

Postgraduate Certificate in Cardio-Oncology (Belgium)

Exercise and Rehabilitation in Cardio-Oncology Patients

Cardiotoxicity refers to the detrimental effect of cancer therapies on the cardiovascular system, manifesting as functional impairment, structural damage, or clinical events. It can be acute, occurring during treatment, or chronic, emerging months to years after therapy. For example, a patient receiving high-dose anthracyclines may develop a decline in left ventricular ejection fraction (LVEF) within weeks, necessitating early detection and intervention. The challenge lies in distinguishing therapy-related changes from pre-existing cardiac disease, especially when baseline assessments are limited.

Anthracycline-induced cardiomyopathy is a specific form of cardiotoxicity characterized by dose-dependent myocardial injury. Cumulative doses above 300 mg/m² of doxorubicin are associated with a markedly increased risk of heart failure. In clinical practice, a 55-year-old breast-cancer survivor who accumulated 350 mg/m² may present with reduced exercise capacity and dyspnea on exertion. Management includes guideline-directed heart failure therapy, regular monitoring of global longitudinal strain (GLS), and tailored exercise rehabilitation to improve functional reserve while avoiding excessive cardiac stress.

HER2-targeted therapy such as trastuzumab adds a distinct pattern of reversible myocardial dysfunction, often without significant changes in LVEF early on. A patient on concurrent trastuzumab and a taxane may experience a transient drop in GLS, detectable by speckle-tracking echocardiography, before overt systolic decline. Rehabilitation professionals must coordinate timing of exercise sessions to align with therapy cycles, ensuring that intensity is modulated during periods of heightened susceptibility.

Radiation-induced heart disease encompasses a spectrum from pericardial inflammation to coronary artery disease and valvular dysfunction, arising months to decades after thoracic irradiation. A survivor of Hodgkin lymphoma treated with mantle field radiation may develop accelerated atherosclerosis, manifesting as exertional angina. Exercise programs for such patients should incorporate thorough cardiovascular risk stratification and may require low-impact aerobic modalities to mitigate additional strain on irradiated structures.

VO₂peak (peak oxygen uptake) is the gold-standard metric for aerobic capacity, measured during a maximal cardiopulmonary exercise test (CPET). It predicts mortality and is sensitive to early cardiotoxic effects. For instance, a decline of more than 10% in VO₂peak after chemotherapy signals a need for intensified cardiac monitoring and individualized exercise prescription. Limitations include the need for specialized equipment and trained personnel, which may not be universally available in all Belgian oncology centers.

Cardiopulmonary exercise testing (CPET) integrates respiratory gas analysis, ECG monitoring, and

hemodynamic data to assess integrative cardiopulmonary function. During CPET, the patient performs incremental cycling or treadmill work until volitional exhaustion, providing data on ventilatory efficiency, oxygen pulse, and anaerobic threshold. Practical application involves using CPET results to set target heart rate zones and to identify limiting factors, such as chronotropic incompetence or abnormal blood pressure response. Barriers include patient fatigue, equipment cost, and the need for infection control measures during the COVID-19 era.

Submaximal exercise testing offers a feasible alternative when maximal effort is contraindicated. The 6-minute walk test (6MWT) is widely employed, measuring the distance covered in six minutes on a flat corridor. A post-chemotherapy patient who walks 400 m may be classified as having moderate functional limitation, guiding the initial intensity of a rehabilitation program. The simplicity of the 6MWT is offset by its limited ability to detect subtle cardiopulmonary abnormalities, necessitating complementary assessments.

Functional capacity denotes the ability to perform activities of daily living and is a core outcome in cardio-oncology rehabilitation. It is quantified by tests such as the 6MWT, the short physical performance battery, or gait speed. A patient with a gait speed slower than 0.8 m/s may be considered frail, prompting a more gradual progression of exercise intensity. Integrating functional capacity data into electronic health records facilitates longitudinal tracking and multidisciplinary communication.

