Thieme

Successful Rehabilitation of a 22-Year-Old Outpatient after Heart Transplantation with Severe Complications

Case Report

Erfolgreiche Rehabilitation eines 22-jährigen ambulanten Patienten nach Herztransplantation mit schwerwiegenden Komplikationen

Fallbericht

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ZUSAMMENFASSUNG

Hintergrund Es besteht Einigkeit darüber, dass Übungstherapie ein wichtiger Bestandteil der Rehabilitation von Patienten nach Herztransplantation (HTX) ist. Neuere Studien zeigten, dass intensives Intervalltraining effektiver ist als geringes bis moderates Intensitätstraining. Mehrere Studien beschrieben die Reinnervation des para- und sympathischen Nervensystems. Die Konsequenzen dieser Ergebnisse wurden jedoch nicht umgesetzt, und aktuelle Leitlinien zur Verordnung von Training bei HTX liegen nicht vor. Außerdem können Komorbidität und negative Nebeneffekte in der klinischen Praxis den Rehabilitationsprozess nach HTX erschweren.
Ziel Dieser Fallbericht beschreibt ein erfolgreiches individuelles Rehabilitationsprogramm.
Methode Nach einer orthotopen HTX litt ein 22-jähriger Patient unter schwerwiegenden Komplikationen mit einer zerebrovaskulären Episode, die eine Hemiplegie und ein akutes beidseitiges Nierenversagen auslöste. Massive Einschränkungen in täglichen Aktivitäten aufgrund physischer, sozialer und psychologischer Faktoren traten auf. Obwohl diese Faktoren das Rehabilitationsprogramm beeinflussten, verhinderten sie nicht die Anwendung eines erfolgreichen intensiven Intervall-Trainingsprogramms.
Ergebnisse/Schlussfolgerung Trotz massiver Einschränkungen zu Beginn, hielt sich der Patient an ein konsequentes Übungstherapieprogramm einschließlich hoch intensives Training und gewann an Unabhängigkeit und besserer Lebensqualität.

ABSTRACT

Background There is a consensus that exercise therapy is an important component in patient rehabilitation after heart transplantation (HTX). Recent studies showed that intensive interval training is more effective than low to moderate intensity training. Several studies described reinnervation of both the para- and sympathetic nervous system. The consequences of these findings have, however, not been implemented and up-to-date guidelines on exercise prescription in HTX do not exist. Furthermore, in clinical practice comorbidity and negative side-effects can aggravate the rehabilitation process after HTX.
Objective This case report describes a successful individual rehabilitation programme.
Method After an orthotope HTX A 22-year-old male patient suffered from severe complications with a cerebrovascular accident causing a hemiplegia and an acute both-sided renal failure. Massive restrictions in daily activities due to physical, social and psychological factors became apparent. Although these factors affected the rehabilitation process, they did not inhibit the successful application of an intensive interval exercise programme.
Results/Conclusions Despite massive initial restrictions the patient well tolerated a consequent exercise therapy programme consisting of high intensity training and attained independency and a better quality of life level.

Introduction

The opportunity to rehabilitate a young adult after heart transplantation (HTX) in a private physiotherapy institution in Switzerland is not very common. Although there had been 134 people on the waiting list in 2015 in Switzerland, only 40 people underwent heart transplantation [30]. As a consequence only patients with severe terminal heart failure, where other possible interventions (medication, catheterisation and electrical therapy) had shown no effect and any contraindications were considerated for HTX. Despite the often deconditioned state [22] one year patient survival rate after HTX in Switzerland is about 80 % [23]. But even after HTX, medication with complex interactions and without high-risk negative side-effects is essential.

During rehabilitation of patients after HTX physiotherapists are confronted with various problems. Some of these are a result of the disease, operation and medication, whereas others are related to the patients themselves as unique individuals with their own needs and wishes. A classification according to the International Classification of Functioning (ICF; [33]) can be helpful to categorize and identify factors that determine the individual health problem. It allows the consideration of not only anatomic and functional factors, but also psychological and social aspects.

