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Incline and decline treadmill trotting produce electromyographic changes in specific canine shoulder muscle activity: implications for therapeutic exercise

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Objective
To identify the effects of incline and decline treadmill trotting on forelimb muscle activity in dogs using electromyography (EMG).

Methods
Data were collected for a prospective within-subject, repeated-measures study in January and February of 2025 where subjects were trotted on a level treadmill, 5% incline, 10% incline, 5% decline, and 10% decline. Surface EMG data were collected bilaterally from the scapular portion of the deltoideus, lateral head of the triceps brachii, and biceps brachii, and fine-wire EMG data were collected from the supraspinatus muscle. Repeated-measures ANOVA tests were conducted followed by post hoc pairwise comparisons when significant main effects were seen ($P < .05$).

Results
Data were collected from 12 adult large-breed dogs. Peak supraspinatus activity increased by 6.5% (95% CI, 0.1% to 11.8%) from 0% to 5% incline and by 5.7% (95% CI, 1.6% to 15.5%) from 5% to 10% incline. Average triceps muscle activity increased by 17.9% (95% CI, 0.6% to 3.7%) from 0% to 10% incline, by 12.5% (95% CI, 1.2% to 5.9%) from 5% to 10% incline, and by 9.3% (95% CI, 1.1% to 1.7%) from 5% to 10% decline. Peak triceps and average deltoideus activity followed similar trends. Biceps brachii activity showed no significant changes.

Conclusions
Muscle activities of the supraspinatus, triceps, and deltoideus all exhibited significant changes during incline and/or decline treadmill trotting. The biceps brachii was not significantly affected by any condition tested.

Clinical Relevance
The findings support the use of incrementally increasing or decreasing levels of treadmill trotting to progressively load specific forelimb musculature in canine rehabilitation.

Keywords: electromyography, therapeutic exercise, canine, biceps brachii, supraspinatus

Trotting is a commonly prescribed exercise in canine rehabilitation and conditioning programs due to its symmetrical limb loading and repeatable gait pattern. Manipulation of incline and decline during selected therapeutic exercise, including treadmill activity, is thought to alter joint mechanics and increase or decrease load on limbs with the goal of selectively targeting tissues during rehabilitation and conditioning.[1] Prior studies[2–7] have demonstrated that incline and decline walking and trotting influence kinematics, temporospatial parameters, and muscle activation patterns in dogs and horses, but electromyography (EMG) data have mainly focused on the muscle activity in the pelvic limb. The use of treadmill walking at incline and decline

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and other select therapeutic exercises conducted at incline and decline have also been indicated to target specific muscles or groups of muscles and are routinely incorporated as rehabilitation or conditioning programs advance.[1,8,9]

Information is needed regarding muscle activity during incline and decline activity in canine rehabilitation protocols used for the management of orthopedic disease or injuries. Conditions commonly undergoing rehabilitation include biceps tendinopathies, supraspinatus tendinopathies, and other injuries to the shoulder stabilizing muscles, which are increasingly seen in companion, sporting, and working dog populations.[10–13] Currently, there are limited data on changes in muscle activity in the thoracic limb in relation to incline and decline trotting. The majority of EMG studies evaluating thoracic limb muscle activity include EMG data collection during agility-related tasks,[14–16] EMG activity when compared to stance,[9] and EMG activity during level walking and trotting.[16]

The thoracic limb plays a primary role in body weight support and postural stability during trotting. The shoulder and elbow musculature contribute to shock absorption, braking, and propulsion. Individual muscles demonstrate task-specific activation patterns that reflect their biomechanical roles.[14–17] Understanding how incline and decline trotting alter thoracic limb muscle activity is clinically relevant for designing evidence-based rehabilitation protocols for conditions such as shoulder arthropathies, shoulder tendinopathies, elbow arthropathies, and postoperative recovery while attempting to avoid overloading compromised structures.[10,18,19]

