ORIGINAL ARTICLE

Virtual cardiovascular magnetic resonance training proves feasible and effective: survey data from international participants of the CMR Academy Berlin, Germany

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Aims	This study aims to evaluate the success of the cardiovascular magnetic resonance (CMR) imaging Academy Berlin's transition from in-person to online CMR imaging training during the global pandemic 2020 and to gather recommendations for future courses.
Methods and results	We conducted an online survey targeting CMR course participants from both the pre-pandemic, in-person era and the pandemic, online era of the CMR Academy Berlin. The survey primarily used Likert-type questions to assess participants' experiences and preferences. A total of 61 out of 158 invited participants (38.61%) completed the survey, with 31 (50.82%) being in-person alumni and 30 (49.18%) being online alumni. Both in-person [83.87% (26/31)] and online [83.33% (25/30)] participants rated the course as either 'very good' or 'excellent', and both groups found the course either 'extremely helpful' or 'very helpful'. However, a higher percentage of in-person participants [96.77% (30/31)] felt comfortable asking questions compared to online participants [83.33% (25/30); $P = 0.025$]. The majority in both groups preferred a written exam [total: 75.41% (46/61); in-person alumni: 77.42% (24/31); online alumni 73.33% (22/30)]. In terms of course format preferences, in-person courses were preferred by both in-person alumni [38.71% (12/31)] and online alumni [60% (18/30)], almost as much as a hybrid format combining in-person and online elements [in-person alumni: 41.94% (13/31), online alumni: 30% (9/30)].
Conclusion	The transition from in-person to online CMR training at the CMR Academy Berlin was successful in maintaining overall satisfaction. However, there is room for improvement in terms of increased interaction, particularly for online participants.

Future CMR- and potentially also cardiac computer tomography-courses should consider adopting a hybrid format to accommodate participants' preferences and enhance their learning experience, especially to gain level II competency, whereas level I virtual only might be sufficient.
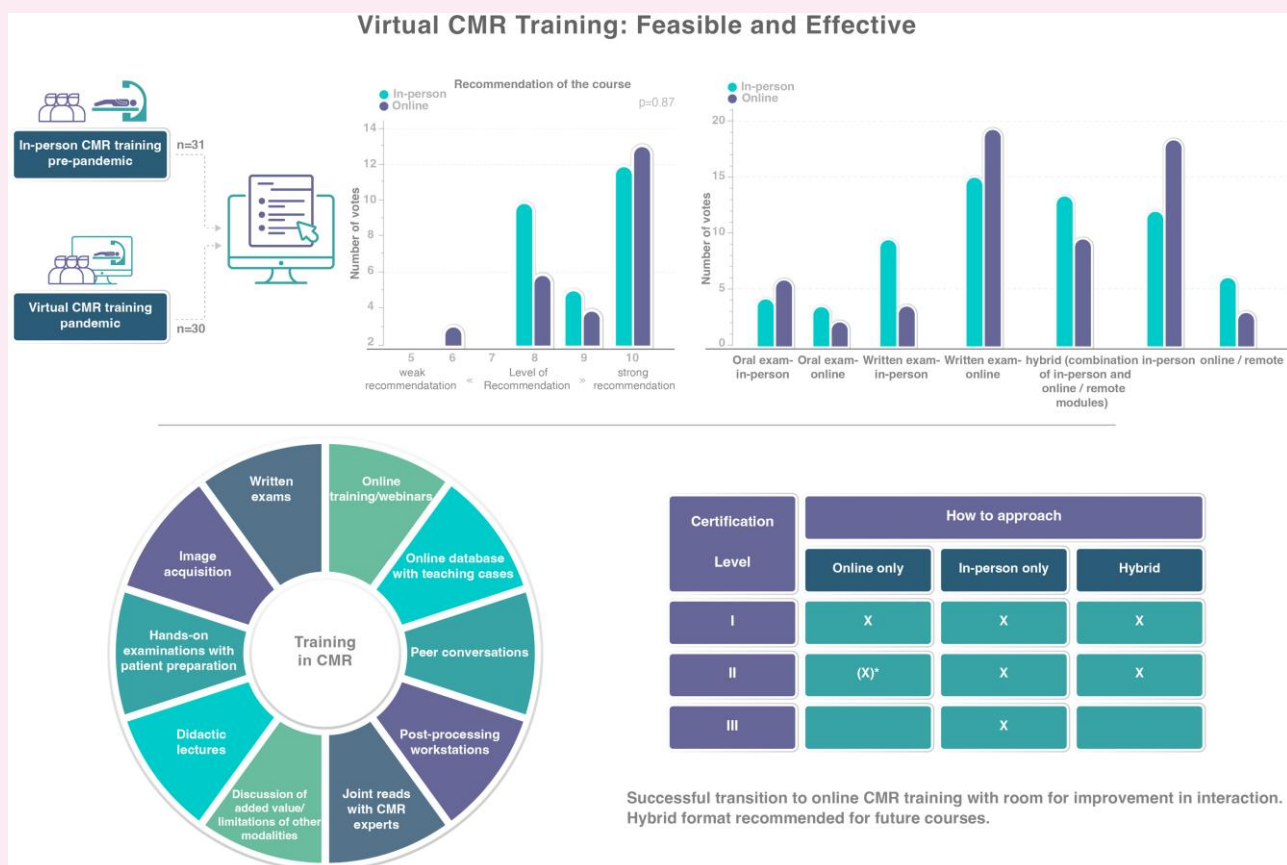
Lay summary

The COVID-19 pandemic has greatly changed the landscape of medical education, necessitating the shift from traditional in-person learning to online platforms. This study evaluated how well an online training programme for cardiovascular magnetic resonance imaging (CMR) was received by doctors who attended the CMR Academy in Berlin, Germany.