Heart failure can have numerous different causes. An idiopathic dilated cardiomyopathy is the most common cause to be found in young people [6, 32]. Patients considered for HTX are set on a waiting list. In Switzerland the average number of days on the waiting list for HTX is 302 days [29]. During this period the patients become more and more deconditioned accompanied by reduced maximum oxygen consumption (VO_2max) and poor aerobic capacity [5]. Changes in the skeletal muscle including impaired skeletal muscle metabolism, reduced oxidative enzyme activity, altered fibre-type composition and decreased capillarisation become also apparent [26].

As soon as a suitable donor heart is found the patient receives a complex and high-risk operation lasting four to six hours in one of the three specialized hospitals in Switzerland (Bern, Lausanne, Zürich). The implanted donor heart is completely denervated and does not respond to manipulations of the sympathetic nervous system. Therefore, HTX recipients have significant higher heart rates at rest (intrinsic heart rate [14]) and typically lies between 90 and 110 beats, depending on age and health [13, 20]. The response to activity and exercise is then mainly controlled by catecholamines of the adrenal glands resulting in significantly slower heartrate increase at onset of exercise, a reduced peak heart rate and a slower heart rate decrease after exercise [20]. Usually, a growing arterial blood pressure occurs [19, 24]. 70 – 95 % of patients suffer from arterial hypertension after HTX [18]. The genesis of arterial hypertension involves many pathophysiological mechanisms depending on the transplanted heart, but also on (vital) immunosuppressive medication [3].

Arterial hypertension is not a harmless comorbidity of HTX, since it is associated with graft impairment and general survival [3]. More side-effects of immunosuppressive (including corticosteroid) medication are growing infection risk, renal insufficiency (kidney failure; [15]), higher cancer risk [27], skeletal muscle myopathy [16, 27] and osteoporosis [5, 16].

Patient Rehabilitation after HTX

The rehabilitation process after HTX involves multiple disciplines. Along with the medical team consisting of surgeons, cardiologists and nurses, nutrition specialists, social workers, psychologists, care coordinators and – of course – physiotherapists are necessary [13]. In patient care communication within this multidisciplinary healthcare team is essential [24]. Since physical activity has proven to be of great relevance in post-transplantation rehabilitation [10], physiotherapists play an important role. They must have insight in the pathophysiological background of the pre- and postoperative situation in order to be able to apply an adequate exercise programme.

During the past four decades the number of reports about the positive effects of physical exercise in patients after HTX has rapidly and unmistakably grown [17]. Patients after HTX tolerate well endurance and resistance training [17]. There is a growing consensus that specific endurance and resistance training can reduce and prevent negative side-effects of immunosuppression and corticosteroids, such as osteoporosis and skeletal muscle myopathy [5, 31].

A meta-analysis of 2011 concluded that exercise training after HTX can be recommended to improve VO_2max and muscle strength [11]. A recent study showed that a 12 week exercise therapy in patients after HTX was effective in reducing blood pressure and that it had no impact on the control group without exercise therapy [21]. Carvalho et al. [7] described exercise training to be an important tool in patients after HTX to improve exercise capacity, muscle strength, quality of life and the chronotopic response. There is, however, no agreement about the most adequate exercise method.

Low to moderate intensity exercise is reported to be safe and recommendable in patients after HTX [8]. In recent studies high intensity (and high intensity interval) exercise programmes produced even better performances in patients after HTX than moderate ones [8, 20, 25]. The results are yet equivalent to sedentary or moderately trained healthy subjects [8, 20, 25]. The widespread belief for decades that the transplanted heart remains denervated was largely disproved by the detection of sympathetic and parasympathetic reinnervation [10, 12]. The consequences of these findings have not yet been implemented and up-to-date guidelines on exercise prescription in HTX do still not exist [20].

