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The effects of altered distances between obstacles on the jump kinematics and apparent joint angulations of large agility dogs

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ABSTRACT

Canine agility is a rapidly growing sport in the UK. However, there is a paucity of scientific research examining jump kinematics and associated health and welfare implications of the discipline. The aim of this research was to examine differences in jump kinematics and apparent joint angulation of large (>431 mm at the withers) agility dogs ($n = 54$), when the distance between hurdles was altered (3.6 m, 4 m and 5 m apart) and to determine how level of skill impacted upon jump kinematics.

Significant differences were observed for both the take-off ($P < 0.001$) and landing distances ($P < 0.001$) between the 3.6 m, 4 m and 5 m distances. Further differences were observed when level of skill was controlled for; take-off ($F[3,55] = 5.686$, $P = 0.002$) and landing ($F[3,55] = 7.552$, $P < 0.001$) distances differed at the 3.6 m distance, as did the take-off distance at the 4 m hurdle distance ($F[3,50] = 6.168$, $P = 0.001$). Take-off and landing speeds differed for hurdle distances ($P < 0.001$) and level of skill ($P < 0.001$). There were significant differences in apparent neck angle during take-off and landing ($P < 0.001$), lumbar spine angles during take-off, bascule and landing ($P < 0.01$), and in shoulder angles during the bascule phase ($P < 0.05$). The results indicate that agility dogs alter their jumping patterns to accommodate the spacing between hurdles, which ultimately may impact long term health and welfare due to altered kinematics.

Introduction

Dog agility is a discipline whereby handlers navigate their dog around a set course, in the fastest time, without faults. The majority of obstacles are upright hurdles, set at a predetermined height in relation to the dog's height at the withers (Table 1). Dogs are further categorised by skill through a grading system (Table 2). In the UK, the majority of competitions are held under the auspices of The Kennel Club (KC).

Despite growing popularity, little research has examined jump kinematics of competitively trained agility dogs. Colborne (2007) suggested that canine kinematic studies were approximately 20 years behind human gait analysis and 10 years behind equine gait analysis. The minimum distance between hurdle fences varies between governing bodies and ranges from 3.6 m (KC)[1] to 5 m (Fédération Cynologique Internationale [FCI]).[2] What effect the distance between fences has upon the kinematics of agility dogs, and how this influences performance and potential injury risk, is currently unknown. Much discussion is drawn from current equine literature due to the paucity of canine agility research (Powers, 2002; Colborne, 2007).

Birch and Lesniak (2013) demonstrated in agility dogs that as fence height increased flexion of the scapulohumoral joint and extension of the sacroiliac joint also increased. Pfau et al. (2011) found that there were higher vertical loads, peak forces and impulses in the front limbs upon landing over a hurdle than compared to a long jump.

Levy et al. (2009) reported that 33% of agility dogs had sustained an injury, with 58% of injuries occurring during competition, mirroring findings in equine studies (Singer et al., 2008). Shoulder injuries are commonly reported in agility dogs[3] and specialised rehabilitation veterinary practices[4] are being set up to accommodate canine athletes.[5] Neck, shoulder and back injuries were found to be most common, often occurring whilst jumping hurdles (Cullen et al.,

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[1] See: The Kennel Club, 2013. Agility. http://www.thekennelclub.org.uk/activities/agility/ (accessed 2 February 2015).

[2] See: Fédération Cynologique Internationale, 2012. Agility regulations of the Fédération Cynologique International. http://www.fci.be/en/Agility-45.html (accessed 2 February 2015).

[3] See: O'Cannapp, S., 2007. Shoulder conditions in agility dogs. Focus on Canine Sports Medicine. http://www.akcchf.org/assets/files/canine-athlete/Biceps-injury.pdf (accessed 2 February 2015).

[4] See: Smart Clinic, 2014. Welcome to SMART vet Wales. http://www.smartvetwales.co.uk./ (accessed 2 February 2015).

[5] See: Pet Rehab, 2013. Pet rehab fitness training. http://pet-rehab.co.uk/fitness-training/ (accessed 2 February 2015).

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Table 1
Jump height categories under Kennel Club regulations.

Category	Height to the withers	Jump height
Small	<350 mm	350 mm
Medium	351 mm–430 mm	450 mm
Large	>431 mm	650 mm

Table 2
Level of skill as defined under Kennel Club regulations.

Grade	Ability	Progression
1	Beginner	All dogs and handlers with no previous wins in agility
2	Beginner	All dogs and handlers who have won one agility class or three jumping classes at grade 1
3	Novice	All dogs who have won one agility class or three jumping classes at grade 2. Or all dogs with handlers who have previously won out of grades 1 and 2
4	Novice	All dogs who have won one agility class or three jumping classes at grade 3.
5	Novice	All dogs who have won one agility class or three jumping classes at grade 4.
6	Advanced	All dogs who have won three classes, with at least one of which being in agility at grade 5.
7	Advanced	All dogs who have won four classes, two of which must be in agility at grade 6.

2013a and b). These preliminary findings again are similar to those that are seen in equine studies (Clayton and Barlow, 1989). Research is needed to examine the impact of such activities on the health, welfare and longevity of agility dogs.

