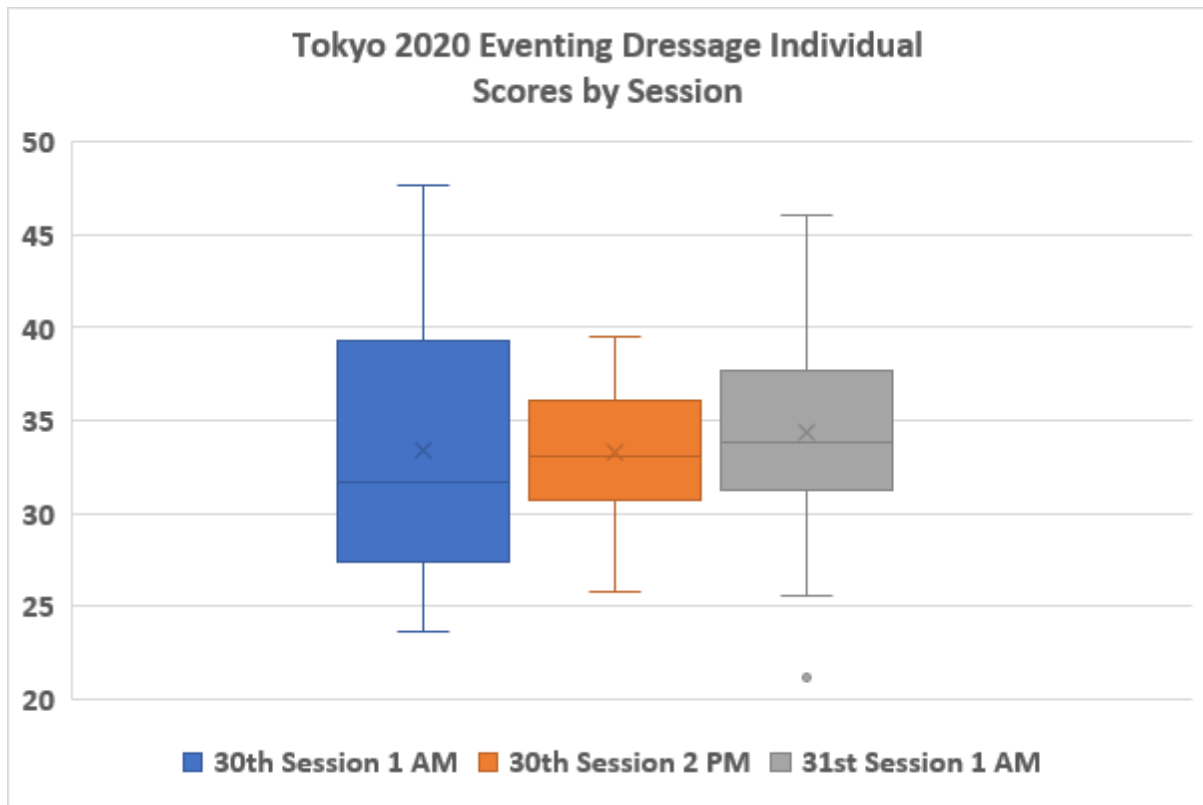
Although the 2<sup>nd</sup> and 3<sup>rd</sup> session were hotter and had a greater range in WBGT, there was no evidence of an effect of order of go on score in any session and no clear evidence of a difference between sessions; the spread of scores was actually greatest for Session 1 on the 30<sup>th</sup> August which was the coolest of the 3 sessions. The median score was actually higher on the two hotter sessions:

30<sup>th</sup> July Session 1 AM: median score = 31.7

30<sup>th</sup> July Session 2 PM: median score = 33.1

31<sup>st</sup> July Session 1 Am: median score = 33.8





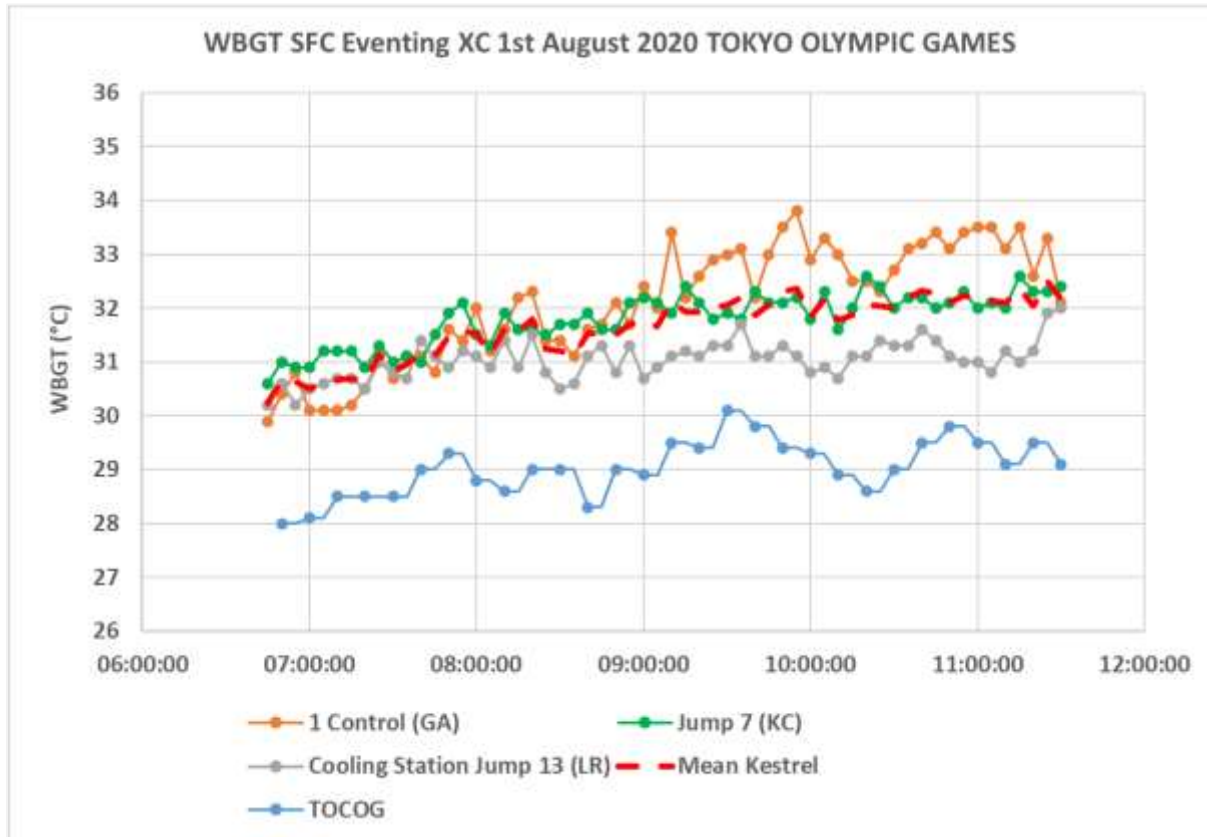
### EVENTING - CROSS-COUNTRY

WBGT Index was monitored at three locations on the XC course using Kestrel 5400 Heat Stress Tracker WBGT meters placed at a height of ~1.2m above the ground. ORANGE (At XC Control) Goran Akerstrom; GREEN (At Jump 7) Karen Coumbe; GREY (At Jump 13) Lars Roepstorff. All stations were in touch by radio and readings were reported in every 10 min and collated at control by Lisa Crump. Readings from the TOCOG station (BLUE) were also monitored. The higher readings from the Kestrel units on course compared with official TOCOG readings is consistent with recordings at the test event in 2019. Whereas the Kestrel units are placed close to the ground the TOCOG readings are from a station on the hill and at several metres above the ground.



The official TOCOG station reported a maximum WBGT Index of just over 30°C whilst the highest on course reading was just below 34°C at around 10:00. WBGT increased between 07:00 and 09:00 and was then relatively constant between 09:00 and 11:30 with a mean for all locations of around 32°C.

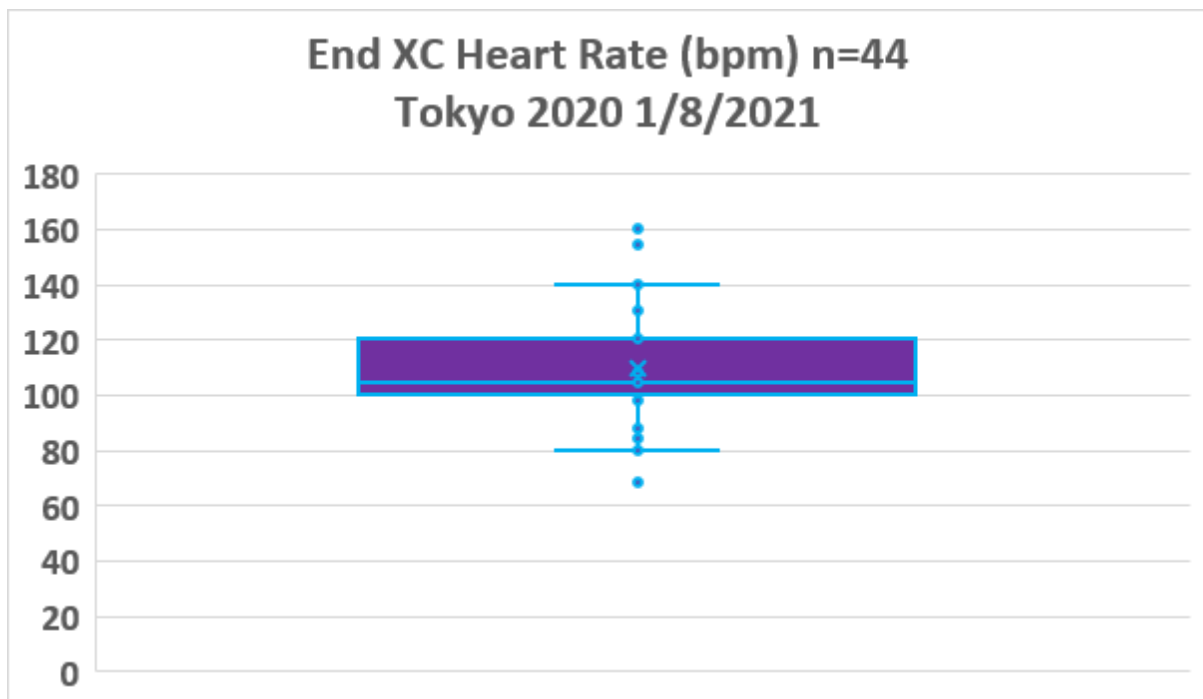
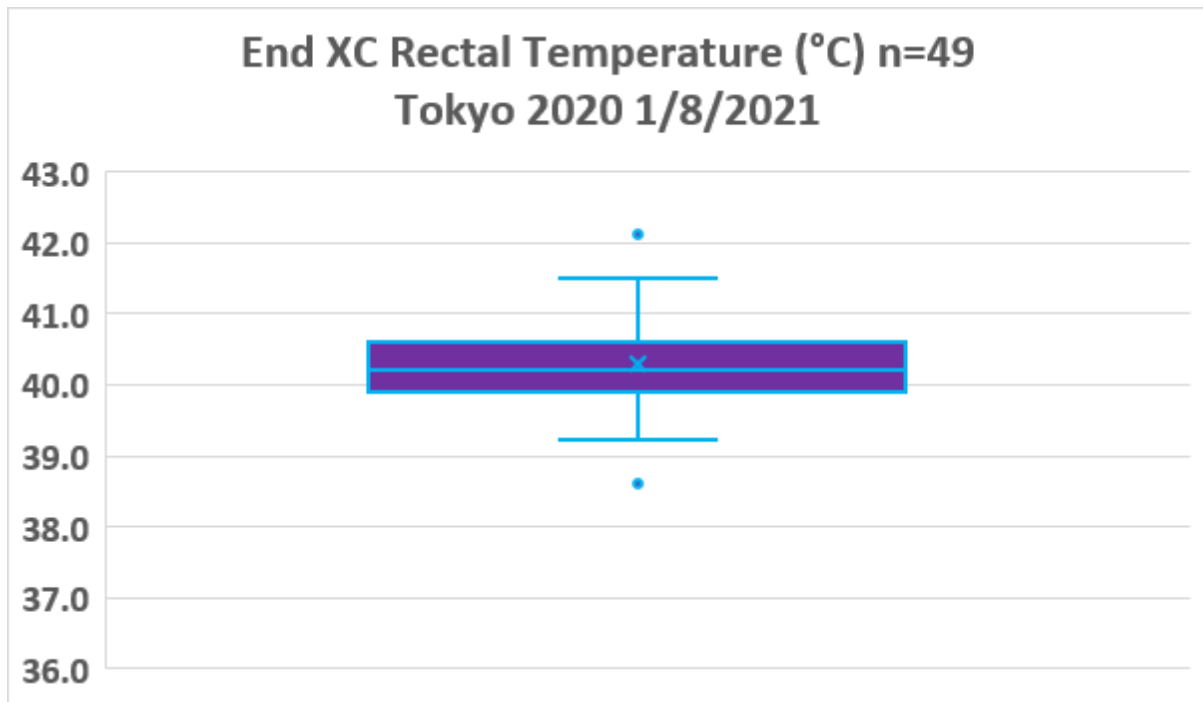
**Start time: 07:45**

