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Do clinicians prescribe exercise similarly in patients with different cardiovascular diseases? Findings from the EAPC EXPERT* working group survey

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*EXPERT stands for: EXercise Prescription in Everyday practice & Rehabilitative Training

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Abstract

Background

Although disease-specific exercise guidelines for cardiovascular disease (CVD) are widely available, it remains uncertain whether these different exercise guidelines are integrated properly for patients with different CVD's. The aim of this study was to assess the inter-clinician variance in exercise prescription for patients with multiple CVD's and to compare these prescriptions with recommendations from the EXPERT tool, a digital decision support system for integrated state-of-the-art exercise prescription in CVD.

Design

Prospective observational survey

Methods

Fifty-three CV rehabilitation clinicians from nine European countries fulfilled to prescribe exercise intensity (based on percentage of peak heart rate (HR_{peak})), frequency, session duration, program duration and exercise type (endurance or strength training) for the same five patients. Exercise prescriptions were compared between clinicians and relations with clinician characteristics were studied. In addition, these exercise prescriptions were compared with recommendations from the EXPERT tool.

Results

A large inter-clinician variance was found for prescribed exercise intensity (median (interquartile range (IQR)): 83(13)% of HR_{peak}), frequency (median (IQR): 4(2) days/week), session duration (median (IQR): 45(18) min/session), program duration (median (IQR): 12(18) weeks), total exercise volume (median (IQR): 1215(1961) peak-effort training hours) and prescription of strength training exercises (prescribed in 78% of all cases). Moreover, clinicians' exercise prescriptions were significantly different from the EXPERT tool prescriptions ($p<0.001$).

Conclusions

This study reveals a significant inter-clinician variance in exercise prescription for patients with different CVD's and disagreement with an integrated version of state-of-the-art exercise prescriptions, justifying the need for standardization efforts regarding integrated exercise prescription in CV rehabilitation.

Keywords: cardiovascular disease, exercise prescription, EXPERT tool

Introduction

Exercise training leads to significant improvements in exercise capacity, muscle strength and endurance, and quality of life in patients with cardiovascular disease (CVD), hereby succeeding to reduce cardiovascular (CV) event rates, hospitalizations and mortality.[1-4] Exercise training is therefore a cornerstone in the multidisciplinary rehabilitation of CVD.[5]

Despite the availability of international exercise guidelines for the secondary prevention of CVD,[5-8] a large variance in exercise prescription (exercise type, frequency, volume, intensity, session duration and program duration) has been found between different CV rehabilitation centres.[9-17] This may be hypothesized to be related to significant differences in characteristics of patients who enter the rehabilitation program, regulations and/or facilities between these different centers. Most importantly, even though international exercise guidelines are widely available for decades and supposed to be well-known, they are mostly disease-specific. It thus follows that there are no guidelines on how to integrate different exercise prescriptions within the same patient with different CVD's and risk factors.

Evidence-based (inter)national standardization initiatives for exercise prescription in CV rehabilitation should, if applied appropriately, remediate such variance in exercise prescriptions. It thus remains to be examined first whether a single patient with different CVD's and risk factors would receive similar exercise prescriptions when generated by different clinicians in multiple countries, and whether these exercise prescriptions are in line with clinical guidelines.

This study therefore compared the exercise prescriptions between clinicians and the EXercise Prescription in Everyday practice & Rehabilitative Training (EXPERT) tool[18,19], which is a digital decision support system for integrated state-of-the-art exercise prescription in CVD. There are no published integrated guidelines compromising different CVD states and risk factors, so in essence the EXPERT tool represents the first of such guidelines. This allows us to inventory to what extent exercise prescriptions from clinicians match with the EXPERT tool exercise prescriptions. It was hypothesized that the variance in exercise prescriptions for patients with different CVD's and risk factors between clinicians could be high and that exercise prescriptions between clinicians and the EXPERT tool therefore could be dissimilar.

Methods

Study design

This was a prospective observational study, approved by a local medical ethical committee (Hasselt University and Jessa hospital, Hasselt, Belgium), adhering to the standards of the Helsinki declaration and all participants gave consent to use the collected data for research purposes. From March 2016 to April 2017, European CV rehabilitation clinicians were requested to formulate exercise training prescriptions for five artificial patient cases. These anonymized data were analyzed for inter-clinician variance in exercise prescription. In addition, these exercise prescriptions were compared with exercise prescriptions from the EXPERT tool.

