kidney and dialysis

Review

# Physical Activity Behaviour in Solid Organ Transplant Recipients: Proposal of Theory-Driven Physical Activity Interventions

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**Abstract:** Physical inactivity is highly prevalent after solid organ transplantation and leads to unfavourable outcomes. This review aimed to understand posttransplant physical activity behaviour and propose physical activity interventions. Michie's Behavioural Change Wheel was applied, in which the Context and Implementation of Complex Interventions framework, the Capability-Opportunity-Motivation and Behaviour model, and the Theoretical Domains Framework were embedded. Various contextual factors were found to modulate physical activity behaviour. Promising strategies to promote long-term physical activity included (i) tailoring of physical activity programs to patients' abilities and preferences; (ii) incitement of intrinsic and autonomous motivation to change; (iii) SMART goals setting (e.g., Specific, Measurable, Achievable, Realistic, Time-bound), (iv) autonomy-supportive co-design of action plans; (v) foster new habit formation; (vi) self-monitoring of physical activity; (vii) follow-up opportunities for evaluation and adjustment; (viii) education of transplant recipients, healthcare providers, and the patients' social network; (iv) improvement of self-efficacy through incremental successes, verbal persuasion, peer modelling, and awareness of exercise-related bodily signals; (x) providing physical activity opportunity within patients' social and environmental setting; (xi) encouragement and support from patients' social network and healthcare providers; and (xii) governmental action that alleviates financial barriers and restructures the physical environment to promote physical activity. These new insights may contribute to physical activity program development for transplantation recipients.

**Keywords:** physical activity; solid organ transplantation; context; barriers; motivators; behaviour; behaviour change

## 1. Introduction

Solid organ transplantation is a life-saving treatment for patients with end-stage solid organ disease. The past two decades, technical and pharmacological advancements substantially improved short-term survival after solid organ transplantation [1] but their benefits on long-term outcome have been somewhat disappointing [2]. Poor uptake of healthy lifestyle practices (i.e., diet, physical activity) undoubtably affects long-term posttransplant physical and mental well-being. This review aims to summarize factors modulating physical activity behaviour in adult solid organ transplant recipients and to subsequently propose promising interventions for the posttransplant adoption of physical active behaviour. Our approach was guided by a combination of theoretical frameworks embedded in Michie's Behaviour Change Wheel (BCW) theory (Figure 1) [3]. Thus, the present study first aimed to understand posttransplant physical activity behaviour (BCW stage 1, steps 1–3) by defining the problem in behavioural terms, and by selecting and specifying the target behaviour. Next, a literature search was conducted to identify contextual factors of physical activity behaviour after transplantation, including patient-reported barriers and motivators for participation in physical activity and exercise-based rehabilitation (BCW stage 1, step 4). Finally, intervention functions, policy changes, and behaviour change techniques were identified (BCW stage 2 and 3, steps 5–7) [3].

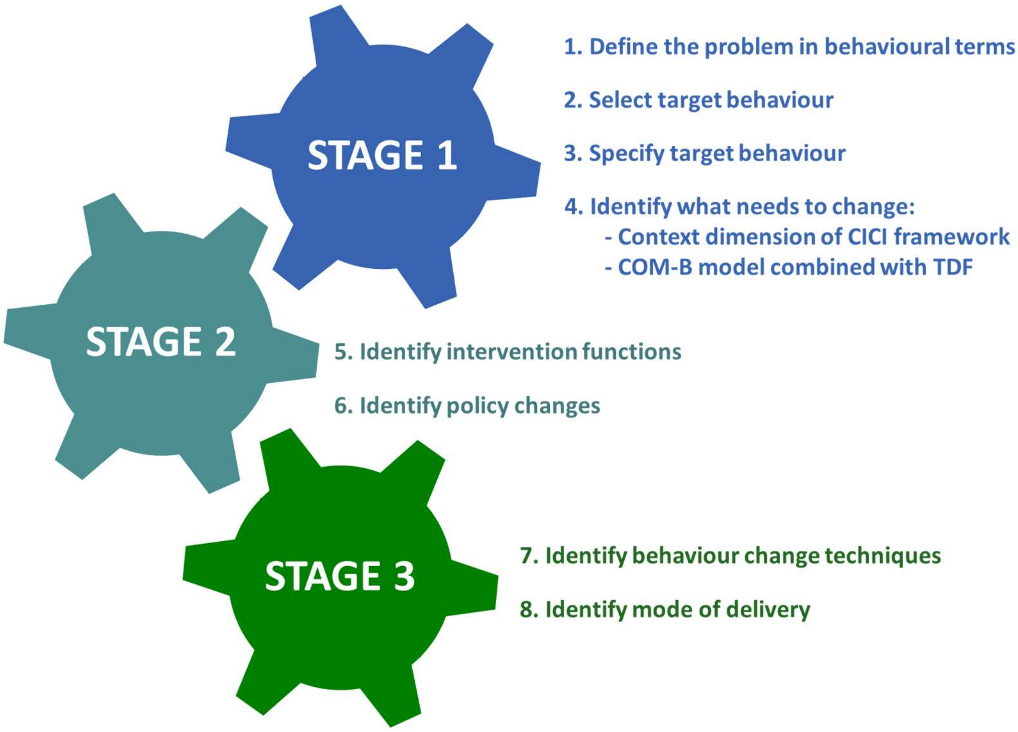


**Figure 1.** Stages and steps of Michie's Behavioural Change Wheel. CICI: Context and Implementation of Complex Interventions; COM-B: Capability-Opportunity-Motivation and Behaviour; TDF: Theoretical Domains Framework.

## 2. Methods

Steps 1–7 of Michie's BCW were used to approach our goals in a systematic and iterative way [3]. Steps 1–3 were based on a narrative review of the literature, step 4 was addressed by a systematic literature review. Within the BCW, we embedded the context dimension of the 'Context and Implementation of Complex Interventions' (CICI) framework [4], as well as the Capability-Opportunity-Motivation and Behaviour (COM-B) system [5], and the Theoretical Domains Framework (TDF) version 2 [6].

First, the initial three steps of BCW stage 1 were addressed. In these steps the low participation rate in posttransplant physical activity (including exercise and exercise-based rehabilitation), the target behaviour, and its consequences were described.

Next, step 4 of BCW stage 1 was conducted to identify the needs in behaviour change. Contextual factors related to posttransplant physical activity behaviour were synthesized using the context dimension of the CICI framework. This context dimension comprises the following seven domains: geographical, epidemiological, socio-cultural, socio-economic, ethical, legal, and political. This framework was embedded in the BCW to facilitate identification and classification of contextual modulators of physical activity beyond patient-reported barriers and motivators. Two independent reviewers (SL and MV) screened the literature for barriers and motivators using the following entry terms in PubMed: ((liver OR kidney OR lung OR heart OR pancreas OR organ) AND (Transplantation OR Recipient*)) AND (physical activity OR exercise OR rehabilitation) AND (facilitat* OR motivat* OR benefit* OR barrier* OR modulat* OR determinant*). Only studies in adult transplant recipients were considered. Identified barriers and motivators were classified according to the COM-B system combined with TDF.

Last, in steps 5–7 of the BCW stage 2 and 3, intervention functions, policy changes, and behaviour change techniques were proposed based on the data obtained in step 4 and subsequently discussed per CICI context dimension domain.

## 3. Results

### *3.1. Physical Inactivity after Organ Transplantation: Prevalence, Consequences, and Target Behaviour: BCW Steps 1–3*

Many solid organ transplant recipients lead a sedentary, physically inactive life [7–11]. Sedentary behaviour refers to "any waking behaviour characterized by an energy expenditure of ≤1.5 metabolic equivalents, while in a sitting, reclining, or lying posture" [12]. Physical inactivity refers to an "insufficient physical activity level to meet present physical activity recommendations" [12]. The 2020 World Health Organization (WHO) Guidelines on Physical Activity and Sedentary Behaviour recommend that adults suffering from chronic conditions regularly engage in moderate- and/or vigorous-intensity aerobic activities during respectively ≥150–300 or ≥75–150 min per week, or an equivalent combination of both [13]. Muscle strengthening activities are recommended at least twice a week. Three times a week, one is recommended to engage in multicomponent physical activities targeting not only aerobic or strength components but also functional balance. Importantly, the WHO guidelines also emphasize the benefits of engaging in any physical activity, even if the aforementioned target range is out of reach. Light-intensity activities (1.5–3.0 metabolic equivalents) are promoted to alternate with or substitute periods of sedentary time.

Current recommendations for transplant recipients either refer to general guidelines of physical activity [14] or specifically recommend exercise training [15–18]. General recommendations to lead an active life do not provide an adequate description of how frequent, how long, how intense, and what type of physical activity one should engage in. Exercise training is defined as a "subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective" [13]. Whereas exercise training is a stronger stimulus for the induction of health benefits than physical activity, its long-term implementation in daily life is far more challenging. In this respect, exercise interventions have emerged as an essential component of the posttransplant recovery phase to improve patients' physical fitness and thus the capacity to engage in physical activity. But once a certain level of physical fitness has been established, the further lifelong engagement in regular physical activity likely requires well-selected behavioural interventions. As for now, the 2020 WHO physical activity recommendations for patients with chronic conditions can be considered the physical activity target behaviour for patients with a solid organ transplantation [13].

In a Dutch cohort of 592 stable transplant recipients, van Adrichem et al. reported that 56% of patients adhered to aerobic physical activity guidelines, with a median time spent on moderate-to vigorous-intensity physical activity of 720 (270–1460) minutes per week. This is considerably less than the general population, of which, on average, 72% meet the physical activity guidelines [8]. Median sedentary time in this cohort was 360 (IQR—Interquartile Range, 240–480) min per day, which was slightly higher compared to the general Dutch population (342 min per day). Similarly, Kallwitz et al. showed that, in an American cohort of 204 liver transplant recipients, only 24% engaged in $\geq$ 150 min of physical activity per week relative to 51% of the overall adult population in the United States [10]. Similar observations have been reported in cohorts of kidney, heart, and lung transplant recipients, with studies consistently indicating lower physical activity levels that do not meet physical activity recommendations [11,16,19–22]. Although weekly engagement in muscle strengthening and multicomponent physical activities is recommended, to the best of our knowledge, no such observational data is available in transplant recipients. The problematically low levels of posttransplant physical activity behaviour and the target behaviour are further refined in Tables 1–3.