Recent work by Cain et al[8] highlighted the importance of integrating incline and decline walking into rehabilitation programs with their findings that there were significant changes in peak and average muscle activity while walking on a treadmill at decline and incline. When developing therapeutic exercise and rehabilitation programs, once dogs are sufficiently conditioned and capable at the walk, trotting is often integrated to advance those programs. Building on this, the objective of this study was to identify changes in peak and average thoracic limb muscle activity during treadmill trotting at varying inclines and declines to better plan a rehabilitation program. This would potentially allow for changes in rehabilitation programs that can incrementally increase load on specific muscle groups and allow for the transition from rehabilitation into conditioning protocols to allow a canine patient to return to work or sport. The objective of this study was to quantify changes in peak and average thoracic limb muscle activity of the scapular portion of the deltoideus, lateral head of the triceps brachii, biceps brachii, and supraspinatus during treadmill trotting at graded inclines and declines compared to trotting on a level treadmill. Our hypothesis was that decline trotting would significantly increase peak and average muscle activity of the selected thoracic limb muscles and that incline trotting would decrease the muscle activity of those same muscles compared to level trotting.

Methods

Subject selection

The subjects included 1 German Shorthaired Pointer, 1 Wirehaired Pointer, 1 Doberman Pinscher, 1 German Shepherd, 1 Dutch Shepherd, 1 Golden Retriever, and 6 mixed-breed dogs. The weight of the subjects varied between 21.4 and 35.2 kg, with body condition scores[20] of 4 to 6/9, and the ages of subjects ranged from 1 to 10 years old. All subjects received neurologic and orthopedic examinations, which were performed by a board-certified sports medicine and rehabilitation veterinarian prior to enrollment. Dogs were excluded if they showed any signs of orthopedic or neurologic abnormalities, including, but not limited to, painful or reduced range of motion in any joint, observable postural or gait abnormality, muscle asymmetry, or abnormal proprioception. In addition to subjective evaluation, objective gait analysis was performed. Kinetic data were obtained using a force platform (AMTI) to ensure soundness before inclusion in the study. Four trials from each ipsilateral limb pair of the dog were obtained at a trot. Velocity and acceleration of the dog were maintained between 1.7 and 2.1 m/s velocity and ± 0.40 m/s^2 acceleration. Average peak vertical force values were used to identify weight-bearing left-to-right asymmetry for each dog; dogs were excluded from the study if there was > 5% asymmetry between the thoracic limbs or pelvic limbs. After subjects were determined to be sound and acceptable for entry into the study, treadmill acclimatization was performed to habituate subjects to treadmill activity prior to data collection events held at a later date. Subjects were habituated using established treadmill training methods, and all dogs were sufficiently habituated prior to data collection.[2,21,22]

This study protocol was approved by the University of Tennessee IACUC (protocol No. 3075) and was performed in accordance with American Association for Accreditation of Laboratory Animal Care and USDA guidelines.

