

Calculation of a Physical Activity Index for Dogs Using Smart Collars

Abstract

Physical activity is an important component of a healthy lifestyle and has multiple health benefits. We analysed biometric data of 280 dogs with accumulated 7,683 days to develop a Canine Physical Activity Index that applies accepted methods of assessing physical activity in people. The Index considers the Intensity and Volume of the activity, expressed in terms of pulse rate, to provide an accurate and quantifiable assessment of the level of physical activity, above and beyond simple activity trackers. Monitoring physical activity in dogs, quantifying it, and providing a numeric scale for comparison and improvement, can be a valuable tool in advancing dogs' health and maintaining wellbeing.

Background

The health benefits of physical activity are well documented. A physically active lifestyle is an important component of health and wellbeing, and led the American Heart Association to recommend regular physical activity for adults and monitoring and assessing their activity through the use of wearable devices. Public health recommendations for physical activity include specific guidelines for intensity and length of activity.¹

In a similar fashion, attention to pets' health and fitness level is increasing in recent years and various pet-related sports are gaining popularity.² However, current guidelines for canine physical activity and definitions of physical fitness are vague and are frequently tied to a specific type of activity (e.g., running, agility).³

The goal of this work was to define a measure of physical activity in dogs. This measure will provide a quantifiable assessment of dogs' physical activity as a health indicator as well as a basis for personalized recommendations for improvement.

Assessing physical activity goes beyond a simple documentation of just activity that common activity trackers do. Simple activity trackers use accelerometers to detect movements in various directions. However, when evaluating physical activity, we consider the relative effort and load of the activity on the individual performing it, and therefore is superior in assessing its correlation with the individual's fitness and health status. Accepted practices in assessing physical activity in people include the measurement of heart rate during the activity:

"The principle underlying the use of heart rate as a measure of physical activity derives from the physiological connection that makes alterations in heart rate indicative of cardiorespiratory stress during movement of any sort, and thus during physical activity and exercise."⁴

Since heart rate increases proportionally with the intensity of aerobic activity, we hypothesize that using pulse rate measurements from PetPace smart collars would yield a valuable indicator for physical activity in dogs.

Suggested Solution

Physical Activity of dogs was defined in 3 categories:

- Physical Activity Intensity, expressed in pulse rate (beats/min), as an indicator of the metabolic demand of the activity
- Physical Activity Volume, or Duration, expressed in minutes/day
- Physical Activity Index, expressed as Intensity times the Volume

Methodology

The analysis was performed in two stages:

First Stage

We used the PetPace database to analyze labeled data of dogs that are recognized as highly active and trained and compared it to dogs that are known to be minimally active secondary to chronic joint disease.

We used activity, pulse, and HRV data of 43 dogs with a total of 1,150 days that are known to be "highly active", and 30 dogs with 700 days labeled as "minimally active". We used sequential forward selection with "WRAPER" method for the analysis, and Python SFS method to choose the number of features providing the highest accuracy for differentiating active vs. non-active dogs. We applied xgboost classifier to test our model with two different subgroups of dogs for training and then testing the model. We tried different models to find the best fit/correlation between the true data and our predicted model (ADA Boost classifier, Random Forest, xgboost classifier, and Gradient Boosting classifier). At the end of this process, we achieved an 86% to 96% accuracy differentiating the active vs. the non-active dogs on the test group.

Second Stage

We used the PetPace biometric database to analyze data of 280 dogs with 7,683 days with various un-labeled activities, that were incorporated into the model developed in the first stage, to generate 4 activity labels: non-active, low activity, medium activity, and high activity. The full description is detailed below.

The dogs selected for the analysis included various breeds, sex, age, weight, health status and activity levels.

For each dog we calculated the Resting Pulse rate, based on pulse readings taken during times of low (resting) activity values. Next, we calculated for each dog its Pulse Reserve Index, which is the difference between the estimated maximum pulse rate for typical pet dogs (which was set categorically at 200 beats/min) and the measured individual Resting Pulse rate value.

$$\text{Pulse Reserve b/min} = 200 \text{ b/min} - \text{Resting Pulse b/min}$$

Activity Intensity

Daily Activity Intensity was calculated as a percentage of the Pulse Reserve.

The maximum pulse rates achieved during periods of activity were compared to the Pulse Reserve and expressed

as a percentage of the total reserve. The table below details the typical correlation between pulse reserve at different activities and the associated effort expected for such activity.^{4,5}

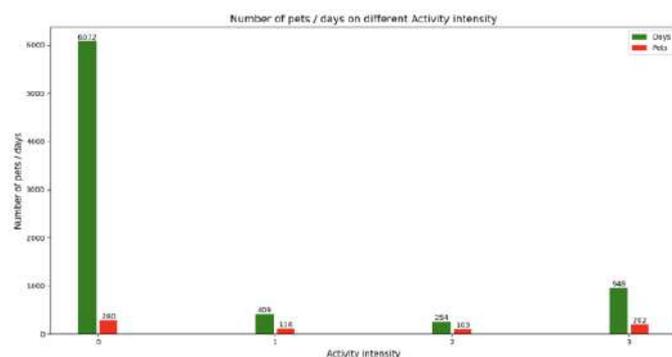
Effort	Pulse Reserve, %	Feels like	Duration (min)	Effect
Very light	50-60	Easy	20-40	Improves overall health, helps recovery
Light	61-70	Manageable	40-80	Improves basic endurance and fat burning
Moderate	71-80	Moderate	10-40	Improves aerobic fitness
Hard	81-90	Difficult, challenging	2-10	Increases maximal performance capacity for short sessions
Maximum	91-100	All-out effort	<5	Help fit athletes develop speed