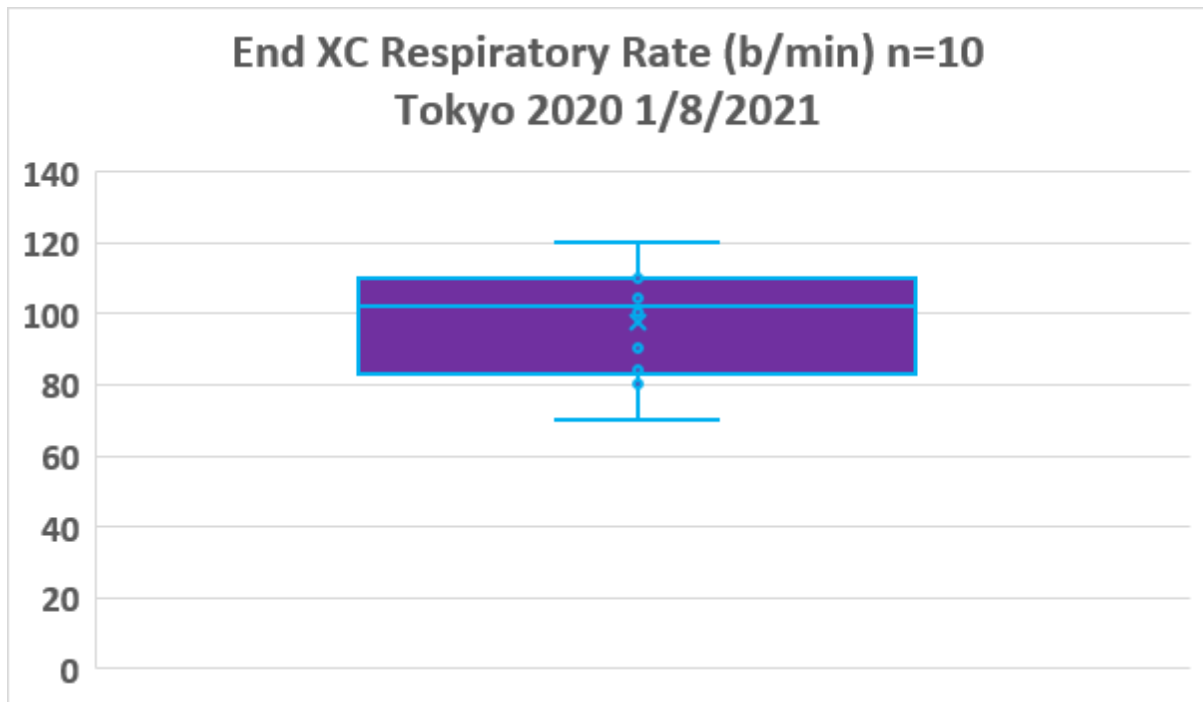


At least one record at one time point post XC was available for 49 horses. For 19 horses, rectal temperatures were recorded at three separate time points. Relatively few respiratory rates were recorded.

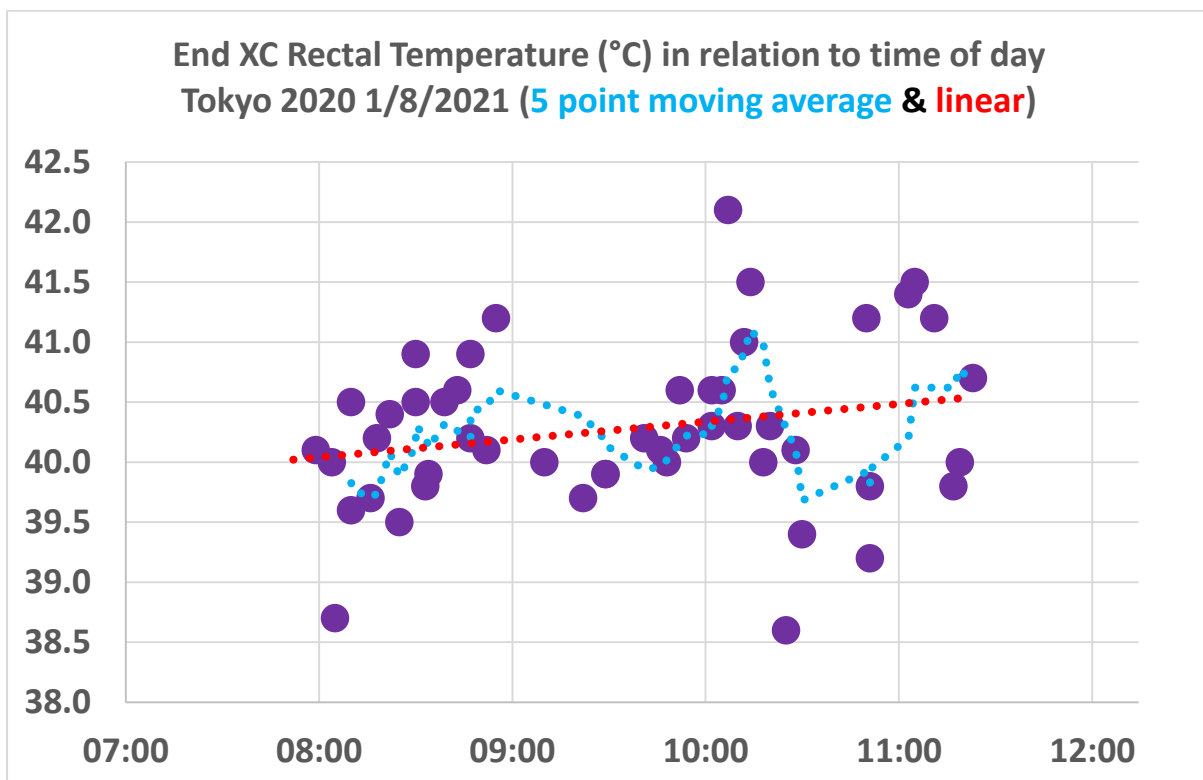
The end XC rectal temperatures, heart rates and respiratory rates were consistent with those seen at 4\* and 5\* XC run over standard length courses in cool-warm thermal conditions.



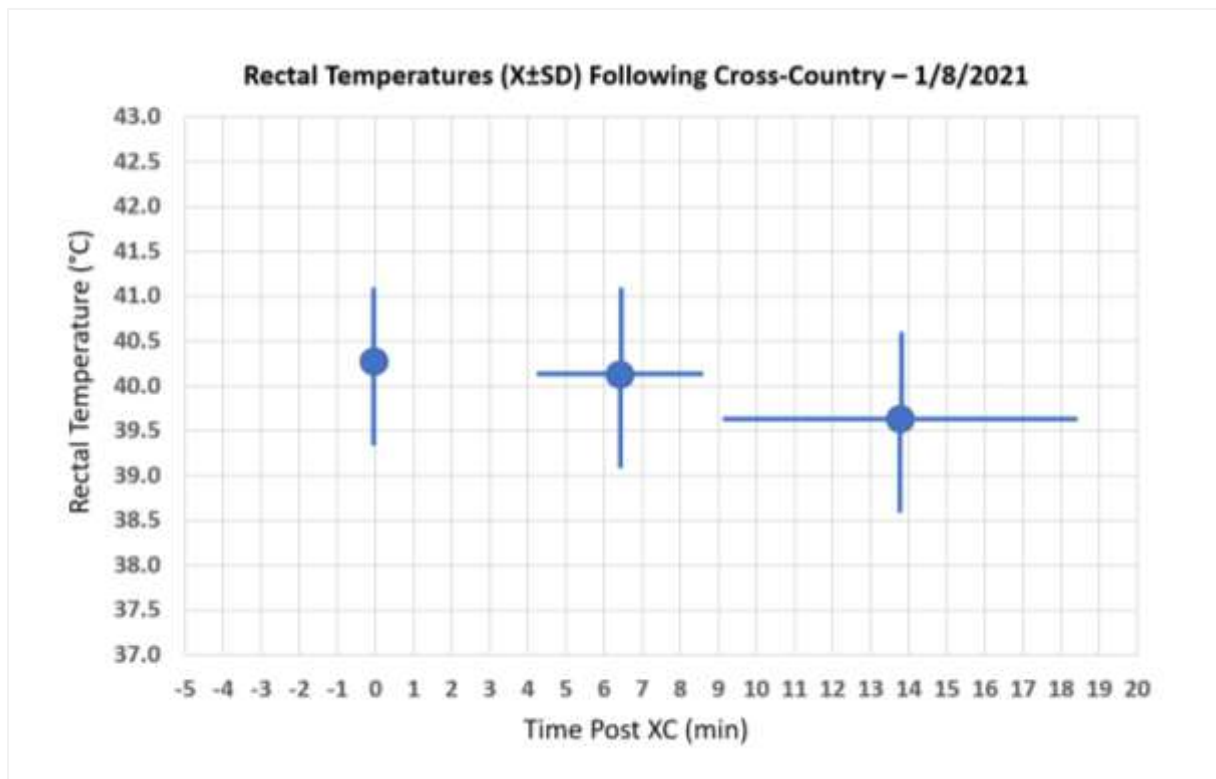




There was a slight trend for end XC rectal temperature to increase with time of day and WBGT Index, but this was only of the order of 0.5°C over 3h (linear) and this trend was not seen with a 5 point moving average. It may be coincidence but the highest rectal temperature of 42.1°C was at around 10:00 which does coincide with the highest Kestrel WBGT at Control and around the time of the highest TOCOG reading. But there is no strong evidence that riders were disadvantaged by the time of starting XC.

