XPRIZE HEALTHSPAN

Leg Extension / Leg Press Power

Clinical Toolkit for Trial Site Teams

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

1. Executive Overview — Leg Extension / Leg Press Power Testing

Muscle power — force multiplied by velocity — is the rate at which the leg extensor muscles can generate force. It is distinct from muscle strength (maximal force alone) and from muscle mass, and we recommend measuring muscle power directly using instrumented equipment such as the Nottingham Power Rig, a Keiser pneumatic leg press, or a Biodex leg press/dynamometer. During the test, the participant pushes a pedal or platform as hard and fast as possible in a single explosive effort, and the device's flywheel or load-cell/encoder system calculates power output directly, in watts (W), from the resistance and velocity achieved.

Muscle power declines earlier and roughly twice as fast with age than strength or lean mass, driven largely by selective loss of fast-twitch (type II) muscle fibers. Leg extension power (LEP) is more strongly associated with gait speed, chair-rise ability, disability, falls, and mortality than grip strength, isolated leg strength, or repetition-based functional tests. In the Copenhagen Sarcopenia Study (N = 1,305, ages 20–93), LEP began declining from the fifth decade of life — earlier than either grip strength or lean mass (Suetta et al, 2019).

For XPRIZE Healthspan trial sites, LEP/leg press power testing offers a direct, instrumented measurement that requires no estimation equation, and the Nottingham Power Rig in particular is the field's most widely validated criterion measure of lower-limb power — the benchmark against which other estimations like the 30-second sit-to-stand power equation were validated. Below-normative power is associated with elevated fall risk, mobility disability, and mortality. Moreover, LEP testing gives sites an actionable, trial-relevant outcome, with some studies showing that LEP testing has acceptable within-person, 1-week test-retest reliability when compared to other measures like knee extensor isometric assessments.

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

Sources:

Suetta, C., Haddock, B., Alcazar, J., Noerst, T., Hansen, O. M., Ludvig, H., ... & Simonsen, L. (2019). The Copenhagen Sarcopenia Study: lean mass, strength, power, and physical function in a Danish cohort aged 20–93 years. *Journal of cachexia, sarcopenia and muscle*, *10*(6), 1316-1329.

2. Site Testing Protocol — Leg Extension / Leg Press Power

This protocol is written to work across the three systems XPRIZE Healthspan competing teams may have access to; should your site have different equipment, please discuss with XPRIZE-Utah DCC and XPRIZE Healthspan staff. Use the equipment your site owns — do not attempt to reproduce another system's exact setup. The steps below are the minimum recommended to obtain a valid, reproducible power value with the fewest trials and the least burden on data collectors and participants.

Equipment options at a glance

System	Setup	Resistance / Effort	1RM Needed?
Nottingham Power Rig	Seated, one leg on footplate connected to a flywheel, arms crossed over chest	Fixed low mechanical resistance; single maximal unilateral kick — power read directly from flywheel's peak angular velocity	No
Keiser Pneumatic Leg Press	Seated leg press, knee ~90° start position, single leg or bilateral per site SOP	Adjustable pneumatic resistance set as % of 1-repetition maximum (1RM); participant presses as fast as possible through full range of motion	Yes
Biodex (Leg Press / Dynamometer)	Seated leg press or knee dynamometer per manufacturer setup	If unit outputs power directly, follow manufacturer protocol; otherwise use the same %1RM approach as Keiser	Yes, if no direct power mode

Other equipment:

- Borg Rating of Perceived Exertion (RPE) CR10 scale
- Clipboard with the data recording sheet (Section 3)

Use the same equipment, 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 move the tested leg through a full, pain-free range of motion against light manual resistance before loading the equipment. Use the same leg at every follow-up visit and document the reason for any change.

Do not test if the participant has:

- A lower-extremity fracture, 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 (all 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 (no pulling on side handles).
- Set and record the seat/carriage position or knee starting angle at baseline; reuse the identical setting at every follow-up visit for that participant.
- Read the standardized instructions, confirm understanding, and answer any questions. Below is the suggested script:
    - For Nottingham Power Rig: "*This equipment measures how much power you produce with a single leg kick. You will first complete two practice efforts at a comfortable intensity, followed by several maximal efforts. For each maximal effort, kick as hard and fast as you can through the full range of motion while maintaining the required body position. You may stop at any time. Do you have any questions?*"
    - For Keiser Pneumatic Leg Press/Biodex (resistance mode): "*This equipment measures how much power you produce while pressing against resistance. You will first complete two practice efforts. We will then gradually increase the resistance. After each effort, I will ask you to rate your exertion using the Borg scale, where 0 means no exertion and 10 means maximal exertion. We will stop increasing the resistance when your rating reaches 8 or higher, or when you cannot complete the full movement in a controlled manner. After a rest period, you will complete two scored efforts by pressing as hard and as fast as*

possible through the full range of motion while maintaining the required body position. You may stop at any time. Do you have any questions?"

