Use of pedometers to measure physical activity in dogs

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Objective—To determine whether pedometers can be used to measure physical activity in dogs.

Design—Cross-sectional study.

Animals—26 dogs.

Procedure—To determine pedometer accuracy, number of steps recorded with the pedometer as dogs walked, trotted, and ran for a distance of approximately 30 m (100 ft) at each gait was compared with actual number of steps. Dogs and owners then wore pedometers for 7 to 14 days, and dog pedometer output was compared with body condition score, owner-reported activity of the dog, and owner pedometer output.

Results—Most owners classified their dogs as active or quite active and indicated that their dogs exercised 3 to 7 days/wk. For all dogs, body condition score was 5, 6, or 7 on a scale from 1 to 9. At a walk, pedometers overestimated actual number of steps by approximately 17% in large and medium dogs and underestimated actual number of steps by approximately 7% in small dogs. No significant differences between pedometer-recorded and actual number of steps were detected when dogs trotted or ran. Number of steps per day for the dogs was significantly correlated with owner-reported activity of the dog (r = 0.305) and number of steps per day for the owners (r = 0.469) and was inversely correlated with body condition score (r = –0.554).

Conclusions and Clinical Relevance—Results suggest that pedometers can measure physical activity in dogs with reasonable accuracy. A lower number of steps per day was associated with a higher body condition score, and less active owners generally had less active dogs. (*J Am Vet Med Assoc* 2005;226:2010–2015)

Obesity is the most commonly diagnosed nutritional abnormality in dogs and may affect up to 44% of the pet dog population.[1-5] It is probable that insufficient physical activity is a risk factor for development of obesity in dogs, as it is in humans.[6] It is also presumed that human inactivity will limit access to physical activity opportunities for pet dogs, although this hypothesis has not been tested.

To our knowledge, there are no reports of objectively measured total daily physical activity in pet dogs. Radiotelemetry has been used to measure physical activity in cats,[7] and although the same approach could be used in dogs, this is an impractical solution for large-scale studies. A few studies have reported owner assessments of pet dog physical activity. In a cross-sectional study[8] of randomly selected dog-owning households in Australia, owners reported that 77% of dogs were taken out for exercise at least once in the week prior to the study, with a median exercise time of 150 min/wk, and duration of exercise was a negative predictor of obesity. In another study[9] in Australia, more than half of randomly selected dog owners reported not walking their dogs in the previous week, and mean dog-walking time was only 57 min/wk. Thus, there appear to be considerable differences between reports, even within similar study populations. In a separate study[10] designed to validate a survey to measure diet and physical activity in pet dogs, 54% of respondents reported walking their dogs 3 to 7 times/wk, with 91% of all walks being > 10 minutes in duration. In this instance, the study population was taken from clients of a university-based veterinary teaching hospital in the United States. Other types of activity were also surveyed (eg, off-leash activity and play with other dogs), but the survey was insufficient for assessing total daily physical activity.

A reasonable assumption is that active pet owners will have more active pet dogs. However, there are few hard data to support this assumption. A small prospective study[11] of new pet owners found that dog owners walked more than cat owners or those not owning pets. In contrast, another study[9] found that non–dog owners were just as likely as dog owners to walk at least 150 min/wk. Moreover, non–dog owners were more likely than dog owners who never walked their dogs to achieve 150 min of walking/wk. Therefore, there is no clear information about any correlation between dog and owner activity levels.

Recent advances in motion sensing through the use of accelerometers and pedometers have opened up new research opportunities for measuring ambulatory physical activity in humans.[12,13] Specifically, pedometers are inexpensive, simple devices that measure ambulatory (walking) activity with acceptable accuracy.[14] Unlike accelerometers, pedometers are not designed to capture the pattern, intensity, or type of physical activity. They also do not adequately capture intensity of specific activities, such as swimming, bicycling, and weight training. Regardless, assembled evidence from 25 studies substantiates the claim that simple and inexpensive pedometers agree acceptably with more expensive accelerometers (median r, 0.86), direct but time-consuming observation (median r, 0.82), estimates and measures of energy expenditure (median r, 0.68), and self-reported physical activity (median r, 0.33).[14]

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The hypothesis that pedometers may also be useful in measuring physical activity in dogs has not been tested. Indeed, pedometers specifically designed for dogs have only recently become available. Before large-scale surveys of pet dog activity can be undertaken or physical activity interventions for dogs can be advocated, basic information about the usefulness of pedometers needs to be acquired. Thus, the purpose of the study reported here was to determine whether pedometers can be used to measure physical activity in pet dogs. For pedometers to be considered useful, they must be reasonably accurate and durable and not be an annoyance to the dog.