We asked both in-person and online course participants about their experiences and preferences for future courses. A total of 61 out of 158 participants (38.61%) responded to our survey. Both in-person and online attendees rated the course as either 'very good' or 'excellent'. However, more in-person attendees felt comfortable asking questions during the course compared to online attendees.

In terms of future courses, most of the participants preferred a blend of in-person and online learning, known as a hybrid format. They felt that online learning had some benefits, such as increased access, especially during a pandemic. However, they missed the interaction and engagement that in-person learning provides. They also preferred written exams to be conducted online.

This study emphasizes the need for future CMR training to be more flexible and include both online and in-person elements. This would not only accommodate the participants' preferences but also enhance their learning experience. It also stresses the importance of interaction during the learning process, which needs to be improved in online platforms. The findings can potentially inform the development of educational frameworks in other areas of medical imaging, like cardiac computer tomography (CT).

Graphical Abstract

Virtual CMR Training: Feasible and Effective

Successful transition to online CMR training with room for improvement in interaction. Hybrid format recommended for future courses.

Introduction

The globals severe acute respiratory syndrome coronavirus-2 (COVID-19) pandemic forced organizations and institutions to immediately change their mode of practice worldwide in 2020.[1] All parts of society have been disrupted by the nationwide lockdown measures to stop the spread of the disease and reduce the infection burden, including medical education, which has been impacted by the suspension of lectures and important exams.[2,3]

Cardiovascular magnetic resonance imaging (CMR) training like workshops and skill training courses in other modalities had been primarily conducted in person. The CMR Academy in Berlin, Germany, was established in 2001 as one of the main interdisciplinary (cardiology and radiology) training centres for both a national and an international audience and is endorsed by the German Cardiac Society, the Society for Cardiovascular Magnetic Resonance (SCMR) as well as the European Association of Cardiovascular Imaging (EACVI). It offers educational courses certified to accomplish the certifications of several CMR societies at different levels.[4] Even before the beginning of the pandemic, distance learning resources in cardiac imaging had been introduced on a national (e.g. by the German Cardiac Society), European (e.g. by the EACVI), or international level (e.g. SCMR)—their modus operandi was an on-demand platform.[5–7]

With the beginning of the COVID-19 pandemic in 2020, the CMR Academy, like many other educational organizations, decided to cancel in-person courses and establish remote CMR certification courses as well as examination opportunities. The new solutions were developed with the goal to satisfy the interests of different stakeholders while respecting the policy measures in response to the pandemic:

(a) maintenance of the course/exam quality expected from academic peers,
(b) adhering to guidelines and obtaining approval from regulatory authorities such as the board chamber of physicians in Berlin, Germany,
(c) facilitation of fairness and safety of the course participants and test-takers. Due to the continued risks of the COVID-19 pandemic, these measures were continued to the courses and examinations in 2021 and 2022.

While it is evident that the mode of teaching is different between a remote and an in-person framework of clinical skill, it is uncertain whether the disadvantages of the new, remote framework outweigh the benefits of the pandemic measures that allow for an individually better view of the images discussed and higher accessibility during a pandemic internationally.[8]

With this analysis, we sought to explore the efficacy of the changes made to adapt the CMR educational formats to the demands due to the pandemic within the framework of the CMR Academy.

Methods

Survey design and distribution

An online survey was used to perform this cross-sectional study. A 29-item questionnaire was developed covering

(a) the general demographics characteristics,
(b) the teaching method experienced,
(c) the perceived benefits and limitations of the respective teaching method, i.e. remotely vs. in-person and
(d) suggestions for future courses (Supplementary Data Online, Supplementary material).

Questions regarding the assessment of the teaching method (b and c) addressed:

(1) the overall impression,
(2) the degree of satisfaction after the course,
(3) the chance to interact during the course,
(4) the organizational framework with regard to the length of the course, the content, and the speakers as well as
(5) suggestions for future courses addressing the preferred mode of examination (oral vs. written and in-person vs. online) and the preferred mode of teaching [in-person vs. online vs. hybrid (combination of in-person and online)].

The questions were mainly five-point Likert-type questions, ranging from extreme agreement to extreme disagreement. The remaining items in the questionnaire comprised a mixture of question styles. Open-ended text responses were not collected. The question items were initially drafted and informally discussed with a group of CMR experts within the CMR Academy before undergoing a careful review and editing process. The possible answers to the respective question were cited with the presented results.

The survey was designed with the web-based platform SurveyMonkey (www.surveymonkey.com/, Momentive Europe UC, Dublin, Ireland). The individually unique and only once accessible link to the webpage of the survey was distributed by email three times, the survey was available between 20 October 2022 and 6 November 2022.

