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RESEARCH ARTICLE

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Exercise prescription by physiotherapists to patients with cardiovascular disease is in greater agreement with European recommendations after using the EXPERT training tool

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ABSTRACT

Background: Exercise prescriptions by clinicians to patients with cardiovascular disease (CVD) often disagree with recommendations, thus requiring improvement.

Aim: To assess whether exercise prescriptions by physiotherapists to patients with CVD are better in agreement with European (ESC/EAPC) recommendations when the EXPERT (EXercise Prescription in Everyday practice & Rehabilitative Training) Training tool is used for digital educational training.

Design: In a prospective non-randomized intervention study.

Methods: Twenty-three belgian physiotherapists first prescribed exercise intensity, frequency, session duration, program duration and exercise type (endurance or strength training) for the same three patient cases, from which the agreement with ESC/EAPC recommendations (based on a maximal score of 60/per case: agreement score) was assessed. Next, they completed a one-month digital training by using the EXPERT Training tool and completed 31 ± 13 training cases. The EXPERT tool is a training and decision support system that automatically generates a (personalised) exercise prescription according to the patient's characteristics, thus integrating the exercise prescriptions for different CVDs and risk factors, all based on ESC/EAPC recommendations. Thereafter, the same three patient cases as at entry of study were filled out again, with re-assessment of level of agreement with ESC/EAPC recommendations.

Results: After using the EXPERT Training tool, the physiotherapists prescribed significantly greater exercise frequencies, program durations and total exercise volumes in all three patient cases ($p < 0.05$). In cases 1, 2 and 3, the agreement score increased from 29 ± 9 (out of 60), 28 ± 9, and 34 ± 7 to 41 ± 9, 41 ± 10, and 45 ± 8, respectively ($p < 0.001$). Hence, the total agreement score increased from 91 ± 17 (out of 180) to 127 ± 19 ($p < 0.001$, +44 ± 32%). A lower starting agreement score and younger age correlated with a greater improvement in total agreement score ($p < 0.05$).

Conclusions: Exercise prescriptions to patients with CVD, generated by physiotherapists, are significantly better in agreement with European recommendations when the EXPERT Training tool is used, indicating its educational potential.

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Introduction

Exercise therapy, as part of a multidisciplinary cardiovascular rehabilitation (CR), leads to significant improvements in exercise capacity, muscle strength and endurance, and quality of life in patients with established cardiovascular disease (CVD) or at high cardiovascular (CV) risk, thereby reducing CV event rates, hospitalisations, and mortality [1,2]. It is therefore a cornerstone in multidisciplinary cardiac rehabilitation (CR) for CV health, as stipulated in international recommendations [3–5].

However, several surveys revealed a worrisome variance in exercise prescription for the same CVD (risk) patient among cardiologists [6] and primary care physicians [7]. Thus, the current exercise prescription in clinical practice is likely to be suboptimal for many patients with CVD (risk), and potentially is in disagreement with current European (ESC/EAPC) position statements and must be improved. Moreover, (the approach in) exercise prescription can be fundamentally different between physicians and other healthcare professionals. In current CR practice, physicians very often examine the medical safety of exercise (by cardiopulmonary exercise testing) and provide the advice to the patient to exercise, while other exercise professionals, such as physiotherapists, work out and apply the concrete exercise modalities (according to the FITT (Frequency, Intensity, Time, Type) principle)) [8]. Actually, physiotherapists are profoundly trained on how to apply the FITT principle to patients in their

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curricula, which is not necessarily the case in physicians [9,10] (hereby sometimes leading to a lower confidence in this skill) [11]. Since in previous studies, mainly physicians were studied [6,7], it is important to specifically analyse whether the FITT modalities are prescribed in a correct manner to CVD patients by physiotherapists and can be improved if this is not the case.

There have been previous attempts to improve exercise prescription in CR. For example, Vromen et al. [12] tested, mostly in physiotherapists, whether a computerized decision support (CDS) system, based on CR guidelines, can improve the personalisation of exercise prescriptions in 10 Dutch CR centres. Despite the introduction of such a CDS system, it did not improve the overall concordance of actual CR prescription by physiotherapists to the personalized training prescription (from 60% to 62%, $P = 0.82$). This study clearly shows that it is not easy to remediate flaws in exercise prescriptions to CVD patients. Vromen et al. argue that clinical decision support systems are not effective when organizational or procedural changes in CR are required.