Work examining equine jump kinematics suggests that fence type and height both impact upon limb placement during the take-off and landing phases, and alter joint angles (Clayton and Barlow, 1989; Powers and Harrison, 1999; Hole et al., 2002). Jumping techniques in untrained, loose schooled horses differ, with 'good' jumpers being able to more accurately judge the optimum take-off distance (Powers and Harrison, 2000). In addition, successful horses were found to take off further from the fence than unsuccessful horses during a puissance competition (Powers, 2002). Wejer et al. (2013) reported that equine jump kinematics were also altered by experience and training, whilst Rorigues et al. (2014) found a decrease in jumping efficiency when the number of jumps increased. Anatomically, equines and canines differ, but it is reasonable to postulate that changes between hurdle distance will affect canine jump kinematics.

The aims of this study were to examine how (1) the distance between hurdles alters the take-off and landing distances; (2) the level of skill affects take-off and landing distances; (3) the apparent shoulder, lumbar spine and neck angles alter between different hurdle placement, and (4) the level of skill affects these apparent joint angles.

Materials and methods

The study gained full ethical approval from Nottingham Trent University Animal, Rural and Environmental Sciences Ethical Review Group (ARES60, 2 October 2012) prior to data collection. Fifty-four large dogs (Table 1), competing at The KC International Agility Festival, were recruited to the study on a volunteer basis (Table 3).

Table 3
Sample demographics.

Breed	Percentage	Mean age (years)
WSD/WSD crosses/BC	80%	6
Retriever/Retriever cross	9%	6
Sight hounds	6%	5
Others (e.g. standard poodle, GSD)	5%	4

WSD, working sheepdog; BC, Border collie; GSD, German shepherd dog.

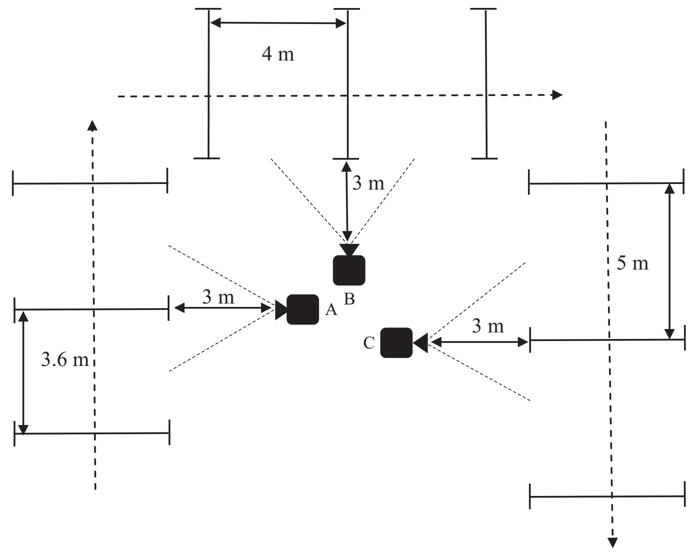

Fig. 1. The layout of the upright hurdles used in the study. A, B and C are camera locations and illustrate the camera's field of view ensuring the take-off and landing phase of the jump is recorded. Broken lines identify direction of travel, with each dog being stopped and restarted between each set of three hurdles.

No dogs were withdrawn from the study following an initial veterinary screen for injuries. The test comprised nine hurdles (650 mm high) in three sets of three; one set 3.6 m apart (KC minimum distance), one set 4 m apart (FCI minimum distance for small dogs) and one set 5 m apart (FCI minimum distance for large and medium dogs). A high definition video camera (JVC GC-PX10 HD, 300 fps) was sited 3 m away from the second hurdle of each set (Fig. 1). Handlers ran their dogs as they would in normal competition with dogs being withdrawn from subsequent analyses if they failed to complete all nine hurdles.

Dogs were classified into levels of skill by the grade within which they were currently competing (Table 2). Beginner dogs competed in grades 1 and 2 ($n = 7$), novice dogs in grade 3 ($n = 10$), intermediate dogs in grades 4 and 5 ($n = 17$), advanced dogs in grades 6 and 7[6] ($n = 20$).

Downstream data analysis was conducted using Dartfish software[7] with the base of the hurdle wing (0.48 m) used to calibrate distances (Fig. 2). Take-off was determined as the frame immediately prior to the dog leaving the ground and measured from the toe of the trailing hind limb to the hurdle wing (Powers and Harrison, 1999). Landing was determined as the frame where the dog first contacted the floor and was measured from the back of the carpus of the leading forelimb to the hurdle wing (Powers and Harrison, 1999).

Apparent neck angle was measured as that formed between the top of the skull, C2 and the top of the scapula. The lumbar spine angle was taken between T13, the top of the ilium and the base of the tail. The shoulder angle was that measured between the top of the scapula, top of the humerus and the elbow. Angles were examined for the take-off, landing and bascule (determined as the midpoint over the hurdle) phases of the jump (Powers and Harrison, 1999; Weigel and Millis, 2014) (Fig. 2).

Inter-observer reliability was examined using Pearson's correlation with repeated measures analysis of variance (ANOVA) and effect size (Cohen's d) examining differences between conditions. Tukey post-hoc tests determined where the differences lay.

Results

Data showed a strong positive correlation (take-off and landing distances $r[96] = 0.992$, $P < 0.001$; apparent joint angles $r[432] = 0.865$, $P < 0.001$) between two independent researchers indicating a high level of inter-observer reliability.

[6] The Kennel Club, 2013. Agility Grading Structure with Win/Points Progression Criteria for 2013. Available at: http://www.thekennelclub.org.uk/media/271056/aggradingstructure13.pdf (accessed 15 February 2015).
[7] See: Dartfish, 2014. http://www.dartfish.com/en/ (accessed 2 February 2015).