Participants

All CMR Academy alumni who participated in courses from 2016 until 2022.

Participant consent and ethical considerations

Participation was voluntary, and participants were informed before starting the survey that all data collected was non-identifiable and would be used primarily for research purposes. The survey link sent out to the participants was individually different and allowed the completion of the survey only once, ensuring a 100% consent rate and preventing multiple responses.

Data analysis

Data was exported from SurveyMonkey to SPSS [IBM SPSS Statistics, version 29.0.0.0 (241), 2022]. SPSS was used to generate graphs and calculate descriptive statistics for the survey responses. Student's t-test was used to compare the demographic characteristics. When multiple answers were possible or the questions were not dichotomous, the overall distribution between groups was compared using a Student's t-test. Mann–Whitney U test was used to compare the responses between the participants who attended in-person and remote courses. P values <0.05 were considered statistically significant.

Results

Cohort demographics

Of the 158 alumni who were approached to contribute to the survey, 38.6% ($n = 61$) of invitees responded, their characteristics are displayed in Table 1.

The alumni ($n = 158$) invited to complete the survey included participants of the CMR level 1 course (62.02%, $n = 98$), the course leading to the CMR level 2 (24.1%, $n = 38$), and the course leading to the CMR level 3 (13.9%, $n = 22$). The completion rate was 29.6% (29 of 98 invitees) in the level 1 group, 71.1% (27 of 38 invitees) in the level 2 group, and 50% (5 out of 10 invitees) in the level 3 group.

Both in-person and online alumni contributed to the completion of the survey equally: 50.8% ($n = 31$) were in-person alumni and 49.18% ($n = 30$) were online attendees. A separate analysis based on the previous CMR experience of the participants showed consistency with the general results, suggesting that the level of experience in CMR did not have a major effect on the survey outcomes (Supplementary data online, Supplementary Material S2).

Table 1   Demographic characteristics

	In-person (n = 31)	Online (n = 30)	Total (n = 61)	P-value
Female sex, n (%)	15 (48.4)	12 (40.0)	27 (44.3)	0.52
Age, years—median (IQR)	40 (40–50)	42 (40–50)	40 (40–50)	0.05
CMR course				0.01[a]
Level 1, n (%)	11 (35.5)	18 (60)	29 (47.5)	
Level 2, n (%)	15 (48.4)	12 (40)	27 (44.3)	
Level 3, n (%)	5 (16.1)	0 (0)	5 (8.2)	
Specialization				0.32
Cardiology, n (%)	26 (83.9)	22 (73.3)	48 (78.7)	
Radiology, n (%)	5 (16.1)	8 (26.7)	13 (21.3)	
Continent of primary occupation				0.75
Africa, n (%)	1 (3.2)	1 (3.3)	2 (3.3)	
North America, n (%)	1 (3.2)	2 (6.7)	3 (4.9)	
Asia, n (%)	4 (12.9)	6 (20)	10 (16.4)	
Australia, n (%)	1 (3.2)	0 (0)	1 (3.2)	
Europe, n (%)	24 (77.4)	21 (70)	45 (73.8)	
Membership CV imaging society, n (%)	27 (87.1)	23 (76.7)	50 (82.0)	0.30
DGK	7 (22.6)	7 (23.3)	14 (23.0)	
EACVI	20 (64.5)	16 (53.3)	36 (59.0)	
ESR	3 (9.7)	2 (6.7)	5 (8.2)	
RSNA	0 (0.0)	1 (3.3)	1 (1.6)	
SCMR	9 (29.0)	8 (26.7)	17 (27.9)	
Other	2 (6.5)	3 (10.0)	5 (8.2)	

CV, cardiovascular; DGK, German Cardiac Society (Deutsche Gesellschaft für Kardiologie); EACVI, European Association of Cardiovascular Imaging; ESR, European Society of Radiology; IQR, interquartile range; n, number; RSNA, Radiological Society of North America; SCMR, Society for Cardiovascular Magnetic Resonance.
[a]Statistically significant.

Assessment of the courses

Figure 1 presents the main parameters of both in-person and online alumni assessed with regard to the CMR Academy courses.

Overall impression

Regarding the overall assessment, most of the votes [in-person alumni: 83.87% (26/31); online alumni: 83.33% (25/30)] rated the attended CMR course overall either 'excellent' or 'very good' from a five-point Likert scale also including the voting options 'good', 'fair', and 'poor'. The distribution between both groups did not differ significantly ($P = 0.68$, *Figure 1A*).

This overall rating is also supported by the question asking whether the alumni would recommend the CMR course to a colleague (*Figure 2*). Here, the alumni also voted positively in major parts: 87.1% ($n = 27/31$)

of in-person alumni and 76.7% ($n = 23/30$) of online alumni voted 8, 9, or 10 on an 11-point Likert scale (from 0 to 10: not at all likely to extremely likely) ($P = 0.71$).

Satisfaction

Regarding the added value of the course, the assessment of whether the course was helpful on a five-point Likert scale ('extremely helpful', 'very helpful', 'somewhat helpful', 'not so helpful', and 'not at all helpful') was successful in both groups, in-person and online: 96.8% ($n = 30/31$) among the in-person alumni and 93.3% ($n = 28/30$) among the online alumni voted either 'extremely helpful' or 'very helpful' ($P = 0.75$).