The EXPERT (EXercise Prescription in Everyday practice & Rehabilitative Training) tool (an online training and CDS system) is a potential method to encourage standardisation of exercise prescription and enhance the implementation of exercise recommendations into practice [13,14]. In the EXPERT tool, ESC/EAPC exercise training recommendations and safety precautions are available for 10 CVDs, five CVD risk factors, and three common chronic non-CV conditions. Importantly, the tool also incorporates a training centre where clinicians can learn how to prescribe exercise to patients with CVD (risk) by solving imaginary patient cases. In this centre, the user can access patient cases where lots of patient data are provided (e.g., CVD risk factors, physical fitness, medication, etc.), and they get immediate feedback on their exercise prescription after a case fill-out, with detailed explanation of why some exercise modalities should be adjusted accordingly. The user is thus trained on how to adjust exercise modalities according to the patient's phenotype (thus integrating the exercise prescriptions for different CVDs and risk factors within the same patient). It is this training centre that could be hypothesized to lead to standardized exercise prescriptions, which are better in agreement with recommendations, when used by physiotherapists.

Therefore, this study aimed to assess whether the use of EXPERT Training tool by physiotherapists would lead to exercise prescriptions that are better in greater agreement with ESC/EAPC recommendations.

Methods

Participants

The study was approved by the ethical committee from Hasselt University, Belgium (registration number: CME2020/056). Participants (physiotherapists, $n = 47$) were recruited between February and April 2022 by mailing from AXXON (Belgian Physiotherapy Association) to their members, and by mailing to personal Flemish physiotherapy networks. After completing an online consent form, explaining the nature and aim of this study, participants were able to enter the study. The study emphasised that participation was voluntary and that their relationship with AXXON was not affected by the decision to participate. Hasselt University provided all necessary documentation regarding email invitations, participant information sheets, consent forms, and privacy notices. Researchers did not have access to any personal details of potential participants.

In this study, only professionally active Flemish physiotherapists were recruited. We deliberately recruited physiotherapists because they are very often involved in the rehabilitation of CVD (risk) patients and thus an important target audience but were rarely studied previously. There were no restrictions on years of experience or characteristics of the setting in which they were active. Participants were excluded from the study if they did not have access to a device that allows the use of the EXPERT tool (explained below). All participants came from Flanders, which is the northern (Dutch-speaking) part of Belgium.

Measurements

The intake assessment consisted of an initial questionnaire including age, sex, qualifications, setting in which they worked (private practice with or without focus on rehabilitation of internal disorders, hospital-based CR program (e.g., individual or group-based, gym or circuit sessions), years of experience, and which guidelines were used/followed.

After completing the baseline assessment (Figure 1), the physiotherapists had to fill out three patient cases with different complexities via the EXPERT tool, without getting feedback on their performance. Each case increased in complexity by increasing the level of CVD risk and the presence of comorbidities. The physiotherapists had to specify their preferred exercise intensity (based on the percentage of peak heart rate (HR)), exercise frequency (days/week), program duration (weeks), exercise session duration (min/session), and whether strength training exercises had to be