Participants

Participants were partially EAPC EXPERT working group members (invited by the study coordinator by personal invitation)[18,19] while others were contacted from within the EAPC EXPERT working group (by personal invitation via EAPC EXPERT working group members): these participants had to be European citizens actively involved in CV rehabilitation. Initially, 73 clinicians agreed to participate, but 20 clinicians did not fill out all five patient cases and were excluded from the analysis. The majority of the remaining 53 clinicians (from Belgium, The Netherlands, Germany, France, United Kingdom, Italy, Spain, Austria, Portugal) were cardiologists (68%), followed by physiotherapists (11%), CV rehabilitation scientists (7%), physiatrists (6%) and sports physicians, general practitioners, rehabilitation physicians and exercise physiologists (2% in each category). There were no restrictions in years of experience (median 10 (interquartile range (IQR) 15) years) or characteristics of the rehabilitation center in which they were active. None of the participants had any experience with the use of the EXPERT tool at the time of patient case fill-out, to allow comparisons with EXPERT tool exercise prescriptions.

Patient cases

The five patient cases that were presented to the clinicians are mentioned in Table 1. In these cases a gradual increase in level of complexity was built in (case 1 was the easiest, case 5 was the most difficult) by increasing the number of CVD risk factors or co-morbidities. Most clinicians filled out their exercise prescriptions online (via the EXPERT tool) while others filled out the same patient cases on paper. All participants received exactly the same written instructions (in a manual) how to fill out these patient cases: participants that prescribed exercise online had free-text fields, while participants that did it on paper had the corresponding writing space. The clinicians were requested to specify exercise intensity (based on percentage of peak heart rate (HR_{peak})), exercise frequency (days/week), program duration (weeks), exercise session duration (min/session) and whether strength training exercises should be executed. From these data total exercise volume was calculated by: number of prescribed weeks (n) * number of prescribed sessions/week (n) * prescribed individual session duration (min) * prescribed exercise intensity (%HR_{peak}), and expressed as peak-effort training hours. In addition, clinicians were requested to indicate whether additional exercise training types, next to endurance or strength training, should be considered. These included, but were not restricted to, handgrip strength training, inspiratory muscle training, calisthenics, balance exercises, etc.

EXPERT tool recommendations

In the EXPERT tool, exercise training recommendations and safety precautions are available for ten CVDs, five CVD risk factors, and three common chronic non-CV conditions. The EXPERT tool also considers the baseline exercise tolerance, common CV medications and occurrence of adverse events during exercise testing.[18,19] This tool is a training and decision support system, designed and built by computer scientists from the Expertise Centre of Digital Media from Hasselt university, in close collaboration with the EAPC EXPERT working group. It automatically provides an exercise prescription according to the characteristics of each patient case, thus integrating different exercise prescriptions for different CVD's and risk factors within the same patient. The exercise prescriptions of the EXPERT tool are based on clinical guidelines,[5-8] evidence and expert opinions, collected by a working group of 33 CV rehabilitation specialists out of 11 European countries.[18,19] This tool was used to generate exercise prescriptions for the five patient cases that were subject of the present study.

Statistical analyses

Statistical analyses were executed by use of SPSS v.24.0 (SPSS Inc., Chicago, USA). According to Shapiro-Wilk and Kolmogorov-Smirnov tests, exercise prescription data, as generated by the clinicians, were not normally distributed. Therefore, data are presented as median (IQR). First, the variance in exercise prescription between clinicians was calculated for every case separately. By Kruskal-Wallis test it was further examined whether exercise prescriptions were different between patient cases. Second, Friedman and Chi-Square tests were used to compare exercise prescriptions generated by the clinicians to exercise prescriptions generated by the EXPERT tool. Third, linear multivariate regression analyses and binary logistic regression analyses were applied to study relations between clinician characteristics (occupation type, years of experience, country) and exercise prescriptions. In these models, parameters with non-normal distribution were first log transformed. Fourth, relationships between exercise parameters were analyzed by univariate Spearman correlations. Statistical significance was set at $p<0.05$ (2-tailed).