It also satisfied the expectations of the majority of both cohorts (five-point Likert scale from 1 to 5 assessing whether the expectations were met: 'much better than expected', 'better than expected', 'about what I expected', 'worse than expected', and 'much worse than expected'): 100% ($n = 31/31$) in the in-person cohort and 90% ($n = 27/30$) in the online cohort voted for either 'much better than expected', 'better than expected' or 'about what I expected' ($P = 0.16$).

Interaction

The opportunity to interact was perceived a bit differently in both groups. While 96.8% ($n = 30/31$) of the in-person alumni felt 'extremely comfortable' or 'very comfortable' asking questions during the course, only 83.3% (25/30) of the online alumni voted for these two options on a five-point Likert scale also including the options 'somewhat comfortable', 'not so comfortable' and 'not at all comfortable' ($P = 0.025$).

While the top vote ('extremely engaging') was not strong in both groups (*Figure 1B*) it scored second after 'very engaging', which got the most votes and was the second option on a five-point Likert scale (from 1 to 5: 'extremely engaging', 'very engaging', 'somewhat engaging', 'not so engaging', and 'not at all engaging'). The distribution of votes overall answers was similar between the in-person alumni [median = 2, interquartile range (IQR): (2–4)] and the online alumni [median = 2, IQR: (2–4); $P = 0.61$].

Organizational framework

The course duration was assessed positively on a five-point Likert scale ('much too long', 'too long', 'about right', 'too short', and 'much too short') in both groups of in-person alumni and online alumni. While no one voted for 'much too long' or 'much too short', 83.9% ($n = 26/31$) of the in-person alumni and 93.3% ($n = 28/30$) voted for 'about right' (*Figure 1C*).

While the content and the speaker assessment were predominantly positive, the assessment of how the alumni rated the value for money question was more heterogeneous overall (*Figure 1D*) but similar between groups [in-person alumni: median = 3, IQR = (2–4); online alumni: median = 3, IQR = (2–4); $P = 0.52$] on a five-point Likert scale ('excellent', 'very good', 'good', 'fair', and 'poor'—translated to a numeric scale from 1 to 5).
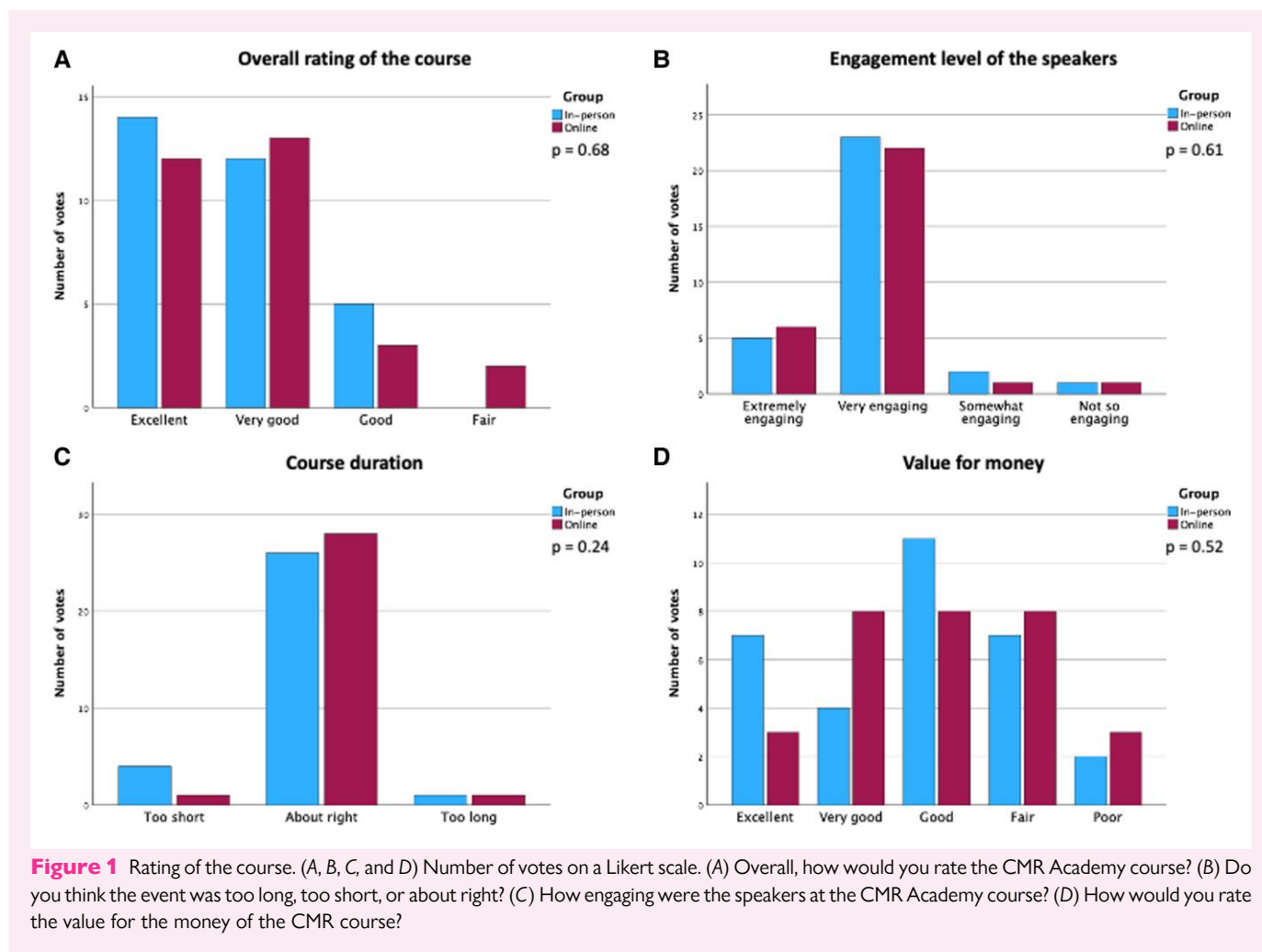
Future requests