Materials and Methods

Dogs—Twenty-six healthy dogs and their owners were recruited from among the staff and students at the Atlantic Veterinary College. The protocol was approved by the University of Prince Edward Island Animal Care Committee, and owners gave informed consent for participation in the study. Prior to initiation of the study, owners were asked to complete a validated survey[10] to gather information on their dog's age, sex, weight, and physical activity. A body condition score ranging from 1 to 9 was assigned by a single, trained veterinary student (MS).[15]

Assessment of pedometer accuracy—Dogs were classified as small (< 9 kg [20 lb]), medium (9 to 23 kg [20 to 50 lb]), or large (> 23 kg [50 lb]). Each dog was assigned a pedometer,[a] and its operation was explained to the owner. Pedometers were worn around the dog's neck by means of an adjustable lightweight chain; therefore, pedometers detected and counted forelimb steps only. To allow dogs to become acclimated to the pedometer, owners were instructed to have the dog wear the pedometer for 3 days, except that owners were instructed to remove the pedometer if the dog went swimming or was bathed.

Following the acclimation period, a research assistant videotaped each dog while it walked, trotted, and ran for a distance of approximately 30 m (100 ft) at each gait. Dogs were leashed and controlled by their owners before, during, and after each trial to minimize accumulation of steps in the immediate pre- and post trial periods. The pedometers were reset immediately prior to the beginning of each trial. The number of steps indicated on the pedometer was recorded for each gait. Each gait was repeated twice, and mean values were calculated. The number of steps taken by the forelimbs in each trial was visually counted from the videotape, and the mean value was compared with the mean value recorded by the pedometer.

Correlation of dog activity with body condition score and owner activity—Following the assessment of pedometer accuracy, owners were instructed to have their dogs wear a pedometer for 7 to 14 days. During this period, owners were asked to wear a pedometer[b] on the waistband of their clothing during waking hours. They were also given a diary in which they were asked to record, on a daily basis, the number of steps indicated on the dog's pedometer; the number of steps indicated on their pedometer; and a brief description of their activities during the day, including time spent in active pursuits with and without their dog. At the end of the test period, the pedometers and diaries were collected. Owners were asked to report any difficulties encountered by the dogs wearing the pedometers.

Statistical analyses—Baseline survey data were collated, and data were expressed as the proportion of respondents in each category. For determination of pedometer accuracy, paired *t* tests were used to compare actual number of steps at each gait with number of steps recorded by the pedometer. The difference between actual number of steps and number of steps recorded by the pedometer was determined for each dog at each of the 3 gaits and expressed as the absolute value of the percentage difference. Mean percentage difference was then calculated for all dogs at each of the 3 gaits and for dogs grouped on the basis of size. The frequency of observing a > 5% over- or underestimation of steps was determined for dogs grouped on the basis of size. The Spearman correlation method was used to determine whether pedometer-recorded number of steps at each gait was correlated with actual number of steps.

Number of steps per day recorded on the dogs' pedometers was compared with dog size by means of 1-way ANOVA. The Spearman rank correlation method was used to determine whether number of steps per day was correlated with body condition score or with mean owner-reported time spent each day in purposeful activity. The Pearson correlation method was used to determine whether number of dog steps per day was correlated with number of owner steps per day; for this analysis, data for the 7 to 14 recording days were used to obtain a single mean value for each variable. For all analyses, values of $P < 0.05$ were considered significant.

Results

Dogs—All dogs were > 1 year old at the time of enrollment in the study (mean ± SD age, 4.6 ± 3.2 years), and most were spayed or castrated (**Table 1**). Sixteen were classified as large dogs. There were 7 medium and 4 small dogs. Breeds included 14 mixed-breed dogs, 2 Border Collies, 2 Shih-Tzus, 1 Labrador Retriever, 1 Silky

Table 1—Demographic data for 26 dogs enrolled in a study to determine whether pedometers can be used to measure physical activity in dogs.

