

BMJ Open Telephone health coaching with exercise monitoring using wearable activity trackers (TeGeCoach) for improving walking impairment in peripheral artery disease: study protocol for a randomised controlled trial and economic evaluation

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ABSTRACT

Introduction Peripheral artery disease (PAD) is the third most prevalent cardiovascular disease worldwide, with smoking and diabetes being the strongest risk factors. The most prominent symptom is leg pain while walking, known as intermittent claudication. To improve mobility, first-line treatment for intermittent claudication is supervised exercise programmes, but these remain largely unavailable and economically impractical, which has led to the development of structured home-based exercise programmes. This trial aims to determine the effectiveness and cost advantage of TeGeCoach, a 12-month long home-based exercise programme, compared with usual care of PAD. It is hypothesised that TeGeCoach improves walking impairment and lowers the need of health care resources that are spent on patients with PAD.

Methods and analysis The investigators conduct a prospective, pragmatic randomised controlled clinical trial in a health insurance setting. 1760 patients diagnosed with PAD at Fontaine stage II are randomly assigned to either TeGeCoach or care-as-usual. TeGeCoach consists of telemonitored intermittent walking exercise with medical supervision by a physician and telephone health coaching. Participants allocated to the usual care group receive information leaflets and can access supervised exercise programmes, physical therapy and a variety of programmes for promoting a healthy lifestyle. The primary outcome is patient reported walking ability based on the Walking Impairment Questionnaire. Secondary outcome measures include quality of life, health literacy and health behaviour. Claims data are used to collect total health care costs, healthcare resource use and (severe) adverse events. Outcomes are measured at baseline, 12 and 24 months.

Strengths and limitations of this study

- To our knowledge, this pragmatic clinical trial conducted in a health insurance-based setting is the first to investigate the clinical effectiveness of a structured home-based exercise programme in patients with peripheral artery disease.
- Collecting data on healthcare costs and utilisation allows a comprehensive economic evaluation of a structured home-based exercise programme in patients with peripheral artery disease.
- An initial 1 hour baseline assessment based on remote activity monitoring data determines the current walking impairment in order to create a training plan tailored to varying fitness levels; however, the validity of this assessment method has not been established yet.
- Since a potentially high attrition may endanger the internal validity of the results, a linear mixed model without any ad hoc imputation is used in order to deal adequately with missing values arising from study dropouts.
- The heterogeneity of intervention delivery given the pragmatic trial approach ensures the generalisability of the results applicable to the real-world clinical practice, which yet may lead to a dilution of the treatment effect.

Ethics and dissemination Ethical approval has been obtained from the Medical Association Hamburg. Findings are disseminated through peer-reviewed journals, reports to the funding body, conference presentations and media press releases. Data from this trial are made available to the public and researchers upon reasonable request.

TRIAL REGISTRATION NUMBER

NCT03496948 (www.clinicaltrials.gov), Pre-results.

INTRODUCTION

Peripheral artery disease (PAD) is the third most prevalent atherosclerotic cardiovascular disease with over 200 million people affected worldwide and has become one of the leading causes of disability and death.^{1 2} It is characterised by the progressive narrowing of the peripheral arteries resulting in the reduction of blood supply, eventually leading to functional impairment and mobility loss.³ If not intervened sufficiently early, the atherosclerotic processes can lead to ulcer formation and gangrenous necrosis (ie, critical limb ischaemia),⁴ and may affect other vascular beds with potentially fatal consequences.^{5 6} PAD is markedly more prevalent in the elderly population, estimating that 5.4% and 18.6% of individuals aged from 45 to 49 and 85 to 89 years are affected, respectively.^{1 2} The amount of people with PAD has risen rapidly in recent years, with a sharp increase by nearly 25% between 2000 and 2010 in the general population.² Likewise, in Germany, the amount of PAD-related hospitalisations increased by 20.7% between 2005 and 2009, from 400 928 to 483 961. Meanwhile, hospital reimbursement costs for the treatment of PAD have grown nationwide from €2.14 billion in 2007 to €2.6 billion in 2009, a 21% increase within 2 years.⁷ Major risk factors are tobacco smoking and diabetes, followed by high cholesterol, hypertension, history of cardiovascular disease (ie, coronary heart disease, stroke) and chronic kidney disease.^{1 2 8 9}

The most common clinical manifestation is leg pain while walking, known as *intermittent claudication* (IC), which reflects impaired haemodynamics and vascular dysfunction.^{10 11} IC is associated with diminished mental health and lower quality of life, thus reducing symptom burden is the cornerstone of the comprehensive care for patients with PAD.^{12–15} Besides pharmacotherapy, risk factor management and surgical revascularisation procedures, exercise-based interventions provide substantial mental and physical health benefits for patients with IC.^{16–19} Accordingly, formal *supervised exercise programmes* (SEPs) are shown to be effective in the treatment of PAD with IC and are recommended as first-line therapy with the highest level of evidence in a variety of published clinical guidelines.^{20–22} SEPs involve the use of intermittent walking exercise and are minimum 3-month commitments, with at least three sessions per week (30–60 min per session) provided in a clinical setting (eg, hospital outpatient setting, outpatient facility or a physician's office). Although SEPs commonly form part of usual care, its use is hampered by low uptake and adherence rates, possibly due to copayment requirements and lack of reimbursement, lack of available local training centres and the burden of travelling.^{23 24} These obstacles highlight the need for innovative models of care, which have led to the emergence of structured *home-based* exercise programmes

(HEPs) where SEPs are not available or impractical to deliver.²⁵ According to clinical practice guidelines, structured HEPs can serve as a useful alternative to SEPs^{20 22} as they improve walking impairment²⁶ and are preferred by patients over SEPs.²⁷ Structured HEPs are performed independently by the patient but follow an exercise regimen similar to that of SEPs, with a duration of 3–6 months. Protocols of structured HEPs show considerable variation with regard to programme duration, form of exercise, exercise frequency and duration, and intervention components used (for an overview, see Hageman *et al*).²⁸ To achieve benefits, structured HEPs include psychological behaviour change techniques (eg, goal setting, barrier identification and motivational interviewing), regular follow-ups with a healthcare professional or coach (eg, face-to-face and phone), activity monitoring and feedback (eg, wearable activity trackers and logbooks), patient education or any combination thereof.²⁸ Although inferior to SEPs,^{24 28–30} structured HEPs have been shown to improve performance-based,^{31–40} patient-reported^{31–38 40} and cardiorespiratory fitness³⁹ outcomes with high adherence,^{31 37} whereas unstructured exercise giving merely 'go home and walk' advice to patients with symptomatic PAD has proven ineffective.⁴¹

