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Limitations of force platform gait analysis

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Force platform gait analysis provides an objective outcome measure of limb function that is precise, accurate and has been shown to be a sensitive and specific diagnostic test. Yet, many clinicians are reluctant to accept results of papers that use the ground reaction forces (GRF) measured by force platform gait analysis. Some of this reluctance may be because force plate measures have limitations in what they can do, some is because the methodology from a paper that used it may have errors in methods and some may be from the clinicians being either naive of the science or they are reluctant to accept the finding because it is not what they want to see or want to believe.

Force platforms, in general are not mobile. Thus the patient must be brought to the area where gait analysis is performed. Force platforms are extremely durable and can be placed in an active hallway of a hospital making this relatively moot. In addition, pressure platforms and pressure walkways are mobile and it has been demonstrated that the vertical GRFs they generate are nearly identical to that of traditional force platforms. Force platform gait analysis takes the time of the patient, owner, veterinarian and technician. This can be a real problem when one tries to institute routine gait analysis into a busy outpatient schedule. A fee for the objective data it creates can be assessed and many owners, when explained the usefulness of the test, are happy to pay for this. I would also suggest that like most equipment and computational software the more one uses it the easier and quicker it is to use. However, it undoubtedly takes longer than visual objective measures of gait. Force platforms are another financial investment that is difficult to make profitable unless you routinely use it to perform funded research. Force platforms can be difficult to use on small or giant breed dogs. A typical acceptable foot strike includes a single front leg followed by the ipsilateral rear leg. Only one foot can be on the platform at a time because the forces are additive. Small dogs tend to put too many feet on the platform at once (this can be addressed by “splitting the plate” to some degree) and giant dogs tend to step over the plate (this can be addressed by slowing patient velocity or using multiple plates). Force platforms are ideal for lameness in a single leg but data can be difficult to interpret when lameness or disease is in multiple legs. This is particularly true if the status of the disease is changing in multiple legs. Given that most of the breeds that are affected with orthopedic problems generally have multiple diseases in multiple joints this causes a problem. In studies that evaluate bilateral conditions it is preferable to gather data from all limbs and focus the treatment effect on a single limb. This is a reasonable approach as long as comparisons between treatments are made or a control group is included.

Like all diagnostic tests, gait analysis must be performed correctly to have output that is useful. Over the past 20-years many papers have described the key components to correctly performing gait analysis. That said, I still read papers and review papers that have errors. First, it is critical that velocity and acceleration are monitored. Both influence GRFs and they have a paradoxical effect on peak vertical force (PVF) and vertical impulse (VI). For example, as velocity increases PVF will increase and VI will decrease. This leads into the second point, both PVF and VI should be documented and used as output measures. While they can both increase in limb function improves they are influenced paradoxically by other things in gait (such as velocity). Looking at a single output provides little information. Second, dogs of similar stature need to be compared or, at a minimum, balanced between study groups. This is because most investigators measure torso velocity, not limb velocity. It is easy to imagine a beagle and a great dane both walking with the same torso velocity. However, since the great dane has a long stride it has a slower limb velocity than the beagle even though they are covering the same distance over time. Limb velocity affects stance time and stance time proportionally affect VI. Another way to control for this is to either measure limb length in the study population or to control for stance time instead of torso velocity in the study groups. Similar to making a diagnosis for a disease GRF can be complemented with other parameters to strengthen the case that an intervention either led to an improvement or did not. Owner surveys have become popular but many overlook the use of 2D or 3D kinematics, accelerometers, and pedometers as objective methods of documenting gait.

The greatest limitation to data that is collected at a veterinary hospital is that it measures a moment in time, not the day to day level of activity of the dog at home. Use of a pedometer or accelerometer can be used to measure patient activity level at home over an extended period of time. In one study pedometers were successfully used to measure physical activity in dogs over a 14 day period. Pedometer accuracy varied depending upon the patient’s size (overestimated walking in large dogs and underestimated walking in small dogs), but correlated well to overall reports of the dogs activity level at home and the dog’s condition body.
score. Accelerometers are a bit more sophisticated in that some can measure changes in acceleration in the x-, y- and z-axis. Thus, body movement in any direction is measured. In one study that determined variability in accelerometer data in companion dogs it was reported that large day-to-day and even week-to-week variations occurred in dogs but within dogs, a full 7-day comparison of total activity counts from one week to the next provided the least variable estimate of the dogs’ activity. They also reported that accelerometers may be most useful for documenting changes in the dog’s activity over time. Given the limitations both pedometers and accelerometers have in their estimates of a patient’s activity level these methods are probably suited for use in studies that wish to compare large groups of dogs that have similar body size and shape. To the authors knowledge these methods have not been applied to dogs after RCCL surgery and their use would be beneficial for outcome comparisons.

The stereometric method of documenting kinematics employs visible markers that are attached to the skin on rigid segments of the body (e.g. joints centers of rotation or bony prominences) and tracks their motion using imaging equipment. Using triangulation of the views from an array of cameras and the known location of each camera, computer software computes the coordinates for each marker. Two-dimensional methods have a diminished time and financial investment for the laboratory or clinic that will only perform this method occasionally but joint motions can only be determined in one plane. Three-dimensional methods generally employ the use of 3-8 cameras. Motion data allows for calculation of time/distance parameters (velocity, cadence, stance and swing times, etc.) and the angular position of the joints (hips, knees, and ankles) during the different phases of gait. These methods have been well described and demonstrated in both normal dogs at a trot, in dogs with orthopedic disease and in dogs swimming.

REFERENCES