Variable	Category	No. of dogs	Percentage
Sex			
	Sexually intact male	2	8
	Castrated male	15	58
	Spayed female	9	35
Age			
	1–6 y	20	77
	≥ 7 y	6	23
Weight			
	< 9 kg (20 lb)	4	15
	9–23 kg (20–50 lb)	6	23
	> 23 kg (50 lb)	16	62
Body condition score			
	5	13	50
	6	10	38
	7	3	12
Reason owned			
	Pet	23	88
	Other*	3	12
Other pets in household			
	Yes	20	77
	No	6	23
Activity level			
	Calm or sedate	5	19
	Moderately active	13	50
	Quite active	8	31
Confined during the day			
	No	21	81
	Confined to kennel or run	4	15
	Confined to fenced yard	1	4
No. of hours outside per day			
	< 3	18	73
	3–10	7	27

*Includes show dogs, working dogs, guard dogs, and dogs kept for breeding.

Terrier, 1 Weimaraner, 1 Rottweiler, 1 Golden Retriever, 1 Akbash, 1 Chihuahua, and 1 Pug. Thirteen dogs had a body condition score of 5, with the remainder having higher scores, indicating that they were overweight. However, none of the dogs were classified as obese (body condition score of 8 or 9).

Twenty-one owners classified their dogs as moderately or very active. Twenty-one of 26 (80.7%) dogs had the run of the house during the day; those that spent time outdoors during the day were either in a fenced yard or a kennel. Fifteen dogs were walked on a leash for the purpose of exercise for > 10 minutes at least once a week (**Table 2**). Twenty-two dogs were allowed off-leash exercise. In addition, 18 dogs played with other dogs at least once a week, and 8 played retrieving games with their owners.

Assessment of pedometer accuracy—When all 26 dogs were considered as a group, actual number of steps over a distance of approximately 30 m was not significantly different from number of steps recorded by the pedometer, regardless of gait (**Table 3**). Mean percentage difference between actual and pedometer-recorded number of steps was approximately 15% for the 3 gaits, and actual number of steps was significantly ($P < 0.001$) correlated with number of steps recorded by the pedometer at the walk ($r = 0.853$), trot ($r = 0.840$), and run ($r = 0.761$). When dogs were grouped on the basis of size, there were significant differences between actual number of steps at a walk and number of steps recorded by the pedometer. For 17 of the 22 medium or large dogs, number of steps recorded by the pedometer was higher than the actual number of steps. In contrast, for 2 of the 4 small dogs, number of steps recorded by the pedometer was lower than the actual number of steps. No significant differences were detected at the 2 other gaits.

Table 2—Owner-reported level of activity for 26 dogs enrolled in a study to determine whether pedometers can be used to measure physical activity in dogs.

Variable	Category	No. of dogs	Percentage
Leash walks			
	No	11	42
	Yes	15	58
Frequency of leash walks			
	1–2 times/wk	2	13
	3–7 times/wk	7	47
	> 7 times/wk	6	40
Duration of leash walks			
	< 10 min	0	0
	> 10 min	15	100
Reason for leash walks			
	Urination and defecation	6	40
	Exercise	15	100
	Shows	1	7
Pace of leash walks			
	Walk	13	87
	Run or jog	2	13
Off-leash walks			
	No	4	15
	Yes	22	85
Frequency of off-leash walks			
	1–2 times/wk	1	5
	3–7 times/wk	9	41
	> 7 times/wk	12	54
Duration of off-leash walks			
	< 10 min	2	9
	> 10 min	20	91
Intensity of off-leash walks			
	Walking	2	9
	Some running	10	45
	Mostly running	10	45
Frequency of play with other dogs			
	Never	4	15
	< 1 time/wk	4	15
	1–3 times/wk	9	35
	> 3 times/wk	9	35
Plays retrieving games			
	No	18	69
	Yes	8	31

Correlation of dog activity with body condition score and owner activity—For all 26 dogs, mean ± SD number of steps per day was 20,561 ± 7,734 steps/d. In comparison, mean number of steps per day for the 26 owners was 12,237 ± 3,565 steps/d. Mean numbers of steps per day for small (18,585 ± 3,530 steps/d), medium (19,205 ± 2,916 steps/d), and large (21,722 ± 2,182 steps/d) dogs were not significantly different from each other.