For practical reasons we divided the Pulse Reserve range into 3 categories:

- 50%–60% of the pulse reserve – low Intensity
- 61%–80% of the pulse reserve – moderate Intensity
- >81% of the pulse reserve – high Intensity

Example calculation:

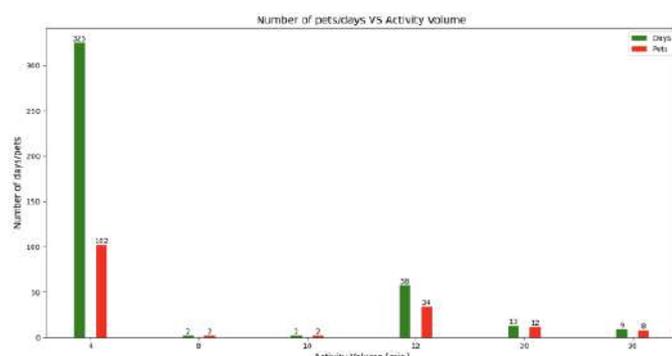
low Intensity (score 1): pulse during exercise = (50%–60% x Pulse Reserve) + Resting Pulse



Histogram chart showing the number of dogs that reached each intensity level. Of the 280 dogs evaluated, all dogs had at least one day on record with very low Intensity activity, and 202 dogs (72%) had at least 1 day on record with high Intensity.

Activity Volume

Daily Activity Volume was calculated as the duration of time (in minutes) in which the dog was on a certain Activity Intensity level, as calculated in the previous step. For example, highest Volume is achieved when the dog maintains a certain Intensity (calculated in the previous stage) for a 30 minutes



activity session. We created a scale with incrementally increasing scores for various volumes starting with 4 minutes and up to 30 minutes of continuous physical activity.

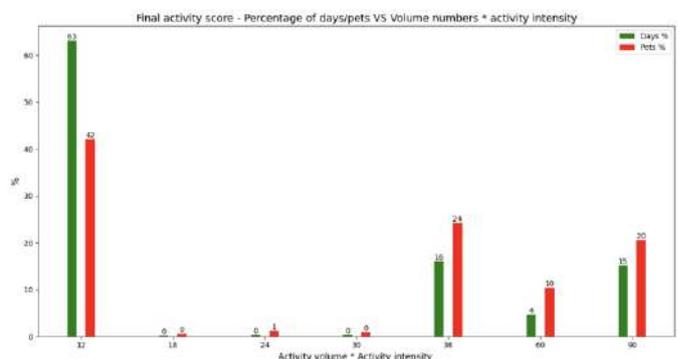
The chart above shows the Volume histogram of dogs who had low Intensity activity. 63% of the dogs (n=102) had at least one day of very low Intensity and low Volume (4 minutes). On the other hand, 5% of the dogs (n=8) had at least one day of very low Intensity but high Volume (30 minutes).

Physical Activity Index

To calculate the Physical Activity Index, which is the metric that represents the level of physical activity achieved, we multiplied the scores of Intensity and Volume that were calculated in the previous steps.

This measure provides a quantitative indication of the total physical activity performed by a specific dog on a given day, and serves as a basis for health assessment and planning for improvement.

The following chart, for example, shows the Physical Activity Index calculated for all the dogs in the high Intensity group. It shows that 42% of the dogs in this group (n=84) had at least one day in which they reached an Index score of 12 (Intensity score 3 x Volume score 4). 20% (n=40) of the dogs had at least one day in which they reached the highest possible score of 90 (Intensity score 3 x Volume 30).



Conclusions

We were able to define and measure Physical Activity in dogs based on pulse and activity data as detected by a PetPace smart collar. We developed a general scoring system, i.e., an Index, that can be calculated daily for each individual dog. The process of calculation of the Index follows accepted methods of assessing physical activity in people.

This Physical Activity Index described here provides a tool for continuous monitoring of dogs' physical activity, which is a component of their health and wellbeing status, as well as a quantifiable basis for guided plans for improvements through adjustments of Intensity, or Volume, or both. The Index can also be used for comparison of Physical Activity in different dogs. Pet parents, veterinarians (e.g., for prognosis or rehabilitation purposes), researchers, and other caretakers will be able to use this measure to assess and improve the health and wellbeing of their dogs.

The Physical Activity Index goes beyond a simple documentation of activity because it also considers the effort and the stress applied to the cardiovascular system during exercise. By measuring the resting pulse rate and the pulse rate reached during activity every day for every individual dog, we can assess the true impact of measured activity on that dog's fitness level.

Full Disclosure

The authors declare that this work was sponsored by PetPace LTD.

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