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Review Article

In–hand training of Piaffe and passage with leg stimulation: A literature–based biomechanical argument for why this method fails to produce true collection

Markus Scheibenpflug

Equinelibrium, 5316 Leuggern, Aargau, Switzerland

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ABSTRACT

In–hand training of piaffe and passage via tactile leg stimulation (Handarbeit mit Touchieren) is widely practised in dressage, yet consistently produces horses that elevate their legs without achieving collection — a pattern termed Schenkelgänger (leg–movers) in classical German equitation. Based on published kinetic, kinematic, and electromyographic literature, this review argues that tactile leg stimulation activates the spinal nociceptive withdrawal reflex, an unloading movement mechanistically opposed to the elastic tendon rebound and ventral muscular chain activation that define true collection. Repetitive reflex conditioning will reinforce dorsal extensor dominance (M. longissimus dorsi), suppress the abdominal–serratus suspension mechanism, and produce the characteristic postural markers: croup–higher–than–withers topline geometry, and thorax lowering in the absence of spring–loading. Concurrent head restraint will amplify this pathomechanism via brachiocephalicus overactivation. Collection training should prioritise trunk–first engagement and hindlimb loading over peripheral leg stimulation.

1. Introduction

In–hand training of highly collected movements — piaffe and passage — has been a cornerstone of classical dressage methodology for several centuries [1]. The trainer works the horse from the ground, using a whip or schooling stick to touch the hind or forelimbs in rhythm with the desired diagonal movement. The primary pedagogical rationale is to teach the horse the mechanics of the movement without the weight of the rider, allowing direct visual feedback and mechanical control. In learning–theory terms, the tactile touch is intended to function as a cue established through negative reinforcement and progressive shaping, with the stick later replaced by the rider's aids as the movement becomes established [2].

Despite its long tradition and widespread use, the biomechanical consequences of this approach have received little critical scientific scrutiny. In the author's clinical experience, a consistent failure pattern is repeatedly observed in horses trained primarily by this method: rhythmic, apparently cadenced leg elevation without the postural prerequisites of true collection. These horses are termed Schenkelgänger (leg–movers) in classical German equitation — as opposed to Rückengänger (back–movers), in which energy flows from a loaded hindlimb through an engaged abdominal chain and swinging back into an elevated, self–carried frame [1].

The key postural indicators of the Schenkelgänger are: (a) isolated limb elevation without trunk lifting, (b) a topline that rises toward the croup rather than the withers — the inverse of true collection — and (c) a visibly lowered thorax, indicating absence of the serratus–abdominal suspension mechanism [3]. These findings indicate that the ventral muscular chain is not activated and that movement is driven by spinal flexion reflexes and dorsal extensor activity, not by elastic tendon rebound and abdominal engagement.

This review integrates published kinetic, kinematic and electromyographic literature with anatomical and neuromuscular analysis to provide a mechanistic explanation of why tactile leg stimulation is structurally unsuitable for developing true collection, and proposes a biomechanically coherent training alternative.

E-mail address: office@equinelibrium.ch.

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2. Biomechanical requirements of true collection in piaffe and passage

2.1. The collection continuum: collected trot — passage — Piaffe

Collection in the trot family represents a progressive shift of the ground reaction force (GRF) vector from propulsive–horizontal to supporting–vertical, accompanied by increasing hindlimb joint engagement and forehand elevation. Weishaupt et al. [4] quantified this progression on an instrumented treadmill in six Grand Prix dressage horses: passage showed hindlimb impulse increases of +39.9% relative to collected trot, with a 4.8% reduction in the forehand load fraction. Velocity decreased by 43% while stance duration increased proportionally, indicating a shift from propulsion to support.

In piaffe, this loading pattern reaches its extreme. Clayton and Hobbs [5] measured three–dimensional GRFs in seven Olympic–level dressage horses: peak vertical force remained higher at the forelimbs (7.39 ± 0.99 N/kg vs. 6.41 ± 0.64 N/kg), yet the hindlimbs carried proportionally more body weight impulse than in either collected trot or passage — consistent with the classical definition of haunches–lowering. Horizontal force components showed high step–to–step variability (GRF SD > 15%), interpreted as reflecting the balance challenge of supporting the body on a single diagonal pair at near–zero velocity [5]. Consistent with this, Clayton et al. [6] showed that dressage horses actively control the moments acting around the centre of mass when performing passage, underscoring that passage quality is a whole–body balance task rather than a product of isolated limb elevation.