Results

Exercise prescriptions: inter-clinician comparisons

Exercise prescriptions for each patient case are displayed in Table 2. It was observed that the prescribed endurance exercise intensity, frequency, session duration and prescription rates of strength training were significantly different between patient cases ($p<0.05$). The most intense and longest exercise sessions were prescribed to patient case 2 (leading to the greatest total exercise volume), while the least intense and shortest exercise sessions were prescribed to patient case 3. Strength training was most often prescribed to patient case 3, and less often to patient case 4. In addition, the variance of prescribed exercise intensity, frequency, session and program duration, and total exercise volume was considerably different between patient cases. The greatest variance in prescribed exercise intensity and frequency was observed in patient case 5 and 3, respectively. The greatest variance in prescribed session duration and program duration, and total exercise volume was observed in patient case 2 and 4, respectively.

When combining all five patient cases, a large inter-clinician variance was found for exercise intensity (median (IQR) 83(13)% of HR_{peak}), frequency (median (IQR) 4(2) days/week), session duration (median (IQR) 45(18) min/session), program duration (median (IQR) 12(18) weeks), total exercise volume (median (IQR) 1215(1961) peak-effort training hours) and whether strength training was prescribed (this was prescribed in 78% of all cases) (Figure 1 and Table 2).

Exercise prescriptions: correlations between exercise modalities

When analyzing all patient cases (n=265), significant statistical correlations were found, but all these correlations had small effect sizes (< .3). Exercise session duration correlated significantly ($p<0.05$) with exercise frequency ($r=-0.16$) and program duration ($r=0.28$). In addition, exercise frequency correlated significantly ($p<0.05$) with program duration ($r=-0.20$) and exercise intensity correlated significantly with program duration ($r=-0.25$). Finally, exercise session duration was longer when strength training was prescribed ($p<0.05$). Surprisingly, no significant correlation was observed between exercise intensity and session duration ($p>0.05$).

Exercise prescriptions: correlations with clinician characteristics

According to multivariate regression analyses, the clinician's country was significantly ($p<0.05$), although weakly, related to prescribed exercise intensity (adjusted model $r^2=0.04$, standardized coefficient (SC) beta: -0.16). Program duration was significantly ($p<0.05$, adjusted model $r^2=0.15$) related to years of experience (SC beta: -0.16), country (SC beta: 0.16) and type of occupation (SC beta: 0.21). Total exercise volume was significantly ($p<0.05$), although weakly (adjusted model $r^2=0.08$), related to type of occupation (SC beta: 0.19) and years of experience (SC beta: -0.13).

Comparisons between clinicians' exercise prescriptions and EXPERT tool exercise prescriptions

Exercise prescriptions were significantly different between clinicians and the EXPERT tool ($p<0.001$, Table 1 and 2), except for implementation of strength training ($p>0.10$). Even though many additional exercise-training types can be prescribed (such as handgrip strength training, inspiratory muscle strength training, balance exercises etc.), only in 34 patient cases (out of 265) clinicians proposed such additional exercise training types. These included: inspiratory muscle training, calisthenics, Nordic walking and flexibility exercises.

Discussion

This study, as the first of its kind, showed that in Europe a large inter-clinician variance in exercise prescription for CVD (risk) patients was present, even when generated by experienced CV rehabilitation specialists (median 10 years of experience). Moreover, exercise prescriptions generated by clinicians were significantly different from exercise recommendations generated by the EXPERT tool.

The observed large inter-clinician variance in exercise prescription for patients with different CVD's and risk factors could be hypothesized to be related to different habits in exercise prescription, knowledge of clinical guidelines and education and/or organization of the rehabilitation unit both in and between countries.[20] In addition, some national guidelines on exercise training in CVD are (slightly) different from international guidelines,[21,22] which may also lead to inter-clinician variance in exercise prescriptions when clinicians from different countries are included. Most importantly, these different exercise prescriptions may also originate from the lack of guidelines on how to integrate different exercise prescriptions within the same patients with different CVD's and risk factors. Next to these hypothesized causes, different exercise prescription routines may also be due to legal constraints (national regulations for re-imbursement of rehabilitation sessions, which can affect program duration and total number of exercise sessions) as well as environmental constraints (limited infrastructure and center/hospital facilities, which may affect the capability to implement strength training exercises or other exercise training types). For example, very long programs (up to 40 weeks) are advised to significantly affect blood lipid profile, which may be unachievable by many rehabilitation centers/hospitals.[23]