Given the promising results demonstrating the *efficacy* of structured HEPs in previous explanatory trials, pragmatic trials (ie, with high external validity) are urgently warranted to establish the *effectiveness* of structured HEPs with the goal to inform clinical practice and to shape healthcare policies.⁴² In response to the lack of effectiveness trials, while drawing on best available evidence and experience with previous telecoaching studies,⁴³ three German statutory health insurance funds (*KKH Kaufmännische Krankenkasse*, *TK Techniker Krankenkasse* and *mhplus Krankenkasse*) launch TeGeCoach, a 12-month long-structured HEP that involves telemonitored intermittent walking exercise using wearable activity trackers with medical supervision by a physician, and motivational interviewing-based telephone health coaching. TeGeCoach provides a streamlined, structured HEP approach based on current evidence using several components that have been shown to be beneficial; telephone health coaching have been shown to be a cost efficient and effective tool in the management of other chronic diseases,^{44–46} supporting physical activity and dietary behaviour change.⁴⁷ Therefore, structured HEPs involving telephone health coaching may also offer great potential for patients with PAD, although the frequency of coaching conversations may play a critical role in whether telephone health coaching is beneficial.⁴⁸ With regard to the mode of exercise, intermittent walking exercise has been proven to be effective in patients with IC, which involves repeated bouts of exercise to maximally tolerable claudication pain alternated with recovery breaks.⁴⁹ Likewise, the use of activity trackers alone or as an intervention modality are considered a convenient way for facilitating physical activity^{50 51} with long-term health benefits,⁵² while remote activity monitoring (eg, by a coach) may

improve walking impairment and significantly lower the costs of healthcare in PAD patients.⁵³ Among older adults, the use of activity trackers is well accepted and may be effective to encourage physical activity,^{54 55} with behavioural change techniques such as social support and motivating feedback facilitating their (long-term) use.^{56 57} Furthermore, adding some kinds of counselling to the use of wearable activity tracker (eg, activity monitor-based counselling) could allow the health coach to deliver behaviour change techniques and to support sustained exercise. For example, using an activity tracker with regular feedback combined with access to SEPs has proven to improve functional walking performance and quality of life in PAD patients.⁵⁸ Similarly, telephone health coaching combined with activity monitoring was found to increase physical activity and reduce sedentary behaviour in elderly people.⁵⁹

The aim of this study is to explore the effectiveness of TeGeCoach, a structured HEP for patients with PAD. A randomised controlled trial of 1760 patients with PAD is conducted to determine whether TeGeCoach improves patient-reported walking impairment while lowering healthcare costs at 12-month and 24-month follow-up, compared with the usual care of PAD (care-as-usual, CAU). It is hypothesised that TeGeCoach improves walking impairment and lowers the costs of healthcare that are spent on patients with PAD. Given the size and remote nature of the study (ie, no personal contact to research staff), as well as the pragmatic trial approach (ie, measurement of outcomes should be patient relevant and should not interfere with the usual care),⁶⁰ it was opted to use only patient-reported outcome measures (PROMs), while collecting healthcare utilisation and costs from claims data. PROMs emphasise the patient perspective by collecting information that are directly relevant to the patients; with growing interest in comparative effectiveness research, PROMs are commonly used in clinical trials to measure treatment effects.⁶¹ If effective, TeGeCoach could be widely integrated into PAD usual care with the potential to provide health benefits for patients with PAD while reducing healthcare costs.

METHODS

Trial design

This is a two-arm, parallel-group, open-label, pragmatic, randomised, controlled superiority trial embedded within three German statutory health insurance funds (*KKH Kaufmännische Krankenkasse*, *TK Techniker Krankenkasse* and *mhplus Krankenkasse*). It is designed to compare the effects of TeGeCoach (intervention arm) to the CAU, conducted in a health insurance system-based setting (figure 1). Trial initiation was in 4/2018 and ends in 2/2021. The recruitment period was 9 months (4/2018 to 12/2018; table 1). The study is conducted in full compliance with Good Clinical Practice quality standards and in accordance with the Declaration of Helsinki of 2008.

It is expected that final results are reported after study completion in 2021.

This study protocol is reported in accordance with the CONSOLIDATED STANDARDS OF REPORTING TRIALS (CONSORT) statement,⁶² the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) statement;⁶³ the SPIRIT Patient-Reported Outcome (PRO) extension⁶⁴ and the Template for Intervention Description and Replication checklist.⁶⁵

Patient and public involvement statement

This research was planned without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

Participants

Participants have to meet the following criteria: registered with one of the participating statutory health insurance funds (*KKH Kaufmännische Krankenkasse*, *TK Techniker Krankenkasse* and *mhplus Krankenkasse*); aged between 35 and 80; German-speaking; access to a telephone (land-line or mobile) and a primary or secondary diagnosis of PAD at Fontaine stage IIa (>200m, Fontaine stage IIa) or IIb (<200m, Fontaine stage IIb) within the last 36 months (corresponding ICD-10-German Modification codes I70.21, I70.22 and I73.9). Participants should have no primary or secondary diagnosis of PAD at Fontaine stage I (asymptomatic) within the last 12 months, and no diagnosis of Fontaine stage III (ischaemic rest pain) or IV (ulcer, gangrene) within the last 36 months to increase diagnostic accuracy (corresponding ICD-10-German Modification codes I70.23, I70.24 and I73.25).

Exclusion criteria for participants are immobility that goes beyond claudication (Fontaine stage III or IV; inability to carry out intervention); (chronic) physical conditions that interfere with the intervention (eg, COPD); cognitive disorders (inability to carry out intervention); severe and persistent mental disorders (adherence reasons); suicidality (safety reasons); life-threatening illnesses (safety reasons); active or recent participation in any other PAD intervention trial; ongoing hospitalisation; (self-reported) alcoholism and/or other drug dependency (adherence reasons) and heart failure-graded NYHA classes III and IV (inability to carry out intervention and competing risks).

Recruitment

Participants

Recruitment of participants is managed by three statutory health insurance funds in Germany: *KKH Kaufmännische Krankenkasse*, *TK Techniker Krankenkasse* and *mhplus Krankenkasse*. Eligible participants are retrospectively identified using ICD-10-GM diagnosis codes from inpatient and outpatient encounters, which are routinely collected for reimbursement purposes (claims data). Due to the high