Instrumentation and data collection

The target muscles were identified by direct palpation by the same 2 researchers to maintain consistency with sensor placement. Large areas surrounding the sensor locations were clipped with a number 40 blade and shaved with a safety razor, and then the skin was cleaned with chlorhexidine scrub and isopropyl alcohol to remove oil, dirt, and debris that may have interfered with data collection. Surface EMG electrodes (Trigno; Delsys), which are capable of capturing both intertial measurement unit (IMU) and EMG data simultaneously, were placed bilaterally over the scapular portion of the deltoideus, lateral head of the triceps brachii, and biceps brachii following established preparation and placement guidelines to minimize crosstalk and motion artifact.[4,22] Muscle activity was recorded using 6 surface EMG Avanti sensors on the left and right biceps brachii, deltoideus, and triceps brachii, and 2 fine-wire EMG Avanti sensors (Delsys) were placed into the supraspinatus muscles bilaterally. A combination of vertical acceleration and sagittal plane angular velocity data from the IMU from the right biceps brachii sensor was used for gait cycle and event detection. The same 2 examiners placed all EMG and IMU sensors in all dogs to ensure consistent positioning **(Figure 1)**. Double-sided adhesive tape (Trigno Systems adhesive interfaces; Delsys) and a topical adhesive (Gel Control; Loctite) were used to affix the sensors to the skin. For fine-wire EMG placement, an SC area over the supraspinatus site of needle insertion was desensitized with 0.25 mL of 2% lidocaine per side and allowed time to reach effect prior to sensor insertion. Special care was taken to remain superficial to prevent changes in muscle activity that were reported in previous studies.[23] Then, a presterilized 27-gauge, 30-mm-length needle with preloaded paired fine-wire electrodes (Rhythmlink) was aseptically and briefly inserted into the supraspinatus muscle. The needles were then removed while the electrode wires remained embedded in the target muscle belly. Two of the subjects required sedation due to behavioral concerns and were sedated with 3 µg/kg IV dexmedetomidine for placement of fine-wire EMG leads and were subsequently reversed with an equivalent volume dose of IM atipamezole. Though this use of sedation and reversal medication could have hypothetically had an effect on muscle activity, this technique is necessary and has been previously used for IM fine-wire EMG.

Dogs were then trotted on a Fit Fur Life treadmill (Professional Model; Fit Fur Life Ltd) at between 5.2 and 8.0 km/h (1.44 and 2.2 m/s), where velocity was determined and maintained for each individual dog as they comfortably transitioned and consistently maintained a trot under all of the 5 target conditions: level, 5% incline, 10% incline, 5% decline, and 10% decline. When switching between incline and decline states, dogs were unloaded from the treadmill to allow for the equipment to be adjusted to the next desired position. Treadmill positions were created using a combination of the treadmill's programable elevation features and external blocks, and the percentage of slope for each position was measured using a Risepro digital protractor and inclinometer to ensure incline and decline slope accuracy. During data collection, the order of the treadmill position was chosen randomly to reduce any bias from fatigue or variables associated with position changes during data collection. At each treadmill position, multiple 30-second recordings were collected to ensure usable data were obtained. Recordings were retained only when the gait pattern was visually acceptable to observers and EMG sensor signals demonstrated adequate quality, with at least 10 acceptable gait cycles observed.

Figure 1—Visual image depicting a study subject showing the locations of the surface and fine-wire electromyographic (EMG) sensors from a left-lateral view.

Data processing

The EMG signals were exported from Trigno Discover (Version 2.0, Delsys) into Visual3d (Version 2024.10.4, HAS Motion), where they were high-pass filtered with a cutoff frequency of 40 Hz to reduce movement artifacts. The signals were then full-wave rectified and low-pass filtered at 15 Hz to produce an enveloped EMG signal. Peak and average enveloped EMG values were then normalized to the maximum observed signal across all treadmill positions for each muscle separately.[24]

Statistical analysis

The average values from normalized peak and average enveloped EMG signal for each muscle from 10 gait cycles at all 5 treadmill positions were tested for normality and found suitable for parametric analysis using Shapiro-Wilk tests. Repeated-measures ANOVA tests were performed to evaluate the effect of treadmill position on normalized peak and average EMG for each muscle. When significant main effects were seen within a muscle, post hoc pairwise comparisons with Bonferroni correction were performed to determine differences between 0%, 5% incline, 10% incline, 5% decline, and 10% decline positions using least significant difference tests. All statistical analyses were performed using SPSS (version 29; IBM Corp), with significance set at $P < .05$.

Results

Data collection was attempted for 12 dogs, and EMG data from 9 of those 12 dogs were deemed acceptable. Three data sets were excluded due to signal dropout during data collection because EMG sensors became disconnected or other technical difficulties discovered during data processing after acquisition.

