SYNCHRONIZATION AND TOWING EFFECT ON ADULT ONE-DOG CANICROSS PERFORMANCE

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Canicross is competitive team sport in which a human athlete is towed via a canine athlete on an elastic gangline. Although human performance factors play a role in the success of the canicross team, the interaction between human and canine athletes may also play a crucial role on the performance of the team. The purpose of this study was to assess the synchronization patterns across different locations in competitive canicross events and investigate the influences of canine mass on a timed trial event. Video was taken at five locations along the trail of two different competitive canicross events. Synchronization was mapped and a total synchronization score was given to each of the 19 canicross teams. The results of the current study suggest that neither synchronization score nor human to canine mass ratios were correlated with performance.

KEYWORDS: canine, propulsion, running, sled dog racing.

INTRODUCTION: Canicross is a competitive aerobic running sport in which a human athlete is towed behind a one or two dog team via an elastic gangline (IFSS- International Federation of Sleddog Sports, 2017). The objective of canicross is to work as a team (human and canine) to get from point “A” to point “B” as quickly as possible. Not only are individual human aspects important in determining performance, such as VO_{2max} and running economy, but also the interactions between the human and canine athlete (Brandon, 1995; Foster & Lucia, 2007). The human canicross athlete is essentially being propelled or towed by their canine teammate. Towing, or adding a forward horizontal force to an object being towed, will result in an increase in velocity of the towee, as long as the tower has a greater velocity and sufficient mass. This interaction is similar to that of adventure running, where one team member is allowed to tow another member in order to decrease the slower member’s overall time (Grabowski & Kram, 2008). Graboski and Kram (2008) found benefits of towing when the mass of the tower increased, however runner synchronization was not examined.

Synchronization occurs when two oscillatory systems adjust their behaviors to obtain a state of unison after some interaction (Mosekilde, Maistrenko, & Postnov, 2002). This concept is better understood when observing the relationship between horse and jockey. In horse racing, the jockey aims to decrease the negative interactions on the horse, which in turn decreases the amount of additional energy needed to continue the desired movement. In canicross, synchronization may have an effect on overall performance, where a suboptimal level of synchronization between human and canine, may be detrimental to the performance of the team.

The purpose of the current study was to assess the synchronization patterns across locations in two competitive canicross events and investigate the influences of canine mass on a timed trial event. We hypothesized that synchronization scores will decrease across the locations as the human starts to fatigue. We also hypothesized that average synchronization and human to canine mass ratio will be positively correlated to performance.

METHODS: Nineteen (9 males and 10 females) adult competitive canicross athletes competing in either Redpaw’s Dirty Dog Dryland Derby (Pearson, WI, USA) or the Hateya Trail Run (Kenosha, WI, USA) volunteered to participate in this study (mean ± SD: age = 39.90 y. ± 8.39, height = 1.74 m ± 0.11, human (towee) mass = 77.95 kg ± 18.80, canine (tower) mass = 27.60 kg ± 8.05). The university’s Institutional Review Board and Institutional Animal Care and Use Committee granted approval of the study (HS 17-888).

Upon arrival at the event, participants signed an informed consent and completed a short canicross experience survey. Mass of the human and canine participants were taken using a portable force plate (ACP-1033 AccuPower, AMTI, Watertown, MA, USA) and a standard stadiometer (Zhejiang, China). Participants were then asked to prepare for the event normally. Before the canicross event, a mixture of five standard camcorders recording at 30 - 240 Hz were set up on a tripod at various level locations perpendicular to the race trail. Cameras captured a sagittal plane image as the participants ran past.

Following the event, raw kinematic data were uploaded into an automatic digitizing software (Kinovea, Version 0.8.15, www.kinovea.org) for data analysis. Footage was standardized to 30 Hz for the data processing. During data processing, a standard time of one second (30 frames) was chosen and the gait phases, for both human and canine, were mapped at each frame. Flight was defined as when there was no contact with the ground. Braking was defined as the phase from first ground contact until mid-stance, with mid-stance being defined as when the shank was directly over the lateral malleolus or when the stifle joint is directly above the paw. Propulsion was defined as the period from mid-stance to toe-off.

Each gait phase was assigned a specific numerical value, where propulsion received the numerical number of one (1), mid-stance or flight, received a number of zero (0), and braking received a negative one (-1). These numbers were assigned according to amount of contribution that the phase of the stance would provide to the horizontal propulsion force. Since propulsion contributes to a forward horizontal force, this was indicated with a positive number, whereas braking decreases the forward horizontal force provided by the athlete so a negative value was given (Kram, Griffin, Donelan, & Chang, 1998; Walter & Carrier, 2007). Mid-stance and propulsion was thought not to contribute, nor oppose, either increasing or decreasing forward horizontal propulsion, therefore it was given the number zero.