The inter-clinician variance was of unexpected magnitude for all exercise modalities: exercise intensity (median (IQR) 83(13)% of HR_{peak}), frequency (median (IQR) 4(2) days/week), session duration (median (IQR) 45(18) min/session), total exercise volume (median (IQR) 1215(1961) peak-effort training hours) and program duration (median (IQR) 12(18) weeks). Interestingly, these exercise prescriptions were further modulated by the clinician's country (for exercise intensity) and by clinician's type of occupation and years of experience (for exercise program duration and total exercise volume). Certain logic and expected relations between exercise modalities (for example a higher exercise intensity should correlate with a shorter exercise session duration) were absent and the observed significant relations ($p<0.05$) within this study were poor ($r<0.30$). This may indicate that prescriptions of certain exercise modalities were not corrected for by (necessary) adaptations in other exercise modalities. As these exercise prescriptions were generated by experienced CV rehabilitation clinicians, an even greater inter-clinician variance may be expected in non-experts or less experienced colleagues.

The exercise prescriptions generated by clinicians were significantly different from the prescriptions by the EXPERT tool ($p<0.001$), except for the implementation of strength training and total exercise volume. This was of no surprise as the EXPERT is new and was not yet used by the study participants. But this comparison shows which training modalities must be optimized during exercise prescription. Moreover, clinicians hardly prescribed additional exercise training types (next to endurance or strength training), such as Nordic walking, calisthenics and inspiratory muscle strength training. Although it cannot be guaranteed that the EXPERT tool provides a proven 'golden standard' exercise prescription, this instrument approaches exercise prescription as mentioned in clinical guidelines and is completed with expert opinions agreed upon in the working group consortium. As such, the EXPERT tool recommends exercise prescriptions according to the state-of-the-art knowledge in CV rehabilitation.

These data indicate that standardization of exercise prescription in CV rehabilitation is warranted. Some factors influencing the variance in exercise prescription might be reversible or directly related to the clinician's adherence to, or knowledge of, clinical guidelines. In addition, it seems very important to achieve agreement between different national exercise guidelines and international exercise recommendations. Moreover, the currently existing exercise guidelines do not mention how to integrate exercise prescriptions for different CVD's and risk factors within the same patient, making exercise prescription in clinical practice challenging. These factors are good candidates to be tackled in standardization efforts. Such standardization may then lead to optimization of the clinical benefits and medical safety of exercise intervention in CVD (risk). The EXPERT tool is such an instrument and can assist in this endeavor by recommending exercise prescriptions according to an integrated interpretation of published guidelines, especially in patients with different CVD's and risk factors, and by providing a training environment for novice clinicians. In other fields of medicine, as well as in cardiovascular rehabilitation, such decision support systems have been shown to be effective to increase the implementation of clinical guidelines into clinical practice.[24-28] In addition, it may be relevant to set up a performance measure assessment system for CV rehabilitation units. Although patient referral could be used as a performance measure,[29] as well as service delivery,[30] whether the prescribed exercises are in line with exercise guidelines could be an additional, but crucial, performance measure to lead to quality improvement of CV rehabilitation throughout Europe. Such an initiative would be well in line with the strategic goals of the European Association of Preventive Cardiology (EAPC).

A large majority of CVD risk patients in Europe are prevented from achieving their lifestyle, blood pressure, lipids and glucose goals.[31] This may be due to suboptimal prescription, or lacking adherence to these prescriptions, of cardioprotective medication, insufficient smoking cessation or low implementation rate of dietary interventions. Data from the present study suggests that suboptimal exercise prescription may also be present in routine clinical practice and should be taken into account as a potential explanation for insufficient CVD risk factor control in Europe.

This study may have been prone to some limitations. As the EAPC consists of >3000 members from >40 countries, data from the present study warrant confirmation from a larger survey throughout Europe. In addition, the study sample was too small to examine whether guideline adherence is different between different countries or age groups, whether the educational background affects guideline adherence, and whether a similar inter-clinician variance in exercise prescriptions for CVD (risk) patients can be observed in other continents as well, and in other healthcare professions being underrepresented in the current survey. It may be questioned whether the participants are a representative sample of European CV exercise prescribers. We confirm that all participants are actively involved in cardiovascular rehabilitation, of which some participants are also actively involved in clinical studies within this field and/or authors on important publications in the field of CV rehabilitation. As a result, data from the present study reflect the inter-clinician variance for exercise prescription in more experienced clinicians. This variance remains however to be studied in novice or less experienced clinicians.