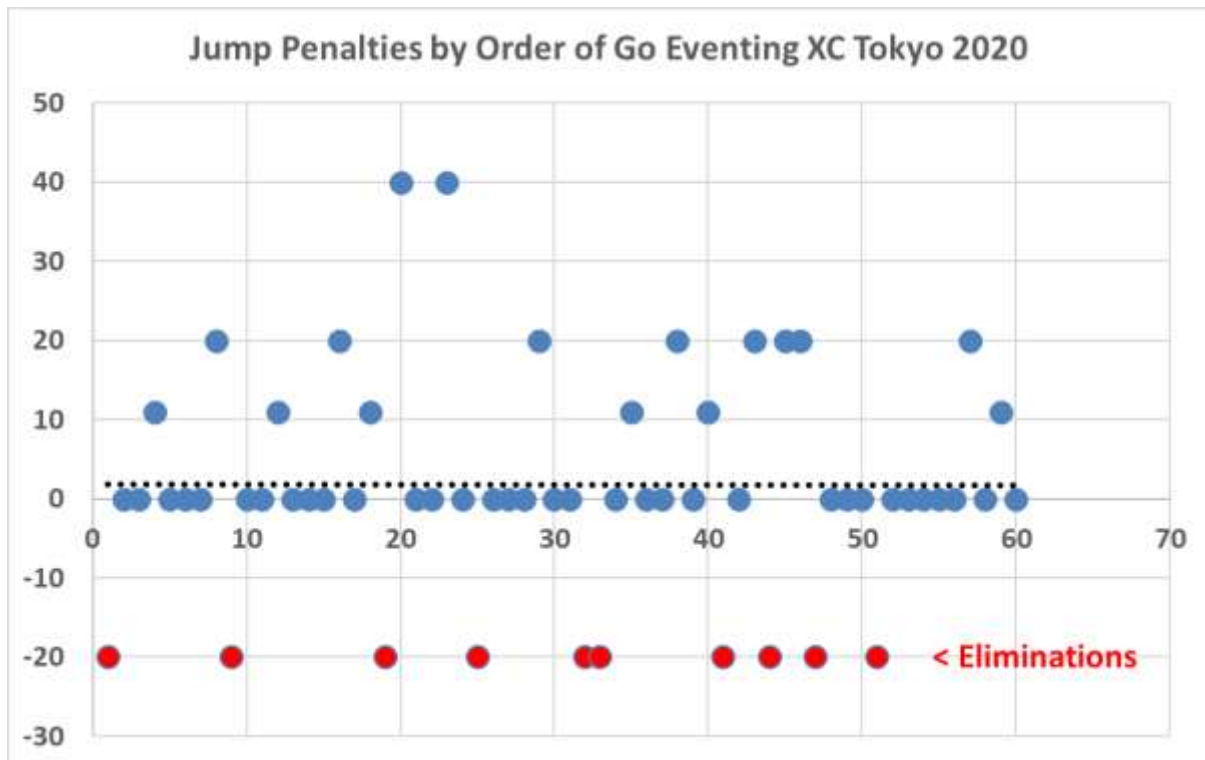


Recovery in rectal temperature on the whole was good as there was a small drop around 6min and a further drop by 13.5min. Without cooling the rectal temperatures at end XC would be expected to increase by at least  $\sim 1^{\circ}\text{C}$ .

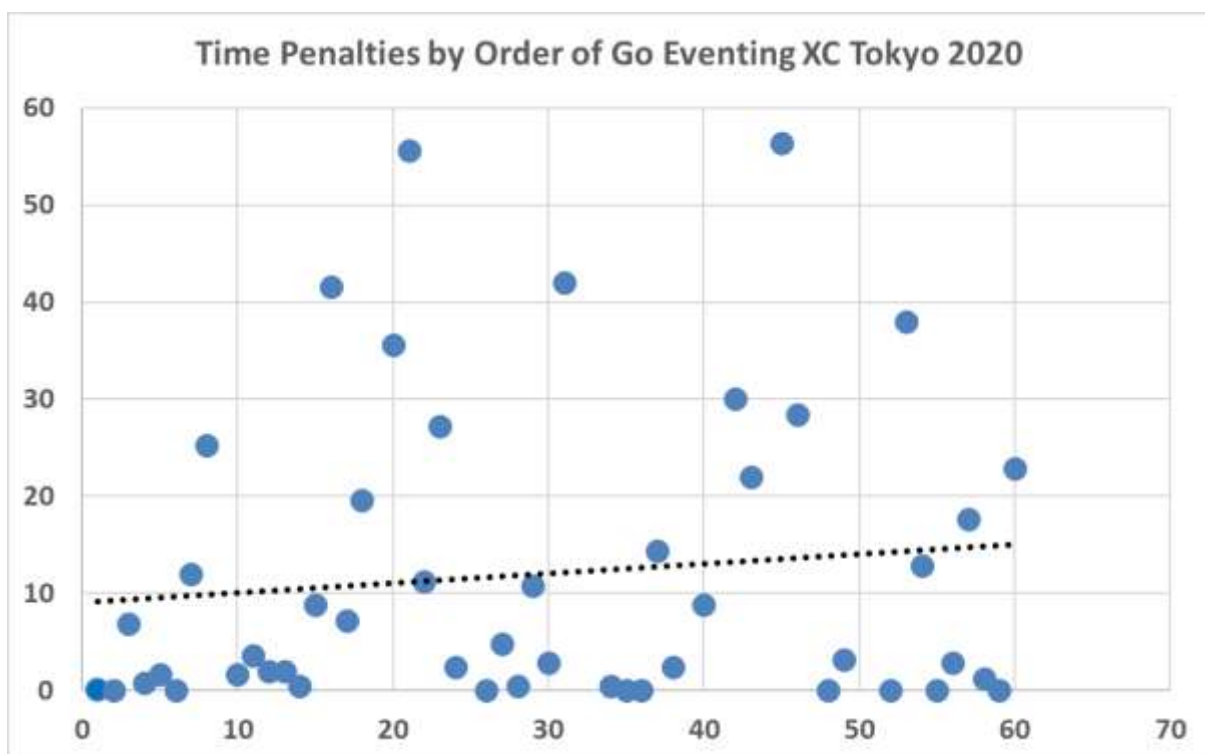


Two horses were not effectively cooled on arrival and showed a large increase in rectal temperature: No. 11 (ITA) which peaked at  $42^{\circ}\text{C}$   $\sim 4$  minutes after arrival and No.4 (SUI) which increased by  $1.5^{\circ}\text{C}$  by 10 min after arrival.

There was no evidence of any effect of order of go, and therefore thermal environmental conditions, on jump penalties and eliminations which were evenly distributed. The graph below shows a linear regression line indicating no trend.

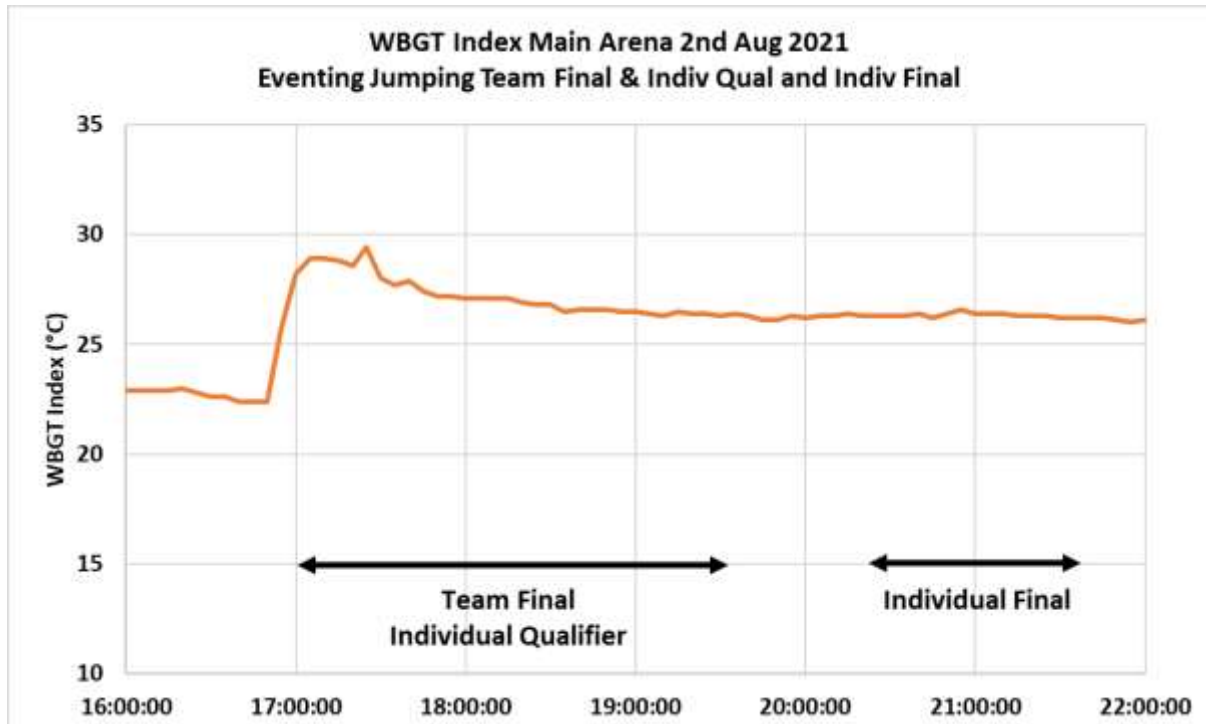


However, there was a very weak trend for horses starting later to have slightly more time penalties.



## EVENTING - JUMPING

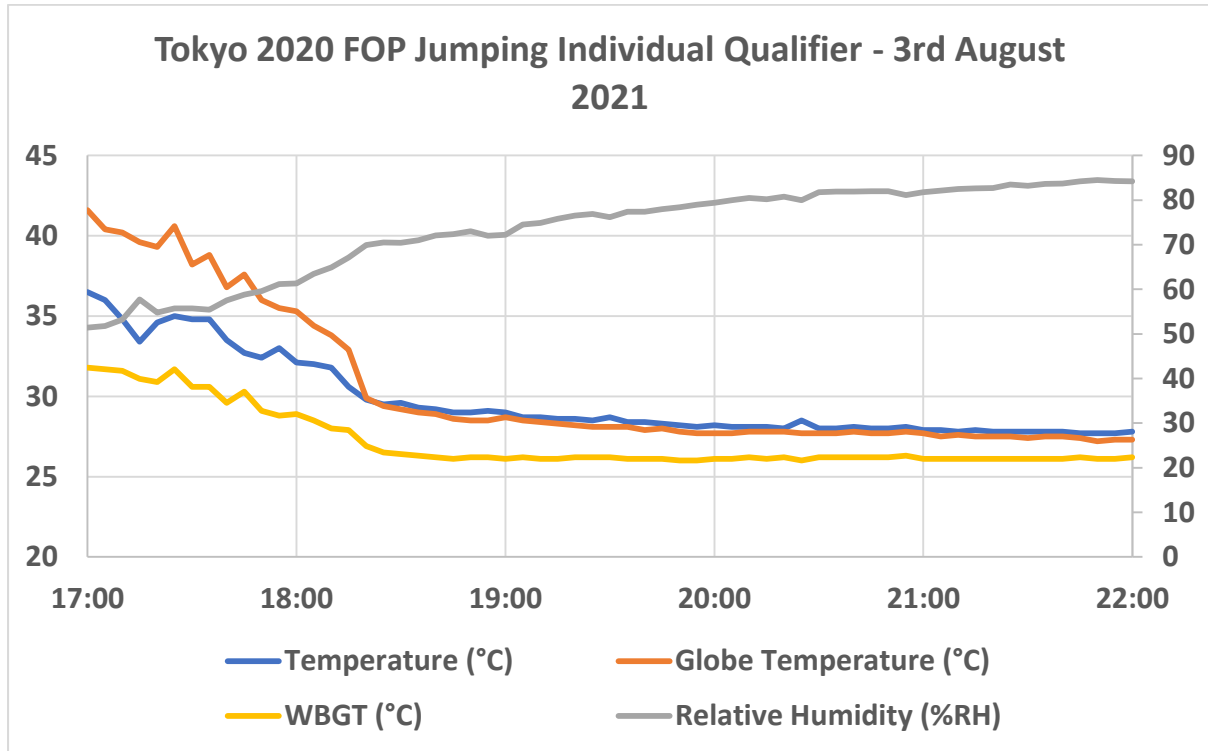
During the afternoon of the 2<sup>nd</sup> August there was rain and the skies were overcast, leading to cool conditions for the first horses warming up around 16:00. However, just prior to the start of the session the skies cleared and due to the high humidity the WBGT index increased rapidly from around 22°C to 29°C over 20 minutes. However, a WBGT Index of 29°C at 17:00 was typical of the conditions seen during the Games and consistent with historic climate analysis and onsite recording. There was no evidence that horses that were earlier were disadvantaged by the conditions. This is not unexpected given the short duration of this phase.



