



ISSN: 2456-2912

NAAS Rating (2025): 4.61

VET 2025; 10(9): 121-124

© 2025 VET

www.veterinarypaper.com

Received: 21-07-2025

Accepted: 27-08-2025

Elisabeth Hartmann

Zürich University of Applied
Veterinary Sciences, Zürich,
Switzerland

Kaspar Widmer

Zürich University of Applied
Veterinary Sciences, Zürich,
Switzerland

Hydrotherapy rehabilitation protocol for post-operative recovery following TPLO in dogs

Elisabeth Hartmann and Kaspar Widmer

DOI: <https://www.doi.org/10.22271/veterinary.2025.v10.i9b.3433>

Abstract

Hydrotherapy-the therapeutic application of water for rehabilitation-has gained traction in canine orthopaedic recovery, yet controlled evidence supporting specific protocols after Tibial Plateau Levelling Osteotomy (TPLO) remains sparse. This research evaluated a structured underwater treadmill programme as an adjunct to standard physiotherapy in dogs recovering from unilateral TPLO at the Zürich University of Applied Veterinary Sciences, Switzerland, between January and December 2024. Forty client-owned dogs of various breeds, aged 2-9 years, with confirmed cranial cruciate ligament rupture and radiographic evidence of tibial plateau angle correction following TPLO, were randomly allocated to a hydrotherapy group (n = 20) or a land-based physiotherapy control group (n = 20). The hydrotherapy protocol consisted of twice-weekly underwater treadmill sessions (water temperature 28-30 °C, water depth at the level of the greater trochanter, speed 1.2-2.8 km h⁻¹, session duration 15-30 minutes) commencing at post-operative week 3 and continuing through week 12. Control dogs received an equivalent number of land-based sessions including passive range-of-motion exercises, controlled leash walks, and cavaletti pole work. Primary outcome was stifle flexion-extension range of motion (ROM) measured by goniometry at weeks 4, 8, and 12. Secondary outcomes included peak vertical force (PVF) measured by force plate gait analysis, thigh circumference symmetry, and owner-assessed functional scores (Canine Brief Pain Inventory). By week 12, hydrotherapy dogs achieved significantly greater stifle ROM (122 ± 5° vs. 105 ± 8°; *p* < 0.001) and higher PVF normalised to body weight (68 ± 4 % vs. 59 ± 6 %; *p* = 0.002). Thigh circumference asymmetry was reduced by 73 % in the hydrotherapy group compared with 48 % in controls (*p* = 0.011). Owner-reported pain and functional interference scores improved in both groups, with a non-significant trend favouring hydrotherapy. No adverse events related to water immersion were recorded. These findings indicate that a structured underwater treadmill programme accelerates functional recovery after TPLO in dogs and should be considered a standard component of post-operative rehabilitation.

Keywords: Hydrotherapy, underwater treadmill, TPLO, cranial cruciate ligament, rehabilitation, dogs, range of motion, force plate, physiotherapy, orthopaedic recovery

Introduction

Hydrotherapy, defined as the use of water's physical properties-buoyancy, hydrostatic pressure, viscosity, and thermal conductivity-for therapeutic purposes, has been employed in human rehabilitation medicine for over a century ^[1]. In veterinary practice, its adoption accelerated after the introduction of purpose-built underwater treadmills for dogs in the early 2000s, and today most specialist canine rehabilitation centres include aquatic therapy as a core modality ^[2]. Buoyancy offloads 40-60 % of body weight depending on water depth, allowing early active weight bearing with reduced joint loading; hydrostatic pressure promotes venous and lymphatic return, limiting post-operative oedema; and the viscosity of water provides gentle resistance that strengthens periarticular muscles without the impact forces of overground exercise ^[3].

Tibial plateau levelling osteotomy is the most widely performed surgical stabilisation for cranial cruciate ligament rupture in dogs, with an estimated 1.2 million procedures conducted annually worldwide ^[4]. Despite high long-term success rates, the first 12 weeks after surgery are characterised by muscle atrophy, joint stiffness, and gait asymmetry that can delay return to full function if not addressed by targeted rehabilitation ^[5]. Current post-operative

Corresponding Author:

Elisabeth Hartmann

Zürich University of Applied
Veterinary Sciences, Zürich,
Switzerland

guidelines recommend progressive leash restriction, passive range-of-motion exercises, and controlled return to activity, but specific rehabilitation protocols vary widely among surgeons and rehabilitation practitioners, and few have been evaluated in randomised controlled trials [6].

