Evaluating Pekin duck walking ability using a treadmill performance test

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ABSTRACT Gait scoring is the most popular method for assessing the walking ability of poultry species. Although inexpensive and easy to implement, gait scoring systems are often criticized for being subjective. Using a treadmill performance test we assessed whether observable differences in Pekin duck walking ability identified using a gait scoring system translated to differences in walking performance. One hundred and eighty ducks were selected using a three-category gait scoring system (GS0 = smooth gait, n = 55; GS0.5 = labored walk without easily identifiable impediment, n = 56; GS1 = obvious impediment, n = 59) and the amount of time each duck was able to sustain walking on a treadmill at a speed of 0.31 m/s was evaluated. The walking test ended when each duck met one of three elimination criteria: (1) The duck walked for a maximum time of ten minutes, (2) the duck required support from the observer's hand for more than three seconds in order to continue walking on the treadmill, or (3) the duck sat down on the treadmill and made no attempt to stand despite receiving assistance from the observer. Data were analyzed in SAS 9.4 using PROC GLM. Tukey's multiple comparison test was used to compare differences in time spent walking between gait scores. Significant differences were found between all gait scores ($P < 0.05$). Behavioral correlates of walking performance were investigated. Video recorded during the treadmill test was analyzed for counts of sitting, standing, and leaning behaviors. Data were analyzed in SAS 9.4 using a negative binomial model for count data. No differences were found between gait scores for counts of sitting, standing, and leaning behaviors ($P > 0.05$). In conclusion, the amount of time spent walking on the treadmill corresponded to gait score and was an effective measurement for quantifying Pekin duck walking ability. The test could be a valuable tool for assessing the development of walking issues or the effectiveness of treatments aimed at promoting leg health.

Key words: leg health, assessment, Pekin duck, gait

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INTRODUCTION

Poor walking ability presents a number of animal welfare and economic concerns for producers of poultry raised for meat. Mobility problems have been associated with pain, discomfort, and the inability to reach needed resources such as food and water (McGeown et al., 1999; Danbury et al, 2000; Weeks et al, 2000), and can lead to increased culling from the flock (Butterworth, 1999; Sanotra et al., 2001). Currently, visual gait scoring systems are most commonly used to evaluate the walking abilities of poultry (Mench, 2004). During gait scoring, observers assign birds to gait categories based on a description of the way in which the bird walks. The gait scoring method is easy to implement, and can be used to assess a large number of birds in a relatively short period of time. However, due to concerns about the method's reliability and validity, its meaningfulness has often been questioned (Farm Animal Welfare Council, 1992; C. Byrd, unpublished data). As a result, the development of quantitative methodologies for measuring animal mobility has been cited as an important and needed area of research (Scientific Committee on Animal Health and Welfare, 2000).

The general concerns surrounding the reliability and validity of poultry gait scoring systems also apply to Pekin ducks. Karcher et al., 2013 raised the concern that gait scoring conducted after ducks had been handled may lead to biased results as the ducks are likely to have an increased motivation to distance themselves from the observers and may be able to mask mild gait impediments. The authors also noted that there is a general lack of information on what constitutes "normal" duck gait, making gait scores difficult to interpret. In an effort to address the meaningfulness of a gait

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scoring system commonly used for Pekin ducks, one study used a pressure pad to assess whether gait score definitions translated to quantifiable changes in duck gait parameters (Makagon et al., 2015). Ducks with higher gait scores, thought to indicate poorer walking ability, were found to place uneven pressure on their two legs, more so than ducks assigned to lower, better, gait score categories. Additionally, ducks deemed to have poorer gait were found to travel a shorter distance over 4 steps as compared to ducks with good walking ability. These results indicate that gait score does translate to measurable differences in gait structure. However, the relationship between gait score and walking performance (i.e., whether ducks with a limp or deemed to have an awkward gait are able to walk for equally long distances as those with good gait) remains unclear.

The objective of this study was to determine whether differences in gait score would correspond to differences in walking performance evaluated using a treadmill test. Given the increase in energy expenditure as a result of compromised walking ability (Waters and Mulroy, 1999) we hypothesized that ducks with poor walking ability would walk for shorter periods of time compared to ducks with good walking ability. We additionally expected ducks with poor gait to sit, stumble, and lean on the treadmill more frequently than ducks deemed to have good gait.