In conclusion, a large inter-clinician variance in exercise prescription for CVD patients is present and clinicians' exercise prescriptions are significantly different from exercise prescriptions generated by the EXPERT tool. The present data confirms the importance and justify the need for standardization efforts regarding integrated exercise prescription in CV rehabilitation.

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Conflicts of interest: none

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Tables and figures

Table 1 Survey patient cases, together with exercise prescription as generated by the EXPERT tool

Case 1	Case 2	Case 3	Case 4	Case 5
Age: 65 years Body height: 171 cm Body weight: 65 kg Sex: male VO2max: 2500 ml/min, 38.5 ml/kg/min (116% of predicted normal value) Resting HR: 55 bts/min Peak exercise HR: 123 bts/min Total cholesterol: 180 mg/dl Fasting glycaemia: 92 mg/dl Blood pressure: 145/82 mmHg Medication intake: beta-blocker, nitrate, statin, antiplatelet. Referred to rehabilitation for: acute myocardial infarction with PCI. Co-morbidities: None.	Age: 55 years Body height: 160 cm Body weight: 85 kg Sex: female VO2max: 1600 ml/min, 18.8 ml/kg/min (108% of predicted normal value) Resting HR: 102 bts/min Peak exercise HR: 151 bts/min Total cholesterol: 267 mg/dl Fasting glycaemia: 108 mg/dl Blood pressure: 115/72 mmHg Medication intake: statin, ACE-inhibitor, orlistat, antiplatelet, metformin, sulfonylurea. Referred to rehabilitation for: obesity. Co-morbidities: type 2 diabetes. Additional information: gonarthrosis present.	Age: 70 years Body height: 182 cm Body weight: 80 kg Sex: male VO2max: 1500 ml/min, 18.7 ml/kg/min (73% of predicted normal value) Resting HR: 52 bts/min Peak exercise HR: 112 bts/min Total cholesterol: 189 mg/dl Fasting glycaemia: 102 mg/dl Blood pressure: 125/80 mmHg Medication intake: statin, antiplatelet, beta-blocker, digitalis, mucolytics, bronchodilators. Referred to rehabilitation for: AMI with CABG. Co-morbidities: Heart failure with preserved ejection fraction, mild COPD.	Age: 65 years Body height: 165 cm Body weight: 90 kg Sex: female VO2max: 1450 ml/min, 16.1 ml/kg/min (90% of predicted normal value) Resting HR: 52 bts/min Peak exercise HR: 100 bts/min Total cholesterol: 234 mg/dl Fasting glycaemia: 115 mg/dl Blood pressure: 135/75 mmHg Medication intake: beta-blocker, statin, exogenous insulin, nitrate, erythropoietin. Referred to rehabilitation for: stable myocardial ischemia (threshold at 87 bts/min) Co-morbidities: renal failure, type 1 diabetes. Additional information: chronic aspecific low back pain present.	Age: 79 years Body height: 170 cm Body weight: 59 kg Sex: male VO2max: 1250 ml/min, 21.2 ml/kg/min (88% of predicted normal value) Resting HR: 56 bts/min Peak exercise HR: 111 bts/min Total cholesterol: 178 mg/dl Fasting glycaemia: 125 mg/dl Blood pressure: 135/87 mmHg Medication intake: beta-blocker, bronchodilator, antiplatelet. Referred to rehabilitation for: peripheral vascular disease. Co-morbidities: cachexia and frailty, COPD.
EXPERT exercise prescription				
INTENSITY Moderate HR 82-95 bts/min SESSION DURATION 20 up to 60 min FREQUENCY	INTENSITY Moderate HR 122-131 bts/min SESSION DURATION 30 up to 60 min FREQUENCY	INTENSITY Moderate HR 76-87 bts/min SESSION DURATION 20 up to 60 min FREQUENCY	INTENSITY Moderate HR 71-80 bts/min SESSION DURATION 30 up to 60 min FREQUENCY	INTENSITY Up to claudication threshold SESSION DURATION 20 up to 60 min FREQUENCY