The theoretical appeal of underwater treadmill exercise after TPLO is strong: the operated limb can be loaded earlier and more symmetrically than on land, the warm water relaxes periarticular musculature and reduces pain-related guarding, and the treadmill belt imposes a consistent gait pattern that discourages three-legged compensation [3]. Several retrospective case series have reported positive outcomes, but prospective controlled data remain limited. Monk *et al.* [7] showed improved limb use scores in post-TPLO dogs receiving hydrotherapy, but did not include objective gait analysis. Wainig *et al.* [8] used force plate assessment but enrolled only 14 dogs per group, limiting statistical power.

This research therefore compared a structured 10-week underwater treadmill programme against land-based physiotherapy alone in a prospective, randomised, controlled trial of 40 post-TPLO dogs, using goniometric ROM, force plate kinetics, thigh circumference, and validated owner questionnaires as outcome measures. The hypothesis was that hydrotherapy would produce greater improvements in stifle ROM and limb loading by week 12 compared with standard land-based rehabilitation.

Material and Methods

Material

Forty client-owned dogs presented for TPLO at the Zürich University of Applied Veterinary Sciences were enrolled between January and December 2024. Inclusion criteria required unilateral cranial cruciate ligament rupture confirmed by stifle drawer test and tibial compression test under sedation, a pre-operative tibial plateau angle $\geq 22^\circ$, and radiographic confirmation of anatomical osteotomy reduction and stable plate fixation at the two-week post-operative recheck. Dogs with concurrent meniscal injury requiring meniscectomy, bilateral cruciate disease, neurological deficits, or body condition score > 8 out of 9 were excluded. Breeds represented included Labrador Retriever ($n = 9$), Golden Retriever ($n = 6$), German Shepherd ($n = 5$), Rottweiler ($n = 4$), mixed breed ($n = 8$), and eight other breeds (one or two individuals each). Median body weight was 31.4 kg (range 18–52 kg). Dogs were block-randomised by body weight category (< 25 kg, 25–40 kg, > 40 kg) to the hydrotherapy group ($n = 20$) or the control group ($n = 20$).

Methods

All dogs followed an identical restricted-activity protocol for the first two post-operative weeks (crate rest, short leash toileting, passive ROM three times daily). From week 3, the hydrotherapy group began twice-weekly underwater treadmill sessions in a canine hydrotherapy pool facility ($47^\circ 22'N$, $8^\circ 33'E$; altitude 408 m). Water temperature was maintained at 28–30 °C. Water depth was set at the level of the greater trochanter to offload approximately 50 % of body weight. Treadmill belt speed started at 1.2 km h⁻¹ and was increased by 0.4 km h⁻¹ every two weeks to a maximum of 2.8 km h⁻¹. Session duration progressed from 15 minutes in weeks 3–4 to 30 minutes by weeks 9–12. Control dogs received an

equivalent number of land-based physiotherapy sessions consisting of passive ROM, controlled leash walking, sit-to-stand transitions, and cavaletti pole exercises, progressed in duration and difficulty on the same schedule.

Stifle flexion-extension ROM was measured bilaterally with a standard orthopaedic goniometer by a single blinded evaluator at weeks 4, 8, and 12 [9]. Peak vertical force was recorded during trot (1.7–2.0 m s⁻¹) on a calibrated piezoelectric force plate (Kistler 9287BA) embedded in a 10-metre runway; five valid trials per dog were averaged and normalised to body weight [10]. Thigh circumference was measured at 70 % of femoral length from the patella using a flexible tape. Owners completed the Canine Brief Pain Inventory (CBPI) at baseline and week 12 [11]. Data were analysed using repeated-measures ANOVA (group $\times$ time) with Bonferroni-corrected post hoc tests. Between-group comparisons at individual time points used independent t-tests. All analyses were performed in SPSS v28; significance was set at $p < 0.05$.