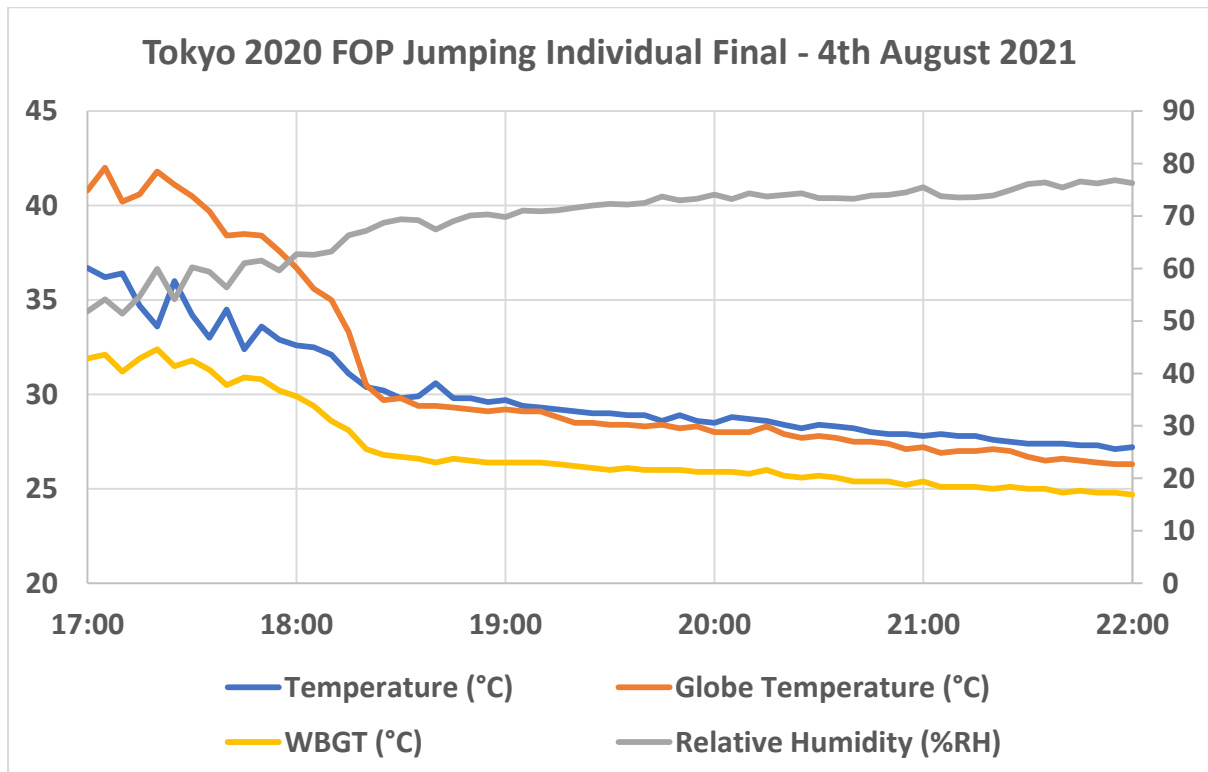
**JUMPING**

Although the 3<sup>rd</sup> and 4<sup>th</sup> August were hotter in the 2h prior to competition starting at 19:00, conditions during each day of Jumping were always between 25 and 28°C WBGT and were relatively stable. Based on this data, Jumping could have started at 18:30, although on the 3<sup>rd</sup> and 4<sup>th</sup> Aug this would mean horses warming-up an hour before would have experienced a WBGT of ~32°C. There was no evidence of any advantage due to order of go in either the Individual or Team Qualifiers.

