XPRIZE HEALTHSPAN

# Knee Extensor Isokinetic Power

Clinical Toolkit for Trial Site Teams — Biodex & HUMAC NORM

*Executive Overview · Site Testing Protocol · Data Recording Sheet · Age/Sex Normative Reference*

## 1. Executive Overview — Knee Extensor Isokinetic Power Testing

Isokinetic dynamometry (e.g., the Biodex System 3/4 Pro or the HUMAC NORM by CSMi — the Cybex NORM's direct successor) is a seated testing system that holds the speed of a limb's movement constant while a load cell records the torque (Nm) the participant produces throughout the full range of motion. This “accommodating resistance” loads the knee extensors near-maximally at every joint angle — a dynamic, movement-based test, unlike single-angle isometric testing or the single-effort isoinertial tests (e.g., the Nottingham Power Rig or the Keiser leg press) used elsewhere in this toolkit family.

Because the dynamometer's angular velocity is fixed and precisely known, mechanical power output can be calculated directly from the torque the device records — Power (W) = Torque (Nm) × angular velocity (rad/s) — with no separate power sensor or estimation equation required. This makes isokinetic testing, per Wilk, Arrigo & Davies (IJSPT, 2024), a good method for objectively quantifying dynamic knee-extensor power.

Quadriceps (knee extensor) power declines steeply with age — an estimated ~6.5 W/year in men and ~4.2 W/year in women (Wrucke et al., J Appl Physiol, 2024) — and predicts balance, gait speed, and chair-rise performance in older adults. For XPRIZE Healthspan, the isokinetic approach — regardless of whether a team uses a Biodex or a HUMAC NORM or similar isokinetic dynamometer — turns the derived power value (W) into a directly comparable primary outcome, computed by each device's torque and velocity readouts.

This isokinetic power outcome is conceptually the same construct (mechanical power output of the knee extensors, in watts) as the leg-press power outcome in the companion toolkit, but the two are not numerically interchangeable — a single-joint, fixed-velocity isokinetic value and a multi-joint, ballistic leg-press value may have different reference thresholds for judging and may not be pooled or converted into one another for analysis.

Derived peak power normalized to body mass (W/kg) is the **primary judging measure** for this test in the XPRIZE Healthspan Competition.

*Sources:*

1. *Wilk, K. E., Arrigo, C. A., & Davies, G. J. (2024). Isokinetic testing: why it is more important today than ever. International Journal of Sports Physical Therapy, 19(4), 374.*
2. *Wrucke, D. J., Kuplic, A., Adam, M. D., Hunter, S. K., & Sundberg, C. W. (2024). Neural and muscular contributions to the age-related differences in peak power of the knee extensors in men and women. Journal of Applied Physiology.*
3. *Wilk, K. E., & Andrews, J. R. (1993). The effects of pad placement and angular velocity on tibial displacement during isokinetic exercise. Journal of Orthopaedic & Sports Physical Therapy, 17(1), 24-30.*

# 2. Site Testing Protocol — Knee Extensor Isokinetic Power

The protocol below works on either gold-standard isokinetic system XPRIZE Healthspan competing teams are likely to own; should your site have different equipment, please discuss with XPRIZE-Utah DCC and XPRIZE Healthspan staff. Use the equipment your site has — do not attempt to reproduce the other vendor's exact hardware. The steps below use a single fixed testing velocity and the minimum number of trials needed to derive a valid, reproducible, cross-site-comparable power value.

## Equipment options at a glance

| System | What It Provides | Notes for This Protocol |
|---|---|---|
| Biodex System 3 / 4 Pro | Seated multi-joint isokinetic dynamometer; knee attachment with restraint system and adjustable lever arm | Set knee-extension/flexion attachment; align dynamometer axis to the knee; perform manufacturer gravity correction before testing |
| HUMAC NORM (CSMi) | Seated multi-joint isokinetic dynamometer (successor to the Cybex NORM); 4 resistance modes | Use the knee attachment in standard isokinetic (concentric) mode; align dynamometer axis to the knee; perform gravity correction before testing |

Other equipment:

- Clipboard with the data recording sheet (Section 3)

*Use the same dynamometer, same leg, and same seat/setup value for every visit with a given participant. Conduct testing at approximately the same time of day, when feasible, and use the same examiner whenever possible.*

## Pre-test screening

Select the leg to be tested before beginning the assessment at baseline. Confirm the participant can extend and flex the tested knee through a full, pain-free range of motion against light manual resistance before loading the dynamometer. Use the same leg at every follow-up visit and document the reason for any change.