Electromyography data from the right side versus left side were analyzed and showed no significant difference ($P > .05$), allowing for left and right measurements to be pooled. To limit the effect of skin motion artifact on the EMG signal, 1 author (JR) extensively experienced in analyzing EMG data reviewed each trial for each dog to ensure the quality of data included in the analysis. Trials with excessive motion artifact, represented by values and patterns inconsistent with EMG data, were excluded from the final analysis. Of the possible 18 data sets obtained from each muscle pair from the 9 dogs, the final data set included 14 EMG observations from the triceps brachii, 7 EMG observations from the biceps brachii, 14 EMG observations from the scapular portion of the deltoideus, and 15 EMG observations from the supraspinatus. In this study, the peak muscle activity represented the highest value of muscle activity recorded, and the average muscle activity was an indication of total muscle activation during a single gait cycle.[25]

Supraspinatus muscle

Significant main effects were seen for peak supraspinatus muscle activity ($P < .001$; **Table 1**). Post hoc pairwise comparisons for peak supraspinatus activity showed significant increases between 0% and 5% incline ($P = .046$ [6.5%]) and 5% to 10% incline ($P = .019$ [5.7%]; **Figure 2**; **Tables 2 and 3**). Changes with decline were smaller and not statistically significant. Average supraspinatus activity did not differ significantly among treadmill positions.

Scapular portion of the deltoideus

Significant main effects were seen for average deltoideus muscle activity ($P = .005$; Table 1). Post hoc pairwise comparisons for average deltoideus activity showed significant increases between 0% and 5% decline ($P = .025$ [12.5%]), 0% and 10% decline ($P = .001$ [20.3%]), and 5% decline and 10% decline ($P = .03$ [6.9%]; Figure 2; Tables 2 and 3). The greatest increases were observed at 10% decline. Peak deltoideus activity did not differ significantly among treadmill positions.

Lateral head of the triceps brachii

Significant main effects were seen for both peak ($P = .036$) and average ($P = .001$) triceps brachii muscle activity between treadmill positions

Table 1—Mean and SD for average and peak electromyography with main effects (*P* value) and effects sizes (η^2) between positions.

Muscle activity	Level mean (SD)	5% Incl mean (SD)	10% Incl mean (SD)	5% Decl mean (SD)	10% Decl mean (SD)	*P* value (η^2)
Peak triceps	0.303 (0.110)	0.318 (0.091)	0.353 (0.100)	0.279 (0.084)	0.307 (0.077)	.036 (0.176)*
Average triceps	0.117 (0.046)	0.121 (0.038)	0.138 (0.042)	0.108 (0.041)	0.118 (0.039)	.001 (0.292)*
Peak biceps	0.235 (0.095)	0.218 (0.082)	0.212 (0.106)	0.259 (0.065)	0.276 (0.034)	.424 (0.168)
Average biceps	0.082 (0.024)	0.099 (0.039)	0.100 (0.046)	0.098 (0.019)	0.111 (0.024)	.070 (0.339)
Peak deltoid	0.248 (0.094)	0.283 (0.112)	0.280 (0.115)	0.287 (0.102)	0.292 (0.119)	.402 (0.073)
Average deltoid	0.128 (0.037)	0.130 (0.043)	0.129 (0.045)	0.144 (0.042)	0.154 (0.045)	.005 (0.247)*
Peak supraspinatus	0.478 (0.088)	0.509 (0.102)	0.538 (0.115)	0.424 (0.103)	0.429 (0.074)	< .001 (0.375)*
Average supraspinatus	0.173 (0.039)	0.177 (0.030)	0.187 (0.035)	0.165 (0.031)	0.182 (0.029)	.069 (0.152)

*Significant differences $P < .05$.
Decl = Decline. Incl = Incline.