Both physical activity and physical fitness have repeatedly been shown to predict posttransplant outcome and survival [19,23–28]. Low levels of physical activity cause poor cardiorespiratory, muscle, and motor fitness, which in turn may promote physical inactivity. Physical inactivity synergizes with the deleterious effects of immunosuppressive therapy on metabolic and cardiovascular health. Compared to the general population, kidney transplant recipients are three-to-five-fold more likely to develop cardiovascular disease [29]. After liver transplantation, the incidence of major cardiovascular events increases from 11% at one year, to 14–21% at five years, and 30% at eight years posttransplant [30,31]. The incidence of new-onset diabetes after transplantation ranges from 12–45% [32] and negatively correlates with moderate to vigorous physical activity levels [33]. Both in the general and the transplant population, physical activity and physical fitness are established risk factors for cardiovascular disease [10,28,34–38], which currently represents one of the leading causes of death following transplantation [30,33,39,40]. Observational studies in kidney transplant recipients have suggested that physical activity may contribute to preservation of graft function [9,41], although intervention studies still need to confirm such findings. Lastly, in the general population, regular engagement in physical activity enhances immunosurveillance against pathogens [42] and adverse outcome following SARS-CoV-2 infection [43]. However, these findings need to be confirmed in the immunosuppressed transplant population.

Physical activity, and in particular exercise training, not only brings physical, but also social and mental health benefits [44–46]. Exercise training has been shown to improve symptoms of fatigue [47], reduce levels of anxiety and depression [48], and result in improved health-related quality of life in transplant recipients [18]. Furthermore, exercise-based rehabilitation facilitates return to work after transplantation [49], presumably in part as a result of reduced posttransplant fatigue and increased physical functioning [50–53].

It thus becomes clear that a lack of sufficient physical activity is unfavourable for transplant recipients' physical, mental, and social well-being. A better understanding of the contextual factors, implicated in this behaviour is required to develop thoughtful interventions that promote the uptake of a life-long physically active behaviour.

**Table 1.** Definition of the problem.

| Leading Question | Possible Answer |
|---|---|
| What is the problem/behaviour | The majority of transplant recipients do not meet physical activity guidelines and are less physically active compared to the general population [8,54]. Most studies evaluating adherence to physical activity recommendations evaluate participation in aerobic physical activity (150 min/week at moderate intensity, 75 min/week at vigorous intensity, or an equivalent of both). However, physical activity guidelines additionally include recommendations on muscle strengthening activities ($\geq$2×/week) and multicomponent physical activities targeting postural balance during aerobic and/or muscle strengthening activities ($\geq$3×/week), such as for instance dancing, yoga, gardening, and sports [13]. Nowadays, recommendations increasingly emphasize the need to replace sedentary behaviour with light physical activity [13,55–57].<br>Exercise and exercise-based physical rehabilitation are subsets of physical activity. For the sake of simplicity, low participation rates to posttransplant exercise-based rehabilitation are acknowledged, but in the present manuscript not discussed as the primary focus. |

**Table 1.** *Cont.*

| Leading Question | Possible Answer |
|---|---|
| Where does it occur | Physical activity can be performed as incidental physical activity (e.g., housework, transportation-related physical activity), occupation-related physical activity, or as activities performed for enjoyment or to improve or maintain physical and mental well-being. Physical activity can be performed everywhere: indoors, outdoors, at home, at work, in sports centres, at rehabilitation centres, etc. |
| Who is involved? | Transplant recipients' family members, friends, peers, health care providers (e.g., general practitioners, transplant physicians, transplant nurses, care assistants, physiotherapists, psychologists, social assistants, occupational therapists, dieticians) as well as patient organisations and policy makers (e.g., national policy makers, middle and top management of transplant centres) may modulate patient's engagement in physical activity. |

**Table 2.** List of possible target behaviours.

| Possible Target Behaviour | Impact of Behaviour Change | Likelihood of Change | Spillover Effect | Measurement |
|---|---|---|---|---|
| Reduction of sedentary behaviour | Mortality: + [58]<br>CV health: + [59,60]<br>Physical fitness: + [61]<br>HRQOL: + [62] | ++ | + | ++ (e.g., accelerometers such as ActivPal and Actigraph) |
| Aerobic activity: 150 min at moderate intensity, 75 min at vigorous intensity, or an equivalent combination of both | Mortality: ++ [63,64]<br>CV health: ++ [63,65,66]<br>Physical fitness (cardiorespiratory fitness): ++ [18,65]<br>HRQOL: + [65] | + | ++ | ++ (e.g., Heart monitor, training diary) |
| Muscle strengthening activity: ≥2×/week | Mortality: + [63,64]<br>CV health: + [18,63]<br>Physical fitness (muscle fitness): ++ [18,67]<br>HRQOL: + [68] | + | ++ | ++ (e.g., training diary) |
| Participation in WHO recommended volume and intensity of aerobic, muscle strengthening, and multicomponent physical activities | Mortality: ++ [64]<br>CV health: ++ [63]<br>Physical fitness (cardiorespiratory, muscle, and motor fitness): ++ [18]<br>HRQOL: + [18,60] | + | ++ | ++ (e.g., accelerometers, training diary) |

CV: cardiovascular; HRQOL: Health related quality of life; ++, very promising; +, promising; ±, not promising but worth considering; −, unacceptable.

**Table 3.** Specification of target behaviours.

| Target Behaviour | Physical Activity Participation |
|---|---|
| Who | Solid organ transplant recipients |
| What | Any bodily movement produced by the skeletal muscles that requires increased energy expenditure above resting requirements and involves household tasks, leisure time activity, and structured physical activity (including exercise and exercise-based rehabilitation) [13]. Physical activity dimensions include frequency, intensity, time/duration, and type. |
| When | After solid organ transplantation:<br>- During acute hospitalization after transplantation: exercise-based rehabilitation<br>- Early (1–6 months) after transplantation: exercise-based rehabilitation and physical activity<br>- Long-term (>6–12 months) after transplantation: physical activity |

**Table 3.** *Cont.*

| Target Behaviour | Physical Activity Participation |
| --- | --- |
| Where | Engagement in physical activity can be performed everywhere: at home, at work, indoors, outdoors, in sports and health care centres, etc. |
| How | A plethora of physical activity types exists. E.g.,<br>- Incidental activity (e.g., household tasks, transport)<br>- Leisure activities<br>- Planned and structured activity and exercise<br>- Sports (either or not competitive)<br>- Exercise-based rehabilitation: mobility, aerobic, strength, balance, flexibility, and functional exercises |
| How often | Any reduction in sedentary behaviour and any increase in physical activity is believed beneficial for patients' health, though specific physical activity goals have been reported as well (cf. Table 2.) |
| With whom | Physical activity can be performed with:<br>- Alone or in group<br>- Friends<br>- Family<br>- Peers<br>- Colleagues<br>- Pet(s)<br>- Health care providers |

### *3.2. Contextual Factors Implicated in Posttransplant Participation in Physical Activity: BCW Step 4*

To better understand the discrepancy between the ongoing versus target behaviour and to identify the needed change (step 4 of the BCW), the context and modulating factors of physical activity behaviour (including exercise-based rehabilitation) need to be taken into account. According to the CICI framework, "context reflects a set of characteristics and circumstances that consist of active and unique factors, within which the implementation is embedded" [4]. The context dimension of the CICI framework consists of seven domains that classify factors that may interact with, influence, modify, facilitate, or constrain physical activity behaviour, physical activity interventions, and their intervention implementation in solid organ transplant recipients [4]. The use of CICI's context dimension facilitated classification and discussion of contextual factors that modulate physical activity beyond patient-reported barriers and motivators. Nonetheless, our primary focus concerned patient-reported barriers and motivators to physical activity (including exercise and exercise-based rehabilitation), for which a systematic review was performed.

Our literature search on patient-reported barriers and motivators identified 19 eligible records from 17 independent studies (Figure 2). The barriers and motivators were classified according to COM-B and TDF (Table 4) and subsequently embedded and discussed below according to the context dimension of CICI. The identified barriers and motivators were related to participation in physical activity and/or exercise [8,11,54,69–79], exercise-based rehabilitation [80–83], or participation in the World Transplant Games [84]. The terms physical activity and exercise were often used interchangeably, making it impossible to make a clear distinction between these variables. E.g., studies evaluating barriers and motivators for physical activity asked patients whether 'exercise or sports gave them unpleasant bodily signals' [69] and whether 'negative attitudes towards exercise' [79] were considered barriers to participating in physical activity.