**Do not conduct the test if the participant has:**

- Lower-extremity fracture in the past 6 months, or a lower-extremity joint replacement or ligament repair in the past 6 months, without surgeon clearance
- Cardiac event or unstable angina in the past 6 months
- Severe uncontrolled hypertension, defined as seated systolic blood pressure > 180 mmHg or diastolic blood pressure > 100 mmHg *(measured earlier in visit)*
- Acute deep vein thrombosis in the past 4 weeks
- Significant knee or hip pain that prevents a full, controlled push against resistance.

## Standardized setup (both systems)

- Record which leg is tested (right/left and dominant/non-dominant) at every visit.
- Seat the participant upright, hips and back against the seat back, arms folded across the chest (do not allow the participant to grasp the dynamometer frame or seat rails with their hands), with the hip at approximately 85–100° flexion; secure the trunk, pelvis, and thigh with restraint straps.
- Align the dynamometer's mechanical axis of rotation with the participant's knee joint axis (lateral femoral epicondyle).
- Attach the lower-leg pad/cuff with a strap positioned just proximal to the malleoli.
- Record the seat position, axis height, and lever-arm length at baseline; reuse the identical setting at every follow-up visit for that participant.
- Set the range-of-motion (ROM) mechanical stops from full extension (0°, or 5° short of full extension to avoid an end-range braking artifact) to 90–95° of knee flexion.

- Read the standardized instructions verbatim, confirm understanding, and answer any questions. Below is a suggested script.
    - "*This equipment is called a dynamometer. It measures how much power you produce while straightening your knee at a controlled speed. The straps will help keep you in the correct position. During the test, kick out as hard and as fast as possible while maintaining the required body position. You will first complete 3-4 practice repetitions, followed by 5 maximal effort repetitions. You may stop at any time. Do you have any questions?*"

## Manufacturer mandatory steps

*Should your system require, perform built-in gravity correction procedure or other mandatory calibration steps per manufacturer instructions before any test trial.*

## Step 1 — Familiarization

Complete 3–4 submaximal concentric knee-extension repetitions at the test velocity of 180°/s so the participant understands the movement and cadence. These are not scored. Examiners may clarify instructions and correct technique during familiarization.

## Step 2 — Standardized test velocity

Set the dynamometer to a single fixed concentric angular velocity of 180°/s for knee extension. This velocity must be used at every site, on every device, for every participant and visit. *Do not substitute a different velocity or a vendor-specific power metric as the primary outcome, even if your site's usual clinical protocol differs.*

- 180°/s approximates functional movement speed and produces substantially lower patellofemoral compressive and anterior tibial shear forces than the historically common 60°/s (Wilk & Andrews, 1993; cited in Wilk et al., IJSPT 2024) and remains reliably "catchable" by older participants.

## Step 3 — Scored trials

- Instruct the participant to kick out as hard and as fast as possible through the full set range of motion for the knee extensors. Only the concentric phase is scored.
- Perform 3-5 maximal concentric knee-extension repetitions at 180°/s, with the system's standard passive return between reps. At least three repetitions are required for scoring, and no more than five repetitions should be completed. If the first set contains fewer than three repetitions (i.e., a technically invalid first set), a second set may be performed after at least 60 seconds of rest. Do not perform more than two sets.
- Provide standardized verbal encouragement during scored trials. During each repetition, say "*Hard and fast*", and after the final repetition, say "*Stop and relax*".

## Early Termination

Stop the test immediately if the participant declines to continue or if the examiner determines that continuing would be unsafe. Attend to the participant until stable and record peak torque for all completed repetitions and reasons for early termination.

## After the Test

- Assist the participant in safely exiting the dynamometer
- Offer the participant water and allow the participant to sit and rest as needed
- Record any symptoms experienced during or after the test
- Complete the source document fully and accurately.

## What to record

Peak torque as recorded by the device software.

