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Title of the publication-based thesis

# *Exercise is medicine in cancer!*
# *But how do we implement exercise into routine clinical care?*

presented by
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*In dem Augenblick, in dem man sich endgültig einer Aufgabe verschreibt, bewegt sich die Vorsehung auch. Alle möglichen Dinge, die sonst nie geschehen wären, geschehen, um einem zu helfen. […]*

***Was immer Du kannst, beginne es.***
***Kühnheit trägt Genius, Macht und Magie.***

***Beginne jetzt***.

*Johann Wolfgang Goethe*

# *Danksagung*

Damals stand ich auf Bühnen zur „Bewegten Pause“ und habe Patienten, Angehörige, Mediziner und Wissenschaftler auf Kongressen und zwischen Fachvorträgen animiert sich zu bewegen – Arme hoch und nach unten, jetzt die Knie heben und einmal drehen. Heute stehe ich dort als Wissenschaftlerin, stelle meine Forschungsergebnisse vor, darf Fragen beantworten und meine Expertise teilen. Meine Entwicklung habe ich meinem großartigen Umfeld zu verdanken und ich möchte hier den Raum für ein herzliches Dankeschön geben.

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*„Es braucht ein Dorf […] zum Schreiben einer Doktorarbeit.“*

Heidelberg, April 2024

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# Abstract

*"Exercise is medicine in cancer!"* is a statement that is based on a large body of scientific evidence and continues to be increasingly incorporated into the care of oncological patients. Exercise has become an important pillar in the prevention and treatment of cancer- and cancer-treatment-related side effects. Despite the extensive evidence on the effects of exercise in cancer, the implementation of cancer exercise programs is still heterogenous and fragmentary. Barriers to offer cancer-specific exercise opportunities are diverse and are mostly located on the level of finances, education, personnel resources and missing collaborations. Moreover, the majority of health care professionals (HPCs) do not recommend exercise as a standard of their oncological care plan nor do they refer patients into local exercise programs. Further, due to the complexity of cancer disease and the diverse side effects of its treatment, different types of exercise offerings are required, ranging from general community-based programs to very specific and individually supervised offerings. Due to the presented issues, different exercise care pathway models have been developed in the US, Canada and Australia in which the treating HCP advises physical activity to their patients and refers them into suitable exercise programs. As a leading example in Germany, the network OnkoAktiv provides a professional network of clinical institutions including their HCPs and quality-assessed cancer exercise programs to enable comprehensive exercise care. Although OnkoAktiv has been seen as a successful running example of an exercise care network, the network has not been evaluated to date. Moreover, there is a gap of knowledge about how to implement exercise into different settings of the German health care system.

Given this urgent need for research, this cumulative dissertation intended to contribute to the following research areas by (a) investigating exercise implementation barriers and facilitators of the network OnkoAktiv institutions, (b) analysing and illustrating the network compositions of the regional OnkoAktiv networks and to define practical implications for further network development and (c) giving an overview about existing oncological exercise programs in the European region and to discuss current cancer exercise implementation perspectives in Europe.

The three manuscripts contained in this dissertation present results of three different studies. All studies are part of the comprehensive evaluation concept of the networks OnkoAktiv and aimed to evaluate OnkoAktiv on two levels, the regional OnkoAktiv networks (RE) and certified training institutions (TR) as well as the network frame (European exercise programs).

The evaluation of the regional OnkoAktiv networks (RE) and certified training institutions (TR) in the first manuscript was executed in a sequential mixed methods design. 16 qualitative interviews were conducted with the leaders of the RE and TR. Then, 89 TR were invited to a quantitative, cross-sectional

survey. 11 facilitators each for RE and TR, 7 barriers for RE and 5 for TR could be found. Barriers were for example missing comprehensive funding concepts for the OnkoAktiv network structures, a lack of knowledge of HCPs and exercise trainers, low numbers of patient referral, and missing collaborations between network stakeholders. Facilitators could be identified on the level of internal organizational resources, support by OnkoAktiv staff and collaboration between exercise institutions and HCPs. The findings indicate challenges on different level of OnkoAktiv for the implementation of exercise network structures.

The second manuscript aimed to analyse the structure of the individual regional OnkoAktiv networks and classified them into their organisational forms. A social network analysis could be performed for 11 regional OnkoAktiv networks. In smaller networks, several individual professionals were linked "from service to service" through linkage, whereas the more integrated networks revealed a core-periphery-structure. Overall, collaborative networks such as OnkoAktiv enable the involvement of professional actors from different operational fields. Linking different actors and building a network core for control and organization is important for building networks such as OnkoAktiv.

The third manuscript intended to analyse existing cancer-specific exercise programs in the European Union and neighbouring countries and to discuss implementation perspectives in the European context. Through a cross-sectional survey, 81 exercise programs from 15 different countries could be investigated. The included exercise programs were highly diverse in terms of structural and organizational characteristics and there was a high need of collaborations with HCPs and educational courses for trainers. For the integration of exercise into existing cancer care settings, a close interaction and collaboration between the cancer clinicians and exercise providers is necessary.

All in all, this cumulative dissertation provides a roadmap on why, where and how to implement exercise into cancer care structures in Germany, including barriers, facilitators, important stakeholder and organisational steps that should be considered.

# List of scientific manuscripts for the publication-based dissertation

## Manuscript I

Voland A, Lohmann A, Ansmann L, Wiskemann J. Barriers and Facilitators for the Implementation of Exercise Oncology Provision in Germany: A Multilevel, Mixed-Methods Evaluation of the Network OnkoAktiv. Eur J Cancer Care (Engl) 2023; 2023: 1–9
[https://doi.org/10.1155/2023/6270049]

## Manuscript II

Voland A, Köppel M, Peters S, Wiskemann J, Wäsche H. Exploring the organisational structure of networks for exercise oncology provision: a social network analysis of OnkoAktiv. BMC Health Serv Res 2023; 23(1): 555
[https://doi.org/10.1186/s12913-023-09572-8][PMID: 37244985]

## Manuscript III

Voland A, Campbell A, Wiskemann J. Characteristics and perspectives of cancer exercise programs in Europe and neighboring countries: an explorative cross-sectional survey. Under review in Supportive Care in Cancer on March 04, 2024.

# 1 General Background

## 1.1 Introduction

Worldwide, cancer is one of the leading causes of mortality in countries of low-, middle- and high-income level with around 14.1 million new cancer cases and 8.2 million cancer death per year. In Europe, 3.2 million new cancer cases and 1.7 million deaths due to a cancer disease are estimated by the European commission for 2040 [1]. Most common cancers are breast (27%), colon (13%) and lung (9%) for women and prostate (23%), lung (14% and colon (14%) for men. The incidence trends of all types of cancer have continued to increase over the last decade, however, overall cancer death rates have been steadily decreasing in Europe [1, 2]. The decrease of death rates can be mainly explained by the highly individualized and multidisciplinary oriented oncological therapy approaches that have been implemented in cancer care. Next to primary therapy methods, supportive care provision has been grown up to an important pillar in modern oncology. Hence, exercise oncology shows itself with an outstanding evidence of scientific knowledge and takes an important role in the management of cancer- and cancer therapy-related side effects [2]. Several national and international organizations such as the Clinical Oncology Society of Australia, the American College of Sports Medicine (ACSM) and the World Health Organization (WHO) recommend the avoidance of inactivity and participation in regular exercise for cancer patients [3]. Researchers developed different pathways of exercise care that systematically include all phases along the cancer care continuum to facilitate current exercise recommendations within daily practices [4]. Exercise care in the context of this dissertation refers to the comprehensive provision of exercise advise, referral and suitable training options for oncological patients along the cancer care continuum. The continuum describes the stages of cancer care from diagnosis, treatment to rehabilitation and onwards [5]. Within exercise care pathway models, medical and exercise professionals provide a connected chain of care in which patients receive physical activity assessments, exercise advice and referral into an appropriate exercise program. However, notable gaps in knowledge of health care practitioners (HCPs) and clinical infrastructure are still existent and impede the implementation of exercise as a standard of care in oncology [6]. Moreover, researcher highlighted that the current provision of cancer-specific exercise programs is highly heterogenic and fragmentary within and across countries and does not meet the demands of oncological patients [5, 7–9]. To increase the availability of program accessibility, community-based exercise facilities such as community-gyms, health care or rehabilitations centers gained more attention within the last decade [10]. Within several community-based institutions and settings, special trained exercise trainers in oncology provide appropriate exercise programs for cancer patients. The evaluation of community-based exercise programs, including their implementation into clinical or community-based settings and the pathways of exercise care have become major attention in research [5, 10–12]. For example, the

Exercise Oncology Knowledge Mobilization Initiative underlines an urgent need for research in regard to the best practices to implement exercise support as a standard pillar of care in oncology [6].

In purpose of structuring the present dissertation within the overall scientific knowledge, the following section about the general background of this work, briefly outlines the current advancements and results in the field of research in exercise oncology (chapter 1.2). Thereafter we describe different perspectives in regard to exercise program implementation in cancer care (chapter 1.3). We complete chapter one by revealing gaps in previous research and defining our research questions (chapter 1.4) as well as we show results of previous work that were incorporated into this work (chapter 1.5).

## 1.2 Physical activity and cancer

A large body of scientific evidence shows the positive effects of physical activity before, during and after cancer therapy [2]. Physical activity improves cardiorespiratory and muscular fitness and function (e.g. peak oxygen consumption, maximal strength, flexibility) [13–17], immune response [18] and quality of life [19–22] in cancer patients. Further, regular physical activity builds muscle and bone mass [23–26] and increases psychological functions such as self-esteem and self-efficacy [27]. Structural exercise programs have shown a positive impact on several highly prevalent cancer and cancer-specific side effects such as fatigue [28–30], chemotherapy-induced polyneuropathies [31–33], lymphedema [34–36], mental health [37–39] and cognitive function [40, 41]. Furthermore, latest data indicate a preventive effect on long-term complications in the field of cardio- [42, 43], neuro- [31] and bone toxicity [23, 44]. Moreover, observational studies reveal the positive effect of physical activity and exercise on overall survival rates [45, 46] and cancer-specific mortality [47, 48]. Specifically, researchers reported a mortality rate reduced up to 50% for breast, colon and prostate cancer for physical active patients [47]. First pilot studies observed an improvement in chemotherapy tolerance in correlation to exercise [49, 50]. Portiaumpai and colleagues [51] highlighted that supervised exercise programs resulted in higher chemotherapy completion rates, which resulted in higher medication rates and lower risks of cancer recurrence. In addition, some studies have shown that exercise during and after cancer treatment may reduce emergency department visits, hospitalization and the length of hospital stays [49–51]. The positive effects of exercise have been demonstrated for most types of cancer, independently of exercise timing (e.g. during or after active cancer treatment) [21]. Many benefits have been achieved by the general exercise recommendation of the American College of Sports Medicine (ACSM) for cancer patients of 150 to 300 weekly minutes of at least moderate physical activity. In addition, the ACSM defined specific exercise guidelines for individual cancer- or cancer-therapy related side effects [2]. For example, the minimal effective dose to reduce cancer-related fatigue is defined as an aerobic exercise training for about 30 minutes (65% $HR_{max}$ or 45%$_{VO2max}$) on three days per week in combination with strength training (60% 1-RM, 2 sets, 12-15 reps) on two days

per week. Next to fatigue, specific exercise recommendations have been extracted from literature for the investigated outcomes quality of life, physical function, lymphedema, depressive symptoms and anxiety. For other outcomes such as sleep deprivation, bone health, cardiotoxicity or polyneuropathy, the existing evidence is still too small to determine specific training recommendations [2]. However, several initiatives such as the bone health initiative [26], actively working on precise guidelines to provide save exercise guidelines for specific target groups.

**Contraindication and risk stratification to exercise**

In order to exercise safely, cancer patient should undergo risk management that is provided by their HCP or exercise professional. As seen in table 1, risks to exercise can be differentiated between general and cancer or cancer-treatment specific contraindication.

*Table 1: General and cancer-specific contraindication to exercise for cancer patients and survivors*

| General contraindications | Cancer-specific contraindications |
|---|---|
| **No strenuous physical activity is advised for:**<br>• acute cardiovascular diseases<br>• severe chronic heart disease<br>• untreated high blood pressure<br>• acute thrombosis<br>• Aneurysms<br>• severe lung diseases<br>• acute and chronic infections or inflammations<br>• untreated severe hyperthyroidism<br>• other organ changes | **No strenuous physical activity is advised for:**<br>• 24 hours after chemotherapy<br>• severe nausea/vomiting, pain, dizziness<br>• fever (body temperature > 38 °C) or acute infection<br>• incomplete wound healing<br>• Thrombopenia (platelet count <20,000 /µl)<br>• acute bleeding or severe bleeding tendency<br>• recent thrombosis or embolism<br>• serious acute neurological disorders<br>• bone metastases or osteolysis that threaten stability or whose stability is unclear |

Next to the contraindication listed in table 1, further risk management should be provided in special circumstances such as impaired immune, cardiac and respiratory function, port, intestinal stoma, surgical scars as well as brain- and bone metastases and tumours. The three risk groups impaired immune, cardiac and respiratory function will be described below as examples for exercise risk management.

The impairment of a patients´ immune function can be checked based on the number of leukocytes in the blood (normal values: 4,000 – 10,000 cells/µl). If this indication has been confirmed via blood tests, there is a need to take special attention to hygiene. The patient should avoid swimming pools and public training facilities or peak times to decrease the risk of infection. A very sensitive target group are patient after stem cell transplantation. Their immune function is significantly impaired in the first

100 days after transplantation and needs special attention. For case of impaired immune function, literature provides evidence in the reduction of chronic inflammation through combination strength and endurance training of moderate intensity in cancer patients [18].

The impairment of cardiac function can be triggered by anthracyclines (epirubicin, idarubicin, doxorubicin) and results in the damage of the heart muscle (dose-dependent), cardiac arrhythmias (acute) and heart failure (long-term). In the care of impaired cardiac function, regular cardiological examinations should be carried out to rule out long-term consequences (1 – 2 times per year). In addition, a medical assessment is advised, as some cardiovascular diseases represent an absolute contraindication to exercise. The exercise training should be stopped immediately, if the patient feels pressure in the chest, chest tightness/pain (angina pectoris), heart palpitations/stumbling, shortness of breath or severe dizziness [42].

Cancer patient with impaired lung function such as pulmonary fibrosis, chronic pleural effusions, recurring pneumonia or performance-limiting shortness of breath vicious often avoid physical activity due to insecurity and fears. Such patients should perform respiratory gymnastics and train their respiratory muscles in the back, trunk and abdominals. Further, they should avoid exposure to cold, dusty or dry air to reduce any coughing or lung irritations. Exercise trainers should be particularly careful when dosing training intensities and might take daily performance fluctuations into account [52]. Patients with tracheostomy are able to participate in moderate training without peak loads. However, some exercises may not be possible while lying on their back or stomach. Water sports without special protection are life threatening.

In summary, current evidence in exercise oncology shows that exercise is a save [2, 17] (in consideration of possible contraindications and individual risk management) and effective way to manage and reduce several cancer- and cancer-treatment-related side effects. However, the knowledge transfer from clinic to community settings and the comprehensive provision of exercise across regional borders remains crucial. In consideration of thousands of new cancer patients per year, exercise provision is still fragmentary and highly heterogeneous. Due to this issue, we need specific strategies to drive the implementation of oncological exercise programs and their allocating pathways forward that roll out the current exercise guidelines into general public spaces. Therefore, the following part of this dissertation is intended to contribute to the current knowledge on exercise pathway models in oncology, different types of oncological exercise programs and a brief discussion on implementation perspectives.

## 1.3 Exercise implementation in cancer care

Despite the vast evidence of exercise efficacy in oncology, research has shown that many HCPs do not recommend exercise as a standard of their oncological care plan. The number of cancer patient that receive exercise recommendation during their medical consultations are highly heterogeneous across

countries, medical settings and professional groups. For example, Haussmann et al. [53] investigated that more than 70% of HCPs promoted physical activity to their cancer patients in Germany. Other authors from the US and Canada highlighted that only around 35-55% of medical professionals advice some or any exercise to their cancer patients [54–56]. Schmitz et al. showed that only 19-23% of oncology physicians and 9% of nurses referred patients into some kind of exercise programs in the US [4]. Further, research has shown that patients that receive some advice to exercise by their doctor are more likely to participate in exercise than patients who does not [57, 58]. The exercise referral scheme 'Rezept für Bewegung' ('Exercise on Prescription') received greater attention in Germany since 2019. The referral scheme encourages physicians to give verbal advice via written prescriptions to patients. After the short physical activity counselling, 50% of patients attended an exercise course in a sports club and increased their daily physical activity [59].

However, barriers to incorporate exercise counselling and recommendations into the clinical routine are diverse and highly dependent on the physician's interest, their time and organizational parameters (e.g. time). Often stated problems to implement exercise counselling were lack of awareness of exercise benefits for patients, non-commitment to provide exercise care by HCPs, lack of time, uncertainty in regard to exercise safety, lack of available programs and need for educational training about exercise for HCPs [53, 60, 61]. The qualitative evaluation if the German model project "Exercise on Prescription" showed further that a lack of local exercise offers and the direct cost coverage by health insurance companies were major problems for the project implementation [62].

Despite this problem, current research shows the importance of brief communication exchange between oncologists and their patients in regard to exercise. Patients show a high level of trust to their oncology care team and as such, it can be motivational and reassuring to discuss exercise within their consultations [57, 58, 63]. Jones et al. [57] showed a significant difference in total exercise between the study group that received exercise recommendations by their oncologists versus usual care (mean difference 3.4 MET hr per week; p=.011).

### 1.3.1 Pathways of exercise care

To address the issue that HCPs do not discuss exercise routinely with their patients nor do they refer them to suitable exercise options, different exercise care pathway models have been developed. Such pathway models involve HCPs and exercise professionals to provide exercise advice, risk management and exercise referrals. To provide a brief overview of existing pathway models, this dissertation offers a brief overview about five exemplary pathways in the following section.

Santa Mina and colleagues [64] developed an exercise pathway model that starts with the identification of patients who could benefit from exercise and goes along with referral processes into

suitable exercise programs. The pathway involves all stakeholder along the cancer care continuum such as HCPs, exercise professionals and community exercise trainers. Cancer patients might enter the pathway at any point after their cancer diagnosis. HCPs are guided to utilize screening- and individual risk stratification methods and to refer patient into suitable exercise programs. Risk stratification to exercise can be done by different screening check lists such as tools by Brown [65], Burr [66] or the U.S. National Comprehensive Center [67]. Please find more information about contraindications and risk stratification to exercise in in chapter 1.1 of this dissertation. Involved HCPs screen and triage patient according to their risk of safety, define the appropriate supervision or initiate additional screening before starting to exercise [64]. Figure 1 shows the simplified pathway model by Santa Mina et al. from cancer diagnosis to different physical activity options based on the risk management outcomes.

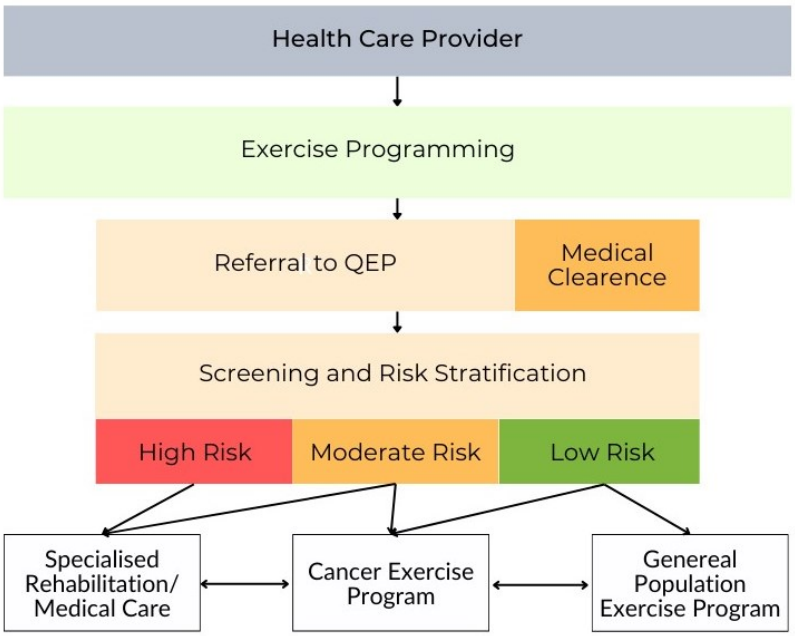



*Figure 1: Exercise pathway model by Santa Mina et al.; adapted and simplified [64]*

Another model has been provided by Dalzell et al. [68], the ActiveOnco model of care. It provides exercise prescription, physical activity promotion and the transition from hospital to community-based exercise. HCPs are involved in the ActiveOnco model to provide appropriate risk stratification (triage) to ensure exercise safety. Dalzell and colleagues defined specific guidelines for the exercise counselling and patient referral process. If one or more of the following characteristics were indicated in any patient, exercise had to be advised by the responsible HCP: a significant decrease in activity level (<3-4 MET-hours per week), high fatigue level (VAS >3/10), muscular weakness, peripheral neuropathies or loss of balance and coordination. Then, patients underwent physical exams, medical briefings and were categorised into complex or non-complex groups, based on their medical history. Non-complex

patients were referred into community-based exercise programs, emphasising exercise promotion and exercise barrier management. Complex patients (e.g. with very high fatigue levels, pain or significant peripheral neuropathies) had to be referred to special in oncology educated physical therapists. Those regularly consulted the multidisciplinary oncological team to discuss the patient's progress of disease and it´s treatment side effects. Dalzell et al. reported that around 30% of patients needed special rehabilitation interventions (e.g. clinical exercise supervision) but most patients (around 70%) could be referred to community-based exercise programs or started home-exercise interventions.

A more detailed screening and referral framework for personalized interventions in exercise oncology has been provided by Stout et al. [69]. The screening framework involves five domains that characterize the individual's medical status to different time points along the personalized treatment pathway. It assesses most relevant medical elements to identify individual risks, needs and referral considerations in regard to exercise. The domains include cardiometabolic status (e.g. hyperlipidaemia, hypertension, type 2 diabetes), oncological impairments (e.g. bone metastasis), aging factors (e.g. fragility, dementia), behavioural attributes (e.g. lack of time or motivation) and environmental characteristics (e.g. limited access to exercise facilities). Similar to other screening methods, Stout and colleagues classify patients into low, moderate and high complexity groups that define the level of exercise supervision. Further, they define a group of patients that is able to exercise independently in any setting of individual preference without any supervision. The "algorithm" describes specifically what, who and where exercise programming can be done for every group of patient and complexity. For example, low complexity patients can be referred into group or supervised cancer exercise programs or perform lifestyle coaching and impairment monitoring, which are executed by exercise physiologists or cancer exercise trainers in gyms, fitness or wellness centers. In contrast, high complexity patients might participate in supervised exercise programs after physicians´ clearance and medical check-up in acute rehabilitation settings or outpatient clinics, supervised by special for oncology-educated physiatrists.

Another recent exercise care pathway has been provided by Schmitz and colleagues in the course of the American College of Sports Medicine Roundtable in 2019. The ACSM referral process is based on the concept "Assess, Advise, Refer" which was first introduced by the exercise is medicine initiative (EIM) in 2007. The concept aims to engage clinicians to make exercise referrals a standard of practice, within an easy, straightforward framework (see figure 2).

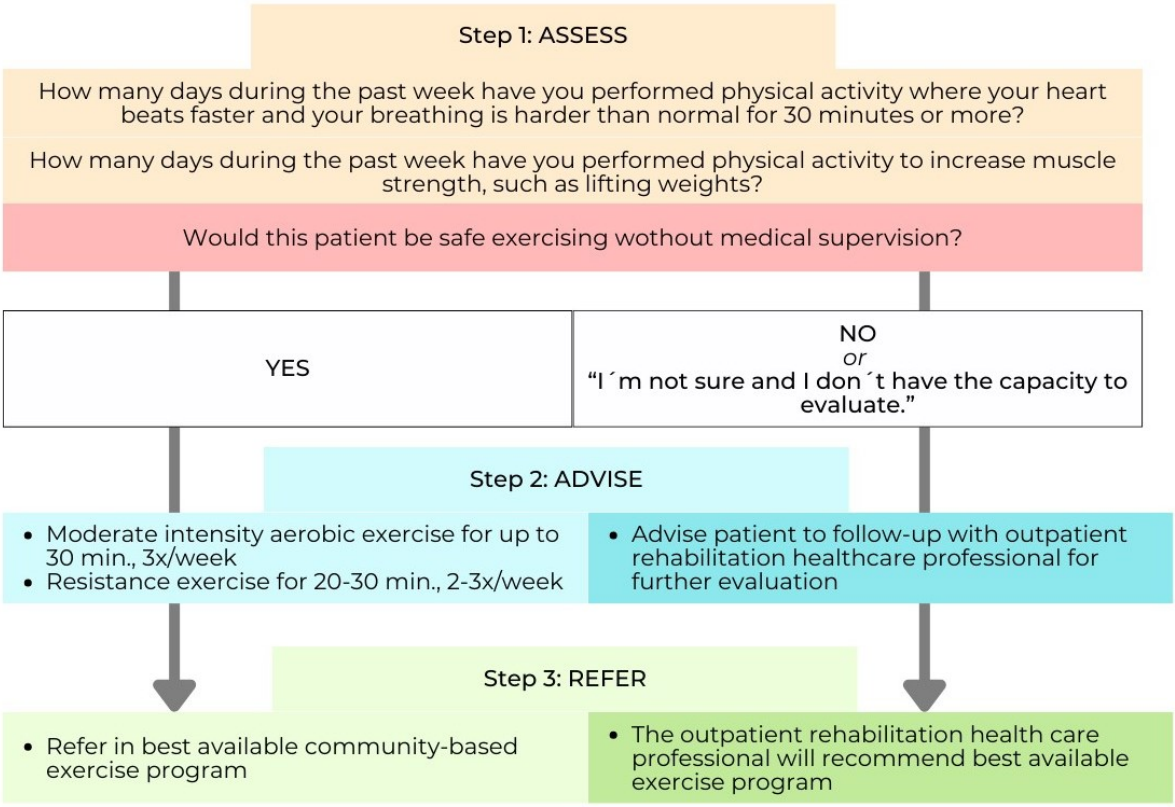



*Figure 2: Oncology Clinicians´ Guide to Referring Patients to Exercise adapted from Schmitz et al. [4]*

The first step "Assess" starts with the assessment of the current physical activity level within regular time intervals. Two sample questions that can be incorporated into the clinician's practice are presented in figure 2. Before starting step two "Advise", HCPs need to make sure that exercise would be safe without medical supervision via risk assessments (see chapter 1.1 on details to exercise risks stratification). Based on the assessment, the following steps lead into two different pathways. If the answer in regard to exercise safety is "Yes", HCPs should advise to increase the current physical activity level if the patient does not reach the exercise recommendation of a combined aerobic and resistance exercise program of 150 minutes per week (according to ACSM) and refer into the best available exercise program. The third step "Refer" should be based on current activity levels, medical status and patients' individual preferences. If the answer to exercise safety is "No" or "I´m not sure or I don´t have the capacity to evaluate", HCPs advice and refer patients to exercise professionals for further assessment, education, support and supervision (e.g. outpatient rehabilitation centers or exercise therapists in oncological clinics). The authors highlight that it is not in the scope of oncology clinicians to give specific exercise prescriptions nor to evaluate for symptoms such as depression, anxiety or exercise-related conditions. However, as stated earlier, HCPs play an important role in the promotion of exercise and pointing patients to suitable services that meet their specific needs in regard to exercise safely.

Summarized, there is some international promising evidence about the successful implementation of exercise pathways in cancer care. However, limited knowledge about different cancer exercise settings and complex decision making to connect each cancer patient to the "right exercise option" at the "right time" are barriers for the successful pathway implementation [70]. Therefore, the following part discusses different models of exercise program stratification and the necessary educational level for exercise professionals in different settings.

### 1.3.2 Types of cancer exercise programs

Depending on the patient's characteristics, medical history, acute therapy-related symptoms and personal preferences, there are different types of exercise programs in which patients can be referred, to exercise safely at all times during and after cancer treatment [4, 64, 70]. The Exercise in Cancer Evaluation and Decision Support (EXCEEDS) algorithm provides a conceptual model that describes exercise/rehabilitation services based on the level of specialization. The algorithm differentiates between four level of exercise specialisation that are illustrated in figure 3. Overall, the level of exercise program specialisation increases with the level of the patient's complexity. Patients with complex cancer- and cancer-treatment related symptoms should exercise in cancer rehabilitation settings, whereas patients with lower complexities might participate in supervised, cancer-specific, community-based exercise programs in community facilities or even in home-based unsupervised settings.

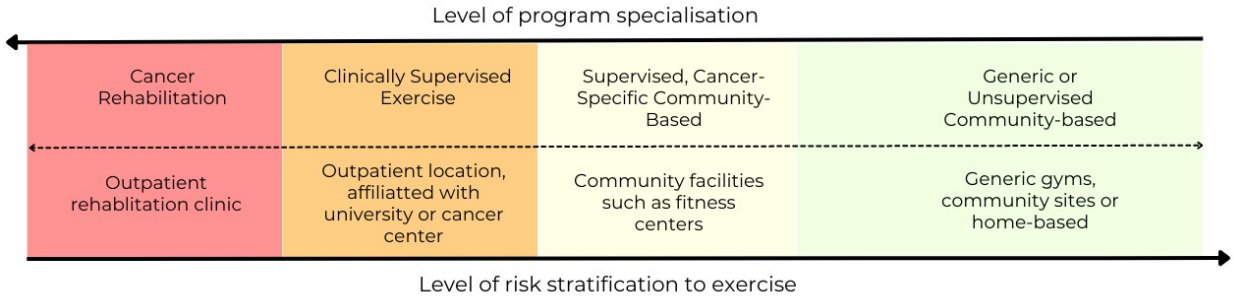



*Figure 3: EXCEED Algorithm: Level of program specialisation and risk stratification in different exercise settings; adapted from Covington et al. [70]*

Another, but very similar exercise program stratification has been provided my Schmitz and colleagues [4] and is shown in figure 4. The model illustrates different program options from healthcare provider supervised exercise programming to self-directed community-based programs [4]. Further, it provides examples for types of settings and the qualification of healthcare provider that carry out the individual exercise program. According to Schmitz et al., the communication and referral processes between these settings along the cancer-care continuum are still crucial.