After completion of mapping, the proper numerical values (based on the gait phase of the human and canine) were assigned at each frame. Each frame column was then given a summed value, which indicated the synchronization at that one frame. The total sums for each frame were then added together to obtain a total synchronization score (Figure 1). This was done for every team at each location, where a higher total synchronization score indicates better synchronization.

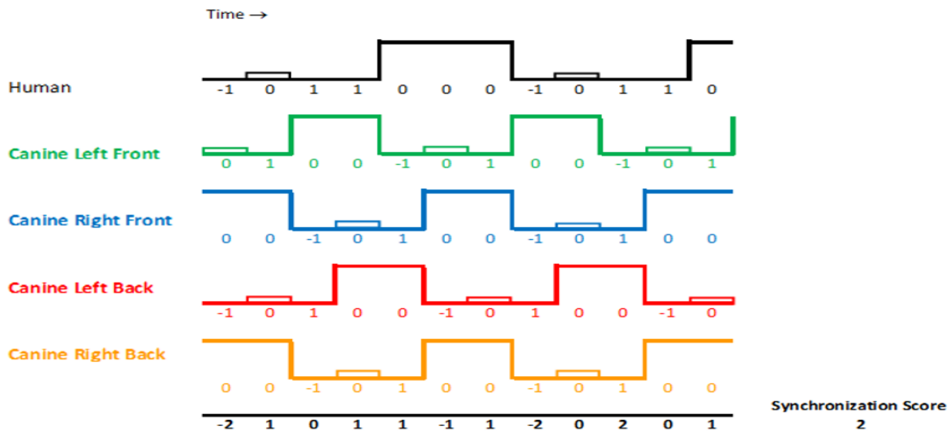

Figure 1: **Mapping and computing synchronization scores.**

Statistical analysis (SPSS, v.24) included correlations between time trial performance, survey and synchronization variables ($p<0.05$). A one way repeated measures ANOVA was also used to determine differences in synchronization scores across locations.

RESULTS: Three of the five video locations were used at each race event due to either clarity issues or technology malfunctions. Due to the two events being different distances, an average pace was used to compare race performance across the groups, because an athlete with a faster pace indicated better performance. Table 1 displays the descriptive data.

There were no significant correlations between the average pace and any of the other performance variables (Table 2). Human to canine mass ratio was also not significantly correlated to any of the synchronization values or average pace.

Table 1: Mean and standard deviation of performance variables.

	Mean ± SD	N
Average Pace (min/mile)	9.08 ± 2.68	18
Human-to-Canine Mass Ratio	3.04 ± 1.12	19
Average Synchronization	22.98 ± 6.45	15
Location 1 Synchronization	21.75 ± 7.88	12
Location 2 Synchronization	27.64 ± 7.41	11
Location 3 Synchronization	17.44 ± 7.92	9

Table 2: Correlation between various potential performance variables.

		Mass Ratio	Average Synch.	Location 1 Synch.	Location 2 Synch.	Location 3 Synch.
Average Pace	Correlation Value	0.000	0.029	-0.090	0.461	0.569
	Significance (p)	0.999	0.922	0.792	0.154	0.110
	N	18	14	11	11	9
Mass Ratio	Correlation Value		0.388	0.544	0.176	0.225
	Significance (p)		0.153	0.067	0.606	0.560
	N		15	12	11	9

A one way repeated measures ANOVA was used to compare synchronization within locations. Mauchly's test of sphericity indicated no violation of sphericity ($p = 0.275$), however there was no significant results found within the locations where $f(2,8) = 2.884$, $p=0.114$, effect size = 0.419. Although no significant results were seen in the one way repeated measures ANOVA, location three tended toward having a lesser synchronization score (Table 3).

Table 3: Means and standard deviations of synchronization scores across Redpaw's Dirty Dog Dryland Derby.