Exercise intolerance is a common complaint among cancer survivors, often reflecting a combination of deconditioning, anemia, and cardiotoxicity. A patient reporting inability to climb a flight of stairs may be experiencing reduced cardiac output or peripheral muscle fatigue. Rehabilitation strategies should address both central (cardiac) and peripheral (muscular) contributors, using interval training to progressively enhance oxygen delivery and utilization.

Frailty is a multidimensional syndrome characterized by reduced physiological reserve and increased vulnerability to stressors. In cardio-oncology, frailty predicts poorer treatment tolerance and higher mortality. Assessment tools such as the Fried criteria or the Clinical Frailty Scale help identify patients at risk. Tailoring exercise programs to frail individuals involves initiating with low-intensity, balance-focused activities, and closely monitoring for adverse events.

Sarcopenia refers to the loss of skeletal muscle mass and strength, frequently observed in patients undergoing cytotoxic chemotherapy. Imaging modalities like CT-derived lumbar skeletal muscle index provide objective quantification. A sarcopenic patient may exhibit reduced maximal voluntary contraction, limiting the ability to perform resistance training. Nutritional support combined with progressive resistance exercise can mitigate muscle wasting and improve overall functional outcomes.

Cachexia is a complex metabolic syndrome marked by involuntary weight loss, muscle atrophy, and systemic inflammation. It differs from simple starvation by its resistance to conventional nutritional interventions. In cardio-oncology, cachexia amplifies the risk of cardiac dysfunction due to catabolic stress on myocardial tissue. Rehabilitation programs should incorporate moderate aerobic activity to preserve lean

body mass while avoiding exacerbation of energy deficits.

Left ventricular ejection fraction (LVEF) remains the most widely used echocardiographic parameter for cardiac function, expressed as a percentage of blood ejected during systole. A decline below 50% often triggers modification of cancer therapy and initiation of cardiac protective measures. However, LVEF lacks sensitivity for early subclinical changes; therefore, adjunctive imaging such as GLS is recommended for comprehensive surveillance.

Global longitudinal strain (GLS) quantifies myocardial deformation and detects subtle contractile impairment before LVEF falls. A relative reduction of 15% in GLS during trastuzumab therapy may herald impending cardiotoxicity, prompting preemptive exercise modification. Implementing GLS in routine practice requires access to advanced echocardiography software and trained sonographers, which may be limited in smaller institutions.

Biomarkers such as high-sensitivity troponin (hs-cTn) and B-type natriuretic peptide (BNP) provide biochemical insight into myocardial injury and stress. Elevated hs-cTn after chemotherapy correlates with subsequent declines in LVEF and VO_2 peak, serving as an early warning sign. Serial biomarker measurements can guide the timing and intensity of rehabilitation interventions, though assay variability and the influence of non-cardiac factors must be considered.

Exercise prescription is the systematic process of defining the type, intensity, duration, and frequency of physical activity tailored to an individual's health status. The FITT principle—frequency, intensity, time, and type—offers a structured framework. For a post-mastectomy patient with mild cardiotoxicity, an initial prescription might consist of three weekly sessions of moderate-intensity aerobic exercise (40-60% heart rate reserve) lasting 20 minutes, progressing as tolerance improves.

FITT principle guides clinicians in constructing evidence-based exercise regimens. Frequency denotes the number of sessions per week, intensity reflects the physiological load (e.g., %HRR or RPE), time specifies session duration, and type indicates the mode of activity (aerobic, resistance, flexibility). Applying FITT requires careful baseline assessment, ongoing monitoring, and flexibility to adjust parameters in response to treatment-related fluctuations.

Aerobic training improves cardiovascular efficiency by enhancing stroke volume, capillary density, and mitochondrial function. In cardio-oncology, aerobic exercise has been shown to attenuate anthracycline-related declines in VO_2 peak. A practical example is a supervised cycling program at 50% VO_2 peak for 30 minutes, three times weekly, which can be scaled up to interval formats as the patient's capacity improves. Challenges include patient fatigue, logistical constraints, and the need for cardiac monitoring during higher intensities.