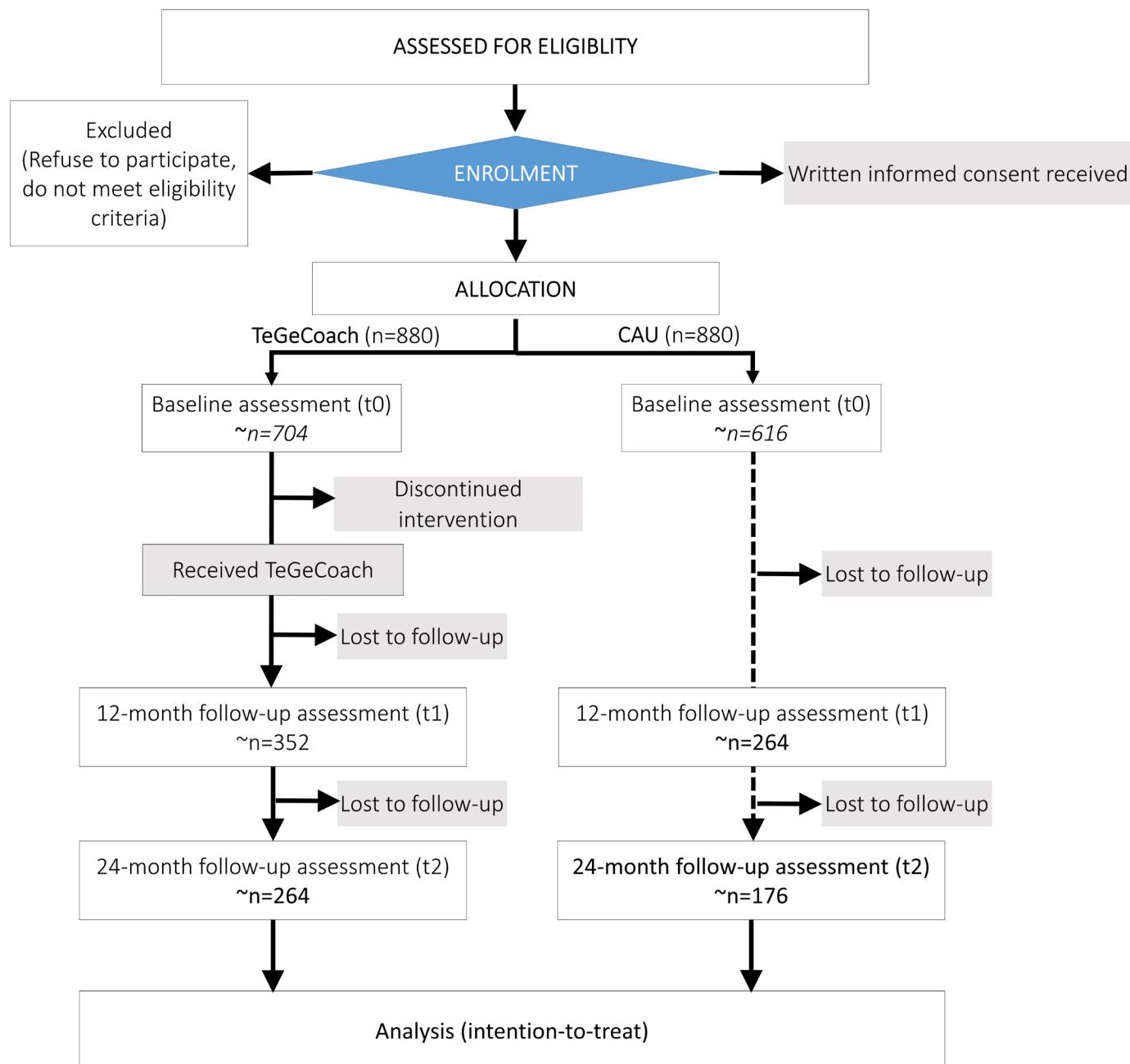


Figure 1 Prospective flow chart of the study design. CAU, usual care of PAD; PAD, peripheral artery disease; TeGeCoach, telemonitored intermittent walking exercise with medical supervision by a physician and telephone health coaching.

number of diagnostic errors and poor coding habits in outpatient settings, exclusion criteria are only checked using inpatient diagnosis codes.

An iterative recruitment process was developed, as substantial challenges to the recruitment of clinical trials have been shown in the PAD population.⁶⁶ Eligible participants are contacted by their health insurance fund to explain the purpose of the study and to confirm their PAD diagnosis by questioning them about their symptoms. Eligible participants receive a study information letter that is supplemented with consent and permission forms (ie, authorisation for release of medical reports by the contracted physician to the health coach). If interested to participate, they are asked to sign all documents and send

them back to their health insurance fund. Eligible non-responders who are still interested in the study but have not given written consent are followed up by phone to be reminded of the trial. Once the written consent has been received, a query is submitted to the data warehouse of the respective health insurance fund which automatically assigns a pseudonym to the participant. No participant will be enrolled without full, written informed consent.

Physicians

Each participant allocated to TeGeCoach must be medically supervised by a physician, which is a prerequisite for receiving the TeGeCoach intervention; participants can elect their preferred physician prior to programme start,

Table 1 Trial registration data

Data category	Information
Primary registry and trial identifying number	ClinicalTrials.gov (NCT03496948)
Date of registration in primary registry	23 March 2018
Source(s) of monetary or material support	Innovation Fund, Federal Joint Committee (G-BA)
Trial sponsor	KKH Kaufmännische Krankenkasse
Contact for public queries	FB (frank.bienert@kkh.de), KKH Kaufmännische Krankenkasse
Contact for scientific queries	FR (f.rezvani@uke.de), University Medical Center Hamburg-Eppendorf
Public title	TeGeCoach—a home-based exercise programme using telephone health coaching with telemonitoring for patients with peripheral artery disease
Scientific title	Telephone health coaching with exercise monitoring using wearable activity trackers (TeGeCoach) for improving walking impairment in peripheral artery disease: study protocol for a randomised controlled trial
Countries of recruitment	Germany
Health condition(s) or problem(s) studied	Peripheral artery disease (PAD)
Intervention(s)	Active comparator: telemonitored intermittent walking exercise with medical supervision by a physician and telephone health coaching (TeGeCoach) Active comparator: care-as-usual (CAU)
Key inclusion and exclusion criteria	<p>Ages eligible for study: ≥ 35 years and ≤ 80 years</p> <p>Sexes eligible for study: both</p> <p>Accepts healthy volunteers: no</p> <p><i>Inclusion criteria:</i> ≥ 35 years and ≤ 80 years, insured at one of the participating statutory health insurance funds, access to a telephone, primary or secondary diagnosis of PAD at Fontaine stage IIa/b within the last 36 months, no primary or secondary diagnosis of PAD at Fontaine stage I within the last 12 months, no diagnosis of Fontaine stage III/IV within the last 36 months</p> <p><i>Exclusion criteria:</i> immobility that goes beyond claudication, inability to carry out intervention (chronic) physical conditions that interfere with the intervention, cognitive disorders, severe and persistent mental disorders, suicidality, life-threatening illnesses, active or recent participation in any other PAD intervention trial, ongoing hospitalisation, alcoholism and/or other drug dependency, heart failure graded NYHA classes III and IV</p>
Study type	<p>Interventional</p> <p>Allocation: randomised</p> <p>Intervention model: parallel assignment masking: analysis blinding</p> <p>Primary purpose: prevention</p>
Date of first enrolment	April 2018
Target sample size	1760
Recruitment status	Completed
Primary outcome(s)	<p><i>PROM:</i> walking impairment</p> <p><i>Time points:</i> baseline, 12 and 24 months</p>
Key secondary outcomes	<p><i>PROMs:</i> generic health-related quality of life, PAD-specific quality of life, depression, generalised anxiety disorder, alcohol use, nicotine dependence, health literacy, patient activation</p> <p><i>Claims data:</i> total healthcare costs, healthcare resource use, (severe) adverse events</p> <p><i>Time points:</i> baseline, 12 and 24 months</p>

NYHA, New York Heart Association; PROM, patient-reported outcome measures.

or are alternatively referred to an already contracted physician by their health coach. To encourage physicians to participate, they enter into an integrated care contract with the respective health insurance fund that

provides financial incentives for the delivery of special medical services throughout the intervention.⁶⁷ The enrolment and reimbursement of contracted physicians is coordinated by medical networks (Kassel, Germany), a

company that is specialised on the management of integrated care programmes within the §140a volume V of the German Social Security Code. If the physician of choice refuses to participate, the participant is referred to a nearby contracted physician who has already entered into the integrated care contract. Once enrolled, the health coach contacts the contracted physician to discuss their tasks during the course of the study. Due to recruitment barriers, it is possible that no suitable physician can be found for the patient by the end of the recruitment phase. For safety reasons, participants for whom no physician can be appointed do not receive TeGeCoach.