Mode of examination

The majority in both groups voted for a written exam [total: 75.4% (46/61); in-person alumni: 77.4% (24/31); online alumni 73.3% (22/30)] as shown in *Figure 3A*. An online-based written exam was also preferred in both groups in comparison to an in-person written exam, also among the in-person alumni (written exam in-person vs. online: 9 vs. 15 by the in-person alumni, 3 vs. 19 by the online alumni).

Mode of teaching

As shown in *Figure 3B*, the least preferred way of teaching is an online-only course [in-person alumni: 19.4% (6/31), online alumni

Figure 1 Rating of the course. (*A*, *B*, *C*, and *D*) Number of votes on a Likert scale. (*A*) Overall, how would you rate the CMR Academy course? (*B*) Do you think the event was too long, too short, or about right? (*C*) How engaging were the speakers at the CMR Academy course? (*D*) How would you rate the value for the money of the CMR course?

10% (3/30)]. In-person courses were preferred by both groups [in-person alumni: 38.7% (12/31), online alumni 60% (18/30)], nearly as much as a hybrid format combining in-person and online elements [in-person alumni: 41.9% (13/31), online alumni 30% (9/30)].

Discussion

This analysis examined the feasibility, satisfaction, and future preferences of physicians attending CMR courses either in-person or online for the first time. The global COVID-19 pandemic necessitated a rapid shift to remote frameworks in medical education, making it essential to assess the implemented new courses, participants' perceptions, and requests for future adjustments.

The analysed survey stresses that the combination of in-person and online elements is preferred in future educational frameworks in CMR, addressing the often-neglected advantages of in-person training.

Moreover, to evaluate the efficiency of the training, we implemented daily Q&A sessions with multiple-choice questions and interactive case reviews, known as 'joint case reviews'. These sessions served as a practical tool for assessing the participants' grasp and application of the course content. This interactive approach not only facilitated the consolidation of knowledge but also allowed us to continuously monitor and adjust the course content based on the participants' performance.

The analysed survey highlights that a combination of in-person and online elements is preferred in future educational frameworks in CMR—a vision that is reflected by many key opinion leaders describing the future of education in general and medical education in particular.[9–13] This approach addresses the often-neglected advantages of in-person training. The German CMR Academy, an institution with long-standing experience in cardiovascular (CV) imaging education, had a 38.6% response rate from invited alumni, including both in-person and online course attendees. The response rate of our survey, at 38.6%, is closely aligned with the average response rate of 44.1% identified in a meta-analysis studying online surveys in education-related research.[14] By chance, the groups were balanced in size ($n = 31$ in-person alumni, $n = 30$ online alumni) and well-balanced in key characteristics, such as sex, age, professional background, and area of occupation. The balanced sex distribution in both groups is noteworthy, as women faced more academic and career progress obstacles during the pandemic, primarily due to the traditional allocation of housework to women.[15] The only difference concerning the two groups, in-person and online, is in the composition of the alumni who completed the CMR level 3 course who are only present in-person but not online since CMR level 3 courses necessitate in-person-only education.