Clayton [7] classified piaffe kinematically as a 'walking gait' (no aerial phase), but noted that vertical GRF pattern and centre–of–mass control strategies remain spring–mass–like, implying that elastic energy storage and release of the distal limb must function during piaffe despite the absence of a suspension phase.

2.2. The elastic rebound mechanism

In all collected gaits, elevation of the diagonal pairs arises primarily from elastic rebound of the distal limb tendon–ligament apparatus, not from active muscular limb–lifting [8]. Under load, the fetlock joint undergoes controlled hyperextension, storing energy in the superficial digital flexor tendon (SDFT), deep digital flexor tendon (DDFT), and suspensory ligament. At push–off, this elastic energy is released, contributing an upward impulse that supplements muscular force [9].

This mechanism requires: (1) the hindlimb to step sufficiently under the centre of mass to load the fetlock into the spring range; (2) a short, active stance phase during which elastic energy is stored and released rather than dissipated through prolonged static load; and (3) a freely transmitting thoracolumbar spine to propagate the impulse cranially, the dorsal excursion of which is measurable at the trunk and saddle in high–level dressage horses [10]. All three conditions require prior activation of the ventral muscular chain, and are absent in peripheral leg stimulation protocols.

2.3. The ventral muscular chain

The equine trunk functions mechanically as a bow–and–string system: the thoracolumbar vertebral column forms the bow; the abdominal musculature — primarily M. rectus abdominis — forms the string [11]. When the string is taut (active abdominal engagement), the bow arches upward, enabling efficient impulse transmission from the hindlimb through the spine to the forehand. When slack, the bow sags into hollow–back configuration, blocking transmission and forcing horizontal rather than vertical hindlimb push.

Three structures constitute the relevant ventral chain: M. rectus abdominis (primary trunk lifter; Type–I dominant, optimised for sustained postural work [12]); M. serratus ventralis (anti–gravitational stabilisation of the thorax between the forelimbs, preventing ribcage drop [3]); and Mm. scaleni (cervico–thoracic junction stabilisation, inhibited by brachiocephalicus overactivation).

Rivero and Piercy [12] demonstrated that M. longissimus dorsi is Type–II dominant, optimised for explosive burst effort, not sustained postural work. EMG studies by Crook et al. [13] and Wakeling et al. [14] confirmed that longissimus activity is inversely correlated with back–-swing amplitude: when the longissimus contracts, it extends and hollows the back, blocking transmission rather than supporting it.

2.4. Topline geometry as a diagnostic indicator

In correctly collected movement, withers rise above the croup as hindlimb engagement increases — the withers–higher–than–croup geometry being the postural signature of an active ventral chain and a spring–loaded hindlimb. The inverse geometry — croup higher than withers — indicates caudally positioned hindlimbs, an unsupported thorax, and active longissimus. Gomez Alvarez et al. [15] demonstrated that a high head–and–neck position, commonly enforced in in–hand work via side reins, produces thoracic extension and lumbar flexion — directly generating this inverse topline.

Lesimple et al. [16] correlated observable topline concavity (active brachiocephalicus / blocked serratus chain) with significantly elevated paravertebral muscle tension by surface EMG across all thoracolumbar sites, providing direct evidence that the postural markers of the Schenkelgänger correlate with demonstrable spinal muscular pathology.

3. Mechanism of action of tactile leg stimulation

3.1. Neurological basis of the leg–tap response

Tapping the distal hindlimb with a whip elicits a spinal flexion reflex (nociceptive withdrawal reflex, NWR): cutaneous afferents activate spinal interneurons driving flexor contraction (hip, stifle, hock) while inhibiting extensors via reciprocal inhibition [17]. This reflex is subcortical, rapid (< 50 ms), and entirely independent of hindlimb loading mechanics, abdominal activation, or central postural programme initiation.

The critical distinction: the NWR produces leg elevation as an unloading movement — the hindlimb is withdrawn from the ground — whereas true collection requires leg elevation as a consequence of loaded spring rebound — the hindlimb is pushed upward by elastic energy stored during stance. These are mechanistically opposite sequences. Spinal reflex conditioning cannot transform an unloading movement into a loading movement.

3.2. Postural consequences of repetitive leg stimulation

Repetitive NWR activation combined with restricted head carriage creates a consistent postural compensation cascade. To avoid aversive stimulation, the horse preemptively withdraws the distal limb, requiring dorsal musculature activation (longissimus, semispinalis) to stabilise the trunk against the asymmetric unloading [13,14]. This produces: (1) longissimus contraction and back hollowing; (2) abdominal chain inhibition; (3) serratus ventralis inability to maintain thoracic elevation; (4) thorax drop and croup–high topline; (5) brachiocephalicus activation to stabilise the neck against head restraint; and (6) scaleni inhibition with cervico–thoracic stiffening.

