nature portfolio

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Last updated by author(s): Nov 3, 2023

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

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 (*n*) 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 *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☒	☐ 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. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐ 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 *d*, Pearson's *r*), 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	Data collection was performed using GNU Compiler (GCC) Arm Embedded Toolchain version 5, Visual Studio Code version 1.62 (with C language), CMake version v3.21.1, Python version 2.7, PyKst, Kst Plot Version 2.0.8, Qualisys Track Manager (QTM) version 2021, and IMU-based real-time gait metric estimation (Arens et al., 2021). Controls for robotic apparel were adapted from (Kim et al., 2022; Kim et al., 2019).
Data analysis	Data was processed and analyzed using Matlab version R2021a.

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 study data necessary to interpret, verify, and extend this work are available in the Source Data section. This includes data for Figures 1-5 and Extended Data Figures 2-5.

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	This initial work prioritized rigorous testing with repeated measurements on a single participant as a consideration-of-concept study to assemble potential evidence on the durability of device-related effects on freezing of gait. Given the nature of the single-subject study, and that there are no sex-related differences in FOG prevalence, sex was not considered in the study design. We did not make any claims or findings regarding sex.
Reporting on race, ethnicity, or other socially relevant groupings	Due to the nature of single-subject case study, race and ethnicity was not considered in the study design. Therefore, no claims or findings were made regarding race or ethnicity.
Population characteristics	The participant was a 73-year-old male (173cm, 93.5kg) with Parkinson's Disease (PD) of 10 years (Hoehn & Yahr stage: 2, MDS-UPDRS Part III motor examination: 33/132, New Freezing of Gait Questionnaire: 19/28). He underwent deep brain stimulation surgery to the globus pallidus internus 5 years following diagnosis, and the stimulator is constantly turned on throughout the day. Pharmacologic management included 1.5 tablets of 25-100 mg carbidopa/levodopa taken 4 times per day, amantadine twice per day, and entacapone taken 4 times per day. Despite surgical and pharmacologic management in addition to implementing behavioral strategies, the participant endured substantial, incapacitating freezing of gait (FoG), where he experienced numerous freezing episodes (>10/day) with associated daily falls.
Recruitment	General recruitment procedures involved utilization of registries maintained by various institutions in the Greater Boston Area, study flyers, and in-person recruitment efforts. The participant contacted the study team with his interest in participating after hearing about the study from a local Parkinson support group. Our inclusion criteria included individuals with idiopathic Parkinson's disease, with ages of 18-75 years, have trouble walking due to FoG but able to walk at least 20 meters independently. Data from a single participant may limit generalization to other FoG phenotypes, thus warranting future larger studies.
Ethics oversight	All study procedures were approved by Harvard Longwood Campus Institutional Review Board (IRB15-1816) and conducted according to the Declaration of Helsinki.

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	This initial work prioritized rigorous testing with repeated measurements on a single participant (N=1) as a consideration-of-concept study to assemble potential evidence on the durability of device-related effects on FoG. A sample size of a single participant with repeated measurements and varying levels of provocation was sufficient to examine the device's feasibility. The promising findings of this consideration-of-concept trial prompt further investigation to validate the effects of the robotic apparel on a broader range of individuals with PD with FoG and across a range of FoG phenotypes.
Data exclusions	In this study, the controller of the robotic apparel was designed to assist straight-ahead walking but was not optimized for turning. Consequently, when the participant made a wide U-turn at the end of the walkway under ASSIST ON condition, while most steps were assisted, some steps were missed due to the lack of a specific turning algorithm. In such cases, the corresponding turning portion was excluded from the data analysis, which accounted for 2.9% of the total time during all ASSIST ON trials. This exclusion criterion was pre-established.
Replication	The repeated measurements comprising of 5 study visits across 6 months served as replication of the experimental effects. All attempts at replication were successful, notably 0% time spent freezing for all indoor walking trials. We have made the experimental data available and provided all materials and methods used to replicate the results.
Randomization	Randomization related to intervention group does not apply to our study design. Based on study procedures, all experimental conditions (i.e., walking with assistance vs. walking with assistance turned off vs. without wearing the robotic apparel) were in a randomized order.
Blinding	This single-subject study was performed without any group allocation, so the blinding was not relevant to the study. Furthermore, due to the inherent nature of the wearable robotics study, we couldn't blind a study participant to his testing conditions (i.e. walking with assistance vs. walking with assistance turned off vs. without wearing the robotic apparel).

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