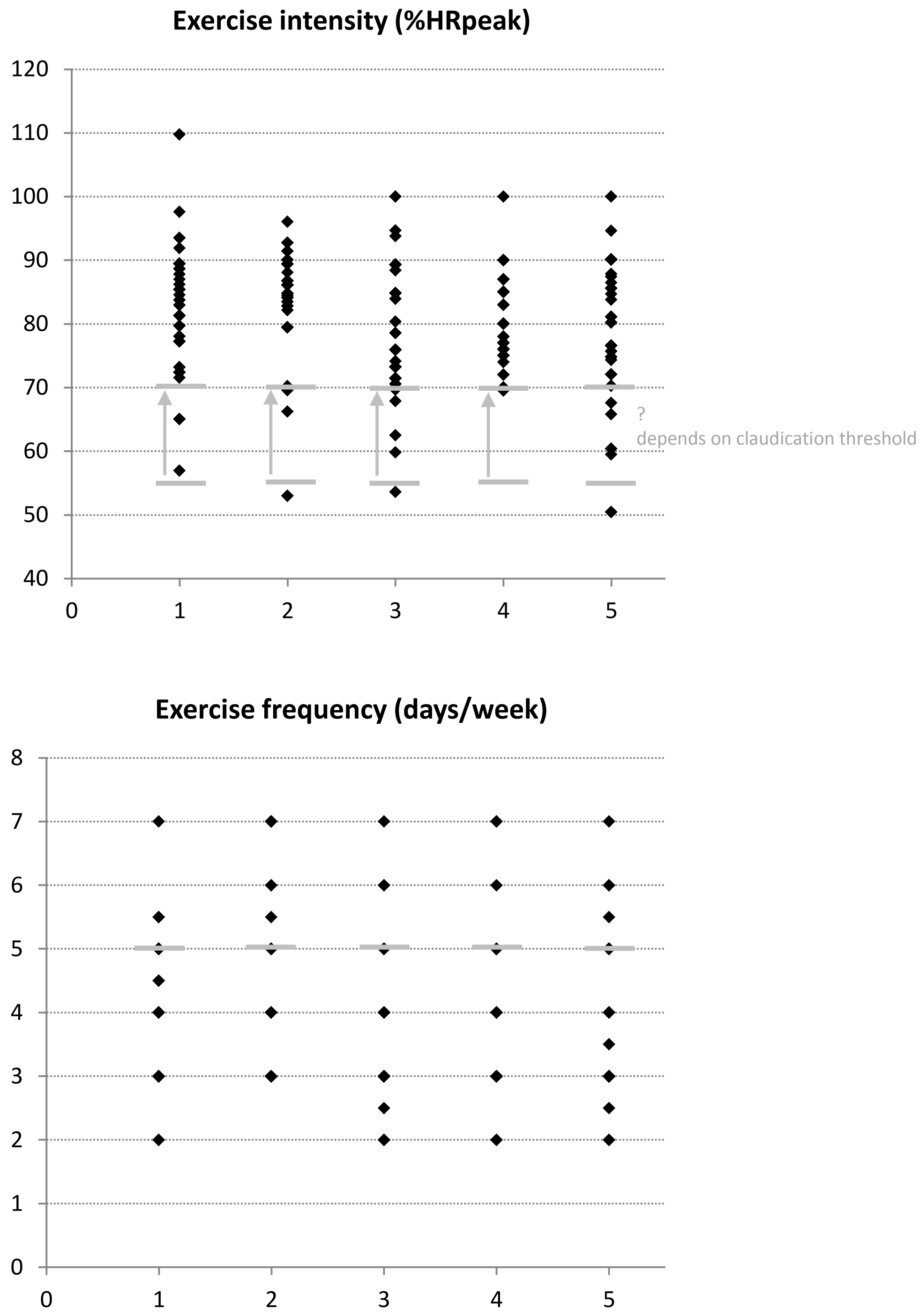
5 days/week MINIMAL DURATION 40 weeks STRENGTH TRAINING yes ADDITIONAL TRAINING STRATEGIES Additional isometric handgrip exercise training is advised.	5 days/week MINIMAL DURATION 40 weeks STRENGTH TRAINING yes ADDITIONAL TRAINING STRATEGIES Additional isometric handgrip exercise training is advised. >900 kcal/week of energy expenditure should be achieved.	5 days/week MINIMAL DURATION 40 weeks STRENGTH TRAINING yes ADDITIONAL TRAINING STRATEGIES In case of CABG surgery, strength training for the arm muscles are only allowed when the sternum is stabilized. Add inspiratory muscle training (IMT). Additional isometric handgrip exercise training is advised. >900 kcal/week of energy expenditure should be achieved. Breathing exercises should be added.	5 days/week MINIMAL DURATION 40 weeks STRENGTH TRAINING yes ADDITIONAL TRAINING STRATEGIES Ending an exercise bout with HIT training is advised to prevent post-exercise hypoglycemia. Additional isometric handgrip exercise training is advised. >900 kcal/week of energy expenditure should be achieved. Flexibility and balance exercises should be added.	5 days/week MINIMAL DURATION 12 weeks STRENGTH TRAINING Yes ADDITIONAL TRAINING STRATEGIES Nordic walking and arm cranking exercises may be promoted. Additional isometric handgrip exercise training is advised. Muscle electrostimulation, balance training, or tai chi may be added. Breathing exercises should be added.