MATERIALS AND METHODS

The experimental protocol was approved by the Purdue Animal Care and Use Committee.

Birds and Facilities

The study was conducted over the course of six days during the months of August and October 2014. The 180 30-31 day old ducks included in this study were raised in a tunnel-ventilated commercial facility with plastic slatted flooring. The ducks were housed in mixed sex, single strain (Y-cross) flocks of approximately 5,400 ducks. Feed and water were provided *ad libitum* via an automated pan feeder and nipple drinker system. All management and husbandry was conducted according to the company's standard operating procedures.

The ducks were selected for their walking ability using a gait scoring system modified from the 3-point gait scoring systems previously used for scoring ducks (e.g., Jones and Dawkins, 2010; Karcher et al., 2013; Makagon et al., 2015). Following the previously established definitions, ducks with a gait score of 0 (**GS0**) waddled and walked with a smooth gait, while those with a gait score of 1 (**GS1**) were defined as walking with a slight limp, or having a labored walk. The exact visible cause for the limp (*e.g.* bumblefoot) was not taken into consideration during the selection process, but ducks with obvious valgus-varus deformations were excluded from the study. Because some of the observed ducks failed to fall into either of these descriptions, a gait score 0.5 (**GS0.5**) category was added. GS0.5 ducks were defined as having a walk that was slightly uneven or stiff, but having no obvious limp. Ducks categorized as having a gait score of 2 (**GS2**; poor gait), as defined in the original 3-point gait scoring system, were excluded from this study. By definition, these ducks would have been unable to walk on a treadmill. Sixty ducks of each gait score (GS0, GS0.5, GS1) were included in the study. Ducks that fit the gait criteria were identified and selected by the observer in groups of 10 (with each gait score represented by three or four birds to be tested within a two hour time block) as he walked slowly through the flock. Therefore, the ducks were not handled before gait scoring. The selected birds were marked with a nontoxic marker by gait score and placed in a holding pen within the barn.

Duck selection and all treadmill tests were performed by a single observer (C.B.). The observer wore a disposable white Tyvek coverall, hair net, and plastic boots throughout the study. The ducks had daily interactions with humans during routine husbandry checks, but no previous experience with the observer.

Treadmill Performance Test

A treadmill (Body Solid T-50; Body-Solid Inc., Forest Park, IL) designed for human use with a speed range of 0.04 to 2.2 m/s (0.1 to 5.0 mph) was used. The walking surface (45 cm × 129.5 cm) was surrounded by a custom built wooden enclosure. The enclosure featured one plywood wall, which helped decrease exposure to disturbances that could have affected the duck's performance (such as a person walking by). Plexiglass covered the front and other side of the treadmill and the top of the treadmill was left open, allowing light to enter. The control console was detached from and placed behind the treadmill allowing the observer to conveniently change speed settings without distracting the tested bird. A mirror placed at the front of the treadmill was used to keep the duck's attention and encourage it to walk forward.

The treadmill performance test consisted of five phases. A duck was randomly chosen from the group of ten previously gait scored ducks, placed on the treadmill and allowed 30 seconds to acclimate (phase 1). The treadmill was then set to a speed of 0.13 m/s (0.3 mph) for 30 seconds (phase 2). During this time, the observer knelt down at the back end of the treadmill, held out his hand, moved his fingers and used his voice to encourage the duck to walk forward by making a quiet "hiss" sound for the entire phase. This was followed by a 15 second period at 0.22 m/s (0.5 mph; phase 3) and 15 seconds at 0.31 m/s (0.7 mph; phase 4). During phase 4, the observer only used his voice for encouragement. In the final phase (phase 5), the speed of 0.31 m/s (0.7

mph) was maintained and the observer moved to the right of the enclosure, out of the duck's sight. During this phase, the observer could no longer use his hand to encourage the duck to walk unless the duck fell behind a "cut-off" marker, comprised of a set of hanging beads located 30.5 cm from the back end of the treadmill.