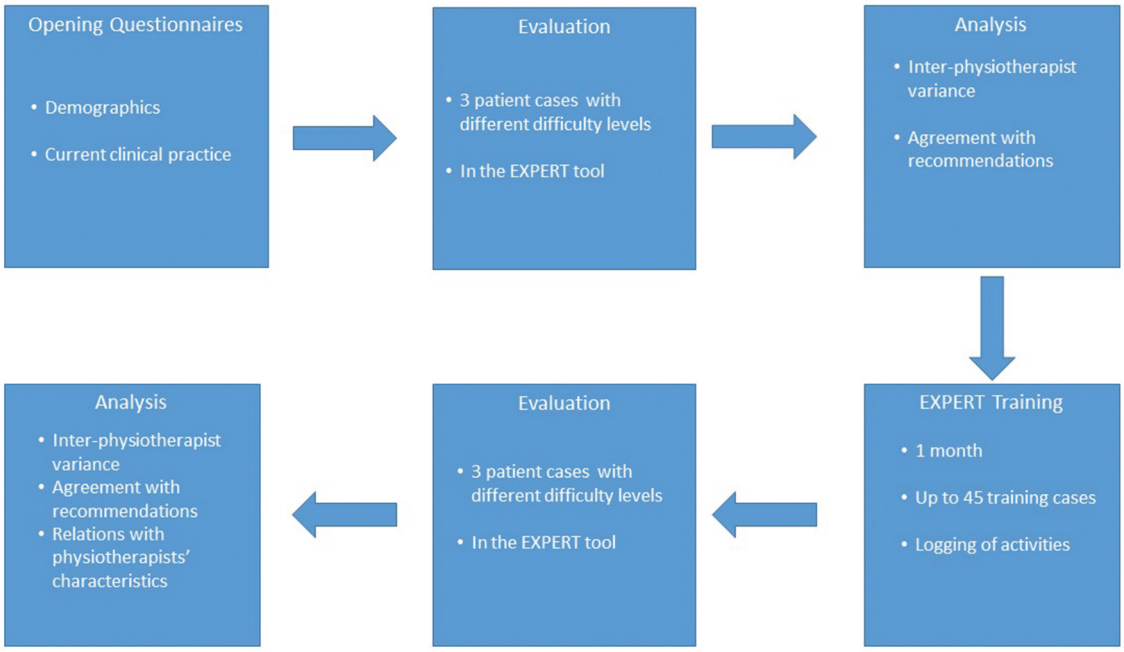

Figure 1. Study flowchart.

Table 1. Description of the entry and follow-up assessment cases.

	Case 1	Case 2	Case 3
Diagnosis	AMI with PCI	AMI with CABG	Myocardial ischemic threshold @ 90 bts/min
CV risk factors	Dyslipidemia Hypertension	Obesity Dyslipidemia Hypertension	Type 2 diabetes Hypertension
Non-cardiovascular comorbidities	-	COPD	Sarcopenia Frailty
Age (years)	71	76	71
Body weight (kg)	65	80	90
Body height (cm)	171	182	165
Sex (M/F)	M	M	F
VO2max (l/min)	2.5	1.5	0.767
HRrest (bpm)	55	52	52
HRmax (bpm)	123	112	100
Blood pressure (mm/Hg)	145/82	125/80	135/75
Fasting glycemia (mg/dl)	95	102	115
Total cholesterol (mg/dl)	180	189	234
Smoker	No	No	No
Medication intake	Beta Blocker Statin	Beta Blocker Statin	Beta Blocker Statin Insulin

AMI, acute myocardial infarction; Bpm, beats per minute; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; F, female; M, male.

executed. Furthermore, they were asked to indicate whether additional exercise training types had to be considered, e.g., handgrip strength training, inspiratory muscle training, callisthenics, balance exercises, etc. A detailed description of the patient cases can be found in Table 1.

EXPERT training tool and follow-up

The EXPERT tool is a training and decision support system, designed and built by computer scientists from Hasselt University, in close collaboration with the EAPC EXPERT Network group [13,14]. It automatically generates a (personalised) exercise prescription according to the characteristics of each patient case, thus integrating the exercise prescriptions for different CVDs and risk factors within the same patient, all based on ESC/EAPC recommendations, evidence, and expert opinions, collected by a working group of 33 CV rehabilitation specialists from 11 European countries. The EXPERT training centre is another working mode of the EXPERT tool. Exploring more than 60 imaginary but realistic cases with different levels of complexity, a rehabilitation expert or trainee gets acquainted with do's and don'ts for exercise prescription for CV patients. He/she can check immediately to what extent his/her exercise prescription behaviour is in line with the ESC/EAPC recommendations incorporated in the EXPERT tool.