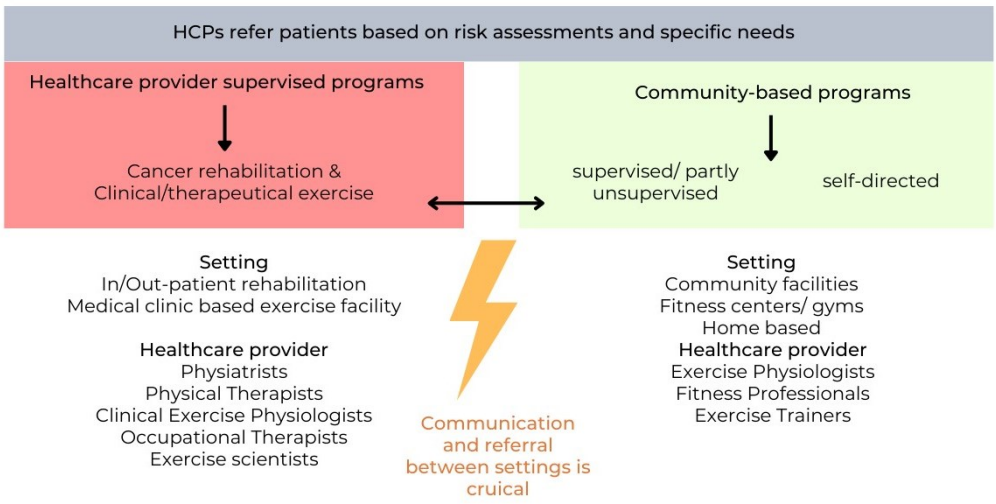



*Figure 4: Types of exercise programs, adapted illustration from Schmitz et al. [4]*

To provide a deeper understanding of different exercise options for cancer patients, the following section of this dissertation discusses the differences between exercise programs in clinical and community-based settings, provides different examples in each setting and defines the appropriate educational level for exercise professionals.

**Exercise programs in clinical settings**

The most intensive supervised, cancer-specific exercise programming takes place in clinical or therapeutical settings such as hospitals, physical therapy practices, palliative care or in/out-patient ambulatory centers. Clinical supervised exercise programs are mainly offered during treatment to prevent, minimize or reduce cancer-treatment-related side effects and functional regression. Although, such programs can be also performed after treatment to optimize rehabilitation and physical recovery. Examples of healthcare provider supervised exercise programming include the Wellness and Exercise for Cancer Survivors Program [71], the ActiveOnco program [68] and the Personal Optimism With Exercise Recovery (POWER) program [72]. Such programs are lead by workforce-licensed rehabilitation professionals (physiatrists or physical and occupational therapists) [73] also called "clinical exercise professional". They have specialised knowledge, education and skills to enable exercise programming for complex cancer patients (e.g. multimorbidity, high levels of cancer-therapy-related side effects, bone metastasis) but also special knowledge in screening methods, counselling and exercise supervision. Their goal is to diagnose functional and conditional limitations, provide physical assessments, to develop treatment plans, educate patients about their deficiencies and document patients' care and their progress. Training and level of degree of the profession clinical exercise professional varies across regions and countries. It can include the completion of medical school including physical therapy training programs (e.g. clinical doctoral degree in physical therapy), a physical therapist degree with advanced skills and knowledge in oncology rehabilitation or the

completion of a Bachelor/Master degree in occupational/exercise science or related fields [73]. Examples of educational programs for clinical exercise professionals are further the CanRehab Courses or the ACSM/Exercise is Medicine educational level 3. Exercise programs within clinical setting mostly have a structured transition plan to move patients, when they are ready, to more community-based, home-based and less specialised exercise programs.

**Exercise programs in community-based settings**

Next to the clinical setting, there are many types of community-based exercise program for cancer patients and survivors based on the underlying setting. For example, such programs might be cancer-specific such as courses for breast cancer survivors [74–77], open for all cancer diseases during or after acute treatment [78, 79] or open for the general public [80, 81]. Some community-based programs are supervised, but most programs have been implemented to be self-directed or fully unsupervised with some introductory sessions. They may also offer exercise options such as football [82, 83], dance classes [84, 85] or rowing. Further, some community-facilities offer self-directed exercise programs for home-based trainings without any supervision [86]. Community-based exercise programs are located in public spaces such as public gyms [76], sports associations [82, 87] or non-profit organizations [74, 80, 88, 89] without clinical integration. They are often perceived as more affordable and accessible. Community-based exercise programs are mainly served by workforce-exercise physiologists or educated exercise trainers that are often but not necessarily trained in oncology [73]. Their goal is, in contrast to clinical exercise professionals, to improve fitness and increase physical conditioning. They focus on, for example increasing strength, aerobic capacity, flexibility and further design exercise prescriptions and training plans. Such exercise trainers might earn a Bachelor or master's degree in exercise physiology, science or related fields and might be certified through special educational oncology courses [73]. Examples of educational licenses in community-settings are the ACSM/ACS Certified Cancer Exercise Trainer, Can Rehab Courses, Maple Tree Alliance or country specific rehabilitation licenses [5].

**Evaluation of community-based cancer exercise programs**

Since most studies have shown the efficacy of exercise in clinical trials (see chapter 1.1), current research has been further extended to investigate the efficacy of exercise programs in community-settings as prescribed above. Three current reviews revealed a positive effect of exercise in community-based programs on quality of life, physical function and fatigue-levels in cancer patients [10, 28, 86]. Moreover, there are several individual program evaluations that show the successful implementation of cancer-specific exercise programs in different types of public facilities. One of the best investigated programs is Livestrong at the YMCA [90]. This US-nation-wide, community-based physical activity program offers cost-free exercise to cancer survivors that are medically cleared by a

health care professional. The program is design for 12 weeks with two 75-90 minutes session per week and has been facilitated by the YMCA and YMCA-certified instructors. The YMCA-instructors provide tailored programming, addressing the social, physical and medical needs of each participant. An estimated 62,000 cancer survivors participated in over 240 locations in 42 states since the start of the program in 2018 [91]. Researchers evaluated the Livestrong program in regard to the effects on fitness and quality of life outcomes [78, 79] and long-term benefits in regard to physical function [92]. Other well-evaluated community-based programs are for example the FitStep for Life program in the US [93] or the Wellspring Cancer Exercise program [80] in Canada. The FitStep for Life program has been evaluated within a 5-year evaluation. Enrolled participants (n=701) in the FitStep program were referred to an individualized exercise program in one of 14 community centers. The program promoted the positive impact of exercise on several subscales (e.g. physical function, vitality, social and mental function) of quality of life after a three-month time point [93]. The Wellspring Cancer Exercise program evaluation took place in four Wellspring sites, a charitable organization that offers community-based exercise programs for cancer patients. Researcher revealed significant improvements in e.g. cancer-related fatigue, endurance capacity, social well-being and balance after the 30-week intervention [80]. Alternative programs such as community-based football for men with prostate cancer [82, 83, 87] or ballroom dancing for cancer patients [84, 85] have been analysed on different patient related outcomes. They show a variety of positive effects on physical outcomes (e.g. bone mineral density, jumping high, endurance capacity), quality of life and reduction in fatigue. However, the effects were not consistent across all programs. Other community-based exercise programs currently undergo extensive evaluation protocols such as the Alberta Cancer Exercise (ACE) program that will be investigated through a 5-year hybrid effectiveness and implementation study. The program takes place at YMCAs, Wellspring centers, municipal fitness centres and academic fitness facilities in seven cities in Canada. Researchers aim to enrol 2500 participants. The evaluation includes individual level and organizational level outcomes [89]. The results of the study are still awaited.

### 1.3.3 Implementation perspectives in community settings

To date, we have some convincing examples of successful running community-based exercise programs. However, this is still not enough to serve the high amount and demand of cancer patients across many countries. Based on current knowledge, many barriers exist that hinder the implementation of new exercise programs or prevent running programs from expanding [5]. Researchers investigated several barriers and facilitators for the implementation of exercise programs in oncology. For example, Santa Mina et al. [9] discovered four main barriers in regard to exercise implementation: lack of funding, lack of physician support, patient barriers to participate (e.g. program location) and disease progression. Whereas program enablers were: patient participation (e.g.

personalized care, awareness of benefits), local partnerships and specific program characteristics (e.g. timetable of courses). Coletta and colleagues [5] argued that most programs are missing health care coverage and sustainable financial support that impede the overall, long-term cost coverage of e.g. facilities, equipment and staff. They further revealed a lack of knowledge of exercise trainers and obligatory educational courses within existing academic institutions (e.g. exercise physiology, kinesiology, physical therapy). Kauffeldt et al. [12] explored determinants of community-based exercise program implementation for breast cancer survivors by interviewing several exercise program provider. Similar to Santa Mina et al., they found patient-related barriers (e.g. treatment schedule, disease progression) as most frequently named by program leaders. Other barriers were mainly located in the outer setting of the program (e.g. staff support, available facilities, integration of cancer care team). The most frequent named facilitator was the establishment of external partnerships (e.g. for patient recruitment or professional collaboration) [12]. Another perspective presented IJsbrandy et al. [61] about barriers and facilitators from the healthcare professionals´ view. They highlighted several characteristics that impede exercise program implementation such as non-tailored programs to patient's needs, missing knowledge, skills and commitment of HCPs, ineffective collaborations and networks between hospitals and exercise programs as well as poor communication between stakeholders. Granger et al. [94] highlighted the following points as most important to integrate an exercise program into lung cancer clinical care: evidence to be physical active in oncology, enough time for HCPs to educate patients, program funding, clear referral pathways as well as education and knowledge of HCPs and exercise professionals. A more recent multiple-case study by Czosnek et al. [95] identified 11 implementation strategies that could explain the successful implementation of exercise into cancer care. This included for example knowledge, skills and resources by the program stakeholder as well as optimism and simplified decision-making processes in regard to exercise care.

Despite the growing evidence about exercise implementation in cancer care, there is not much knowledge about oncological exercise care implementation in the German health care system [10]. One of the leading examples in Germany is the network OnkoAktiv. OnkoAktiv aims to connect HCPs with exercise professionals and institutions to provide comprehensive and high-quality exercise care for cancer patients. The following part gives a brief overview about the overall functioning of the network OnkoAktiv and the pathway of exercise care, which has been implemented within the network.

### 1.3.4 The network OnkoAktiv

The network OnkoAktiv project at the National Center of Tumor Diseases (NCT) in Heidelberg emerged in 2012 to enable exercise for cancer patients at every stage of treatment. Since 2014, the project has been operating through the OnkoAktiv association at the NCT Heidelberg e.V.. Today, OnkoAktiv sees

itself as an integrating, nationwide network that involves all stakeholder in the field of exercise oncology. The network provides transparency and quality assurance across exercise settings and regional borders. Exercise institutions cooperating with OnkoAktiv are certified through quality indicators and ensure professional exercise care appropriate to the therapy and health situation of each cancer patient. The following table represents the structural and process quality indicators of the OnkoAktiv catalogue of quality criteria, which are adopted from the quality seal catalogue SPORT PRO FITNESS by the German Olympic Sports Confederation (DOSB).

*Table 2: Structure and quality parameter for the quality assessment of the network OnkoAktiv training and therapy institutions*

| **Structure quality** | **Process quality** |
|---|---|
| Qualifications of staff | Care of the patient and therapeutic presence |
| Participation in educational trainings provided by OnkoAktiv | Training documentation |
| Resources for individual patient support (e.g. anamneses, counselling, training plans) | Consultations about the patient's training progression |
| Types of exercise program offered | Documentation of the patient's training absence |
| Sports equipment | Giving feedback to OnkoAktiv |
| Hygiene | |
| Sanitary/changing areas | |
| Security | |
| Training or contract conditions | |

Further, certified training institutions confirm the implementation of the OnkoAktiv pathway of exercise care (see next part). Since the beginning, OnkoAktiv operates in cooperation with an interdisciplinary and independent advisory board made up of HCPs, scientists and experts from the healthcare landscape. The overall goal of OnkoAktiv is to enable exercise counseling and referral in to all kinds of exercise settings, from community-based to clinical. Therefore, OnkoAktiv forms a nation-wide network of oncological comprehensive centers (CCCs) and certified exercise programs. Further, OnkoAktiv promotes the knowledge exchange between sports and exercise therapy, sports science, medicine, nursing and other professional groups working in oncology through frequent round tables. The network offers further education in oncology for exercise-oriented specialists and creates a platform for conducting scientific studies.

**The OnkoAktiv pathway of exercise care**

Although there has been such a large body of scientific knowledge in exercise oncology, current exercise provision is still fragmentary and heterogenic in Germany. Collaborations between HCPs within the clinical environment and exercise trainers in community-settings remain crucial. Therefore, the network OnkoAktiv implemented a comprehensive pathway of exercise care from clinical institutions to certified exercise programs that offer specific exercise options for cancer patients. The

pathway represents the OnkoAktiv care model and is based on the Exercise Is Medicine (EIM) initiative, launched by the ACSM in 2007 and further developed by Schmitz et al. [4] in the course of the ACSM exercise guidelines for cancer survivors in 2019 [2]. The exercise care pathway has been described in detail in manuscript 3 as a leading example in Europe. In Summary, the pathway is assembled out of three major steps (Assess, Advice, Refer) that include all important stakeholders from clinic to community settings. Although, this exercise care pathway is a successful example of stakeholder involvement and collaborations in the field of oncology, such pathway is not the current standard of oncological care in most European countries.

**Current OnkoAktiv network developments**

To this day, OnkoAktiv counts 17 cancer competence centers called "regional OnkoAktiv centers" and around 200 certified training institutions across Germany (*current status: April 2024*). Each regional Onkoaktiv center builds their own exercise-related network within a defined region in Germany (e.g. Heidelberg, Frankfurt/Main, Hamburg, Kiel, Berlin, Potsdam, Dresden) that involves exercise facilities and HCPs from different fields in oncology. Together, they provide oncological exercise care for patients in all stages of cancer treatment and rehabilitation as well as inter-organizational collaboration between the medical and community setting. Further, OnkoAktiv consolidates all network participants within the online-based OnkoAktiv map (*https://netzwerk-onkoaktiv.de/karte/).* The OnkoAktiv map is an online search engine which displays all OnkoAktiv member in google maps and provides detailed information about each exercise facility. User can contact the favoured facility directly via an easily accessible online form. Additionally, OnkoAktiv develops informational materials about cancer and exercise for different target groups (e.g. patients, HCP, exercise trainers) and implemented social media channels for better target group reach. Educational courses are offered to all target groups, to provide continuous education across the network. OnkoAktiv implemented network quality round tables, open to all network members, where current research in exercise oncology and individual experiences within daily practice are discussed.

### 1.3.5 Social networks in sports research

As stated above, the implementation of exercise care pathways into the health care system requires the collaboration of various stakeholders such as HCPs and exercise professionals within and across different institutions. For example, Santa Mina et al. [9] highlighted the importance of local partnerships, support and advocacy of important leaders and a supportive clinical network as program enablers to implement exercise into clinical care structures. Also Kennedy and colleagues [8] defined specific target groups to implement their exercise program into practice. For example, they involved the general hospital management as political decision-making body, next to oncologists, exercise physiologists, patient service officers, billing officer and external center leaders. Researchers out of

different exercise- and health-related fields such as sports tourism [96, 97], public health [98, 99], medical care services [100] have shown that interorganisational networks can create many benefits like increased resources, trustworthiness as well as knowledge and competency exchange. Cousens et al. [101] highlighted that networks can facilitate the coordination of services or resources through trustworthy linkages between organisations and their actors. Provan et al. [102] examined within their analysis of the Centre of Health Promotion in Arizona, Canada, that collaborative networks improve the possibilities to serve clients through the better utilisation of services, the accessibility of new knowledge and skills, enhances the status of their public profile and increases their influence within the community. The comprehensive collaboration of services within and across organizations can lead to common goals, better performance, valuable access to information, innovative ideas and vision [97]. Although, there is an increasing amount of evidence on the positive outcomes on interorganisational relations, the implementation of organisational networks in sports remains crucial and unexplored [98]. For example, Cousens and colleagues [101] analysed two community sports networks (basketball, swimming) in Canada to increase sports participation. They concluded that collaboration in community sports has not been widely implemented yet. There is some evidence about cooperation within the community sports networks, however, relationships between stakeholder remained weak. Interestingly, the highest concern to implement collaborative networks in swimming and basketball was the lack of resources such as staff, time or finances. There is one recent review by Timm et al. [98] that investigated only eight studies which explored social networks focusing on the promotion of physical activity. According to their findings, collaborative interorganisational networks in sports encounter many challenges (e.g. heterogeneity of their target group, low network density, many weak ties, network governance). The authors conclude that physical activity promotion networks require further systematic evaluations to address the lack of knowledge, understanding and evidence about interorganisational collaboration in sport networks.

**Social networks in exercise oncology**

As described above, the analysis and evaluation of networks in sports remain a relatively young scientific approach. There are only a small number of studies investigating networks in exercise oncology. One recent published study by Wagoner et al. [103, 104] called Exercise for Cancer to Enhance Living Well (EXEL) aimed to build HCP (clinical) and trained fitness professionals (fitness) networks, utilizing the “Hub- and Spoke Framework” to support exercise implementation for cancer patients in rural and remote communities across Canada. Central network zones, called “Hubs” are clinical exercise physiologists including their medical team that provide knowledge, education and support to external HCPs and exercise professionals, as their “Spokes”, within the surrounding communities. The EXCEL´s HCP-network counted 163 clinical contacts, and the qualified-exercise professional network 45 members within the first year of implementation. Overall, 290 cancer patients

enrolled in EXCEL to participate in one of the offered exercise programs. The authors concluded a promising implementation phase of the stakeholder networks to provide comprehensive exercise offerings to patients in rural and remote communities. Especially the in EXCEL involved HCP-networks supported the increased exercise program referrals from patients living in rural areas.

In course of this dissertation the concept of social networks has been utilized as scientific methodology as well as theoretical background. Given the fact of many connected actors (including the organization they represent) such as clinical institutions, medical practices, sports clubs, fitness centers, municipal facilities or charities, the analysis of inter-organisational relations through the methodology of social network analysis (SNA) holds promising insights for OnkoAktiv. Following the ground work by Wäsche et al. [105] the conceptual typology of SNA in the context of sports research helps to understand social systems including their relations, resources and functioning.

## 1.4 Gaps in previous research and research questions

Overall, there have been some successful examples of exercise implementation into cancer care systems through the development of care pathways. However, current literature shows that there is a lack of evidence and knowledge (translation) in regard to exercise implementation and HCP involvement [5, 6, 8, 106]. The exercise oncology knowledge mobilization initiative from 2021 highlighted an urgent need for innovative research to support best practice solutions that implement exercise into cancer care. The researchers defined several knowledge mobilisation themes such as the following [6]:

- Integrating qualified exercise professionals into primary cancer care teams
- Establishing resources for referring cancer survivors between medical- & community-based cancer exercise services
- Improving cancer survivor transitions across medically supervised, community-based, & self-directed exercise settings

Based on our previous sections and the present themes for research in the field of exercise implementation for cancer patients, we have defined the main research goal and three main research gaps for the evaluation of the network OnkoAktiv.

**Main research goal**

The aim of this work was a multi-level, mixed-methods evaluation of the network OnkoAktiv as the first oncological exercise care structure in Germany. The evaluation concept intended to provide a deeper understanding of the current status and developments of OnkoAktiv as well as to discuss current perspectives on how to implement cancer exercise programs into different settings of the German cancer care system.

**Research Gaps**

### 1.4.1 Cancer exercise program implementation

Despite of a growing number of OnkoAktiv network members, there is not much knowledge about the efficacy and effectiveness of exercise programs within the network OnkoAktiv. Before starting this work, there were no structural collected information about network implementation barriers and facilitators on the level of OnkoAktiv certified exercise programs and regional OnkoAktiv networks. However, other already evaluated cancer-specific exercise programs in the US and Canada [10] highlighted the effectiveness of community-based exercise programs to improve quality of life in cancer patients. Although, several studies have shown a gap between the currently strong evidence about the importance of exercise in oncology, exercise implementation and the knowledge translation into practice and the community level [4, 6, 9, 61]. Therefore, our first goal was the evaluation of exercise program implementation barriers and facilitators within OnkoAktiv to guide future implementation approaches and to improve the overall network efficacy [107].

Research Question of Manuscript 1

- What are barriers and facilitators for the implementation of OnkoAktiv network structures on the levels of regional OnkoAktiv networks and OnkoAktiv certified exercise programs?

### 1.4.2 Exercise networks in oncology

Most exercise programs and exercise-related networks are tailored to the needs of the individual region such as the US, Great Britain or Europe or the particular institution like clinics, rehabilitation centers or health-related gyms. However, there is not much knowledge about the composition and forms of exercise networks in oncology and existing collaborations between networks members in different social fields [98]. Given the fact of many diverse actors in sports, who act mostly cross-disciplinary on a relational level, the lack of scientific information about their interactions (and its effects) on network development is immense [105]. Further, the integration of exercise programs for cancer patients into existing health care and community structures such as oncological clinics remains crucial and only somewhat explored. There is little known about the needs for exercise network development and advancements in the field of oncology. Therefore, our second goal was to analyse, illustrate and evaluate the network compositions of the individual regional OnkoAktiv networks and to define practical implications for further network development.

Research Questions of Manuscript 2

- What are the major network characteristics of each OnkoAktiv network and how can they be classified into their developmental stage of organizational forms.

- What implications and tasks for demand-oriented network implementation and further development in exercise oncology can be defined?

### 1.4.3 Characteristics of cancer exercise programs in the European region

As stated above, exercise implementation for cancer patients into cancer care has been fragmentary and heterogeneous. Although, there are some promising examples of oncological exercise programs in the US [78, 92, 93], Canada [71, 75, 80, 108] and Australia [7], little is known about successful running programs in the European Union and neighboring countries [10]. Specifically, there are little information about what works for whom under which circumstances such as the underlying institutional organisation, staff education, program finances and stakeholder collaborations as well as what kind of exercise is provided to what types of cancer patients. Further, exercise program implementation barriers and enablers within the field of oncology for the European region are not systematically evaluated yet [10]. Based on this gap of knowledge, our third goal was to give an overview about existing oncological exercise programs in the European region and to discuss current implementation perspectives to improve exercise integration into cancer care.

Research Questions of Manuscript 3

- What are the characteristics of cancer-specific exercise programs in the European Union and neighboring countries?
- What are the barriers and facilitators to implement cancer exercise programs of the identified institutions?
- What are perspectives to improve cancer exercise implementation into cancer care in the European region?

## 1.5 Preliminary work

**Network OnkoAktiv evaluation from patients' perspective**

A first attempt to systematically understand and evaluate the network OnkoAktiv took place in our own preparatory work through a patient evaluation. Various structural and process parameters from the OnkoAktiv catalog of quality criteria, as well as various patient related outcomes were measured using quantitative questionnaires at three points in time (T1: initial contact with OnkoAktiv; T2: start of training at the training institution; T3: 8 weeks of training completed). Over the course of six month, OnkoAktiv referred 86 patients to 34 different training institutions. Thereof, 60 patients (39 women; 21 men) could be recruited for the evaluation from which 43 patients reached measurement point T3 (71%). The average time for exercise referral was 42 days (Min.: 5; Max.: 110 days). There was a significant improvement in global quality of life and an increase in total activity in MET minutes after 8 weeks of training participation. Fatigue, sleep disorders, physical functional limitations and

concentration difficulties were reported as the greatest problem and side effect areas of cancer therapies. Almost all measured outcomes indicated a positive trend of improvement. 93% of patients showed high patient satisfaction and quality rating in regard to OnkoAktiv services. The overall dropout rate was 28%, which was associated with an increased burden of symptoms due to fears and worries, as well as financial problems. The evaluation is currently being continued to gain more information about the effectiveness of exercise programs within the network OnkoAktiv.

**Network member routine survey**

Since 2020, we request quantitative data from the regional OnkoAktiv networks and the certified exercise institutions twice per year. The routine survey includes information about the overall number of cancer patients in each institution, number of patient referrals, types of exercise programs offered and collaborations with local clinics and HCPs. The current analysis of the routine survey includes five time points from January 2020 to June 2023. Due to the COVID19-pandemic, data is missing from July 2020 to June 2021.

OnkoAktiv training and therapy institutions

The mean number of cancer patients in all training institutions that participated in the survey was 24 (Min.: 11; Max.: 35). As shown in table 3, the mean number of total cancer patients in the OnkoAktiv institutions increased over the years, however, more than half of all OnkoAktiv institutions did not answer the survey or they could not give any information about the number of patients. Furthermore, the restrictions of the COVID-19-pandemic had a major impact on the patient numbers. The average number of patients newly admitted to the institution from 2020 to 2023 was 13 (Min.: 9; Max.: 24). The mean number of patients that were referred through OnkoAktiv was 3.4 (Min.: 2; Max.: 5), but did not change between 2020 to 2023.

*Table 3: Overview of data from the OnkoAktiv routine survey 2020-2023*

| **Year*** | **2020_1** | **2021_2** | **2022_1** | **2022_2** | **2023_1** | **Mean [M]** |
|---|---|---|---|---|---|---|
| Total number of network member [n] | 55 | 78 | 85 | 104 | 112 | - |
| Number of institutions that participated in the survey [n] | 49 | 45 | 81 | 86 | 67 | - |
| Overall number of oncological patients in each certified institution [M] | 11 | 21 | 30 | 24 | 35 | 24.2 |
| Number of patients newly admitted within the past 6 month [M] | 9 | 9 | 12 | 24 | 11 | 13.1 |
| Number of patients referred by OnkoAktiv [M] | 3 | 5 | 3 | 4 | 2 | 3.4 |

Legend: * years are divided into 1: January-June and 2: July-December

Around half of the survey participants offered general rehabilitation sport and general physiotherapy or physiotherapy on exercise devises (Krankengymnastik- KG/ Krankengymnastik am Gerät – KGG). Some institutions (15-20%) also covered the oncological training therapy (OTT) and special oncological rehabilitation sport groups. Table 4 summarizes the exercise programs offered within the OnkoAktiv training institution from 2020 to 2023.

*Table 4: Exercise programs offered within the OnkoAktiv training institution from 2020-2023*

| **Year*** | **General Rehabilitation [%]** | **Oncological Rehabilitation [%]** | **OTT [%]** | **KG [%]** | **KGG [%]** |
|---|---|---|---|---|---|
| 2020_1 | 42 | 15 | 21 | 49 | 46 |
| 2021_2 | 49 | 12 | 22 | 49 | 53 |
| 2022_1 | 41 | 17 | 26 | 52 | 57 |
| 2022_2 | 44 | 14 | 21 | 44 | 52 |
| 2023_1 | 55 | 18 | 25 | 48 | 52 |
| | | | | | |
| **Mean [%]** | **46.2** | **15.2** | **23.0** | **48.4** | **52.0** |
| | | | | | |

*Legend:* * years are divided into 1: January-June and 2: July-December*; OTT= Oncological training therapy; KG= physiotherapy; KGG=physiotherapy on exercise devises*

Training institutions that collaborated with oncological clinics or HCPs in their local area showed eight collaborations on average. However, more than half of institutions did not name any regional collaboration with the medical target group. If any collaboration existed, clinics and HCPs referred a mean number of 10 patients over a period of six month to the local training institution.

Regional OnkoAktiv networks

The total number of regional OnkoAktiv networks in June 2023 was 15. From 2021 to 2023, a mean number of 80 to 100 patients (Min: 2; Max: 600) received an exercise consultation through the OnkoAktiv networks over the course of six month. However, there is a wide range of numbers which indicates that some institutions do a lot of exercise consultations and some do very few. Since 2021, the number of patient referrals into external exercise programs has remained the same. On Average, around 25 to 30 patients (Min: 1; Max: 116) are referred within 6 month per regional network. However, as seen in the consultation query, there is a wide range of numbers across the regional networks. Moreover, it should be highlighted that around twice as many patients were referred in an exercise facility not certified by OnkoAktiv as into programs that hold an OnkoAktiv certification. Such facilities can include rehabilitation sport groups or sports associations that fall under the member area "supporting members" which can not be certified or they simply have not been recruited for the network yet. Further, each regional OnkoAktiv network collaborates with four to seven oncological

clinics or medical professionals. The following table 5 summarizes the routine data for the regional OnkoAktiv networks from July, 2021 to June, 2023.

*Table 5: Routine data from the regional OnkoAktiv networks from 2021-2023*

| **Year*** | **2021_2** | | **2022_1** | | **2022_2** | | **2023_1** | | **Mean [M]** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Total number of regional networks [n] | 14 | | 14 | | 14 | | 15 | | - | |
| Number of institutions that participated in the survey [n] | 12 | | 12 | | 12 | | 15 | | - | |
| Exercise consultations per 6 month [M] | 102 | | 82 | | 94 | | 83 | | 90 | |
| Patient referrals into external programs [M] | Cert. | Not cert. | Cert. | Not cert. | Cert. | Not cert. | Cert. | Not cert. | Cert | Not cert. |
| | 15 | 16 | 6 | 19 | 6 | 22 | 11 | 18 | 10 | 19 |

Legend: * years are divided into 1: January-June and 2: July-December; cert: certified programs; not cert: programs not certified through OnkoAktiv

# 2 General methods

## 2.1 Comprehensive evaluation concept

The methodological design of this work followed an explorative, mixed-methods approach and is based on current recommendations from the field of health services research [109]. The mixed-method approach combined qualitative and quantitative research methods to provide a deeper understanding of the network actors opinions and objective network structures.

The methodological approach to evaluate the network OnkoAktiv is based on three network levels (see Figure 5). In this work, we included level 1 to 3 (regional OnkoAktiv networks, certified training and therapy institutions, patients) as well as the network frame (cancer exercise programs in Europe) into the evaluation concept. Each level was evaluated in its own complexity. The results of all manuscripts are cross-linked in this dissertation. With this approach, the individual points of view of the network actors were recorded and the objectivity of the evaluation were achieved through a "crossover" of the evaluation results. The evaluation methodology of the individual network levels is presented below. However, the patient's level has not been presented in one of the manuscripts yet, the methodological approach of the patient´s level is described in this work to show the full evaluation concept.

| Level of evaluation | Qualitative methods | Quantitiatve methods |
|---|---|---|
| European cancer exercise programs | - | Structural comparison of cancer exercise programs in the European region |
| Regional OnkoAktiv networks Germany | Semi-structured interviews about barriers and facilitators for the implementation of OnkoAktiv | Egocentric Social Network Analysis |
| Certified OnkoAktiv training and therapy institutions Germany | Semi-structured interviews about barriers and facilitators for the implementation of OnkoAktiv | Survey about barriers and facilitators for the implementation of OnkoAktiv and cancer exercise programs |
| Cancer patients referred into cancer exercise programs through OnkoAktiv | - | Questionnaire on structural and process quality indicators, patient-related outcomes, network efficacy at 3 timespoints |

*Figure 5: Comprehensive evaluation concept of the network OnkoAktiv in Germany and the "European frame"*

## 2.2 Participants

Level 1: Regional OnkoAktiv networks

The study participants in the regional OnkoAktiv networks were the responsible, coordinating exercise professionals who administrate the local OnkoAktiv network, provide patient screening, counselling and referral. They further serve cancer patients with special needs such as bone metastasis or severe treatment-related side effects (e.g. risk assessment, exercise counselling, program referral). Their workspace is integrated into a cancer care clinic or rehabilitation centers including the HCPs working there. Most OnkoAktiv coordinators possess a bachelor´s and/or master's degree in exercise physiology or relevant other degrees in the field of exercise and are further specialised in the field of exercise in oncology.