*The primary judging measure, peak power, will be derived from the recorded peak torque by the XPRIZE-Utah DCC. If your device's software also reports an "Average Power" value directly, record it as a secondary field.*

# 3. Data Recording Sheet (Paper Source Document)

*Complete in ink at time of testing. Transcribe into the XPRIZE Healthspan Database according to the site SOP. Complete one form per visit.*

| | | | |
|---|---|---|---|
| **Participant ID #1 (Subject ID)** | | **Participant ID #2** | |
| **Site / Clinic ID** | | **Visit / Timepoint** | |
| **Date of Test (DD-MMM-YYYY)** | | **Examiner Initials** | |

| | |
|---|---|
| **Equipment Used** | ☐ Biodex System 3 ☐ Biodex System 4 Pro ☐ HUMAC NORM (CSMi)<br>☐ Other *(prior approval is required)*: _____ |

## Pre-test screening

| Item | Response |
|---|---|
| Any absolute contraindication present? | ☐ Yes — DO NOT TEST<br>☐ No<br>→ If yes, reason(s) test was not conducted (Select all that apply).<br>☐ Lower-extremity fracture in the past 6 months, or a lower-extremity joint replacement or ligament repair in the past 6 months, without surgeon clearance<br>☐ Cardiac event or unstable angina in the past 6 months<br>☐ Severe uncontrolled severe hypertension, defined as seated systolic blood pressure > 180 mmHg or diastolic blood pressure > 100 mmHg *(measured earlier in visit)*<br>☐ Acute deep vein thrombosis in the past 4 weeks<br>☐ Significant knee or hip pain that prevents a full, controlled push against resistance.<br>☐ Other (specify) _____ |
| Tested knee moves through full pain-free ROM vs. light manual resistance? | ☐ Yes<br>☐ No — DO NOT TEST |
| **Gravity correction performed before testing?** | **☐ Yes**<br>**☐ No — DO NOT PROCEED if required**<br>☐ Not applicable |
| Familiarization (3–4 submaximal reps at 180°/s) completed? | ☐ Yes ☐ No |
| Leg tested | ☐ Right ☐ Left<br>☐ Dominant ☐ Non-dominant |
| Same leg tested at first baseline visit? | ☐ Yes ☐ No<br>→ If no, reason(s) test was not conducted: _____ |

## Minimal inputs required to score the test

| Field | Value |
|---|---|
| Seat position / dynamometer axis height (site setting) | _____ |
| Lever-arm length (cm from knee axis) | _____ cm |
| ROM used (degrees, extension to flexion) | ____° to ____° |
| Trial 1 peak torque (Nm) as displayed by device | _____ Nm |
| Trial 2 peak torque (Nm) as displayed by device | _____ Nm |
| Trial 3 peak torque (Nm) as displayed by device | _____ Nm |
| Trial 4 peak torque (Nm), if performed | _____ Nm |
| Trial 5 peak torque (Nm), if performed | _____ Nm |
| Device “Average Power” (W), if displayed (secondary field only) | _____ W |
| Was the test stopped early? | ☐ Yes ☐ No |
| If stopped early, specify reason(s) for early termination | ☐ Participant declined to continue<br>☐ Musculoskeletal joint pain<br>☐ Muscle cramping<br>☐ Equipment or technical issue<br>☐ Other (specify) _____ |

*Record all device-specific seat-position settings as displayed by the system used. Angular velocity used must be 180°/s. Transcribe all raw torque values shown by the device into the XPRIZE Healthspan Database according to the site SOP.*

## Adverse Events during or after the test

| Symptom | Y / N | Symptom | Y / N |
|---|---|---|---|
| Shortness of breath | ☐ Y ☐ N | Wheezing | ☐ Y ☐ N |
| Angina/Chest pain | ☐ Y ☐ N | Severe fatigue | ☐ Y ☐ N |

Notes:

# Clinical Protocol Acceptance Page

*XPRIZE Healthspan*

**Clinical Protocol Title:** Knee Extensor Isokinetic Power

**Version Number and Date:** v1 13Oct2026

*This document will be available on a publicly accessible website. SAB members, finalist teams, and their participating sites will be provided with the URL to access the document during the XPRIZE Healthspan competition. No account or login will be required.*

*By signing below, I confirm that I have reviewed and **approved** this protocol from a scientific perspective for use by the finalist teams to collect participant data for XPRIZE Healthspan competition judging.*

**XPRIZE Healthspan Leadership Approval**

Jamie Justice, PhD. Executive VP of XPRIZE Health Domain

_____

***Name, Credentials, Role*** ***eSignature & Date***

*By signing below, I confirm that I have reviewed and **endorsed** this protocol from a scientific perspective for use by the finalist teams to collect participant data for XPRIZE Healthspan competition judging.*

**Utah Data Coordinating Center Endorsement**

Alayne Markland, DO, MSc, Executive Director, Center of Aging

_____

***Name, Credentials, Role*** ***eSignature & Date***

Huong Meeks, PhD, MStat, MPH, Assistant Professor

_____

***Name, Credentials, Role*** ***eSignature & Date***