The amount of time each duck spent walking on the treadmill at the maximum speed of 0.31 m/s (during phase 4 and 5 combined) was recorded. Ducks that failed to reach phase 4 (n = 10; did not walk or would not walk without consistent support of the observer's hand) were excluded from the study and replaced with a duck from the same gait score category. The trial ended when the duck reached one of three elimination criteria: 1) the duck fell behind the "cut-off" marker, and required the support of the observer's hand for more than three seconds to continue walking, 2) the duck lay down on the treadmill and glided to the end without making an attempt to stand, 3) the duck walked for 10 minutes, the maximum allotted time per trial. Following the trial, ducks were weighed and placed back into the flock. The evaluation of each group of 10 lasted no longer than 2 hours. A total of 30 ducks was evaluated per day.

A balanced incomplete block design was used with 2-hour time periods (the time allotted for each group of 10 ducks to be tested) serving as blocks. The order of duck testing within each block was randomly generated before testing began to account for a possible order effect. One GS1, four GS0.5, and five GS0 ducks were removed from the data set, as their testing time ended before the birds reached one of the elimination criteria (*e.g.*, when a duck ran off the end of the treadmill during the test). Statistical analysis was conducted using PROC GLM in SAS 9.4. To confirm the best fitting model, the GLMSELECT variable selection method was used. Time block, day, gender, gait, and weight were tested as explanatory variables for time spent walking. Of these, the procedure selected gait and weight as the only independent variables for use in the model. None of the interactions were found to be significant and were, therefore, removed from the model. Time spent walking by each duck was used as the dependent variable while gait (0, 0.5 and 1) and weight were investigated as independent variables. Weight was treated as a covariate in the model. Tukey's multiple comparison test was used to assess differences between treatment groups.

Behavioral Correlates Associated with Walking Ability

Behavioral data were transcribed from videos recorded during the treadmill performance test using a Sony HD camera (HDR-CX190; Sony Corporation, Tokyo, Japan) positioned approximately 91 cm behind the end of the treadmill. Because the observer was positioned between the duck and the camera during phase 1 to 4 of testing, behavioral observations were only conducted during phase 5 of the treadmill test. Continuous observations were used to calculate the number of times each duck stumbled (lost its balance but resumed walking before its belly touched the tread surface), sat down on the tread (placed belly on the tread surface with legs no longer moving), or leaned on the enclosure (made contact with one wall of the treadmill enclosure while continuing to walk). A negative binomial model for count data in SAS 9.4 was used for statistical analysis. Counts of stumbling, sitting, and leaning were individually treated as predictor variables of gait score with time spent walking serving as a covariate in each model.

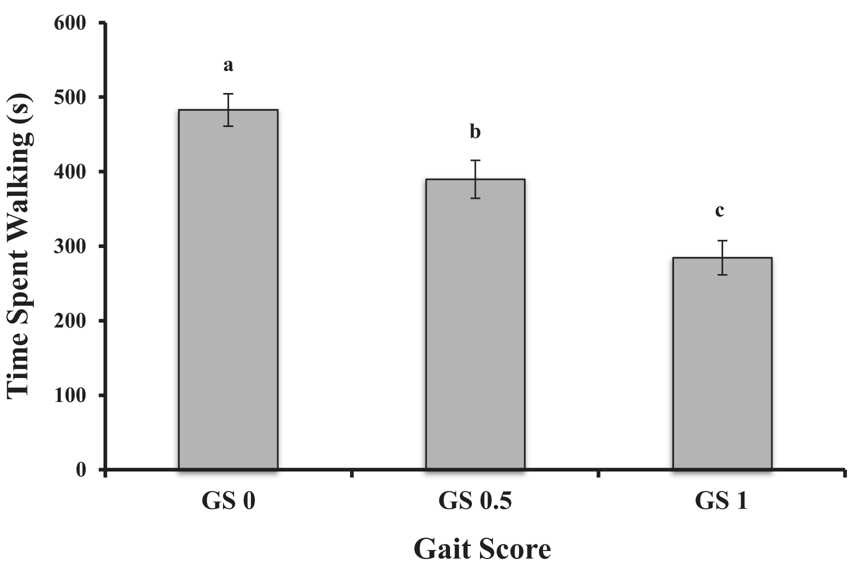

Figure 1. Mean time spent walking (±SE) by ducks with GS0 (best walking ability) to GS1 (moderate walking ability). Different superscripts indicate significant differences ($P < 0.05$).

Table 1. Description of duck weight by gait score. Mean weight, median weight, and weight range are presented.