Level 2: Certified training and therapy institutions

The study participants in certified OnkoAktiv training institutions were exercise trainers with basic to advanced educational knowledge about oncological diseases. They provide targeted exercise programming for cancer patients based on the OnkoAktiv recommendations. Depending on the underlying institutional setting, such exercise trainers work as for example workforce-exercise physiologists with bachelor's degrees or physiotherapists, although it is not mandatory in most fitness settings.

Level 3: Patients

Oncological patients were included in the OnkoAktiv evaluation after they received exercise counseling at the National Center of Tumor Diseases (NCT) Heidelberg and were referred to a certified OnkoAktiv training and therapy institution to participate in an exercise program. No exclusion criteria were defined in regard to disease, therapy status, therapy phase, age or gender. In order to participate in the exercise programs, a declaration of fitness for sport or, analogously, a medical clearance, using the rehabilitation model 56 or G850 was mandatory.

Frame: Oncological exercise programs in Europe and neighbouring countries

On the superior network level, exercise programs for cancer patients in the European Union and neighbouring countries were included. Study participants were the leaders of the included exercise programs. Selected programs had to be ongoing and accessible for the overall cancer community in community-based settings such as gyms, fitness/health centers, physical therapy practices or municipalities or clinical settings such as hospitals or rehabilitation centers. They needed to provide at least part-time supervised, specific cancer-related exercise programs. Exclusion criteria were for example self-organized groups, social media/online programs without supervision or clinical trials (see manuscript 3 for the full listing of inclusion and exclusion criteria).

## 2.3 Data collection and instruments

Level 1: Regional OnkoAktiv networks

On the level of the regional OnkoAktiv networks, two methodological approaches have been applied. First, OnkoAktiv coordinators took part in a qualitative interview about barriers and facilitators in regard to the implementation of the OnkoAktiv structures and processes. The interview guideline was developed based on the Consolidated Framework for Implementation Research (CFIR), then conducted and recorded using a video conference platform. See manuscript 1 for more information about the survey development. Second, the OnkoAktiv coordinators participated in a quantitative egocentric social network analysis (SNA) that was based on a standardized questionnaire. The SNA provided information about the overall structure of their local network, including most relevant contact persons, their job position and the organisation they represented. Further, we asked about relational types (patient-related, influential, financial, public communication-related), importance of relations, duration of collaborations as well as most important individuals within their network.

Level 2: Certified OnkoAktiv training and therapy institutions

On the level of the certified OnkoAktiv training and therapy institutions, a mixed-methods design has been applied. As we did with the regional OnkoAktiv networks, a qualitative interview was conducted based on the Consolidated Framework for Implementation Research (CFIR) with purposeful selected network member. Since the OnkoAktiv network is growing fast within the last years, some participants were a member of OnkoAktiv for several years and some have just recently joined the network. In this case, purposeful sampling was conducted for qualitative research by following the criteria: year of certification and number of patient referral by OnkoAktiv, to find the most appropriate and, in regard to OnkoAktiv, experienced participants. The mixed-methods approach enabled the comparability of both network level 1 and 2. Thereafter, we developed a questionnaire for all OnkoAktiv training institutions based on our qualitative data and an extended literature research [8, 9, 11, 12, 61, 107]. The questionnaire followed the three main topics: the evaluation of structures in regard to the network OnkoAktiv, the evaluation of structures to implement exercise programs in regard to the German health care system and solutions for perceived implementation barriers. See manuscript I for more details on the questionnaire development and content. The survey was sent to all network members via email.

Level 3: Patients

During a timeframe of six months, a quantitative, prospective, one-arm longitudinal survey was carried out at three measurement points (T1: initial contact at OnkoAktiv, T2: successful placement at an OnkoAktiv training institution, T3: completion of the 8th training week). On the administrative level,

the overall number of registrations, successful patient referrals, duration of referral processes and dropout rates were documented. The study survey included the standardized questionnaire Core Quality of Life Questionnaire of the European Organization for Research and Treatment of Cancer (EORTC-QLQ C30, Version 3) to measure the multidimensional quality of life. Further, the NCCN distress thermometer was used to record the psychosocial stress of oncological patients based on a thermometer scale from 1-10. The measurement of patient satisfaction was grounded on the established ZUF-8. [7]. The physical activity level measurement instrument was based on the Godin-Shephard Leisure-Time Physical Activity Questionnaire [9], which has already been widely used to categorize active and inactive people [10]. The query for the OnkoAktiv quality criteria was developed in regard to the OnkoAktiv catalogue of quality criteria. This part included the following eight process parameters: anamnesis, sports medical examination, individual training recommendation, information about the training, data transmission, information content of the consultation as well as the period and delays in the mediation. At the level of the training institutions, the following quality criteria were included in the questionnaire: support from the training staff, availability of staff, contractual conditions, individuality of the training, training documentation, short interviews, absence control. Responses could be selected on a 4-point Likert scale from “do not agree at all” to “strongly agree”.

Frame: Oncological exercise programs in Europe, UK and neighbouring countries

For the collection and analysis of cancer exercise programs in the European region, we applied the questionnaire template of the RE-AIM-framework. The framework provides a set of standardized questions to help researchers to evaluate the implementation status of their targeted interventions. Therefore, the questions need to be adopted according to the focused intervention and modified based on the question templates of the RE-AIM framework. The applied questionnaire included the following dimensions: Reach (demographics, target population, number of patients per year), Efficacy (program goals, endpoints, measurements of success and outcomes, attrition-rate), Adoption (locations, program staff, staff education, factors to widespread adoption of program), Implementation (structure of program and program options, requirement for patient participation, duration, services, supervision, types of exercise, funding and payment options) and Maintenance (strategies for maintenance, stakeholder commitment). Furthermore, barriers, challenges and facilitators within the RE-AIM categories have been recorded. The survey implied multiple choice and closed questions as well as questions that have to be rated on a scale from 1 (not confident at all) to 10 (completely confident). See manuscript 3 for detailed information on the questionnaire development and contents.

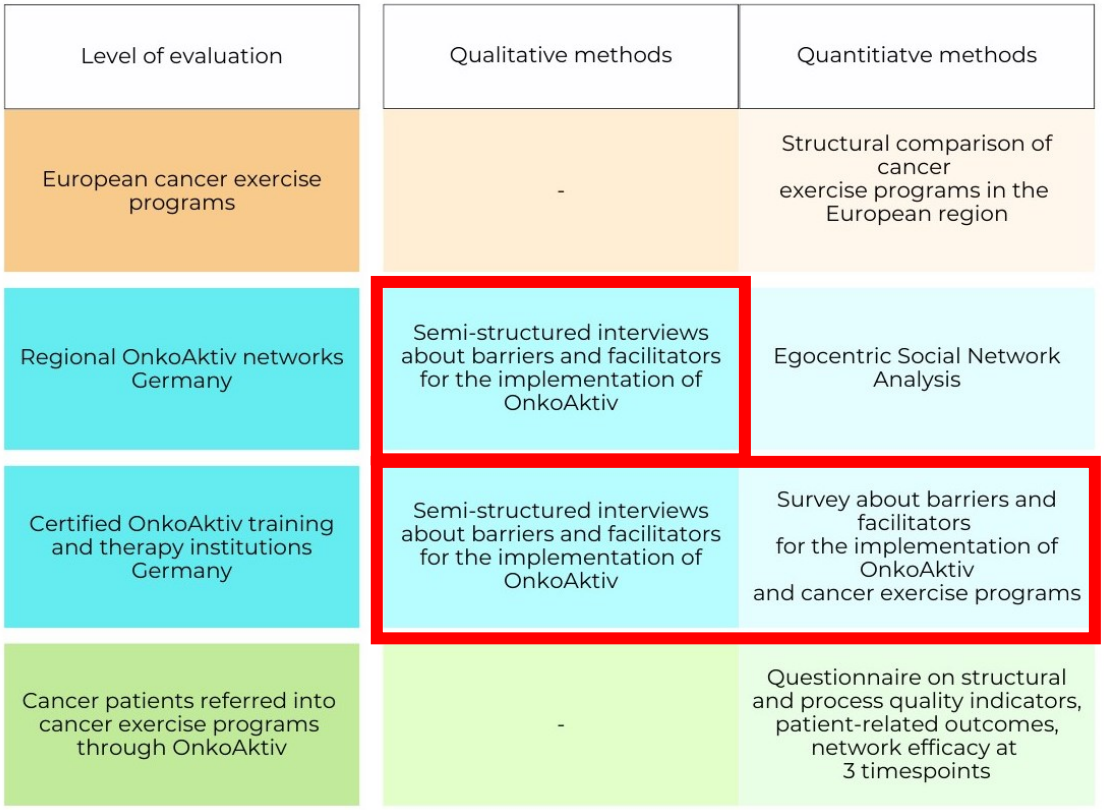
# 3 Manuscript I

Voland A, Lohmann A, Ansmann L, Wiskemann J. Barriers and Facilitators for the Implementation of Exercise Oncology Provision in Germany: A Multilevel, Mixed-Methods Evaluation of the Network OnkoAktiv. Eur J Cancer Care (Engl) 2023; 2023: 1–9
[https://doi.org/10.1155/2023/6270049]

**Level of the evaluation concept**

Regional OnkoAktiv networks

Certified training and therapy institutions




The **supplementary material** for this manuscript can be found on pages 117ff.

# **Barriers and facilitators for the implementation of exercise oncology provision in Germany:** A multilevel, mixed-methods evaluation of the network OnkoAktiv

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## Abstract

***Background***: Strong evidence supports the beneficial impact of exercise on cancer patients. However, the provision of exercise programs in Germany is highly heterogeneous. Therefore, the network OnkoAktiv (OA) enables patient consultations and referrals from coordinating regional OA centers (RE) into community-based exercise programs (CBEP). ***Objective***: The aim of this study was to identify barriers and facilitators for the implementation of OA network structures from the perspective of RE and certified CBEP. ***Methods***: This evaluation was executed in a sequential mixed methods design. We conducted 16 qualitative interviews with each leader in RE and certified CBEP. Then, 89 certified CBEP were invited to a quantitative, cross-sectional survey. ***Results***: We identified 11 facilitators each for RE and certified CBEP, 7 barriers for RE and 5 for certified CBEP. Barriers dealtwith for example financing OA network structures, lack of knowledge of exercise trainers, inadequate patient referral and missing collaborations by health care professionals (HCPs). Most named facilitators were adequate internal organizational resources, support and reachability of OA staff and collaboration with HCPs. ***Conclusion***: Our findings indicate different challenges for the implementation of OA network structures. Future implementation efforts should consider the evaluation of individual barriers and the development of specific solutions.

**Background**

A large body of scientific evidence supports the positive impact of exercise and physical activity on cancer patients and survivors [1]. As a result, the American College of Sports Medicine encourages health care professionals (HCPs) to refer patients into cancer-specific, community-based exercise programs (CBEP) [2, 3]. Moreover, a recent review highlights the effectiveness of CBEP to improve quality of life in cancer patients [4], although, the translation of exercise recommendations into clinical practice has been a major challenge. Researchers developed different pathway models in which patients transit from clinical structures into supervised or self-managed exercise programs to guide exercise implementation [1, 3, 5]. Such pathway models have been described as a turning point for the integration of exercise in oncological care programs [6]. However, the involvement of public exercise facilities (e.g. gyms, sport clubs, rehabilitation centers, physical therapy practices) is crucial for the comprehensive implementation of exercise [7, 8]. Further, considering the increasing number of cancer patients per year [1], the number of qualified professionals and supporting exercise facilities will require substantial expansion [6]. In response to these challenges, the network OnkoAktiv aims to certify exercise facilities that offer specific programs for cancer patients, educate exercise professionals in the field of oncology and connect them to clinical institutions (including HCPs). Together, they provide a comprehensive pathway of exercise care.

The OnkoAktiv pathway of exercise care

The OnkoAktiv pathway starts with the identification and screening of patients in regard of their physical activity level (e.g. insufficient physical activity level or present symptom that can be evidently managed by exercise). Such screening strategies can be provided by HCPs like oncologists or nurses. If no general or specific contraindications to exercise (e.g. bone metastasis, cardio-vascular diseases) are indicated, HCP should advise exercise to their patients and refer them to the best available CBEP if possible [2]. If the screened patient needs further evaluation and a clear up for physical activity safety due to complex therapy-related side effects or other indications, they need to be referred to an exercise specialist. Exercise specialists offer individual physical activity consultations and further assessments depending on patients' needs [5]. In the context of OnkoAktiv, exercise specialists are organized in regional OnkoAktiv centers (RE) located in comprehensive cancer centers (CCC) in Germany. Every RE engages as single coordinating institution that recruits patients, offers consultations (including risk assessment and triage), exercise recommendation and collaborates within multidisciplinary teams. RE provide access to certified CBEP through patient referral processes and build up their own regional networks. Therefore, OnkoAktiv certifies local exercise institutions based on defined quality indicators which are adopted from the quality seal catalogue SPORT PRO FITNESS by the German Olympic Sports Confederation (DOSB). The certified CBEP can be located in for example local gyms, rehabilitation centers, physical therapy practices or municipal facilities. Within such institutions, exercise trainers provide comprehensive exercise supervision for cancer patients based on physical activity recommendations. They implement the OnkoAktiv quality indicators that assure high quality exercise program execution. Figure 1 illustrates the pathway model of exercise care and the respective OnkoAktiv network structures.

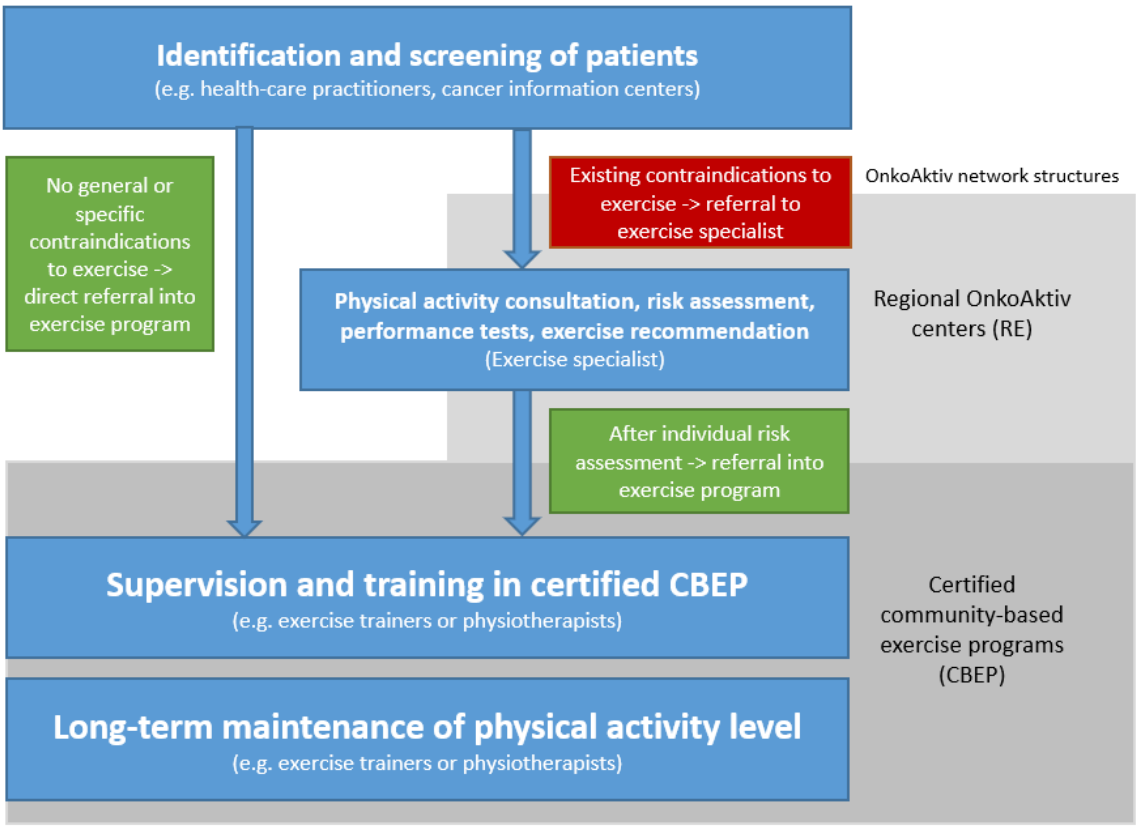


*Figure 1: The OnkoAktiv pathway model of exercise care and incorporated OnkoAktiv structures; CPEB= community-based exercise programs; RE= regional OnkoAktiv centers*

To this day, OnkoAktiv counts 14 RE and 106 certified CBEP across Germany. Although constantly expanding, an evaluation of the network OnkoAktiv has not been executed yet, compared to other CBEP and exercise oncology networks. For example, Neil-Szatramko et al. [9] reported 58 publications about CBEP evaluations in a recent review. Accordingly, there is a need for an OnkoAktiv network evaluation, precisely the analysis of network implementation barriers and facilitators.

**Aim of Study**

The aim of this study was to identify barriers and facilitators for the implementation of OnkoAktiv network structures on the levels of RE and certified CBEP.

**Methods**

We conducted a cross-sectional, mixed-methods study of the network OnkoAktiv. First, we applied a parallel design of qualitative interviews of RE and certified CBEP. Then we performed a sequential design for certified CBEP in which we developed a quantitative questionnaire. The questionnaire was used to survey all certified CBEP in the network to confirm the results from the qualitative analysis. [10]. We aligned our evaluation on the current recommendation of the German network of health care science as well as the Medical Research Council framework and evaluation and complex interventions [10–12]. The study protocol has been approved by the ethics committee of the medical faculty at the university Heidelberg (S-942/2021 and S-915/2019).

**Study population and sampling**

For the qualitative evaluation, we included all RE who have been a part of OnkoAktiv up to June 2021. The interview participants in RE were the responsible, coordinating exercise professionals. Those cancer exercise

professionals show higher educational credentials for exercise in oncology to serve patients with special needs (e.g. risk assessment, consultation, referral) and to administrate collaboration with HCPs and exercise trainers. They own mostly a bachelor and/or master degree in exercise physiology or relevant other degrees in the field of exercise. They are further specialised in exercise oncology through further trainings. For the selection of certified CBEP, we conducted purposeful sampling by the following criteria: year of certification and number of patient referral. We chose five certified CBEP that have been a member of OnkoAktiv from 2012-2019 and five, that joined the network from 2020-2021. We contacted institutions with highest referral numbers to make sure they have enough experience to be able to rate the OnkoAktiv services. Our interview participants in CBEP were exercise trainers with basic to advanced educational knowledge about oncological diseases. They provide targeted exercise programming for cancer patients. Depending on the underlying institutional setting, such exercise trainers work as workforce-exercise physiologists with bachelor degrees, although it is not mandatory in most fitness settings.

In the quantitative survey, we surveyed all certified CBEP that have been a member of OnkoAktiv up to 2021. We informed all potential candidates via email about the study and retrieved written informed consent.

**Data collection and instruments**

Qualitative interviews

We developed the interview guideline for both RE and certified CBEP, based on the Consolidated Framework for Implementation Research (CFIR). Please find the interview guideline in **supplement 1.** The CFIR is a validated and widely applied framework that assesses existing and potential barriers and facilitators of program implementation [13–15]. We adapted the guideline questions according to the available services of OnkoAktiv. The interviews were conducted and recorded using a video conference platform. Our interview guideline underwent cognitive pre-test discussions and one pilot interview for testing plausibility and tangibility of questions. After each interview, the interviewer provided a post-script with details about date, time, overall impressions and potential distractions regarding mood, language or misunderstandings.

Quantitative survey

We developed the quantitative survey based on our qualitative data and an extended literature research [9, 13, 16–19]. The qualitative analysis revealed three main topics for our survey: the evaluation of structures in regard to the network OnkoAktiv, the evaluation of structures to implement exercise programs in regard to the German health care system and solutions for perceived implementation barriers (see figure 2). The item generation followed the quality dimensions of the structure-process-outcome quality of care model by Donabedian [20]. Items that evaluated parameters regarding OnkoAktiv included e.g. quality of patient referrals, reachability of staff and re-financing costs. Items that evaluated structures of the German health care system included parameters on organisational (e.g. institutional resources, collaborations with HCPs) and system level (e.g. insurance coverage, political regulations). We generated the items for “solutions to network barriers” out of the qualitative interviews and existing literature.

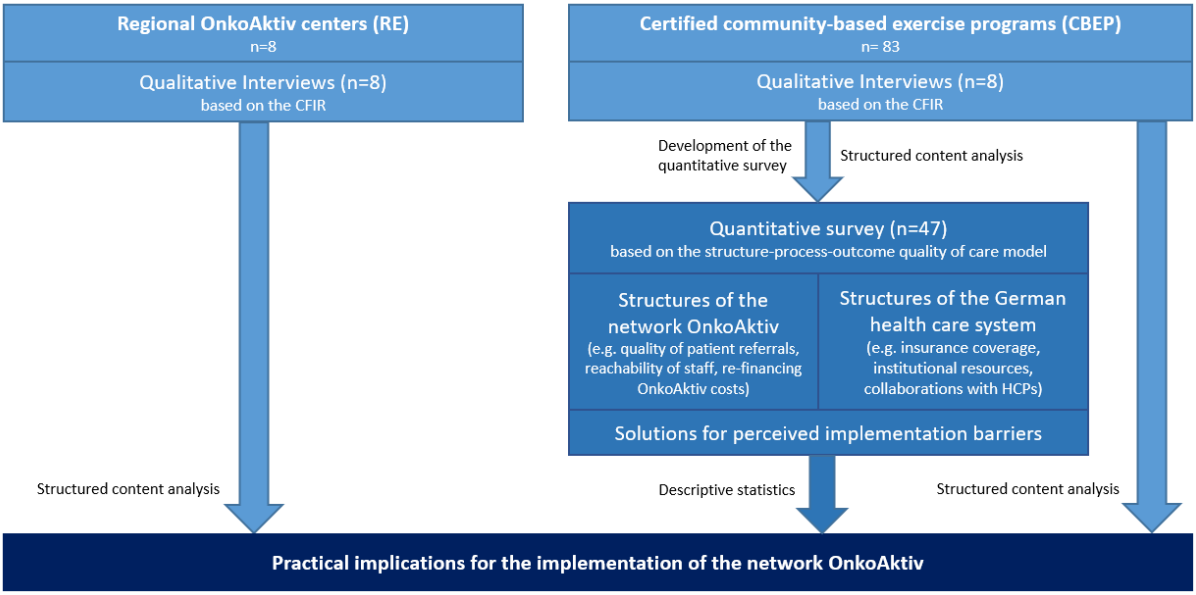


*Figure 2: Methodological flow chart of the mixed-methods design; RE=regional OnkoAktiv centers; CBEP= community-based exercise programs; HCPs= Health care professionals*

**Data analysis**

The qualitative data were analysed by structured content analysis according to Kuckartz et al. [21] and by using the software MAXQDA Version 2020. Each interview was selectively transcribed verbatim based on defined transcription rules [3]. We defined the first set of main- and subcategories a priori (deductive), based on the CFIR framework. All other main- and subcategories were developed inductively. Two exercise scientists (AV; AL and AV; AK) coded each of the first three transcripts of the RE and certified CBEP interviews independently and elaborated sub-categories. Then, the second coding process followed. Scientists profoundly discussed all main- and subcodes after analysis have been undertaken and confirmed a general categorical system. The study advisor (JW) verified the categorial system as third, independent person. Then, all data were coded using the elaborate category system. Please find the adapted CFIR-codebook including the domain and construct descriptions in **supplement 2**. After the full analysis of data, scientists rated all codes into barriers or facilitators and one scientist (AV, AL) executed a quantitative analysis. For simplification, we reported only codes that emerged more than five times in all interviews. The three scientists were experienced in the transcription and analysis of qualitative interviews and attended educational study courses at university level.

The quantitative survey of certified CBEP were analysed by calculating descriptive statistics using the programs IBM SPSS Statistics 26 and Microsoft Word Excel 2016. We calculated mean values of the five-point Likert-scale answer formats. Then, we categorized all items with a mean value <3 as barriers and items with a mean value >3 as facilitators. Mean values of =3 were ranked as neutral items. The rating rules are based on the CFIR rating rules that represent positive or negative influences on the investigated implementation [22]. We translated the bi-polar answer format into percentages. Further, we combined our findings of the qualitative interviews and quantitative survey of certified CBEP in the results part to reduce the complexity of our data.

**Results**

In the following, we report all facilitators and barriers across CFIR categories for regional OnkoAktiv centers (RE). Then we report the

results of the quantitative survey of the certified community-based exercise programs (CBEP), combined with the results of the qualitative content analysis of certified CBEP interviews. Please find the full list of barriers and facilitators of the qualitative content analysis for RE and certified CBEP with anchor quotes and frequency of codes in **supplement 3.**

*Analysis of barriers and facilitators for the implementation of OnkoAktiv structures in regional OnkoAktiv centers (RE) based on qualitative interviews*

We contacted all eight eligible RE from January to April 2021 by email. All contact persons responded with an interest to participate (100% recruitment rate). Our interviewee were two men and six women, executing the position of OnkoAktiv coordinators to manage their local OnkoAktiv network. The interviewed RE were located in cancer care clinics (n=6), exercise associations (n=1) or rehabilitation centers (n=1). The mean duration of OnkoAktiv membership was 4 years (min=2; max=8). We analysed eleven facilitators for RE. We found the greatest number of codes in the "inner setting", within the codings "resources" (structural infrastructure; knowledge of team members), "structural characteristics" (clinical integration, integrated sports association) and "cooperation" (in-house collaboration with HCPs). In the "outer setting" the following facilitators could be analysed for RE: existing CBEP in the geographical periphery, cooperation with university, program location in or near cities and collaboration with external HCPs. Furthermore, "design and quality of OnkoAktiv structures" as well as "knowledge and belief about the innovation" could be emphasized as facilitators. Last, we rated the "usage of OnkoAktiv material" as a major facilitator for implementation.

The analysis indicates seven barriers for RE. We identified "financing of OnkoAktiv services" and "complexity of OnkoAktiv certification and networking" as implementation barrier. The category "outer setting" revealed two barriers, "time to travel for patients" and "missing referrals and knowledge by HCPs". The "inner setting" reveals several barriers regarding internal resources like scarcity of time, staff and structural infrastructure. Further, "missing certifications and knowledge of exercise trainers" could be defined network barrier. Last, for all RE "COVID-19 restrictions" have been a major problem for the implementation of OnkoAktiv structures.

Solutions to barriers for RE are for example educational courses for HCPs and exercise trainers to increase their specific knowledge about exercise oncology. Further, working materials, guidelines and individual financing options for exercise programs could decrease structural barriers for RE (see all solutions in **supplement 4**).

*Analysis of barriers and facilitators for the implementation of OnkoAktiv structures in certified CBEP based on the qualitative interviews and quantitative survey*

We contacted 11 certified CBEP by email or phone call, from which eight agreed to participate in the qualitative interview (response rate 72%). The interviewee were five men and three women, executing their job position as the leading person of exercise therapists within their exercise institution. Selected institutions were gyms or physical therapy practices with special exercise programming for cancer patients. Mean time for OnkoAktiv memberships was 4 years (min=1; max=7). We retrieved 47 quantitative surveys from 83 certified CBEP, which represents 53% of the total number of OnkoAktiv institutions. Participants were 32 men and 15 women working as institutional leader or exercise therapist. Types of institutions were clincial facilities with special exercise programs, physical therapy practices

and gyms. We will further report the quantitative results combined with the findings of the qualitative interviews. The quantitative analysis revealed that close to all (95%) OnkoAktiv institutions ranked the quality criteria for OnkoAktiv certification as easy or neither easy nor complex. Most participants perceived the costs for general network tasks as low or neutral (M=3.5; SD=.75). Although, the detailed analysis of certification criteria indicated that 53% of institutions made structural alterations to meet certification requirements. We could identify similar facilitators in the qualitative interviews. Our interviewee highlighted "high adaptability of OnkoAktiv structures" and "low complexity of certification" as network facilitators. OnkoAktiv materials (e.g. certification material (M=4.3;SD=.61) patient information letter (M=4.3; SD=.64), brochure (M=4.5; SD=.60) have been ranked as good to very good in the quantitative survey (see table 1), just as our interview participants. Additionally, process quality shows overall high ratings in the survey. Please find the bar graph of the OnkoAktiv process quality parameter in **supplement 5**. Also, support during certification process and reachability of OnkoAktiv staff have been graded as very good. Our data shows that OnkoAktiv increases the the therapeutical quality in 50% of institutions (M=3.7; SD=1.0) and patients' satisfaction (M=3.7; SD=.97) in around 60%. Further 70% rated a higher professional impression due to the OnkoAktiv certification (M=3.7; SD=1.07).

In contrast, patient referral by OnkoAktiv (M=2.9; SD=1.42) and the implementation of marketing strategies and material (M=2.4; SD=.91) scored lowest in our survey (defined as barrier), with more than 50% of participants saying they receive rarely to none of these OnkoAktiv services. Same results indicating the qualitative interviews in which "missing marketing strategies" have been ranked as network barrier. Furthermore, 90% of OnkoAktiv institutions reported that OnkoAktiv did not support outreach to or increased attention of HPCs and medical institutions. The following table (see table 1) presents barriers (BA), facilitators (FA) and neutral items (N) regarding structural, process and outcome parameter of OnkoAktiv.