This cascade — driven by the training method — produces all biomechanical signatures of the Schenkelgänger. The horse may display apparent rhythmic piaffe–like movement while being in complete postural failure relative to collection requirements.

3.3. The role of head restraint

In–hand work is commonly performed with side reins or similar devices. These restrict natural cervical kinematics and force neck stabilisation via the brachiocephalicus and sternomandibularis complex. Gómez Álvarez et al. [15] demonstrated that enforced high head–and–neck positions alter thoracolumbar kinematics (thoracic extension and lumbar flexion), and Lesimple et al. [16] linked sustained postural concavity to elevated paravertebral muscle tension. Neither study tested the present mechanism directly; on the basis of these data, however, it is biomechanically plausible that ventral neck–chain activation impairs serratus–scaleni function and reinforces dorsal extensor dominance, further entrenching the Schenkelgänger posture. Van Breda et al. [18] measured physiological stress markers across head–neck positions and found that constrained positions produced significantly elevated HRV and cortisol compared to natural or forward–downward carriage — implicating measurable welfare costs beyond the biomechanical failure.

4. Biomechanical comparison: true collection vs. Schenkelgänger

Table 1 summarises the key biomechanical differentiators between a correctly collected horse (Rückengänger) and a horse trained primarily by tactile leg stimulation (Schenkelgänger).

5. Clinical diagnostic criteria

Table 2 presents observable diagnostic signs that reliably distinguish the Schenkelgänger from true collection in field conditions without instrumentation.

6. Biomechanically coherent alternatives

Rejecting tactile leg stimulation as the primary modality does not require abandoning in–hand work. It requires redirecting the training objective from peripheral leg elevation to central trunk activation.

Trunk–first activation: Collection training should begin by establishing active abdominal engagement before requesting collected steps. Exercises that load the hindlimb under the centre of mass — rein–back to halt transitions, circle transitions, shoulder–in in walk — develop the ventral chain before leg elevation is requested. Recent surface–EMG work confirms that targeted in–hand exercises — dynamic mobilisation ('carrot') stretches and therapeutic trunk exercises — selectively activate the rectus abdominis, external abdominal oblique and longissimus dorsi [19], providing an evidence–based, trunk–first alternative to leg tapping.

Loading rather than lifting: The training cue for increased hindlimb activity should produce more weight–bearing (spring–loading), not less (withdrawal). This is achieved through forward–upward collection (half–halts into forward energy) rather than backward compression or whip–induced withdrawal.

Head–neck freedom: Side reins should be removed or loosened to allow natural cervical kinematics. The head–neck position in true collection is a consequence of thoracic elevation, not its cause [15]. A free poll and relaxed brachiocephalicus are prerequisites for scaleni function and serratus chain activation.

Transition–based quality testing: Collection quality should be evaluated through immediate, tension–free transitions (piaffe to passage and back; collected trot to halt). If the horse requires multiple external aids, the preceding movement was compression rather than collection — consistent with the GRF findings of Clayton and Hobbs [5].

Sequential preparation: Given that the elastic rebound mechanism requires progressive loading through collected trot and passage before piaffe with correct mechanics is achievable [7], the training sequence should follow: free walk → working trot → collected trot (verified ventral chain activation) → passage (confirmed by suspension quality) → piaffe. Bypassing this sequence by directly inducing piaffe–like steps via leg tapping installs the Schenkelgänger compensation from the outset.

Table 1
Biomechanical comparison of true collection and in–hand leg–stimulation–-trained Piaffe/passage.

Parameter	True Collection (Rückengänger)	Schenkelgänger (Leg Stimulation)
Limb elevation mechanism	Elastic tendon rebound (loading)	Spinal withdrawal reflex (unloading)
Abdominal chain	Active (M. rectus abdominis)	Inhibited by dorsal co–contraction
M. serratus ventralis	Active: thorax elevated	Insufficient: thorax drops
M. longissimus dorsi	Relaxed: allows back swing	Contracted: hollows back
Topline geometry	Withers higher than croup	Croup higher than withers
Brachiocephalicus	Inactive: free cervico–thoracic junction	Active: blocks serratus chain
Hindlimb position	Steps under centre of mass (loading)	Lifted away from ground (unloading)
Pelvic tilt	Ventral (haunches lowering)	Absent / dorsal
Forward readiness	Immediately available	Absent: no stored energy
GRF hindlimb impulse	Dominant; low step–to–step variability	High horizontal variability

Table 2
Observable clinical signs of the Schenkelgänger in field conditions.

