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TITLE: The Agility Health Study- physical demands in the performance of agility dogs

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SUMMARY

Agility is a popular dog sport nationally and internationally. Scientific studies report risks for injuries related to the sport and the agility community rise welfare concerns about the increasing physical demands in agility. The Agility Health Study was started to meet the demand of scientific knowledge on this topic. The overall aim of the Finnish Agility Study was to clarify the physical demands agility has on the dogs' musculoskeletal system and with that knowledge contribute to improve the safety and welfare of agility dogs.

An online survey was distributed to Finnish agility dog owners to collect information on training, management, and competition routines and to assess risk factors in competing agility dogs. Finnish agility dogs trained agility 1–2 times a week, with active training time of 18 minutes. Dogs competed 2.1 runs per month at a speed of 4.3 m/s. Warm-up and cool-down were used regularly, the dogs had a high level of general exercise and musculoskeletal care was a routine. The rate of competition-related injuries was 1.44 injuries/1000 competition runs. The main risk factors for agility-related injury were several previous agility-related injuries, older age when starting course-like training, high training frequency and vertebral anomaly. One of the most important protective factors were moderate competition frequency.

Healthy, competing Border Collies were evaluated to investigate the effect of jump height and the A-frame performance on the dogs' kinematics (movement of the dog, joint angles) and forces (kinetics) exerted on the dogs' musculoskeletal system at take-off and landing. Force-plates and a motion capture system with reflective markers were used to collect the data. The dogs jumped bar jumps in at three different heights and completed the A-frame in a straight line. During take-off to a bar jump, the increased jump height was associated with increased braking forces and decreased horizontal propulsion. There was increased vertical and decelerative forces, and larger joint angles with higher bar heights. When the dogs landed from a bar jump, horizontal propulsion and vertical impulses increased at higher jump heights. This may indicate greater load on tissues at higher bar heights. The increasing forces with increasing bar height and the fact that the bar jump is the most common obstacle on an agility course, may influence agility-related injuries. Preliminary results from the A-frame study show that carpal joint extension at take-off to and landing from the A-frame, is similar as during take-off to and landing from a bar jump 100% height at the dog's height at the withers. Detail kinetic and kinematic data describing the running contact technique, will improve the understanding of the physical stresses on dogs performing the A-frame.

Twenty-eight healthy Border Collies performed three obstacle sequences, a straight line and two with sport-specific accelerations and turns outdoors on sand and natural grass. To measure running speed, GPS devices were attached to each dog using a custom-made harness. Several surface parameters, including moisture, force reduction, shear and penetration resistance were tested on both surfaces on every test day. The speed of the dogs was higher on sand compared to natural grass, but only when the dogs ran in a straight line. This can be explained with the influence of the handler. The properties of natural gras, especially moisture, varied between different study days compared with sand. There is a need for future studies to identify suitable and safe surface options for the agility sport.

BACKGROUND

The dog sport agility has increased in popularity worldwide during the last decades and only in Finland there are estimated 13,500 enthusiasts practicing the sport. In Finland agility is already since several years recognized as an official sport discipline and from the beginning of 2024 the new animal welfare act is expanded to regulate dog sport and tests, including agility competitions. There is a genuine interest in the society to improve the safety and welfare on dogs used in work and sports. Therefore, scientific knowledge on physical demands in agility is needed urgently.

Approximately one-third of agility dogs suffer a sport-related injury during their active life (Cullen et al 2013, Inkilä et al 2022), with the bar jump, A-frame, and dog walk being the most injury-prone obstacles (Cullen et al, 2013, Inkilä et al 2022, Markeley et al 2022). Knowledge regarding training, competition, and management routines of agility dogs is lacking. Dog agility is clearly associated with risks for sport-related injuries, but risk factors for injury are yet to be determined. Bar jumps are also the most common obstacle on agility courses (Cullen et al 2013). Larger dogs jump typically higher bar heights in relation to their wither height than most smaller dogs. Therefore, the frequent exposure and the reported association with injuries make bar jumps an important factor to consider when investigating agility dogs' safety and welfare.