When working in the EXPERT Training tool in this study, the user selects an imaginary case (there are 15 cases each in class 'easy', 'medium' and 'difficult'). The patient data corresponding to the case are displayed together with the selected indications and contributing factors. However, before the EXPERT tool proposes a recommendation, the user has to fill in his/her own prescription. Afterwards, the EXPERT tool's exercise prescription according to the ESC/EAPC recommendations is shown in another recommendation panel below the user's prescription. In this way, the vertical alignment of the components of the exercise prescription of the user's prescription and the EXPERT recommendation can be easily compared.

The participants were given access to the tool for 1 month, in which they were requested to fill out as many patient cases as possible, starting with the easy cases (week 1), medium cases (from week 2), and difficult cases (from week 3). The fill-out of all available cases was not mandatory. The participants' patient case fill outs were logged.

The same three entry patients cases were presented again after the one-month training period for re-assessment of exercise prescription.

Patient case agreement score calculation

Based on the fill-out of the three patient cases, a score to assess the level of agreement with ESC/EAPC guidelines was calculated. A score of 0, 5, or 10 was assigned to exercise prescriptions for each modality separately (i.e., intensity, frequency, session duration, program duration and the addition of strength training). Determination of the agreement score per modality was done as follows:

- A score of 0 was assigned when the physiotherapists' prescriptions were fully out of the range prescribed by the EXPERT tool.
- A score of 5 was assigned when the physiotherapists' prescriptions were partially within the range prescribed by the EXPERT tool.
- A score of 10 was assigned when the physiotherapists' prescriptions were fully within the range prescribed by the EXPERT tool.

For the additional training prescriptions (e.g., inspiratory muscle training, balance training, etc.), a score of 0 was assigned when prescribing no additional training modes or additional training modes were not correct. A score of 5 or 10, respectively, was assigned when the prescribed exercise training was partially or fully in accordance with the EXPERT tool prescriptions.

So, for each case, a total agreement score of 60 could be achieved.

Statistical analyses

Statistical analyses were executed using SPSS v.24.0 (SPSS Inc., Chicago, USA). Averages ± standard deviations and percentages were calculated. For each case, total exercise volume (expressed as peak-effort training minutes) was calculated by number of prescribed weeks (n) * number of prescribed sessions/week (n) * prescribed individual session duration (min) * prescribed exercise intensity (%HR_{peak}). Shapiro–Wilk tests confirmed a normal distribution of the primary outcomes (physiotherapists' agreement scores), as well as for the secondary outcomes (physiotherapists' proposed exercise modalities for the three patient cases). Changes during follow-up were examined by paired-sample T-tests. One-way ANOVA or Pearson correlations were performed to examine relations between baseline characteristics (age, sex, qualifications, experience, and setting) and physiotherapists' prescriptions. The statistical significance was set at $p < 0.05$ (2-tailed).

Results

Baseline characteristics

Forty-seven physiotherapists gave consent and participated in this study, of which 23 completed the one-month training and provided full fill-outs of the patient cases (of which the data can be analysed). They completed 31 ± 13 (out of 45 available) training cases within 1 month. The characteristics of these 23 physiotherapists are shown in Table 2.

Table 2. Participants' characteristics.

Sex (M/F)	8/15
Age#	
<30 years	14
30–39 years	4
40–49 years	3
50–59 years	2
Qualifications#	
Graduate/BSc Physiotherapy	3
Licentiate	1
MSc Physiotherapy	18
Ph.D.	1
Work setting#	
Hospital	12
Private practice	4
Hospital & private practice/hospital	6
Education	1
Number of years delivering cardiac rehabilitation?	
<1 year	7
1–5 years	11
6–10 years	1
>10 years	4
Use of guidelines when prescribing exercise to patients with (elevated risk for) cardiometabolic disease#	
EAPC	9
KNGF	8
EAPC + KNGF	3
Other	3

Data are expressed as n.

BSc Bachelor of Science; EAPC European Association of Preventive Cardiology; F female; KNGF Koninklijk Nederlands Genootschap voor Fysiotherapie; M male; MSc Master of Science.

Table 3. Three cases with EXPERT vs. physiotherapist proposed' prescriptions at entry and after using the EXPERT Training tool.