Start time: 19:00

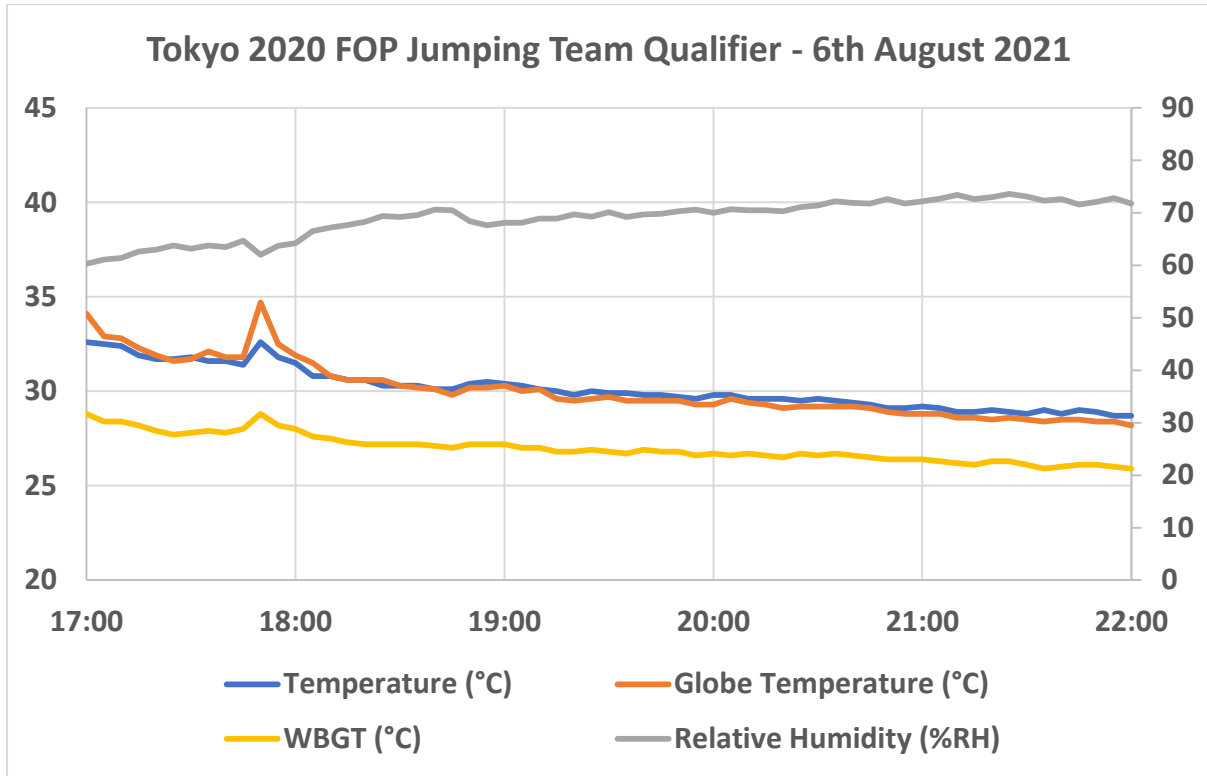


Start time: 19:00

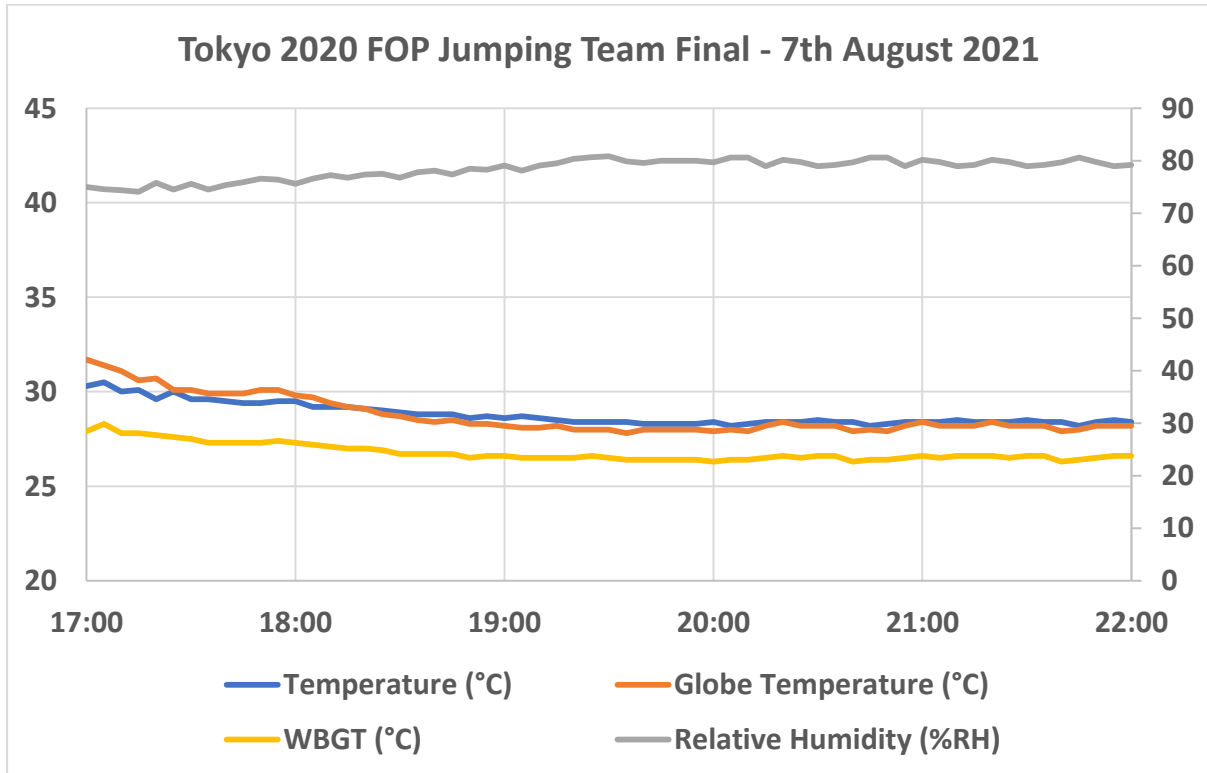




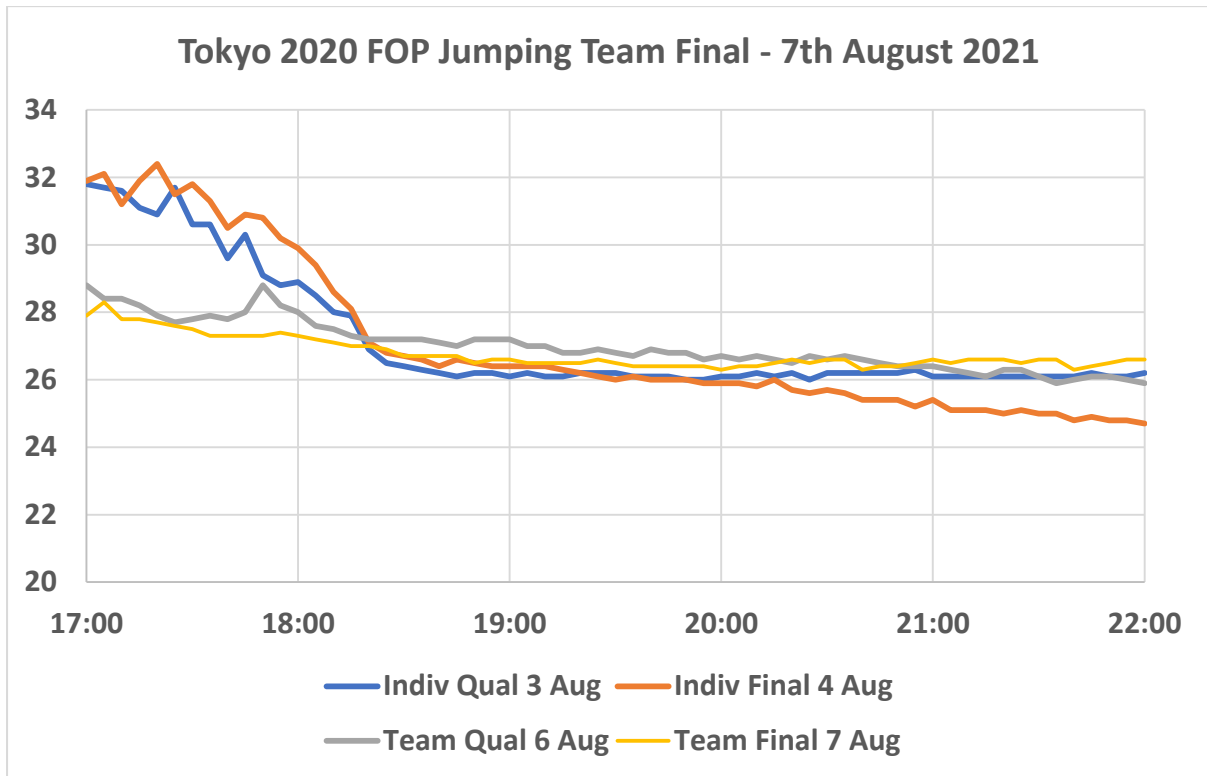
Start time: 19:00



Start time: 19:00



Start time: 19:00





## PARA DRESSAGE

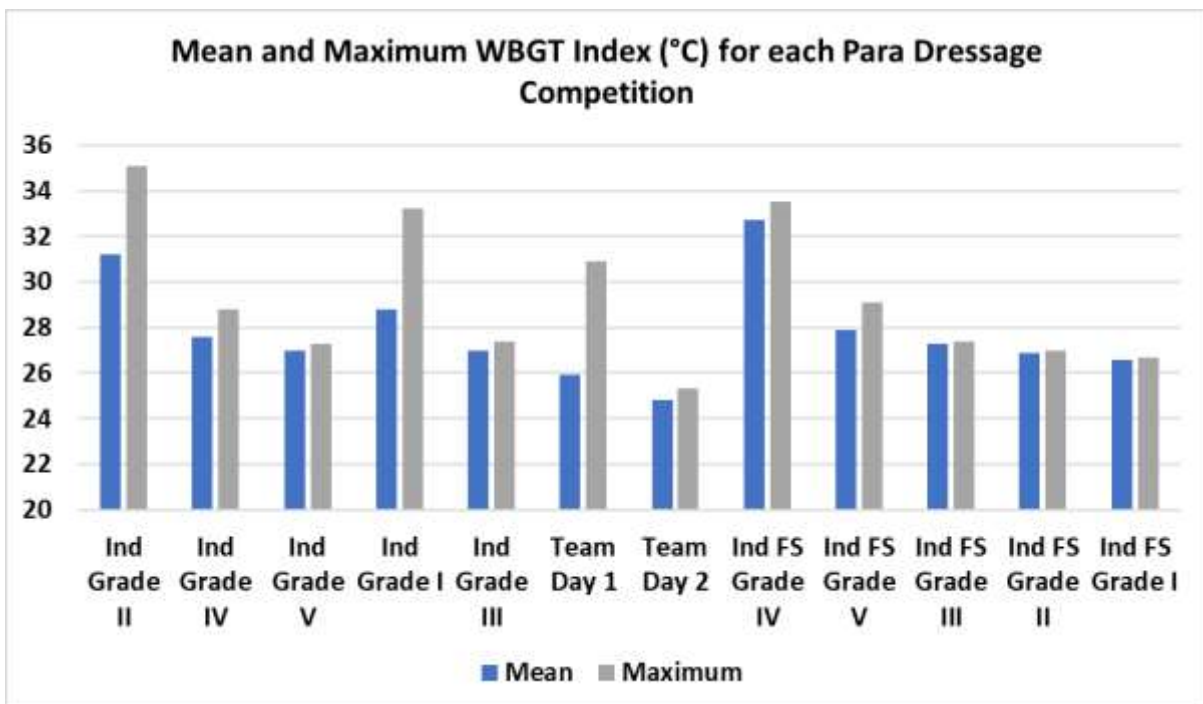
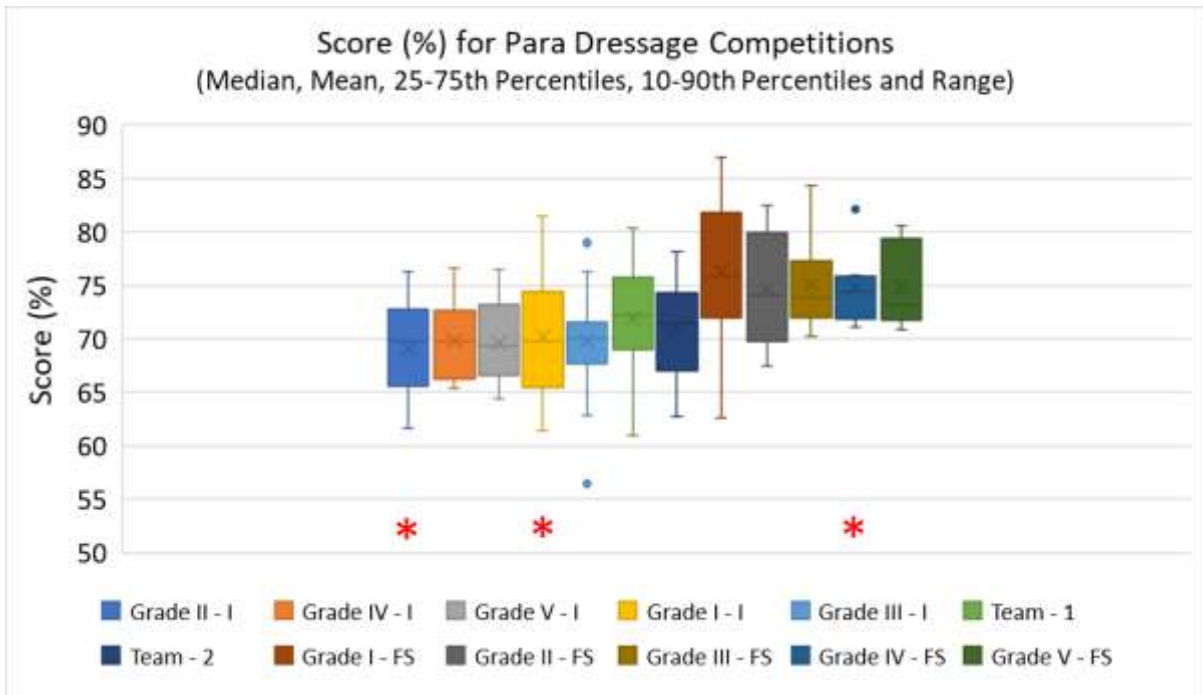
Thermal conditions and air quality were not recorded in barns during the Paralympic period. The only conditions recorded were those of the FOP. Despite the Paralympics starting one month later, the thermal environmental conditions were not dissimilar to those recorded during the Olympic period in the main arena at EQP. The earlier start times therefore resulted in horses and riders competing in the following events being exposed to WBGT (Kestrel) in the range 30-35°C either during warm-up and competition or during warm-up but not competition:

- 26<sup>th</sup> August – Individual Test Grade II
- 27<sup>th</sup> August – Individual Test Grade I
- 28<sup>th</sup> August – Team Test to Music
- 30<sup>th</sup> August – Individual Freestyle Grade IV
- 30<sup>th</sup> August – Individual Freestyle Grade V

The average, minimum and maximum WBGT index during each competition period are shown in the table below.