Gait	Sample size	Mean weight (kg)	Median weight (kg)	Weight range (kg)
0	55	3.66	3.69	3.08 to 4.35
0.5	56	3.72	3.75	2.96 to 4.30
1	59	3.72	3.77	2.67 to 4.35

RESULTS

Treadmill Performance Test

There was a significant effect ($P < 0.001$) of gait score on the time ducks spent walking at a speed of 0.31 m/s. Tukey's comparison tests found significant differences between all gait scores (Figure 1). On average, ducks with GS0 walked for the longest amount of time (least squares mean = 475.26 s) followed by ducks with GS0.5 (least squares mean = 392.42 s) and GS1 (least squares mean = 287.80 s), respectively. There was an effect of weight on time spent walking ($P = 0.007$); however, weight had no significant interaction with gait. Therefore, weight was treated as a covariate in the model (see Table 1 for weight information by gait). Heavier birds tended to walk for shorter periods compared to lighter birds within their respective gait scoring categories.

Behavioral Correlates Associated with Walking Ability

Table 2 summarizes the incidence of leaning, sitting, and stumbling by ducks with GS 0, 0.5, and 1. No effect of gait score on counts of sitting, stumbling, or leaning was found. Across gait score categories, increased time spent walking was associated with more incidences of leaning ($P < 0.001$, Figure 2).

Table 2. Mean counts (±SE) of sitting, stumbling and leaning by ducks with good (GS0) to moderate (GS1) walking ability. Behavior was not affected by gait score (all $P > 0.1$).

Behavior	GS 0	GS 0.5	GS 1
Lean	16.8 (±1.9)	13.4 (±1.5)	16.8 (±1.3)
Sit	0.9 (± 0.25)	1.4 (± 0.6)	1.2 (± 0.3)
Stumble	1.3 (± 0.3)	1.0 (± 0.2)	0.7 (± 0.2)

DISCUSSION

In agreement with our hypothesis, time spent walking significantly decreased as gait score increased. This lends support to previous research, which also showed positive relationships between gait scores and additional quantifiable measurements of duck walking ability. Specifically, increased gait score was previously found to be significantly associated with changes in hip angle (Robison et al., 2015) as well as reduced body weight, distance traveled in a predetermined number of steps, and increased differences in applied pressure between the left and right legs (Makagon et al., 2015). Together, the present results and those of previous studies support the use of gait scores by trained observers for providing meaningful information about Pekin duck walking ability.

Within each gait score, heavier birds tended to walk for a shorter period of time, however, there was no significant interaction between weight and gait score. This is contrary to a number of published studies with broilers (Kestin et al., 2001; Sanotra et al., 2001; Aydin et al., 2010) and ducks (Makagon et al., 2015; Robison et al., 2015) that have found weight to be inversely correlated with gait score. The lack of evidence for this interaction in the present study may be reflective of the gait score system used to categorize the birds, specifically the absence of data from ducks with severe walking impairments, and the introduction of the GS0.5 category.

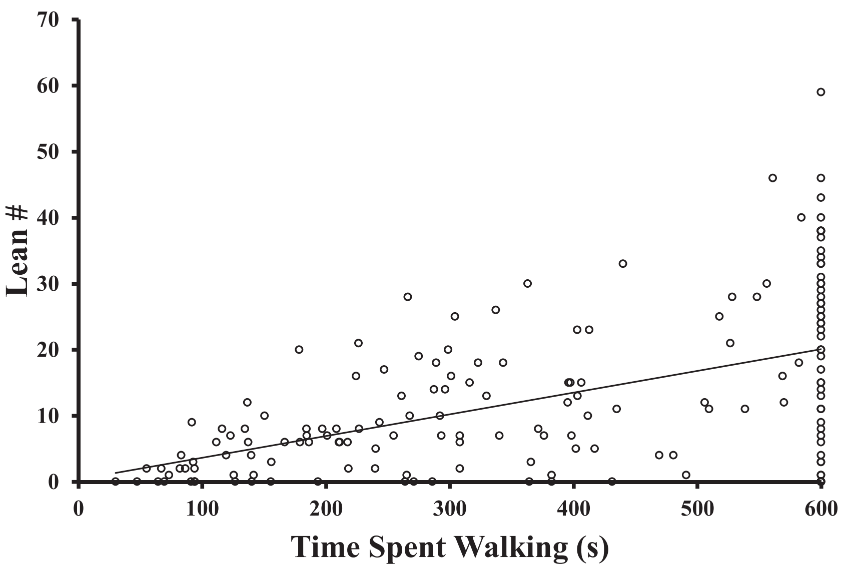

Figure 2. Across gait score categories, the number of leaning bouts increased with time spent walking ($P < 0.001$).