Bar height has for a long time been reason for debate in agility (Pfau et al 2011) and 2018 in Finland, the maximum bar height of jump obstacles in all dog height categories was reduced by five centimeters according to renewed international FCI regulations. In addition, a new, fourth dog height category, was introduced to FCI regulations in 2023 to reduce bar heights for some dogs who used to compete in the "large" category. Similar rule changes aiming to reduce bar heights and adding height categories have been made to national agility regulations in Europe and in the United States. So far decisions for regulation changes have been based on anecdotal evidence since scientific reports on the effect of bar height on jumping kinetics and kinematics is limited.

Another important obstacle to consider in the agility safety and dog welfare debate is the A-frame, that is clearly related to injuries in agility (Inkilä et al 2022, Markeley et al 2022). However, research has so far failed to explain the reasons for this (Appelgrein et al 2019, Cullen et al 2017). The agility community consider the running-contact technique safer and less wearing to the dog in comparison with the traditional stopped-contact technique. The justification is that, although speed increases, less forces are exerted on the front limbs during a running-contact compared during a stopped contact. To date, there are no scientific evidence to support this argument.

Different surface materials are used in agility training and competition, including natural grass, sand, artificial turf, dirt as well as various types of rubber mat and foam (Jimenez et al 2022). In human and equine sports medicine, the surface properties and how different surfaces relate to injury and performance have been investigated extensively. The interest in surfaces in dog sports is rapidly increasing, but it is not known which surfaces would be most suitable and safe for the agility sport. A recent Internet-based survey of 308 agility dogs reported less signs of decreased performance on natural grass and dirt compared to other rubber mat, artificial turf, sand or foam mat (Jimenez et al 2022). Another study reported agility that dogs sustain most injuries on dry outdoor surfaces (Levy et al 2009). The Finnish Agility Dog Survey did not find surface to be associated with elevated risk of injury, however slipping was associated with injuries (Inkilä et al 2022). In racing greyhounds faster track conditions are associated with injuries (Iddon et al 2014). To our knowledge, this study is the first to describe the effect of surface conditions on the speed and performance of competing agility dogs.

In this research report we present the two published articles (The Finnish Agility Dog Survey Part I and II), preliminary results from our A-frame study and the most interesting and significant results from three studies currently in manuscript preparation (effect of fence height on jumping kinetics and kinematics and running speed on two different surfaces). For reader convenience we have numbered the studies I-VI.

AIMS AND OBJECTIVES

The overall aim of the Finnish Agility Study was to clarify the physical demands agility has on the dogs' musculoskeletal system to improve the safety and welfare of agility dogs.

Study I: The Finnish Agility Dog Survey- Part I

The aim of the study was to provide knowledge regarding training, competition, and management of agility dogs.

Study II: The Finnish Agility Dog Survey- Part II

The aim of this study was to provide a more complete understanding of agility-related injuries in competition-level agility dogs. The objectives were to describe agility-related injuries and to provide information on training, competition, and management of agility dogs before injury. Further objective was to identify risk factors for agility-related injury.
We hypothesized that previous musculoskeletal injuries, increased training and competition frequency, and higher competition speed are associated with increased odds for agility-related injury.

Study III and IV: Effect of jump height on kinetics and kinematics during take-off and landing in agility dogs.

The aim of this study was to examine the effect of bar height on ground reaction forces and sagittal plane kinematics during take-off and landing. Additionally, limb coordination, horizontal velocity, take-off distance, and take-off angle in relation to bar height were evaluated to explain the jump performance in detail.
We hypothesized that an increase in bar height lead to increased range of motion (ROM) in limb joints and increased kinetic forces.

Study V: Kinetics and kinematics of agility dogs during A-frame performance using the running contact technique.

The objective was to describe the kinetics and kinematics of the running-contact technique during the A-frame performance.

