

Determining force-velocity isokinetic capacities to individualize muscle strengthening in sports rehabilitation

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Individualizing muscle strengthening is central to sports rehabilitation, yet clinicians often rely on isolated metrics such as peak torque or limb symmetry. These measures are informative but do not describe how force is expressed across contraction velocities, which is a key determinant of power production and high-velocity functional capacity. Force-velocity profiling provides a practical reasoning framework to classify deficits as force-oriented or velocity-oriented and to tailor exercise selection and loading accordingly. When high-velocity or high-power functional tasks are not yet feasible, torque data collected at multiple angular velocities using isokinetic dynamometry can provide a controlled basis for early assessment of muscle performance, provided these data are interpreted within a clinical reasoning framework. In this context, isokinetic force-velocity capacities do not replace functional testing; rather, their clinical interpretation can help plan and justify progression toward higher-velocity and more sport-specific exposures. The clinical value lies less in utilization of technology than in the interpretive lens of the testing results that links assessment to prescription. From an international perspective, this framework is adaptable across diverse practice settings and may improve coherence between assessment, strengthening prescription, and functional progression after injury.

INTRODUCTION

Isokinetic dynamometry is widely used in sports physical therapy because it provides a controlled way to quantify joint torque across range of motion at predefined angular velocities. Yet, interpretation often collapses into a few familiar numbers: peak torque at one velocity, a limb symmetry index, or an agonist-antagonist ratio. These outputs are easy to report and provide an important starting point for objectifying strength, but they can hide the information clinicians need most—why a patient can meet a “strength target” and still struggle with fast, powerful, or reactive demands.

Muscle function is multidimensional. Force, velocity, and power interact, and the limiting quality changes with the task. Maximal force capacity matters for restoring baseline strength, but rapid force production and high-velocity force expression are central to explosive actions and reac-

tive control.¹ Power production depends on both ends of the force-velocity continuum and can be shaped through training choices that emphasize either force or velocity.² The clinical implication is simple: if we can describe how force production changes as contraction velocity increases, we can prescribe strengthening more precisely by aligning exercise selection and dosing (load and velocity) with the identified force- or velocity-related limitation.

FORCE-VELOCITY PROFILING AS A FRAMEWORK FOR CLINICAL REASONING

Force-velocity profiling translates the principles of the force-velocity relationship into an actionable output. In performance settings, profiling methods have been validated for ballistic movements such as jumping, using practical inputs to estimate force, velocity, and power in field

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conditions.³ Profiles are summarized using global parameters such as theoretical maximal force (F0), theoretical maximal velocity (V0), and maximal power (Pmax), and interpreted to guide individualized programming emphasis.⁴ The same logic could be applied to rehabilitation when clinicians must individualize strengthening beyond “more load” versus “more reps.”

Isokinetic dynamometry has well-described applications and limitations, including cost and limited accessibility in many clinical settings, as well as sensitivity to positioning, familiarization, instruction, and interpretation.⁵ Reliable measurement also requires device-level accuracy; mechanical reliability and validity of torque, velocity, and position have been demonstrated for commonly used systems when standardized procedures are followed.⁶ Profiling does not remove these requirements—it heightens them—because a profile is only as trustworthy as its inputs.

When torque is sampled across several angular velocities, strength capacities have been usually and interpreted as disconnected peaks without considering the continuum of the force-velocity relationship between two independent qualities: the force at low velocity and the force at high velocity. For instance, a relatively low F0 suggests a force-oriented deficit (reduced torque even at slower velocity). A relatively low V0 suggests a velocity-oriented deficit (a disproportionate drop as velocity increases, despite acceptable low-velocity strength). A reduced Pmax can reflect combined limitations or an imbalanced profile. Clinically, this distinction should guide exercise selection and training emphasis to target the identified force- or velocity-related deficits not just what to report.