For 22 of the 26 dogs, a minimum of 5 days' worth of paired data for number of steps recorded by the pedometer and owner-reported time spent each day in purposeful activity was available (**Figure 1**). A Spearman correlation coefficient was calculated for each of the 22 dogs, and the overall mean correlation coefficient (mean ± SD, 0.305 ± 0.103) was significantly ($P = 0.008$) different from 0, indicating that pedometer-recorded activity was positively correlated with subjective owner assessment of activity level.

For all 26 dogs, the mean number of steps per day recorded by the pedometer was calculated, and mean values were calculated for dogs grouped on the basis of body condition score. Mean ± SD numbers of steps per day for dogs with body condition scores of 5, 6, and 7 were 22,421 ± 1,949 steps/d, 18,333 ± 2,145 steps/d, and 11,816 ± 554 steps/d, respectively. Calculation of the Spearman correlation coefficient indicated that there was a significant ($P < 0.003$) inverse correlation ($r = –0.554$) between body condition score and mean number of steps per day.

Mean number of steps per day during the 7- to 14-day study period were calculated for owners and their dogs. Owner activity was significantly ($P = 0.016$) correlated with dog activity ($r = 0.469$; **Figure 2**), with correlation coefficients for individual owner-dog pairs ranging from –0.66 to 0.95. To understand differences between owners and their dogs, information regarding physical activity recorded by the owners in their diaries was examined for representative owner-dog pairs. Thus, while it was impossible to review every possible scenario, it appeared that differences in dog versus owner activity were common and related to the amount of freedom the dog had during the day while its owner was at work, the frequency with which the owner participated in physical activities without the dog, and the number of people involved in the care of the dog.

Table 3—Comparison of number of steps recorded by a pedometer and actual number of steps, as determined by review of a videotape, for 26 dogs that walked, trotted, and ran for a distance of approximately 30 m (100 ft) at each gait.

Gait	Dog size	Pedometer-recorded No. of steps	Actual No. of steps	Percentage difference
Walk				
	All	87.3 ± 17.2	78.4 ± 18.1	16.3 ± 11.1
	Large	81.1 ± 8.9	70.5 ± 5.1*	19.6 ± 12.2
	Medium	90.9 ± 20.3	78.5 ± 16.1†	16.3 ± 6.9
	Small	108.3 ± 19.7	119.8 ± 10.4†	7.1 ± 7.1
Trot				
	All	63.7 ± 14.5	59.1 ± 14.9	14.4 ± 9.9
	Large	60.0 ± 12.5	54.8 ± 9.3	11.6 ± 5.6
	Medium	62.8 ± 10.1	55.5 ± 9.3	19.3 ± 14.3
	Small	88.0 ± 14.5	95.0 ± 3.9	16.1 ± 9.0
Run				
	All	41.9 ± 13.9	43.3 ± 10.8	15.5 ± 9.6
	Large	37.0 ± 11.5	40.3 ± 7.5	14.0 ± 8.9
	Medium	46.2 ± 13.7	42.2 ± 7.2	18.4 ± 11.0
	Small	62.7 ± 3.3	70.7 ± 5.2	16.0 ± 8.1

Data are given as mean ± SD. Dogs were grouped on the basis of body weight as small (< 9 kg [20 lb]; n = 4), medium (9 to 23 kg [20 to 50 lb]; 6), or large (> 23 kg; 16).
*Significantly ($P < 0.05$) different from number of steps recorded by the pedometer. †Significantly ($P < 0.01$) different from number of steps recorded by the pedometer.

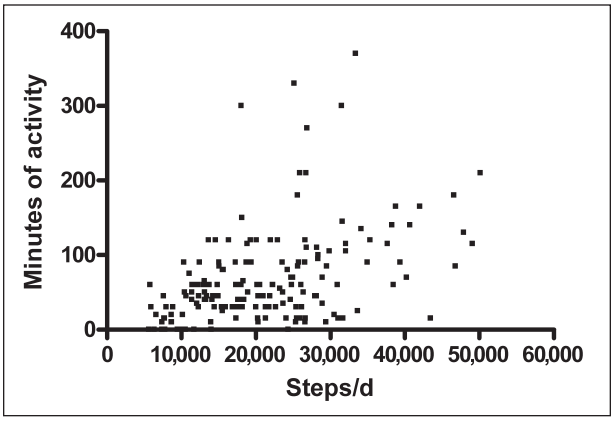

Figure 1—Scatterplot of number of steps per day recorded with a pedometer and owner-reported time spent in purposeful activity each day for 22 dogs.

