Supplementary file 1

TREND statement checklist for the EMS-PL HF STUDY protocol

Transparent Reporting of Evaluations with Nonrandomized Designs

Reference: Des Jarlais DC, Lyles C, Crepaz N; TREND Group. Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: the TREND statement. Am J Public Health. 2004;94(3):361–6.

Manuscript: "Efficacy and safety of cardiac rehabilitation augmented with whole-body electrical muscle stimulation in older patients with reduced and mildly reduced ejection fraction heart failure (EMS-PL HF STUDY): a study protocol for a three-arm, parallel-group, sham-controlled, non-randomised controlled clinical trial with sequential cohort allocation".

Trial registration: DRKS00040045 (registered 24 April 2026).

Section / Topic	Item No.	Descriptor	Reported in manuscript (section)
Title and Abstract	1	Information on how units were allocated to interventions; structured abstract recommended; information on target population or study sample.	Title page: design described as non-randomised controlled clinical trial with sequential cohort allocation. Abstract: Background, Methods, Outcomes, Discussion, Trial registration, Keywords (structured).
Introduction: Background	2	Scientific background and explanation of rationale; theories used in designing behavioral interventions.	Background section: Burden of HF; heart–muscle axis and sarcopenia challenge; rationale for PME and WB-EMS; Objectives.
Methods: Participants	3	Eligibility criteria for participants, including criteria at different levels (individuals, providers, sites); method of recruitment; recruitment setting; research setting.	Methods → Trial design and setting; Eligibility criteria (inclusion and exclusion); Recruitment; Interventions (eligibility criteria for individuals delivering the intervention).
Methods: Interventions	4	Details of the interventions intended for each study condition and how and when they were actually administered; content; delivery method; unit of delivery; deliverer; setting; exposure quantity and duration; time span; activities to increase compliance or adherence (e.g., incentives).	Methods → Interventions: Standard CR (all cohorts); standardised in-suit exercise protocol; WB-EMS device; active WB-EMS programme; sham WB-EMS programme; concomitant nutritional intervention; criteria for

			modifying or discontinuing the allocated intervention; strategies to improve adherence; permitted and prohibited concomitant care. Illustrations: Figures 1–4.
Methods: Objectives	5	Specific objectives and hypotheses.	Background → Objectives (primary, secondary efficacy, secondary safety, with pre-specified hypotheses).
Methods: Outcomes	6	Clearly defined primary and secondary outcome measures; methods used to collect data; methods used to enhance the quality of measurements (e.g., training of assessors, multiple observations); information on validated instruments.	Methods → Outcomes: Primary outcome (change in peak VO_2 by CPET, Guazzi interpretation); secondary outcomes; harms; Methods → Data collection (validated instruments: EQ-5D-5L PL, IPAQ PL, Senior Fitness Test; trained physiotherapists; EACVI-compliant echocardiography).
Methods: Sample size	7	How sample size was determined; explanation of any interim analyses and stopping rules.	Methods → Sample size (effect size assumptions, α, power, dropout); pre-specified safety stopping rules at the individual level (CK threshold, clinical deterioration) described under Interventions and Monitoring.
Methods: Assignment method	8	Unit of assignment; method used to assign units to study conditions, including details of any restriction (e.g., blocking, stratification, minimisation); inclusion of aspects employed to help minimise potential bias induced by non-randomisation (e.g., matching).	Methods → Assignment of interventions: unit of assignment = individual patient; sequential cohort allocation in a pre-specified order (active EMS → sham EMS → standard CR), filling each cohort to n = 15 before opening the next. No randomisation, blocking, stratification or matching was used; mitigation of selection bias is addressed in the same subsection.
Methods: Blinding (masking)	9	Whether or not participants, those administering the interventions, and those assessing the outcomes were blinded to study condition assignment.	Methods → Assignment of interventions → Blinding: participants in active and sham WB-EMS cohorts blinded to stimulation

			condition (identical suit, contact time, exercise protocol and visual interface); standard-CR-alone cohort cannot be blinded. Outcome assessors (CPET, echocardiography, laboratory) blinded; statistician analyses cohort-coded dataset.
Methods: Unit of analysis	10	Description of the smallest unit that is being analysed to assess intervention effects (e.g., individual, group, or community); if the unit of analysis differs from the unit of assignment, the analytical method used to account for this.	Methods → Data collection, management and analysis: unit of analysis = individual participant; identical to unit of assignment.
Methods: Statistical methods	11	Statistical methods used to compare study groups for primary methods outcome(s), including complex methods for correlated data; statistical methods used for additional analyses, such as subgroup analyses and adjusted analyses; methods for imputing missing data, if used; statistical software or programs used.	Methods → Statistical methods: modified ITT analysis; ANCOVA with admission value as covariate and cohort as fixed factor; pairwise Bonferroni-adjusted contrasts; multiple imputation under MAR; pre-specified per-protocol sensitivity analysis; pre-specified sensitivity analyses for non-randomised allocation (baseline-covariate adjusted ANCOVA, calendar-time adjustment, propensity-score IPTW); subgroup analyses (HFrEF vs HFmrEF, sex); SAP finalised and dated before database lock.
Results: Participant flow	12	Flow of participants through each stage of the study: enrollment, assignment, allocation and intervention exposure, follow-up, analysis (a diagram is strongly recommended); enrollment, assignment, allocation, and intervention exposure; follow-up; analysis; description of protocol deviations from study as planned, along with reasons.	Methods → Recruitment + Assignment of interventions: prospective documentation of all consecutive ward admissions and reasons for non-enrolment to allow a CONSORT-style flow diagram (Figure 5). Final numbers to be reported in the primary results manuscript.
Results: Recruitment	13	Dates defining the periods of recruitment and follow-up.	Title page and Methods → Trial design and setting: first participant enrolled 19