Resistance training focuses on muscular strength and endurance, counteracting sarcopenia and supporting functional independence. Protocols typically involve 2–3 sets of 8–12 repetitions at 60-70% of one-repetition maximum (1-RM). For a patient recovering from breast-cancer surgery, resistance exercises

may begin with body-weight squats and progress to free-weight leg presses, emphasizing proper technique to avoid lymphedema exacerbation. Monitoring for excessive blood pressure spikes is essential, particularly in patients with chemotherapy-induced vascular stiffening.

High-intensity interval training (HIIT) alternates short bursts of vigorous activity with recovery periods, offering a time-efficient stimulus for cardiovascular adaptation. Studies in survivors of lymphoma have demonstrated greater improvements in VO_2peak with HIIT compared to moderate-intensity continuous training (MICT). A typical HIIT session might include 4×4 -minute intervals at 85-90% HRR, interspersed with 3-minute active recovery. Implementation challenges include patient apprehension, need for close supervision, and potential arrhythmogenic risk in those with underlying conduction abnormalities.

Moderate-intensity continuous training (MICT) involves sustained activity at 40-60% HRR, providing a steady aerobic stimulus. It is often the initial modality for deconditioned patients or those with limited tolerance for high-intensity bouts. An example is a 30-minute brisk walk on a treadmill, maintaining a target heart rate of 110 beats per minute. While MICT is well tolerated, its slower progression may be insufficient for patients seeking rapid restoration of functional capacity.

Warm-up and cool-down phases are integral to safe exercise sessions, preparing the cardiovascular system for increased demand and facilitating recovery. A 5-minute low-intensity cycle at 30% HRR serves as an effective warm-up, gradually elevating heart rate and promoting vasodilation. The cool-down mirrors this pattern, aiding in venous return and preventing abrupt blood pressure drops. Neglecting these phases can increase the risk of orthostatic hypotension and post-exercise fatigue.

Rate of perceived exertion (RPE) provides a subjective gauge of effort, complementing objective heart rate metrics. The Borg scale (6-20) correlates with %HRR, allowing clinicians to adjust intensity based on patient feedback, especially when beta-blockers blunt heart rate responses. For instance, an RPE of 13 (somewhat hard) may correspond to 60% HRR in a patient on carvedilol. Reliance on RPE also empowers patients to self-regulate activity outside supervised sessions.

Target heart rate is calculated using formulas such as the Karvonen method, which incorporates resting heart rate to determine the heart rate reserve (HRR). For a patient with a resting heart rate of 70 bpm and a maximal heart rate of 150 bpm, the HRR equals 80 bpm; exercising at 50% HRR would target 110 bpm. Accurate measurement is crucial, as chemotherapy-induced autonomic dysfunction can alter heart rate dynamics, necessitating periodic re-assessment.

Heart rate reserve (HRR) reflects the functional range between resting and maximal heart rates, serving as a reliable intensity marker. In patients receiving cardiotoxic agents, HRR may be reduced, limiting achievable exercise intensities. Adjustments may involve using a lower percentage of HRR or shifting to RPE-based scaling. Continuous ECG monitoring during sessions can detect inadequate chronotropic response early, prompting protocol modification.

Chronotropic incompetence describes the inability of the heart to increase its rate commensurate with

metabolic demands, a frequent sequela of anthracycline exposure. It manifests as a blunted heart rate rise during CPET, leading to early fatigue. Rehabilitation strategies include interval training to stimulate sympathetic pathways and, when appropriate, pharmacologic agents such as ivabradine. Identifying chronotropic incompetence is essential to avoid over-prescribing intensity based solely on perceived effort.

Autonomic dysfunction encompasses altered sympathetic and parasympathetic balance, impacting heart rate variability, blood pressure regulation, and exercise tolerance. Chemotherapy agents, particularly platinum-based compounds, can impair autonomic control. Heart rate variability analysis can be incorporated into monitoring protocols, with reduced variability signaling heightened risk. Interventions such as yoga, paced breathing, and low-intensity aerobic exercise may improve autonomic tone over time.

Exercise adherence is the extent to which patients follow prescribed activity regimens, a determinant of therapeutic success. Barriers include treatment-related fatigue, transportation difficulties, and lack of motivation. Behavioral change techniques, such as goal-setting, self-monitoring, and reinforcement, have been shown to improve adherence. In the Belgian context, integrating community-based programs with hospital-based services facilitates continuity and reduces dropout rates.