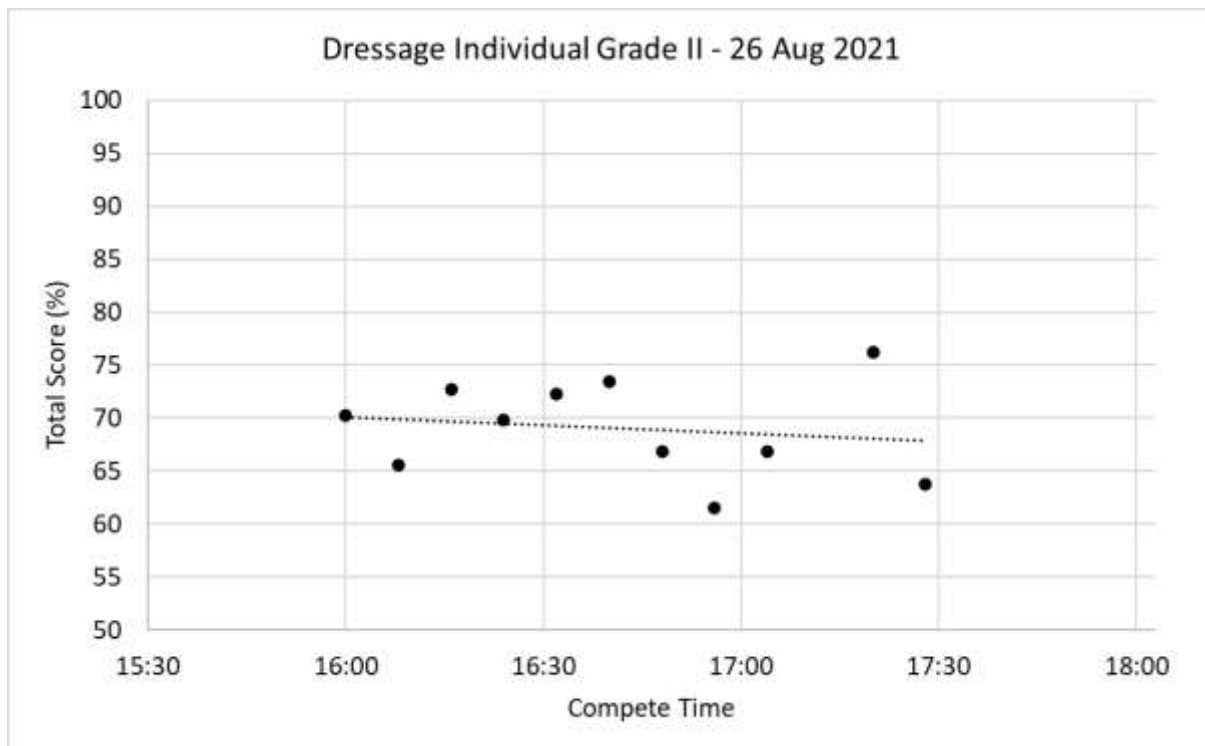
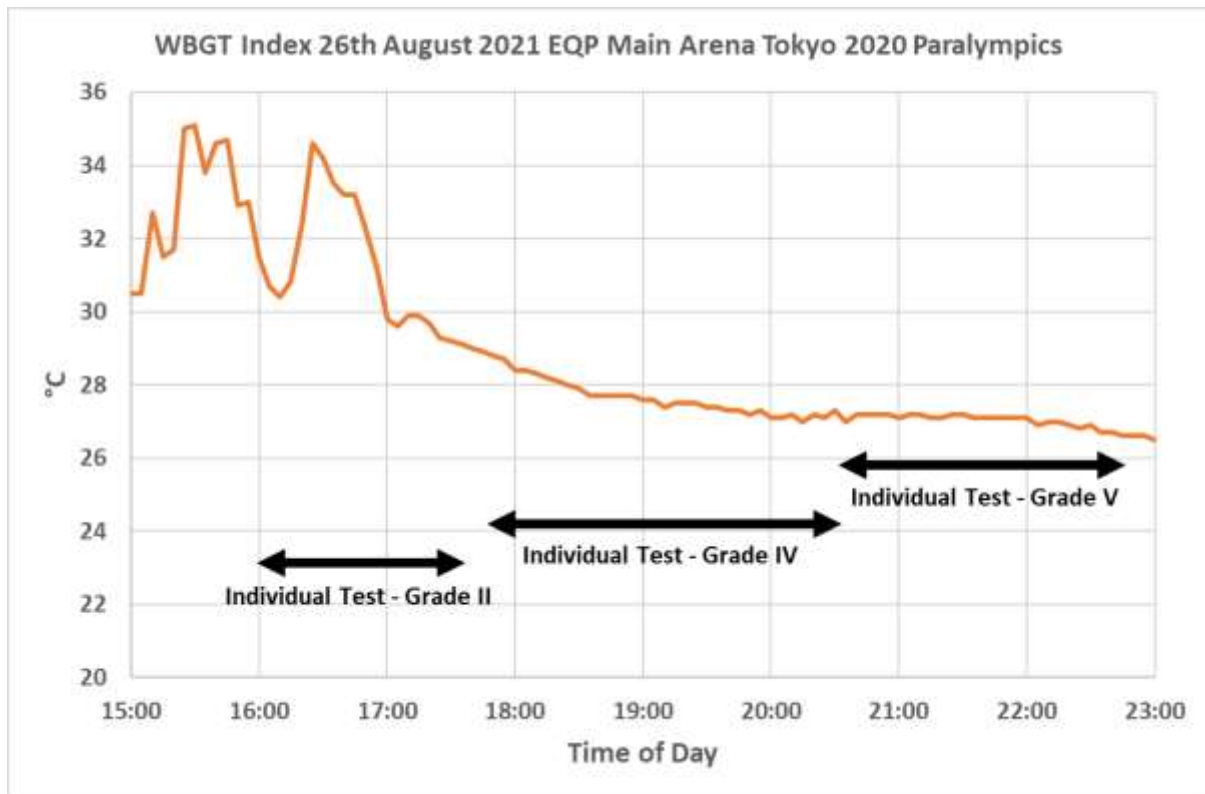
Date	Test	WBGT (°C, mean)	WBGT (°C, min)	WBGT (°C, max)
26 <sup>th</sup> August	Individual Test Grade II	31.2	29.1	35.1
26 <sup>th</sup> August	Individual Test Grade IV	27.6	27.0	28.8
26 <sup>th</sup> August	Individual Test Grade V	27.0	26.6	27.3
27 <sup>th</sup> August	Individual Test Grade I	28.8	27.4	33.2
27 <sup>th</sup> August	Individual Test Grade III	27.0	26.6	27.4
28 <sup>th</sup> August	Team Test to Music Day 1	25.9	24.4	30.9
29 <sup>th</sup> August	Team Test to Music Day 2	24.8	24.4	25.3
30 <sup>th</sup> August	Individual Freestyle Grade IV	32.7	30.6	33.5
30 <sup>th</sup> August	Individual Freestyle Grade V	27.9	27.5	29.1
30 <sup>th</sup> August	Individual Freestyle Grade III	27.3	27.0	27.4
30 <sup>th</sup> August	Individual Freestyle Grade II	26.9	26.6	27.0
30 <sup>th</sup> August	Individual Freestyle Grade I	26.6	26.5	26.7

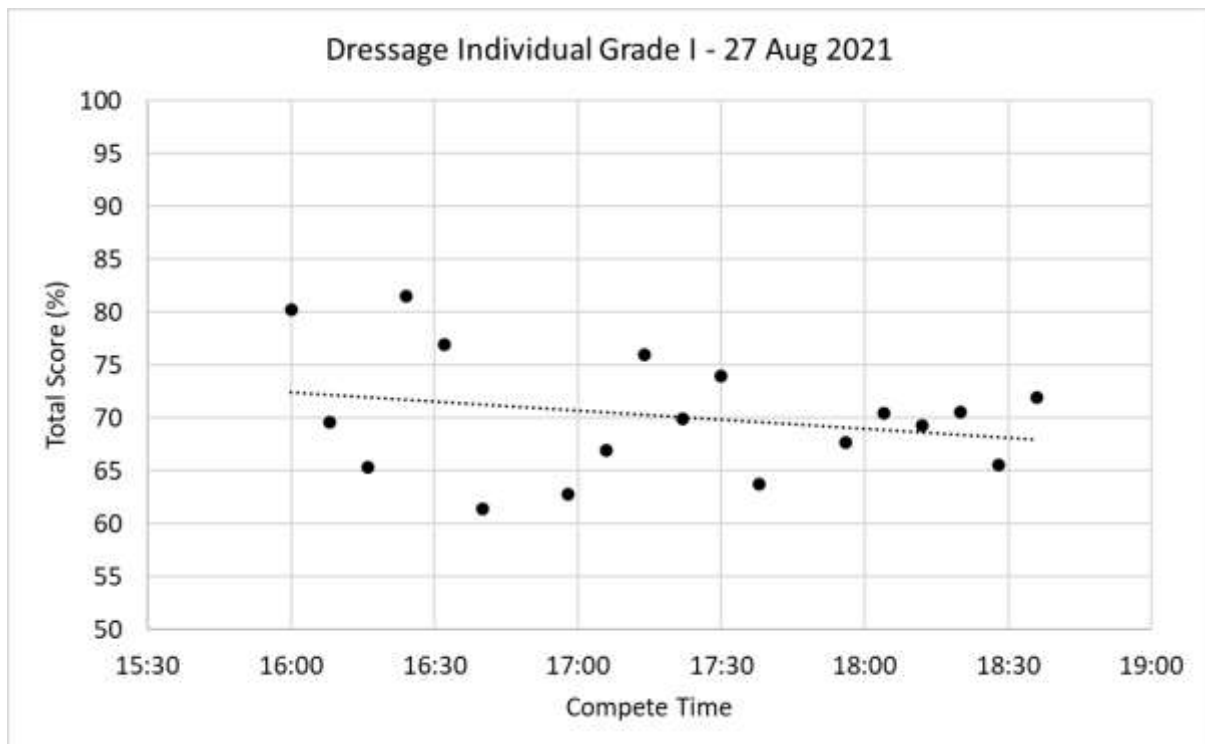
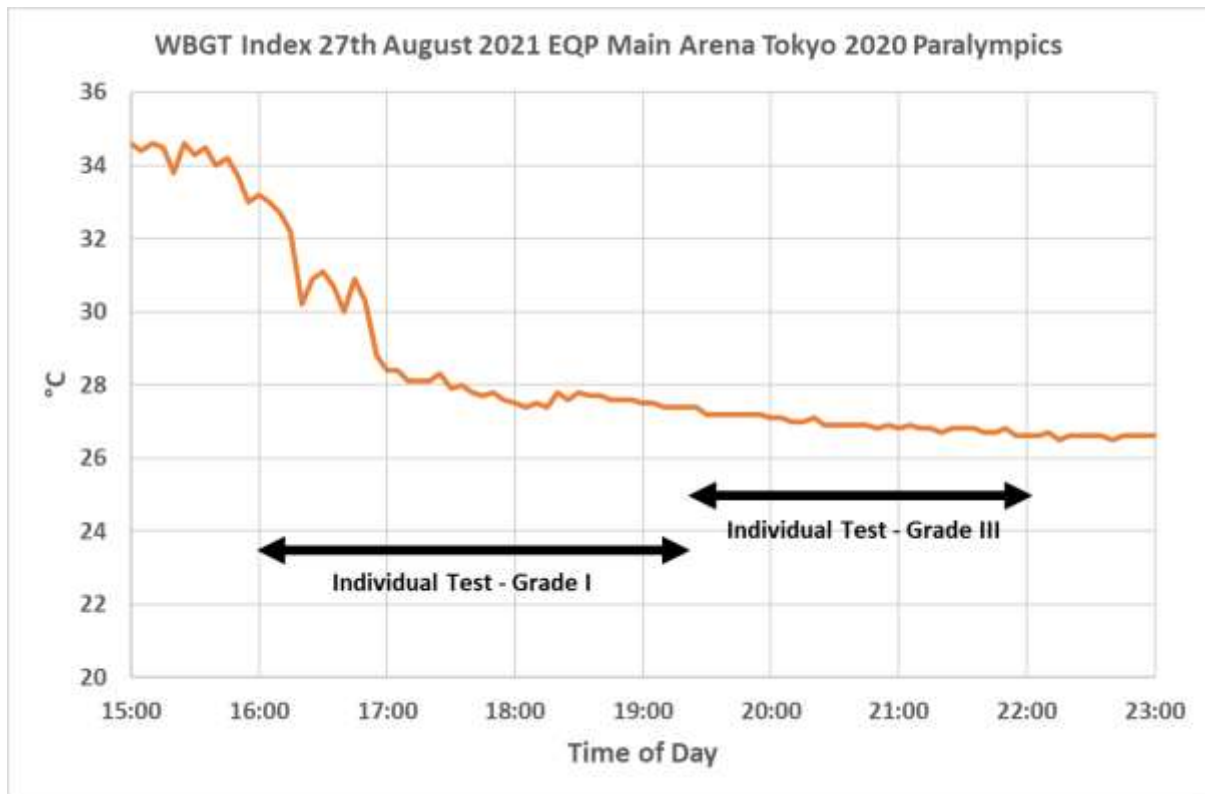
However, there was no evidence within each competition that the thermal environmental conditions had any effect on horses scores. In the figure below, the red asterisks denote competitions during which the average WBGT Index exceeded 28°C. There is no evidence to suggest that the distribution of marks was different during more thermally competition periods.