Treatment allocation and blinding

Participants are allocated in a 1:1 ratio to either the TeGeCoach or CAU group, stratified by health coaching centre using a permuted block method within each stratum. In order to prevent selection bias and to eliminate any predictability (allocation concealment), participants are randomly allocated via Sealed Envelope (London, UK), a secure internet-based randomisation service including concealment, stratification and blocking for each health coaching site.

Blinding of care providers (health coaches and contracted physicians) and participants is not possible because of obvious differences between the TeGeCoach intervention and CAU. However, as supported by the CONSORT guidelines, blinding of the analysis is achieved by engaging an independent data analyst and by withholding information about how the groups were coded before analytical decisions have been completed.⁶⁸

Interventions

TeGeCoach

TeGeCoach is a 12-month long-structured HEP that is designed to inspire healthy habits in patients with PAD based on the transtheoretical model of behaviour change. The main strategies used to improve health outcomes include patient-centred motivational interviewing, shared decision making and active listening, aiming to help patients to enhance their individual motivation for exercise and receive the support needed to improve their condition.

Telemonitored intermittent walking exercise

Patients are instructed to continuously wear an activity tracker device (ie, from getting up to going to bed; not while showering, bathing and swimming). Two different brands of activity tracker are used that record the number of steps (*KKH Krankenkasse* and *mhplus Krankenkasse*: AS 95 Pulse by Beurer; *TK Techniker Krankenkasse*: Mi Band 2 by Xiaomi). The data from the activity tracker are transmitted automatically to the health coaching platform once per day over the internet using a SIM card modem (econnect, IEM GmbH). A 60-min baseline assessment is initially taken to evaluate the patient's individual walking capacity whereby patients are instructed to walk at a brisk pace (defined as >50 steps/min) until maximal tolerable

claudication pain is reached, followed by breaks and continued walking when the pain subsides (intermittent walking). The net brisk walking time (>50 steps/min) during the 60min baseline assessment is used to assign patients to one of three intermittent walking plans of increasing duration; the patient is assigned to level A (15-min exercise, including breaks) if he/she is able to walk less than 15min during the baseline assessment, level B (30-min exercise, including breaks) if he/she is able to walk 15–30min, and level C (60-min exercise, including breaks) if he/she is able to walk 30–60min. Patients are instructed to walk intermittently at a brisk pace (>50 steps/min) on at least 5 days per week. The assignment to one of the training levels is not conclusive; the coach regularly reviews, and if necessary, adjusts the walking plan after every coaching session. The goal is to progressively increase walking intervals and shortening breaks until painless walking exercise (or bearable pain) without breaks needed has been achieved by the patient, suggesting to switch to the next training level. In addition to exercise sessions, the health coach also sees the absolute number of steps per day as a measure of overall physical activity. To ensure patient safety, the contracted physician initially reviews the proposed exercise plan, checks if any contraindications to exercise exist and whether all important comorbidities such as high blood pressure, diabetes and coronary heart disease are sufficiently treated. Furthermore, they receive three health reports from the health coach during the course of the programme, which are important for the joint exchange of information to provide collaborative care.

Telephone health coaching

Over the course of 12 months, patients regularly receive health information leaflets and have up to nine structured 30–60min phone calls with their health coach. During these structured phone calls, the health coach and the patient jointly discuss the progress towards exercise goals and review the activity tracker data to check whether the patient adheres to the walking plan. For this purpose, exercise sessions (ie, intermittent walking represented as changes between walking and break intervals) are visualised and automatically identified as an exercise session by the health coaching platform. Additional phone calls are warranted when no data have been received, no steps were taken or when coaches are alerted that the amount of exercise days has fallen below an individual threshold. During these calls, barriers like lack of motivation, exercise intolerance or technical issues are discussed and how they can be overcome through behavioural support. Along with the walking exercise, patient-tailored topics of interest that are relevant to the management of PAD are discussed in order to improve health literacy, to facilitate patient empowerment and to adopt a proactive stance in dealing with their disease. The health coaching curriculum includes knowledge of PAD, PAD medication, comorbidities of PAD and other related health topics (eg, tobacco use and nutrition). The

health coaches use an electronic documentation system to monitor the coaching process (*KKH Kaufmännische Krankenkasse* and *mhplus Krankenkasse*. Picama Managed Care, Trustner GmbH; *TK Techniker Krankenkasse*. Philips GmbH Market DACH). The telephone health coaching is carried out by three health coaching centres that are located throughout Germany, each affiliated to one of the three statutory health insurance funds (Health Coaching Center of *KKH Kaufmännische Krankenkasse*, Telemedical Center at Robert-Bosch-Hospital on behalf of *TK Techniker Krankenkasse*, Health Coaching Center of *mhplus Krankenkasse*) and are staffed with licensed health workers (eg, nurses, physical therapists and medical assistants). To ensure high-quality health coaching, health coaches are regularly supervised by a team of experts and receive 51 hours of training, including 19 hours of programme training, 7 hours of medical training, 8 hours of group supervision and 1 hour of individual supervision. Compliance to coaching guidelines are continuously monitored and reviewed. In addition to the structured TeGeCoach intervention, participants have regular access to CAU as described below.

After 12 months, there is an additional 12 months of unstructured follow-up in which patients have no interaction with their health coach but still have access to their activity tracker device, which they may continue to use to self-monitor their physical activity.

Care as usual

Patients allocated to CAU receive usual medical care through the regular statutory healthcare system. Additionally, participants receive PAD patient information leaflets from their statutory health insurance fund, with each health insurance fund providing its own leaflets. These leaflets provide information about course offerings of the respective health insurance fund to encourage regular exercise and to promote lifestyle changes, including SEPs (vascular and cardio exercise), physical therapy, nutritional assistance programmes, smoking cessation programmes, weight loss programmes, as well as patient education programmes for obesity and diabetes. It is thereby ensured that participants allocated to CAU receive genuine usual care as supplied in everyday practice.

Outcome measures

Outcome measures are listed in [table 2](#) along with timing of assessment; the effectiveness of TeGeCoach is measured based on PROMs, claims data and activity tracker data. PROMs are collected at baseline (t0), at 12 (t1) and 24 (t2) months.