Criterion	Finding in Schenkelgänger
Topline direction	Croup higher than withers; backline slopes forward–downward
Thorax height	Ribcage visibly low between forelimbs; girth area sunken
Brachiocephalicus	Visible muscular strand ventral to jugular groove
Atlas wings	Not visible: overridden by active ventral neck musculature
Back swing	Absent or inverted: saddle area drops rhythmically during the stance phase of each stride (i.e. in motion, not at the halt)
Limb–trunk coordination	Legs elevated while trunk remains static or descends
Transition test	Hesitant; requires repeated aids; no immediate energy release
Tail carriage	Held or clamped: dorsal spinal tension
Fetlock loading	Reduced fetlock extension and diminished elastic loading/rebound relative to true collection (a difference of degree, not a complete absence of stance–phase loading)

7. Discussion

The critique of in–hand leg stimulation requires careful distinction between in–hand work as a method (which has genuine value when applied correctly) and the specific technique of leg tapping as the primary collection stimulus. The central argument of this review is not that in–hand work is inherently harmful, but that its most common implementation — tactile leg stimulation combined with head restraint — produces neurological and muscular responses mechanistically incompatible with collection prerequisites.

Correctly applied, in–hand work has a defensible pedagogical rationale: the whip or stick placement serves as a tactile cue that, through negative reinforcement and shaping, can familiarise the horse with the timing and footfall of the movement; as collection develops, the stick is intended to be progressively withdrawn and replaced by the rider's aids [2]. The argument advanced here is therefore not against the use of cues or in–hand schooling as such, but against reliance on the nociceptive withdrawal reflex as the mechanism of limb elevation — a mechanism that is antagonistic to, and cannot be shaped into, the loaded elastic rebound that defines collection.

The spinal flexion reflex (leg withdrawal) and the abdominal spring mechanism (trunk loading) are anatomically antagonistic: activating one inhibits the other. The kinetic data of Weishaupt et al. [4] and Clayton and Hobbs [5] confirm that true passage and piaffe are defined by increased hindlimb loading impulse, not increased leg elevation per se. The EMG and kinematic data of Crook et al. [13], Wakeling et al. [14], and Gomez Alvarez et al. [15] collectively demonstrate that the postural configuration induced by standard in–hand training directly suppresses the ventral chain function required for collection.

A significant limitation of this review is the absence of controlled experimental studies directly comparing leg–stimulation–trained versus trunk–first–trained horses using simultaneous kinetic, kinematic, and EMG measurements. No published study has directly quantified Schenkelgänger versus Rückengänger piaffe with concurrent force plate and back–kinematics data. It should also be acknowledged that several of the foundational kinetic and kinematic datasets are now more than a decade old; recent surface–EMG studies of trunk–muscle recruitment during in–hand exercises [19] are consistent with, and reinforce, the trunk–first interpretation, but a contemporary, integrated dataset specific to piaffe and passage remains lacking. This represents a critical gap in equine sports science literature. A prospective study is in preparation by the author to address this gap.

A secondary limitation is that the clinical assessment criteria in Section 5 have not been validated against instrumental standards in a formal study. They represent biomechanically derived predictions requiring blinded inter–rater reliability testing and correlation with instrumental measurement for formal validation.

8. Conclusion

In–hand training of piaffe and passage by tactile leg stimulation systematically produces the Schenkelgänger: isolated leg elevation without collection, inverse topline geometry (croup higher than withers), thorax lowering, and absent abdominal–serratus trunk–suspension. This pattern is a predictable biomechanical consequence of the method — the spinal flexion reflex activated by leg tapping is mechanistically incompatible with the elastic tendon rebound and ventral chain activation that define true collection.

Published kinetic, kinematic, and EMG evidence consistently supports that collection is a trunk–first phenomenon driven by abdominal engagement and hindlimb loading, not a leg–first phenomenon driven by reflex elevation. Training methods for piaffe and passage must be redesigned accordingly — prioritising ventral chain activation, free cervical kinematics, hindlimb loading, and transition–based quality assessment over visual leg elevation as the primary success criterion.

Declarations

Ethical approval

Not applicable (review article; no animal experiments conducted).

Generative AI statement

An AI writing assistant (Claude, Anthropic) was used for language editing and document formatting during preparation of this manuscript. The scientific content, literature synthesis, clinical interpretation, and all conclusions are solely the work of the author. AI was not used for analysis, data interpretation, or literature search. This declaration is made in accordance with Elsevier’s policy on AI–assisted writing.

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Declaration of competing interest

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