*Table 1: Structural, process and outcome quality items of OnkoAktiv network structures graded into barriers (BA), facilitators (FA) or neutral items (N) based on mean values (M) on a Likert scale from 1-5 and standard deviation (SD).*

| **Structural quality** | **M** | **SD** | **BA** | **FA** |
|---|---|---|---|---|
| Re-financing of costs for network participation | 3.4 | .65 | N | N |
| General network costs | 3.5 | .75 | | x |
| Promotion/marketing material | 3.8 | .91 | | x |
| Simplicity of OnkoAktiv quality criteria | 4 | .89 | | x |
| Website/newsletter | 4.2 | .61 | | x |
| Certification material | 4.3 | .61 | | x |
| Patient information letter | 4.3 | .64 | | x |
| Brochure | 4.5 | .60 | | x |
| | | | | |
| **Process quality** | **M** | **SD** | **BA** | **FA** |
| Implementation of marketing strategies | 2.4 | 1.27 | x | |
| Patient referral by OnkoAktiv | 2.9 | 1.42 | N | N |
| Expenditure of work for network activities | 3.6 | .64 | | x |
| Regular communication with OnkoAktiv members | 3.6 | 1.16 | | x |

| | | | | |
|---|---|---|---|---|
| Transfer of current knowledge into practice | 3.7 | 1.07 | | x |
| Content of educational network meetings | 4 | .67 | | x |
| Support during certification process | 4.4 | .60 | | x |
| Reachability of OnkoAktiv staff | 4.4 | .78 | | x |
| | | | | |
| **Outcome quality** | **M** | **SD** | **BA** | **FA** |
| Patients satisfaction | 3.7 | .97 | | x |
| Therapeutical quality | 3.7 | 1.0 | | x |
| Professional impression | 3.7 | 1.07 | | x |

Legend: *Items were categorized as barrier with a mean value <3 and as facilitator with a mean value >3; mean values of =3 were ranked as neutral items (neither nor).*

Solutions to barriers on the level of CBEP are for example the expansion of exercise program promotion by oncology clinics and patient referrals by HCPs, to increase overall attention of oncological CBEP. Additionally, different marketing materials such as print media or photos and texts for social media can be provided by OnkoAkiv.

*Analysis of barriers and facilitators on the level of the German health care system for the implementation of oncological exercise programs in certified CBEP based on the qualitative interviews and quantitative survey*

Our data revealed different facilitators on the level of the German health care system to implement oncological exercise programs. First, survey respondents reported that there is a medium to high pressure to implement oncological programs because of low program availability in their regions. We also identified "low regional competition" and "need for program or strategic change" in our qualitative interviews. Around 80% of participants rated their time, staff and structural resources as adequate for the implementation of oncological exercise programs. Similar, our interviewee emphasised available resources as important facilitators for program implementation in the qualitative interviews. On the other hand, we also identified several barriers. As seen in table 2, most participants rated general exercise program funding in oncology as difficult (M=2.4; SD=1.22). Likewise, our interviewee in the qualitative interviews reported great problems in the general funding of oncological exercise programs. Further, respondents ranked knowledge about exercise and cancer of HCPs as inadequate and assessed their collaboration as low to not existent. Likewise, "missing cooperation and referrals by HCPs" was a major barrier in the qualitative analysis. The following table (see table 2) presents all implementation barriers (BA), facilitators (FA) or neutral items (N) on the level of the German health care system.

*Table 2: Barriers (BA), facilitators (FA) or neutral items (N) on the level of the German health care system to implement exercise programs, based on mean values (M) on a Likert scale from 1-5 and standard deviation (SD).*

| **Health care structure and patient contact** | **M** | **SD** | **BA** | **FA** |
|---|---|---|---|---|
| Pressure for program implementation | 4.5 | .56 | | x |
| Resource: structural | 3.8 | 1.14 | | x |
| Resource: time | 3.6 | 1.12 | | x |
| Resource: staff | 3.5 | 1.26 | | x |
| Patients psychological condition | 2.7 | 1.11 | N | N |
| Financing of exercise program | 2.4 | 1.22 | x | |

| | | | | |
|---|---|---|---|---|
| Complexity of oncological diseases | 2.2 | .92 | x | |
| Uncertainty in therapy with acute patients | 2 | 1.29 | x | |
| | | | | |
| **Health care professionals** | **M** | **SD** | **BA** | **FA** |
| Collaboration with oncologists and practitioners | 2.5 | 1.29 | N | N |
| Referral of patients from health care professionals | 2.4 | 1.29 | x | |
| Knowledge of HCPs about exercise | 1.8 | .72 | x | |
| Contact: HCPs (e.g. oncologists, nurses) | 2.4 | 1.07 | x | |
| Contact: Clinics and ambulances | 1.9 | 1.01 | x | |
| Contact: Rehabilitation centers | 1.4 | .82 | x | |
| Contact: Universities | 1.5 | .83 | x | |
| Contact: Other exercise institutions | 1.5 | .78 | x | |
| Contact: regional OnkoAktiv centers | 1.5 | .75 | x | |

Legend: *Items were categorized as a barrier with a mean value <3 and as a facilitator with a mean value >3; mean values of =3 were ranked as neutral items (neither nor).*

Solutions to barriers on the level of the German health care system are located on the network level such as to increase patient referrals by HCPs and exercise program promotion by clinics. Also, accelerate regional networking with other exercise institutions. Financial barriers needs to be handled by finding different financial options for exercise programs.

**Discussion**

Overall, our study findings indicate different barriers and facilitators for regional OnkoAktiv centers (RE) and certified community-based exercise programs (CBEP). Importantly, facilitators and barriers need to be distinguished between the network OnkoAktiv and the general health care system. The most discussed barriers for RE dealt with financing OnkoAktiv network services as well as missing knowledge of exercise trainers. The most named facilitators for RE were internal organizational resources as well as collaboration with HCPs. In contrast, certified CBEP reported inadequate patient referral by OnkoAktiv, missing marketing strategies, collaboration and referrals by HCP, followed by problems in financing exercise programs as major implementation barriers. Facilitators were support and reachability of OnkoAktiv staff as well as low work expenditure for OnkoAktiv network tasks. In the following, we will discuss the most important barriers and facilitators for certified CBEP and RE classified into the CFIR categories. Finally, we will describe practical implications for each CFIR domain according to our findings.

Innovation characteristics of OnkoAktiv

The certification processes of RE and certified CBEP have been an important pillar for quality management within the network. The certification supports a high standard of quality parameters, guarantees professional supervision of patients and promotes continuous education of exercise trainers. From the perspective of RE and TI, the certification criteria of OnkoAktiv were perceived as feasible. Although, half of certified CBEP made structural alterations to meet certification requirements. Further, the financial aspect of program implementation has been a major challenge for OnkoAktiv institutions. RE reported that financing the OnkoAktiv services (e.g. patient consultations, risk assessments) has been the highest financial burden. In contrast, certified CBEP emphasized OnkoAktiv network costs as low.

Although they reported problems in clearing costs with health care insurances. Missing health care coverage and financing options of oncological CBEP are still major problems for program execution. Similar results reporting existing oncological CBEP in the US, Canada and Australia [16, 18, 23–26] as well as two current reviews [4, 9]. For instance, the Canadian Survivorship Exercise Program (SEP) by Santa Mina and colleagues revealed that funding has been a core problem for program implementation. Hence, they have been financially supported by the Canadian hospital foundation and different fundraising initiative [25]. Also Kennedy et al. described program costs as a core issue in the execution of a co-located exercise clinic [16]. Granger et al. reported perceived barriers including lack of time and funding from physiotherapists perspective in regard to the implementation of exercise into lung cancer clinical care [26]. Santa Mina et al. have recommended several funding streams for long-term maintenance of CBEP, like national granting agencies, insurance companies, private donors, corporate sponsors or grant applications [25]. The high adaptability of OnkoAktiv structures can help to find suitable funding streams and adapt OnkoAktiv services to the individual exercise institution.

Inner Setting of OnkoAktiv institutions

In the inner setting that describes e.g. the structural characteristics, team culture and internal communication of institutions, RE reported inadequate resources in regard to time, staff and organizational structures. In contrast, certified CBEP rated their internal resources as adequate for program execution. This underlines a different resource availability for RE and TI. The Rehabilitation and Exercise Oncology model of care (ActiveOnco) highlighted the fact that exercise program development is limited by the cost of human resources, physical resources and public funding that limit the extent and overall adoption of exercise [27]. As a solution, the Survivorship Exercise Program (SEP) integrated a multidisciplinary team to spread tasks and working load across team members. For example, the medical director overseas patient's health status and refers potential patients into SEP. Exercise prescription and programming is provided by exercise trainers, researchers contribute expertise and develop new approaches to deliver exercise to patients. Further, the SEP was supported by the patient support and education department of the comprehensive cancer treatment and research center to increase their personal and structural resources [25]. Additionally, networking with local associations and the municipal commune might support the allocation of communal facilities to increase training spaces. The foundation of an independent sports association might further increase the provision of equipment and structural resources.

Outer Setting of OnkoAktiv institutions

The outer setting covers parameters such as the degree an institution is networking with other external organisations or external competitive peer pressure for program implementation. Here, RE and certified CBEP reported that collaboration with HCPs and their referral of patients into CBEP have been fundamental barriers. Overall, there is inadequate collaboration between certified CBEP and several target groups like HCPs, clinics and ambulances, rehabilitation centers and other exercise institutions. We found several reasons for the lack of collaboration. Research shows that lack of time, workload and availability of CBEP are most important barriers for HCPs, next to concerns regarding program safety and patients health status [28, 29]. IJsbrandy et al. identified further

organizational barriers, for example poor communication, ineffective collaboration and undefined roles [19]. Although, several authors revealed that 50-75% of HCPs promote physical activity to patients [28–31]. Further, 75% of oncological nurses inquired about physical activity during visits, giving to around 65% of patients some kind of physical activity recommendation. However, their data indicated that nurses struggle with the "right recommendation" and are often unsure what to recommend [32]. Our data shows that missing knowledge of HCPs about exercise has been a major barrier. This can be resolved by educating HCPS about physical activity counselling and referral. Fowles and colleges showed that HCPs felt significant more confident in providing exercise recommendation for patients after participating in an exercise is medicine workshop [33]. Additionally, regular educative events such as educational meeting, outreach audits, feedbacks and computerized reminders can increase professional expertise [34]. Moreover, a coordinated, supportive network can enhance referrals of patients and information sharing by HCPs [3, 35]. Schmitz et al. engaging clinicians to assess, advise and refer patients into CBEP and further support them through exercise guidelines and consultation material [36]. Santa Mina et al. shows clinical pathways, individualized according to the environmental context to support HCPs in their exercise consultations [3]. Additionally, marketing strategies and further trainings have been ranked highest as network enablers in our study. Therefore, OnkoAktiv plays an important role in the development of regional, supportive micro-networks between HCPs and exercise professionals as well as the provision of educative events and material. Such materials might include implementation guidelines, brochures, marketing templates, educational videos or inhouse trainings.

Practical implications

Barriers and facilitators range across CFIR domains, which necessitate an individual evaluation of existing barriers within the OnkoAktiv institutions. We defined specific practical implications to resolve different barriers for the OnkoAktiv implementation. For example, if RE perceive a lack of knowledge by exercise trainers, specific educational courses need to be introduced. Further, if certified CBEP do not access enough resources for their marketing and program promotion, a variety of promotional material for network members, patients and HCPs (e.g. newsletter, social media, flyer, brochures) should be created and provided by OnkoAktiv. We summarized all practical implications for RE and certified CBEP based on the CFIR domains in **supplement 3.**

Limitations

Our paper must be interpreted in light of several limitations. First, our target groups were limited to the institutions of the network OnkoAktiv in Germany and we assume to only picture larger OnkoAktiv institutions in which patients has been referred. Smaller institutions could be underrepresented due to missing referral records. For the qualitative interviews, social desirability of our interview partner could have affected the description and disclosure of information. The overall assessment of program implementation was negatively influenced by the COVID-19 pandemic. Further, the quantitative part was limited to the number of survey retrieved, that was around 50% of the total number of OnkoAktiv institutions.

Conclusion

This study identified several barriers and facilitators for the implementation of the network OnkoAktiv using a mixed-methods approach. Our findings indicate that RE and certified CBEP face multiple, different challenges for the implementation of

OnkoAktiv. Future implementation efforts might consider the evaluation of individual barriers of RE and certified CBEP (e.g. missing referrals and knowledge by exercise and HCPs, financing options) and specifically develop solutions to promote and support the successful implementation (e.g. conduct regular educational courses, apply multiple funding streams, support collaboration with HCPs).

**List of abbreviations**

| | |
|---|---|
| CBEP | Community-based exercise programs |
| HCPs | Health care professionals |
| PA | Physical activity |
| CCC | Comprehensive cancer centers |
| CFIR | Consolidated framework for implementation research |
| M | Mean value |
| SD | Standard deviation |
| n | Number |
| N | Neutral |
| BA | Barrier |
| FA | Facilitator |

**Availability of data and materials**

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Conflict of interest**

JW invented and founded the network OnkoAktiv and is currently a member of the association board. The other authors declare that they have no competing interests.

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Not applicable

**Ethics approval and consent to participate**

The study protocol has been approved by the ethic committee of the university clinic Heidelberg (S-942/2021 and S-915/2019).

**Supplementary description**

Supplement 1 (.docx): Interview guidelines for regional OnkoAkitv centers and certified training institutions

Supplement 2 (.docx): CFIR domains, constructs and definitions including the adaptation to the network OnkoAktiv with specific examples

Supplement 3 (.docx): Barriers and facilitators for the implementation of OnkoAktiv structures in RE/CBEP and practical implications

Supplement 4 (.docx): Solutions to network barriers for certified training institutions

Supplement 5 (.docx): Bar graph of the OnkoAktiv process quality parameter

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# 4 Manuscript II

Voland A, Köppel M, Peters S, Wiskemann J, Wäsche H. Exploring the organisational structure of networks for exercise oncology provision: a social network analysis of OnkoAktiv. BMC Health Serv Res 2023; 23(1): 555
[https://doi.org/10.1186/s12913-023-09572-8][PMID: 37244985]

**Level of the evaluation concept**

Regional OnkoAktiv networks

| Level of evaluation | Qualitative methods | Quantitiatve methods |
|---|---|---|
| European cancer exercise programs | - | Structural comparison of cancer exercise programs in the European region |
| Regional OnkoAktiv networks Germany | Semi-structured interviews about barriers and facilitators for the implementation of OnkoAktiv | Egocentric Social Network Analysis |
| Certified OnkoAktiv training and therapy institutions Germany | Semi-structured interviews about barriers and facilitators for the implementation of OnkoAktiv | Survey about barriers and facilitators for the implementation of OnkoAktiv and cancer exercise programs |
| Cancer patients referred into cancer exercise programs through OnkoAktiv | - | Questionnaire on structural and process quality indicators, patient-related outcomes, network efficacy at 3 timespoints |

The **supplementary material** for this manuscript can be found on pages 133f.

# **Exploring the organisational structure of networks for exercise oncology provision:** A social network analysis of OnkoAktiv

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## Abstract

***Background:*** Structured exercise programs provide considerable health benefits for cancer patients. Therefore, various OnkoAktiv (OA) networks were established in Germany with the aim to connect cancer patients with certified exercise programs. However, knowledge about the integration of exercise networks into cancer care systems and conditions of interorganisational collaboration is lacking. The aim of this work was to analyse the OA networks to guide further network development and implementation work. ***Methods:*** We used methods of social network analysis within a cross-sectional study design. Network characteristics were analysed such as node and tie attributes, cohesion and centrality. We classified all networks into their level of organisational form in integrated care. ***Results:*** We analysed 11 OA networks with 26 actors and 216 ties on average. The smallest network counted 12 actors/56 ties, the largest 52/530. 76% of all actors operated within the medical/exercise sector, serving 19 different medical professions. In smaller "linkage" networks, several individual professionals were linked "from service to service", whereas the more integrated networks revealed a core-periphery-structure. ***Discussion:*** Collaborative networks enable the involvement of professional actors from different operational fields. This study provides an in-depth understanding of underlying organisational structures that provides information for further development of exercise oncology provision.

## Background

A large body of evidence supports the significant positive effects of physical activity and exercise in cancer patients and survivors [1]. Several cancer- and cancer-treatment related side effects such as cancer related fatigue, anxiety, secondary lymphedema or functional disabilities can be prevented or diminished by exercise therapy [2]. Moreover, long-term observational studies have shown a 40-50% decrease in cancer-related mortality for breast-, colon- and prostate cancer in physically active patients [3, 4]. However, the current situation of exercise oncology provision in Germany is fragmentary and heterogenous. Most exercise programs and networks are tailored to the needs of the individual region or institution. They differ from one region to another in many aspects. Further, there is not much knowledge about the integration of exercise provision into cancer care systems and collaborations between care services [5]. Especially the development of exercise-oncology clinical pathways [6], based on collaborations across different care sectors remain an important aspect for exercise care integration [7]. Specific knowledge about methods and models on pooled administration, funding and service delivery would be essential for comprehensive exercise implementation, as recommended by the American College of Sports Medicine (ACSM). The ACSM engages health care professionals (HCPs) to screen, advice and refer cancer patients into different types of exercise programs according to their needs [6]. To serve the demand of an exercise care in Germany, the nation-wide network OnkoAktiv was established. It aims to connect clinical structures (including their stakeholders) with community-based exercise programs (e.g. gyms, fitness centers) to enable patient referral into cancer-specialized exercise programs [8].

To date, 15 regional OnkoAktiv networks, coordinated through regional OnkoAktiv centers, have been established as "sub-networks" of OnkoAktiv. Each regional OnkoAktiv network works independently under the "OnkoAktiv umbrella" and integrates the OnkoAktiv instruments and processes (e.g. screening, exercise consultation, referral processes) into their local clinical context. Regional OnkoAktiv networks are managed by OnkoAktiv coordinators. The collective OnkoAktiv network has been growing fast over the years, although a structural and research-based network evaluation has not been applied yet. There is currently no systematic approach to either record existing inter-organisational collaboration within physical activity networks in oncological settings nor to measure exercise care integration into cancer care systems [9]. Accordingly, the World Health Organisation (WHO) states within the global action plan on physical activity, that collaboration across and between all stakeholder at all levels is needed to realize the multiplicative benefits of a more physically active world [10]. Further, the emergence of clinical pathway of exercise care show promising results in regard to exercise integration, however, current findings reveal major challenges with HCP collaborations and referral processes from clinical to exercise settings [5]. In summary, the development of collaborative networks in exercise oncology can be rated as highly important for the integration of exercise into cancer care. Therefore, this work aimed better understand the collaborative structures of the OnkoAkiv networks to enhance further network development. The analysis followed two main goals:

1. To describe each OnkoAktiv network in regard to their major network characteristics and classify each network into their developmental stage of organizational forms.

2. To define implications and tasks for demand-oriented network implementation and further development in exercise oncology.

**Theoretical framework for the analysis of the OnkoAktiv networks**

Social network analysis (SNA) allows to describe, explore and understand social systems [11–13]. For this reason we used SNA in our study on OnkoAktiv networks. There are various methodological concepts in SNA such as the analysis of node and tie attributes, cohesion and centrality (see Wäsche et al. [13] for further explanations). For the purpose of this study, we used the following concepts [14, 15].

First, we analysed all OnkoAktiv networks as ego-networks, where the individual network, from an ego´s view, is in the focus of analysis. To explore the characteristics of the OnkoAktiv networks, node and tie attributes were identified. This involves the task and profession of network actors (node attributes) as well as their types of relations (tie attributes). With regard to node attributes, the actor's task and profession were collected, which reveal information about the network actors. This implies, for example, the profession "doctor". A doctor is associated with a set of tasks and attitudes that doctors "should do" (25). Tie attributes represent actions and relations between actors such as collaborations in regard to patient care or financing services. They contribute to a better understanding of interaction pattern and allow to characterize the set-up and interaction patterns of OnkoAktiv networks.

To shed light on network cohesion, we used the parameter average degree. It reports the mean number of ties of each actor, indicates the overall cohesiveness of OnkoAktiv networks and enables a structural comparison.

Centrality defines the position of an actor within a network. We utilized two centrality measurements. Degree centrality identifies central, well connected and important actors in OnkoAktiv networks besides ego. Betweenness centrality describes the extent to which an actor bridges two parts of a network. Actors with high betweenness, also called brokers, have high control over the flow of information and resources in the network [14, 16–20]. According to current research [21], centrality can be a valid measure in ego-centric networks. Therein, centrality reflects an alter´s level of embeddedness in ego´s network and this in turn builds for example trust and willingness to engage with this actor (even though it is a very subjective point of view). Therefore, how the OA coordinator perceives a structural position of an actor is a key factor to exchange resources or information.

To analyse the macro-structure, network core and periphery can be considered [13, 22]. The nodes (actors) of a network are partitioned in two groups: the well-connected core and the nodes in the periphery of a network. The continuous model defines, in which each node is assigned a measure of coreness that presents the position of a node in relation to the estimated network center [22].

To classify networks in health and social care, different models of organisational forms have been identified within the literature [23–25]. Such models position social networks along a continuum of organisational forms and support the classification of OnkoAktiv networks into their level of network maturity. For our analysis, we applied the continuum by Leutz [25], in which three levels "linkage", "co-ordination" and "full integration" have been utilized. In theory, the form "linkage" is associated with a number of stakeholders (e.g. HCPs) that are losely connected but understand on both sides, who needs to take care of what service, how costs are spread and who receives the benefits. The network structure is informal and flat. In co-ordinated networks, defined networks structures and network managers are installed to coordinate care services across the care system. However, co-ordinated networks are

operating mostly on existing and separate structures, also financial and clinical responsibilities remain separate (e.g. individual health care coverage for each service). Such networks provide cross-institutional collaboration but without any bounding contract. The highest level "full integration" builds a new care service in which resources such as finances, staff or expertise are pooled. Multidisciplinary teams define common benefits and they control the new program as the "whole".

According to Leutz [25], the demand of care integration into the system is based on patients' needs such as complexity of disease, level of impairments or cancer- and cancer-therapy-related symptoms. For the categorisation of patients, the "prehab-/rehab-triangle" by the Macmillan Cancer Support in the United Kingdom can be applied. The triangle distinguishes patients between universal, targeted and specialist in which patients can move up or down if, their disease diminish or progresses. Universal exercise programs are applicable for anyone with cancer, targeted programs are designed for people with cancer with acute chronic symptoms of their disease and/or long-term conditions. Specialised programs are applicable to patients with cancer who have complex needs, severe physical impairments or disabilities, unstable conditions or low physical activity levels [26]. The dimensions of patients' needs (mild, moderate, severe) have been also described by Leutz [25]. Figure 1 illustrates the level of patients' needs in relation to the organisational level of integration by Leutz [25] and the defined tasks for HCPs according to the ACSM recommendations [6].

## Methods

Sampling, data collection and study instruments

We applied an ego-centric network analysis within a cross-sectional study design which elaborates the existence of collaborations from the OA coordinator's view.

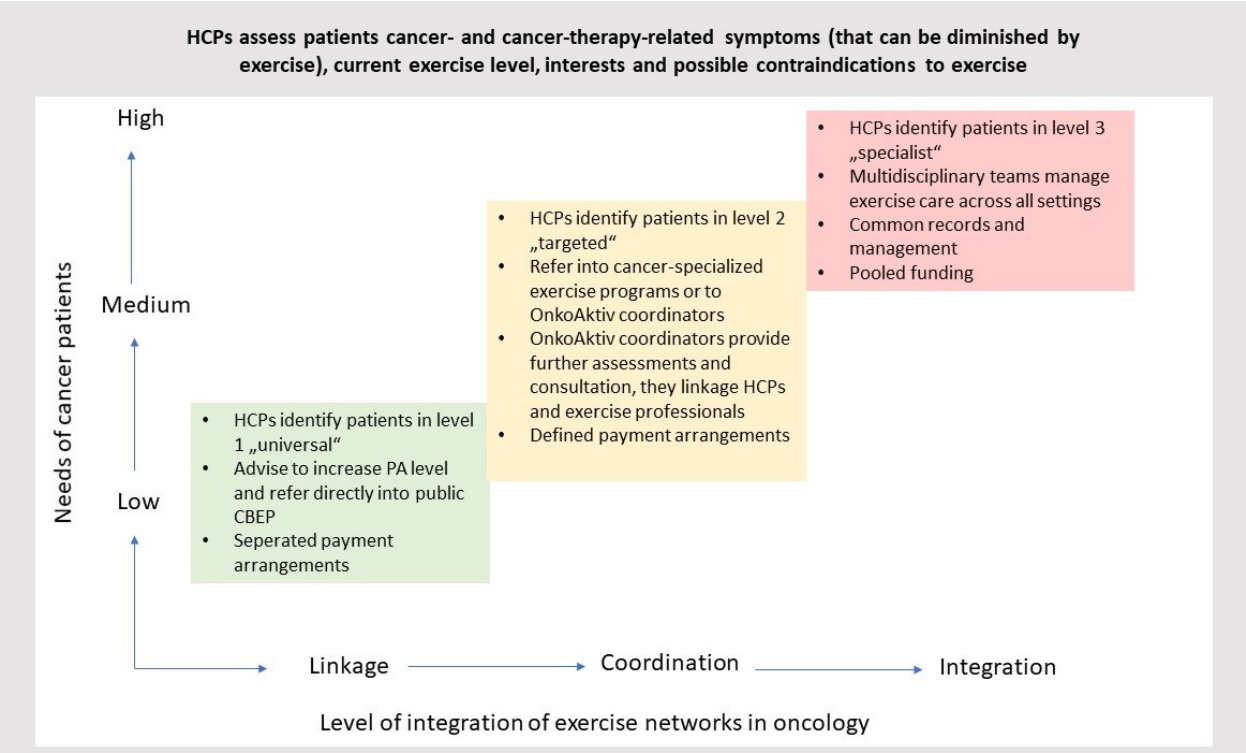


*Figure 1: Tasks for HCPs in relation to the level of patients' needs and the organisational level of network integration adapted by Leutz [25]*

After agreement of the consent of research, the interviews were held online via the video conference platform Zoom, based on a standardized questionnaire.

The OnkoAktiv coordinator was the leading professionals of each regional OnkoAktiv network and the interview participant in this study Our questionnaire followed the methodological process of egocentric SNA by Borgatti [14] and Perry [21]. First, we asked OnkoAktiv coordinators as our "ego" to list their most relevant contact persons including their job position and the organisation or unit they represent via name generators. For the application of name generators, we pre-defined deductive categories (medicine/exercise science, charitable foundations, associations in the fields of physical activity/exercise, cancer associations, university, health care insurances, local organisations). We then applied name and relations interpreters including information about type (patient-related, influential, financial, public communication-related) and importance of relations, duration of collaborations and single important positions of individuals. Finally, we asked ego about all alter-alter-connections to construct a full network matrix. The study protocol has been approved by the ethics committee of the medical faculty at the University Heidelberg (S-942/2021 and S-915/2019).

Network measurements

Based on the theoretical framework in the introduction about SNA measurements and concepts, we applied the following structural parameters [13]:

- Node and tie attributes: task and profession of actors, tie distribution
- Cohesion: number of nodes and ties, average degree
- Centrality: degree and betweenness centrality
- Macrostructure: core-periphery-structures

Further, we classified all networks into the continuum of organizational forms by Leutz [25].

Those network measurements helped to describe each OnkoAktiv network in regard to their major network characteristics. Further, the visualisation of specific network measurements through network graphs enabled the classification of each network into their developmental stage of organizational forms. Although we applied an ego-centric network analysis, full network measurements such as centraliy have been applied. Clearly, the most central actor in ego-centric networks is ego, however, degree centrality also discovers actors that are central within a given network besides ego. The same counts for betweenness centrality. We were interested in other influential actors next to ego, that have the power to control network flows such as information or resources.

Data analysis

For data management, descriptive statistics, and computation of network measurements, we used the programs UCINET 6 for Windows – Version 6.730 and Microsoft Word Excel 2016. All networks were symmetrised and calculated as undirected, dichotomous networks. We defined the largest network A as our "benchmark" network to compare the OnkoAktiv networks to each other. The categorisation of organisational forms was based on the classification parameter in table 1.

Table 1: Parameters for classification into organizational forms adapted from Leutz [25]

| | **Linkage** | **Co-ordinated** | **Full integration** |
|---|---|---|---|
| **Structural typology** | Single actors within existing services are linked "service to service" | Single actors are coordinated by network managers (from within or outside the network) | A new program/service has been created with pooled benefits and recourse, sharing costs and defined tasks. Multidisciplinary teams control jointly all perspectives of the new service |
| **Actor responsibilities** | Screen, inform and refer patients to "other services" within the care system, responsibilities are separate | Managers share clinical information, manage transitions, coordinate benefits and the sequence of services ("care management")<br>Network actors/groups not bounded by any binding contract, responsibilities remain separate | Multi-disciplinary professional teams with joint clinical and contractual responsibilities<br>Apply case management |
| **Administrational body** | None | Administration through elected network members | Managed through an individual, neutral administrative body |
| **Patients' needs** | Universal | Targeted | Specialist |

Data visualisation

For data illustration, the visualization software Gephi (Version 0.9.2) was deployed. We applied the "Yifan Hu" algorithm for all networks. Depending on the interest of visualization, we changed node size and color for better visualization (see captions of graphs).

## Results

Descriptive statistics

We held 11 interviews with OnkoAktiv coordinators. Four networks (A, C, G, H) had been an OnkoAktiv member for more than 3 years, the other seven networks had been network members for less than 3 years at the time of data collection. A full overview of network can be seen in table 2.

Node and tie attributes: What are the tasks and professions of the network actors?

The categorization of actors into pre-defined sectors showed that 76% of all actors held a professional position within the medical/exercise science sector. However, smaller networks indicated higher numbers (up to 100%) of medical professions compared to larger networks. Subsequently, larger networks showed more diversity in their professional distribution.

As seen in figure 2, network A was the only network that involved all pre-defined categories of operational positions. A detailed analysis of the medical/exercise science sector showed 19 different professions with the highest number of actors in exercise science/ sports medicine (M=8; min=2; max=18). Thereafter, most collaborations existed with oncologists, clinical directors, gynecologists, cancer rehabilitation and physiotherapists across all networks.