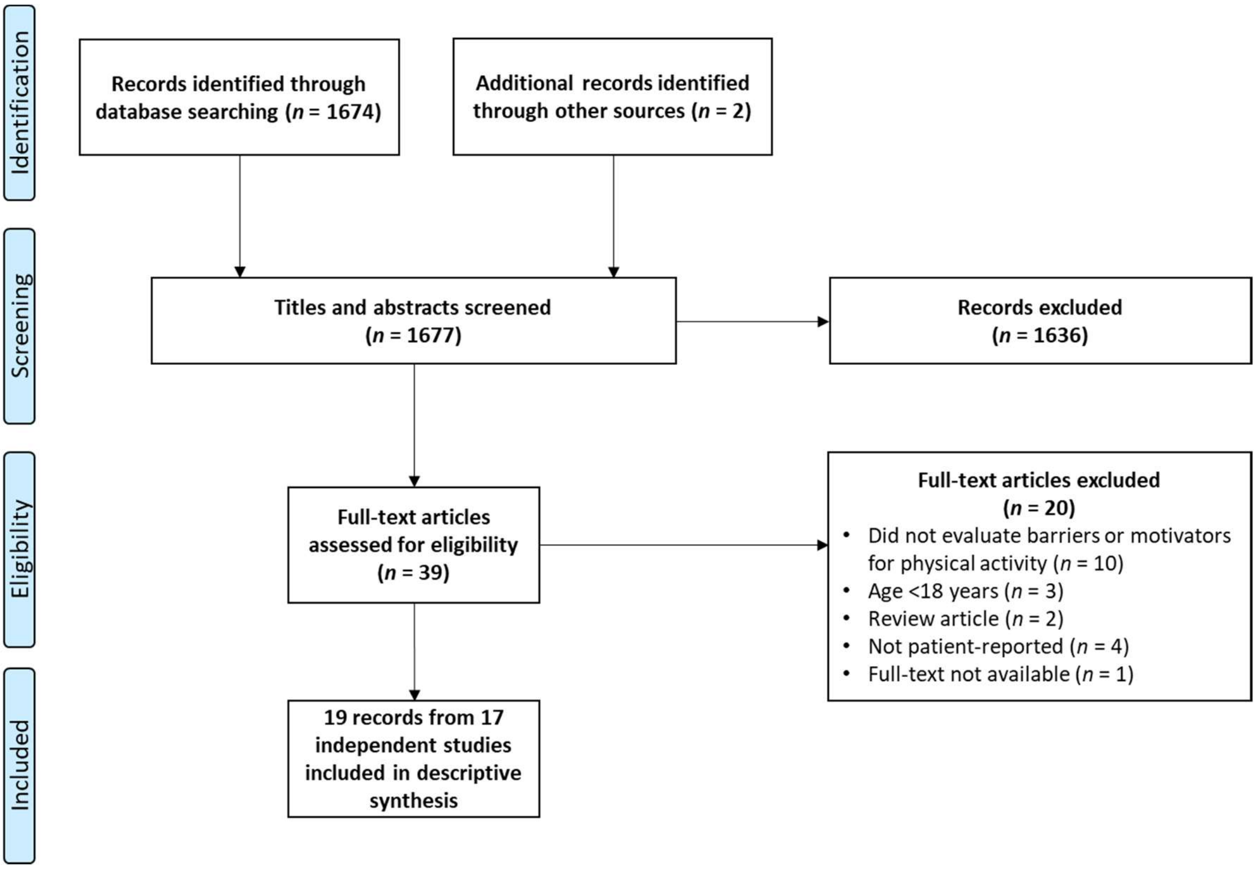


**Figure 2.** Flow chart literature search on barriers and motivators to participating in posttransplant physical activity.

**Table 4.** Identified barriers and motivators to physical activity classified according to TDF embedded in COM-B.

| COM-B | TDF | What Needs to Happen for Target Behaviour To Occur? | Barriers | Motivators |
|---|---|---|---|---|
| **Physical Capability** | Physical skills | Being physically able to be physically active | *Evaluated in 12/19 records*<br>General health and symptoms [69,71,80] (K/Li/M)<br>Kidney disease [69] (K)<br>Comorbidities that interfere with physical activity [11,80,82] (K/M)<br>Physical limitations in relation to transplantation [11,82] or slow recovery after transplantation [71] (K/Li/M)<br>Feeling too fatigued or low energy levels [11,69,73,82,83] (K/Lu/H/M)<br>Feeling too sick to exercise [79] (K)<br>Physical pain [70,83] (K/H)<br>Having open incision [79] (K)<br>Shortness of breath [69,83] (K/H)<br>Inadequate strength to perform activities [11,72] (M)<br>Side effects of immunosuppressant's [11,72] or medication [81] (M)<br>Being overweight [11] (M)<br>Avoiding direct sunlight due to higher risk of skin cancer when taking immunosuppressant's [79] (K)<br>Restrictions towards exercise (lifting and contact sports) [74] (K) | *Evaluated in 11/19 records*<br>Perceiving feelings of health and benefits from physical activity [72,81,82] Feel healthier and generally better [71,74,81,83] (K/Li/H/M)<br>Reduce specific health risks [74] (K)<br>Increase energy [69,83] (K/H)<br>Decrease pain [69] (K)<br>Increase mobility [74] and muscle strength [11,69] (K/M)<br>Manage weight [11,69,81] (K/M)<br>Improve endurance [73] (Lu)<br>Consequences of inactivity [11,82] (K/M)<br>Longevity of the transplanted kidney [74] (K)<br>Improvements in body and transplant conditions and feeling the transplant becoming stronger [83] (H)<br>Recognition that PA is essential for prolonging their lives and maintain the quality of their health [77] (M) |
| **Psychological Capability** | Knowledge | Patients (and health care providers) require the knowledge about why, how, when, how often, and with who to be physically activity in a safe way | *Evaluated in 9/19 records*<br>Lack of knowledge about the benefits of physical activity [11,69] (K/M)<br>Lack of knowledge about appropriate exercise [74] or unsure how to exercise safely [81] (K/M)<br>Health care providers' lack of expertise, lack of medical clearance, lack of specific advice, and conflicting or vague advice [11,71,74,77,84] (K/Li/M)<br>Health care providers not recommending or advising against physical activity [79,80] (K/M)<br>Health care providers not providing answers on questions about exercise limitations [74] (K)<br>Desire for (currently lacking) exercise guidelines [74] (K)Desire to three different types of guidance: (i) standardized guidance, (ii) prescriptive (individualized) guidance, and (iii) supervised guidance/sessions both individual and in group [74] (K)<br>Exercise advice and guidance not priority of the National Health Service (UK) [74] (K) | *Evaluated in 7/19 records*<br>Knowing the value and benefits of increased PA [69,79] (K)<br>Having knowledge about PA [72] (M)<br>Receiving information on how to exercise [69] (K)<br>Expertise of personnel [11] (M)<br>Physician recommendations to PA [72,80] (M)<br>Individualized timely advice consistent across the multidisciplinary team [71] (Li)<br>Accessible and comprehensive rehabilitation as a potential source for guidelines around proper exercise and transplant appropriate milestones [77] (M) |
| | Emotion and behavioural regulation | Apply the knowledge about correct physical activity frequency, intensity, type, and duration.<br>Development of coping strategies for barriers | *Evaluated in 2/19 records*<br>A previous routine without physical activity [11,82] (K/M)<br>Post-transplantation life events [11] (M) | *Evaluated in 5/19 records*<br>Coping [11,82] (K/M)<br>Physical activity as routine habit [11,79,82] (K/M)<br>Exploration of new capabilities and refine their understanding of their trans liminal, transplanted body-self [54] (N)<br>Self-determination [71] (Li) |

**Table 4.** *Cont.*

| COM-B | TDF | What Needs to Happen for Target Behaviour To Occur? | Barriers | Motivators |
|---|---|---|---|---|
| | Memory, attention & decision processing | Notice and remember to be physically active during daily life | *Evaluated in 1/19 records*<br>Not remembering to be physically active [79] (K) | *Evaluated in 0/19 records* |
| **Physical Opportunity** | Environmental context and resources | Availability and accessibility of physical activity facilities and opportunities.<br>Financial resources and insurances to be physically active | *Evaluated in 8/19 records*<br>Lack of access to (safe) physical activity facilities [69,74,77,79,81] and a lack of opportunities to participate in a physical activity program [80] (K/M)<br>Costs of physical activity [74,81] costs of fitness/rehabilitation centres [72,79,80], and limited financial resources [11,69] (K/M)<br>Bad weather [11,69,74,79,81] (K/M)<br>No private insurance [70,72] (K/M)<br>No transportation to a gym [79] (K)<br>Far distance from rehabilitation centre [80] (M)<br>No place to sit down while exercising outside [69] (K)<br>Poor sidewalks [69] (K) | *Evaluated in 6/19 records*<br>Having financial resources [69] and having private insurance [70] (K)<br>Proximity to an exercise facility [72] and environmental opportunity to be physically active [71] (Li/M)<br>Outdoor activities (views and fresh air) and walking (preferred activity as it could be easily fitted into daily life) [74] (K)<br>Exercise classes (structured and motivational) and individual exercise preferences (especially influencing continued exercise behaviour) [74] (K)<br>Workable and constructive exercise program [83] Taking precautions when training outdoors and adjusting the way of exercise to fit themselves [83] (H) |
| **Social Opportunity** | Social influence | An encouraging and supporting social network | *Evaluated in 4/19 records*<br>Lack of general encouragement, lack of support from family and friends [69], and lack of support from physicians [81] (K/M)<br>Low expectations from family, friends, and health-care providers [69] (K)<br>Negative social influence [71] (Li)<br>Not knowing other kidney transplant recipients who are physically active [74] (K)<br>Expectations of others that kidney transplant recipients should not exercise [74] (K) | *Evaluated in 9/19 records*<br>Having support and encouragement from family, friends, peers (peer modeling), and others [11,69,71,72,79,81,83] (K/Li/H/M)<br>Physical activities with others [69,79], friends/family [74], and in group [11,81] (K/M)<br>Making new friends by physical activity [74] (K)<br>Encouragement, support, and empathy from healthcare providers [69,71,83] (K/Li/H)<br>High expectations from family, friends and healthcare providers [69] (K)<br>Having a supportive exercise leader [69] (K)<br>Exercising on the job [74,79] (K)<br>Not wanting to let people down if they had planned to exercise together [74] (K) |