The transition to online courses was successful, as the high level of satisfaction in the in-person cohort was maintained in the online cohort (*Figure 1A*). Over 90% of participants in both groups evaluated their
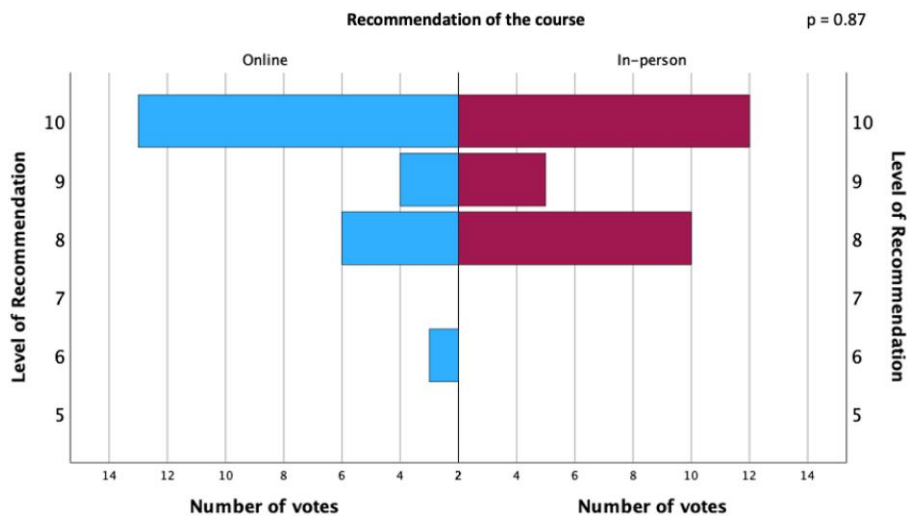
Figure 2 Recommendation of the course by the participants. Number of votes on a 11-point Likert scale (0–10, 'not at all likely' to 'extremely likely'). Question asked: How likely is it that you would recommend the CMR Academy course to a colleague?
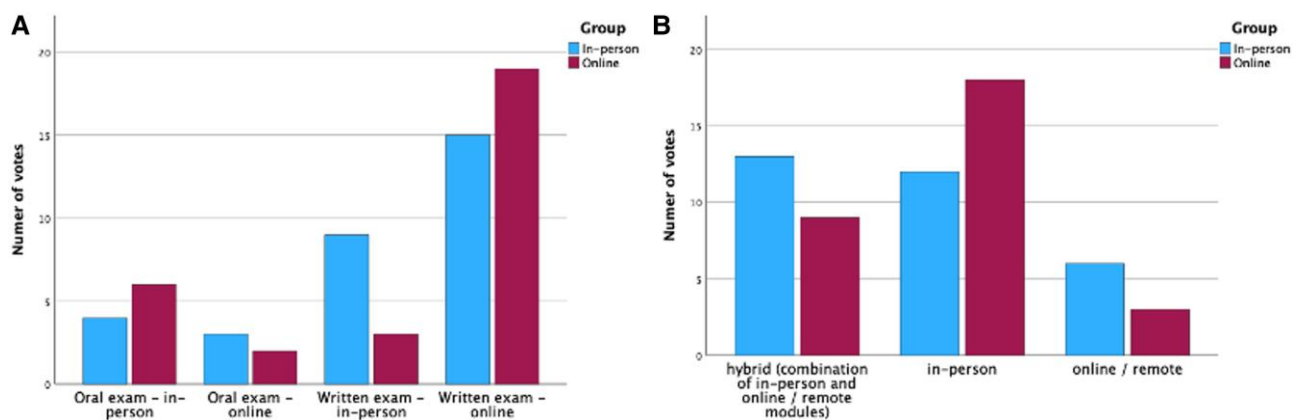

Figure 3 Preferences for future exams and courses. (*A*) Preferred mode of examination. (*B*) Preferred mode of teaching.

respective courses as 'very' or 'extremely helpful,' meeting or exceeding their expectations. Most alumni would recommend the CMR course to a colleague (*Figure 2*). However, the survey revealed the disadvantages of online courses, primarily in terms of interaction. While speakers were perceived as engaging in remote courses, online attendees felt less comfortable asking questions compared to in-person alumni. This finding could be attributed to various factors, including a higher threshold to participate, and increased social performance pressure in online settings. Over 90% in both groups evaluated their respective course as 'very' or 'extremely helpful', meeting or exceeding their expectations.

In detail, the online training programme was comprehensive and incorporated a variety of elements including didactic lectures, interactive case discussions, question-answer sessions, case reviewing, hands-on reporting practice, CMR atlas sessions, and CMR physics sessions. We were also able to successfully include remote scanner training in our current online training format, having solved local legal issues and

obtained the necessary patient consents. Our approach followed the guidelines described by the SCMR in their Level II virtual training guidelines and adhered to the requirements set by the Ärztekammer Berlin (the local regulatory authority for medical education) for online teaching.[6]

One of the measures to ensure the quality of virtual CMR training in the published SCMR guideline is to conduct virtual training only at centres with prior in-person training experience, which is fulfilled at our centre.[6] Our study also found that course fees were perceived as too high by both in-person and online alumni, despite the high satisfaction with the courses.

However, the survey also revealed disadvantages of the online course that include the perceived reduced opportunity to interact with instructors. While the speakers were perceived as engaging in remote courses, alumni of the online courses felt less comfortable asking questions compared to the in-person alumni. Several reasons contribute to this finding including a higher threshold to participate.

Participants who do not know each other and do not interact with one another aside from the classes are more reluctant to ask a question, which is more often the case in remote-only classes.[16] In addition, on-line classes increase the social performance pressure as the attention of the group is focused on the person asking, while during in-person meetings, questions might be asked quickly between a participant and a lecturer, or between participants and not always include the whole class.[16]

Another aspect rated poorly in our questionnaire is the value for money assessing the courses while the satisfaction with the course *per se* is high. This reflects that the course fees are perceived as too high—by both the in-person and the online alumni, to the same extend. In the past and at present, most participants have paid for a significant portion or even the entire course fees themselves. However, as CMR becomes increasingly important in cardiology and more widely available, there is a

growing need for institutions to ensure the presence of well-trained CMR professionals. As a result, institutions should take on a more active role in covering or supporting training costs. The updated German cardiology curriculum for board certification now mandates CMR training, which further emphasizes the responsibility of institutions where cardiology residents are trained to provide adequate educational opportunities.[17] If offering in-house training is not an option, these institutions should actively support residents in attending the necessary external courses to guarantee the provision of high-quality training.