Table 2: Overview on OnkoAktiv network measurements ordered by network size

| Networks | G | I | L | M | D | H | J | E | B | C | A |
|---|---|---|---|---|---|---|---|---|---|---|---|
| # of nodes | 12 | 16 | 17 | 19 | 19 | 23 | 26 | 32 | 33 | 39 | 52 |
| # of ties | 56 | 92 | 68 | 148 | 166 | 216 | 190 | 224 | 202 | 478 | 530 |
| Average Degree | 4.7 | 5.75 | 4.0 | 7.8 | 8.7 | 9.4 | 7.3 | 7.0 | 6.1 | 12.3 | 10.2 |
| **Tie attributes** | | | | | | | | | | | |
| Patient-related [%] | 50.0 | 56.3 | 64.7 | 84.2 | 63.1 | 69.6 | 65.4 | 65.6 | 72.7 | 38.5 | 52.9 |
| Influence [%] | 58.3 | 68.8 | 58.8 | 36.8 | 52.6 | 47.8 | 69.2 | 75.0 | 45.5 | 82.1 | 82.4 |
| Finances [%] | 16.7 | 25.0 | 35.3 | 21.1 | 26.3 | 39.1 | 34.6 | 25.0 | 9.1 | 20.5 | 33.3 |
| Public communication [%] | 50.0 | 81.3 | 70.6 | 57.9 | 36.8 | 69.6 | 23.9 | 56.3 | 75.8 | 25.6 | 35.3 |
| Years of collaboration [Avg] | 6.8 | 4.0 | 4.9 | 3.9 | 1.0 | 6.3 | 4.8 | 1.8 | 2.1 | 5.1 | 7.0 |
| Importance; 1-10 [Avg] | 7.0 | 5.9 | 7.2 | 6.3 | 7.3 | 7.0 | 4.8 | 8.4 | 6.7 | 6.5 | 5.7 |
| **Core nodes** | | | | | | | | | | | |
| # of core nodes [n] | 7 | 2 | 3 | 11 | 13 | 8 | 7 | 5 | 3 | 15 | 6 |
| [%] of total nodes | 58 | 13 | 18 | 58 | 68 | 35 | 27 | 16 | 9 | 39 | 12 |

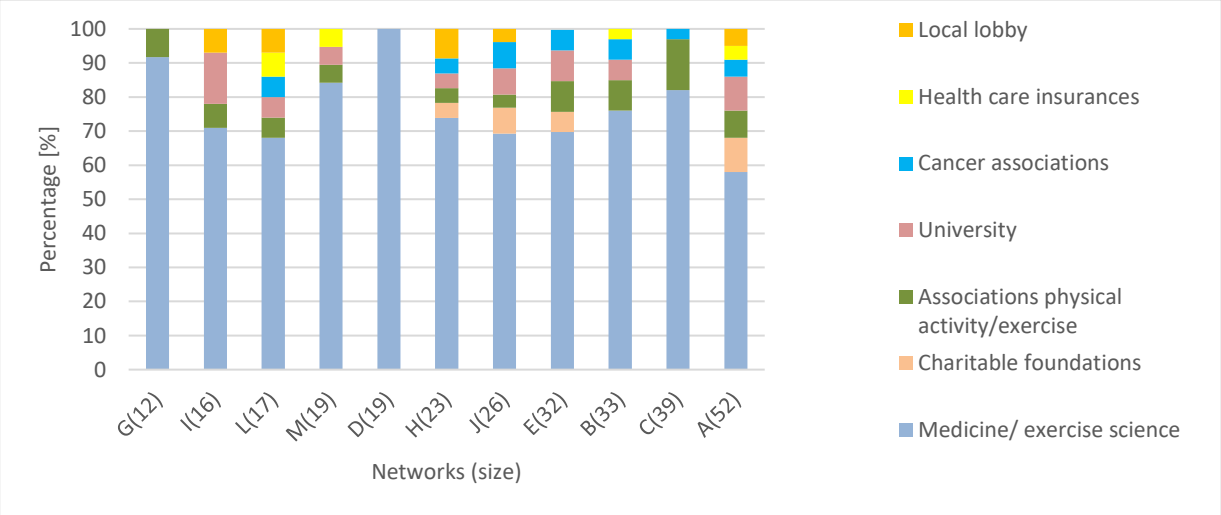


*Figure 2: Distribution of actor-categories across networks in percentage; networks are sorted according to network size from left (G=smallest network) to right (A=largest network)*

The OnkoAktiv networks included 5-9 different medical health care professions regardless of their network size. A detailed analysis of medical professions in number of actors and percentages can be found in supplement 1. Each OnkoAktiv network had one to three subjectively perceived very important network actors, which all held medical-related professions. Most important actors in the three smallest networks (G, I, L) were clinical directors, leading clinical nurses and oncologists and leading exercise scientists. The professions of the most important actors in the three largest networks (A, C, B) were equal to the professions of the most important actors in the smaller networks. However, perceived leaders in larger networks came from different

regions across Germany, whereas leaders in smaller networks worked in the same organisation as the interviewee.

Analysing the distribution of network ties, we found no consistent pattern across types of ties (patient-related, influence, finances and public-communication-related). However, financial ties showed the lowest incidence on average (see table 2).

Cohesion: number of nodes and ties, average degree

The network sizes (total number of actors) ranged from n=12 (network G) to n=52 (network A) with an average number of actors of n=26.2 (SD=11.3). The total number of indirect ties ranged from n=56 (network G) to n=530 (network A), with an average number of ties of n=215.5 (SD=147.2). The mean average degree of all actors in the networks was 7.6 (SD=2.4), with the highest average degree of 12.3 (network C) and the lowest of 4.9 (network L). Figure 3 shows all OnkoAktiv networks, sorted according to their network size. The network visualizations revealed that smaller networks tend to connect different groups with high cohesion, whereas larger networks build tight connected core and loose peripheral structures.

Centrality: Who are actors in the center of the network?

For the comparison of OnkoAktiv networks, the largest network A (n=52 nodes), network H with the median size (n=23 nodes) and the smallest network G (n=12 nodes) will be reported as exemplary networks. Within our benchmark network A, degree centrality ranged from 4 to 51, with five nodes (A00, A01, A07, A08, A10) having more than 20 ties. Next to Ego (A00), A07 (119.8) and A08 (73.7) showed the highest betweenness centrality.

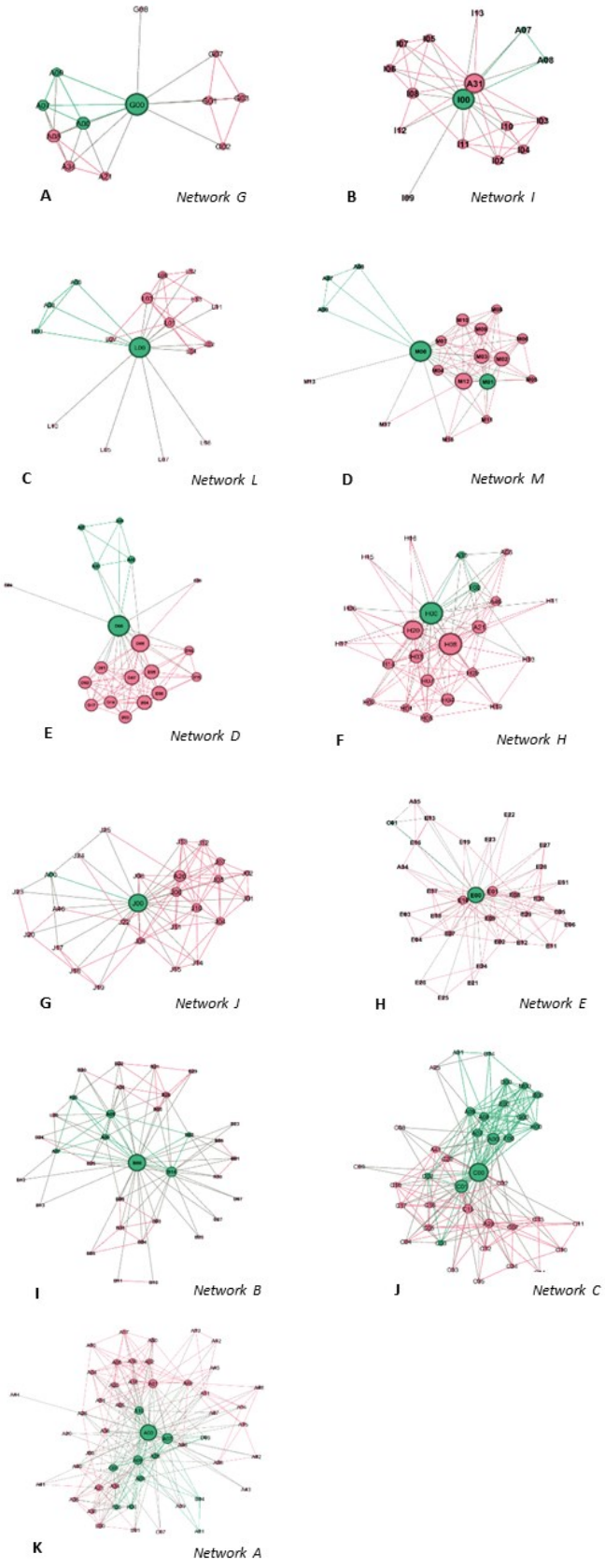


*Figure 3: All OnkoAktiv networks sorted according to their network size (sub-figures A-K); nodes represent network actors; green color: member of OnkoAktiv; red color: other nodes; size of nodes indicates the degree of each actor; links represent a collaborative relationship*

In network H, degree centrality ranged from 3 to 22 ties. The highest degree centrality was around 55% lower than in network A. Two nodes (H00, H08) held more than 20 ties each. Ego (H00) and H08 revealed the highest betweenness centrality (both 44.61). The analysis of network G displayed a range of degree centrality from 1 to 11. The highest degree was around 80% lower than in network A. Besides ego (G00), all nodes held 6 or less ties respectively, which is less than 50% of ties compared to network A and H. Ego showed the highest betweenness centrality (35.2), all other nodes revealed a betweenness of <1.

Macrostructure of OnkoAktiv networks

Based on the continuous core-periphery model [22] the number of core nodes in all OnkoAktiv networks ranged from 2 to 15 (M=7.3; SD=4.0). The number of core nodes did not increase with the total number of actors. Further, core nodes in smaller networks were either located only in ego´s organisation or the core split in two parts of different groups with ego as broker. In larger networks, the core operated on an inter-organisational network level, with actors from different regions and institutions in several important positions, like leading exercise scientists and clinical directors.

Network classification: Continuum of organizational forms

Based on the classification criteria described earlier (see table 1), the analysis and visualization showed a systematic growth of structural maturity and level of exercise care integration. Although, OnkoAktiv networks presented some types of hybrid variations. *Linkage:* We categorized networks G, I, L, M and D as linkage [25]. See figure 4 for two examples in the category linkage. Within linked networks, most actors were connected to each other in an unorganized manner “from service to service”. The OnkoAktiv coordinator (ego) sit between two parts of the network and linked some single nodes from the periphery. The core was shifted to one side of the network with ego sitting on its edge. Overall number of nodes and ties was low compared to more integrated networks. Nevertheless, individual network components showed higher levels of intra-connectivity between actors but not any or just a few cross-sectional ties between separate components (see network G). Overall distribution of different professions was high, although most actors originated from regional institutions.

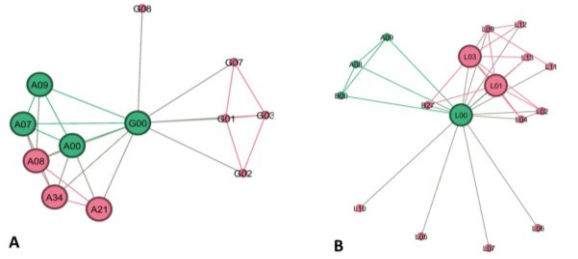


*Figure 4: Example of “Linkage” (sub-figure A: network G; sub-figure B: network L); nodes represent network actors; green colour: member of OnkoAktiv; red colour: other nodes; large nodes indicate the network core; links represent a collaborative relationship*

*Co-ordinated networks*: As seen in figure 5, networks H and J could be classified as co-ordinated networks. Departments and network components were cross-linked (e.g. network J: A00-J25-A26) and multiple nodes were in similar structural positions, having many ties to the same actors (e.g. A26/J06/J10). Core nodes operated in different clinical professions and spread across institutions. Most actors were located in the medical sector (69-74%).

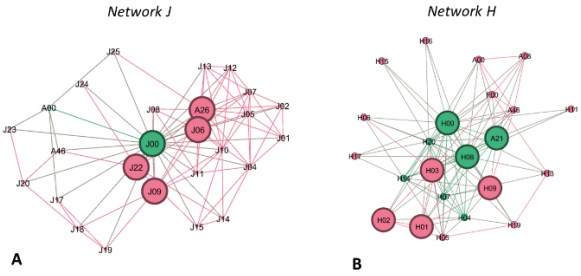


*Figure 5: Examples of co-ordinated networks (sub-figure A: network J; sub-figure B: network H); nodes represent network actors; green colour: member of OnkoAktiv; red colour: other nodes; large nodes indicate the network core; links represent a collaborative relationship*

*Full integration:* We ranked networks E, B, C and A as full integration, although they also showed pattern of co-ordinated network structures as hybrid variations. Figure 6 illustrates two OnkoAktiv networks (C, A) as example for hybrid versions. The full integrated networks revealed an enlarged network size (n>30 nodes; n>200 ties). They showed a clear core-periphery structure with multiple peripheral nodes/subgroups.

The core transitioned to the level of network administration. As it can be seen in network C, the type of nodes in the network core changed from intra-organisational to inter-organisational collaborations and included nodes from other OnkoAktiv networks (e.g. core of network C: C01, C00, C15, A00, A07, A08, A09, A28, F00, G00, H00, E00, D00, M00, B00). Further, the core-actors in network A were organized as neutral administrative body to administrate the network. However, we must point out that none of the OnkoAktiv networks had fully reached the highest, integrated stage ("new service") of organizational forms yet.

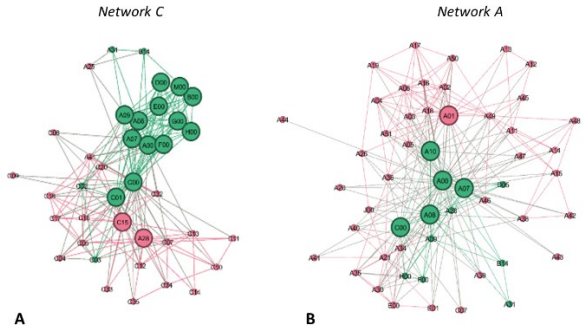


*Figure 6: Example of more integrated networks as hybrid-version (sub-figure A: network C; sub-figure B: network A); nodes represent network actors; green colour: member of OnkoAktiv; red colour: other nodes; large nodes indicate the network core; links represent a collaborative relationship*

## Discussion

The network OnkoAktiv aims to integrate exercise services into the German cancer care system. Thus, OnkoAktiv builds regional "sub-networks" that connect health care professionals (HCPs) and actors from different relevant fields with cancer-specific exercise programs to provide a comprehensive exercise provision for cancer patients. To date, there is only little knowledge about the individual OnkoAktiv network composition. Therefore, the objective of this study was to analyze the current network structures of 11 OnkoAktiv networks in regard to their major characteristics and collaborative structures. Further, they have been classified into their stage of organizational forms and implications for further network development in the field of exercise oncology have been made. In the following, we first discuss the structural characteristics the analysis revealed, before describing the organisational forms and practical implications for OnkoAktiv.

Node and tie attributes: What are the tasks and professions of the network actors?

Our analysis indicated that smaller networks included more similar professions than larger networks. Interestingly, even smaller networks with less than 20 nodes involved at least four and up to nine medical professions into their network. Larger networks spanned their ties into other operational fields and showed a greater network diversity. Economic researchers examined different types of group diversity and their advantages. One type of diversity has been described as "variety" that assumes that members within units differ from one another with regard to categorical attributes such as functional background or expertise. Diversity on categorical attributes is associated with greater creativity, innovation, increased flexibility, better decision-making processes and firm performance [27–29]. Different researchers examined that collaboration in healthcare appears more likely on the horizontal, rather than across units (vertical) [30, 31]. OnkoAktiv aims to encourage HCPs and exercise professionals to collaborate across professional fields to provide the highest value of exercise care for cancer patients.

Cohesion: number of nodes and ties, average degree

OnkoAktiv networks presented a high range in network size, number of ties and average degree. High average degree has been indicated with higher trust and perceived value in public health collaborations [32]. However, high average degree could also result in redundancies of relations. The creation and sustainability of any relation needs ego´s resources, like time and personnel, which is why some relations might deliver barely any advantages. The development of new network relations is only reasonable if the potential new network actor holds different and not yet existent resources. Further, one scarce resource in OnkoAktiv networks are relations into the financial sector. Interestingly, several community-based exercise program evaluations highlighted that long-term funding and cost coverage have been major problems in exercise program implementation [33–35].

Centrality: Who are actors in the center of the network?

The analysis of degree centrality illustrated that central actors (besides ego) with high degree centrality were highly important and held mostly influential positions like clinical directors or leading oncologists. Those influential actors can inhibit or foster the creation of social capital by linking multiple other important actors from different fields to their network [36]. Moreover, central nodes might be important "change-makers" that control power and the flow of information or resources [37, 38]. Long argues that important actors with high degree centrality can play the role of initiators or a natural governmental body [39]. OnkoAktiv coordinators showed high betweenness centrality and owned high influence on network flows as brokers between different parts of the network. They supported inter-organisational collaborations by linking actors from different social fields [36–38, 40].

Organisational forms in exercise oncology: Implications for the network OnkoAktiv

The studied OnkoAktiv networks could be classified into a continuum of organisational forms that is based on the work by Leutz [25]. OnkoAktiv networks, defined as "linkage", showed some ties between medical professionals and the OnkoAktiv coordinator who acts as bridging component. In this early stage of organisational forms, network coordinators should start with an analysis of potential professional leaders, their relational structure, the formation of individual benefits and usefulness of network membership for each actor [24, 25]. They should promote and support communication between potential network members [41]. This strategy corresponds to "diffusion of innovations" theory as described by Rogers [42], considering the "knowledge" and "persuasion"-stages of potential members as crucial for project implementation. Accordingly, the decision-making process of participation is an "information-seeking" process in which potential participants increase their persuasion about membership advantages. Networks categorised as "linkage" prosper through individual engagement, perceived personal value, knowledge-exchange and service to service engagement. Based to the ACSM guidelines [6], professional linkage provides the opportunity to refer cancer patients from service (e.g. primary care) to service (exercise programs). In this stage, HCPs should assess cancer- and cancer-therapy-related symptoms (that can be diminished by exercise), current exercise level, interests and possible contraindications to exercise. If they characterise patients in level 1 as „universal" they advise to increase or maintain physical activity levels and refer their cancer patient directly into public CBEP. Further network development may result in a transition into more integrated, co-ordinated networks. Several recent studies analysed hospital networks in

health care as co-ordinated networks [12, 43, 44]. In our study, we classified networks H and J in this stage because horizontal and vertical links have been created between organisational units. Such collaborations enhance productivity, intellectual content and the creation of new forms of resources [32, 45]. Although, collaboration may come with challenges on different levels, like lack of staff, time and structural resources, low motivation, hindered goal consensus or agreement of decision-making [32, 46, 47]. In this stage, OnkoAktiv coordinators need to support a shared vision and clearly define the network mission statement. They coordinate benefits, manage the sequence of services, share clinical information within a planned framework and manage patient transitions between services [25]. Co-ordinated networks can handle patients in level 2 "targeted". They should get referred by HCPs into cancer-specialized exercise programs or to OnkoAktiv coordinators, who enable further assessments and exercise consultations to clear up exercise safety [6].

The transition into the highest form of integrated networks has been discussed from different perspectives in research [23–25]. It is important to underline that full integration of health services does not have to be the optimal outcome. Based on the work by Lawrence and Lorsch [48], the level of integration should be connected to the degree of specialization of healthcare services that is needed to serve the individual patient. The higher the need for specialization, the greater the demand of integration. What we have seen in OnkoAktiv networks is, that in larger, more integrated networks, the core of the network worked as administrative body, connecting the local network to others across regions. Further, the core connected many oncological specialists within a core-periphery-structure that was able to serve highly vulnerable patients as case management. However, the more integrated OnkoAktiv networks should be also able to serve universal patients and support direct linkage between HCPs and exercise programs to prevent oversupply of services. As seen in figure 1, before starting any exercise intervention, cancer patients need to get screened and classified into their level of complexity, individually cleared up to exercise and then referred into the appropriate exercise care program. Table 3 summarizes the operations for OnkoAktiv coordinators in different levels of organisational network forms based on our argumentation. In our framework, a network can transit into a higher level of network forms when all operations of the lower stage have been accomplished.

Limitations

Our study was limited by the number of OnkoAktiv networks and the openness of OnkoAktiv coordinators to share information about their relations. We had no access to the collaborative stakeholders for interviews to enable a full network analysis, which is why we applied an ego-centric network analysis. However, using centrality parameters in ego-centric networks analyses might be biased by ego's subjective perspective. As it has been discussed by Borgatti [49] as well as Henderson [50], the ethical base of SNA can be restrictive or denying due to vulnerable work-related information. Further, the subjective estimation of ties between actors could be incomplete and missing data may result from oblivion or response-fatigue. Further, the definition of network boundaries has been challenging because of overlapping fields of activities and dynamic work-relationships. Our results should be interpreted with caution because of a missing proof of correctness of ego´s answers [51]. The practical implications (see table 3) only represent cross sectional, descriptive data and allow no generalization.

Table 3: Summary of network classification parameters and operations for OnkoAktiv coordinators in different stages of network forms

| **Operation** | **Linkage** | **Co-ordination** | **Full Integration** |
|---|---|---|---|
| Function of coordinators | Initiation of collaboration between stakeholder and professional leader, support of communication and share of knowledge. Definition of network vision and mission statement.<br>Clarify and define jointly individual tasks, responsibilities and proposals of each network member. | Administration of network members, align network goals to "core business" of network members.<br>Support shared vision, keep individual responsibilities in subgroups, create joints for collaboration and a "platform" for communication (e.g. regular meetings) | Provision of all care services as integrated care model. Develop a new administrative system and a shared vision and mission statement. Implement pooled funding options. |
| Key player involvement | Analysis of "core"-actors and important key player inside the organisation:<br>Involvement of clinical managers, heads of exercise or oncology department, leading clinical nurses and oncologists | Analysis of important and influential "peripheral"-actors inside and outside the organisation<br>Inside: e.g. physio- and exercise therapy, urology, haemato-oncology, gastroenterology or breast care centers<br>Outside: Involvement of health and annuity insurance, self-help groups or cancer care society | Fully integrate key player into a "new organisation" with multidisciplinary teams |
| Funding | Individual/separate | Individual/separate | Individual/separate or pooled |
| Patients need | Universal | Targeted | Specialist |

While network governance (or management) was not an explicit aspect of this study, further research should consider network governance modes [52] with regard to effective network management and how this might contribute to a better exercise integration into cancer care.

## Conclusion

This work aimed to better understand the collaborative network structures of OnkoAkiv and to define specific tasks for further network development. We could classify each network into their developmental stage of organizational forms and highlighted specific network characteristics for each OnkoAktiv network. Based on our analysis, we developed operations for network coordinators in different stages of network forms to enhance their local networks.

Collaborative networks enable the integration of pathways of exercise care into oncology that involve stakeholder from different medical and social fields. While there is little research about exercise integration into oncology settings, the network OnkoAktiv provides an example of relevant actors such as oncologists, sport scientists or clinical directors can be connected for a comprehensive exercise provision. However, more longitudinal studies are required to examine network maturity and activities that influence network outcomes such as efficiency.

**List of abbreviations**

| | |
|---|---|
| WHO | World Health Organisation |
| SNA | Social network analysis |
| HCP | Health care practitioners |
| NAO | Network administrative organisation |
| M; Avg | Mean value; Average |
| SD | Standard deviation |
| N | Number |

## Declarations

### Ethics approval and consent to participate

The study protocol has been approved by the ethic committee of the university clinic Heidelberg (S-942/2021 and S-915/2019). All methods were carried out in accordance with relevant guidelines and regulations. Our research, involving human participants and human data, has been performed in accordance with the Declaration of Helsinki. The informed consent to participate was obtained from all participants.

### Consent for publication

Not applicable.

### Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### Competing interest

JW invented and founded the network OnkoAktiv and is currently a member of the association board. The other authors declare that they have no competing interests.


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### Author´s contribution

AV, MK, SP, JW and HW made substantial contributions to the conception and design of work. AV carried out the acquisition and analysis of data. AV and HW executed the interpretation of data. AV wrote the manuscript with input from all authors. All Authors substantively revised the final manuscript. HW supervised the project. All authors have approved the submitted version (and any substantially modified version that involves the author's contribution to the study) and agreed to be personally accountable for the author's own contributions.

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# 5 Manuscript III

Voland A, Campbell A, Wiskemann J. Characteristics and perspectives of cancer exercise programs in Europe and neighboring countries: an explorative cross-sectional survey. Submitted to Supportive Care in Cancer on March 04, 2024.

**Level of the evaluation concept**

Network frame: Exercise programs in the European region

| Level of evaluation | Qualitative methods | Quantitiatve methods |
|---|---|---|
| European cancer exercise programs | - | Structural comparison of cancer exercise programs in the European region |
| Regional OnkoAktiv networks Germany | Semi-structured interviews about barriers and facilitators for the implementation of OnkoAktiv | Egocentric Social Network Analysis |
| Certified OnkoAktiv training and therapy institutions Germany | Semi-structured interviews about barriers and facilitators for the implementation of OnkoAktiv | Survey about barriers and facilitators for the implementation of OnkoAktiv and cancer exercise programs |
| Cancer patients referred into cancer exercise programs through OnkoAktiv | - | Questionnaire on structural and process quality indicators, patient-related outcomes, network efficacy at 3 timespoints |

The **supplementary material** for this manuscript can be found on pages 135ff.

# **Characteristics and perspectives of cancer exercise programs in Europe and neighboring countries:** an explorative cross-sectional survey

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## Abstract

***Purpose***: There is strong evidence on the positive effects of physical activity interventions in cancer patients. However, there is only limited knowledge about cancer exercise programs (CEP) in the European context. Therefore, this survey aimed to analyze CEP in the European Union and neighboring countries and to discuss implementation perspectives. ***Methods***: We conducted an explorative cross-sectional study in which we contacted leaders of exercise oncology programs across the European region. Data were systematically collected through a quantitative survey based on the RE-AIM framework. ***Results***: We analysed 81 exercise programs from 15 different countries, from which 32% were located in community-based settings and 31% in hospital clinics. Most programs employed 1 to 5 employee within 1 to 2 program locations, serving 50 to 150 patients per year. Up to 70% of surveyed exercise programs collaborated health care professionals (HCPs). Programs were delivered by various exercise professionals with diverse educational levels and qualifications such as academic degrees (52%) or specific oncology educational certificates (45%). Established programs reported a high need of collaborations with HCPs, educational courses for physical fitness trainers and the integration of programs into cancer care systems. Program funding and HCP support were the most frequent barriers for program implementation. ***Conclusion***: Our study has shown that CEP are highly diverse in terms of organizational characteristics. There is a high need for a structural network linking HCPs and exercise trainers. Additionally, educational courses should provide the needed knowledge to enable professional exercise care in oncology for both target groups.

## Background

To date, there is broad evidence on the positive effects of exercise interventions in oncology [1]. Exercise provides a large body of health benefits such as increased physical function, cardiovascular capacity and muscular strength [2–5]. Further, exercise has proven its positive effects on cancer and cancer treatment-related side effects such as fatigue [6], lymphedema [7], anxiety and depression [8, 9], bone health [10] as well as quality of life [3, 5]. Moreover, long-term observational and follow-up studies have shown beneficial impact of exercise on treatment tolerance [11] as well as overall cancer-specific survival rates [12–15]. Although exercise has been proven to be safe and beneficial for people with cancer [16], the knowledge transfer into practice has been fragmentary and complex [17]. Current research revealed that health care professionals (HCPs) do not recommend exercise in their medical consultations regularly due to insufficient knowledge about exercise or insufficient resources [18–22]. Further, missing collaboration between HCPs and exercise professionals as well as an overall lack of cancer-specific exercise programs were described as high barriers for comprehensive exercise provision [23–25]. However, there is some good knowledge about successful oncological exercise program implementation in the US [26–28], Canada [29–32] and Australia [33] such as the Livestrong program at the YMCA (US) [27], the Fitstep for Life program (US) [28] or the Wellspring Cancer Exercise program (Canada) [31]. Although, little is known about cancer exercise programs in the European Union and its neighboring countries [34].

## Aim of study

The aim of this survey was to analyse existing cancer-specific exercise programs in the European Union and neighboring countries to find similarities and differences to existing program evaluations. We aimed to find out information about individual program characteristics as well as barriers and facilitators to implement cancer exercise programs into different settings in cancer care.

## Study design and pre-testing

We conducted an explorative, cross-sectional study design and developed a novel questionnaire (see study instruments). The new developed questionnaire passed through three cognitive pre-tests and discussions with independent exercise scientists in regard to test logic, completeness and understanding. The cognitive pre-tests were one on one discussions between the first author and the invited scientists in which every question of the questionnaire has been discussed. Furthermore, four exercise scientists tested the survey under real conditions.

## Study population and procedure

Our study population included leaders of oncological exercise programs in the European Union and neighboring countries. Neighboring countries were defined as countries that directly border the European Union or have access to the Mediterranean. Selected programs had to be ongoing and accessible for the overall cancer community. The study included exercise programs that were located in community settings (e.g., fitness centres, community exercise facilities) with supervision or clinical and therapeutical settings open for the community (e.g., hospital, rehabilitation centre), independent of their status as non-profit and for- profit organization. Excluded from our study were self- organized groups (e.g., walking groups or self-help groups), educational counselling without structured exercise, online programs only, clinical trials, events only and private businesses without personal contact (e.g., online programming only).

We applied several approaches to find relevant participants for our survey. We contacted the official addresses of all leaders in the field of exercise oncology in our target area, which we have found through expansive research. We used the country-specific filter in the in the American College of Sports Medicine (ACSM) database "Moving Through Cancer" as well as the contact list of the National Expert Group on *Exercise* Therapy and Physical Activity in Oncology (NEBKO) and shared our intent on multiple social media channels (Facebook, Instagram, Linked In). We utilized the principle of snowball sampling and asked study participants for more potential contacts, whom we then contacted [35]. The study information and consent of research were sent to all eligible addresses via email. After informed consent, participants could answer the questionnaire online. The study protocol has been approved by the ethics committee of the medical faculty at the university Heidelberg (S-942/2021 and S-915/2019).

**Instruments and variables**

We developed our questionnaire based on the RE-AIM framework [34, 36–38]. The framework provides a question template that needs to be adopted by the researchers to help them to evaluate the implementation status of their targeted interventions. Latest systematic reviews and exercise program evaluations utilised it as a guideline to develop recommendations regarding exercise program execution [36, 39, 40]. The RE-AIM framework includes the following dimensions in our study: Reach (demographics, target population, number of patients per year), Efficacy (program goals, endpoints, measurements of success and outcomes, attrition-rate), Adoption (locations, program staff, staff education, factors to widespread adoption of program), Implementation (structure of program and program options, requirement for patient participation, duration, services, supervision, types of exercise, funding and payment options) and Maintenance (strategies for maintenance, stakeholder commitment) of the surveyed programs. Furthermore, we asked for barriers and facilitators within the RE-AIM categories. The survey comprised multiple choice and closed questions. Please find the questionnaire of this study in the additional file 1.