	CASE 1			CASE 2			CASE 3		
	EXPERT tool recommended prescriptions	Proposed physiotherapists' prescriptions at entry	Proposed physiotherapists' prescriptions at follow-up	EXPERT tool recommended prescriptions	Proposed physiotherapists' prescriptions at entry	Proposed physiotherapists' prescriptions at follow-up	EXPERT tool recommended prescriptions	Proposed physiotherapists' prescriptions at entry	Proposed physiotherapists' prescriptions at follow-up
Intensity (HR, bpm)	82–102	102 ± 10	97 ± 9*	76–93	95 ± 9	89 ± 7*	≤90	80 ± 9	80 ± 6
Frequency (sessions/week)	7	3.7 ± 1.1	5.9 ± 1.5*	7	4.1 ± 1.4	5.9 ± 1.4*	7	4.2 ± 1.5	6.1 ± 1.3*
Session duration (min)	20–60	47 ± 15	46 ± 6	20–60	50 ± 16	50 ± 8	30–60	48 ± 15	46 ± 9
Program duration (number of weeks)	>12	19 ± 11	26 ± 7*	>24	21 ± 9	31 ± 8*	>24	22 ± 12	31 ± 9*
Strength training	Yes	20/23 Yes	20/23 Yes	Yes	21/23 Yes	20/23 Yes	Yes	20/23 Yes	20/23 Yes
Total exercise volume (peak-effort training minutes)	-	3026 ± 2060	5460 ± 1818*	-	3667 ± 1935	7511 ± 2563*	-	3531 ± 2369	6921 ± 2790*

Data are expressed as mean (minimum – maximum value).
*Significantly different from entry assessment ($p < 0.05$).

Exercise prescriptions before and after using the EXPERT Training tool

After using the EXPERT Training tool, the physiotherapists prescribed exercise frequency, program duration and total exercise volume were significantly increased across all three patient cases ($p < 0.05$, see Table 3). In some patient cases, the exercise intensity was also lower ($p < 0.05$). Hence, the exercise prescriptions felt better in the ranges as recommended by the EXPERT Training tool. Clinically relevant additional exercise recommendations were more often provided after follow-up for nearly all criteria (see Table 4).

Although the averages remained the same for some exercise modalities (see Table 3), the standard deviations were remarkably lower, or the standard deviations remained the same although the averages increased substantially during follow-up (i.e., exercise frequency, session duration, program duration, and total exercise volume). This indicates that the variance between participants was significantly lower during follow-up.

These changes did have an impact on the physiotherapists' agreement scores. In case 1, this increased from 31 ± 9 (out of 60) to 43 ± 9, in case 2 from 29 ± 8 to 43 ± 10, and in case 3 from 34 ± 9 to 47 ± 9 (all $p < 0.001$). Hence, the total agreement score for the three cases increased from 94 ± 19 (out of 180) to 133 ± 22 ($p < 0.001$, see Figure 2: in 22 out of 23 participants an improvement was noticed). The latter corresponds to a relative increase in agreement with ESC/EAPC recommendations by 45 ± 30%.

A greater relative improvement (% change) in total agreement score for the three cases during follow-up correlated significantly with a lower starting total agreement score ($r = -0.60$, $p < 0.05$) and a younger age ($r = -0.47$, $p < 0.05$). At entry of study, the age correlated significantly with the starting total agreement score ($r = 0.53$, $p < 0.05$).

Discussion

This study shows that exercise prescriptions to patients with CVD, generated by physiotherapists, are significantly better in agreement with ESC/EAPC recommendations, when the EXPERT Training tool is used.