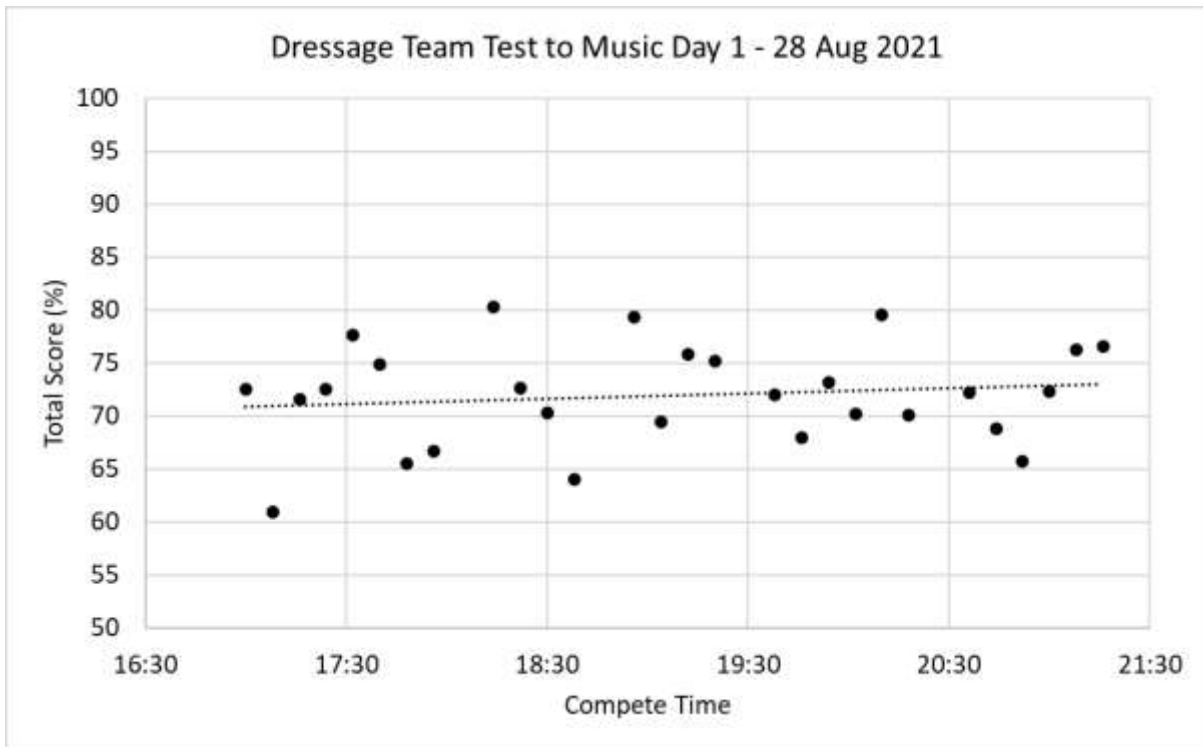
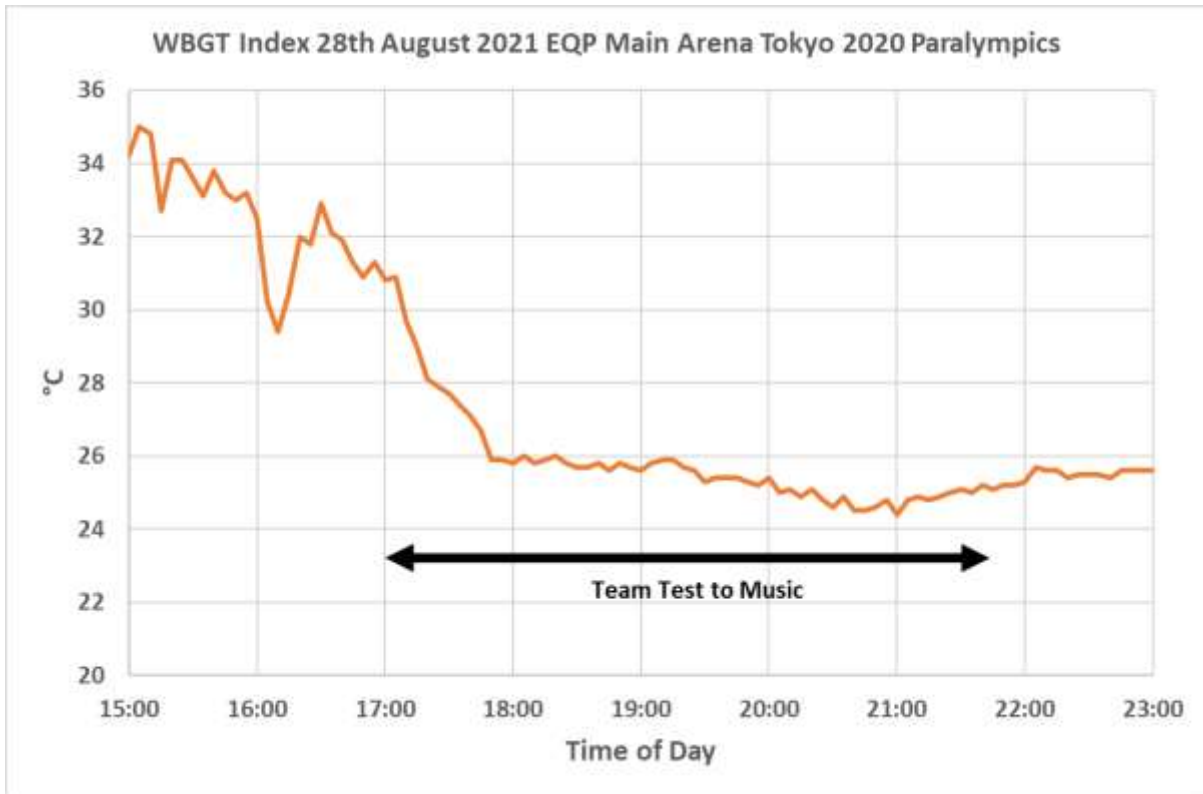
#### Key

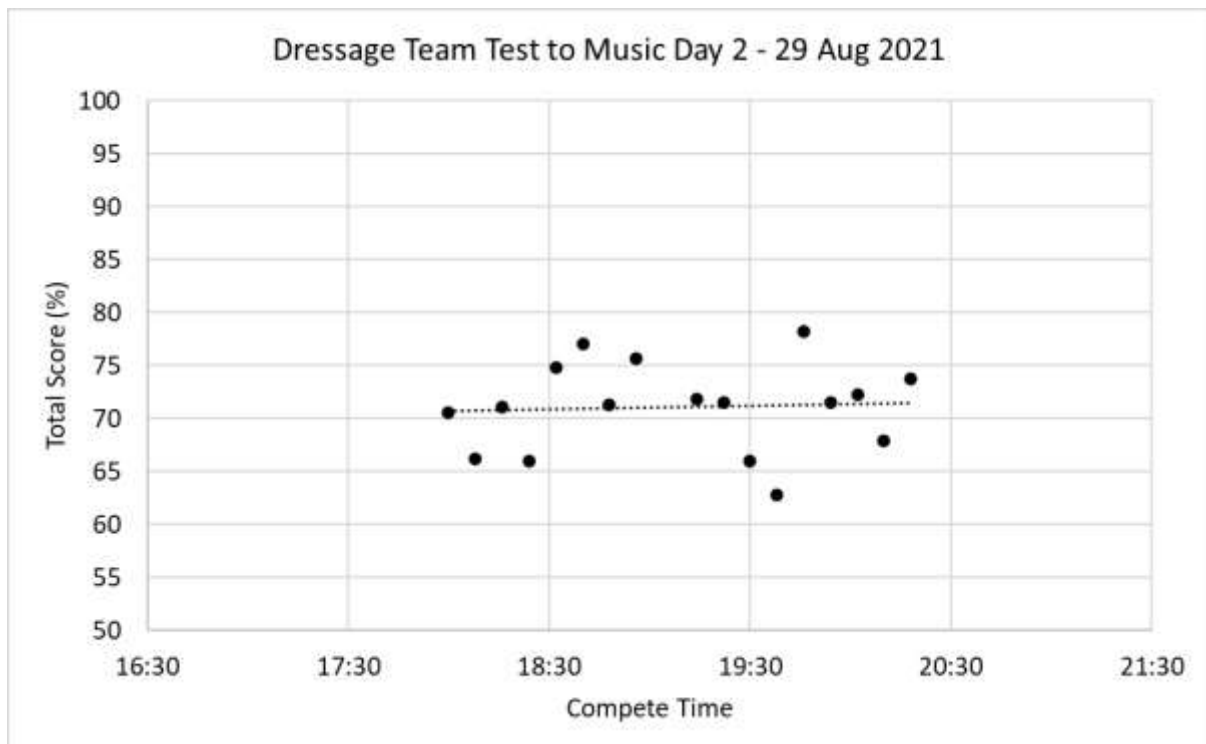
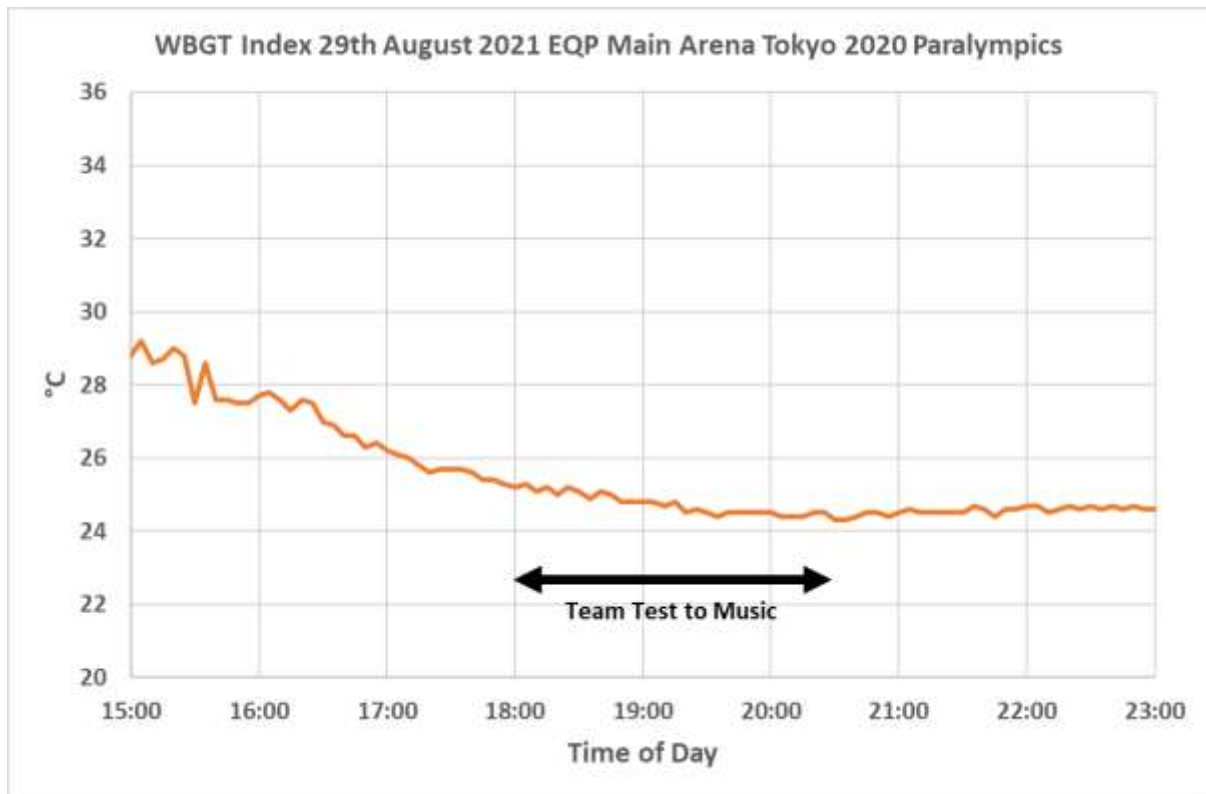
Ind Grade II	Individual Test Grade II
Ind Grade IV	Individual Test Grade IV
Ind Grade V	Individual Test Grade V
Ind Grade I	Individual Test Grade I
Ind Grade III	Individual Test Grade III
Team Day 1	Team Test to Music Day 1
Team Day 2	Team Test to Music Day 2
Ind FS Grade IV	Individual Freestyle Grade IV
Ind FS Grade V	Individual Freestyle Grade V
Ind FS Grade III	Individual Freestyle Grade III
Ind FS Grade II	Individual Freestyle Grade II
Ind FS Grade I	Individual Freestyle Grade I