	Mean ± SD	N
Location 1	23.80 ± 9.94	5
Location 2	28.20 ± 7.95	5
Location 3	17.40 ± 8.88	5

DISCUSSION: The main finding is that throughout the length of Redpaw's Dirty Dog Dryland Derby, synchronization scores did not change significantly. This may indicate that the human and canine have reached their optimal team synchronization at location one and hold that synchronization through the race. However, another possibility is that because of the low number of participants who had sufficient data, these findings may not reveal the interaction between human and canine as the event progresses. Although there were no significance differences between the locations, location three synchronization scores tended toward being lower than the two previous locations. This may indicate that the athletes were starting to fatigue near the end of the race, where changes in running patterns could decrease the synchronization score.

Neither synchronization score nor time trial performance (average pace) were correlated with performance variables as hypothesized. Because the mass of the tower was dramatically less than that of the towee in all cases, the additional horizontal force provided by the canine did not seem to play as big of a role in performance time as previously thought. These findings are slightly different when compared to Graboski and Kram (2008) for adventure running where they saw significant increases in the benefits of towing when the mass of the tower was increased. The difference in findings can likely be contributed to the mass of the canine in comparison to the human and the resultant of the line of pull that the canine provides to the human when compared to a human tower. Where if the canine's mass was dramatically increased, there would also be an increase in benefits of towing as seen by Graboski and Kram (3).

The mean mass ratios displayed in the current study where 3.04 kg ± 1.12 with an average tower mass of 27.60 kg ± 8.05 and an average towee mass of 77.95 kg ± 18.80. Whereas the study by Graboski and Kram (2008) had an average tower mass 68.25 kg ± 12.05. This drastic difference in tower mass could be why the current study had no significant findings in human to canine mass ratios on performance. Additionally when a human athlete is being towed by another human athlete, the line of tow is more horizontal when compared to being towed by a canine athlete. When the canine is towing the athlete, the horizontal force the canine is exhibiting on the human, is less than the force in the gangline because of the angle of the tow, which is influenced by the height of the dog and the length of the elastic gangline. Because of this increase, the force being produced by the canine is not as effective in producing forward horizontal force direction as a human tower.

A limitation in the current study is the high variability between canicross athletes and the experience levels of the canicross teams. Although both events were considered competitive races, the Hateya Trail Run event drew more recreational canicross athletes in comparison to Redpaw's Dirty Dog Dryland Derby. This became evident when mapping the canicross systems and comparing the amount of time the canine was propelling the human athlete. Another large limitation in this study was the differences in lengths of the events and the number of participants that had sufficient video data to compute synchronization scores at all locations. Because of the differences in race length, average pace was used as the performance determinant. This is slightly flawed because those competing in the longer event could be using a different pacing strategy when compared to those who ran the shorter event. An additional limitation may be in the calculation of synchronization, where weighting of the synchronization summation could differ if two limbs were used compared to the four in the current study. Although all of the legs in the canine help in propulsion, the front legs assist more in stabilization compared to the back legs, which contribute mostly to propulsion.

CONCLUSION: Synchronization between human and canine in a canicross system may be a factor that influences overall performance; however, the current study found no significant correlation between the two. This study also found no correlation between performance and human to canine mass ratios. This leads us to believe that because of the angle of the resultant force produced by the canine, mass ratios did not play a large factor on performance. This information would be beneficial to canicross athletes who are trying to select a canine to produce optimal performance. However, the researchers of the present study did not find any advantages to having a larger canine (smaller human to canine mass ratio) or a higher synchronization score on performance.

REFERENCES

Brandon, L. (1995). Physiological factors associated with middle distance running performance. *Sports Medicine (Auckland, N.Z.)*, *19*(4), 268–277.

Foster, C., & Lucia, A. (2007). Running economy. *Sports Medicine*, *37*(4–5), 316–319.

Grabowski, A. M., & Kram, R. (2008). Running with horizontal pulling forces: the benefits of towing. *European Journal of Applied Physiology*, *104*(3), 473.

IFSS- International Federation of Sleddog Sports. (2017). Retrieved from http://www.sleddogsport.net/

Kram, R., Griffin, T. M., Donelan, J. M., & Chang, Y. H. (1998). Force treadmill for measuring vertical and horizontal ground reaction forces. *Journal of Applied Physiology*, *85*(2), 764-769.

Mosekilde, E., Maistrenko, Y., & Postnov, D. (2002). *Chaotic synchronization: applications to living systems*. World Scientific.

Pérez, Ó. P., García, L. M., Joan, K., & Barlow, D. (2016). *Canicross y mushing, entrenamientos.* (No. PR-6) (pp. 2–4). University of Vigo.

Walter, R. M., & Carrier, D. R. (2007). Ground forces applied by galloping dogs. *Journal of Experimental Biology*, *210*(2), 208–216.

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