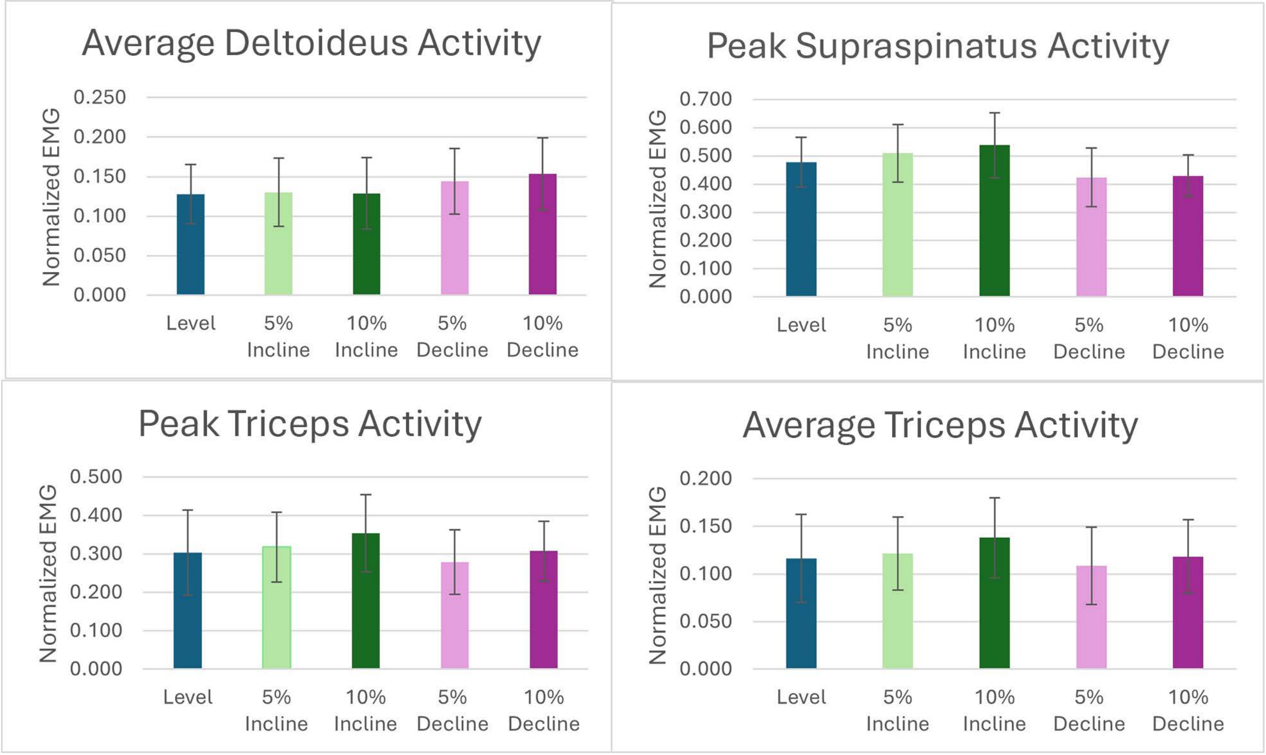

Figure 2—Pairwise comparisons for average deltoideus, peak supraspinatus, peak triceps brachii, and average triceps brachii EMG where significant main effects were seen between positions.

Table 2—Pairwise comparisons for average and peak electromyography where significant main effects were seen between positions.