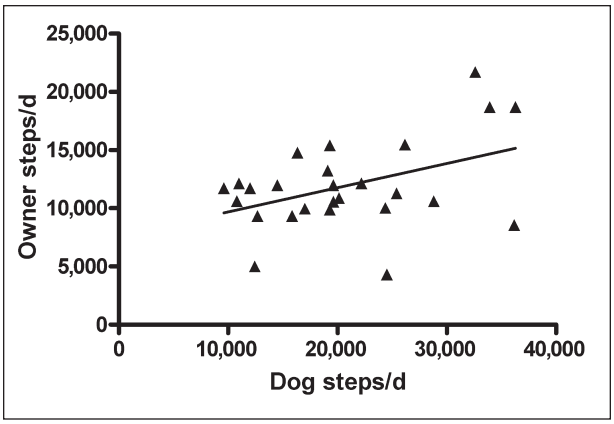

Figure 2—Scatterplot of number of steps per day (mean values for a 7- to 14-day period) recorded with pedometers for 26 dogs and their owners. The solid line represents the Spearman correlation ($r = 0.469$).

Difficulties with dog pedometers—Dogs appeared to tolerate the pedometers, and no difficulties were reported by the owners. Two recurrent problems that occurred during the course of the study were malfunction of the pedometer because it got wet and loss of data because the pedometer needed new batteries. Pedometers used in the study got wet not because dogs were allowed to swim, which owners were cautioned against, but because dogs walked through tall dew-covered grass. This was sufficient in some cases to render the pedometer unusable as a result of rusting of the working parts. It was difficult to dry the pedometers because they were held together by 4 tiny screws.

Discussion

Results of the present study suggest that accuracy of the pedometers we used to measure dog activity level was similar to accuracy reported for pedometers used to measure human physical activity in research settings.[14] We also found that dog activity level, as reflected by the number of steps per day recorded by the pedometer, was positively correlated with the owner's subjective assessment of the activity level of the dog and the owner's own activity level and inversely correlated with the dog's body condition score. As a practical matter, the pedometers we used were subject to failure if they became wet. Also, because the batteries failed in some of the pedometers during the study, it would be advisable in future studies to replace all batteries at the outset.

Pedometers are increasingly being used as an adjunct to physical activity interventions for humans. In addition, they have proven to be a useful research tool for the study of human activity patterns. In particular, pedometer-measured physical activity correlates with body mass index (a measure of fatness in people),[16,17] waist circumference,[17] and percentage body fat measured by impedence.[16] Moreover, in longitudinal studies[18,19] in which participants were instructed to increase their physical activity and to use the pedometer for motivation and feedback, the number of steps per day typically increased by approximately 50%. The increase in physical activity was associated with improvements in a number of health indices in ostensibly healthy participants[18] and in participants with type 2 diabetes mellitus.[19] Therefore, it may be possible to design interven-

tions that will help veterinarians promote healthier living standards for pet dogs. Before this can happen, however, the usefulness of pedometers needs to be assessed.

To determine whether the pedometer was sufficiently accurate to detect differences in activity levels, we compared the number of steps recorded with the pedometer with the actual number of steps taken, as determined from videotapes, over a distance of approximately 30 m at 3 gaits (walking, trotting, and running). At the walk and the trot, the pedometer tended to overestimate the actual number of steps taken by large and medium dogs by approximately 17%. This might have been due to random swinging of the pedometer on the chain; however, when we attempted to eliminate the swinging by attaching the pedometer to the dogs' collars, the discrepancy became larger rather than smaller. In 8 of the 16 large dogs, the pedometer underestimated the actual number of steps by > 5% when the dogs were running. At a walk or trot, there are distinctive movements of each of the dogs' forelimbs (and the thoracic girdle) with each step, whereas at a run, both front feet are extended (although not equally) and hit the ground close together in time when the hind limbs are flexed at the hips. As a result, when dogs are running, there may not be sufficient left-right deflection of the thoracic girdle to cause the pendulum in the pedometer to register a step. Despite these discrepancies, there was still a high correlation between number of steps recorded by the pedometer and actual number of steps at each of the 3 gaits, and correlation coefficients were similar to that reported for a pedometer used by human subjects ($r = 0.82$).[14]