In general, a wide inter-clinician variability is noticed for exercise prescription to patients with CVD (risk), when cardiologists and primary care physicians were studied [6,7]. In this study, such variability was now also noticed in physiotherapists, next to a low level of agreement with ESC/EAPC exercise recommendations. This variance in exercise prescription could be hypothesised to be related to different habits in exercise prescription, knowledge of recommendations, education, or organisation of the rehabilitation units and private practices [15,16]. In addition, some locally used recommendations on exercise training in CVD are different from international recommendations [17] which may also lead to variance in exercise prescriptions. Fortunately, this study shows that such variance could be remediated significantly. Indeed, we noticed that after the use of the EXPERT Training tool, the physiotherapists' exercise prescriptions to patient cases of CVD were 45 ± 30% more in agreement with the ESC/EAPC recommendations. Moreover, although the averages remained the same for some prescribed exercise modalities, the standard deviation was remarkably lower, or the standard deviations remained the same although the averages increased substantially during follow-up (i.e., exercise frequency, session duration, program duration, total exercise volume). This indicates that the variance between physiotherapists is significantly lower and that they agree better on exercise modalities among themselves. Finally, also clinically relevant additional exercise recommendations were more often provided by the physiotherapists after follow-up for nearly all criteria. All these data are promising, and even greater/better results could probably be obtained if the EXPERT Training tool is further refined for this specific educational aim and/or used for a longer duration. For example, better/more detailed immediate feedback could be provided, and more patient cases with very different CVD risk profiles can be included, among others. This may also help to further improve the additional exercise recommendations, since particularly here significant room for improvement remains present.

After using the EXPERT Training tool, the exercise frequency, program duration and total volume of exercise were significantly and consistently increased in all three patient cases. Because the total volume of exercise and total duration of program participation are currently considered as the key drivers to many clinical benefits of exercise in CVD [18–20], this outcome thus would predict clinically more effective CR programs. However, it does remain to be shown that the use of the EXPERT Training tool does lead to clinically more effective CR programs.

A lower baseline total agreement score for all three patient cases and younger age were significantly related to greater improvements in total agreement score during follow-up. This indicates that, in particular, those physiotherapists who

Table 4. Relevant additional exercise recommendations for three patient cases at entry and during follow-up.

Case 1			Case 2			Case 3		
EXPERT tool recommended prescriptions	Proposed by physiotherapists at entry	Proposed by physiotherapists at follow-up	EXPERT tool recommended prescriptions	Proposed by physiotherapists at entry	Proposed by physiotherapists at follow-up	EXPERT tool recommended prescriptions	Proposed by physiotherapists at entry	Proposed by physiotherapists at follow-up
√ Strength training: 2 days/week, 40-80% of 1RM, 12–15 reps/set **CRITERION 1** √ >900 kcal/week of energy expenditure should be achieved for affecting lipid profile (HDL-c) **CRITERION 2** √ Additional isometric handgrip exercise training is advised for optimised blood pressure control **CRITERION 3**	CRITERION 1: 0/23 2: 1/23 3: 1/23	CRITERION 1: 6/23 2: 8/23 3: 11/23	√ Strength training: 2 days/week, 40–80% of 1RM, 12–15 reps/set to 60–70% of 1RM, 8–12 reps/set. **CRITERION 1** √ Inspiratory muscle training after CABG surgery (from 30 up to 60 of Pimax, 20–30 min/session, 3–5 days/week). Session: Start at 20 and go to 45 **CRITERION 2** √ Advice exercise modalities with large caloric expenditure (walking, jogging, stepping etc.), >900 kcal/week of energy expenditure should be achieved for optimised blood lipid control (HDL-c) **CRITERION 3** √ Additional isometric handgrip exercise training is advised for optimised blood pressure control **CRITERION 4**	CRITERION 1: 0/23 2: 2/23 3: 2/23 4: 0/23	CRITERION 1: 7/23 2: 10/23 3: 12/23 4: 11/23	√ Advice exercise modalities with large caloric expenditure (walking, jogging, stepping etc.), >900 kcal/week of energy expenditure should be achieved for optimised blood lipid control (HDL-c) **CRITERION 1** √ Strength training: 2 days/week start at 30–70% 1RM (6–8 reps/set) and go to 70–85% 1RM (12 reps/set), at least 21 sets. **CRITERION 2** √ Electro muscle stimulation (EMS) in case of significant muscle weakness can be added **CRITERION 3** √ Additional isometric handgrip exercise training is advised for optimised blood pressure control **CRITERION 4** √ Balance training or tai chi may be added for balance training **CRITERION 5** √ Start at low and go to moderate exercise intensity because of significant deconditioning **CRITERION 6**	CRITERION 1: 1/23 2: 0/23 3: 0/23 4: 0/23 5: 0/23 6: 0/23	CRITERION 1: 10/23 2: 6/23 3: 2/23 4: 8/23 5: 4/23 6: 3/23