WHEN HIGH-VELOCITY FUNCTIONAL TASKS ARE NOT YET FEASIBLE: BRIDGING THE DECISION GAP

This approach is useful when clinicians must decide what to train before maximal functional testing is appropriate. Many patients cannot safely demonstrate maximal sprinting, reactive plyometrics, or high-velocity change-of-direction early in recovery because of irritability, confidence, or load tolerance. Isokinetic testing provides a controlled environment for testing using predefined ranges and velocities. However, it lacks ecological validity relative to functional tasks, as it involves open-chain, single-joint testing and angular velocities that remain substantially lower than those observed during sport-specific movements. In this limited context, force-velocity profiling may serve as an analytic proxy for velocity-related capacity during early rehabilitation, while acknowledging that isokinetic-derived metrics may not directly translate to functional performance and that functional exposure must be rebuilt progressively.

For profiling to be clinically useful, it must translate into decisions with minimal constraints. A pragmatic workflow can be implemented with modest adaptations to existing routines. First, test with intention: include a range of angular velocities that captures both high-torque and higher-velocity conditions, rather than repeating a single habitual

velocity. The exact set will depend on the joint and setting, but the principle is breadth. Note that for some joints, as for knee extensors, the usual range of velocities covered by isokinetic devices is insufficient to determine force-velocity capacities (testing velocities up to 300 °/s for a total velocity spectrum reaching 1000°/s).⁷ Further work is thus required on this point. Moreover, special attention must be paid to standardization of the warm-up, positioning, familiarization trials, and gravity correction, because methodological error can distort slope and intercept.⁵

Second, interpret the profile to generate a *working hypothesis*, then confirm with function as tolerance improves. If the profile suggests a force-oriented deficit (low F0), prioritize high-tension work: heavier resistance, longer contraction times, adequate rest, and progressive loading that targets maximal torque capacity. If the profile suggests a velocity-oriented deficit (low V0), prioritize intent and velocity: submaximal loads moved fast, controlled ballistic tasks, and graded plyometrics when clinically appropriate and symptom-tolerated.

PRACTICAL IMPLICATIONS FOR CLINICIANS

Third, apply velocity-based principles to dose training, not to chase technology. In high-resource environments, movement velocity can be monitored with transducers or wearable sensors, enabling feedback and autoregulation. Practical guidance on velocity-based prescription has been available for more than a decade,⁸ and recent critical syntheses highlight both benefits and constraints, including device validity and the need for consistent coaching cues.^{9, 10} Where tools exist, clinicians can also use velocity loss thresholds to manage fatigue and ensure repetitions remain “fast enough” for the intended stimulus.¹¹ Load-velocity relationships can further support day-to-day load selection and intensity estimation.¹²

Finally, re-test to detect meaningful change and keep individualization honest. A program designed to improve velocity expression should plausibly shift V0 and Pmax, even if F0 changes modestly; a heavy strength emphasis may primarily shift F0. This linkage between “what we trained” and “what changed” supports clinical reasoning and can prevent stagnation under generic progressions. It also helps communication: explaining that a limitation is “velocity of force expression” rather than “lack of strength” can improve engagement and adherence.

From an international perspective, force-velocity profiling has an underappreciated advantage: it can be comparatively equitable if available. In some regions and practice settings, isokinetic dynamometry is available (e.g. in hospitals, universities, or private centers) even when advanced field technologies are unavailable. While access to isokinetic equipment is a clear and important barrier in many settings, an additional and often underappreciated challenge lies in the lack of shared methodological standards—how many velocities are minimally sufficient, what range of velocities should be covered, how profiles should be modeled and reported, and how interpretation should translate into programming decisions. International collab-

oration could therefore focus on pragmatic consensus and clinician-facing resources, including open templates, minimal reporting standards, and shared case examples that reduce variability without demanding new hardware.

CONCLUSION

Rehabilitation is increasingly expected to restore not only strength but the capacity to express strength at different velocities during functional tasks. Relying on peak torque alone risks missing clinically meaningful differences in how patients generate torque across the velocity spectrum. Force–velocity profiling derived from multi-velocity isokinetic testing offers a concise, actionable summary of how strength is expressed across contraction velocities, helping clinicians distinguish force-limited from velocity-limited deficits and tailor training so that “stronger” also becomes “faster” and more transferable to real-world movement de-

mands. This shift can improve clinician confidence, progression timing, and return-to-activity planning.

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CONFLICTS OF INTEREST

The authors report no conflicts of interest.

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