This case report portrays the rehabilitation of a patient after HTX. An individual therapy approach based on the biopsychosocial model with the main outcome measure of improving independency and quality of life was performed. In order to achieve these objectives, knowledge of scientific recommendations as well as patient values had to be combined and adjusted. During the rehabilitation aerobic fitness (VO_2max), heart rate reserve (HRR), power (Watt), recovery (heart rate/time) as well as subjective (self-assessment by numeric rating scale with 4 items: overall well-being, physical and social function, mental health) quality of life were objectively evaluated.

Date: 14.11.2014 Patient: B.L. Age: 23		**ICD:** State after HTX, CVI with Hemiplegia left, renal failure	Medication: Immunosuppression, Corticosteroids, Beta-blocker Coordinator: MK
Patient/family perceptions of problems and disabilities	Restricted function left body side Reduced endurance and general condition	Difficulties in quick and uphill walking. Difficulties in climbing stairs. Difficulties in using left arm in daily activities (dressing, washing, lifting etc.) Able to cycle on a tricycle	Unable to work Unable to participate in sports club Dialysis 3 x 4h/week
	Body structures/functions ⟷	**Activities** ⟷	**Participation**
Health professional identification of mediators relevant to target problems	Restricted strength left body side (b7302) Restricted trunk strength (b7305) Increased muscle tonus left leg (b7351) Reduced local and total endurance (b7402)	6MWT: 420 meters (d450.3) Fine hand use (d440.3) Lifting and carrying objects (d430.3) Carrying out daily routine (d230.3) General condition: NSR 40/100 VO_2max: 22.11ml/(kg.min) HRR:29 QL: 35/100	Work and employment (d859.3) Recreation and leisure (d920.3)
Personal factors		**Environmental factors**	
Active coping strategy (CSQ 60/100) Distress because of surrounding factors as economic dependency and conflicts with authorities		Missing social contacts without work and participation in clubs (e325-3). Well integrated and supporting family (e310+3). Support of professional health care team (e355+3). Conflicts with authorities of transportation (e5408-3) and insurance & finance (e5658-3)	

▶ **Fig. 1** Rehabilitation Problem-Solving Form (RPS-Form) showing the patient's health problem [28]. (Quelle: M. Kandel; graf. Umsetzung: Thieme Gruppe).