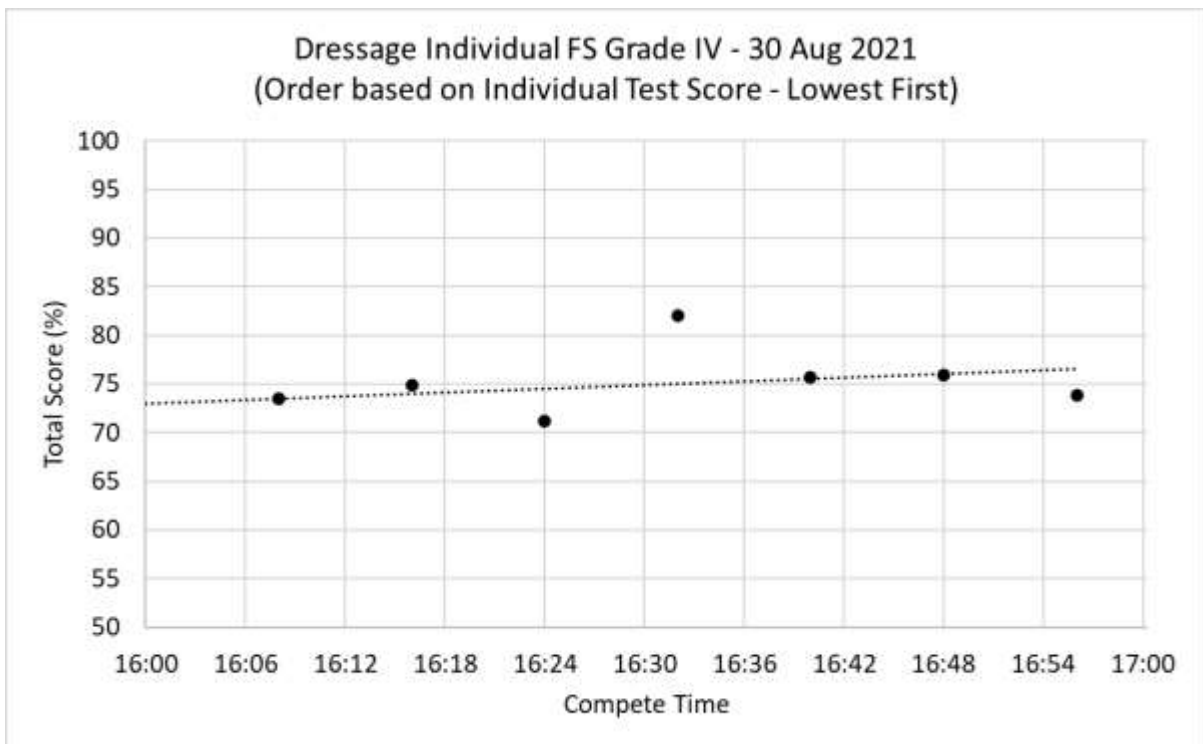
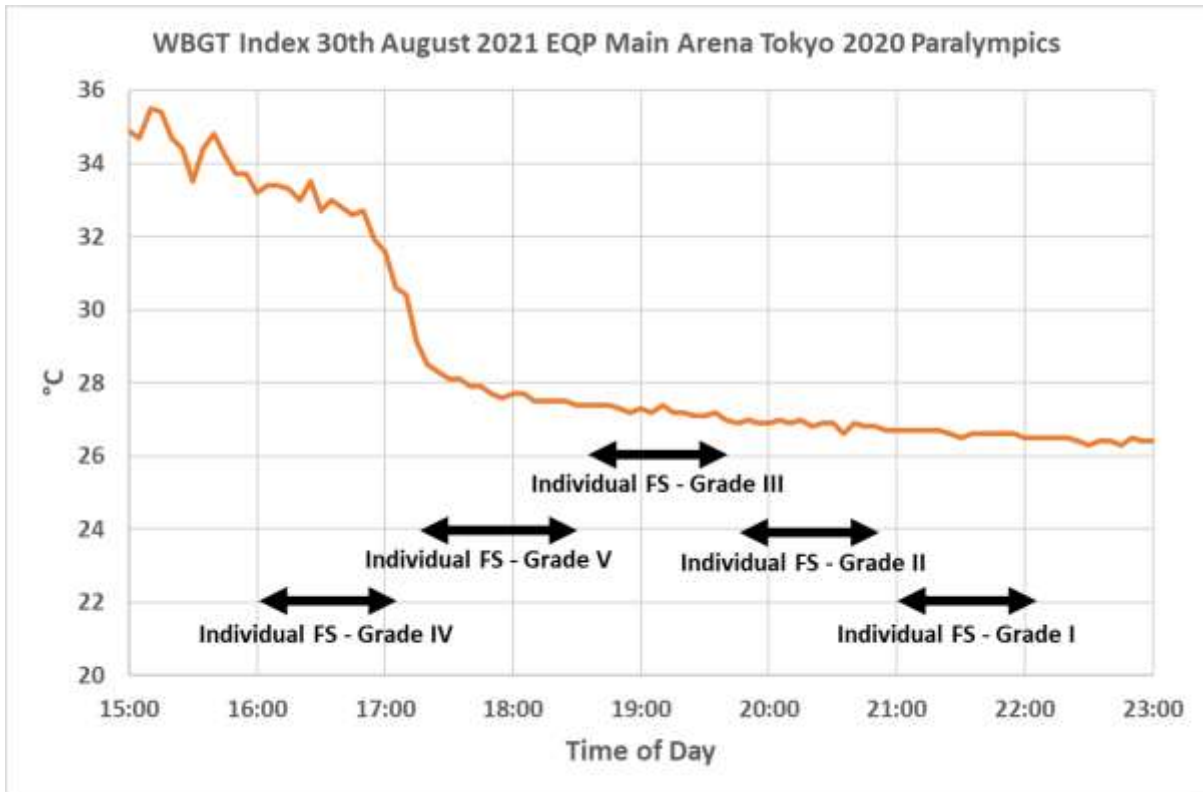


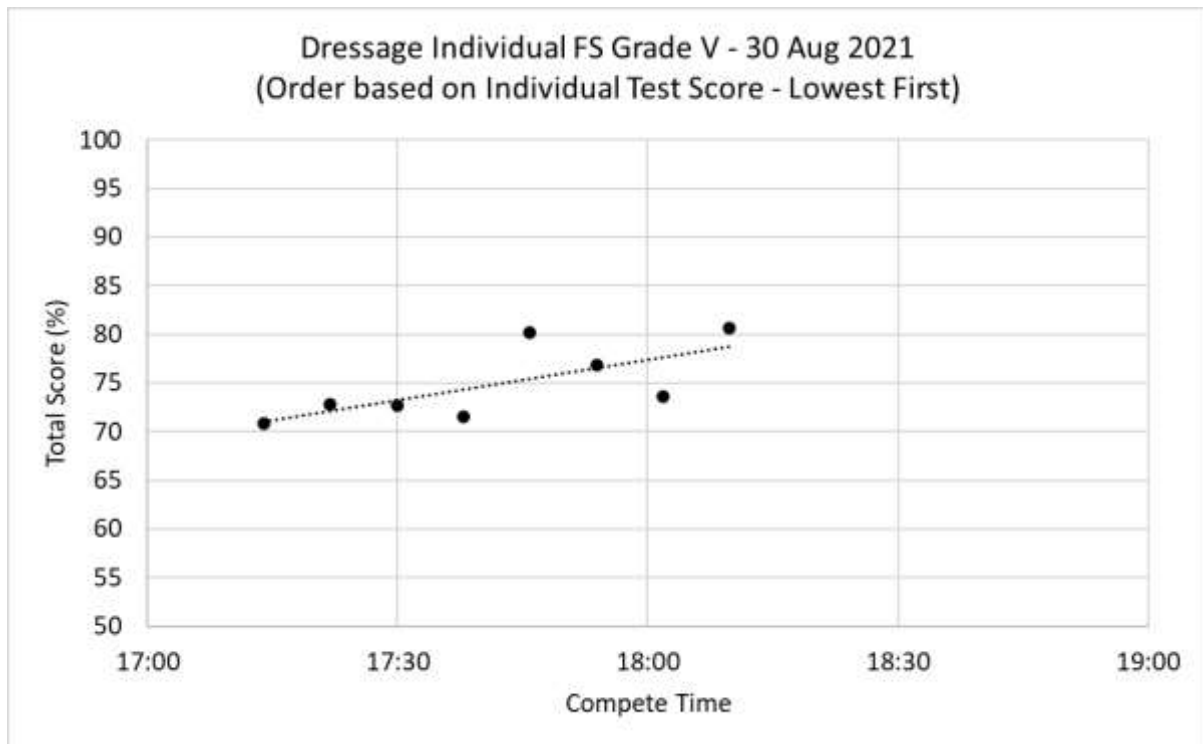


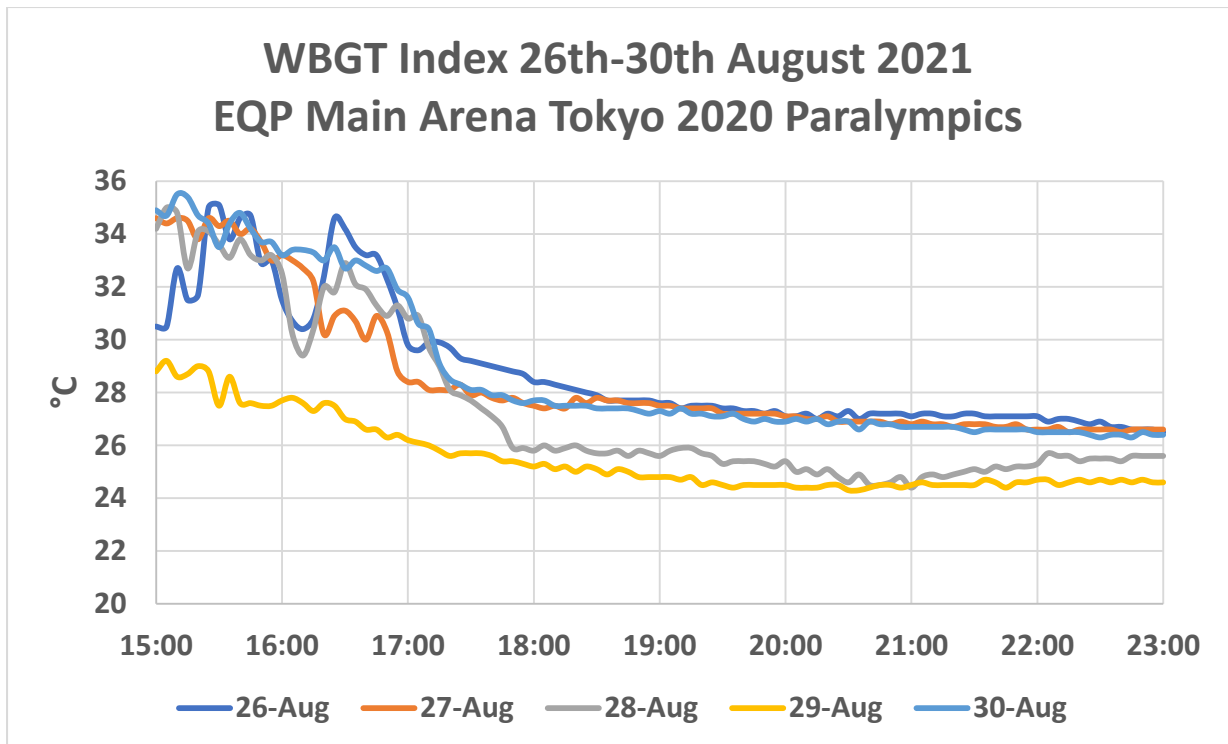












**APPENDIX**

**Barn at EQP**



**Indoor Arena at EQP**





Stables at SFC





Cooling area at SFC XC warm-up area



Cooling area at end of XC