In small dogs, the pedometer consistently underestimated by 10% to 15% the number of steps taken at all gaits. This might be explained by the smaller deflections of the thoracic girdle in these dogs. In people with mobility impairments that cause shuffling gaits, pedometer accuracy is reduced.[20]

The level of inaccuracy observed in the present study (> 10%) likely means that the dog pedometer has limited usefulness for studies that require a high level of precision, although consistent inaccuracy in individual pedometers could be documented and corrected for. However, the device might still be useful for intervention studies if it can detect day-to-day differences in dogs' activity. To address this question, we compared number of steps per day recorded by the pedometer with the owner-reported time the dog spent in physical activity. In general, owner-reported time spent in purposeful activity correlated with number of steps per day recorded by the pedometer, although this analysis was limited by potential bias introduced by the owners' inability to continuously observe their dogs throughout the day. This suggests that the pedometer could be useful as a device for monitoring overall activity on a daily basis; knowledge of baseline activity could form the foundation for interventions that incorporate use of pedometers.

In people, physical activity measured with a pedometer is inversely correlated with body mass index,[16,17] waist circumference,[17] and percentage body fat.[16] Results of the present study indicated that number of steps per day recorded by the pedometer was negatively correlated with body condition score, the most practical method for determining degree of fatness in dogs.[15] However, it is important to point out that this association is not proof that low activity levels lead to obesity because it is probable that being overweight limits activity, thus creating a vicious cycle. Nonetheless, the observation lends support to the idea that increasing physical activity in dogs may assist in weight-loss programs, as is the case in humans. Unfortunately, there are few objective, prospective studies to support this contention. In an unpublished study of spontaneously overweight and obese dogs, we recently found that addition of 135 minutes of brisk walking each week to a diet regimen did not significantly increase the rate or amount of weight loss.

Increasing automation of activities formerly performed manually by people is assumed to contribute to the growing obesity epidemic in humans.[21] The increasingly sedentary human lifestyle is presumed to be reflected in the lifestyle of dogs (eg, fewer opportunities for walks or active play with owners and more restrictions on dog freedom dictated by increasingly urban environments and smaller homes and yards). The present study found that there was a positive correlation between owner activity and dog activity when mean number of steps per day was calculated over a 7- to 14-day period. However, considerable variability among owner-dog pairs was observed. Some factors that might account for the variability include dogs having multiple caregivers, such that the primary owner might not be the primary dog walker; owners having active jobs, while their dogs spend most of the day inside without stimulation to play or be active; dogs being outside most of the day with a large yard for play while the owners have a sedentary job; and owners participating in physical activity during leisure time without the dog. Many other factors could be considered. However, in general in the present study, it was apparent that more active owners had more active dogs. This might reflect the value that such owners place on physical activity as part of the overall family lifestyle.

Owning a pet dog might also be an impetus for owners to walk more. In a previous study,[11] for instance, it was shown that dog owners walked more than cat owners and individuals who did not own pets. Owners in the present study accumulated more steps per day (> 10,000 steps/d) than did participants in several other studies[17,22,23] involving healthy adults in North America. However, another study[9] found that non–dog owners were just as likely as dog owners to walk at least 150 min/wk. The use of pedometers to measure activity of owner-dog pairs may provide more information about the possible joint health benefits to people and their dogs of the adoption of more active lifestyles.

Results of the present study suggest that pedometers can measure physical activity in dogs with reasonable accuracy. A lower number of steps per day was associated with a higher body condition score, and less active owners generally had less active dogs. Future studies are required to determine whether physical activity measured with a pedometer correlates with a broader range of health indices in dogs. Such information could assist veterinarians in promoting healthier lifestyles for dogs. It may also be possible to develop pedometer-based physical activity interventions that could be prescribed for inactive, overweight dogs, possibly together with their owners.

a. Optimal Health Products, San Antonio, Tex.
b. Yamax-200, New Lifestyles, Deep River, ON, Canada.

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