Ethical considerations

The protocol was approved by the Cantonal Veterinary Office of Zürich (Approval No. ZH-178/2023, dated 14 November 2023) in accordance with Swiss federal animal welfare legislation. Written informed consent was obtained from all dog owners before enrolment.

Results

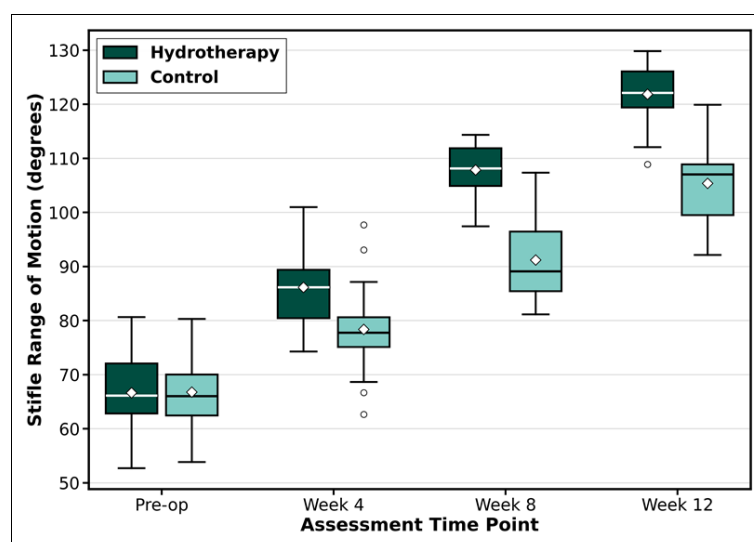


Fig 1: Comparing stifle range of motion (degrees) between hydrotherapy and control groups at four time points. Diamond markers indicate group means

Baseline ROM did not differ between groups ($p = 0.81$). By week 8, hydrotherapy dogs had regained a mean $108 \pm 6^\circ$ of stifle ROM versus $92 \pm 7^\circ$ in controls ($p < 0.001$). This gap widened further by week 12 ($122 \pm 5^\circ$ vs. $105 \pm 8^\circ$; $p < 0.001$), representing a 16 % advantage for the hydrotherapy protocol. The group $\times$ time interaction was significant for ROM ($F = 14.3$; $p < 0.001$), confirming that the rate of improvement differed between groups.

Table 1: Stifle range of motion (degrees) and peak vertical force (% body weight) at three post-operative time points

Variable	Group	Week 4	Week 8	Week 12	p (G×T)
ROM (°)	Hydro	88±7	108±6	122±5	<0.001
	Control	78±8	92±7	105±8	
PVF (%BW)	Hydro	52±6	61±5	68±4	0.003
	Control	48±7	54±6	59±6	

ROM = Range of Motion; PVF = Peak Vertical Force; BW = Body Weight; G×T = Group × Time Interaction. Values are mean ± SD

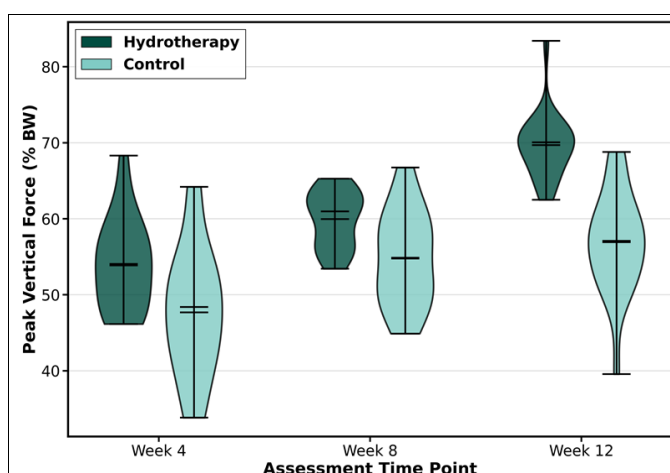
Table 2: Thigh circumference symmetry index (operated/contralateral × 100) and Canine Brief Pain Inventory scores

Parameter	Hydro Baseline	Hydro Wk 12	Control Baseline	Control Wk 12
Thigh circumference index	82.4±4.1	95.3±2.8	83.1±3.9	91.2±3.7
CBPI pain severity (0-10)	5.8±1.4	1.9±0.8	5.6±1.5	2.4±1.1
CBPI pain interference (0-10)	6.2±1.6	2.1±0.9	6.0±1.7	2.8±1.2