The alumni voted for future in-person or hybrid meetings to be taught, while the exams should be written exams conducted online.

Especially advanced imaging techniques including computer tomography (CT) and CMR benefit from the accessibility of online training as the image acquisition has been robustly standardized, often acquired with a technician only. The Society of Cardiovascular Computed Tomography published a concept including multimodal parts of training dependent on the abilities and the general training of the clinical fellows, including major remote learning approaches.[18] These concepts cannot be translated to all modalities as echocardiography for example requires a higher degree of hands-on training since image acquisition is much more examiner-dependent.[19]

While the preferred method in our questionnaire was a hybrid format that promises to combine the advantages of both training concepts, in-person and online, it introduces obstacles participating in some, vulnerable groups of participants:

(a) Physicians from remote regions attending in person. Physicians from low- and middle-income countries have the highest obstacle in this regard as they have the highest financial and time investment regarding travel to the training centre which is usually in a region with higher availability of CMR.

Table 2 Recommendation of modalities for future certifications

Certification level	How to approach		
	Online only	In-person only	Hybrid
I	X	X	X
II	(X)	X	X
III	–	X	–

Online only under specific conditions (e.g. pandemic, participants from low- and middle-income countries).
Recommended; X: recommended; (X): reluctantly recommended; (−) not mandatory.
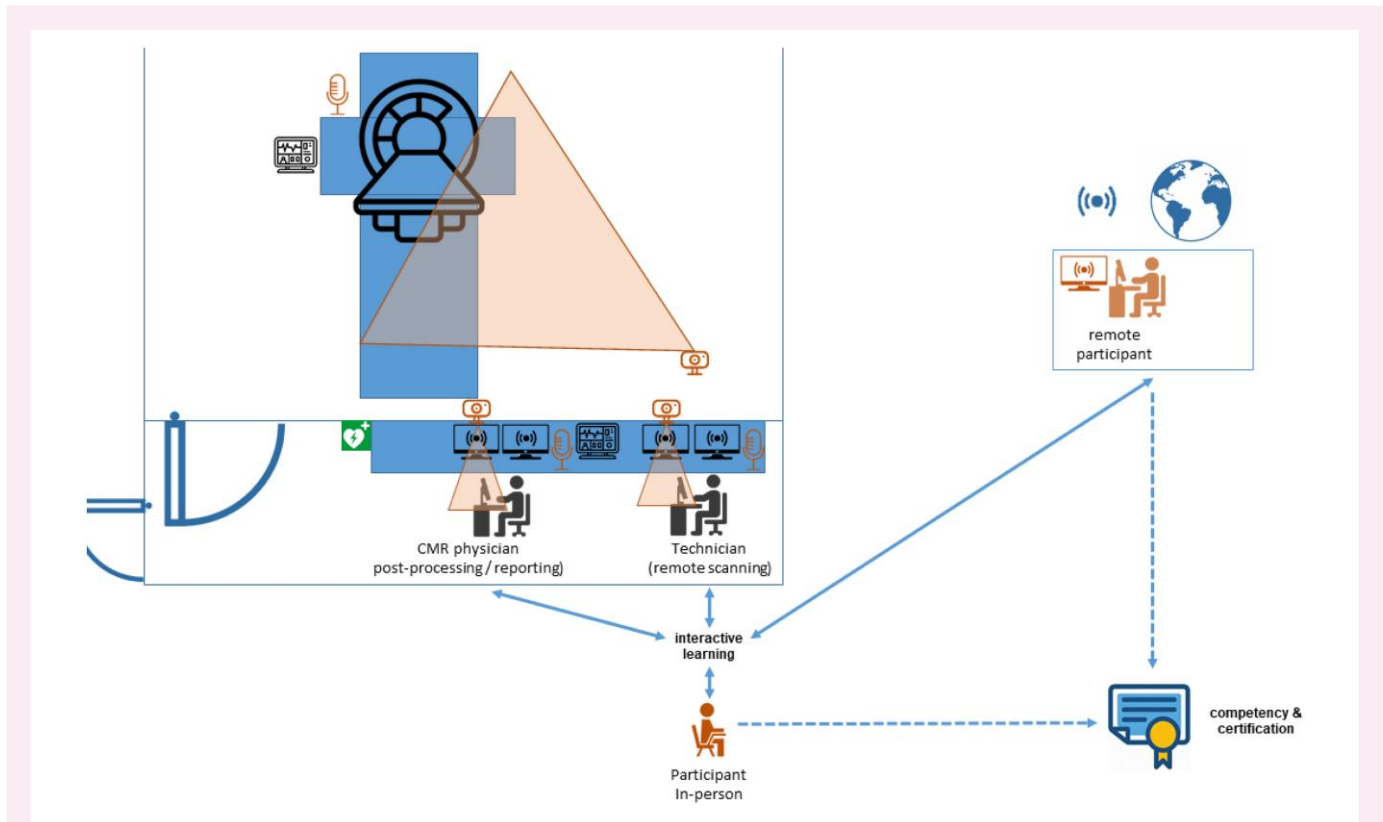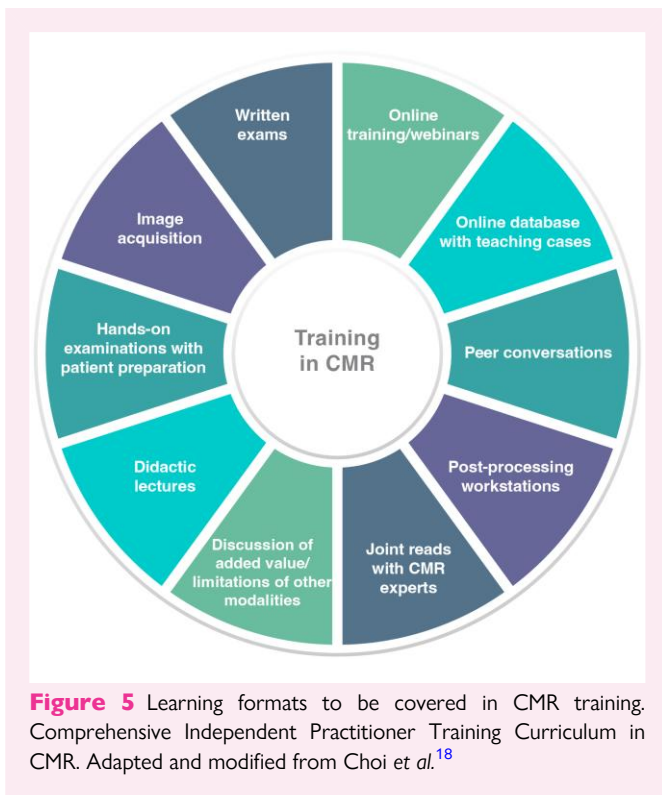