**Table 4.** *Cont.*

| COM-B | TDF | What Needs to Happen for Target Behaviour To Occur? | Barriers | Motivators |
| --- | --- | --- | --- | --- |
| **Automatic motivation** | Emotion | Positive emotions related to physical activity | *Evaluated in 11/19 records*<br>General anxiety [73,82], anxiety about physical activity [69], and fear of movement [75] (K/Lu)<br>Fear of damaging the transplanted organ [11,81,83], increasing pain or injury [69,81]; negative effects [69,81]; infection [81]; rejection [73]; making health worse [69], and falling [69] (K/Lu/H/M)<br>General fear of activities outdoors [83], or fear of outdoor activities due to fear for crime [69] or fear of being affected by a certain disease [83] (K/H)<br>Depression [69] and low health-related quality of life [72] (K/M)<br>Heightened sense of self-awareness during exercise and heightened awareness of normal exercise effects (i.e., increased blood pressure, heart rate) [74], insecurity with the body and body signals [11,77], and unpleasant sensations associated with exercise [69] (K/M)<br>Greatened awareness of normal exercise effects, such as dehydration [74]; concerns exercise will make you too thirsty [69] (K)<br>Being cautious about doing too much, feeling fatigued and not wanting to become more fatigued [69,74] (K)<br>Self-consciousness about appearance [69] (K)<br>Emotional trauma, most often as a direct result of transplant experience, including illness, the transplant procedure itself, and post-transplant recovery [77] (M) | *Evaluated in 10/19 records*<br>Wanting to decrease depression and anxiety [69] (K)<br>Perceived health related quality of life, well-being and benefits [77,81–83] (K/H/M)<br>Encourage a return to leisurely and meaningful activities [81] (M)<br>Sense of duty to enact health, self-care, and donor-directed gratitude [11,54,74,77] and moral imperative to move [77] (K/N/M)<br>Physical activity as a way of connecting to their donor as means of keeping part of their donor 'alive' for the sake of their respective donor families [77] (M)<br>Transplant specific distress relates to feelings of 'needing to' participate in physical activity in order to avoid negative feelings such as guilt or shame [78] (M)<br>Feeling better and giving 'mental clarity' [74] (K)<br>Becoming more optimistic and outspoken by physical activity [83] (H)<br>Stress relief and 'take their mind off their transplant and related worries' [74] (K)<br>Frustration, stress, and guilt for missing exercise sessions [74] (K)<br>Feeling favourable towards exercise [79] (K)<br>Positive psychological growth (also correlates with autonomous self-regulation) [78] (M)<br>Enjoying new physical experiences and sensations [77] (M)<br>Managing emotional and physical trauma [77] (M) |
| | Reinforcement | Strategies for possible problems | *Evaluated in 0/19 records* | *Evaluated in 0/19 records* |
| **Reflective motivation** | Intentions | Have willingness to be physically activeHave a plan on physical activity | *Evaluated in 6/19 records*<br>Lack of motivation [54,69,71,74,79,81] (K/Li/N/M)<br>Lack of interest in physical activity [69] (K)<br>Dislike exercise [79] (K)<br>Being lazy [79] (K) | *Evaluated in 4/19 records*<br>Being motivated to be physically active [11,82] or internal need to exercise [74] (K/M)<br>High level of motivation or a desire to stay healthy [72] (M) |
| | Beliefs about consequence | Correct beliefs of resulting consequences of physical inactivity | *Evaluated in 3/19 records*<br>Not believing the advice that is given [71] (Li)<br>Perceiving only few health benefits by physical activity [11,80] (M) | *Evaluated in 2/19 records*<br>The belief that implementing advice would be beneficial [71] (Li) |

**Table 4.** *Cont.*

| COM-B | TDF | What Needs to Happen for Target Behaviour To Occur? | Barriers | Motivators |
|---|---|---|---|---|
| | Beliefs about capabilities | Correct beliefs about capabilities to be physical activity | *Evaluated in 9/19 records*<br>Low exercise self-efficacy [8,11,70,75] (K/M)<br>Low expectations by self [8,69] (K/M)<br>Low self-confidence [8,69,71,74,79,80] (K/Li/M) | *Evaluated in 8/19 records*<br>Beliefs in one's ability to be physically active [69] (K)<br>Having confidence about physical activity [72,80] and becoming more confident by physical activity [83] (H/M)High self-efficacy [8,11,75] (K)<br>Self-management [74] (K) |
| | Goals | Correct beliefs of own responsibility for outcome and priority setting | *Evaluated in 6/19 records*<br>Having other priorities [11,69] and other commitments [73] (K/Lu/M)<br>Lack of time [69,73,79,81] or time commitment [80] (K/Lu/M) | *Evaluated in 4/19 records*<br>Setting and wanting to achieve goals, goal progress, and priorities [11,82] (K/M)<br>Structured approach [74] (K)<br>Building toward more challenging and ambitious physical activity while realizing new capabilities [54] (N) |
| | Social/ professional role and identity | Compatible set of behaviours with professional identity | *Evaluated in 3/19 records*<br>Feeling if they are required to fulfil a social role (i.e., caretaker in their family) [11] (M)<br>Work and family responsibilities [80] (M)<br>Physically demanding job [69] (K) | *Evaluated in 6/19 records*<br>Doing house chores and moving around at home [79] (K)<br>Walking with the dog/walking to the bakery [79] (K)<br>Self-identity shifting from ill, abnormal, and deficient body to a healthy body capable of physical performance and feelings as they have a 'new' body [54,77] (N/M)<br>Feeling of normality [74] or come back to real life again [83] (K/H) |

K: Kidney transplant cohort; Li: Liver transplant cohort; Lu: Lung transplant cohort; H: Heart transplant cohort; M: Mixed transplant cohort; N: cohort not specified.

Five studies (six records) focused solely on kidney transplant recipients ($n$ = 741) [69,70,74,75,79,82], one study on liver transplant recipients ($n$ = 13) [71], one study on heart transplant recipients ($n$ = 8) [83], one study on lung transplant recipients ($n$ = 111) [73], and one study did not specify the transplant population ($n$ = 13) [54]. Eight independent studies (nine records) evaluated barriers and motivators in cohorts of various organ transplant recipients, i.e., 531 kidney transplant recipients, 250 liver transplant recipients, 148 lung transplant recipients, 114 heart transplant recipients, and four multi-organ transplant recipients [8,11,72,76–78,80,81,84]. Based on limited literature data, there are no differences in barriers and motivators between different solid organ transplant groups [11,76]. Various methods were used, with the majority of studies applying semi-structured interviews [11,70,71,74,79,81,83] and others using web-based questionnaires [72,73,80,84] or standardized questionnaires, such as Barriers and Motivators Questionnaire [8,69], the Exercise Benefits/Barriers Scale [82], Tampa Score of Kinesophobia [75], Inventory of Physical Activity Objectives questionnaire [76], Behavioural Regulation in Exercise Questionnaire-2 [78], Perceived Physical Activity Scale (sub-scale of the Physical Self- Efficacy Scale) [75], or Exercise Self-Efficacy Scale [8].

#### 3.2.1. Geographical Context

According to the CICI framework the geographical context refers to “the broader physical environment, landscapes and resources, both natural and transformed by humans (e.g., infrastructure), available in a given setting” [4].

##### Environmental Context and Resources (TDF)

As demonstrated in transplant recipients [69,74,79,81] and other patient populations [85–88], the ease of access and proximity to exercise or physical rehabilitation centres influences a patients’ inclination to make use of it. Environmental factors such as the lack or poor quality of sidewalks, lack of safe exercise grounds, and lack of places to rest during outdoor physical activity withhold transplant recipients from engaging in physical activity [69]. Additionally, poor or inclement weather is frequently reported as an environmental barrier [11,69,74,79,81]. Low volume of patients in centralized regions discourages transplant centres from organizing outpatient exercise-based rehabilitation programs [89]. Some cardiologists reported feeling hesitant referring patients to a cardiac rehabilitation facility that is not part of their own health system, out of concern that referred patients may seek treatment elsewhere afterwards [86]. It is not unlikely that transplant physicians from smaller centres experience similar hesitancy towards referral of patients to physical rehabilitation programs in larger transplant centres.

Some insights from the general population should be taken into account. In middle- and high-income countries, attributes of an urban environment such as high residential density, good public transport service, proximity to recreational parks, and mixed land use may substantially increase physical activity [90,91]. An international cross-sectional study in 6822 adults cited rates of 68–69 min per week [91]. In low- and middle-income countries, however, residents of urban regions demonstrate lower physical activity than those of rural areas [91]. Sedentary behaviour shows a weaker association with neighbourhood environmental attributes [92], but people living in urban versus rural areas tend to be less sedentary, probably because of better access to various day-to-day destinations such as shops, parks, and public transport [92].

#### 3.2.2. Epidemiological Context

According to the CICI framework the epidemiological context refers to “the distribution of diseases or conditions, the attributable burden of disease, as well as determinants of needs in populations, including demographics” [4].

Sex, Age, and Transplant Type

The majority of transplant recipients are men (65%) [93], while the age distribution amongst patients receiving a transplant shows that 4% is 0–14 years, 44% is 16–55 years, 30% is 56–64 years, and 22% is >65 years old (https://www.eurotransplant.org/statistics/annual-report/, accessed on 10 January 2022). Some studies have indicated that older [11,28] and female [8] transplant recipients tend to be less physically active, but, interestingly, reported no significant differences in physical activity levels [8,76] or barriers and motivators [11,76] between the different organ transplant recipient groups. One study documented that lung and heart transplant recipients participated more in high levels of physical activity [72], while another study did not identify such differences [8]. The above-mentioned observations corroborate findings in the general population, in which female sex, older age, overweight, smoking, and poor self-rated health are associated with lower adherence to physical activity recommendations [94,95].