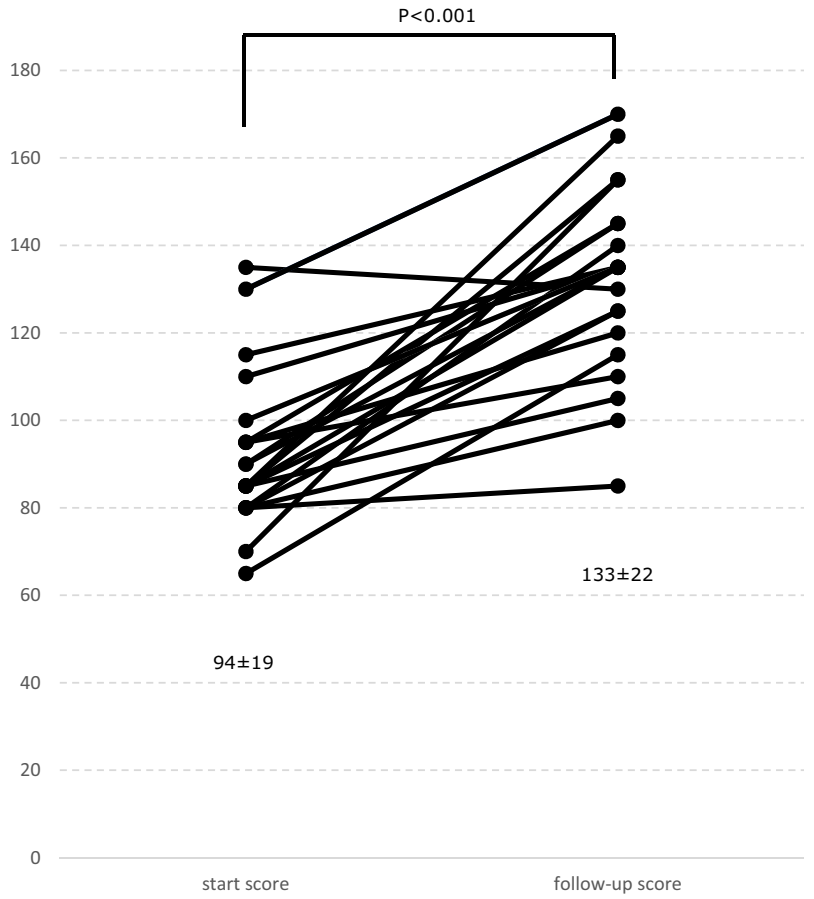

Figure 2. Participants' total agreement score (out of 180) at entry and during follow-up ($n = 23$).

struggle to prescribe exercise to patients with CVD, which may include the younger colleagues, could benefit the most from this training.

This study is limited by the fact that it is not a randomized controlled trial. However, it seems very unlikely that exercise prescriptions made by physiotherapists would improve spontaneously during follow-up without getting (online) training. Moreover, only 23 participants were involved, which could be considered as a small study covering only one group of healthcare professionals. However, the changes we observed were large and significant ($p < 0.001$ for total agreement score and separately for each patient case) and this is the first study of its kind. Hence, subsequent studies with larger samples from different groups of healthcare professionals are warranted (e.g., physiatrists, cardiologists, nurses, etc.). From 47 participants, only 23 fully completed the online training, and hence, there is a significant drop-out. It should thus be studied what predicts premature drop-out during online training and how we can increase the willingness to work with the EXPERT Training tool.

In conclusion, exercise prescriptions to patients with CVD, generated by physiotherapists, are better in agreement with ESC/EAPC recommendations, when the EXPERT Training tool is used, indicating its educational potential.

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Disclosure statement

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Author contributions

D.H., K.C., and V.C contributed to the conception and design of the study. N.M. and W.R. contributed to data collection and/or analysis. All authors participated in writing of the study and substantively revised it. All authors approved the submitted version and have agreed both to be personally accountable for their own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated.

Data availability statement

The data underlying this article will be shared on reasonable request to the corresponding author.

Trials registration

This study was registered in ClinicalTrials.gov with the registration number NCT05449652

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