Statistical analysis

All items were analysed by descriptive statistics using IBM SPSS Statistics 26 and Microsoft Excel 2016. We conducted frequency counts, minimums, maximums, mean values, median and standard deviations. After the first explorative analysis we included a subgroup analysis to get more information and differences about specific exercise program locations. We executed the $chi^2$-test of independence to examine the differences between defined subgroups. The subgroup "clinical setting" included all programs in hospital clinics or physiotherapy practices, the subgroup "community setting" took all community-based exercise (e.g. gyms, community health and fitness centers, municipalities) or home-based programs into account. We assumed a statistically significant relationship between two variables if $p<.05$.

## Results

General exercise program overview

In total, we analysed 81 exercise programs from the 15 different countries. The survey participants were mainly program directors (38%) and physiotherapists (30%). Programs were mostly located in community-based settings (32%) and hospital clinics (31%). Most participants led one to two program locations and one to five employees. Several public locations have been qualitatively listed such as municipal facilities, schools, faculty of sports in university, cancer associations, outdoor or online trainings. Subsequently, we classified 45

programs in the subgroup “clinical setting” and 36 programs in the subgroup “community setting”. More than half (55%) of programs collaborated with one to five external exercise venues for patient referral. Table 1 provides a general overview of the exercise program characteristics included in this study.

*Table 1: General exercise program overview*

| | | N | % of total N |
|---|---|---|---|
| **Total # of programs** | | 81 | 100 |
| **Countries** | Netherlands | 16 | 20 |
| | Italy | 13 | 16 |
| | United Kingdom | 11 | 13 |
| | Switzerland | 8 | 10 |
| | Spain | 6 | 7 |
| | Germany | 5 | 6 |
| | Portugal | 5 | 6 |
| | Denmark | 4 | 5 |
| | Israel | 3 | 4 |
| | Ireland | 3 | 4 |
| | Other | 3 | 4 |
| | France | 2 | 2 |
| | Slovenia | 2 | 2 |
| | Other | 3 | 4 |
| | | | |
| **Position of study participants** | Program director | 31 | 38 |
| | Physiotherapist | 25 | 30 |
| | Clinical exercise scientist | 21 | 26 |
| | Exercise professional | 19 | 23 |
| | Other | 12 | 15 |
| | Health care professional | 9 | 11 |
| | | **N** | % of total N |
| **Location** | Community based exercise programs | 32 | 40 |
| | Hospital clinic | 31 | 38 |
| | Physiotherapyclinic | 14 | 17 |
| | Home-based | 4 | 5 |
| | | | |
| **# of locations within the program** | 1 | 32 | 39 |
| | 2 | 14 | 17 |
| | 3 | 4 | 5 |
| | 5 | 4 | 5 |
| | > 5 | 10 | 12 |
| | | | |
| **# of locations/collaborations to refer patient to external venues** | 1-5 | 44 | 54 |
| | 6-10 | 3 | 4 |
| | 11-15 | 3 | 4 |
| | > 20 | 2 | 2 |
| | No external locations/collaborations | 28 | 34 |
| | | | |
| **# of employee** | 1-5 | 65 | 80 |
| | 6-10 | 10 | 12 |
| | 16-20 | 1 | 1 |
| | > 20 | 4 | 5 |

Reach of intended target population

The target age of participants in the analysed programs was distributed as followed: 83% adults (40-65 years), 68% elderly (>65 years), 55% young adults (18-39 years) and 22% teenagers and children (<18 years). Most programs targeted both gender (80%) and served all types of cancer (58%). However, 29% of programs focused on breast cancer patients only. Most programs targeted the cancer or cancer-treatment specific side effects fatigue (80%) and functional disabilities (61%).

Around half (51%) of programs served under 50 patients per year, 36% of programs up to 150 patients per year. Further nine programs (11%) served more than 250 patients per year. Most programs collaborated with oncologists (71%), oncology nurses (57%), physiotherapists (56%) and HCPs (46%). However, there was a high variability of 18 different collaborating profession. As shown in table 3, a detailed analysis of program collaborations indicated that programs in clinical settings held more associations with oncologists, oncology nurses and out-patient-clinics than programs in community settings.

Effectiveness of exercise programs

In the dimension of effectiveness, most programs aimed to improve quality of life (95%), reduce cancer therapy related side effects (86%) and increase overall activity level (83%). Mean value of withdrawal rate in percent for 12 weeks was 15% (N=50; SD=12.96) and for one year 26% (N=41; SD=20.34). There were no major differences between the clinical and community setting subgroup in terms of effectiveness.

Adoption of exercise programs

Most exericse programs were led by physical fitness trainers (55%) and physiotherapists (51%), some programs were supervised by clinical exercise scientists (29%) or HCPs (11%). However, participants listed another seven different staff categories for program delivery such as volunteers, CrossFit trainers, kinesiologists or sport medicine doctors. Our subgroup analysis indicated that physiotherapists mostly deliver exercise programs in clinical settings, whereas fitness trainers execute programs in community settings (see table 3 for statistical outcomes). Program staff mostly possessed an academic degree in exercise/ rehabilitation science (51%) or an educational certificate in exercise oncology (45%). Further, participants specified multiple individual certifications such as CanRehab qualifications, university course/students, Crossfit certificate, lymphedema care training or self/internal developed courses.

The most important factor for successful program adoption in a new region was a professional network that included the oncology healthcare team (66%), existing trained staff (51%), the integration of the exercise program into a clinical structure (50%) and financial support/ funding (43%).

Implementation of exercise programs

Around 60% of programs utilized promotional material for patient recruitment. The most selected requirement to participate in a cancer-specific exercise program was the clearance to exercise safely by HCPs (60%). Further, exercise programs in clinical settings selected medical receipts for insurance coverage more often as requirement for program participation than programs in community settings. There were no exercise program participation requirements in 9 out of 81 programs (11%). The length of program differed between 6 weeks and one year.

*Table 2: Exercise program characteristics*

| | | N | % of total N (81) |
|---|---|---|---|
| **Requirements for patients' participation** | Health care practitioner or oncologist clearance due to safety | 49 | 60 |
| | Health/fitness assessment (e.g., 6 min-walk test, max strength) | 26 | 32 |
| | Counselling with exercise professional | 22 | 27 |
| | Medical prescription (insurance cover) | 21 | 26 |
| | Other | 9 | 11 |
| | No requirements | 10 | 12 |
| | | **N** | **%** |
| **Program options** | Group exercise - gym or fitness center | 55 | 67 |
| | Individual supervised exercise - gym or fitness centres | 49 | 60 |
| | Individual online supervised exercise - home based | 21 | 26 |
| | Individual unsupervised exercise - home based | 20 | 24 |
| | Individual supervised - patient room in the ward | 14 | 17 |
| | Individual unsupervised exercise - gym or fitness centres | 8 | 10 |
| | | **N** | **%** |
| **Types of exercise within own program** | Aerobic training (e.g., cycling, walking, running, rowing) | 68 | 83 |
| | Functional Training without/small equipment | 67 | 82 |
| | Coordination and balancing training | 65 | 79 |
| | Stretching and flexibility training | 54 | 66 |
| | Strength training on machines | 42 | 51 |
| | Yoga, Tai Chi, Qigong | 15 | 21 |
| | Other | 17 | 18 |
| | | **N** | **%** |
| **Costs of program** | Free without costs | 51 | 62 |
| | Individual payment option | 24 | 29 |
| | Medical recipe (insurance cover) | 17 | 21 |
| | Monthly membership | 15 | 18 |
| | Time cards (e.g.,10 or 20 time-cards) | 7 | 9 |
| | Other | 13 | 16 |

As further illustrated in table 2, most institutions delivered group exercise (68%) and/or individual supervised exercise (60%). The most frequent type of exercise offered were aerobic training (83%), functional training without/small equipment (82%) and balancing training (79%). The study participants specified 17 additional exercise options that were offered within their exercise institution such as climbing, football, Pilates or dance classes. Program institutions followed different exercise guidelines, although 60% of institutions adopted the ACSM guidelines [2]. Personal experiences (e.g., best practice, practical exchange with colleagues) have been applied by 43%. Participants also reported several other individual exercise guidelines, such as the CanRehab guidelines, the International Pediatric Oncology Exercise Guidelines (iPEOG), guidelines by the Slovenian Faculty of Sport and the Italian Consensus Conference Recommendation. More than half of analysed programs were free (62%) or they implemented individual payment options (29%). Several funding streams have been listed. 38% of programs were private-funded (e.g., sponsorships, donations), 33% public-funded (e.g., government-funded) and 26%

self-funded (e.g., membership fees, time cards).

From the study participant's perspective, most important structures for program implementation were multidisciplinary teamwork within their exercise program (54%), partnerships with local organizations (35%), clinical care referrals and involvement (35%) and ongoing advanced training for staff (35%). Spreading awareness through advertisement, social media and word- of mouth was significantly more important for programs in community than in clinical settings (see table 3). As illustrated in figure 1, lack of funding was the greatest challenge for consistent program implementation (65%), followed by lack of HCP support (37%) and lack of trained people (35%).

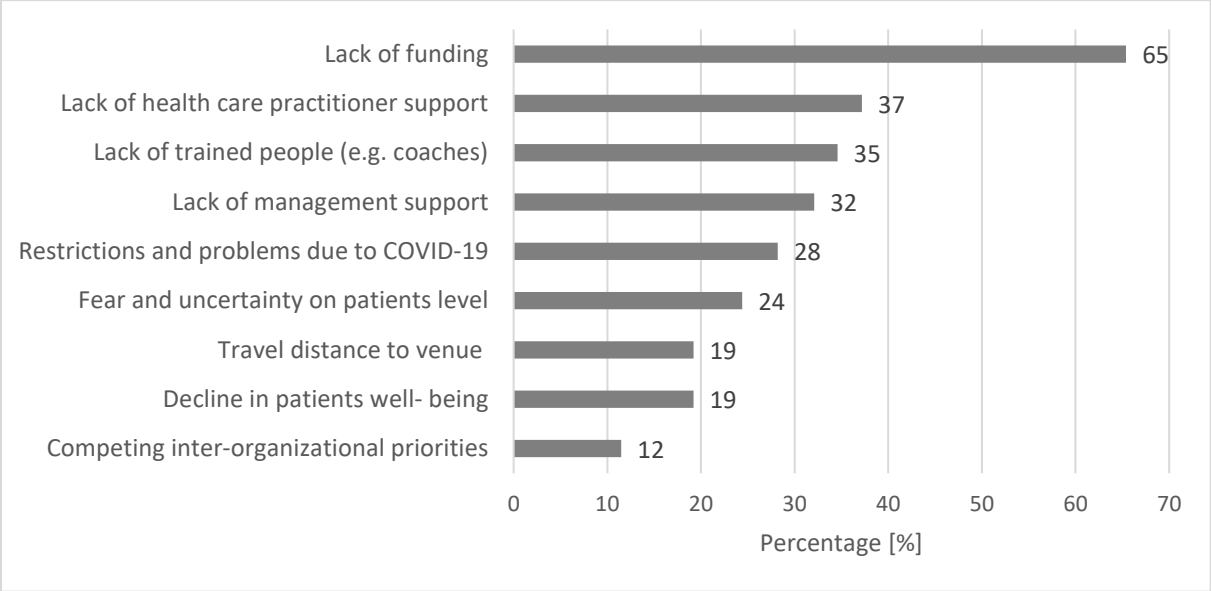


*Figure 1: Barriers for consistent cancer exercise program implementation*

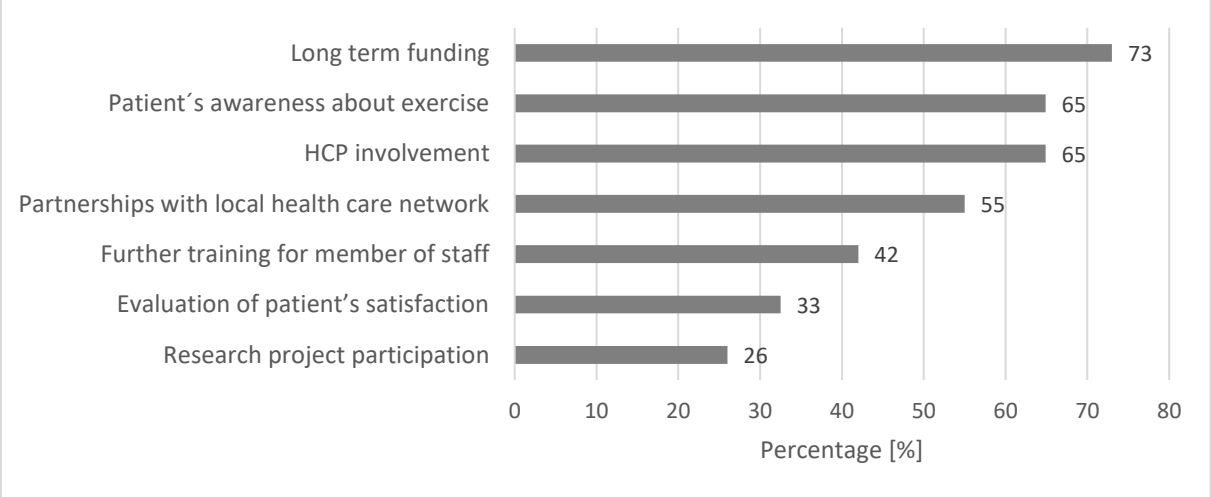


*Figure 2: Key components for successful maintenance of community-based exercise programs for cancer patient*

*Table 3: Statistical outcomes based on the Chi² tests on the differences between clinical and community-based exercise program settings.*

| **Variables** | **Setting of exercise program** | | | | **df** | **$x^2$ value** | **p-value*** |
|---|---|---|---|---|---|---|---|
| | clinical (n= 33) | | community-based (n= 48) | | | | |
| **Program collaborations** | **yes (n)** | **no (n)** | **yes (n)** | **no (n)** | | | |
| with oncologists | 28 | 5 | 28 | 19 | 2 | 6.37 | .041 |
| with oncology nurses | 24 | 9 | 21 | 26 | 2 | 6.99 | .030 |
| with out-patient clinics | 10 | 23 | 5 | 42 | 2 | 8.84 | .012 |
| with exercise professionals | 9 | 24 | 26 | 21 | 2 | 6.99 | .030 |
| **Exercise training staff** | | | | | | | |
| Physiotherapists | 23 | 10 | 29 | 18 | 2 | 8.59 | .014 |
| Exercise professionals | 11 | 22 | 31 | 16 | 2 | 9.18 | .010 |
| **Participation requirements** | | | | | | | |
| Medical recipe | 14 | 19 | 7 | 40 | 2 | 8.00 | .018 |
| **Facilitator for program implementation** | | | | | | | |
| Spreading awareness through advertisement | 5 | 28 | 23 | 22 | 2 | 11.24 | .004 |

*Statistically significant ($p<0.05$)

Maintenance of exercise programs

Our analysis revealed that around half of exercise programs existed up to three years (52%) and around one third of programs have been running for at least seven years. As illustrated in figure 2, selected key components for successful long-term maintenance of exercise programs were long-term funding (73%), clinical and health care practitioner involvement (65%) and building patients' awareness about exercise (65%). The most important key stakeholder commitment, necessary to continue exercise program delivery long term was the support of HCPs (82%).

## Discussion

### Types and characterises of exercise programs

Our study has shown that exercise programs in the European Union and neighboring countries served heterogenic target groups in terms of types of cancer, age and gender. Most programs could be categorized as small, with 1 to 2 locations and up to 5 employees, supervising 50 to 150 patients per year. Our results are consistent with the review by Covington and colleagues, who found mostly community-based exercise programs that were designed for smaller groups of patients [34]. Considering the overall cancer incidence of around four million cases in Europe per year in 2022, this is just a very small percentage of patients that are or can be served [41]. Furthermore, exercise programs in our study showed different organizational characteristics (e.g. requirements for participation, program options such as group training, payment regulations) and provided a variety of exercise options. The structural variety of exercise program characteristics in oncology were also found in two recent reviews [25, 42]. The variety of cancer exercise programs and it´s individual specialisation is required to meet the special needs of cancer patients. Depending on the patients´ complexity and interests, the most suitable exercise programs should be choosen to prevent an over- or under supply of exercise care services [43, 44]. A suitable categorization of cancer exercise programs can be described as followed:

*Specialised programs for patients who have complex or severe needs, impairments or comorbidities.*

- Supervised cancer-specific exercise programs in clinical/therapeutical settings (*e.g. hospital, In/Out-patient clinic,* physiotherapy*)*
  *Program example are* the Wellness and Exercise for Cancer Survivors Program [32], ActiveOnco [45], POWER [46] and MoveMore program [47]

*Targeted programs for patients with acute chronic or latent severe side effects of disease or treatment or long-term conditions*

- Supervised/ unsupervised cancer-specific exercise programs in community-settings (Specialized fitness gyms, health- and community centers, online-programs)
  *Program example are the network OnkoAktiv [48], Livestrong at the YMCA [26, 27, 49, 50], Alberta Cancer Exercise (ACE) [38], Fitstep for life [28, 51], Live Now [33], Wellspring Cancer Exercise Program (WCEP) [31]*

*Universal programs for people with cancer without contraindications*

- Supervised/unsupervised exercise programs in community-based exercise programs (usual fitness gyms, health- and community centers, online-programs)
  Program examples include all kinds of public exercise provision.
- Self-directed exercise programs (home-based, online-programs)

**Educational requirements and exercise guidelines**

The exercise program staff, who participated in our study, owned various exercise credentials and country-specific certifications. Moreover, different exercise guidelines have been applied, depending on the geographical location and their regional regulations. The heterogeneity of exercise staff credentials and applied exercise guidelines have been discussed in various studies [17, 52–54]. Thinking about the potential complexity of cancer patients and risks that come with some cancer and cancer-related side effects such as bone metastasis, lymphedema or polyneuropathy, the heterogeneity of exercise staff credentials and exercise guidelines may severely impact the quality of exercise care. According to current literature, exercise professionals need different educational levels in oncology to provide save exercise programming depending on the underlying setting and the target group the program intents to serve [54]. For example, exercise professionals in community settings need basic educational knowledge about cancer, its treatments and side effects. They provide universal or targeted programming and supervision for cancer patients.

Exercise professionals in clinical/therapeutical settings need specialised knowledge and skills to enable exercise programming for complex patients (e.g., high complexity of cancer-therapy related side effects, risk of bone metastasis). Examples of existing educational programs for exercise professionals are the ACSM/EIM Level 1/2/3 [55], CanRehab Courses [56], Maple Tree Cancer Alliance [57], German cancer rehabilitation trainer licence [58], Oncological Training Therapy (OTT) [59] or Thrive and Cancer Exercise Training Institute (CETI) [60]. However, we must point out that there are no consistent course structures or requirements of credentials for cancer exercise professionals in Europe yet. Although, there are some pathbreaking examples such as the ACSM/EIM educational initiatives [61].

**Barriers and Facilitators for exercise program implementation**

Our analysis showed a high demand of collaborations between HCPs and exercise professionals. This result is consistent with a recently published comprehensive network analysis of the network OnkoAktiv that highlighted the importance of local networks [62]. The outcomes of the network analysis and the work by Santa Mina and colleagues [63, 64] support the high need of inter-organisational and inter-disciplinary collaborations in exercise care. This goes in line with the fact that most participants in our study rated multidisciplinary teams, local partnerships in the community as well as clinical care referral pathways as highly important. One currently implemented exercise care pathway that aims to fill the need of inter-professional network development is the MOVE-ONKO project in Germany [65].

On the other side, program funding and the lack of HCP support were highest barriers for program implementation. Accordingly, several authors have outlined that funding is one of the leading challenges for exercise program implementors due to missing cost coverages by health care providers [42, 52, 64, 66]. This goes in line with our study in which around 40% of programs were private funded as well as around 25% self-funded.

**Study limitations**

Our data is limited to the subjective responses of our participants. Our approach to recruit study participants might have resulted in exercise programs being missed, because we relied on our existing networks, internet registries, e-mailing and social media promotion. We further did not structurally screened all oncology treatment centers in Europe for exercise program implementation and did not include clinical structures that only provided exercise advise and referral. Therefore, we cannot rule out that we missed existing cancer exercise programs and our analysis provides only some exemplary exercise programs. Further, it is not clear, whether our respondents understood the precise differences between the RE-AIM categories due to language barriers. We assume that some results might overlap across RE-AIM categories (e.g., difference between adoption and implementation barriers). Additionally, our results might be also influenced by the Covid-19 pandemic.

**Conclusion**

Our study has shown that cancer exercise programs in Europe and neighboring countries are highly diverse in terms of structural and organizational characteristics and were delivered by exercise professionals with varying educational levels and qualifications. Participating programs reported a high need of collaborations with HCPs, educational courses for exercise professionals and the integration of programs into cancer care systems. Overall, the European region needs a comprehensive and uniform guideline of cancer exercise care including educational resources for HCPs and exercise professionals to enable quality-assessed care for cancer patients.

**List of abbreviations**

| | |
|---|---|
| ACSM | American College of Sports Medicine |
| EIM | Exercise is Medicine |
| OTT | Oncological Training Therapy |
| CETI | Cancer Exercise Training Institute |
| HCPs | Health care practitioners |
| M | Mean value |
| SD | Standard deviation |
| N | Number |
| Avg | Average |

## Statements and Declarations


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### Competing Interests

JW invented and founded the network OnkoAktiv and is currently a member of the association board. AC is the founder and director of CanRehab and a member of a number of international advisory groups working on cancer rehabilitation such as the WHO cancer rehabilitation group and moving through cancer. AV declares that there are no competing interests.

### Author´s contribution

AV, AC and JW made substantial contributions to the conception and design of work. AV carried out the acquisition and analysis of data. AV, AC and JW executed the interpretation of data. AV wrote the manuscript with input from all authors. All Authors substantively revised the final manuscript. JW supervised the project.

All authors have approved the submitted version (and any substantially modified version that involves the author's contribution to the study) and agreed to be personally accountable for the author's own contributions.

### Ethics approval

The study protocol has been approved by the ethic committee of the university clinic Heidelberg (S-942/2021 and S-915/2019). All methods were carried out in accordance with relevant guidelines and regulations. Our research, involving human participants and human data, has been performed in accordance with the Declaration of Helsinki.

### Consent to participate

The informed consent to participate was obtained from all participants in the study.

## Supplementary Materials

Additional file 1 (.pdf): Full questionnaire for the leaders of the included oncological exercise programs

Additional file 2 (.docx): Reporting Guidelines STROBE checklist

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# 6 General discussion

As described in the first part of this dissertation, there is a large body of scientific evidence on the positive effects of physical activity and exercise for cancer patients and survivors. However, the landscape of offered oncological exercise programs in Germany is fragmentary and highly heterogeneous. Although exercise has grown up to an important pillar in oncological care, it is not exactly clear how to implement exercise into different cancer care settings. Furthermore, different pathway models (see part 1.3.1), in which patients are referred from clinical institutions to different exercise opportunities, have been reported in different countries such as the US and Canada. There is not much knowledge about the implementation of exercise care into cancer care systems in Germany or Europe. The network OnkoAktiv aims to connect health care professionals (HCPs) within clinical institutions with therapeutical or community-based exercise programs (and their exercise professionals) to enable comprehensive exercise care for cancer patients and survivors across Germany.

The present cumulative dissertation aimed to evaluate the network OnkoAktiv on different network levels and presents first results about network structures and functioning including their network facilitators and barriers. First, this work investigated implementation barriers and facilitators on the level of the regional OnkoAktiv networks and certified training institutions (manuscript 1). Second, characteristics of 11 regional OnkoAktiv networks and their developmental stage have been analysed and implication for further network development were defined (manuscript 2). Third, different oncological exercise programs in the European region have been evaluated and compared to give recommendation about a possible pathway of exercise care in this specific region (manuscript 3). The main findings of the examined study questions are summarized in the following chapter (Chapter 6.1) and are then integrated into the broader context of research (Chapter 6.2). After presenting the strength and limitations of this work (Chapter 6.3), implications for further research on exercise implementation in oncology are derived (Chapter 6.4). The dissertation concludes with practical implications for the implementation of OnkoAktiv structures and processes in different regions in Germany and Europe (Chapter 6.5), followed by the final conclusion of this work (Chapter 6.6).

## 6.1 Summary of main findings

Answering the first research question about barriers and facilitators for the implementation of OnkoAktiv network structures, the data presented in this dissertation showed different fields of discussion for regional OnkoAktiv networks and certified exercise institutions. On the level of regional OnkoAktiv networks, most named barriers were missing knowledge of exercise trainers and HCPs, complexity of OnkoAktiv certification and networking as well as missing patient referrals from clinical institutions. Barriers of certified exercise institutions dealt with low patient referral by OnkoAktiv,

missing marketing strategies and outreach to HCPs. Further, general program funding due to missing health insurance coverage as well as and low engagement of HCPs in collaborating with exercise institutions were main barriers on the global level of the German health care system. Most relevant facilitators of regional OnkoAktiv networks were existing resources (e.g. structural infrastructure, staff, knowledge), collaborations with medical professionals such as oncologists as well as different external cooperation with universities, HCPs or local exercise institutions within local networks. Facilitators for certified exercise institutions were neutral costs for OnkoAktiv network activities (e.g. participation in network round tables), adaptable OnkoAktiv network processes and a wide range of materials to serve cancer patients´ needs. The results indicate different challenges on both network level that should be considered for future OnkoAktiv implementation plans and further network development. Some exemplary solutions to solve specific implementation barriers included educational courses for exercise trainers and HCPs, the development of guidelines and tools to support HCPs with patient triage and referrals as well as the expansion of exercise program promotion across different channels such as flyer, newsletter or social media.

The second manuscript offered a detailed analysis of OnkoAktiv network characteristics and their developmental stage of organisational forms through an ego-centric social network analysis. The study analysed 11 regional Onkoaktiv networks from which the smallest counted 12 actors and the largest 52. More than 75% of all network actors operated in the medical or exercise science sector including 5 to 9 different medical health care professions. The highest number of collaborations existed between the OnkoAktiv coordinators and oncologists, clinical directors, gynecologists, cancer rehabilitation and/or physiotherapists across all networks. All OnkoAktiv networks could be ranked into a continuum of network forms. In smaller networks, several individual actors were linked loosely and uncoordinated together whereas the more integrated networks revealed a core-periphery-structure with a tightly linked and co-ordinated core and single connected actors in the periphery. The study on the OnkoAktiv organizational network forms revealed information about underlying network structures and possible implications to further network development. Collaborative networks such as OnkoAktiv that involve professionals from different operational fields support the successful implementation of exercise care into the cancer care system in Germany.

The third study investigated characteristics of 81 cancer-specific exercise programs from 15 different countries in the European Union, United Kingdom and neighbouring countries. One-third of programs were based each in community or clinical settings, serving up to 150 patients per year. Most programs have been carried out within exercise institutions with 1 to 2 locations, but no patients have been referred to external partner in the program’s periphery. Most institutions saw a high need of collaborations with HCPs, although, up to 70% of participants collaborated with medical professionals

at some point of their exercise protocol. The analysed exercise programs have been delivered by various kinds of exercise professionals (e.g. fitness trainers, physiotherapists) and several educational level of operating trainers have been reported. Although there seem some kind of educational requirements for exercise trainers working with oncological patients across countries, there are no standardized educational trainings and certifications for the program executing staff. Participants classified the integration of oncological exercise programs into cancer care systems as high need for exercise implementation. Further, program funding and support by oncologists were most frequent named barriers. Based on the results, the study outcome suggests that exercise program implementation into cancer care settings requires close collaboration between exercise and medical professionals as well as community-settings to facilitate such programs. Therefore, the manuscript proposed one plausible example of a pathway of exercise care for the European context.

## 6.2 Integration of study results into the broader context

The study results of the individual manuscripts have been integrated into the broader research context and discusses organizational settings for oncological exercise program implementation in Germany.

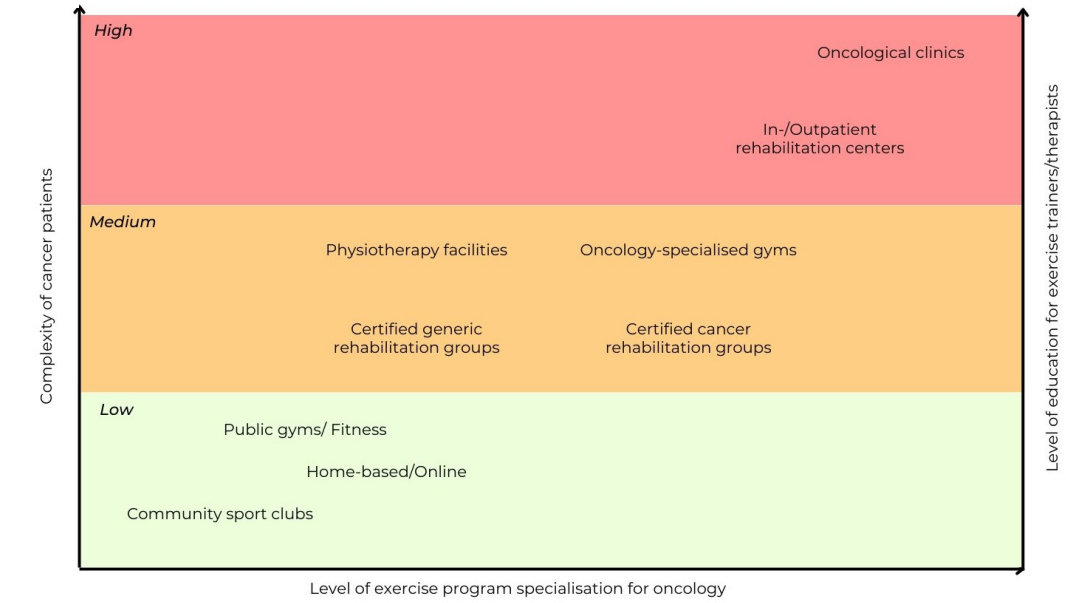
### 6.2.1 Organizational settings for cancer exercise program implementation in Germany

Oncological exercise programs can be implemented in different organisational settings (clinical or community-based facilities) in Germany. As already discusses in chapter 1.2, the appropriate setting for cancer patients to participate in any type of exercise depends on their individual therapy status and risk assessment and stratification. Further, the patient´s personal interest in specific types of sport activities as well as the patient´s health and physical literacy [110, 111] should be further taken into account before referring the patient into any type of exercise program. The inclusion of the four parameter (therapy status, risk stratification, interest and health/physical literacy) is the basis for patient-centered care in exercise oncology.