COVID-19 Pandemic

The ongoing COVID-19 pandemic has emerged as an additional barrier for transplant recipients to engage in physical activity [96,97]. Due to immunosuppressive therapy, vaccination efficacy is often compromised and patients are at a higher risk for severe complications of SARS-CoV-2 infection [98]. Transplant recipients are likely to experience greater fear for COVID-19 and, accordingly, display behaviours to minimize infection risks (e.g., avoiding crowds, social distancing, masking) [99]. The COVID-19 pandemic therefore strengthens the already existing barriers such as lack of community, exercise facilities, equipment, and space [97]. Transplant recipients are also hesitant to attend hospital-based physical rehabilitation programs because of the increased risk for viral and bacterial infections (personal observation). Despite the COVID-19 pandemic, engaging in physical activities remains feasible, and include activities such as walking, household chores, caring of children and pets, gardening, and do-it-yourself activities, which some transplant recipients mentioned as their preferred physical activities [74,84].

Physical Skills and Limitations (TDF)

Various comorbidities originating from pre-existing organ disease, immunosuppressive therapy, and a history of physical inactivity cause transplant recipients to experience physical barriers to engage in physical activity or attending an exercise-based rehabilitation program. These include impaired physical fitness, shortness of breath, fatigue, low strength, side-effects of medication (including immunosuppressants), and overweight [8,11,69,71–74,80,81]. While pharmacological immunosuppression may hinder physical activity engagement due to its exerted effects on physical fitness, body composition, and cardiovascular health, it may also discourage participation in physical activities taking place in the water (e.g., swimming pool, lake, sea) and/or direct sunlight given patient's predisposition to bacterial infections and skin cancer, respectively.

### 3.2.3. Socio-Cultural Context

Socio-cultural constructs that may influence the uptake of a physically active lifestyle include behaviour patterns, attitudes, values, knowledge, beliefs, and social roles shared among members of a community [4].

Ethnicity and Culture

Cultural, religious, and traditional gender role beliefs may impact physical activity. Some cultures, for instance, expect women to fulfil the role of main care provider at home (e.g., maintaining the household, providing care for the family), which may limit their participation in physical activity due to time constraints or the expectation that dedicated personal time should not be prioritized [100]. A qualitative study in 10 Omani public health managers indicated that socio-cultural norms restricted women's participation in outdoor physical activity [101]. An Omani women walking by herself in the streets is not considered socially acceptable behaviour. Also, using public transportation rather than private vehicles is culturally frowned upon. Besides these stigmas, physical activity is seen as an unimportant part of life in the Omani culture. Muslim women may experience further barriers because of gender segregation and clothing requirements [102,103].

The racial and ethnic diversity of patients on today's transplant waiting lists reflects the multicultural society. In the United Kingdom, 31% of patients on the transplant waiting list are from Black, Asian, or ethnic minority communities [104]. Little is known on the impact of ethnicity on physical activity behaviour among patients following transplantation. A training study in kidney transplant recipients reported that patients from ethnic minorities were more likely to prematurely end their participation to an exercise intervention [100]. Participants reported challenges related to exercise in a mixed gender group, where cultural appropriate clothing was essential. From other populations such as cardiac disease patients, it is known that the referral rate, enrolment, and completion of cardiac rehabilitation programs are lower for racial/ethnic minorities [88].

Knowledge (TDF)

Transplant recipients' knowledge on 'the why' (benefits) and 'the how' (frequency, intensity, time, and type) to safely participate in physical activity is most likely to modulate their behaviour [69,71,72]. A 'movement' culture in the transplant health care management, characterized by a care team who acknowledges, assesses, counsels, promotes, and organizes physical activity and exercise-based rehabilitation is expected to have considerable impact on its patients' knowledge, motivation, and willingness to become physically active. Physicians who fail to recommend physical activity is perceived as a major barrier to lead an active lifestyle [69,79,80]. Along this line, the lack of expertise in physical activity of health care providers as perceived by the patients acts as barrier to become physically active [11,69,71]. To date, consensus is poor among transplant professionals about the patients' need for physical activity counselling and exercise-based rehabilitation (personal observations). Furthermore, the optimal mode of physical activity and volume of exercise-based rehabilitation and long-term physical activity engagement still remains to be established. It is likely that a lack of knowledge on this topic causes transplant professionals to underestimate the health benefits of physical activity and hence limit their referral and counselling rates [105]. This is accompanied by the perceived urgent need for physical activity and exercise guidelines for the transplant population [74].

Social Influences; Social/Professional Role, and Identity (TDF)

Outside the transplant setting, only 25% to 50% of physicians counsel their patients to engage in physical activity or exercise [106]. This behaviour pattern is hindered by lack of time [107,108], high professional workload [109], lack of skills [109], lack of knowledge, lack of confidence [110,111], lack of training [105], perceived lack of guidelines about physical activity counselling [107], and judicious estimate of a patient's lack of willingness to change physical activity behaviour [112]. The health care providers' behaviour patterns with regard to physical activity and exercise-based rehabilitation counselling and prescription varies widely between transplant centres and types of transplant recipients [89]. Physicians active in the transplant setting reported similar barriers to physical activity counselling; with lack of time (56%), lack of exercise guidelines (53%) and lack of confidence (24%) as main barriers [113].

Health care providers' behaviour patterns are of great importance for transplant recipients. Expectations, encouragement and support from health care providers are major modulators of their engagement in physical activity or exercise-based rehabilitation [54,70,73,79,109]. The same is seen for expectations, encouragement and support from family, friends, and peers [11,69,71,72,79].

The transplant recipient's perception of their requirement to fulfil social or professional roles, e.g., caretaking of family members or work/family responsibilities, may receive priority over engagement in physical activity [11,80]. This barrier may have substantial consequences in cultures where involvement of family members in healthcare is evident and intergenerational support for individuals with long-term health conditions is obvious, e.g., the South Asian culture. Importantly, South Asian chronic kidney disease patients identified themselves as having a role within the home as the main care provider, which placed challenges on time and access to exercise services in the community [100]. Other activities in the social context, such as house chores and running errands, however, may promote physical activity [79].

Goals; Intentions; Emotional/Behavioural Regulation (TDF)

The lack of time and the lack of time commitment, which are frequently mentioned barriers [69,79–81], are likely related to a lack of interest [69], having other priorities [11,69], and lack of motivation [70,74,84,96]. The absence of physical activity habits as part of daily routine obviously decreases transplant recipients' likeliness to engage in physical activity [11,82].

Emotions; Beliefs about Capabilities; Beliefs about Consequences (TDF)

Transplant recipients may want to or may feel obligated to show gratitude to their donor, by engaging in physical activity and to lead a healthy lifestyle [54,114]. Some may initiate physical activity to avoid feelings of guilt or shame. However, motivation originating from such negative feelings is unlikely to lead to long-term physical activity behaviour change [78]. Participation in physical activity and sports may also serve to gain a sense of normalcy in daily life, a sense of being healthy, and a sense of achievement and improved mental well-being [54,69].

Transplant recipients commonly report insecurities about their body and the body signals during exercise, which may hinder engagement in physical activity [11,69,74]. Anxiety, which probably relates to this insecurity, is also reported as a major barrier to engagement in physical activity. This anxiety refers to both general anxiety [73] and anxiety about physical activity [41,70,108], as well as more specific fears of damaging the transplanted organ [11,74,81], increasing pain or injury [11,70], infection [81], rejection [73], damaging health [69], and falling [69]. Accordingly, fear of movement [75] is an important modulating factor to engage in physical activity, together with the closely related modulator physical activity self-efficacy [8,11,75,79]. Along the same line, self-confidence [8,69,71,73,74,80], expectations from self [8,69], self-efficacy [8,11,70], self-consciousness about appearance [69], and the trust patients place in their health provider's advice [71] modulate physical activity behaviour.

### 3.2.4. Socio-Economic Context

According to the CICI framework, the socio-economic context "comprises the social and economic resources of a community and the access of a population to these resources" [4].

Convincing evidence shows that in the general population, an individual's or a group's higher social standing, measured as a combination of education, income, and professional occupation positively correlate with physical activity [115]. The likelihood of meeting physical activity guidelines decreases with decreasing socio-economic status [94].

Education Level of Transplant Recipients

Kidney transplant recipients who have a higher educational background are more likely to participate in physical activity [116]. Conversely, transplant recipients with higher educational background often lead a more sedentary lifestyle, presumably consequent to their sedentary profession [8].

Environmental Context and Resources (TDF)

Chronic organ disease and transplantation may lead to financial vulnerability [86], and this in turn may impact physical activity behaviour [69]. The employment rate in recently transplanted individuals is lower than that of an age-matched general population, with the majority of transplant recipients not establishing gainful employment after transplantation [51,52,117,118]. Data from one study suggests that patients who are not actively working are less physically active [8]. Whether or not insurance covers the costs associated with exercise-based rehabilitation, physical activity counselling, and membership of a sports club can impact the likelihood of transplant recipients to engage in such activities [72,83,89]. Of note, low employment rates are in part due to physical disabilities [50,51] which may be overcome by an exercise-based rehabilitation [49].

Transplant recipients may benefit from a disability income that, depending on the country, is either regulated by a public health care system and/or private health insurance. In the United States kidney transplant recipients who have private primary insurance (rather than Medicare/Medicaid) are more likely to engage in physical activity [70], presumably reflecting a higher socio-economic status.

#### 3.2.5. Ethical Context

The ethical context comprises "reflections of morality, which encompasses norms, rules, standards of conduct and principles that guide the decisions and behaviour of individuals and institutions" [4].

Transplant recipients may want to express their gratitude to the donors' 'gift of life' by leading a healthy lifestyle. Alternatively, by doing so, they may also want to demonstrate to society their worthiness of receiving the graft [114]. By exploiting the recipients' feelings, health care professionals may use the 'gift of life' metaphor to influence a transplant recipients' attitude towards physical activity, but this comes at the potential cost of causing distress, and of reducing the self-perceived identity to a status of 'transplant recipient' [119,120].