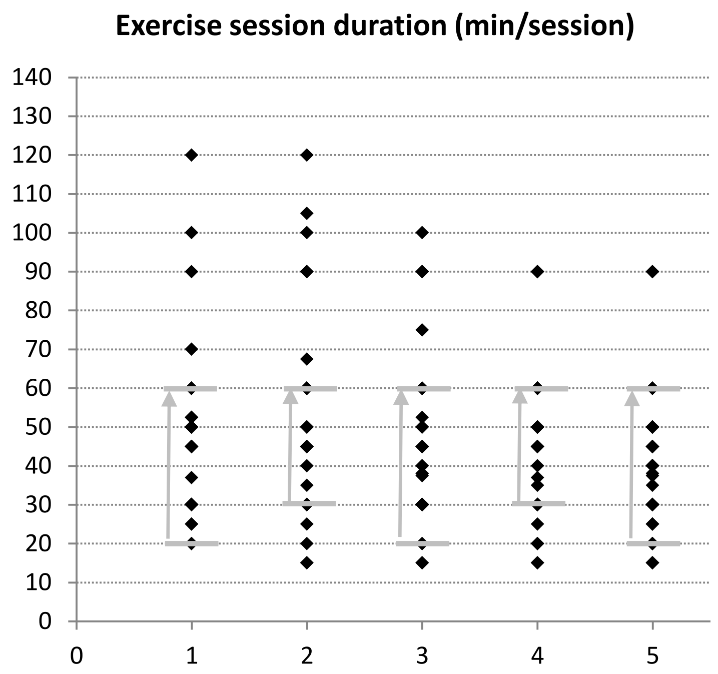
Table 2 Exercise prescriptions, as generated by clinicians, for five patient cases

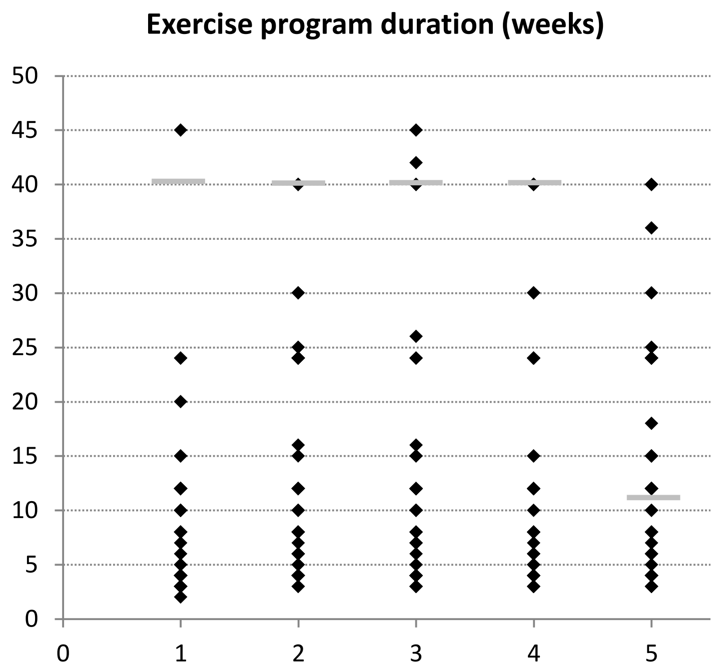
Exercise modality	**Patient case**					P-value between cases
	1	**2**	**3**	**4**	**5**	
Intensity (%HR_{peak})	83 (14)	85 (7)	76 (17)	78 (9)	80 (16)	0.033
Variance	87	72	92	47	122	
Frequency (days/week)	4 (2)	4 (2)	3 (2)	4 (2)	3 (2)	0.047
Variance	1.3	1.3	1.6	1.2	1.2	
Session duration (min/session)	45 (30)	50 (30)	38 (30)	45 (30)	40 (20)	0.047
Variance	367	507	392	305	258	
Program duration (weeks)	8 (50)	12 (18)	12 (9)	12 (18)	12 (17)	0.081
Variance	127	145	180	194	134	
Total exercise volume (peak-effort training hours)	1024 (1231)	1669 (3538)	1205 (1392)	1215 (4013)	1034 (1680)	0.054
Variance	2231179	7662867	3060335	5621496	2178928	
Strength training (yes/no)	41/12	38/15	45/7	35/18	48/5	0.012
Strength training (% yes)	77	72	86	66	78	