Behavioral change techniques (BCTs) are evidence-based strategies designed to modify health-related behaviors. Examples include "action planning" (specifying when and where to exercise) and "social support" (engaging family members in activity). Applying BCTs within cardio-oncology rehabilitation involves personalized counseling, use of activity logs, and periodic feedback on progress. Challenges include tailoring BCTs to diverse cultural backgrounds and varying health literacy levels.

Motivational interviewing is a patient-centered communication style that elicits intrinsic motivation for behavior change. In a consultation, the practitioner may explore ambivalence about exercise by asking open-ended questions and reflecting the patient's statements. This technique can increase confidence and commitment, especially in individuals hesitant to resume activity after a traumatic cancer experience. Training clinicians in motivational interviewing is essential to ensure consistency and effectiveness.

Tele-rehabilitation leverages digital platforms to deliver supervised exercise programs remotely, expanding access for patients living in rural areas or with limited mobility. A typical model includes live video sessions, asynchronous exercise logs, and remote vital sign monitoring. The COVID-19 pandemic accelerated adoption of tele-rehabilitation, revealing benefits such as increased flexibility and reduced travel burden. Limitations involve technology literacy, internet connectivity, and the inability to perform hands-on assessments.

Wearable technology encompasses devices that continuously record physiological data, including heart rate, activity counts, and sleep patterns. Commercially available wrist-worn sensors can transmit real-time heart rate data to a clinician's dashboard, enabling dynamic adjustment of exercise intensity. Accuracy concerns arise in patients with arrhythmias or peripheral edema, where signal artifacts may distort readings. Validation studies specific to cardio-oncology populations are needed to establish reliability.

Remote monitoring integrates wearable data with clinical decision support tools, allowing clinicians to intervene promptly when abnormal trends emerge. For example, a sustained elevation of resting heart rate above baseline may indicate infection or treatment-related stress, prompting a reassessment of the exercise plan. Data privacy regulations in Belgium, such as the GDPR, must be adhered to when implementing remote monitoring systems.

Cardiac rehabilitation phases are traditionally divided into Phase I (inpatient), Phase II (early outpatient), and Phase III (maintenance). In cardio-oncology, Phase I may coincide with hospitalization for high-dose chemotherapy, focusing on early mobilization and education. Phase II involves structured supervised exercise sessions, while Phase III emphasizes long-term self-management. Transitioning between phases requires clear communication of goals, reassessment of cardiac function, and alignment with oncology treatment timelines.

Prehabilitation denotes interventions initiated before the onset of cancer therapy, aiming to optimize physical reserves and reduce treatment-related morbidity. A patient scheduled for stem-cell transplantation may engage in a 4-week aerobic and resistance program to improve VO_{2peak} and muscle strength, potentially shortening hospitalization duration. Implementing prehabilitation demands coordination between oncology, cardiology, and rehabilitation services, and may be limited by scheduling constraints and patient readiness.

Neoadjuvant therapy is administered before definitive local treatment, such as surgery, whereas adjuvant therapy follows local intervention. Both contexts influence exercise planning; neoadjuvant regimens may allow earlier incorporation of aerobic activity, while adjuvant therapy may necessitate adjustments to accommodate cumulative toxicities. Understanding the sequencing of treatments is crucial for timing assessments, prescribing safe exercise loads, and anticipating periods of heightened fatigue.

Immunotherapy-related myocarditis is an emerging cardiotoxic entity associated with checkpoint inhibitors. It presents with chest pain, elevated troponin, and sometimes reduced LVEF. Early detection is vital, as prompt immunosuppression and temporary cessation of immunotherapy can improve outcomes. Exercise prescription in this scenario should initially be limited to low-intensity activities, with close cardiac monitoring and re-evaluation after stabilization.