Study VI: Running speed of agility dogs on two different surfaces- sand and natural grass.

The objective was to compare speed of the dog during sport-specific performances in agility on two surfaces: sand and natural grass and to compare the different measurable properties of natural grass and sand. Our hypothesis was that the maximum speed is over 10 m/s, the speed range 5-6 m/s and that the average speed is slower on sand than on grass.

MATERIALS AND METHODS

The Agility Health study is partly a PhD project and research collaboration between the Department of Equine and Small Animal Medicine, University of Helsinki, Finland, the Department of Clinical Sciences, Swedish University of Agricultural Sciences, Uppsala, Sweden, the NeuroMuscular Research Center, Faculty of Sport and Health Sciences, University of Jyväskylä, Finland and the Faculty of Kinesiology, University of Calgary, Canada and EstiMates Ltd. Espoo, Finland.

For the Finnish Agility Dog Survey Part I and II, no ethical approval was required according to the requirements of the Viikki Campus Research Ethics Committee (no live animals were used) and the Finnish National Board on Research Integrity TENK. The Viikki Campus Research Ethics Committee approved the study design for III-V (statement 10/2019) and for study VI (January 28, 2020). Participants were recruited through social media and local agility clubs. All participating dog owners were given written and oral information about the study, and they provided signed consent for participation of their dog.

In study I and II, the Finnish Agility Dog Survey-Part I and II, A Finnish language retrospective online survey was developed using expert opinions, cognitive interviews, check lists, and a test group. The survey consisted mostly of close-ended multiple-choice questions. The final survey used skip logic, with only applicable questions shown to the respondent. The survey contained questions about signalment, the dog's and the main handler's experience in agility, health history of the dog and questions dealing with the context of the injury, description of the injury, treatments used, and time to recovery. Training practices and musculoskeletal care prior to the injury were also included.

In study I, the Finnish Agility Dog Survey-Part I Finnish owners and handlers of 745 competition-level agility dogs provided information on training routines and management of these dogs during one year free of agility-related injuries. Competition routines were collected from the national competition results database. Descriptive statistics were used to summarise the data. Pearson's chi-squared and Kruskal–Wallis tests were used to evaluate the association between a dog's competition level and training and competition variables.

In study II, the Finnish Agility Dog Survey-Part II the online survey was used to collect data on 864 Finnish competition-level agility dogs, of which 119 dogs (14%) had suffered an agility-related injury during 2019. Data included injury details, health background, experience in agility, and sport and management routines prior to the injury. Descriptive statistics was calculated for all variables. Risk factors for injury were evaluated with multivariate logistic regression.

In studies III-V, the same patient population was utilized. It consisted of Border Collies competing in agility. Inclusion criteria in all studies were: physical exam and lameness examination without abnormal findings, no illnesses requiring days out of training for the last two months and dog competes in agility. Exclusion criteria were that strangers can't handle the dog, or the dog has trained or competed in agility during the preceding two days. Prior to the experiments, a veterinary orthopedic surgeon conducted physical and orthopedic examinations on all dogs. Dogs were excluded if they were not considered fit to perform (e.g. heart murmur, lameness, painful reactions during manipulation of joints).

In study III and IV, (effect of jump height at take-off and landing), seventeen Border Collies were included, eight were females and nine males. Age mean ± standard deviation was 4.2 ± 2.1 years and wither height 51.8 ± 3.2 cm. The dogs performed bar jumps in a straight-line at 80%, 100% and 120% of the dogs' wither height. Impulses of fore- and hindlimb (FL/HL) pairs were calculated from forces measured by two force plates (AMTI, 1000 Hz). Sagittal joint kinematics of the shoulder, elbow, carpus, hip, stifle, and tarsal joints, trunk horizontal velocity (THV) at touch-down of trailing forelimb (TrFL), take-off distance (TOD) and take-off angle (TOA) were calculated from reflective markers (Vicon Nexus, 13 cameras, 200 Hz). Mean values were calculated from ≥2 trials/jump height. Repeated measures ANOVA and linear mixed models were used for statistical analysis.