	Mean difference	*P* value	Lower bound	Upper bound
Peak triceps activity				
Level vs 5° Incl	−0.015	.492	−0.059	0.03
Level vs 10° Incl	−0.050	.063	−0.103	0.003
Level vs 5° Decl	0.024	.269	−0.021	0.07
Level vs 10° Decl	−0.004	.845	−0.044	0.036
5° Incl vs 10° Incl	−0.035	.006*	−0.059	−0.012
5° Incl vs 5° Decl	0.039	.152	−0.016	0.094
5° Incl vs 10° Decl	0.011	.672	−0.043	0.065
10° Incl vs 5° Decl	0.074	.029*	0.009	0.14
10° Incl vs 10° Decl	0.046	.161	−0.021	0.113
5° Decl vs 10° Decl	−0.028	.040*	−0.055	−0.001
Average triceps activity				
Level vs 5° Incl	−0.005	.463	−0.018	0.009
Level vs 10° Incl	−0.021	.01*	−0.037	−0.006
Level vs 5° Decl	0.008	.309	−0.009	0.025
Level vs 10° Decl	−0.002	.836	−0.018	0.015
5° Incl vs 10° Incl	−0.017	< .001*	−0.024	−0.009
5° Incl vs 5° Decl	0.013	.036*	0.001	0.025
5° Incl vs 10° Decl	0.003	.634	−0.011	0.017
10° Incl vs 5° Decl	0.030	.003*	0.012	0.048
10° Incl vs 10° Decl	0.020	.037*	0.001	0.038
5° Decl vs 10° Decl	−0.010	.006*	−0.016	−0.003
Average deltoideus activity				
Level vs 5° Incl	−0.002	.816	−0.024	0.019
Level vs 10° Incl	−0.001	.921	−0.021	0.019
Level vs 5° Decl	−0.016	.025*	−0.03	−0.002
Level vs 10° Decl	−0.026	< .001*	−0.038	−0.014
5° Incl vs 10° Incl	0.001	.783	−0.009	0.012
5° Incl vs 5° Decl	−0.014	.099	−0.031	0.003
5° Incl vs 10° Decl	−0.023	.017*	−0.042	−0.005
10° Incl vs 5° Decl	−0.015	.139	−0.036	0.006
10° Incl vs 10° Decl	−0.025	.020*	−0.045	−0.005
5° Decl vs 10° Decl	−0.010	.030*	−0.018	−0.001
Peak supraspinatus activity				
Level vs 5° Incl	−0.060	.046*	−0.118	−0.001
Level vs 10° Incl	0.054	.079	−0.007	0.116
Level vs 5° Decl	0.049	.091	−0.009	0.108
Level vs 10° Decl	0.031	.156	−0.014	0.076
5° Incl vs 10° Incl	0.085	.019*	0.016	0.155
5° Incl vs 5° Decl	0.081	.008*	0.025	0.136
5° Incl vs 10° Decl	0.060	.046*	0.001	0.118
10° Incl vs 5° Decl	0.109	.001*	0.052	0.166
10° Incl vs 10° Decl	−0.054	.079	−0.116	0.007
5° Decl vs 10° Decl	−0.049	.091	−0.108	0.009

*Significant differences $P < .05$.

Table 3—Percentage differences between positions.

	% differences					
Muscle activity	**Level vs 5 Inc**	**Level vs 10 Inc**	**Level vs 5 Dec**	**Level vs 10 Dec**	**5 Inc vs 10 Inc**	**5 Dec vs 10 Dec**
Peak triceps	−5.0	−16.5[a]	7.9	−1.3	−11.0*	−10.0*
Average triceps	−3.4	−17.9*	7.7	−0.9	−14.0*	−9.3*[b]
Peak biceps	7.2	9.8	−10.2[a]	−17.4[a]	2.8	−6.6
Average biceps	−20.7[a]	−22.0[a]	−19.5[a]	−35.4[a]	−1.0	−13.3[a]
Peak deltoid	−13.7[a]	−12.9[a]	−15.7[a]	−17.7[a]	0.7	−1.7
Average deltoid	−1.6	−0.8	−12.5*	−20.3*	0.8	−6.9*[b]
Peak supraspinatus	−6.5*[b]	−12.6	11.3[a]	10.3[a]	−5.7*[b]	−1.2
Average supraspinatus	−2.3	−8.1	4.6	−5.2	−5.6	−10.3

Negative indicates second value greater than first.
*Significant differences.
[a] Noteworthy (> 10% change) but not significant. [b]Significant but questionable clinical importance (< 10% change).