Primary outcomes

- ▶ *PROM*: walking impairment (WIQ).^{69–72}

Secondary outcomes

- ▶ *PROMs*: generic health-related quality of life (EQ5D-5L and SF-12 questionnaires);^{73–76} PAD-specific quality of life (VascuQoL-25 questionnaire);^{77 78} depression

Table 2 Participant timeline: time schedule of enrolment (eligibility screen, informed consent, pseudonymisation and allocation), study arms (TeGeCoach or CAU) and measurements (questionnaires and claims data)

	Study period			
	Enrolment	Allocation	Postallocation	
Time point*	t1	t0	t1	t2
Enrolment				
Eligibility screening (claims data)	X			
Informed consent	X			
Pseudonymisation		X		
Allocation		X		
Study arms				
TeGeCoach (intervention)		◆-----◆-----◆		
CAU (control)			----->	
Measurements				
Intervention and control arm				
PROMs (questionnaires)†		X	X	X
Cost and medical outcomes (claims data)‡		◆-----◆-----◆		
Intervention arm only				
ZAPA questionnaire			X	
Walking exercise parameters (activity tracker data)§		◆-----◆		

*t1, ~1 month before patient in; t0, baseline; t1, 12-month follow-up; t2, 24-month follow-up.

†WIQ, EQ5D-5L, SF-12, VascuQoL-25, PHQ-9, GHD-7, AUDIT-C, FTND, HLQ, PAM-13.

‡Healthcare costs, healthcare resource use (severe) adverse events.

§Exercise adherence, amount of steps/net walking time (>50 steps/min) per day/week. AUDIT-C, Alcohol Use Disorders Identification Test; CAU, care-as-usual; EQ5D-5L, ; FTND, ; GAD-7, Generalized Anxiety Disorder-7; HLQ, Health Literacy Questionnaire; PAM-13, Patient Activation Measure; PHQ-9, Patient Health Questionnaire-9; PROMs, patient-reported outcome measures; SF-12, 12-Item Short Form Health Survey; VascuQoL-25, 25-item Vascular Quality of Life Questionnaire; WIQ, Walking Impairment Questionnaire; ZAPA, Satisfaction with Outpatient Care with Focus on Patient Participation.

(PHQ-9 questionnaire);⁷⁹ generalised anxiety disorder (GAD-7 questionnaire);^{80 81} alcohol use (AUDIT-C questionnaire);^{82–84} nicotine dependence (FTND);⁸⁵ health literacy (HLQ);^{86 87} patient activation (PAM-13 questionnaire).^{88 89}

- ▶ *Claims data*: Total healthcare costs, that is, inpatient hospital care costs; outpatient (ambulatory) services and primary care costs, costs for drugs and other medical supplies, sick pay costs; healthcare resource use, that is, time period until hospitalisation, probability of hospitalisation, number and duration of inpatient hospitalisation, outpatient medical treatment, drug dose; (severe) adverse events, that is, death, amputation and revascularisation (see online supplementary file).

Additional outcomes (intervention arm only)

- ▶ *PROM*: patient satisfaction (ZAPA questionnaire).⁹⁰
- ▶ *Activity tracker data*: exercise adherence, for example, number of alerts and corresponding phone calls made when step frequency or the duration of exercise sessions fall below an individual threshold range;

amount of steps/net walking time (>50 steps/min) per day/week.

Sample size

To find a 'meaningful' effect that is clinically relevant, practicable and economically feasible, the sample size is calculated based on the distribution-based minimal clinically relevant difference (MCID) for small changes on the WIQ following 3 months of a structured HEP that have been determined in previous studies (WIQ speed MCID: 6%; WIQ distance MCID: 5%; WIQ stair climbing MCID: 5%).⁹¹ As TeGeCoach is more intensive and longer, a small-to-moderate group difference was estimated ($f=0.15$), while accounting for the inherited heterogeneity of this pragmatic trial that could lead to a dilution of the treatment effect. Assuming a response rate of 30% (TeGeCoach) and 20% (CAU) from baseline 24-month follow-up (t_2),^{43 92} a sample size of 1760 (880 per group) is required to have 176 and 264 participants at t_2 in the CAU and intervention arm, respectively, which is sufficient to detect the estimated small-to-moderate effect with 80% power and a 5% level of significance (Gpower V.3.1.9.2).

Data collection and management

Data management and storage are carried out in compliance with the General Data Protection Regulation in the European Union and Good Scientific Practice guidelines by the German Research Foundation.⁹³ To ensure confidentiality, all data are collected, processed, analysed and stored in deidentified form by replacing personally identifying information of each participant with a unique patient identification number (ie, by pseudonymisation), which allows to combine data from multiple sources and to merge longitudinal data. Linkage to an identity (depseudonymization) is not possible without a separately stored pseudonymisation key, which is protected by technical and organisational measures.

At each study point, the data coordinators of the health insurance funds send out a set of paper-based questionnaires (PROMs) to the participants. Participants are asked to send them back to the Department of Medical Psychology at the University Medical Center Hamburg-Eppendorf. To maximise response rates, participants who have not send their questionnaire back in time receive a postal reminder after 2–4 weeks. All participants are followed up at t_1 and t_2 , irrespective of whether questionnaires have been returned at previous study points. Questionnaire data are entered into an electronic database, with only authorised personnel being allowed to retrieve, enter or change data. For data quality and monitoring purposes, validation checks regarding out of range data, illogical and invalid responses and data entry errors are performed.

Claims data are routinely collected for the purpose of billing and contains information on all contacts with the healthcare system including ICD codes, operations and procedure key codes (the German equivalent to the

American procedure coding system), medication prescriptions and amount of sick leaves. After study completion, the health insurance funds assemble and pseudonymise the claims data and send it to the study team (University Medical Center Hamburg-Eppendorf). No individual insurance information can be identified from this data.

Activity tracker data are automatically uploaded to the electronic documentation system via SIM card modem (econnect, IEM GmbH) once per day. The statutory health insurance funds share the activity tracker data with the study team in pseudonymised form.

All data are stored for a maximum of 10 years, securely locked in cabinets and saved on password-protected computers in areas with restricted access. Personally identifiable information of participants and pseudonymisation keys are only accessible to the data coordinators at each health insurance fund. The pseudonymisation keys are deleted 2 years after study completion so that virtually from this point all data are fully anonymised. Regarding dissemination, all publicly available data are fully anonymised and do not disclose identities. Participants have the right to be informed about their data. If a participant decides to withdraw from the trial prematurely, the data already collected may be used, unless revoking their informed consent. Deletion of the data cannot be requested if the data have already been anonymised.

Statistical analysis

Analyses are by intention-to-treat in accordance with the CONSORT guidelines, that is, participants who do not adhere to or withdraw from the prescribed TeGeCoach intervention and for whom no doctor could be appointed (see the 'Recruitment' section) are included in the analyses as randomised. For questionnaire data, changes from baseline to follow-up measurements are compared between study arms using linear mixed models.⁹⁴ Single imputation using the Expected-Maximisation algorithm are applied for item-level missing data. Scale-level imputation of missing data is not necessary since this is fully handled by estimating mixed models with full information maximum likelihood.^{95 96} In order to take correlation between the observations into account, models are adjusted for participant and health coaching centre characteristics. For claims data, changes over time between groups are compared between study arms using random-effects regression models (difference-in-differences method) after eliminating differences in observable baseline characteristics between groups with the use of entropy balancing.⁹⁷ Entropy balancing allows a better balancing compared with conventional processes such as propensity matching. Tests of treatment effects are conducted at a two-sided significance level of 0.05. In order to check the robustness of the results, subgroup analyses are performed to determine the influence of baseline characteristics (eg, degree of walking impairment), health insurance fund (ie, *KKH Kaufmännische Krankenkasse*, *TK Techniker Krankenkasse* and *mhplus Krankenkasse*) and type of analysis (ie, intention-to-treat and per-protocol).