In study V, (A-frame), fourteen of the Border Collies from the jump height experiment also performed the A-frame in a straight line using the running-contact technique. Limb joint angles, body angle, approach horizontal velocity and horizontal acceleration were calculated from reflective markers (Vicon Nexus, 13 cameras, 200 Hz) during take-off to and landing. Descriptive statistics were used to present the data. Comparison to the bar jump is made were applicable.

In study VI (surface comparison), the participating 28 Border Collies performed three different obstacle sequences, sequence A in a straight line and sequence B and C with sport-specific accelerations and turns outdoors on sand and natural grass. Obstacle sequences were identical on both surfaces. The dogs needed three successful trials from each sequence without faults on both surfaces. To measure average and maximum speed, GPS devices (PlayerTek, Catapult) were attached to each dog using a custom-made harness. GPS devices were synchronized with time gates to mark start and stop of each obstacle sequence.

Surface parameters were tested on both surfaces from 10 determined spots on the expected running path on every test day. A moisture-meter Fieldscout was used to measure surface moisture. A Portable Falling Weight deflectometer (Fieldman) was used to measure force reduction (FR, unit %), energy of restitution (ER, unit %) and Deformation (mm). The Going stick was used to measure shear and penetration resistance. A linear mixed model suitable for cross-over study design was used for statistical analysis. Differences between surfaces (natural grass and sand) and measurement days and surface parameters were analysed with two-way analysis of variance models separately for each parameter using the surface, measurement day and their interaction as explaining factors.

RESULTS

The results from the **study I, the Finnish Agility Dog Survey- Part I** showed that most dogs trained agility 1–2 times a week, median active training time of 18 minutes. Dogs competed in a median of 2.1 runs per month at a speed of 4.3 m/s. Training surfaces commonly used were different types of artificial turfs and dirt. Warm-up and cool-down seemed established routines, and more than 60% of the dogs received regular musculoskeletal care, such as physiotherapy or massage. Almost 80% of dogs conditioning exercises. Dogs were walked for a median of 1.5 hours daily. A dog's competition level was associated with competition ($p < 0.001$) and training frequency ($p < 0.001$) so that dogs at higher levels competed more but trained less compared to dogs at lower levels.

The results from **study II, the Finnish Agility Dog Survey- Part II** showed that the rate of competition-related injuries was 1.44 injuries/1000 competition runs. The front limb was injured in 61% of dogs. In 65% of dogs, the injury presented as lameness. The main risk factors for agility-related injury during 2019 were multiple previous agility-related injuries (OR 11.36; 95% CI 6.10–21.13), older age when starting course-like training (OR 2.04 per one year increase; 95% CI 1.36–3.05), high training frequency, diagnosis of lumbosacral transitional vertebra, and physiotherapy every two to three months compared with never. Some protective factors were moderate competition frequency and A-frame performance technique.

Study III (effect of jump height at take-off), showed that trunk horizontal velocity (THV) at touch-down of trailing FL decreased with increasing jump height ($p<0.001$). Take-off angle (TOA) became steeper ($p<0.001$) with no effect on take-off distance (TOD) ($p=0.34$). Mean differences between heights 80% and 120% were -0.37 m/s in HV and 6.30 degrees in TOA. With increasing jump height, the vertical impulse (VI) increased in FLs and HLs ($p<0.001$). Mean differences in VI between heights 80% and 120% were 0.29 Ns/kg in FLs and 0.24 Ns/kg in HLs. The decelerative horizontal impulse (HI) values decreased in both limb pairs ($p<0.001$) with mean difference between heights 80% and 120% being -0.097 Ns/kg in FLs and -0.054 Ns/kg in HLs. The accelerative HI decreased in FLs and HLs ($p<0.001$). The mean differences in accelerative HI between heights 80% and 120% were -0.071 Ns/kg in FLs and -0.046 Ns/kg in HLs. Sagittal range of motion was greater, through increased peak flexion or extension, at 120% bar height than at lower bar heights ($p<0.05$) in almost all measured limb joints. With increasing bar height, the horizontal velocity of trunk decreased ($p<0.010$), and take-off angle became steeper ($p<0.001$),