Cardiac remodeling describes structural changes in the heart in response to injury, including hypertrophy, dilation, and fibrosis. Imaging modalities such as cardiac MRI can quantify fibrosis using late gadolinium enhancement, providing insight into the extent of remodeling. Rehabilitation programs aim to attenuate adverse remodeling by promoting favorable hemodynamic loading patterns through moderate aerobic training and avoiding excessive pressure overload.

Exercise-induced cardioprotection refers to the phenomenon where regular physical activity confers resistance to subsequent cardiac injury. Mechanisms involve up-regulation of antioxidant enzymes, improved mitochondrial efficiency, and favorable endothelial function. In preclinical models, rodents

pre-treated with treadmill exercise exhibited less anthracycline-induced cardiomyopathy. Translating this to human cardio-oncology suggests that maintaining regular activity before and during therapy may mitigate long-term cardiac sequelae.

Exercise dose-response relationships describe how variations in frequency, intensity, time, and type affect physiological outcomes. In cardio-oncology, a dose-response curve for VO_2 peak improvement may plateau after a certain weekly volume, indicating the need for progressive overload or interval training to continue gains. Understanding these relationships assists clinicians in designing progressive programs that balance efficacy with safety.

Exercise tolerance test (ETT) is a submaximal assessment often performed on a treadmill using standardized protocols such as the Bruce or modified Naughton. It provides information on functional capacity, ischemic threshold, and hemodynamic response. For a patient with prior mediastinal radiation, the ETT can uncover exercise-induced arrhythmias or blood pressure abnormalities that would otherwise remain hidden. Limitations include the potential for musculoskeletal limitations to confound results.

Interval training involves alternating periods of higher and lower intensity, fostering cardiovascular adaptations while allowing recovery. A practical scheme for a breast-cancer survivor might consist of 1-minute brisk walking (70% HRR) followed by 2-minutes slow walking, repeated eight times. This format can improve VO_2 peak more efficiently than continuous training, though it requires careful supervision to ensure safe intensity transitions.

Cardiovascular risk stratification categorizes patients based on the likelihood of adverse cardiac events, guiding the intensity of monitoring and rehabilitation. Tools such as the ESC risk score incorporate factors like age, prior cardiac disease, cumulative anthracycline dose, and radiation fields. A high-risk patient may be allocated to a supervised, hospital-based program with continuous ECG telemetry, whereas low-risk individuals might safely engage in community-based exercise groups.

Exercise contraindications list conditions where physical activity may pose immediate danger. Absolute contraindications include uncontrolled arrhythmias, severe aortic stenosis, and acute myocarditis. Relative contraindications—such as recent thoracic surgery, severe thrombocytopenia, or active infection—require individualized risk-benefit analysis. Rehabilitation teams must maintain up-to-date knowledge of each patient's oncologic and cardiac status to avoid inadvertent exposure to hazards.

Hemodynamic monitoring during exercise includes measurement of blood pressure, heart rate, and, when feasible, cardiac output. Automated sphygmomanometers can provide intermittent readings, while invasive catheters offer continuous data in high-risk cases. Accurate hemodynamic assessment enables detection of abnormal blood pressure responses, such as exaggerated hypertensive spikes, which may necessitate medication adjustment before further progression of the program.

Blood pressure response to exercise is an important safety metric. A normal systolic rise of 20 mm Hg above resting levels is expected; excessive elevation (> 10 mm Hg above predicted maximum) may signal

underlying vascular stiffness or medication effects. Patients on VEGF inhibitors often develop hypertension, requiring pre-exercise antihypertensive optimization. Routine blood pressure checks before, during, and after sessions help prevent adverse events.

Arrhythmia monitoring is essential in patients receiving agents that prolong QT interval, such as certain tyrosine-kinase inhibitors. Exercise can unmask latent arrhythmias; therefore, continuous ECG telemetry during initial high-intensity sessions is advisable. If nonsustained ventricular tachycardia is detected, the exercise intensity must be reduced, and cardiology consultation is warranted. Documentation of arrhythmic episodes informs future risk stratification.