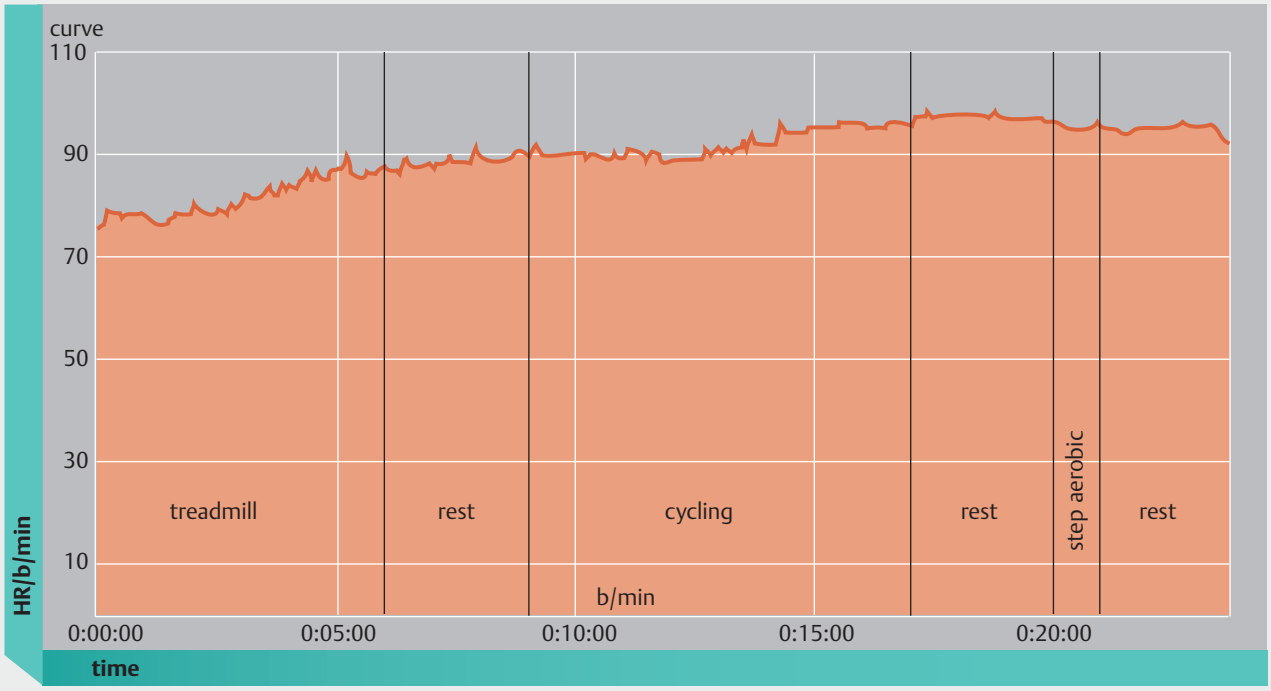
Patient presentation

When a 22 year old athletic male (competitive swimmer) all of a sudden felt sick he first thought of having caught the flu. Within a few days the symptoms got worse and as he started suffering from strong stabbing pain, he was referred to hospital. After a transient ischemic attack (TIA) a splenic as well as a renal infarction and a heart failure due to a dilated cardiomyopathy were diagnosed. Two months later he was set on the waiting list for a HTX and received a mobile biventricular assist device system. This extracorporeal electro-pneumatically driven system was adjusted at a continuous frequency of 70 beats per minute which allowed the patient to stay in his familiar environment and to go for little walks.

During this period the patient experienced several thromboembolic events. Due to the fact that he was again referred to hospital he received an urgent status for transplantation. Eleven months after he had been set on the waiting list a suitable heart was available and the HTX was performed within a few hours. The heart transplantation ran smoothly, subsequently, however, serious complications occurred. The patient had a stroke (cerebrovascular accident) causing a left-sided hemiplegia and an acute renal failure on both sides. Along with intensive stationary rehabilitation, he had to undergo a dialysis for 3 times per week. Although we saw the patient now and then before and after HTX, the consequent rehabilitation as an out-patient in our institution did not start until one year after HTX. During that time he still suffered from several problems regarding all ICF domains (▶ **Fig. 1**).

He had a unilateral left-sided paresis with almost complete loss of arm activity and a reduced muscle control and spasticity in the left leg. As a result of medication (beta blockers) the heart rate at rest was 75 beats/min and the peak heart rate added up to 107 beats/min (heart rate reserve 107 – 75 = 32). The by spiroergometry measured VO_2max was 22.11 ml/min/kg. The patient was able to perform daily activities such as dressing, washing, eating, walking and cycling on a tricycle. But he was incapable to work or participate in social activities. He still had to receive dialysis 3 times per week. His estimated quality of life score was 35/100. In addition to a functional and strength training he performed a consequent endurance training once a week. During the first training the training load was dispensed based on the Borg scale (7 – 20), measured heart rate and oxygen saturation. This first training consisted of treadmill walking, ergometer cycling and dynamic exercises in standing position (▶ **Tab. 1**).

During the first endurance training the heart rate showed a slight increase compared to the beginning of exercise, a reduced peak heart rate and a slower decrease after exercise with a small range in heart rate (23 beats) over the entire training period (▶ **Fig. 2**). Due to several operations during the following year the patient could not always perform this weekly training. He underwent a renal transplantation and some scar corrections, which involved a frequent adjustment of the training programme.