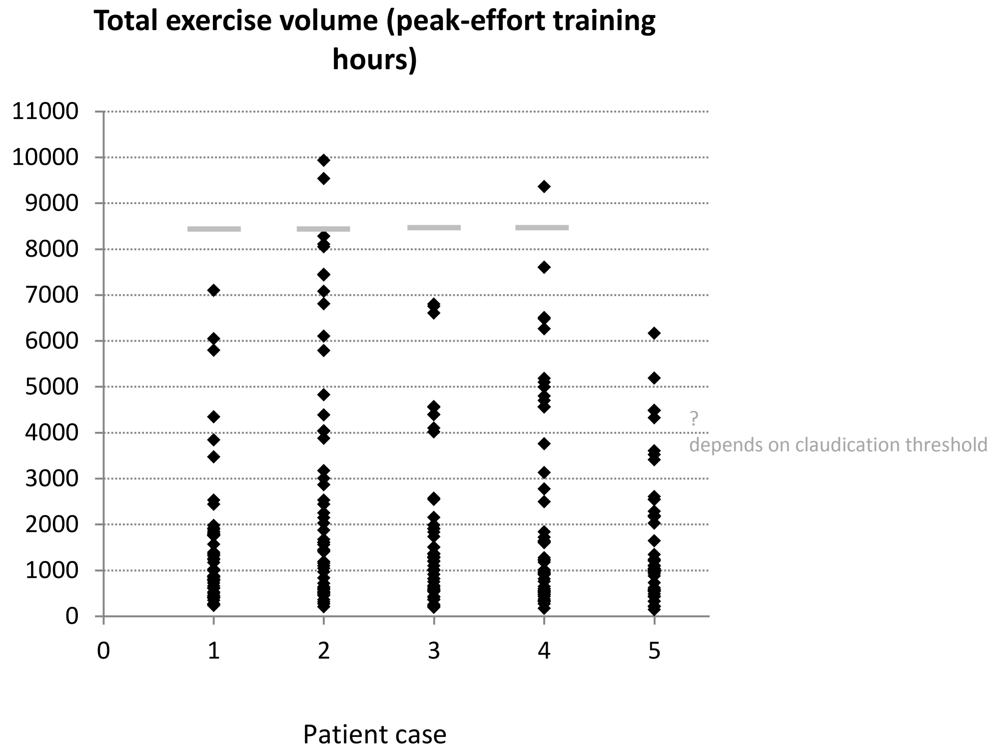
Data are expressed as median (IQR) or number of observations.
Abbreviations: HR, heart rate.
The variance is the square of the standard deviation and measures how far a set of numbers are spread out from their average value.

Figure 1 Inter-clinician variance in exercise prescription for five patient cases (on x-axis): <u>EXPERT tool advices are indicated by grey lines</u>




Exercise session duration (min/session)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5


Exercise program duration (weeks)
50
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5



One point in the figure may reflect multiple clinicians as similar exercise modality selections may have occurred between clinicians