According to the EXCEED Algorithm [70] there are four types of exercise settings that provide suitable exercise care options for oncological patients (sorted by the level of cancer care specialisation): (1) Cancer Rehabilitation, (2) Clinically Supervised Exercise Service, (3) Supervised, cancer-specific community-based exercise and (4) Unsupervised or generic exercise programs. This differentiation might be appropriate for some countries such the US, however, the German system provides some more specific exercise opportunities in different phases of cancer disease and treatment. The following figure 6 illustrates (a) the types of exercise settings in dependence to the complexity of cancer patients, the level of exercise program specialisation for oncology and the level of education for exercise

professionals and (b) settings for oncological exercise programs in Germany in different phases along the cancer care continuum.

(a)




(b)

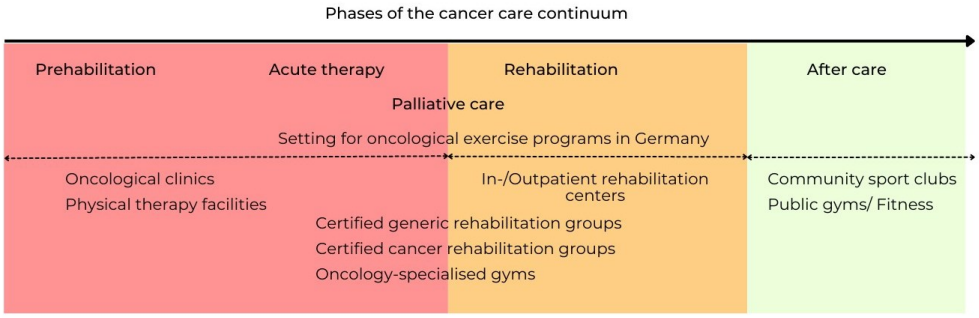



*Figure 6: Cancer exercise program classification integrated into the German health care system; (a) Level of exercise program specialisation for oncology in correlation to the complexity of cancer patients and the level of education for exercise trainers; (b) Types of exercise programs in different phases of the cancer care continuum*

A possible way to differentiate exercise programs for cancer patients is shown in figure 6 (a). The stratification will be described in the following based on the risk stratification to exercise into low, medium and high-risk patients.

**Low risk patients**

Oncological patients who have been stratified into the “low risk” to exercise category can participate in public sport club activities such as offerings in the organized sport, connected to the German Olympic Sports Confederation ('Deutscher Olympischer Sportbund', DOSB) or in public gyms. The participation in general or specific rehabilitation sport groups are covered by health insurances through the rehabilitation sports recipe M56 (Statutory health insurance) or G850 (pension insurance). Further, if a “low risk patient” shows special interest in a specific type of sport such as swimming, dancing or yoga, or they would like to “go back” to their pre-morbidity sport, they can participate in

their favourite sport without any concerns. The participation in public sports activities applies to all low-risk patients, regardless of their therapy status. However, if their health deteriorates or they develop cancer-treatment related side-effects, they should go into consultation with their responsible HCP and may transit into more for oncology specific types of exercise programs.

**Medium risk patients**

As described in chapter 1.2, cancer patients should be classified into the medium-risk category if one or several cancer- or cancer-treatment related side effects or any comorbidities that represent risks to exercise (e.g. heart diseases) exist. However, if the responsible HCPs says "I´m not sure or have no time to classify" or the individual patient wishes specialised supervision, patients should be advised to take part in more for oncology specialized exercise offers. Within the German health care system, three types of exercise facilities/offerings come into question: rehabilitation groups that are certified by the disabled sports association (see "low risk patients"), which are usually linked to a sport club or health care institution, physiotherapy practices or for oncology-specialised gym with special oncological exercise offerings. In the context of physiotherapy practices are different types of exercise prescriptions available. General physiotherapy ('Krankengymnastik', KG) or physiotherapy on exercise devices ('Krankengymnastik am Gerät', KGG) can be prescribed by general practitioners or oncologists. Both recipes include individual training options in groups up to three patients or in 1:1 settings. Additionally, the oncological training therapy (OTT) can be prescribed for patient with private health insurances that includes a personalized devise-based training. Within such settings, exercise trainers with higher educational level in exercise oncology (achieved through special trainings – see manuscript 3 for more details) support cancer patients to exercise safely.

**High risk patients**

On the highest level, patients with severe cancer- or cancer-therapy related side effects, major complications in regard to their cancer disease such as palliative care, severe or multiple comorbidities, or patients who are at high risk for adverse events (e.g. bone metastasis), should participate in exercise offerings in in- or out-patient rehabilitation centers or oncological clinics with special exercise courses. There are some cost-free and low-cost offerings in German oncological clinics in which cancer patients with severe symptoms get highly individual exercise options (e.g. UCT Frankfurt, NCT Heidelberg). Sport therapists in collaboration with medical professionals such as oncologists or radiologists can provide save and highly individualised exercise programming for patients at high risk to exercise. However, the patient´s personal interests in participating in specific types of sports should be also taken into account for this target group. The inclusion of the individual patient´s interest can increase their sports motivation, enjoyment and adherence [112].

Regardless of the risk stratification described above, the patient´s demographic characteristics such as young adults, adults or elderly and the appropriateness of the type of exercise program should be involved. For example, the YOUEX study showed that young adults have diverse interests in exercise options and special interests in online programming. Rehabilitation sports groups with an average age of 60 years and above were not considered age-appropriate for the young target group [113]. Different exercise preferences in cancer patients have been also investigated by Avancini et al. and should be requested in advance [114].

Another possible way to stratify oncological exercise programs in Germany is illustrated in figure 6 (b). Oncological patients may enter exercise programs in different phases of cancer care such as during acute treatment or rehabilitation, or they transit from one phase to the other along the cancer care continuum. For example, one patient may start to exercise during their chemotherapy within a clinical-based exercise program in an oncological clinic. After treatment completion, the patient transits into a rehabilitation program in an out-patient rehabilitation center and further into a community-based exercise offering within a local gym. The transition between settings is crucial and should be supported by the responsible HCP or any exercise professional that manages the patients exercise program. However, the classification into therapy phases does not fit in all cases. For example, some patients may start their cancer treatment without any side-effects and transit into cancer-specific programs only if their side-effects worsen. Other patients may start their exercise program in rehabilitation sport groups already during therapy to work on existing symptoms. Summarized, the exercise setting is highly variable in context of the various cancer treatment options and the individual health status of each cancer patient.

**Educational requirements for exercise trainers**

To date, there are no comprehensive educational requirements for exercise oncology trainers in Germany yet. The necessary level of education about oncology for exercise trainers in community-sport settings is low or not required, only some broader knowledge might be beneficial. However, in order to be able to clear costs of oncological exercise offers with health care insurances as part of prevention and rehabilitation sports, exercise trainers must own special certifications. For example, German cancer rehabilitation trainer licences can be provided by ‘Rehasport Deutschland e.V.’ or the German Association for Health Sports and Sports Therapy (DVGS). Further, there are some promising educational courses for physiotherapists such as the Oncological Training Therapy (OTT) that are billable to private health care insurances. Additionally, study courses in the field of exercise science and therapy include cancer and exercise into their course structure, which improves the knowledge about cancer of future exercise professionals. Educational modalities for exercise trainers in cancer care settings are discussed in detail in manuscript 3.

### 6.2.2 Costs and finances of cancer exercise programs

Each setting in which oncological exercise programs can be implemented require different considerations in regard to their costs and funding options. According to current research, one of the major problems of long-term maintenance of cancer exercise programs is the refinancing situation [9, 106, 115]. Most programs are funded privately or self-funded through memberships due to the lack of health care coverage or governmental funding streams [106, 115]. Moreover, there is only limited knowledge about the cost-effectiveness of oncological exercise programs within different settings. Two current reviews revealed that there is no clear answer to the cost-effectiveness of exercise programs in oncology [116, 117]. Only a small number of studies have shown the cost-effectiveness (or at least cost neutrality), but mostly for supervised, high-intensity exercise and non-breast cancer populations [51, 118–120]. Other studies have shown no cost-effectiveness in different cancer populations such as breast and colon cancer [121, 122]. The authors highlighted the problem that most cost-effectiveness-studies in the field of exercise oncology did not include the FITT (frequency, intensity, time, type) – criteria and/or types of exercise [51, 120, 123]. For example, one study by Kampshoff and colleagues [120] revealed that high intensity exercise is cost-effective on the lower bound of the Dutch willingsness-to-pay threshold (24,40€/ quality-adjusted life years (QALY) gained) compared to the low-to-medium exercise intervention group. They highlighted that high intensity exercise might be cost-effective due to the lower health care costs of such exercise programs. However strong conclusions between high- and low-intensity exercise could not be made because the willingness-to-pay thresholds did not include strength and cardiovascular measurements (e.g. handgrip strength, peakVO2) or fatigue level. Another study by Van Waart et al. [118] compared a home-based, low-intensity, self-managed exercise program (Onco-Move) with a supervised moderate-to-high intensity, combined resistance and aerobic exercise program (OnTrack) in regard to their cost-effectiveness. They concluded that the OnTrack exercise program could be considered as cost-effective compared to usual care, whereas the Onko-Move program was not likely to be cost-effective due to high societal costs. They found a high correlation between cost-effective and exercise compliance within the training protocols. In conclusion, the current knowledge about cost-effectiveness of exercise programs in oncology remains unclear, however, supervised programs appear more likely to be cost-effective than home-based and/or self-managed programs. Considering the possible setting of oncological exercise programs in Germany, most programs take place in supervised settings such as gyms, physiotherapy practices or sports clubs. There is a high probability of cost-effectiveness in such settings, although there is currently not much knowledge in the German context.

Next to the costs for exercise program implementation and maintenance in oncology settings, there are different funding options in Germany to cover them. The first implementation of pilot projects, as

a new service, benefit from third party or private funding such as donations or third-party funds by the German Cancer Aid or local cancer foundations. They are able to cover the primary costs for program implementation. Further, resources such as premises or training equipment can be sponsored by municipal facilities, universities, clinics or schools [9]. Knowledge and educated exercise professionals can be provided by health and sports institutions such as rehabilitation centers, clinics or gyms. When the implementation of the intended exercise program was successful, long-term funding will be necessary for program maintenance. The individual exercise program leader should initiate collaborations with greater sponsorships from the industry or integrates the program into an association structure in order to be able to collect membership fees. It needs to be highlighted that there is no “one way” to cover the costs of exercise programming in oncology as long as there is no general health insurance coverage of German health insurances. As a leading example, physiotherapy services have been successful covered by health insurances in Germany. Patients receive a recipe for physiotherapeutic treatment by their practitioner or oncologist based on the ICD10 key [124]. Physiotherapists can then bill the health insurance company for the treatment carried out. According to the compensation agreement (contract according to § 125 paragraph 1 SGB V for physiotherapy), physiotherapists receive compensation of €50.35 per patient (excluding an additional payment of €5.04 by the patient) for device-based physiotherapy (KGG) of 60 minutes (parallel individual treatment of up to 3 patients) [125].

In summary, within each setting in which oncological exercise programs can be implemented, the individual funding options, including the regional characteristics and opportunities should be analysed, and possible collaborations with local stakeholders for exercise program implementation and maintenance should be elaborated. Local sponsorships and long-term funding options are needed to secure long-term financing.

### 6.2.3 The role of OnkoAktiv

The network OnkoAktiv can play a decisive role in the process of implementing exercise referral pathways and exercise programs in Germany through regional network building. On the level of HCPs, OnkoAktiv provides educational courses, presentations and material about the importance of exercise in oncology. OnkoAktiv can help to educate HCPs about the importance of exercise in oncology, the different exercise prescriptions and cost coverage that are available in the German health care system to prescribe exercise “on recipe” as it has been done in the successful running model project “Prescription to Exercise” [59, 62]. Furthermore, OnkoAktiv can provide further trainings to give HCPs the expertise to offer short exercise advise and refer cancer patients into local exercise programs. Such programs can be found through networks like OnkoAktiv in which exercise offers are presented transparently and structured within the OnkoAktiv map.

On the level of exercise institutions, OnkoAktiv provides quality-assessments according to the OnkoAktiv quality parameters and further trainings in oncology for exercise trainers. OnkoAktiv supports the development of collaborations between HCPs and exercise institutions and the implementation of local exercise-related networks. Further, OnkoAktiv provides promotion and marketing material and funding options through benefit events or jointly funded research projects.

In the global context, OnkoAktiv provides necessary resources in terms of knowledge, expertise, experience, staff, promotional material and networking opportunities to provide safe exercise options for cancer patients. Exercise specialists in oncology support the OnkoAktiv network members in all matters relating to the implementation of oncology exercise offers in Germany.

Moreover, OnkoAktiv can act as initiator to promote interorganisational collaborations between local health and exercise professionals and in doing so, further develops the existing regional health care infrastructure to enable the implementation of exercise-care networks. The following figure 7 summarizes the services of OnkoAktiv for HCPs and exercise professionals.


*Figure 7: The role of OnkoAktiv in exercise (pathway) implementation - Overview*

## 6.3 Strength and limitations

The in this dissertation included publications have their own strength and limitations which are addressed in the discussion part of the individual manuscripts. In the following, broad issues that affect the overall evaluation of the network OnkoAktiv are discussed.

First, the evaluation of the network OnkoAktiv was limited to the members of the network which affected manuscript 1 and 2. Thus, the number of participants was relatively small, although the rate of participation was around 50% for the certified OnkoAktiv training institutions in manuscript 1. The collection of data depended on the engagement of each individual participant, especially for the

coordinators of the regional OnkoAktiv networks who filled out multiple questionnaires and gave qualitative interviews (manuscript 1 and 2). Network members that were not interested in participating in the OnkoAktiv evaluation could not be included into the analysis (which may resulted in a positive bias). Our results should be further interpreted with caution and not applied to structures or networks other than OnkoAktiv because the OnkoAktiv exercise professionals might have already good knowledge and interest in oncology. Other exercise facilities (and their staff), outside the network and beyond the German borders, were not included in manuscript 1 and 2. Therefore, the study population was homogenous in terms of interests and educational levels. Further, we applied a cross-sectional study design in all manuscripts that shows a snapshot of the network in the given moment. Longitudinal data would be interesting for further research, in particular, in terms of further network development. Also, we have applied self-developed questionnaires in all partial studies because it was the first evaluation of an exercise oncology network in Germany and Europe. There is only limited knowledge about how to evaluate networks in the field of exercise [105]. Studies from other fields such as addiction or business management were not applicable to the Germany cancer care system [97]. The application of new methods such as social network analysis, to evaluate a network in exercise oncology can be seen as a strength and limitation (see also manuscript 2 for more details). Overall, one of the biggest strengths of our work was the mixed-methods approach that integrated different views and angles through qualitative interviews and quantitative questionnaires. Manuscript 1 matched both methods to obtain the most accurate and detailed results.

Besides these limitations, the evaluation of the network OnkoAktiv has high relevance, novelty and practicality in terms of the implementation of exercise programs in oncology. OnkoAktiv can be seen as a leading example for regional network development and inter-professional collaboration between HCPs and exercise professionals in Germany. In manuscript 1 and 2, nearly all regional OnkoAktiv networks could be included in the evaluation, which represents different regions and federal states in Germany including their different regional structural characteristics. Moreover, we discovered regional differences and similarities across European countries in manuscript 3.

As another strength of this dissertation, the novelty of this work should be highlighted. To my knowledge, manuscript 2 was the first social network analysis in regard to exercise oncology networks. Manuscript 3 was the first structured and research-based collection and analysis of existing oncological exercise programs in Europe and neighbouring countries.

Together, all three manuscripts build one bigger picture of the network OnkoAktiv and the existence of exercise programs in Germany and Europe. Through the analysis of different network levels, the whole OnkoAktiv network could be evaluated and individual barriers and facilitators were discovered.

## 6.4 Content for new fields of research

Each in this work included manuscript offered specific suggestions to further research on the analysed level of the network OnkoAktiv. The following part aims to discuss future directions in research within a broader context and research topics that overlap the here included manuscripts.

Even though, this work was the first evaluation of the network OnkoAktiv that included all network level, the investigation of the patient level was just a small part of this work. Especially network efficacy, in terms of successful training starts of patients that have been referred through OnkoAktiv including their barriers as well as patient-related outcomes such as quality of life or cancer-therapy-related side-effects should be considered in future research. The analysis of patient-level and economic outcomes in regard to exercise could be from high interest for healthcare funders and decision makers such as governmental policy makers or healthcare insurances [117]. To date, there is no comprehensive financial coverage of exercise programs for the general cancer population in Germany. Therefore, high-quality economic/patient-related research may support future decision making in terms of financial resources and provides a research-based infrastructure for the implementation of cancer exercise programs. Further, there is only limited knowledge about the (cost-)effectiveness of oncological exercise programs in different settings in Germany [116]. Additionally, the level of supervision (supervised, partly supervised, home-based, online) that is needed to achieve cost-effective exercise programs for the cancer population and their underlying costs (for professionals and patients) should be further investigated.

Furthermore, future research should aim to investigate the longitudinal network development of OnkoAktiv and forms of exercise-related networks in different geographical regions. Within the field of network science, it would be highly interesting, which keyplayers need to be involved in which part and at which time point of the network implementation and how they can be reached, contribute and integrated into OnkoAktiv. Collaborations between exercise professionals and HCPs as well as the integration of exercise professionals into cancer care teams have been highlighted as highly important for successful exercise network integration and are fields for further research [97, 98, 101].

To enable the rollout of qualified cancer exercise programs across Germany, exercise oncology training standards should be established for exercise professionals across training environments (e.g. physiotherapy, rehabilitation, public gyms/fitness) and provided in all educational settings (e.g. university, (under-)graduate programs, professional trainings). This involves the development of foundational courses and continuous education for exercise professionals in clinical and community-based settings as also described in manuscript 3. The development of appropriate educational opportunities increases the chance of high-quality training standards for cancer patients and multidisciplinary exercise services such as exercise counselling, referral and training supervision [5].

The last field of research that has been revealed by this work are referral pathways into exercise programs. The development of such pathways from clinical settings (e.g. cancer care clinics) to community-based exercise facilities, including screening and referral instruments (digital set ups/ referral app) for HCPs, are new fields of research, which have received more attention in recent years [64, 69]. To support the implementation of referral pathways, assessment and communication tools that facilitate the referral process should be developed. Such tools should be able to provide HCPs with a guideline in which knowledge about exercise recommendations in oncology is prepared and made available in a structured manner. Regional exercise services should be further organized and listed appropriately (e.g. through the network OnkoAktiv). The utilization of referral tools need to be teached to HCPs and exercise professionals with a major focus on interprofessional communication between clinical environments and exercise services [5, 126, 127]. Moreover, all educational approaches should aim to motivate HCPs to discuss the benefits of exercise with their patients according to current guidelines and to increase exercise program referrals with the appropriate level of program supervision (e.g. medically supervision/community-based self-guided).

**Methodological considerations for implementation research and evaluations**

In addition to the content for new research fields, this work revealed some interesting methodological topics that should be included in future implementation research and evaluations in the field of exercise oncology. First, there is only a small number of mixed-methods- approaches that evaluated exercise programs in oncology [76, 87], although this strategy provides promising results while including individual perspectives and quantitative data. Mixed-methods research has been evolved to the gold-standard in implementation research and is recommend by the “Memorandum health services research” of the German Network for Health Services Research [109, 128]. Also, novel methods such as social network analysis can contribute to a better understanding of exercise-related networks, their characteristics (including barriers for network growth) and how to improve inter-professional collaborations [105]. Such methods are not yet widespread but offer a lot of potential for new research and insights in the field if network science.

## 6.5 From research to practice: We have the plan, how do we start?

The following part summarizes practical implications on how to start exercise implementation in a new setting, derived from current literature and the outcomes of this dissertation, under the leading question: ***We have the plan, how do we start?***

OnkoAktiv can be seen as an inter-professional, collaborative network, that builds sub-networks across Germany. Each network can be integrated in different cancer care settings such as cancer care clinics, rehabilitation centers or sports associations in collaboration with university hospitals. To implement a

new network in an individual setting, certain steps should be taken considering the involvement of all new network stakeholders. We assume in the following example, that the OnkoAktiv network coordination will be integrated in a clinical cancer care setting such as an oncological clinic. Further, the network coordinator has contact to cancer patients and medical staff within the clinic. The following steps to implement an exercise care pathway such as OnkoAktiv are based on the Expert recommendations for implementing change (ERIC) [129, 130] and adapted to the needs and demands of the exercise (network) implementation in the given setting.

First, the network implementation starts with the assignment of the network coordinator (implementation advisor) who is responsible for all network activities and can be seen as the network leader [130]. The network coordinator is the special in oncology educated exercise professional that should be integrated into the clinical cancer care team (e.g. clinical oncologists, nurses, radiologist, supportive care team) that provides the patient care within the oncological clinic. The OnkoAktiv coordinator should run a simple network analysis (as described in manuscript 2) to find important keyplayer, also called champions [130], that help to implement the OnkoAktiv network structures. According to manuscript 2, such keyplayer can be professionals in important positions such as the clinic director, clinic management, or leading oncologists within the clinic. Champions can help to implement the OnkoAktiv structures by providing resources (space, material, finances), influence and visibility. They dedicate themselves to the OnkoAktiv mission with their support, promotion and marketing and help the OnkoAktiv implementation driving through existing structures. As highlighted in manuscript 1, promotional material such as flyer, brochures, informational events or educational courses can be extremely helpful to decrease implementation barriers. They further help to increase the support by professional colleagues and the incoming patient flow for the new exercise service. Additionally, the implementation of screening tools or the integration of exercise screening methods in existing clinical tools might facilitate the allocation and referral of patients to the new exercise service. The results of OnkoAktiv network analysis (manuscript 2) has shown that it needs several streams of patients from different HCPs to reach patients in various medical areas.

When implementing the OnkoAktiv network structures in the given institutional context, individual barriers and facilitators should be analysed and considered. A detailed analysis provides a deeper understanding of limiting factors for network implementation and might shows barriers on the structural level (e.g. limited staff, physical resources) or the formal/political level (e.g. support by the organisation, finances). Possible network barriers and facilitators for regional OnkoAktiv networks (lead by the OA coordinator) are described in manuscript 1.

After the network coordination and the new exercise service has been set into the clinical cancer care structure, the network coordinator links regional exercise facilities to the OnkoAktiv network

coordination. The network development has been analysed in Detail in manuscript 2. It can be summarised, that with an increasing number of network actors, the network coordinator shifts into the network center and develops cross-links across the network, which makes it stable and reliable. Overall, the exercise facility recruitment can be done in two ways. First, the patient-orientated way: With each patient consulted and referred, a potential new exercise facility will get asked to join the network. The exercise facility joins the network with their first patient referred. Second, the facility-orientated way: Local exercise facilities will be quality-assessed and ask to join the network first, before referring patients to the new network member. This might be suitable for very large und popular institutions. However, this option has the disadvantage that some exercise institutions may not be assigned a patient for a longer period of time. Although, for both cases, the network advantages (such as further education for trainers, transparency and quality-approval) must be emphasized in particular to the potential network member. Both ways of exercise facility recruitment may contribute to a successful network implementation and development. The OnkoAktiv coordinators may utilize one or both ways altogether. Next to the network development, maintaining the network requires regular meetings, knowledge exchange and evaluation which should be further organized by the network coordinator.

Next to the development of exercise-care networks, oncological exercise programs need to be implemented in different settings (e.g. physiotherapy facilities, sports associations, gyms) and linked to the regional exercise-care network described above. As shown in manuscript 1, several barriers exist for exercise facilities to implement oncological exercise options. However, several exercise options already exist in the German context, where there is usually just a lack of oncological knowledge. Therefore, and one of the most important topics in the “Exercise Oncology Knowledge Mobilization Initiative” [6] is the development and promotion of an evidence-based exercise oncology education model for HCPs and exercise professionals. This includes for example educational meetings and the development and distribution of educational material as already discusses earlier. As pointed out in manuscript 3, the current educational opportunities and structures for medical and exercise professionals working with cancer patients and survivors are highly heterogeneous. The European countries but also different national regions such as the German federal states would profit from a co-ordinated exchange of experiences and an educational model in exercise oncology. Moreover, collaborations across national borders should be promoted by the government to promote scientific knowledge exchange and higher educational standards on the international level. To date, exercise trainers in Germany can participate in educational courses such as the “Oncological Training Therapy” (OTT), the oncology license from the German Association for Health Sports and Sports Therapy (DVGS) or different certification courses offered by the German state and disabled sports associations.

Last, the network implementation should be supported by online tools such as an appropriate data base, apps and websites for data processing and storage, quality monitoring and feedback by all stakeholders. Over time, monitoring and evaluating the network will provide valuable information about implementation problems and necessary modifications to the current standard that should follow.

## 6.6 Conclusion

This first evaluation of the network OnkoAktiv contributes to a better understanding of barriers and facilitators on two network levels (regional OnkoAktiv networks and certified exercise programs) and the characteristics of the individual regional OnkoAktiv networks. This work investigated how network actors are linked to each other in different forms of networks, how the networks are structured and in which ways they can be further developed. Additionally, different oncological exercise programs in the European region have been compaired and implementation perspectives have been provided. Finally, this dissertation defined practical implication for OnkoAktiv as a roadmap for future network implementation plans. Overall, the network OnkoAktiv supports the implementation of exercise into cancer care settings and the development of supportive networks around it. Such networks integrate different clinical and community-based facilities, including their professionals, in which oncological patients receive exercise services such as consultations, referral and supervised training programs. In future, OnkoAktiv will continue to employ and develop “best-practice” strategies to support HCPs and exercise professionals who adopt, implement and maintain exercise care for cancer patients into their routine practices. As the field of exercise moves further into clinical routine, many patients will have access to exercise care and will also be able to benefit from the numerous positive effects of physical activity over the rest of their lives.

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## *List of figures*



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## *List of abbreviations*

| | |
|---|---|
| ACE | Alberta Cancer Exercise |
| ACS | American Cancer Society |
| ACSM | American College of Sports Medicine |
| CFIR | Consolidated Framework for Implementation Research |
| DVGS | German Association for Health Sports and Sports Therapy |
| EORTC | European Organisation for Research and Treatment of Cancer |
| e.g. | For example |
| EIM | Exercise is Medicine |
| EXCEEDS | Exercise in Cancer Evaluation and Decision Support |
| EXEL | Exercise for Cancer to Enhance Living Well |
| HCPs | Health care professionals |
| $HR_{max}$ | Maximal heart rate |
| ICD | International Classification Of Diseases |
| KG | Krankengymnastik (physiotherapy) |
| KGG | Krankengymnastik am Gerät (physiotherapy on devices) |
| MET | Metabolic equivalent |
| NCCN | National Comprehensive Cancer Network |
| NCT | National Center for Tumor Diseases |
| OTT | Onkological Training Therapy |
| POWER | Personal Optimism With Exercise Recovery |
| QALY | Quality-adjusted life years |
| QLQ | Quality of Life |
| RE-AIM | Evaluation framework (Reach, Effectiveness, Adoption, Implementation, Maintenance) |
| SNA | Social Network Analysis |
| SGB | Sozialgesetzbuch (social code of Germany) |
| UK | United Kingdrom |
| US | United States |
| $VO_{2max}$ | Maximal oxygen consumption |
| WHO | World Health Organisation |
| ZUF | Questionnaire to measure patients satisfaction |

# *Supplementary material*

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## Supplementary material for Manuscript I

Supplement 1a/b (.docx): Interview guidelines for regional OnkoAkitv centers and certified training institutions

Supplement 2 (.docx): CFIR domains, constructs and definitions including the adaptation to the network OnkoAktiv with specific examples

Supplement 3a/b (.docx): Barriers and facilitators for the implementation of OnkoAktiv structures in RE/CBEP and practical implications

Supplement 4 (.docx): Solutions to network barriers for certified training institutions

Supplement 5 (.docx): Bar graph of the OnkoAktiv process quality parameter

Supplement 1a: Interview guidelines for regional OnkoAkitv centers

| Subject area | Main questions | Detailed questions (optional) | Maintenance issues |
|---|---|---|---|
| **Structure institution**<br><br>**Structure region**<br><br>**Organizational development**<br><br>**Barriers/ problems**<br><br>**OnkoAktiv documents** | 1. Which existing **structures in your institution** promote the establishment of a regional OnkoAktiv center?<br><br>2. Which existing **structures in your region** support the establishment of a regional OnkoAktiv center?<br><br>3. Were there **areas or structures within the application process that you set up** for OnkoAktiv certification ? If so, what were they and how have they gone so far?<br><br>4. What **barriers or problems** did you encounter when setting up the regional OnkoAktiv center?<br><br>5. Which **materials and tools** helped you the most when setting up the OnkoAktiv structures? | Who can assign patients to you?<br>Is there a screening tool that refers patients to you?<br><br>Do you cooperate with other clinics/doctors? Are there other partnerships that can promote the regional OnkoAktiv center?<br>What structures support the regional center at the patient level (access routes, connection to a clinic)?<br><br>Have you already conducted first patients' consultations?<br>How was risk stratification carried out?<br>Did you use the OnkoAktiv material? How do you rate the application?<br>Were you able to define individual recommendations for exercising?<br>Did you have difficulties?<br>How many patients have you referred to an exercise program? Was the referral successful? If no, why not?<br>How did you get in touch with the training institution?<br>How and how many training institutions did you recruit? Was the recruitment successful? If no, why?<br>Have you already received feedback from any training institution you have recruited? What did this look like?<br>Have you set up a database?<br>Do you evaluate the referral success (patient started training)?<br><br>Were there barriers at the various levels (clinic, specialists, patient, organization) or the process areas mentioned?<br>How did you solve these? | ***For all questions:***<br><br>Can you describe that in more detail?<br><br>Can you think of an example?<br><br>Which of your statements is most important to you? Why?<br><br>Does that have an important meaning for you? Why?<br><br>How exactly can this be seen in everyday life? |

