

Reporting Summary

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Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed
☐	☒ The exact sample size (<i>n</i>) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒ A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒ The statistical test(s) used AND whether they are one- or two-sided <i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i>
☒	☐ A description of all covariates tested
☐	☒ A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒ A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒ For null hypothesis testing, the test statistic (e.g. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> value noted <i>Give P values as exact values whenever suitable.</i>
☒	☐ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐ Estimates of effect sizes (e.g. Cohen's <i>d</i> , Pearson's <i>r</i>), indicating how they were calculated

Our web collection on [statistics for biologists](#) contains articles on many of the points above.

Software and code

Policy information about [availability of computer code](#)

Data collection	Case study I – Data were collected through a 12-camera motion capture system (Vicon Motion Systems Ltd., Oxford, UK) and two force plates (AMTI BP400600, Watertown, USA), and the Vicon Nexus 1.8.5 software was used for data collection and synchronization. Case study II – Data were collected through a 12-camera motion capture system (Vicon Motion Systems Ltd., Oxford, UK) and two force plates (AMTI BMS6001200, Watertown, MA, USA), and the Vicon Nexus 2.11 software was used for data collection and synchronization.
Data analysis	Case study I - Data were analyzed in Vicon Nexus 1.8.5. Case study II - GRFs data were analyzed in MATLAB R2021a. Inverse kinematics and dynamics were conducted in OpenSim v. 4.3 (musculoskeletal model Gait2392) to determine joint angles, torques and powers. Further data filtering was conducted in MATLAB R2021a. An inferential statistical analysis was performed to compare the torques of the contralateral joints when using the two prostheses through a non-parametric paired two-tailed t-test (SPM1d code, vM.0.4.12, www.spm1d.org) in MATLAB. Custom MATLAB code used for data visualisation and figure generation is available from GitHub under https://github.com/IIT-SoftBots/SFPro_NCOMMS_GaitResults .

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio [guidelines for submitting code & software](#) for further information.

Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our [policy](#)

All data supporting the findings of this study are available within the article and its Supplementary Information. Any additional requests for information can be directed to, and will be fulfilled by, the corresponding authors. Source data are provided in the files "Source Data File_SAGITTAL" and "Source Data File_FRONTAL".

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](#). See also policy information about [sex, gender \(identity/presentation\), and sexual orientation](#) and [race, ethnicity and racism](#).

Reporting on sex and gender

Findings do not apply to only one sex or gender. Sex and gender were not considered in the study design. Sex of the studies' participants is reported in the manuscript as self-reported by participants.
We did not conduct a sex- and gender- based analysis as we deem that the main findings (in terms of kinematics and kinetics) are not affected by sex/gender. We believe, indeed, that prosthetic users with different sex/gender would show similar kinematics and kinetics patterns.

Reporting on race, ethnicity, or other socially relevant groupings

As specified in the recruitment below, no discrimination were made when selecting the studies' participants. No socially constructed or socially relevant categorization variables were used. We did not classify people into different categories. Results are not affected by race, ethnicity, or other socially relevant groupings.

Population characteristics

The SoftFoot Pro was tested on two male participants, both 34 years old, with unilateral left-side amputation. Their mean height was 1.85 m and their mean body mass was 87.5 kg.

Recruitment

The subjects were initially contacted by their personal prosthetist in case study I, and by the surgeon who had performed the osseointegration procedure in case study II. They were fully informed that participation was entirely voluntary. Then, they both provided their written informed consent to the testing protocol, which had previously been reviewed and approved by the respective ethics committees of the two studies. In the recruitment phase, no discrimination (e.g., based on socio-economic status, nationality, ethnicity, race, religion, gender/sex) was applied when selecting the participant. However, pregnant women (or suspected to be pregnant) were excluded to minimise the risk of injury in the event of a fall. Lastly, inclusion criteria for study's participants selection included experienced user of the prosthesis (i.e., daily usage of a prosthesis for at least 12 months from amputation) and with an active lifestyle, K4 level. This K-level means that they can walk with variable speed, exceeding basic ambulation skills, traversing environmental barriers, and exhibiting high impact, stress, or energy levels, such as active adult. We believe that other K3 and K4 prosthetic users would show similar kinematics and kinetics patterns.

Ethics oversight

The protocol of the study presented in this paper was approved by the Bioethical Committee of the University of Pisa and the local Ethics Committee of the Hannover Medical School.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size

No sample-size calculation was performed given that the study was envisioned as a validation of the SoftFoot Pro with prosthetic users, i.e. the first time the adaptive foot was tested in vivo.
For this reason, we thought that two participants were sufficient - one tested within case study I (with unilateral Van Nes-Borggreve rotationplasty), and the other within case study II (with unilateral transtibial amputation and osseointegrated prosthetic implant). Moreover, in case study I six valid trials for each limb were collected, while five gait cycles in case study II, and they were judged as sufficient. "A minimum of three consecutive gait cycles for both left and right slides (i.e., a total of six gait cycles)" are suggested, indeed, in guidelines for gait analysis in older adults in clinical settings (Kressig and Beauchet, 2005, Guidelines for clinical applications of spatio-temporal gait analysis in older adults, Aging Clinical and Experimental Research) to consider gait variability. In addition, when walking over ground and not on treadmill, a high number of gait cycles might be challenging to obtain due to the small capture area and considering also participant's fatigue.

Data exclusions	Data from two gait cycles for the level walking task with the participant's own carbon foot in case study II were excluded, because they were found to be invalid, so only 3 gait cycles were valid (i.e. a clean foot strike on each force plate). No other data were excluded from the analysis.
Replication	We have two subjects walking adopting the same prosthesis and results show similar trend in the kinematics and dynamics of the prosthetic-side ankle and hip joints in the two case studies. This proves the reproducibility of the experimental findings. The knee joint in the prosthetic limb exhibits, instead, a different trend due to the different type of amputation in the two subjects.
Randomization	We did not randomize the order of the prostheses to be tested because we thought that the order of the prostheses would not have affected the results.
Blinding	Blinding was not possible for this study because subjects could clearly feel the difference between the two prostheses tested (i.e. a carbon fiber foot and an adaptive prosthesis), above all while negotiating obstacles.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Plants

Seed stocks	Report on the source of all seed stocks or other plant material used. If applicable, state the seed stock centre and catalogue number. If plant specimens were collected from the field, describe the collection location, date and sampling procedures.
Novel plant genotypes	Describe the methods by which all novel plant genotypes were produced. This includes those generated by transgenic approaches, gene editing, chemical/radiation-based mutagenesis and hybridization. For transgenic lines, describe the transformation method, the number of independent lines analyzed and the generation upon which experiments were performed. For gene-edited lines, describe the editor used, the endogenous sequence targeted for editing, the targeting guide RNA sequence (if applicable) and how the editor was applied.
Authentication	Describe any authentication procedures for each seed stock used or novel genotype generated. Describe any experiments used to assess the effect of a mutation and, where applicable, how potential secondary effects (e.g. second site T-DNA insertions, mosaicism, off-target gene editing) were examined.