(Table 1). Post hoc pairwise comparisons for peak lateral head of triceps brachii activity showed significant increases between 5% and 10% incline (*P* = .006 [11%]) and 5% and 10% decline (*P* = .040 [10%]; Figure 2; Tables 2 and 3).

Post hoc pairwise comparisons for average lateral head of triceps brachii activity showed significant increases between 0% and 10% incline (*P* = .010 [17.9%]), 5% and 10% incline (*P* = .001 [14%]), and 5% and 10% decline (*P* = .006 [9.3%]; Figure 2; Tables 2 and 3).

Biceps brachii

No significant differences were identified for peak or average biceps brachii activity across treadmill positions (Table 1).

Discussion

The objective of this study was to identify changes in peak and average thoracic limb muscle activity during treadmill trotting at varying inclines and declines to provide specific information to guide changes in rehabilitation or conditioning programs. We hypothesized that thoracic limb muscle activity would increase with greater declines and decrease with greater inclines. Our hypothesis was partially accepted as average and peak triceps brachii muscle activity increased with greater declines, and average deltoideus muscle activity increased with greater declines.

Our hypothesis was also partially rejected due to several findings: the biceps brachii muscle and average supraspinatus muscle activity had no significant changes across positions. Furthermore, contrary to our initial prediction of decreased activity with incline trotting, peak supraspinatus and triceps brachii activity actually increased, and the triceps brachii had increased peak and average muscle activity with increasing incline.

This study demonstrates that incremental changes in treadmill slope during trotting selectively alter thoracic limb muscle activity patterns in the evaluated musculature in dogs. Incline trotting preferentially increased peak supraspinatus and peak and average triceps brachii activity, supporting its use when the therapeutic goal is to increase concentric muscle force production to propel the dog up an inclined surface and potentially increase dynamic joint stabilization at the shoulder and elbow. Decline trotting increased average deltoideus activity and peak triceps activity, suggesting a potential role for controlled decline trotting in increased braking of the body and potentially improving eccentric muscle activity and shoulder stability. There were no significant changes seen in biceps brachii activity, indicating pathologies in this muscle or tendon may not be a contraindication for the use of incline or decline treadmill trotting in therapeutic exercise or conditioning programs.

The supraspinatus plays a critical role in humeral head stabilization and shoulder extension during gait, particularly with increased propulsion demands, such as dynamic exercise or incline or decline activities.[10,17] Our findings suggest increased demand on the supraspinatus muscle as a generator of propulsive forces and shoulder stabilizer during uphill trotting, consistent with prior EMG and kinematic studies.[8,16] Increased activation during incline trotting suggests that controlled uphill work may be beneficial in later-stage rehabilitation for supraspinatus tendinopathy, shoulder arthropathies, and postoperative shoulder rehabilitation efforts provided tissue healing and joint integrity allow for the increased load.[10,18,26]

Similarly, increased triceps brachii activity seen with increasing inclines aligns with its function as the primary elbow extensor and contributor to propulsion while moving up an inclined surface and controlled loading and braking when moving down a decline surface.[3,27] This has direct relevance for rehabilitative therapy following elbow surgery or injury, where progressive strengthening of elbow extensors is often indicated.[19] Larger increases, particularly those that exceed approximately 10% or more between levels, may be meaningful when designing targeted rehabilitation or conditioning programs, especially when those exercises are repeated during multiple sessions over a period of time.[28,29] However, the magnitude of change observed in this study reinforces the need for gradual progression in rehabilitation or conditioning programs, as emphasized by Cain et al,[8] to avoid excessive joint, muscle, and tendon loading in dogs with residual pathology.