No significant associations were found between gait score and sitting, stumbling, or leaning behaviors. Previous studies evaluating broiler chicken activity budgets noted significantly decreased walking and standing behaviors in chickens with poor walking ability, possibly due to discomfort and an increase in the physical demand needed to perform those behaviors compared to lying (Weeks et al., 2000). Sitting and stumbling behaviors during the treadmill performance test could be expected to occur as a result of discomfort or an increased physical demand required for continuous walking. However, average counts of sitting and stumbling were low across gait scoring categories. One possible reason for this may be due to the duck's motivation to distance itself from the observer, as improvement in observed gait impairment has been demonstrated in response to novel stressors (Gentle and Corr, 1995). Similar to sitting and stumbling behaviors, leaning bouts on the enclosure were not significantly different between gait scores. However, leaning bouts were significantly associated with walking time. Specifically, leaning bouts increased as time spent walking increased, likely due to fatigue.

An intermediate gait score of 0.5 was added to the gait scoring system developed by Jones and Dawkins (2010) for describing ducks that did not definitively fit into the other gait scoring categories (GS0 and GS1). These ducks, described as having an uneven and stiff gait but not immediately obvious walking impairment, walked on the treadmill for significantly longer amounts of time compared to GS1 ducks and significantly shorter amounts of time compared to GS0 ducks. This indicates that the current 3-point system may be over-simplified and could limit the amount of information that is available for evaluating and diagnosing impairment issues (Knierim and Winckler, 2009; D'Eath, 2012). The optimization of current gait scoring methods to accurately reflect quantitative differences could improve our understanding of walking impairment in Pekin ducks. For example, GS 0.5 ducks may be more susceptible to developing severe gait issues compared to GS 0 ducks (C. Byrd, unpublished data). Therefore, a gait scoring system that distinguishes the GS 0.5 group may enable researchers and producers to successfully identify risk factors, causes, or intervention strategies before the lameness is pronounced to prevent progression of walking impairment.

Using the amount of time spent walking on the treadmill as a measure of walking ability, the treadmill performance test shows promise for use in a number of experimental capacities that focus on duck walking ability. As demonstrated, it may be useful as a benchmark for the development of future gait scoring methods. Other uses of the treadmill, such as evaluating changes in walking ability following analgesic treatment, may provide beneficial information on the role pain or discomfort plays as walking impairment increases. Work assessing the effect of analgesic administration on walking ability of broiler chickens and turkeys has reported mixed results (Hocking et al., 1999; McGeown et al., 1999; Corr et al., 2007; Caplen et al., 2013), likely due to a number of factors such as underlying pathology, drug choice, or dosage. To the authors' knowledge, no research on this topic has been published with commercially raised Pekin ducks. The treadmill performance test may also serve as a helpful tool for identifying risk factors and critical periods for employing intervention strategies, or as a tool for genetic selection of leg health. However, all further uses of the test should be performed in the context of the test's limitations. A current limitation of the treadmill test is that it has only been used to evaluate ducks with good to moderate walking ability. It is unclear whether it could be used to differentiate between gradients of poor walking ability. Further treadmill test optimization could reduce the amount of overalap in time spent walking on the treadmill recorded between gait score groups, allowing for more precise categorization of gait score based on time spent walking data. This could be achieved by manipulating treadmill setting, such as requiring ducks to walk faster or adding an incline. For example, while the maximum testing speed used in this study was 0.31 m/s, studies of the duck's respiratory physiology have shown that healthy Pekin ducks are able to sustain a brisk walk on a 3° incline at a speed of 0.4 m/s for at least 15 minutes in standard enviroments (Kiley and Fedde, 1983), and 7 minutes in hypoxic environments (Kiley et al., 1985). Future evaluation and refinement of the method should also accommodate various ages and strains.

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