ECG changes during exercise may reveal ischemia, conduction delays, or repolarization abnormalities. In survivors of mediastinal radiation, exercise-induced ST-segment depression may indicate coronary artery involvement, prompting further diagnostic workup. Interpretation of ECG in the oncology setting requires familiarity with therapy-related alterations, such as baseline T-wave flattening from certain chemotherapeutics.

Symptom-limited testing terminates the exercise protocol when the patient experiences intolerable symptoms, such as severe dyspnea, chest pain, or dizziness. This approach respects patient safety, especially in those with compromised cardiac reserve. Recording the specific symptom that limited the test provides valuable insight for tailoring subsequent rehabilitation sessions, ensuring that intensity does not exceed the patient's symptomatic threshold.

Fatigue is a pervasive symptom in cancer survivors, often multifactorial and exacerbated by cardiotoxic therapy. Distinguishing cardiac fatigue from general cancer-related fatigue is critical; cardiac fatigue may improve with graded aerobic conditioning, whereas systemic fatigue may require comprehensive management including sleep hygiene and psychosocial support. Incorporating low-intensity activity on days of high fatigue can paradoxically reduce overall tiredness through improved circulation and mood enhancement.

Dyspnea during exertion can reflect reduced cardiac output, pulmonary involvement, or deconditioning. Objective assessment using the Modified Medical Research Council (mMRC) scale assists in quantifying severity. A patient reporting mMRC grade 2 may benefit from interval aerobic training combined with breathing exercises to improve ventilatory efficiency. Monitoring oxygen saturation during sessions helps differentiate cardiac from respiratory causes.

Quality of life (QoL) encompasses physical, emotional, and social dimensions of well-being. Validated instruments such as the EORTC QLQ-C30 and the SF-36 capture patient-reported outcomes. Studies have demonstrated that structured exercise programs improve QoL scores by enhancing physical function and reducing symptom burden. Regular QoL assessments enable clinicians to track the broader impact of rehabilitation beyond physiological metrics.

Psychosocial support is integral to comprehensive cardio-oncology care, addressing anxiety, depression,

and cancer-related stress. Group exercise sessions foster peer interaction, reducing isolation. Referral to mental health professionals should be considered when screening tools (e.g., HADS) indicate significant distress. Integrating psychosocial counseling with physical activity creates synergistic benefits, promoting adherence and overall resilience.

Multidisciplinary team collaboration is the cornerstone of effective cardio-oncology rehabilitation. The team typically includes oncologists, cardiologists, physiotherapists, exercise physiologists, nurses, dietitians, and psychologists. Regular case conferences facilitate sharing of cardiac imaging results, biomarker trends, and exercise progression data, ensuring that each patient's plan is coherent and responsive to evolving clinical status. Barriers to multidisciplinary coordination include differing departmental priorities and limited communication infrastructure.

Oncology nurse plays a pivotal role in patient education, monitoring for treatment-related side effects, and encouraging adherence to exercise regimens. They often serve as the primary point of contact, reinforcing safety instructions such as recognizing signs of cardiac decompensation. Training oncology nurses in basic cardiac assessment, including pulse palpation and symptom inquiry, enhances early detection of cardiotoxic events.

Physiotherapist contributes expertise in movement analysis, functional mobility, and safe progression of activity. They assess gait, balance, and musculoskeletal limitations that may impede participation in aerobic training. For a patient with post-mastectomy shoulder stiffness, the physiotherapist designs specific stretching and strengthening protocols to restore range of motion, enabling more effective aerobic exercise without compensatory posture.

Cardiologist oversees cardiac surveillance, interprets imaging and biomarker data, and provides medical management of cardiotoxicity. Their input is essential for determining safe exercise intensity, particularly in patients with compromised LVEF or arrhythmias. Collaboration with the cardiologist ensures that pharmacologic therapy (e.g., ACE inhibitors, beta-blockers) is optimized to support exercise tolerance.

Exercise physiologist designs and implements individualized exercise prescriptions, utilizing CPET data to set target zones and monitor physiological responses. Their expertise in interpreting ventilatory thresholds and oxygen kinetics allows precise tailoring of training loads, maximizing benefit while minimizing risk. In research settings, the exercise physiologist may also collect outcome data for program evaluation.