Study IV (effect of jump height at landing), showed that trunk horizontal velocity at touch-down of trailing FL decreased with increasing jump height ($p<0.001$), landing angle (LA) became steeper ($p<0.001$), and landing distance increased ($p<0.001$). Mean differences between heights 80% and 120% were -0.86 m/s in horizontal velocity, 7.20 degrees in LA, and 0.58 m in LD. As jump height increased, the vertical impulse (VI) increased in both FLs and HLs ($p<0.001$). Mean differences in VI between heights 80% and 120% were 0.42 Ns/kg in FLs and 0.17 Ns/kg in HLs. The decelerative horizontal impulse (HI) was not affected by jump height in either limb pair ($p>0.26$). The accelerative HI increased with jump height in FLs ($p<0.001$) and HLs ($p=0.002$) with mean difference between heights 80% and 120% being 0.092 Ns/kg in FLs and 0.067 Ns/kg in HLs.

From study V, (A-frame), the preliminary results show that carpal extension at take-off to the A-frame in the trailing forelimb (TrFL) was 234 ± 11 degrees and leading forelimb (LeFL) was 235 ± 13 degrees. During the first stride on A-frame carpal extension of the TrFL was 237 ± 11 degrees and LeFL 240 ± 15 degrees. During the last stride on A-frame carpal extension of the TrFL 222 ± 13 was degrees and LeFL 226 ± 14 degrees. Landing from the A-frame, carpal extension was 239 ± 11 degrees in TrFL and 246 ± 13 degrees in LeFL.
At take-off, the body angle at lift-off (LO) of leading hindlimb (LeHL) was 13.0±6.6 degrees. Body angle at touch down (TD) of trailing forelimb (TrFL) on A-Frame was 0.8±8.4 degrees. During landing from the A-frame, the body angle at LO of LeHL was 49.8±3.3 degrees and body angle at TD of TrFL was 38.2±4.7 degrees.
At take-off, approach horizontal velocity was 6.9 ± 0.7 m/s with a mean horizontal velocity of5.6 ± 0.5 m/s. The horizontal acceleration on ground was -1.7 ± 1.8 m/s2. During landing from the A-frame, approach horizontal velocity was 6.0 ± 0.6 m/s with a mean horizontal velocity 5.2 ± 0.5 m/s. Horizontal acceleration on ground was 4.0 ± 1.7 m/s2.

In study VI (surface comparison), results show, that when dogs run in straight line (sequence A), the average speed was statistically significantly ($p = 0.0422$) slower on natural grass than on sand. There were no statistically significant differences between sand and natural grass surfaces when comparing the maximum speed. On sequence B and C, there was no significant difference in average or maximum speed between the two surfaces, but maximum and average speed increased after the first trial. Average speed range for tracks B and C was 5-6 m/s. For Fieldman force reduction (FR) there were statistically significant ($p<0.05$) differences between days on 3 occasions for sand surface, but no statistically significant differences between study days for grass surface. For energy of restitution (ER) and deformation values, there were no statistically significant differences between days for natural grass or sand surface ($p > 0.05$). In the moisture values, there were statistically significant ($p<0.05$) differences between study days on 3 occasions for the sand surface. For the natural grass surface, there were statistically significant differences between days on 8 occasions. For the shear and penetration resistance values, there were no statistically significant differences between days for sand or natural grass ($p > 0.05$).