#### 3.2.6. Political Context

According to the CICI, the political context "focuses on the distribution of power, assets and interests within a population, as well as the range of organizations involved, their interests and the formal and informal rules that govern interactions between them. The domain also comprises the health care system and its accessibility (e.g., delivery of services, leadership and governance, health information, human resources and financing)" [4].

Parties involved in policies related to physical activity and exercise-based rehabilitation include the middle and upper management of transplant centres, regional and national policy makers, and health care insurance companies. Nonetheless, in many countries, the main responsibility for developing and implementing policies related to physical activity in the general population primarily rests at the regional and local levels [121].

Policymakers of transplant centres report considerable barriers to the organization of posttransplant exercise-based rehabilitation programs, including the costs of supervised exercise programs, the lack of space, and the lack of standardized rehabilitation protocols and guidelines [89]. Additionally, specific expertise and dedicated time, with the associated financial resources are required. As such, it is striking to observe that posttransplant exercise-based rehabilitation programs after abdominal organ transplantation are virtually non-existent, while exercise-based rehabilitation after heart or lung transplantation are part of usual care in many centres and countries [89]. As all types of transplant recipients experience clinical benefits from posttransplant rehabilitation, this discrepancy highlights the fact that the field of exercise-based rehabilitation in abdominal organ transplantation lags behind, both at the research and clinical level.

Unfortunately, in today's climate of rising health care costs, medical interventions require a certain degree of cost-effectiveness [122]. The balance between the cost of implementing physical activity and exercise-based rehabilitation programs versus the clinical and economic gains from e.g., lowered productivity losses and reduced need for hospitalizations and medication remains to be evaluated in transplant recipients. However, exercise-based rehabilitation has been shown to be cost-effective in many other chronic disease populations [123,124].

#### 3.2.7. Legal Context

According to CICI, the legal context is "concerned with the rules and regulations that have been established to protect a population's rights and societal interests. Formally, these have to be passed by a competent legislative body like a parliament. Legal norms can mostly be enforced with order and compulsion, which distinguishes them from ethical and social norms" [4].

Reimbursement of physical therapy varies by country, state, type of insurance plan (public or private), type of exercise-based rehabilitation (e.g., inpatient vs. outpatient), and type of organ transplantation. The variable and uncertain insurance coverage of physical activity or exercise-based rehabilitation programs hinder their implementation by health care providers in cancer survivors [125]. Similarly, lack of private insurance coverage in transplant recipients negatively influences the level of physical activity engagement [70,72].

### *3.3. Physical Activity Intervention Development: BCW Steps 5–7*

The notion that a general and unidirectional recommendation from the health care providers is considered sufficiently motivating for transplant recipients to engage in exercise-based rehabilitation and a long-term physical active lifestyle is manifestly outdated. Interventions that aim to achieve long-term behaviour changes should consider using of a combination of promising behaviour change techniques [126], also regarded as the smallest 'active ingredient' of an intervention. Recent developments in the field of behaviour change have led to the definition of 93 internationally agreed and validated behaviour change techniques: the Behaviour Change Technique Taxonomy version1 (BCTTv1) [126]. In the present study, according to steps 5–7 of the BCW, intervention functions, policy changes, and behaviour change techniques (BCTTv1) were proposed per TDF domain (Table 5). The following section first briefly summarises important evidence- and theory-based insights from other populations, and subsequently discusses the identified intervention functions embedded in the seven context domains of CICI.

**Table 5.** Proposed behaviour change techniques per TDF domain.

| COM-B | TDF<br>Target | Intervention Function | Policy Category | Potential BCT |
|---|---|---|---|---|
| **Physical Capability** | **Physical skills**<br>Being physically able to engage in physical activity within a wide range of intensities, volumes, and types. | **Enablement:** Assessment and follow-up of physical fitness, co-morbidities, weight and medication. Manage fatigue and pain to improve patients' ability to be physically active.<br>**Training:** Create a personalized physical activity program and demonstrate exercises that get around physical limitations. | Service regulation | 8.1 Behavioural rehearsal/practice<br>6.1 Demonstration of the behaviour<br>4.1 Instructions on how to perform the behaviour<br>1.2 Problem solving |
| **Psychological Capability** | **Knowledge**<br>Increase knowledge of patients, health care providers, and patients' social network about why, when, how, and how often transplant recipients should participate in physical activity.<br>Development of transplant-specific physical activity recommendations and guidelines. | **Education:** Provide education to transplant recipients and health care providers to increase knowledge and awareness of the why, how, when, and how often transplant recipients should be physically active. Patients' social network should accordingly be educated on these topics.<br>**Environmental restructuring:** Development of uniform transplant-specific physical activity guidelines and recommendations.<br>**Environmental restructuring:** Provision of physical activity and exercise information booklets to share with transplant recipients' social network. | Communication<br>Guidelines | 5.1 Information about health consequences<br>5.3 Information about social and environmental consequences<br>2.2 Feedback on behaviour<br>4.1 Instructions on how to perform the behaviour |
| **Physical Opportunity** | **Environmental context and resources**<br>Creating access and opportunities to participate in physical activity and rehabilitation.Reduce costs of physical activity/rehabilitation. | **Training:** health care providers should provide training in problem-solving thinking to reduce patients' environmental barriers.<br>**Environmental restructuring:** Provision of home-based exercise programs and/or governmental action to create opportunities to be physically active in the community (e.g., sidewalks, mixed land use, transport, parks, etc.).<br>**Environmental restructuring:** Provide financial solutions/support for financial vulnerable transplant recipients.<br>**Environmental restructuring:** Restructuring social environment/network in transplant unit to build a "movement culture". | Service Provision<br>Environmental/social planning<br>Fiscal | 1.2 Problem solving<br>12.1 Restructuring the physical environment<br>12.5 Adding objects to the environment |
| **Social Opportunity** | **Social influences Social—professional role and identity**<br>Creation of an encouraging and supporting environment to participate in physical activity.Integrate physical activity in to social/professional role and identity. | **Environmental restructuring:** Provision of physical activity and exercise information booklets to share with transplant recipients' social environment/network.<br>**Environmental restructuring:** Provision of in group physical activity and exercise programs.<br>**Persuasion:** Creating a social environment in which family, friends, and health care providers actively encourage and support patients to engage in physical activity.<br>**Modelling:** Using champions (individuals who act as "the face" of an implementation effort) and encouraging 'social comparison' to increase perceptions of feasibility, safety, and acceptability of physical activity.<br>**Environmental restructuring:** Integrate incidental physical activities in patients' social roles, e.g., active transport to work or the store, gardening, housework, playing with the (grand)kids. | Environmental/social planning<br>Regulation<br>Service provision | 2.2 Feedback on behaviour<br>2.1 Monitoring of behaviour by others<br>3.1–3.3 Social support (general–practical–emotional)<br>6.2 Social comparison<br>10.4 Social reward<br>12.2 Restructuring the social environment |
| **Automatic and reflective motivation** | **Emotions**<br>**Beliefs about consequences**<br>**Beliefs about capabilities**<br>Reduce anxiety towards physical activity, promoting self-efficacy and confidence. | **Persuasion:** Verbal persuasion from trusted health care providers that transplant recipient is fit to exercise safely.<br>**Education:** Provide education about the safety and benefits of physical activity and in this way increase self-efficacy.<br>**Education/training:** Provide education about the normal physiological effects of physical activity and provide training to recognize and familiarize bodily signals.<br>**Modelling:** Identify experienced physically active transplant recipients to act as champions and role models to help build self-efficacy among other transplant recipients through vicarious learning.<br>**Training:** Graded physical activity program to increase transplant recipients' feelings of self-efficacy through mastery experiences. Focus on small goals and past successes. | Communication<br>Environmental/social planning<br>Regulation<br>Service provision | 5.6 Emotional consequences<br>11.2 Regulate negative emotions<br>11.3 Conserving mental resources<br>8.7 Graded tasks<br>2.6 Biofeedback<br>15.1 Verbal persuasion to boost self-efficacy<br>15.2 Mental rehearsal of successful performance<br>15.4 Self-talk<br>15.3 Focus on past success |

**Table 5.** *Cont.*

| COM-B | TDF<br>Target | Intervention Function | Policy Category | Potential BCT |
|---|---|---|---|---|
| | **Intentions**<br>**Goals**<br>**Emotion and behavioural regulation**<br>Changing priorities and time management towards physical activity.<br>Increase intrinsic motivation.Goal setting in a specific, measurable, achievable, realistic, and timely way.Routine formation. | **Enablement:** Physical activity action planning according to SMART goal setting.<br>**Persuasion:** Discuss with patients' activities and exercise that may be enjoyable to them.<br>**Persuasion:** Discuss with patients how to overcome barriers to engage in physical activity and exercise.<br>**Persuasion:** Increase intrinsic motivation by means of motivation interviewing techniques.<br>**Incentivizing:** Incentivize transplant recipients' physical activity by self-monitoring of physical activity behaviour (reaching goal) or holding individual or team-based play and competitions.<br>**Coercion:** Creating awareness of association between low physical activity and health care costs.<br>**Enablement:** Habit formation. | Communication<br>Environmental/social planning<br>Regulation<br>Service provision | 1.2 Goal setting<br>1.4 Action planning (including implementation intentions)<br>1.6 Discrepancy between current behaviour and goal<br>1.7 Review outcome goals<br>2.3 Self-monitoring of behaviour<br>10.9 Self-reward |

Meta-analyses have indicated the following behaviour change techniques to be effective in (overweight) non-transplanted individuals seeking to adopt and maintain a physically active lifestyle: action planning, self-monitoring of behaviour, instruction on how to perform the behaviour, prompts/cues, behaviour practice/rehearsal, graded tasks, and self-reward [127–129]. Additionally, these studies showed that by inciting an intrinsic and autonomous motivation to change, patient-centred and autonomy-supportive communication methods such as motivational interviewing are helpful to achieve long-term changes in physical activity behaviour [128]. These findings are in line with behaviour change maintenance theories, which highlight the value of sustained maintenance motivators (e.g., enjoyment from and satisfaction with the outcomes from physical activity), self-regulation of physical activity (e.g., monitoring of and overcoming barriers to physical activity), abundant resources and opportunities to be physically active, habit formation, and social support [130].