Data monitoring and harms

This trial is not monitored by a data monitoring committee, and no interim analyses are performed as TeGeCoach is a low risk, non-invasive intervention with no identifiable risks. Over the course of the intervention, participants allocated to TeGeCoach are medically monitored by their treating physician while having regular access to the usual care of PAD. The risks from the use of wearable activity trackers is low; all devices have been certified and conform to health, safety and environmental protection standards for products sold within the European Union (CE certificate).

Ethics and dissemination

The informed consent forms and all other documents that are handed out to the participants have been reviewed and approved by the ethical review bodies (Medical Association Hamburg; reference number: PV5708). The ethics committee will be informed in case of any amendments made to the study protocol or informed consent forms.

Findings are disseminated widely through peer-reviewed manuscripts published in scientific journals, reports to the funding body, international conference presentations and media press releases. Furthermore, the study team realises the value of open science and feels committed to information exchange through data being accessible to the research community. Therefore, in an attempt to tackle the problem of hidden data, deidentified participant data from this trial are made available to the public and the medical research community on reasonable request to the corresponding author.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval Ethical approval has been obtained at the ethics committee of the Medical Association Hamburg (Ärztammer Hamburg; reference number: PV5708).

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Data availability statement None.

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REFERENCES

- Criqui MH, Aboyans V. Epidemiology of peripheral artery disease. *Circ Res* 2015;116:1509–26.
- Fowkes FGR, Rudan D, Rudan I, *et al*. Comparison of global estimates of prevalence and risk factors for peripheral artery disease in 2000 and 2010: a systematic review and analysis. *The Lancet* 2013;382:1329–40.
- McDermott MM, Liu K, Greenland P, *et al*. Functional decline in peripheral arterial disease: associations with the ankle brachial index and leg symptoms. *JAMA* 2004;292:453–61.
- Nehler MR, Duval S, Diao L, *et al*. Epidemiology of peripheral arterial disease and critical limb ischemia in an insured national population. *J Vasc Surg* 2014;60:686–95.
- Criqui MH, McClelland RL, McDermott MM, *et al*. The Ankle-brachial index and incident cardiovascular events in the MESA (multi-ethnic study of atherosclerosis). *J Am Coll Cardiol* 2010;56:1506–12.
- Criqui MH, Ninomiya JK, Wingard DL, *et al*. Progression of peripheral arterial disease predicts cardiovascular disease morbidity and mortality. *J Am Coll Cardiol* 2008;52:1736–42.
- Malyar N, Fürstenberg T, Wellmann J, *et al*. Recent trends in morbidity and in-hospital outcomes of in-patients with peripheral arterial disease: a nationwide population-based analysis. *Eur Heart J* 2013;34:2706–14.
- Eraso LH, Fukaya E, Mohler ER, *et al*. Peripheral arterial disease, prevalence and cumulative risk factor profile analysis. *Eur J Prev Cardiol* 2014;21:704–11.
- Joosten MM, Pai JK, Bertoia ML, *et al*. Associations between conventional cardiovascular risk factors and risk of peripheral artery disease in men. *JAMA* 2012;308:1660–7.
- Hamburg NM, Creager MA. Pathophysiology of intermittent claudication in peripheral artery disease. *Circ J* 2017;81:281–9.
- Hiatt WR, Armstrong EJ, Larson CJ, *et al*. Pathogenesis of the limb manifestations and exercise limitations in peripheral artery disease. *Circ Res* 2015;116:1527–39.
- Gardner AW, Montgomery PS, Wang M, *et al*. Predictors of health-related quality of life in patients with symptomatic peripheral artery disease. *J Vasc Surg* 2018;68:1126–34.
- Maksimovic M, Vlainjac H, Marinkovic J, *et al*. Health-Related quality of life among patients with peripheral arterial disease. *Angiology* 2014;65:501–6.
- Regensteiner JG, Hiatt WR, Coll JR, *et al*. The impact of peripheral arterial disease on health-related quality of life in the peripheral arterial disease awareness, risk, and treatment: new resources for survival (partners) program. *Vasc Med* 2008;13:15–24.
- Smolderen KG, Hoeks SE, Pedersen SS, *et al*. Lower-leg symptoms in peripheral arterial disease are associated with anxiety, depression, and anhedonia. *Vasc Med* 2009;14:297–304.
- Haas TL, Lloyd PG, Yang H-T, *et al*. Exercise training and peripheral arterial disease. *Compr Physiol* 2012;2:2933–3017.
- Hamburg NM, Balady GJ. Exercise rehabilitation in peripheral artery disease: functional impact and mechanisms of benefits. *Circulation* 2011;123:87–97.
- Guidon M, McGee H. Exercise-based interventions and health-related quality of life in intermittent claudication: a 20-year (1989–2008) review. *Eur J Cardio Prevention Rehabilitation* 2010;17:140–54.
- Lane R, Harwood A, Watson L, *et al*. Exercise for intermittent claudication. *Cochrane Database Syst Rev* 2017;12:CD000990.
- Gerhard-Herman MD, Gornik HL, Barrett C, *et al*. 2016 AHA/ACC guideline on the management of patients with lower extremity peripheral artery disease: Executive summary: a report of the American College of Cardiology/American heart association Task force on clinical practice guidelines. *Circulation* 2017;135:e686–725.
- Lawall H, Huppert P, Espinola-Klein C, *et al*. The diagnosis and treatment of peripheral arterial vascular disease. *Dtsch Arztebl Int* 2016;113:729–36.