Decline trotting increased average deltoideus activity and peak triceps activity, suggesting prolonged activation across the entire gait cycle rather than a brief peak loading. Increased average activity during decline likely reflects prolonged eccentric contraction or stabilizing activity during braking and controlled shoulder flexion during descent.[17,21] These findings are consistent with currently accepted biomechanical principles of increased braking and stabilization demands when walking downhill.[17] These findings are also similar with the previously published varying-level treadmill data at the walk by Cain et al[8] that demonstrated significant differences in muscle activity during incline and decline treadmill walking. From a rehabilitation standpoint, decline trotting may therefore be useful for muscle strengthening, retraining neuromuscular control, endurance, and shoulder stability, particularly in dogs recovering from thoracic limb injury, where controlled loading is desired without high peak forces. However, decline work should be applied cautiously in dogs with dynamic shoulder instability or elbow arthropathies as eccentric demands may exacerbate discomfort if introduced prematurely or demand is increased too quickly.[10,18,26] Muscle weakness resulting from joint injury or disease or postoperatively can reduce muscular control and proprioceptive ability. This diminished capacity may lead to premature fatigue, which can further impair fine motor control and accelerate degenerative changes. These risks highlight the importance of making incremental changes in intensity, which can be done by manipulating treadmill level, when initiating or advancing rehabilitation or conditioning programs.[30]

There were no significant changes in peak or average biceps brachii activity, suggesting a relatively consistent functional role during trotting regardless of slope, potentially reflecting its combined role as an elbow flexor and shoulder stabilizer with limited difference in muscle activity during changes in slope.[8,16] The absence of significant changes in biceps brachii activity suggests that treadmill incline and decline may be less effective for selectively targeting this muscle for either rehabilitative or conditioning purposes during trotting. Alternatively, our data may indicate that using incline or decline treadmill activity in cases with concurrent biceps brachii pathology may not be contraindicated. This finding aligns with prior EMG studies[8] demonstrating relatively consistent biceps activation across varying levels of incline and decline treadmill walking.

The limitations of this study include the relatively small sample size and variability in usable EMG recordings across muscles, which is inherent to surface EMG in canine subjects. Despite using previously published and accepted methods, the signal obtained from the biceps brachii muscles did not yield consistently reliable EMG output in all dogs.[4,22] An additional limitation considered is that by using direct palpation of the muscle bellies, there may be individual variability in anatomy or errors with EMG sensor placement. Future studies may consider using musculoskeletal ultrasound to ensure accurate sensor placement, especially in smaller subjects or with smaller muscle bellies. The use of sedation in 2 dogs could have altered muscle activity; however, neither dog's data were obviously different than the others. Additionally, both dogs were determined to be moving normally by visual assessment by a board-certified sports medicine and rehabilitation specialist before data were collected. Future studies featuring greater sample sizes, integrating EMG with 3-D kinematics and ground reaction forces, would further clarify the functional implications of these findings and assist in developing targeted rehabilitation and conditioning programs.

These findings provide clinically relevant insight into how varying treadmill levels can be used to manipulate select thoracic limb muscle demand during trotting. Manipulating treadmill incline and decline during trotting provides a practical and evidence-based method to selectively load specific thoracic limb musculature in dogs. Incline trotting preferentially increases supraspinatus and lateral triceps brachii activation, supporting its use to enhance concentric strength, and elbow extensor engagement in later-stage rehabilitation or performance conditioning. Conversely, decline trotting increases sustained activation of the deltoideus and triceps brachii, suggesting a role in improving braking control and possibly eccentric muscle activity, neuromuscular endurance, and dynamic shoulder stability, particularly in dogs requiring controlled loading during recovery. Importantly, the lack of significant change in biceps brachii activity indicates that incline and decline trotting may be safely incorporated in dogs with biceps-related pathology without disproportionately increasing demand on this structure. Collectively, these findings provide clinicians with objective guidance for selecting treadmill slope as a progressive, muscle-specific loading strategy, allowing rehabilitation and conditioning programs to be tailored to target strength development, joint stabilization, endurance, or return-to-sport goals while minimizing unnecessary stress on vulnerable tissues.

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