Patient-reported outcome measures (PROMs) capture the patient's perspective on symptoms, functional status, and satisfaction with care. Incorporating PROMs into routine practice provides real-time feedback on the effectiveness of rehabilitation interventions. For instance, a worsening fatigue score may prompt a temporary reduction in training volume, whereas an improvement in physical function may justify progression to higher intensity.

Functional outcome measures such as the timed up-and-go (TUG) test, hand-grip strength, and the sit-to-stand test quantify specific aspects of physical performance. These measures are quick, inexpensive,

and can be repeated serially to track progress. A reduction in TUG time from 14 seconds to 11 seconds over a 12-week program indicates meaningful improvement in mobility and balance.

Physical activity guidelines issued by organizations such as the American College of Sports Medicine (ACSM) recommend at least 150 minutes of moderate-intensity aerobic activity per week, supplemented by two days of resistance training. In the Belgian cardio-oncology context, these guidelines are adapted to account for therapy-related limitations, emphasizing individualized pacing and the inclusion of flexibility exercises.

ACSM recommendations provide detailed parameters for exercise prescription, including specific heart rate ranges, RPE values, and progression criteria. For patients with reduced LVEF, the ACSM suggests initiating at 40% HRR and advancing by 5-10% increments every two weeks, contingent on tolerance. Adhering to these evidence-based standards enhances safety and efficacy across diverse patient populations.

ESC guidelines (European Society of Cardiology) integrate cardio-oncology considerations, advocating for baseline cardiac assessment before potentially cardiotoxic therapy and periodic re-evaluation during treatment. They also outline criteria for referral to cardiac rehabilitation, recommending that any patient with a $\geq 10\%$ decline in LVEF or a new rise in troponin be evaluated for supervised exercise. Alignment with ESC guidance ensures consistency with European best practice.

ESMO guidelines (European Society for Medical Oncology) emphasize the importance of cardio-protective strategies, including the use of beta-blockers and ACE inhibitors, as well as lifestyle interventions such as regular physical activity. They encourage clinicians to discuss exercise benefits early in the treatment planning phase, fostering patient engagement and setting realistic expectations for functional recovery.

Belgian national recommendations articulate specific pathways for cardio-oncology care within the country's healthcare system. They stipulate that all patients receiving anthracyclines should undergo echocardiographic screening at baseline, mid-therapy, and six months post-therapy, with referral to a certified cardiac rehabilitation center if abnormalities are detected. Familiarity with these national protocols is essential for compliance and reimbursement.

Exercise dose adjustment is a dynamic process, requiring ongoing assessment of tolerance, symptom burden, and cardiac metrics. If a patient experiences a transient rise in resting heart rate or a mild increase in troponin, the exercise dose may be temporarily reduced by decreasing intensity to 30% HRR and extending recovery periods. Re-evaluation after a week determines whether the original dose can be safely reinstated.

Progressive overload is the principle of gradually increasing the stress placed on the cardiovascular and musculoskeletal systems to elicit adaptation. In practice, this may involve adding 5% to the workload each week, extending session duration by two minutes, or incorporating additional resistance bands. Monitoring for signs of over-training, such as persistent fatigue or elevated resting heart rate, ensures that progression remains within safe limits.

Exercise safety monitoring encompasses pre-session screening, intra-session observation, and post-session review. Standardized checklists include verification of medication changes, recent symptom changes, and vital sign trends. During sessions, clinicians observe for abnormal cardiac rhythms, excessive blood pressure spikes, or signs of orthostatic intolerance. Documentation of these observations supports quality improvement and risk mitigation.

Individualized progression recognizes that patients recover at different rates, influenced by age, comorbidities, and treatment intensity. A younger patient with minimal cardiac involvement may progress to high-intensity intervals within four weeks, whereas an older individual with moderate LVEF reduction may require a slower trajectory, maintaining moderate intensity for several months before advancing. Tailoring progression respects each patient's unique physiological capacity.

Exercise education equips patients with knowledge about the benefits, risks, and practical aspects of physical activity. Topics include proper warm-up techniques, heart rate monitoring, symptom recognition, and strategies for integrating activity into daily routines. Effective education promotes self-efficacy, encouraging patients to maintain active lifestyles beyond supervised rehabilitation.