- 22 Aboyans V, Ricco J-B, Bartelink M-LEL, *et al.* 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS): Document covering atherosclerotic disease of extracranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteries. Endorsed by: the European Stroke Organization (ESO) The Task Force for the Diagnosis and Treatment of Peripheral Arterial Diseases of the European Society of Cardiology (ESC) and of the European Society for Vascular Surgery (ESVS). *European Heart Journal* 2017;39:763–816.
- 23 Harwood A-E, Smith GE, Cayton T, *et al.* A systematic review of the uptake and adherence rates to supervised exercise programs in patients with intermittent claudication. *Ann Vasc Surg* 2016;34:280–9.
- 24 Makris GC, Lattimer CR, Lavida A, *et al.* Availability of supervised exercise programs and the role of structured home-based exercise in peripheral arterial disease. *Eur J Vasc Endovasc Surg* 2012;44:569–75.
- 25 McDermott MM, Polonsky TS. Home-Based exercise: a therapeutic option for peripheral artery disease. *Circulation* 2016;134:1127–9.
- 26 Golledge J, Singh TP, Alahakoon C, *et al.* Meta-Analysis of clinical trials examining the benefit of structured home exercise in patients with peripheral artery disease. *Br J Surg* 2019;106:319–31.
- 27 Harwood AE, Hitchman LH, Ingle L, *et al.* Preferred exercise modalities in patients with intermittent claudication. *Journal of Vascular Nursing* 2018;36:81–4.
- 28 Hageman D, Fokkenrood HJ, Gommans LN, *et al.* Supervised exercise therapy versus home-based exercise therapy versus walking advice for intermittent claudication. *Cochrane Database Syst Rev* 2018;4:CD005263.
- 29 Al-Jundi W, Madbak K, Beard JD, *et al.* Systematic review of home-based exercise programmes for individuals with intermittent claudication. *Eur J Vasc Endovasc Surg* 2013;46:690–706.
- 30 Bäck M, Jivegård L, Johansson A, *et al.* Home-Based supervised exercise versus hospital-based supervised exercise or unsupervised walk advice as treatment for intermittent claudication: a systematic review. *J Rehabil Med* 2015;47:801–8.
- 31 McDermott MM, Liu K, Guralnik JM, *et al.* Home-Based walking exercise intervention in peripheral artery disease: a randomized clinical trial. *JAMA* 2013;310:57–65.
- 32 McDermott MM, Guralnik JM, Criqui MH, *et al.* Home-Based walking exercise in peripheral artery disease: 12-Month Follow-up of the goals randomized trial. *J Am Heart Assoc* 2014;3:e000711.
- 33 Collins TC, Lunos S, Carlson T, *et al.* Effects of a home-based walking intervention on mobility and quality of life in people with diabetes and peripheral arterial disease: a randomized controlled trial. *Diabetes Care* 2011;34:2174–9.
- 34 Cunningham MA, Swanson V, O'Carroll RE, *et al.* Randomized clinical trial of a brief psychological intervention to increase walking in patients with intermittent claudication. *Br J Surg* 2012;99:49–56.
- 35 Cunningham MA, Swanson V, Holdsworth RJ, *et al.* Late effects of a brief psychological intervention in patients with intermittent claudication in a randomized clinical trial. *Br J Surg* 2013;100:756–60.
- 36 Mays RJ, Hiatt WR, Casserly IP, *et al.* Community-Based walking exercise for peripheral artery disease: an exploratory pilot study. *Vasc Med* 2015;20:339–47.
- 37 Gardner AW, Parker DE, Montgomery PS, *et al.* Step-Monitored home exercise improves ambulation, vascular function, and inflammation in symptomatic patients with peripheral artery disease: a randomized controlled trial. *J Am Heart Assoc* 2014;3:e001107.
- 38 Gardner AW, Parker DE, Montgomery PS, *et al.* Efficacy of quantified home-based exercise and supervised exercise in patients with intermittent claudication. *Circulation* 2011;123:491–8.
- 39 Duscha BD, Piner LW, Patel MP, *et al.* Effects of a 12-week mHealth program on Functional Capacity and physical activity in patients with Peripheral Artery disease. *Am J Cardiol* 2018;122:879–84.
- 40 Tew GA, Humphreys L, Crank H, *et al.* The development and pilot randomised controlled trial of a group education programme for promoting walking in people with intermittent claudication. *Vascular Medicine* 2015;20:348–57.
- 41 Mays RJ, Rogers RK, Hiatt WR, *et al.* Community walking programs for treatment of peripheral artery disease. *J Vasc Surg* 2013;58:1678–87.
- 42 Ware JH, Hamel MB. Pragmatic trials — guides to better patient care? *N Engl J Med* 2011;364:1685–7.
- 43 Dwinger S, Dirmaier J, Herbarth L, *et al.* Telephone-based health coaching for chronically ill patients: study protocol for a randomized controlled trial. *Trials* 2013;14:337.
- 44 Härter M, Dirmaier J, Dwinger S, *et al.* Effectiveness of Telephone-Based health coaching for patients with chronic conditions: a randomised controlled trial. *PLoS One* 2016;11:e0161269.
- 45 Härter M, Dwinger S, Seebauer L, *et al.* Evaluation of telephone health coaching of German health insurers with chronic conditions. *Health Educ J* 2013;72:622–34.
- 46 Dennis SM, Harris M, Lloyd J, *et al.* Do people with existing chronic conditions benefit from telephone coaching? a rapid review. *Australian Health Review* 2013;37:381–8.
- 47 Eakin EG, Lawler SP, Vandelanotte C, *et al.* Telephone interventions for physical activity and dietary behavior change. *Am J Prev Med* 2007;32:419–34.
- 48 McDermott MM, Spring B, Berger JS, *et al.* Effect of a home-based exercise intervention of wearable technology and telephone coaching on walking performance in peripheral artery disease. *JAMA* 2018;319:1665–76.
- 49 Parmenter BJ, Dieberg G, Smart NA. Exercise training for management of peripheral arterial disease: a systematic review and meta-analysis. *Sports Med* 2015;45:231–44.
- 50 Lewis ZH, Lyons EJ, Jarvis JM, *et al.* Using an electronic activity monitor system as an intervention modality: a systematic review. *BMC Public Health* 2015;15:585.
- 51 Bravata DM, Smith-Spangler C, Sundaram V, *et al.* Using Pedometers to increase physical activity and improve health. *JAMA* 2007;298:2296–304.
- 52 Harris T, Limb ES, Hosking F, *et al.* Effect of pedometer-based walking interventions on long-term health outcomes: prospective 4-year follow-up of two randomised controlled trials using routine primary care data. *PLoS Med* 2019;16:e1002836.
- 53 Haveman ME, Kleiss SF, Ma KF, *et al.* Telemedicine in patients with peripheral arterial disease: is it worth the effort? *Expert Rev Med Devices* 2019;16:777–86.
- 54 O'Brien T, Troutman-Jordan M, Hathaway D, *et al.* Acceptability of wristband activity trackers among community dwelling older adults. *Geriatr Nurs* 2015;36:S21–5.
- 55 Cadmus-Bertram LA, Marcus BH, Patterson RE, *et al.* Randomized trial of a Fitbit-based physical activity intervention for women. *Am J Prev Med* 2015;49:414–8.
- 56 Ehn M, Eriksson LC, Åkerberg N, *et al.* Activity monitors as support for older persons' physical activity in daily life: qualitative study of the users' experiences. *JMIR mHealth and uHealth* 2018;6:e34.
- 57 Kononova A, Li L, Kamp K, *et al.* The use of wearable activity trackers among older adults: focus group study of tracker perceptions, motivators, and barriers in the maintenance stage of behavior change. *JMIR mHealth and uHealth* 2019;7:e9832.
- 58 Normahani P, Kwasnicki R, Bicknell C, *et al.* Wearable sensor technology efficacy in peripheral vascular disease (wSTEP): a randomized controlled trial. *Ann Surg* 2018;268:1113–8.
- 59 Lyons EJ, Swartz MC, Lewis ZH, *et al.* Feasibility and acceptability of a wearable technology physical activity intervention with telephone counseling for mid-aged and older adults: a randomized controlled pilot trial. *JMIR mHealth Uhealth* 2017;5:e28.
- 60 Loudon K, Treweek S, Sullivan F, *et al.* The PRECIS-2 tool: designing trials that are fit for purpose. *BMJ* 2015;350:h2147.
- 61 Deshpande P, Sudeepthi BLakshmi, Rajan S, *et al.* Patient-Reported outcomes: a new era in clinical research. *Perspect Clin Res* 2011;2:137–44.
- 62 Schulz KF, Altman DG, Moher D. Consort 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMC Med* 2010;8:18.
- 63 Chan A-W, Tetzlaff JM, Altman DG, *et al.* Spirit 2013 statement: defining standard protocol items for clinical trials. *Ann Intern Med* 2013;158:200–7.
- 64 Calvert M, Kyte D, Mercieca-Bebber R, *et al.* Guidelines for inclusion of patient-reported outcomes in clinical trial protocols. *JAMA* 2018;319:483–94.
- 65 Hoffmann TC, Glasziou PP, Boutron I, *et al.* Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ* 2014;348:g1687.
- 66 Guidon M, McGee H. Recruitment to clinical trials of exercise: challenges in the peripheral arterial disease population. *Physiotherapy* 2013;99:305–10.
- 67 Rahman S, Majumder A, Shaban S, *et al.* Physician participation in clinical research and trials: issues and approaches. *Adv Med Educ Pract* 2011;2:85.
- 68 Polit DF. Blinding during the analysis of research data. *Int J Nurs Stud* 2011;48:636–41.
- 69 Regensteiner JG, Steiner JF, Panzer RJ, *et al.* Evaluation of walking impairment by questionnaire in patients with peripheral Arterial-Disease. *Clin Res* 1990;38:A515–A15.