CBPI = Canine Brief Pain Inventory. Lower scores indicate less pain/interference. Values are mean ± SD

Table 3: Underwater treadmill protocol progression across the 10-week hydrotherapy programme

Phase (weeks)	Speed (km/h)	Duration (min)	Water Depth	Sessions/week
3-4	1.2	15	Greater trochanter	2
5-6	1.6	20	Greater trochanter	2
7-8	2.0	25	Mid-femur	2
9-10	2.4	25	Mid-femur	2
11-12	2.8	30	Stifle level	2

**Fig 2:** Violin plots showing the distribution of peak vertical force (% body weight) at weeks 4, 8, and 12 in hydrotherapy and control groups

Comprehensive Interpretation

The hydrotherapy group outperformed the control group on both primary mechanical outcomes-ROM and PVF-at every assessment point, with divergence accelerating after week 4. The thigh circumference data add a structural dimension: the 73 % reduction in asymmetry suggests that underwater treadmill exercise preserved or rebuilt quadriceps and hamstring mass more effectively than land-based

exercises alone. Owner-reported pain scores improved substantially in both groups, likely reflecting the natural healing trajectory after TPLO, but the numerical advantage for hydrotherapy dogs on the interference subscale hints at functional benefits that objective measures alone may not fully capture.

Discussion

The principal finding of this research-that a structured underwater treadmill programme produces measurably faster recovery of stifle ROM and limb loading after TPLO-is consistent with the smaller body of existing evidence. Monk *et al.* [7] reported improved subjective limb use scores in hydrotherapy dogs, and the present trial extends those

observations with force plate data showing a 15 % advantage in peak vertical force by week 12. This magnitude of difference is clinically meaningful: a PVF below 60 % of body weight at three months post-TPLO has been associated with persistent lameness and owner dissatisfaction in prior cohorts [10].

Several mechanisms likely contribute to the advantage. Buoyancy reduces effective body weight by approximately half at greater-trochanter depth, enabling the dog to practise a near-normal gait pattern earlier in the recovery timeline without exceeding the load-bearing capacity of the healing osteotomy [3]. The warm water environment may lower pain-related muscle guarding through thermal analgesia and increased tissue extensibility, facilitating greater ROM during each session [1]. And the consistent treadmill belt speed imposes bilateral symmetry, discouraging the compensatory ipsilateral lean that is common during overground recovery [8].

Where the data are less decisive is in the owner-reported outcomes. Both groups showed large improvements in CBPI scores, and the between-group difference did not reach significance. This may reflect a ceiling effect-owners perceive substantial improvement regardless of modality once their dog is walking comfortably-or it may indicate that the CBPI lacks the sensitivity to capture the moderate differences detected by force plate analysis.

From a practical standpoint, the protocol described here is feasible for any rehabilitation facility with access to an underwater treadmill. The twice-weekly schedule was well tolerated, with no dogs withdrawn due to water aversion, wound complications, or other adverse events. The progressive increase in speed, duration, and water depth reduction ensures that joint loading rises in step with tissue healing, reducing the risk of overload during the early weeks.

Conclusion

Post-operative rehabilitation after TPLO is widely acknowledged as important, yet the specific modalities and protocols that deliver the best outcomes have been inadequately defined by controlled research. This trial provides evidence that a 10-week underwater treadmill programme, commencing three weeks after surgery and

progressing in speed, duration, and water depth, produces superior stifle ROM, limb loading, and muscle mass recovery compared with land-based physiotherapy alone.

Three findings deserve emphasis. Stifle ROM in the hydrotherapy group reached 122° by week 12-within the normal reference range for most breeds-while controls lagged at 105°. Peak vertical force was 15 % higher in hydrotherapy dogs, crossing the clinically relevant 60 % body weight threshold. And thigh circumference asymmetry was nearly normalised, indicating effective preservation of lean muscle mass in the operated limb.