Research data on how behaviour change techniques may stimulate transplant recipients to participate in a long-term physically active lifestyle are scarce. Intervention functions, policy changes, and behaviour change techniques were proposed per TDF domain (Table 5). Intervention functions are embedded and discussed per CICI context dimension domain below.

#### 3.3.1. Geographical Context—Interventions

##### Environmental Context and Resources (TDF)

Healthcare professionals are well placed to assist patients in problem-solving around the environmental barriers [71]. For instance, barriers originating from medical confinement measures, bad weather, or commute to the transplant rehabilitation centre can at least partially be overcome by remotely-mediated home-based programs using teleconference and pre-recorded training videos [131–133]. Transplant recipients have expressed the need for affordable digital health care tools that preferentially include a reward system, integration of multiple functions, and the ability to selectively share information with peers and health care providers [77].

Next, governmental support in the (re-)design of urban environments could promote physical activity by developing safe and highly connected neighbourhoods that allow and promote walking (e.g., high-quality sidewalks, nearby parks, nearby benches to take a rest, mixed land use), cycling (e.g., interconnected and safe cycling lanes), and other activity forms [91,134].

#### 3.3.2. Epidemiological Context—Interventions

##### COVID-19 Pandemic

The COVID-19 pandemic has prompted several transplant centres to transition from centre-based outpatient programs to remote exercise programs, and this was found to show promise in regard to feasibility and effectiveness [77,135].

Although the effects of physical activity and exercise in immunosuppressed transplant recipients remain to be established, it is not unlikely that—in line with observations in the general population—such would improve immunosurveillance [42]. While not objectively documented, heart transplant recipients reported feeling more resilient to infections after a 10–week period of aerobic treadmill training and feeling more confident to engage in social interactions [83].

##### Physical Skills and Limitations (TDF)

Health care providers should not discount the importance of health-related barriers to a patient's physical activity behaviour. These may include fatigue, poor strength, poor cardiorespiratory fitness, poor postural balance, shortness of breath, pain, overweight, comorbidities, and side effects of medication. A thorough review of the patient's medical history and if possible and/or indicated a physical assessment are recommended at baseline, to allow for personalized recommendations to get around and/or treat physical limitations.

In selected patients, exercise training may be part of the solution to physical limitations (e.g., fatigue, low cardiorespiratory and muscular fitness, and poor postural balance) which in turn will reinforce maintenance behaviour of physical activity [11,69,73,79,83].

#### 3.3.3. Socio-Cultural Context—Interventions

##### Ethnicity and Culture

Tailoring physical activity programs to the patient's preferences may prove important to overcome ethnic-specific barriers to physical activity. Initiating or reinforcing group activities in which the patient finds a sense of belonging and connectedness may be important in this regard. In one study, South-Asian women with chronic kidney disease reported identifying themselves as the main care provider in the home [100]. Focusing on increasing incidental physical activity in these patients may be a suitable strategy that respects time constraints associated with their social role. Nonetheless, in this particular study, these patients preferred to use dedicated protected time for physical activity outside the home in the local community [100].

##### Knowledge (TDF)

It is self-evident that transplant recipients and their contacts should have adequate knowledge about why, how, and how often to engage in physical activity, exercise, or exercise-based rehabilitation [11,69,70,72]. Knowledge transfer by health care providers, information from patients leaflets or online resources, and communication with knowledgeable peers, peer-modelling and patient champions are warranted. Transplant recipients specifically value advice and information from those with expertise in both transplantation and physical activity/exercise [11,69,70,72].

In this regard, exercise professionals who are unfamiliar with organ transplantation would benefit from education on transplant procedures, the transplant recovery process, common medication side-effects, and the psychological and physiological impact of underlying disease and transplantation. Transplant physicians should acquire adequate knowledge on the benefits and strategic implementation of physical activity, exercise, and exercise-based rehabilitation [11,69,70,72]. In a 2014 report, transplant physicians almost unanimously acknowledge the value of posttransplant physical activity, but report that they feel insufficiently confident in physical activity counselling [113]. Although this may indicate that continuing education is insufficient, these data reflect the situation in 2014 and may to some extent be outdated. Online resources are increasingly available (e.g., https://canrestore.wordpress.com/healthcare-professionals/, accessed on 17 January 2022) as are opportunities to participate in international scientific symposia (e.g., https://transplantoux-symposium.org/, accessed on 17 January 2022).

##### Social Influences; Social—Professional Identity (TDF)

For physically inactive transplant recipients to truly start engaging in physical activity and move away from procrastinating behaviour, guidance and support by an external social structure seems imperative [136]. Physical activity behaviour is widely influenced by social aspects [137], but living with a chronic disease can be an isolating process [138]. After transplantation, patients may need to rebuild social networks to reintegrate in society; physical activity initiation in group settings may provide such opportunities. Co-creation of physical activity programs should attempt to include the patient's current social network while taking advantage of new network opportunities such as local patient organisations, walking groups, or other physical activity initiatives. Involvement of a community that provides not only opportunity to physical activity engagement, but also support, camaraderie, and accountability is likely to enhance adherence to physical activity and should therefore be part of physical activity interventions [11,69,71,72,74,79,83]. The availability of exercise partners (e.g., from group sessions), transplant-specific sport organisations (e.g., Transplantoux [139]), role models, and, most importantly, encouragement and support from health care providers, family members, and friends are pivotal in this regard [69,71,72].

The patient's family and friends may be insufficiently knowledgeable about the health issue and therefore be more reluctant to support engagement in physical activity. Education of the patient's social network on the benefits of physical activity could be important in this regard.

Over the last decades, the traditional generic advice from health care providers 'to try and be active' is being replaced with patient-centered and autonomy-supportive communication methods. Physical activity interventions are no longer standard programs consisting of predetermined volume, intensity, frequency, type, and timing of physical activity anymore. Instead, programs are highly adapted to the context, preferences, and abilities of the adequately informed patient and are therefore the result of a co-creation process involving careful interaction, mutual respect, and shared decision making. Though initially more time consuming and requiring broader expertise of the health care provider, the proven short—and long-term effectiveness of this approach far outweighs these drawbacks [127–129].

Transplant recipients expressed the preference to be able to participate in physical activity along with other transplant recipients [81]. This environment is expected to provide social support in the form of sharing and learning, accountability, a sense of normalcy, and inclusion [81]. In the older age group of the general population, the perception of commonality and feelings of cohesion and connectedness can predict short- and long-term physical activity adherence [137]. A peer-support system could be a useful intervention strategy for physical activity behaviour change and merits further investigation [71].

Incidental physical activities can be integrated in the patient's social roles, such as active commuting for work and errands, gardening, household chores, playing with the (grand)kids or pets. These types of activities do not require the dedicated time, conscious planning, and physical effort typical of exercise training and may therefore be more easily implemented in daily life.

Goals; Intentions; Emotional/Behavioural Regulation (TDF)

Incidental physical activity may help overcome barriers such as a lack of time, costs, equipment, lack of skills, or poor fitness [140]. Furthermore, when embedded in daily routine, incidental activities require no external motivation to maintain this behaviour in the long term. An alternative to increasing incidental physical activity is the 'snacktivity' approach [141] which promotes the implementation of short (2–5 min) but frequent bouts of physical activity throughout the day. Snacktivity can easily be organized around daily life or work activities: walking during conversations, substituting the stairs for the elevator, or performing simple lower body exercises such as squats and lunges while brushing teeth, vacuuming the house or waiting for the kettle to boil. This approach may be preferred over longer bouts of physical activity, as each 'exercise snack' only requires a small time commitment, no planning, and less effort. Furthermore, in line with incidental physical activity, the snacktivity approach does not require a change of clothes, exercise equipment, or dedicated work out space. The concept also allows to 'start small' and celebrate small successes, which promotes self-efficacy and new habit formation. Lastly, sporadic high-intensity 'exercise snacks' performed either during incidental physical activity (e.g., vigorous cycling during a commute) [140] or as planned exercise snacks (e.g., vigorously ascending a three-flight stairwell several times a day) [142] may serve as a potent intervention to improve and maintain physical health. However, the majority of transplant recipients do not enjoy high-intensity physical activities because of the accompanying bodily signals and discomforts. For these patients, a stepwise approach of reducing sedentary behaviour, and progressively increasing moderate-intensity physical activity may be more appropriate [55].

Whatever the type, intensity, and frequency of physical activity is intended, clear goal setting and a plan of action should be developed. Goals setting typically uses the Specific, Measurable, Achievable, Realistic, and Time bound (SMART) principle [143]. As part of the co-design of the physical activity program, goals should be tailored to patients' abilities, preferences, and perceived barriers or motivators. Goal setting using the SMART acronym has, however, been subjected to critique, among other reasons for not being based on scientific theory [144]. As an example, the process of goal setting in line with the goal-setting theory of Locke and Latham [145] requires initial assessment of commitment, knowledge, resources, and abilities. If present, specific, challenging performance goals (e.g., reach 7500 steps per day) could be set. However, if any of the aforementioned moderators are not present, then specific, challenging learning goals (e.g., identify and implement five ways to increase your daily step count) should be set prior to setting performance goals [144]. Follow-up moments are essential for feedback and adjustment of goals and strategies if so required. In this regard, prompts and cues by means of text-messages or phone calls, are proven to be effective [146–148]. Moreover, today's technology offers patients a wide range of physical activity monitors that allow for self-monitoring and that facilitate evaluation during follow-up, factors known to promote maintenance of physical activity [129].