- 70 McDermott MM, Liu K, Guralnik JM, *et al.* Measurement of walking endurance and walking velocity with questionnaire: validation of the walking impairment questionnaire in men and women with peripheral arterial disease. *J Vasc Surg* 1998;28:1072–81.
- 71 Sagar SP, Brown PM, Zelt DT, *et al.* Further clinical validation of the walking impairment questionnaire for classification of walking performance in patients with peripheral artery disease. *Int J Vasc Med* 2012;2012:1–10.
- 72 Nicolai SPA, Kruidenier LM, Rouwet EV, *et al.* The walking impairment questionnaire: an effective tool to assess the effect of treatment in patients with intermittent claudication. *J Vasc Surg* 2009;50:89–94.
- 73 Herdman M, Gudex C, Lloyd A, *et al.* Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Qual Life Res* 2011;20:1727–36.
- 74 Ware J, Kosinski M, Keller SD. A 12-Item short-form health survey: construction of scales and preliminary tests of reliability and validity. *Med Care* 1996;34:220–33.
- 75 Gandek B, Ware JE, Aaronson NK, *et al.* Cross-Validation of item selection and scoring for the SF-12 health survey in nine countries: results from the IQOLA project. International quality of life assessment. *J Clin Epidemiol* 1998;51:1171–8.
- 76 Hinz A, Kohlmann T, Stöbel-Richter Y, *et al.* The quality of life questionnaire EQ-5D-5L: psychometric properties and normative values for the general German population. *Qual Life Res* 2014;23:443–7.
- 77 Morgan MBF, Crayford T, Murrin B, *et al.* Developing the vascular quality of life questionnaire: a new disease-specific quality of life measure for use in lower limb ischemia. *J Vasc Surg* 2001;33:679–87.
- 78 Mehta T, Venkata Subramaniam A, Chetter I, *et al.* Assessing the validity and responsiveness of disease-specific quality of life instruments in intermittent claudication. *Eur J Vasc Endovasc Surg* 2006;31:46–52.
- 79 Kroenke K, Spitzer RL. The PHQ-9: a new depression diagnostic and severity measure. *Psychiatr Ann* 2002;32:509–15.
- 80 Spitzer RL, Kroenke K, Williams JBW, *et al.* A brief measure for assessing generalized anxiety disorder. *Arch Intern Med* 2006;166:1092–7.
- 81 Löwe B, Decker O, Müller S, *et al.* Validation and standardization of the generalized anxiety disorder screener (GAD-7) in the general population. *Med Care* 2008;46:266–74.
- 82 Bush K, Kivlahan DR, McDonell MB, *et al.* The audit alcohol consumption questions (AUDIT-C): an effective brief screening test for problem drinking. ambulatory care quality improvement project (ACQUIP). alcohol use disorders identification test. *Arch Intern Med* 1998;158:1789–95.
- 83 Bradley KA, DeBenedetti AF, Volk RJ, *et al.* AUDIT-C as a brief screen for alcohol misuse in primary care. *Alcoholism: Clinical and Experimental Research* 2007;31:1208–17.
- 84 Dybek I, Bischof G, Grothues J, *et al.* The reliability and validity of the alcohol use disorders identification test (audit) in a German general practice population sample. *J Stud Alcohol* 2006;67:473–81.
- 85 Heatherton TF, Kozlowski LT, Frecker RC, *et al.* The Fagerstrom test for nicotine dependence: a revision of the Fagerstrom tolerance questionnaire. *Addiction* 1991;86:1119–27.
- 86 Osborne RH, Batterham RW, Elsworth GR, *et al.* The grounded psychometric development and initial validation of the health literacy questionnaire (HLQ). *BMC Public Health* 2013;13:658.
- 87 Nolte S, Osborne RH, Dwingler S, *et al.* German translation, cultural adaptation, and validation of the health literacy questionnaire (HLQ). *PLoS One* 2017;12:e0172340.
- 88 Hibbard JH, Mahoney ER, Stockard J, *et al.* Development and testing of a short form of the patient activation measure. *Health Serv Res* 2005;40:1918–30.
- 89 Zill JM, Dwingler S, Kriston L, *et al.* Psychometric evaluation of the German version of the patient activation measure (PAM13). *BMC Public Health* 2013;13:1027.
- 90 Scholl I, Hölzel L, Härter M, *et al.* Fragebogen Zur zufriedenheit in Der ambulanten versorgung—schwerpunkt patientenbeteiligung (ZapA). *Klinische Diagnostik und Evaluation* 2011;4:50–62.
- 91 Gardner AW, Montgomery PS, Wang M. Minimal clinically important differences in treadmill, 6-minute walk, and patient-based outcomes following supervised and home-based exercise in peripheral artery disease. *Vasc Med* 2018;23:349–57.
- 92 Asch DA, Jedrzejewski MK, Christakis NA. Response rates to mail surveys published in medical journals. *J Clin Epidemiol* 1997;50:1129–36.
- 93 Deutsche Forschungsgemeinschaft. *Sicherung guter wissenschaftlicher Praxis. Sicherung Guter Wissenschaftlicher Praxis: Empfehlungen der Kommission "Selbstkontrolle in der Wissenschaft"*. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA, 2013: 1–109.
- 94 Chakraborty H, Gu H. A mixed model approach for intent-to-treat analysis in longitudinal clinical trials with missing values 2009.
- 95 Twisk J, de Boer M, de Vente W, *et al.* Multiple imputation of missing values was not necessary before performing a longitudinal mixed-model analysis. *J Clin Epidemiol* 2013;66:1022–8.
- 96 Collins LM, Schafer JL, Kam CM. A comparison of inclusive and restrictive strategies in modern missing data procedures. *Psychol Methods* 2001;6:330–51.
- 97 Hainmueller J. Entropy balancing for causal effects: a multivariate reweighting method to produce balanced samples in observational studies. *Political Analysis* 2012;20:25–46.