			May 2025; planned end of recruitment and follow-up 30 June 2027. Trial status section.
Results: Baseline data	14	Baseline demographic and clinical characteristics of participants in each study condition; baseline comparisons of those lost to follow-up and those retained, overall and by study condition; comparison between study population at baseline and target population of interest.	Methods → Assignment of interventions → Concealment/selection bias section and Statistical methods: pre-specified reporting of baseline characteristics by cohort with standardised mean differences on pre-specified prognostic variables. To be reported in the primary results manuscript.
Results: Baseline equivalence	15	Data on study group equivalence at baseline and statistical methods used to control for baseline differences.	Methods → Statistical methods: baseline-covariate adjusted ANCOVA and propensity-score IPTW pre-specified to adjust for any baseline imbalance that may arise from the non-randomised sequential allocation.
Results: Numbers analysed	16	Number of participants (denominator) included in each analysis for each study condition, particularly when the denominators change for different outcomes; inclusion or exclusion of participants lost to follow-up; intention-to-treat analysis described.	Methods → Statistical methods: modified ITT (all enrolled participants in their allocated cohort) + per-protocol sensitivity analysis pre-specified. To be reported in the primary results manuscript.
Results: Outcomes and estimation	17	For each primary and secondary outcome, a summary of results for each estimation study condition, and the estimated effect size and a confidence interval to indicate the precision; inclusion of null and negative findings; inclusion of results from testing pre-specified causal pathways through which the intervention was intended to operate, if any.	Methods → Statistical methods: pairwise contrasts with Bonferroni-adjusted 95% CI pre-specified for primary outcome and analogous estimation for continuous secondary outcomes. To be reported in the primary results manuscript.
Results: Ancillary analyses	18	Summary of other analyses performed, including subgroup or restricted analyses, indicating which are pre-specified and which are exploratory.	Methods → Statistical methods: pre-specified subgroup analyses (HFrEF vs HFmrEF; sex). All sensitivity analyses for non-randomised design are pre-specified.
Results: Adverse events	19	Summary of all important adverse events or unintended effects in each study condition (including summary	Methods → Outcomes → Harms: systematic

		measures, effect size estimates, and confidence intervals).	AE/SAE collection during the entire rehabilitation stay; classification by relationship and severity; pre-specified AEs of interest (arrhythmias, ischaemic events, syncope, skin reactions, symptomatic CK elevation, falls). To be reported in the primary results manuscript.
Discussion: Interpretation	20	Interpretation of the results, taking into account study hypotheses, sources of potential bias, imprecision of measures, multiplicative analyses, and other limitations or weaknesses of the study; discussion of results taking into account the mechanism by which the intervention was intended to work (causal pathways) or alternative mechanisms or explanations; discussion of the success of and barriers to implementing the intervention, fidelity of implementation; discussion of research, programmatic, or policy implications.	Discussion section: limitations (non-randomised design, single-centre setting, modest sample size, short intervention period, open-label standard-CR cohort); mitigating measures (pre-specified eligibility criteria, blinded outcome assessment, pre-specified sensitivity analyses); implications for clinical CR practice and for a future multicentre randomised trial.
Discussion: Generalisability	21	Generalisability (external validity) of the trial findings, taking into account the study population, the characteristics of the intervention, length of follow-up, incentives, compliance rates, specific sites or settings involved in the study, and other contextual issues.	Discussion section: single-centre Polish in-hospital CR setting; representativeness of older HFrEF/HFmrEF population on optimal GDMT; limitations of 3–4-week intervention and lack of long-term follow-up; implications for multicentre confirmatory trial.
Discussion: Overall evidence	22	General interpretation of the results in the context of current evidence.	Background and Discussion sections: results placed in the context of the authors' systematic review of PME in older cardiac rehabilitation patients [16] and previous EMS work in HF (Quittan, Karavidas, van Buuren and others).

Notes: Items 12–22 (Results, Discussion) marked "to be reported in the primary results manuscript" describe pre-specified analytical and reporting plans; the corresponding data will appear in the primary results paper. All TREND items reportable at the protocol stage are covered in the present manuscript. Abbreviations: AE, adverse event; ANCOVA, analysis of covariance; CI, confidence interval; CK, creatine kinase; CR, cardiac rehabilitation; CPET,

cardiopulmonary exercise testing; GDMT, guideline-directed medical therapy; HF, heart failure; HFmrEF, heart failure with mildly reduced ejection fraction; HFrEF, heart failure with reduced ejection fraction; IPTW, inverse probability of treatment weighting; ITT, intention to treat; MAR, missing at random; PME, peripheral muscle electrostimulation; SAE, serious adverse event; SAP, statistical analysis plan; SMD, standardised mean difference; WB-EMS, whole-body electrical muscle stimulation.