- Examiner should give the cue "push/kick as hard and as fast as you can" before every effort — velocity matters as much as force. Provide standardized verbal encouragement during scored trials (Step 3). During each effort, say "*Hard and fast*", and after the final effort, say "*Stop and relax*".

Step 1 — Familiarization

Complete 2 submaximal practice efforts on the test leg at a light, comfortable resistance so the participant understands the movement and cadence. These are not scored. Examiners may clarify instructions and correct technique during familiarization.

Step 2 — Identifying 1-Repetition Maximum (Keiser, Biodex, or resistance-based system)

Skip this step entirely for the Nottingham Power Rig — it uses a fixed low resistance and reads power directly from a single maximal kick.

- Start at the lowest available resistance setting (e.g., ~40 lb / ~18 kg on a Keiser A420, or the manufacturer's minimum).
- Instruct the participant to press through the full range of motion as fast as possible; allow 30 seconds of rest between attempts.
- After each successful, full-range attempt, increase the resistance by one increment and ask the participant to report their Borg CR10 RPE (0-10 scale).
- Continue increasing the resistance until the participant reports an RPE ≥ 8 ("very hard" to "extremely hard") or cannot complete the full range of motion in a controlled manner.
- Record the last resistance level completed successfully through full range of motion as the 1-RM. Stop the procedure at that point — do not attempt a heavier lift.
- Allow at least 2–3 minutes of rest after 1-RM is reached before beginning power trials.

Step 3 — Power Assessment (single simplified protocol)

Use the instructions corresponding to the equipment being used. This is the only scored portion of the test.

Nottingham Power Rig

- Cue, "*Ready? Set. Go!*" and instruct the participant to perform one single maximal unilateral kick.
- Repeat the trial, allowing 30 seconds of rest between kicks, until two consecutive efforts fail to exceed the previous best or a maximum of five trials is reached — whichever comes first.
- Record the single highest power value (W) achieved across all trials on the tested leg.

Keiser Pneumatic Leg Press / Biodex (resistance mode)

- Set the resistance to 70% of the 1-RM identified in Step 2. If your site's SOP already specifies a different fixed % of the 1-RM, keep it consistent across all participants and visits and record which % was used.
- Instruct the participant to press through the full range of motion as explosively as possible; complete 2 trials at the set resistance, allowing 30–60 seconds of rest between trials.
- Record the higher of the 2 peak power values (W).

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 power for all completed repetitions and reasons for early termination.

After the Test

- Assist the participant in safely exiting the system
- 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 power as recorded by the device software.

The primary judging measure, highest peak power, will be derived from the recorded peak power by the XPRIZE-Utah DCC.

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)		**Rater / Tester Initials**	

Equipment Used	☐ Nottingham Power Rig ☐ Keiser Pneumatic Leg Press ☐ Biodex ☐ Other *(prior approval from XPRIZE is required)*: _____

Pre-test screening

Item	Response
Any absolute contraindication present?	☐ Yes — DO NOT TEST ☐ No → If yes, reason(s) test was not conducted (Select all that apply). ☐ 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 severe 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. ☐ Other (specify): _____
Tested leg moves through full pain-free ROM vs. light manual resistance?	☐ Yes ☐ No — DO NOT TEST
Familiarization (2 submaximal reps) completed?	☐ Yes ☐ No
Leg tested	☐ Right ☐ Left ☐ Dominant ☐ Non-dominant
Same leg tested at first baseline visit?	☐ Yes ☐ No → If no, reason(s) test was not conducted: _____

Minimal inputs required to score the test

Field	Value
Seat / carriage position or knee start angle (site setting)	_____

Field	Value
1RM resistance — Keiser / Biodex only; leave blank for Nottingham (circle unit)	_____ lb / kg
Resistance used for power trials (% 1-RM, if different from 70%)	_____ %
Trial 1 peak power (W) as displayed by device	_____ W
Trial 2 peak power (W) as displayed by device	_____ W
Trial 3 peak power (W) — Nottingham only, if performed	_____ W
Trial 4 peak power (W) — Nottingham only, if performed	_____ W
Trial 5 peak power (W) — Nottingham only, if performed	_____ W
Test stopped early? If yes, note reason below	☐ No ☐ Yes

Record all device-specific seat/carriage position settings as displayed by the system used. Transcribe all raw power 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: Leg Extension / Leg Press 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***