DISCUSSION AND CONCLUSION

In Part I of the Finnish Agility Dog Survey, we presented the development and use of the questionnaire. Agility dogs, starting course training generally, rather late, at one year of age. The dogs typically trained agility once or twice a week and competed two runs a month, with one month off each year from agility. This training and competition routines appear modest considering physical stress on the dogs. Warm-up and cool-down routines seemed established, but conditioning exercises were generally performed only occasionally or not even at all. However, the total duration of daily general exercise was high, providing good general conditioning and regular musculoskeletal care was provided for most dogs.

This study provides basic knowledge of training, competition, and management routines of competition-level agility dogs in Finland during an injury-free year. Across competition levels, there are differences in training and competition routines, speed, competition success and management of the dogs. This said, there is always possibility that some respondents understand the questions differently than others. Some respondents may have had difficulties recalling routines possibly causing error. However, the questions were carefully and thoroughly constructed and tested, and we consider this study to provide a trustworthy overview on the topic.

Part II of the Finnish Agility Dogs Survey describes the dogs with agility-related injuries and risk factors for injuries. Agility dogs are prone to soft tissue injuries to their front limbs and most of those injuries occur during obstacle performances. Several new risk factors for injury in agility were identified. Dogs with multiple previous agility-related injuries, lumbosacral transitional vertebra, later starting age in the sport, and high training frequency seemed to be at greater risk for agility-related injury. It must be noted that the statistical models used detect only associations, not causality. Some risk factors may be connected to some other factors, not covered by the questions in the survey.

The knowledge gained from the survey is useful for agility handlers and trainers, veterinarians, physiotherapists, and other professionals that prepare the dogs for the demands of the sport. Reviewing obstacle regulations could aid in reducing some obstacle-related injuries. This information can be used to improve the welfare of agility dogs and has provided justifications for further research on this topic.

In study II and V we investigated the effect of jump height at take-off and landing and we were able to confirm our hypothesis. During take-off to a bar jump, our study showed that increased jump height is associated with increased braking forces and decreased horizontal propulsion. Increased vertical and decelerative forces, and the greater peak flexion and extension angles of joints, may indicate greater load on tissues at higher bar heights. Also, during landing from a bar jump, there was increased horizontal propulsion and vertical impulses of both limb pairs at higher jump heights. Considering this in combination with the bar jump being the most common obstacle on the agility course, this may have an impact on agility-related injuries. This could provide an explanation for the increased odds of injury at higher bar heights in agility dogs.

For study V (A-frame), our original intention was to investigate possible differences in kinetics and kinematics between the running-contact and the stopped-contact technique. Unfortunately, we were not able to recruit dogs using stopped-contact technique, as the use of this technique is continuously decreasing in Finland. However, we decided to report detailed kinetic and kinematic data from the running contact technique, because that would improve the understanding of the physical stresses on dogs performing the A-frame. In this research report we highlight the preliminary results from carpal joint extension at take-off to and landing from the A-frame, that is of similar magnitude as during take-off to and landing from a bar jump 100% height at the dog's height at the withers.

In study VI (surface comparison) we were not able to confirm our hypothesis. The average and maximum speed were significantly higher on sand surface compared to natural grass, but only when the dogs ran in a straight line. There was no difference in speed on the two other sequences including turns and accelerations. One explanation is that handling the dog through the course sequence introduces variation to the performance, which limits small differences to be revealed. Further, when interpreting the surface results, it seemed that natural grass is more inconsistent between different study days. This was especially true for moisture values. People working with maintenance of agility facilities, judges, trainers, and dog handlers should consider that their normal training or competition surface properties may change between days and due to weather conditions. Intensified maintenance may aid in keeping the surface properties more consistent. There is an urgent need for future studies to find suitable and safe surface options for the agility sport.

The Agility Health Study has provided scientific knowledge on training, management, competition routines and injuries in agility dogs and has further explained several aspects of different physical demands in jumping, A-frame performance and running on different surfaces. This information will benefit the agility community and the professionals working with agility dogs to increase safety and welfare of the sport.

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PUBLICATIONS

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https://www.facebook.com/agilitytutkimus/

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