Emotions; Beliefs about Capabilities; Beliefs about Consequences (TDF)

Transplant recipients may feel overprotective over their transplant organ because they are unaware of the benefits of physical activity after transplantation. Such insecurity may lead to low physical self-efficacy and fear of movement, giving rise to a vicious cycle of physical inactivity [75]. Ample evidence supports the importance of physical self-efficacy in lifestyle interventions [75]. Performance accomplishments are the first and most powerful source of self-efficacy. In this regard, 'action planning' and 'focus on small incremental successes may help achieve physical activity goals and increase mastery experience. Second, 'verbal persuasion about patients' ability' can be used by health care providers and peers to increase self-efficacy. Third, 'social comparison', where transplant recipients observe peers succeeding, may increase a patients' confidence to perform the same task. Lastly, moods and emotions, such as anxiety or insecurity perceived as signals of harm (e.g., discomfort, dehydration, or fatigue), may influence how a patient feels about their ability to engage in physical activity and exercise. Exercise-based rehabilitation shortly after transplantation in a safe and supported environment increases the ability to participate in physical activity not only by improving physical fitness, but also by reassuring patients that experienced body signals during exercise are neither harmful nor abnormal [11,75].

Transplant recipients are, however, at an increased risk for developing cardiovascular disease, and should be taught the distinction between normal and abnormal body signals during exercise. A baseline pre-participation medical screening is therefore highly recommended [149]. Furthermore, medical clearance may further reassure transplant recipients that physical activity along the entire spectrum of low to vigorous intensity is safe from a cardiovascular point of view. However, pre-participation screening may also be conceived as a cumbersome and costly barrier for initiation of physical activity [150]. Physical activity programs within the light-to-moderate intensity range do not require pre-participation screening [149].

#### 3.3.4. Socio-Economic Context—Interventions

Environmental Context and Recourses (TDF)

Transplant recipients may experience financial hardship secondary to change in employment status and increased medical expenses [81]. Costs of physical activity [74,81], costs of fitness/rehabilitation centres [72,79,80], and limited financial resources [11,69] are known barriers to physical activity. The development of physical activity interventions should take into account that participation in physical activity may (e.g., golf, fitness center subscription) but by no means should (e.g., walking) be associated with high financial costs. Nonetheless, reimbursement of physical activity and exercise-based rehabilitation may be an important motivator. A recent pilot study in kidney and liver transplant recipients showed that participants who received a wearable physical activity monitor, and who were given health engagement questions and 'loss-framed' financial incentives, increased their daily steps more than those not receiving health engagement questions and financial incentives [151].

#### 3.3.5. Ethical Context—Interventions

The common desire of transplant recipients to play tribute to their donor motivates many to engage in physical activity [77]. However, using the 'gift of life' metaphor to motivate transplant recipients into physical activity participation is a morally questionable strategy, because it exploits and potentially strengthens the sense of guilt, and causes distress [119,120].

#### 3.3.6. Political Context—Interventions

Most transplant physicians prioritize immediate medical care over counselling on physical activity, and—at the most—refer their patients to specialists in the field (e.g., physical therapists). Despite the growing body of (in)direct evidence of the pleiotropic health benefits of physical activity following solid organ transplantation, the promotion of counselling and referral behaviour amongst physicians warrants the refinement of transplant organ-specific recommendations and their implementation strategies [89,113]. Furthermore, diligent cost-effectiveness analyses of physical activity and exercise-based rehabilitation are required for political bodies to support financial reimbursement of such interventions. Studies in the general and cardiac patient population have suggested favourable cost-effectiveness of various physical activity interventions [152–154]. Exercise referral programs that target populations at risk are more cost-effective, and population-level interventions have a higher potential for high cost-effectiveness than individual-level interventions do [152].

#### 3.3.7. Legal Context—Interventions

Lack of resources of financial nature, space, expertise, and/or time, are known barriers for policy makers from transplant centres to provide physical rehabilitation programs and guidance [89]. Government support may be needed to help health care professionals to endorse the promotion of physical activity after solid organ transplantation [108]. Insurance coverage of physical activity programs is often insufficient and unclear [125]. Transparent communication about insurance coverage, to patients and health care providers, could overcome the uncertainty associated with cumbersome reimbursement procedures of physical activity programs [125].

## 4. Limitations

In the present study, target behaviour focused on physical activity, which by definition is an overarching term to denote bodily movement produced by skeletal muscles that increases energy expenditure above 1.5 METs and hence also includes both 'exercise' and 'exercise-based rehabilitation'. Most studies evaluating patient-reported barriers and motivators did not differentiate between physical activity and exercise. However, it is not unlikely that solid organ transplant recipients would ascribe barriers and motivators to each of these three activity types, had they been explained the difference between them. By consequence, promoting physical activity, exercise, and exercise-based rehabilitation may require distinct behaviour change strategies, and further research to explore this question is warranted.

Trials investigating implementation outcomes and strategies for long-term physical activity engagement after transplantation are scarce. The research field is dominated by exercise trials performed in controlled research settings and are therefore associated with high selection bias and questionable potential for implementation [155]. The present study systematically screened the literature for studies evaluating patient-reported barriers and motivators for physical activity (step 4 of the BCW) based on which theory-driven intervention functions, policy changes, and behavioural change techniques were identified (steps 5–7 of the BCW). However, we did not systematically review the literature for evidence-based physical activity interventions.

The final step outlined by the BCW (step 8) includes the evaluation of proposed interventions based on APEASE criteria (affordability, practicality, effectiveness/cost-effectiveness, affordability, safety/side effects, and equity), which helps in selecting the most suitable intervention strategies within a given context and setting. However, since findings would vary between countries, regions, and the context of the local transplant centre, [156], such would require a thorough analysis of the local setting by means of multi-methods analysis, guided by e.g., the Chronic Care Model [157]. The present study therefore may facilitate the development of physical activity interventions, but does not provide a readily implementable physical activity program.

## 5. Conclusions and Take Home Messages

Ample scientific evidence indicates that physical inactivity is a major but modifiable risk factor for adverse outcome after organ transplantation. Physical activity, exercise, and exercise-based rehabilitation interventions are feasible and safe strategies to improve clinical outcome. Unfortunately, in the real world, a major discrepancy exists between the recommendations for physical activity and their application by patients. The present study investigated contextual factors of posttransplant physical activity behaviour, in which patients' perceived barriers and motivators were embedded. Based on this analysis, an array of behavioural change techniques were proposed (Table 5).

Kidney transplant recipients comprised the majority of included individuals ($n$ = 1272; 66%), followed by liver ($n$ = 263; 14%), lung ($n$ = 259; 13%), and heart ($n$ = 122; 6%) transplant recipients. A few studies that included mixed groups of transplant patients reported that no differences in barriers and motivators were apparent between different solid organ transplant groups [11,76]. Below we present a set of selected physical activity intervention strategies we consider most promising to promote patients' long-term physical activity behaviour.

Physical activity programs should be personalized to the patient's abilities and preferences. The plan of action should work around physical limitations and patient-reported barriers, whilst focusing on the patients' motivators. SMART goals should be established, applying a stepwise approach that aims for consecutive small success experiences and habit formation. Habit formation may be facilitated by focussing on incidental physical activity, the snacktivity concept, and inclusion of social relationships in recurrent physical activities. Consecutive small success experiences may be facilitated by replacing sedentary behaviour by light physical activity. Given that light physical activity is not or less accompanied by pronounced bodily signals and discomforts, its long-term implementation may be more likely and, at least for some, serve as a step up to long-term moderate- to vigorous-intensity physical activity goals. Greater and more challenging goals settings may also be of value, particularly when these are meaningful for the patient. Importantly, physical activity interventions should be co-designed by the health care provider and the patient, in which they collaborate as equal team members. The role of the health care player is to incite intrinsic motivation, inform whenever necessary, and stimulate the patient to co-create the intervention through shared decision making. Follow-up prompts that gradually taper over time should be scheduled to enable program adjustments and reinforcement of physical activity maintenance.

Solid organ transplant recipients as well as their social relationships (e.g., family and friends) should be informed about the health benefits of posttransplant physical activity participation. It is important for transplant recipients to know why, how, when, and how often they should engage in physical activity. Furthermore, transplant patients should become aware of what normal bodily signals are that occur in association with physical activity, within a wide range of activity types and intensities. Education and familiarization are useful in that regard. Appropriate knowledge on physical activity is important, but physical activity participation solely out of duty may be insufficient to guarantee maintenance on the long-term. Participation out of interest (e.g., associated social interactions) or habit will likely further promote physical activity on the long-term.

Opportunities to engage in physical activity should be abundant, and the creation of new opportunities should be encouraged. The exploitation of incidental physical activity possibilities and the introduction of 'exercise snacks' may create such opportunities, and so does involvement of the patient's social network. Physical activity in group settings, where patients find a sense of belonging and connectedness, may hold the key to activate some of them. Activities with peers and patient 'champions' are great motivators, but such opportunities may not always be available for all. Environmental barriers for physical activity and exercise-based rehabilitation can be at least partially resolved through remotely-mediated home-based programs and through stimulating the patient's autonomous problem-solving thinking.

Although opportunities may be plentiful, often times, cues for physical activity engagement are required to emphasize them. Cues can manifest in many forms. Smart watches (e.g., commercially available activity trackers) are excellent tools to simultaneously provide cues to engage in physical activity (e.g., buzzing or beeping upon long bouts of sedentary time) and self-monitor physical activity behaviour.

Encouragement and support from the health care team's and recipient's social networks promote physical activity initiation and maintenance. Health care providers will become more likely to support and prescribe physical activity after receiving adequate information on the health benefits of posttransplant physical activity and the specific physical activity recommendations for their patients.

Finally, policymakers may promote physical activity by the thoughtful restructuring of a patients living environment (e.g., sidewalks, mixed land use, interconnected public transport, parks) and by foreseeing financial support to participation in physical activity, particularly in financially vulnerable transplant recipients.

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