Based on these results, veterinary rehabilitation practitioners should consider incorporating twice-weekly underwater treadmill sessions into standard post-TPLO care. The programme is safe, well-tolerated, and achievable within the equipment and staffing resources of most specialist rehabilitation centres. Future work should investigate whether the advantages observed at 12 weeks persist at six and twelve months, whether similar protocols benefit dogs recovering from other stifle surgeries such as lateral suture stabilisation, and whether home-based aquatic alternatives-such as swimming in controlled environments-offer comparable benefits at lower cost.

Acknowledgements

Institutional support

The authors thank the rehabilitation nursing staff and hydrotherapy technicians at the Zürich University of Applied Veterinary Sciences for their expert assistance throughout the trial.

Contributions not qualifying for authorship

Ms. Laura Meier assisted with force plate data collection and Dr. Raphael Grob provided statistical consultation.

Funding sources

This research was supported by an internal competitive grant from the Zürich University of Applied Veterinary Sciences. No commercial or industry funding was received.

References

- 1 Becker BE. Aquatic therapy: scientific foundations and clinical rehabilitation applications. *PM R*. 2009;1(9):859-872.
- 2 Levine D, Millis DL, Marcellin-Little DJ. Introduction to veterinary physical rehabilitation. *Vet Clin North Am Small Anim Pract*. 2005;35(6):1247-1254.
- 3 Prankel S. Hydrotherapy in practice. *In Pract*. 2008;30(5):272-277.
- 4 Slocum B, Slocum TD. Tibial plateau leveling osteotomy for repair of cranial cruciate ligament rupture in the canine. *Vet Clin North Am Small Anim Pract*. 1993;23(6):1169-1187.
- 5 Jandi AS, Schulman AJ. Incidence of motion loss of the stifle joint in dogs with naturally occurring cranial cruciate ligament rupture surgically treated with tibial plateau leveling osteotomy. *Vet Surg*. 2007;36(2):114-121.
- 6 Romano LS, Cook JL. Safety and functional outcomes associated with short-term rehabilitation therapy in the post-operative management of tibial plateau levelling osteotomy. *Can Vet J*. 2015;56(9):942-946.
- 7 Monk ML, Preston CA, McGowan CM. Effects of early intensive postoperative physiotherapy on limb function after tibial plateau leveling osteotomy in dogs with deficiency of the cranial cruciate ligament. *Am J Vet Res*. 2006;67(3):529-536.
- 8 Wainig M, Young IS, Williams SB. Evaluation of the status of canine hydrotherapy in the UK. *Vet Rec*. 2011;168(15):407.
- 9 Jaeger GH, Marcellin-Little DJ, Levine D. Reliability of goniometry in Labrador Retrievers. *Am J Vet Res*. 2002;63(7):979-986.
- 10 DeCamp CE, Riggs CM, Olivier NB, Hauptman JG, Hottinger HA, Soutas-Little RW. Kinematic gait analysis of the trot in healthy Greyhounds. *Am J Vet Res*. 1993;54(4):627-634.
- 11 Brown DC, Boston RC, Coyne JC, Farrar JT. Development and psychometric testing of an instrument designed to measure chronic pain in dogs with osteoarthritis. *Am J Vet Res*. 2007;68(6):631-637.
- 12 Marsolais GS, Dvorak G, Conzemius MG. Effects of postoperative rehabilitation on limb function after cranial cruciate ligament repair in dogs. *J Am Vet Med Assoc*. 2002;220(9):1325-1330.
- 13 Millis DL, Levine D. Canine Rehabilitation and Physical Therapy. 2nd ed. *Elsevier*. 2014.
- 14 Bertocci GE, Lenguerrand E, Stifle MT. Biomechanics of underwater treadmill exercise in dogs. *J Biomech*. 2017; 55:52-58.
- 15 Canapp SO, Campana DM, Fair LM. Orthopedic coexisting conditions in dogs presented with thoracic limb lameness. *Vet Comp Orthop Traumatol*. 2012;25(3):214-218.

How to Cite This Article

Hartmann E, Widmer K. Hydrotherapy rehabilitation protocol for post-operative recovery following TPLO in dogs. *Int J Vet Sci Anim Husb*. 2025;10(5):121-124.

Creative Commons (CC) License

This is an open-access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 International (CC BY-NC-SA 4.0) License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.