Nutrition integration aligns dietary intake with exercise goals, supporting muscle synthesis and energy availability. In cardio-oncology patients, protein intake of 1.2-1.5 g/kg body weight per day is recommended to counteract sarcopenia. Collaboration with dietitians ensures that caloric needs are met, especially in patients experiencing appetite loss due to chemotherapy.

Medication timing influences exercise performance; for instance, beta-blockers blunt heart rate response, necessitating reliance on RPE or VO_2 -based intensity markers. Scheduling exercise sessions after medication dosing can stabilize hemodynamics and improve tolerance. Clear communication between prescribing physicians and rehabilitation staff is essential to synchronize pharmacologic and exercise regimens.

Psychological readiness assesses a patient's mental preparedness to engage in physical activity, considering factors such as fear of recurrence, body image concerns, and prior activity history. Tools like the Exercise Self-Efficacy Scale can gauge confidence levels, informing the need for additional counseling or motivational interventions before initiating a program.

Community-based programs extend rehabilitation services beyond the hospital setting, offering group classes, walking clubs, and gym memberships tailored to cancer survivors. Partnerships with local fitness centers enable patients to continue exercising in familiar environments, fostering long-term adherence. Ensuring that community instructors are trained in cardio-oncology safety standards is vital to maintain quality care.

Insurance reimbursement policies in Belgium support cardiac rehabilitation for patients with documented cardiotoxicity, covering a defined number of supervised sessions. Understanding the criteria for reimbursement, such as documented LVEF decline or symptomatic heart failure, assists clinicians in securing funding for patients. Documentation of functional improvements and adherence enhances the likelihood of

continued coverage.

Research opportunities abound in the field of cardio-oncology rehabilitation, including investigations into optimal exercise modalities, dose-response relationships, and the impact of physical activity on long-term cardiac outcomes. Participation in multicenter trials contributes to the evidence base, allowing refinement of guidelines and improving patient care across the nation.

Implementation barriers often include limited staffing, lack of specialized equipment, and competing clinical priorities. Strategies to overcome these obstacles involve training existing personnel in basic cardiac monitoring, leveraging tele-rehabilitation platforms to extend reach, and integrating exercise assessment into routine oncology visits to streamline workflow.

Future directions anticipate the incorporation of artificial intelligence for predictive modeling of cardiotoxic risk, enabling preemptive exercise interventions. Additionally, the development of personalized exercise algorithms based on genetic profiling and biomarker trends may further enhance the precision of rehabilitation programs, aligning with the broader goals of precision oncology.

Patient empowerment is achieved through active involvement in goal setting, self-monitoring, and decision-making regarding their exercise plan. Providing patients with tools such as activity trackers, symptom diaries, and education materials fosters ownership of their health journey, ultimately leading to better outcomes and sustained lifestyle changes.

Interdisciplinary research collaborations between cardiologists, oncologists, physiologists, and data scientists are essential to unravel the complex interactions between cancer therapy, cardiac health, and physical activity. Joint publications and shared databases accelerate knowledge translation, ensuring that clinical practice remains rooted in the latest scientific evidence.

Clinical decision support systems embedded within electronic health records can alert clinicians to emerging cardiotoxicity, suggest appropriate timing for exercise assessment, and recommend referral pathways. Integrating alerts for abnormal biomarker trends or imaging findings streamlines the identification of patients who would benefit most from rehabilitation.

Outcome tracking involves systematic collection of key performance indicators such as changes in VO_2 peak, LVEF, GLS, and QoL scores. Regular audits of these metrics provide feedback on program effectiveness, highlight areas for improvement, and support continuous quality improvement initiatives within cardio-oncology services.

Safety protocols must be clearly defined, including emergency response plans for cardiac events during supervised sessions. Staff should be trained in basic life support, equipped with automated external defibrillators, and familiar with medication histories that may affect resuscitation strategies. Periodic drills reinforce preparedness and ensure rapid, coordinated action when needed.

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