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| **OnkoAktiv quality catalogue**<br><br>**Costs/ resources**<br><br>**Future**<br><br>**Support**<br><br>**Advantages**<br><br>**Recommendation**<br><br>**Vision** | 6. How do you rate the **feasibility and implementation of the quality criteria specified in the OnkoAktiv quality catalogue**?<br><br>7. Which costs/resources did you consider when setting up the regional Onkoaktiv center?<br><br>8. What problems do you see for **future work** as a regional OnkoAktiv center?<br><br>9. How could we help you in setting up the regional OnkoAkitv center? Is there **a way to support you better** ?<br><br>10. What **individual advantages** do you see for yourself in connection with the OnkoAktiv network?<br><br>11. If another region would like to open a regional OnkoAktiv center, what **tip** would you give?<br><br>12. What are your **goals/vision** for your regional network. | In your opinion, were there missing documents? Would an IT-supported tool help you in regard to OnkoAktiv (e.g. app)?<br><br>Which requirement was the most difficult for you to implement?<br><br>How are the finances and resources (employees, premises, IT) covered?<br><br>Can you identify problems at different levels (patient, clinic, region, organization)?<br>How is your work documented?<br><br>Can you point out opportunities for help in various areas, eg human resources, knowledge, IT?<br><br>Which benefit is most important to you? Are there individual advantages related to your facility?<br><br>Are there any more tips you would give?<br><br>Do you have a vision for the coming year and for the next 5 years? How successful do you think the OnkoAktiv network will be in the coming years? | |
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120 Supplement 1b: Interview guidelines for certified training institutions

| Subject area | Main questions | Detailed questions (optional) | Maintenance issues |
|---|---|---|---|
| **Structure institution**<br><br>**External resources**<br><br>**Motivation**<br><br>**Involvement of employees**<br><br>**Organizational development /adaptation**<br><br>**Barriers** | 1. Which structures and processes at your facility have helped to implement the oncology training programs at most?<br><br>2. What kind of resources helped you to implement OnkoAktiv outside your institution?<br><br>3. When you think back: what **motivated you** to become a member of the OnkoAktiv network?<br><br>4. Describe how participation in the OnkoAktiv network was communicated in your team? What offers are there for employees in your facility with regard to oncological training?<br><br>5. What have you specifically set up or changed in your institution for participation in the OnkoAktiv network and the associated certification?<br><br>6. What were the biggest **problems and challenges** that your institution was confronted with when implementing and | Which spatial structures do you have?<br>What human resources do you have?<br>What financial resources are available to you? Internal and external funds?<br><br>What structures exist within your region that help you implement Onkoaktiv ? (e.g. recruitment by doctors, clinics or rehabilitation centers / access routes for patients / cooperation with clinics)<br><br>Did financial aspects play a role in your decision for or against participating in the OnkoAktiv network?<br>What advantages and disadvantages do you see in being a member of the OnkoAktiv network?<br><br>What was the openness/receptiveness of the management level of your institution?<br>What is the openness/receptivity to participation now/today?<br>Do you get feedback from employees?<br>Do you get feedback from patients?<br><br>Did you train the employees?<br>If yes how?<br><br>Did the documents provided help you?<br>How did you manage to overcome the challenges/problems?<br>Where would you have liked more support? | ***For all questions:***<br><br>Can you go into more detail on that?<br><br>Can you describe that in more detail?<br><br>Can you think of an example?<br><br>the most important for you ? Why?<br><br>Does that have an important meaning for you? Why?<br><br>How exactly can this be seen in everyday life?<br><br>How exactly did that manifest itself? |

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| | maintaining the quality criteria and the network idea of OnkoAktiv?<br><br>7. What do you need in the next 5 years so that the oncological training offer can continue to be implemented? | How does the exchange of information between you and the regional OnkoAktiv centers work?<br><br>What opportunities for improvement do you see that could promote long-term maintenance and permanent implementation of the certified oncological exercise programs? | |
| **Supplement** | Is there anything else you would like to add to the topic? | | |

122 Supplement 2: CFIR domains, constructs and definitions including the adaptation to the network OnkoAktiv with specific examples

| **CFIR domain and constructs** | **CFIR definition [1, 2]** | **Adapted definition to the network OnkoAktiv** | **Specific examples** |
|---|---|---|---|
| **Domain: Innovation characteristics**<br>*Constructs: Intervention source, evidence strength and quality, relative advantage, adaptability, trialability, complexity, design and quality, cost* | Key attributes of interventions influence the success of implementation. | Key attributes of the network OnkoAktiv (e.g. network structure, finances, complexity, quality of services and material) that influence the implementation | Barrier: Limited funding options<br>Facilitator: Availability of brochures, flyer and promotion material |
| **Domain: Characteristics of individuals**<br>*Constructs: Knowledge and belief about the intervention, self-efficacy, individual stage of change, individual identification with organization, other personal attributes* | Characteristics of individuals that represent an organization or are involved in the implementation process. | Characteristics of individuals that are involved in the implementation of OnkoAktiv structures or execute task in regard to oncological exercise programs. | Barrier: Missing staff support<br>Facilitator: Passionate coaches |
| **Domain: Outer Setting**<br>*Constructs: Patient needs and resources, cosmopolitanism, peer pressure, external policy and incentives* | Includes structural, political and social attributes of the setting in which an organization is located | External structures or aspects that affect the implementation of OnkoAktiv or exercise programs execution. | Barrier: Lack of available exercise facilities<br>Facilitator: Cooperation with external medical professionals |
| **Domain: Inner Setting**<br>*Constructs: Structural characteristics, networks and communication, culture, implementation climate, readiness for implementation* | Includes structural, political and cultural attributes through which the implementation is executed | Internal organizational structures or aspects that affect the implementation of OnkoAktiv or exercise program execution. | Barrier: Missing knowledge of coaches<br>Facilitator: Adequate available resources (e.g. facilities, staff) |
| **Domain: Process**<br>*Constructs: Planning, engaging, executing, reflecting and evaluating* | Essential activities that describe the implementation process through planning, engaging, executing and evaluation | Procedural activities that describe the implementation process of OnkoAktiv or oncological exercise programs. | Barrier: limited awareness about exercise programs<br>Facilitator: Engaging with program stakeholder |

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Supplement 3a: Barriers and facilitators for the implentation of OnkoAktiv structures in RE and practical implications

| CFIR Domain | Barrier | Frequency (# of RE) | Anchor quote | Practical implications for RE |
|---|---|---|---|---|
| **Innovation characteristics** | (1) [1;2] Financing OA network structures | 26 (6) | "On the one hand by third-party funds, all along, as far as my position is concerned. Right down to club income, which we mainly get from our patient sports area. My job position is funded fifty-fifty on rehabilitation prescriptions and membership fees, plus further funding by postgraduates. So it just works only because the association is great enough by now so that the patient side can co-finance the employees." (RE1) | Consider multiple funding streams and be creative when raising funds (e.g. research grands, cancer foundations, donations, benefit events, academic scholarships) |
| **Innovation characteristics** | (2) Complexity of certification and networking | 9 (4) | „And I also tried to take their fears a bit and to clarify but I believe that it beats many of people in the first place and maybe puts them off. That you first say, "okay, we'll put it aside for now and maybe someday, but yes...". And it's the same when you want to recruit smaller institutions, such as physiotherapists, I think it's just too big a hurdle." (RE2) | Communicate requirements for certification and network participation in detail. Allow implementation scale up (start with small pilots or demonstration project and gradually roll out full structures) |
| **Outer Setting** | (3) Driving time for patients | 11 (4) | "Yes, the area so, 100 km that's quite a long way in the direction of [place] and there are a few institutions. In [location] for example, there is one practice, that would be 40km away and that is already far away." (RE3) | Evaluate accessibility of exercise programs prior to program implementation (e.g. public transport, parking options)<br>Offer home-based exercise programs and online-trainings |
| **Outer Setting** | (4) [1;2] Missing referrals and knowledge by medical professionals | 15 (4) | „So there are many (practitioners) who don´t have it on their radar. There are, when I did some surveys on congresses, numerous practitioners that don´t know about the rehabilitation prescription. They don´t know that they can prescribe exercise. So those fundamental options that are available, theoretical, they are not utilized and this is not only outside of the [institution] but also within." (RE4) | Conduct educational outreach visits in practices to teach professionals about exercise in oncology and OA structures. Form collaboration and build coalition with stakeholder. Obtain formal commitments. |

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| **Inner Setting** | (5) [1;2] Available resources | 44 (8) | „Exactly, the big issue is simply the resources and financing. On the one side of OnkoAktiv itself but also the therapy and accordingly the exercise therapy for patients. That is, I think, a huge barrier and by participating in various studies with [name], we hope that we can simply expand our resources further. Just as I said, half of my positon is currently third-party-funded. We absolute need more staff to, and this is the goal, establish the whole thing in the long term." (RE2) | Consider the availability of program resources (e.g. facilities, equipment, finances) prior to program implementation and plan resources accordingly. |
| **Inner Setting** | (6) Missing certifications and knowledge of exercise trainers | 17 (4) | „That is a big shortcoming in [townthat there hasn't been any training by now which educate coaches, sports therapists, physiotherapists in the field of exercise therapy in oncology. All licenses, in particular the great ones by [name], that take place in [location] for example, they are too far away for therapists from here in [location]" (RE4) | Provide specialized and ongoing trainings on exercise oncology for trainers (e.g. in house-training, online-module) |
| **Process** | (7) COVID-19 restrictions | 14 (4) | "Yes exactly, corona is the one issue, that has already led to, basically, the whole project being delayed, so starting with the further training with [name], so these agreements." (RE5) | Re-assess implementation plan and consider barriers regarding COVID-19. Offer online/ hybrid-meetings and trainings. |
| **CFIR Domain** | **Facilitator** | **Frequency (# of RE)** | **Anchor quote** | **Practical implications for RE** |
| **Characteristics of individuals** | (1) Knowledge and belief about the innovation | 15 (7) | "The engine was, I would still say, the great engagement and fire of single individuals that believe in this concept or stand for it." (RE1) | Raise awareness about the importance of exercise in oncology and the benefits of the OA membership |
| **Innovation characteristics** | (2) [2] Design and Quality packaging | 23 (4) | "So what we have actually adopted is the fitness for sport certificate and protection for data privacy template. We have adapted it to our center. But those are the formalities that are there and that are super helpful and I gratefully accepted that I could just do it." (RE4) | Offer a variety of materials and templates to help and support program adoption. Provide ongoing consultation. |
| **Outer Setting** | (3) Existing CBEP in the geographical periphery | 16 (5) | "With many associations, that offer rehabilitation sports, with many training institutions, physiotherapy facilities. We are therapeutically very closely positioned." (RE1) | Form collaboration with existing fitness, health and sports facilities in geographical region. |

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| **Outer Setting** | (4) Cooperation with University | 12 (5) | “Especially in [location] and [location] as federal state, which is also located in the periphery, we have two university campuses, that of course do medicine at university level but on the periphery they care about such lighthouse projects, like now the exercise therapy with oncological patients is established and of course you can use a network like this to look for network partners who then transport the knowledge that we have to the periphery.” (RE6) | Develop collaboration with existing university structures (e.g. cultivate relationships with lecturer and professors, implement student courses about exercise in oncology) |
| **Outer Setting** | (5) Located in or near cities | 11 (6) | “Right, so we have many patients that come from the periphery but also many cities in the area or places that have corresponding options as well, whether physiopractices are health centers, clubs, so you can fall back on them. This is a special regional characteristic such an agglomeration of cities.” (RE7) | Establish multi-sectoral cooperation with different stakeholder (e.g. Health care centers, clinics, sports clubs, academic institutions, rehabilitation centers) |
| **Outer Setting** | (6) [1;2] Cooperation and referral by peripheral practitioners and oncologists | 11 (7) | „Exactly, there is definitely an exchange with medical practices, with oncological practices in the area.” (RE3) | Conduct educational outreach visits in practices to teach medical professionals about exercise in oncology and OA structures. Form collaboration and build coalition with stakeholder. Obtain formal commitments. |
| **Outer Setting** | (7) Integration in regional clinical network | 10 (5) | „Apart from that, several clinics. There is not only the [name], but many other clinics in [place], each of them with their microstructures. There is also a cooperation with [Name], for example. The tumor center [location] also tries to link the various oncological clinics. There are many structures, sometimes also parallel structures. And the goal is to somehow bring that together.” (RE4) | Implement OA structures into the clinical network and link OA services to existing clinical processes. |
| | (8) [1;2] Available resources | 34 (7) | "Well, in [institution], where consultations also take place, we are three sports scientists, with a 70% position and two part-time positions. The three of us also carry out the consultations.” (RE3) | Consider the availability of program resources (e.g. facilities, equipment, finances) prior to program |

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| | | | | implementation and plan resources accordingly. |
| **Inner Setting** | (9) Structural characteristics | 55 (3) | "No, I'm happy to say that because it really is a successful concept that you could consider establishing in other clinics as well. We have a total of about 400 participants who are members and pay dues, and of those 400 members, about half are oncology exercise therapy." (RE6) | Evaluate the possibility of founding a sports association or integrate OA into an existing one. |
| **Inner Setting** | (10) Network and communication | 19 (7) | „So the fact that we, as a sports therapy team, had already worked closely with the doctors beforehand, we were also on the visits, so that on the one hand we simply have the oncological know-how and on the other hand we can recruit the patients relatively easy, so or get them anyway." (RE7) | Create clinical teams and establish regular team meetings (e.g. integrate medical professionals into your day to day care) |
| **Process** | (11) [1;2] Access and usage of OA materials | 41 (8) | „And otherwise, what I think is great is the guideline for therapy recommendations, the ACSM guideline. And also the anamnesis sheet. I definitely adjusted it slightly and changed it a bit, but having a structure for us was really good. And the same goes for the patient fax. So I also used the materials, partially adapted to us or to special features. That was definitely helpful in establishing that." (RE2) | Develop and distribute a variety of materials and information to help and support program adoption. |

CFIR, Consolidated Framework for Implementation Science; CFIR domains describe the domain in which the barrier or facilitators is contextualized; frequency column shows the number of times each barriers or facilitator was stated across the interviews of RE and how many interviewee named them; [1] marks categories identified as either barrier or facilitator; [2] marks categories identified on both levels of CBEP and RE; ACSM, American College of Sports Medicine; NCT, National Center for Tumor Diseases;

Supplement 3b: Barriers and facilitators for the implentation of OnkoAktiv structures in CBEP and practical implications

| CFIR Domain | Barrier | Frequency (# of TI) | Anchor quote | Practical implications for CBEP |
|---|---|---|---|---|
| **Innovation characteristics** | (1) [2] High costs/ missing health care coverage of oncological exercise program | 17 (7) | "Yes, I think the fault is mainly in the system. It has to be said that it (exercise therapy) is not remunerated in any way." (TI3) | Consider multiple funding streams and existing non-oncological coverage options. |
| **Innovation characteristics** | (2) Complexity of oncological patients | 10 (6) | „But basically they are quite scared of working with people who are acutely ill or seriously ill, because they are usually used to their knees, back, shoulders and hips, I would say. And when such stories come in and yes, the cooperation with the NCT and the clinic with the chief physicians and so on, not every therapist is that smart, I would say." (TI1) | Offer further education and regular practical exercises for coaches to increase their confidence. |
| **Outer Setting** | (3) [1;2] Missing cooperation and referral by medical staff/oncologists | 29 (8) | "But with the local doctors, we would have actually imagined that it would be easier, so I think my supervisor is someone who goes to the doctors' surgeries and seeks a conversation. The willingness was there in principle, but then the implementation in everyday medical practice, that was lacking, there came only a few patients." (TI5) | Conduct educational outreach visits in practices to teach professionals about exercise in oncology and OA structures. Form cooperation and build coalition with stakeholder. Obtain formal commitments. |
| **Outer Setting** | (4) [1] Missing Marketing and promotion of exercise programs | 5 (3) | "Maybe it's more the direction of, how can we do our marketing or how can we simply do more, how can we make it even more attractive and easy to make it (the therapy) accessible to the public." (TI5) | Create and offer a variety of promotion material for community members, patients and health care professionals (e.g. newsletter, social media, flyer, brochure, newspaper, radio) |
| **Inner Setting** | (5) [1;2]Available resources | 31 (8) | "If no patients are referred by a certain point in time, then it is not profitable for us to turn off the therapist at the weekend and have them receive further training. I mean the membership fee, it's not worth mentioning now, but it's more the time investment and the internal | Consider the availability of program resources (e.g. facilities, equipment, finances) prior to program implementation and plan resources accordingly. |

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| | | | maintenance of structures and constantly calling to mind. So that would be more of a point where I say it could fail." (TI2) | |
| **CFIR Domain** | **Facilitator** | **Frequency (# of TI)** | **Anchor quote** | **Practical implications for TI** |
| **Characteristics of individuals** | (1) Knowledge and belief about the innovation | 27 (7) | „I simply think that this OnkoAktiv network deserves that we spread it as widely as possible. We should make our contribution and we should take this challenge that the OnkoAktiv patients bring with them, we should simply look for them. A really exciting field." (TI7) | Include and build cooperation with passionate leaders, early adopters and stakeholders who are interested in the field of exercise oncology. |
| **Innovation characteristics** | (2) Low costs for OA membership | 7 (3) | "I mean the membership fee, that's not worth mentioning now, but then it's more the time investment." (TI2) | Purposely re-examine OA structures and investments |
| **Innovation characteristics** | (3) [2] Low complexity of certification | 6 (4) | "To be honest, it's been a while for us, but honestly I think it was easy for us in terms of the requirements, because we had already given a lot of structures. And that's why I didn't find it that difficult." (TI6) | Communicate requirements for certification and network participation in detail. |
| **Innovation characteristics** | (4) Resource of innovation | 9 (7) | „Yes, the demand is definitely there. We also like things that are innovative. Well, we are all very innovative and then we jumped on every horse again and again, I would say." (TI1) | Spread current knowledge from research studies and report about ongoing new projects. |
| **Innovation characteristics** | (5) High Adaptability of OA structures | 9 (7) | „We also have onkoaktiv yoga, which is being introduced now, it's not on our homepage yet. But it's not finished yet anyway and onkoaktiv or just normal yoga or Fit for Life that's what I brought to life." (TI8) | Promote OA adaptability and evaluate possible adaptations to individual institutional structure. |
| **Innovation characteristics** | (6) [2] Design and Quality packaging | 9 (6) | "We have the exchange of experience with the NCT itself, these quality circles, which then take place regularly and also simply that you have someone, that you have the experts as contacts if any questions arise. Also, the referral via the studies that is simply something | Offer a variety of materials and templates to help program adoption and support coaches. Provide ongoing consultation. |

| | | | | |
|---|---|---|---|---|
| | | | well-founded. Where you have a contact person at any time if any problems arise." (TI5) | |
| | | | | |
| **Outer Setting** | (7) [1] Marketing and promotion of exercise programs | 35 (8) | „We are also allowed to put out flyers, our magazines, etc., and from there we also get patient referrals, or patients simply get the information that exercise is also a good option, especially in the phase of their acute disease." (TI6) | Create and offer a variety of promotion material for community members, patients and health care professionals (e.g. newsletter, social media, flyer, brochure, newspaper, radio) |
| **Outer Setting** | (8) Low regional competition | 11 (7) | „Having a playground is a real challenge for us, nobody else does that either. That is a unique selling point and no matter what you do in business, once you have a unique selling point the fun begins." (TI7) | Analyse strategically regional competition, conduct local needs assessment and define the unique selling point of the organization. |
| **Outer Setting** | (9) [1;2] Cooperation and referral by peripheral practitioners and oncologists | 27 (7) | „The managing director of the hospital actually approached my supervisor and said whether we didn't want to start a permanent cooperation. So I go to the hospital with my colleague every two weeks from autumn, inform the patients about what we have to offer and we do these groups there too." (TI5) | Conduct educational outreach visits in practices to teach professionals about exercise in oncology and OA structures. Form cooperation and build coalition with stakeholder. Obtain formal commitments. |
| **Inner Setting** | (10) [1;2] Available resources | 79 (8) | "Okay, so I think we have fewer spatial problems because we are a very, very large facility and our fitness area alone has almost 1000 square meters of training space, not counting course rooms, but really pure training space for strength and endurance training and I just think that this structure certainly also makes a positive contribution." (TI6) | Consider the availability of program resources (e.g. facilities, equipment, finances) prior to program implementation and plan resources accordingly. |
| **Inner Setting** | (11) Need for program and strategic change | 19 (6) | „But it's very exciting in terms of content, because we're kind of on the way from the purely orthopedic fitness studio to the internal medicine fitness studio, and that's a very, very exciting challenge. So lungs, heart, tumor, I'll just take the COVID with me now because it's urgent." (TI7) | Support institutional changes by shadowing experts who have already implemented OA structures. Promote adaptability and provide ongoing consultation. |

| | | | | |
|---|---|---|---|---|
| **Process** | (12) [2] Access and usage of OA materials | 11 (4) | „And what I find very, very good, by the way, is not only the general meeting, but also the communication via newsletter and information that comes up, even if it's in the USA or Australia, I've never had anything to do with it, but it shows that the network is alive. Exactly, and I find that very exciting." (TI7) | Develop and distribute a variety of materials and information to help and support program adoption. |

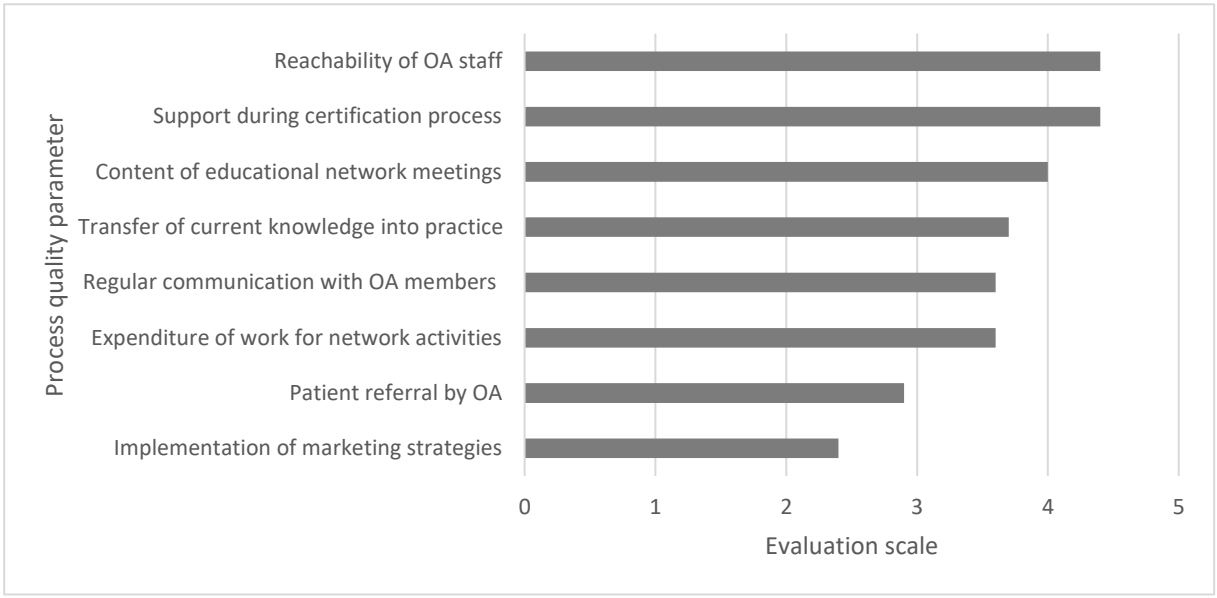
CFIR, Consolidated Framework for Implementation Science; CFIR domains describe the domain in which the barrier or facilitators is contextualized; frequency column shows the number of times each barriers or facilitator was stated across the interviews of CBEP and how many interviewee named them; [1] marks categories identified as either barrier or facilitator; [2] marks categories identified on both levels of CBEP and RE; ACSM, American College of Sports Medicine; NCT, National Center for Tumor Diseases;

Supplement 4: Solutions to network barriers for certified CBEP expressed as mean value (M) and standard deviation (SD) on a Likert scale from 1-5 or percentages

| **Solutions to structural problems (inner setting)** | **M** | **SD** |
|---|---|---|
| Quality indicators for internal processes and structures | 3.5 | 1.14 |
| Guidelines for staff qualification | 3.6 | .98 |
| Integration in scientific studies | 3.8 | 1.22 |
| Financing options of exercise programs | 4.1 | 1.08 |
| Working material (e.g. consultations, training programming) | 4.1 | .82 |
| Further training for exercise trainer | 4.4 | .85 |
| Further training for HCPs | 4.7 | .53 |
| Informational events for patients about exercise and cancer | 4.7 | .45 |
| | | |
| **Solutions to network barriers (outer setting)** | **M** | **SD** |
| Integration of exercise oncology in university courses | 4.1 | 1.12 |
| Increase of regional networking with other exercise institutions | 4.1 | 1.06 |
| Indication of exercise programs from clinics | 4.7 | .59 |
| Referral of patients from HCPs | 4.8 | 0.68 |
| | | |
| **Solutions regarding marketing material** | **%** | |
| External teachers for educational events | 61 | |
| Pre-organized power point sheets for further trainings | 61 | |
| Photos and texts for social media/website | 68 | |
| Print Media (flyer) | 71 | |
| Quality circle and further training for trainers | 82 | |

Legend: *Items were categorized as a barrier with a mean value <3 and as a facilitator with a mean value >3; mean values of =3 were ranked as neutral items (neither nor).*

Supplement 5: Evaluation of OnkoAktiv process quality parameter on a scale from 1-5 (1- not satisfied; 5- fully satisfied)



## Supplementary material for Manuscript II

Supplement 1 (.docx): Analysis of medical professions in number of actors and percentages

Supplement 1: Analysis of medical professions in number of actors and percentages per network

| **Networks** | | **G** | **I** | **L** | **M** | **D** | **H** | **J** | **E** | **B** | **C** | **A** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total # of nodes by network | [n] | 12 | 16 | 17 | 19 | 19 | 23 | 26 | 32 | 33 | 39 | 52 |
| Exercise science/sports medicine | [n] | 5 | 3 | 6 | 5 | 5 | 7 | 2 | 12 | 11 | 18 | 15 |
| | [%] | 42 | 19 | 35 | 26 | 26 | 30 | 8 | 38 | 33 | 46 | 29 |
| Oncology/Haemato-oncology | [n] | 1 | 3 | 3 | 2 | 3 | 2 | 5 | 1 | 5 | 7 | 7 |
| | [%] | 8 | 19 | 17 | 11 | 16 | 9 | 19 | 3 | 15 | 18 | 14 |
| Clinical director | [n] | 0 | 1 | 2 | 4 | 0 | 1 | 1 | 0 | 1 | 2 | 4 |
| | [%] | 0 | 6 | 12 | 21 | 0 | 4 | 4 | 0 | 3 | 5 | 8 |
| Gynecology | [n] | 0 | 0 | 1 | 1 | 1 | 3 | 2 | 1 | 2 | 0 | 1 |
| | [%] | 0 | 0 | 6 | 5 | 5 | 13 | 8 | 3 | 6 | 0 | 2 |
| Rehabilitation | [n] | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 0 |
| | [%] | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 8 | 0 |
| Physiotherapy/Ergotherapy | [n] | 0 | 0 | 0 | 1 | 2 | 1 | 2 | 0 | 2 | 0 | 0 |
| | [%] | 0 | 0 | 0 | 5 | 11 | 4 | 8 | 0 | 6 | 0 | 0 |
| Nursing | [n] | 1 | 0 | 0 | 3 | 0 | 0 | 2 | 1 | 0 | 0 | 0 |
| | [%] | 8 | 0 | 0 | 16 | 0 | 0 | 7 | 3 | 0 | 0 | 0 |
| Surgery | [n] | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 |
| | [%] | 8 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 0 | 0 | 0 |
| Orthopaedy | [n] | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| | [%] | 0 | 6 | 0 | 5 | 5 | 0 | 4 | 3 | 3 | 0 | 0 |
| Psycho-oncology | [n] | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 2 |
| | [%] | 0 | 0 | 0 | 0 | 5 | 4 | 0 | 0 | 0 | 3 | 4 |
| Paediatrics | [n] | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| | [%] | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 3 | 0 | 2 |
| Urology | [n] | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | [%] | 0 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Clinical nutrition | [n] | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| | [%] | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 3 | 0 | 0 | 2 |
| Ear-Nose-Throat | [n] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | [%] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Cardiology | [n] | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | [%] | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Social Service | [n] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | [%] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Neurology | [n] | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | [%] | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Radiology | [n] | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | [%] | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Internal medicine | [n] | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| | [%] | 0 | 6 | 0 | 0 | 0 | 4 | 4 | 0 | 0 | 0 | 0 |
| **Nodes in medical sector** | **[n]** | **10** | **11** | **12** | **19** | **15** | **17** | **17** | **22** | **24** | **31** | **33** |
| | **[%]** | **83** | **69** | **71** | **100** | **79** | **74** | **65** | **69** | **73** | **79** | **63** |
| **Different sectors** | | **5** | **7** | **4** | **9** | **8** | **8** | **9** | **9** | **8** | **5** | **9** |

## Supplementary material for Manuscript III

Supplement 1 (.pdf): Questionnaire for exercise institutions (on request)

Supplement 2 (.docx): Reporting Guidelines STROBE checklist

Supplement 2: Reporting Guidelines STROBE checklist

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

| | Item No | Recommendation | |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | x |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | x |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | x |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | x |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | x |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | x/n.a |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | x |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | x/ n.a |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | x |
| Bias | 9 | Describe any efforts to address potential sources of bias | x |
| Study size | 10 | Explain how the study size was arrived at | x |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | x |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | x |
| | | (*b*) Describe any methods used to examine subgroups and interactions | x |
| | | (*c*) Explain how missing data were addressed | x |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | n.a |
| | | (*e*) Describe any sensitivity analyses | n.a |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | x |

| | | | |
|---|---|---|---|
| | | (b) Give reasons for non-participation at each stage | n.a |
| | | (c) Consider use of a flow diagram | n.a |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | x |
| | | (b) Indicate number of participants with missing data for each variable of interest | x |
| Outcome data | 15* | Report numbers of outcome events or summary measures | x |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | n.a |
| | | (*b*) Report category boundaries when continuous variables were categorized | n.a |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | n.a |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | x |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | x |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | x |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | x |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | x |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | x |

**Note by the authors:**

This study was an explorative cross-sectional study using a questionnaire to investigate oncological exercise programs in the European region. Therefore, we did not include any information about time of exposure, predictors or follow ups. Such criteria were not applicable (n.a.) in our study. Further, we utilized an explorative analysis including counts, minimums, maximums, mean values, median and standard deviations and executed the chi²-test of independence to examine the differences between defined subgroups. Therefore, we did not applied unadjusted or adjusted estimates of statistical regressions in our study.

*Declaration in accordance to § 8 (1) c) and d) of the doctoral degree regulation of the Faculty*

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**Erklärung gemäß § 8 (1) c) der Promotionsordnung der Universität Heidelberg für die Fakultät für Verhaltens- und Empirische Kulturwissenschaften / Declaration in accordance to § 8 (1) c) of the doctoral degree regulation of Heidelberg University, Faculty of Behavioural and Cultural Studies**

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| Datum / Date | |
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