Figure 4 Schematic figure of streaming setup at the CMR scanner.

Figure 5 Learning formats to be covered in CMR training. Comprehensive Independent Practitioner Training Curriculum in CMR. Adapted and modified from Choi *et al.*[18]

(b) Physicians with other, rigid obligations. As in-person training implies the absence from the usual environment and home, physicians interested are less likely to attend if they have other obligations they need to cover in their spare time. This applies mainly to those who are involved with care work. In addition, as many physicians taking the course are cardiologists and radiologists, it is additionally difficult to miss work for prolonged periods given the clinical demands of the job.

In summary, the optimal training method for CMR requires not only to be tailored to the individual skills but also the resources of the participant; the characteristics and the experience of the training centre must also be considered. High-volume centres can more easily offer an online course while ensuring that the participants would learn everything necessary to become proficient with CMR, even if they ask fewer questions than they may at an in-person course. In a centre with fewer cases, it would be preferable to ensure in-person attendance to guarantee the maximal learning effect per case.

The preferred method in our survey was a hybrid format, which promises to combine the advantages of both in-person and online training concepts. This approach is particularly relevant when considering the different levels of CMR certification.[20] However, this introduces obstacles for some vulnerable groups, such as physicians from remote regions and those with home care responsibilities. The ideal training method should consider the skills and resources of participants, as well as the characteristics and experience of the training centre. In *Table 2*, we propose the recommended format (online only, in-person only, hybrid) for participants aiming for a CMR certification level I, level II, or level III based on the results. We illustrated our setup for online access to the medical setup at the CMR scanner in *Figure 4*.

Limitations

Alumni who completed the survey might have a selection bias towards an online affinity. As the online group was not relevantly different from the in-person group in the key questions, this confounder is of a limited extent.

While our study provides valuable insights into the effectiveness of online CMR training, it does not compare the results with other imaging modalities, which might have different requirements and outcomes in an online training setting. Furthermore, we did not evaluate the impact of the training format on exam results, which could provide additional insights into the effectiveness of online vs. in-person training.

Conclusion

In summary, the online courses were a great success that addressed the expectations of the participants well and were helpful to them. Future courses are preferred to consist of both online and in-person elements to allow more interaction and the chance to learn more by asking questions. As illustrated in *Figure 5*, various learning formats, such as lectures, peer discussions, and image acquisition, should be incorporated into CMR training. The findings of this study, along with the recommendations outlined in *Table 2* and the learning formats summarized in *Figure 5*, might contribute to the development of more effective and inclusive educational frameworks in CMR. In addition, the results might serve as a blueprint for structured education in cardiac CT as well.

Lead Author Biography

Dr. Djawid Hashemi, M.Sc., is a dedicated cardiologist and researcher at Charité in Berlin, with a focus on heart failure, cardiac magnetic resonance (CMR), and clinical trials. He holds an M.Sc. in Clinical Trials from the University of Oxford. Dr. Hashemi is actively involved in both national and European Society of Cardiology initiatives, striving to enhance knowledge accessibility among junior cardiologists and researchers. His commitment to medical education and research continues to drive advancements in cardiology.

Author contributions

D.H. and S.K.: conception and design of the study and literature review. D.H.: data collection. D.H. and S.K.: analysis and interpretation of the data. D.H.: drafting of the manuscript. All authors: revising and editing the manuscript.

Supplementary data

Supplementary data is available at *European Heart Journal - Imaging Methods and Practice* online.

Consent

All authors consented with its publication.

Data availability

The data underlying this article are available in the article and its online supplementary material and additional data will be shared upon reasonable request to the corresponding author.

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