▶ **Fig. 2** Heart rate during first interval training. (Quelle: M. Kandel; graf. Umsetzung: Thieme Gruppe).

▶ **Tab. 1** First interval training data.

exercise	performance
treadmill walking	6 min 4 km/h
test	3 min
cycling	3 min 50 watts 1 min 110 watts 3 min 50 watts 1 min 120 watts
rest	3 min
step aerobics on elevated platform	1 min 60 Hz + 15 cm
rest	3 min

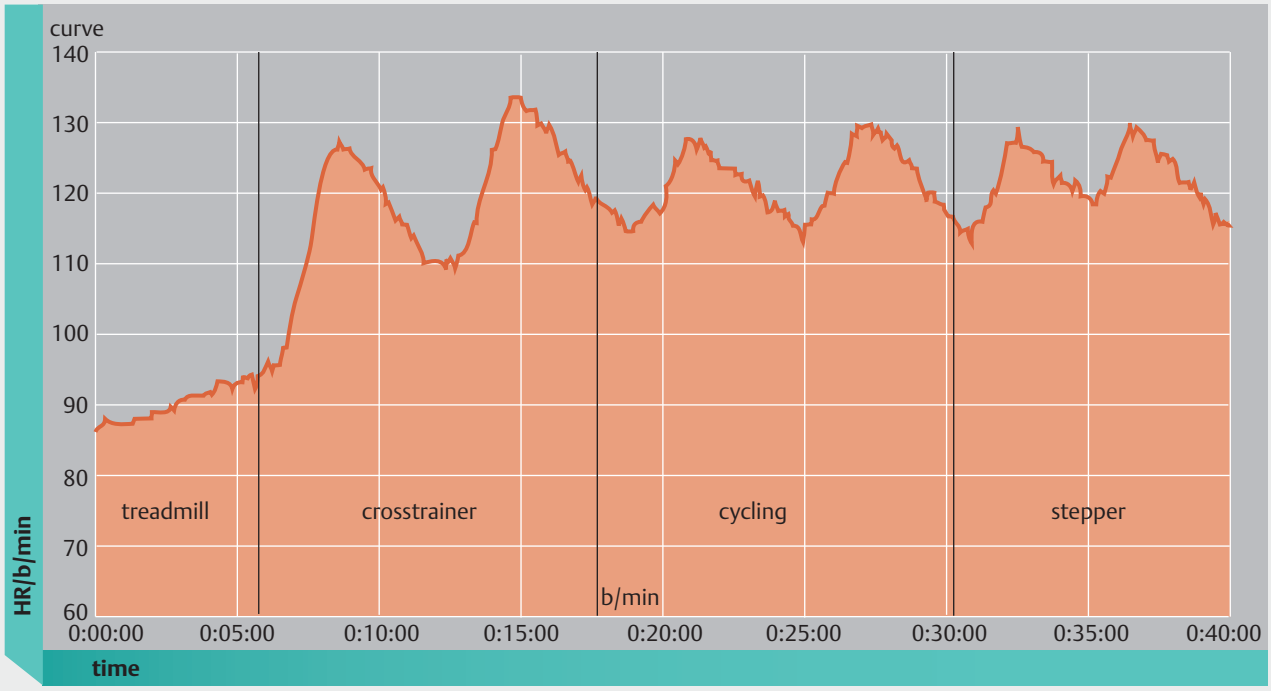
▶ **Tab. 2** Example of interval training one year later.

exercise	performance
treadmill walking	5 min 4.5 km/h (warm-up)
crosstrainer	2 min 125 watts/RPS 60 4 min rest 2 min 125 watts /RPS 60 4 min rest
cycling	2 min 150 watts/RPS 80 4 min rest 2 min 150 watts/RPS 80 4 min rest
stepper	1 min (step 3/10) 3 min rest 1 min (step 3/10)
rest	4 min

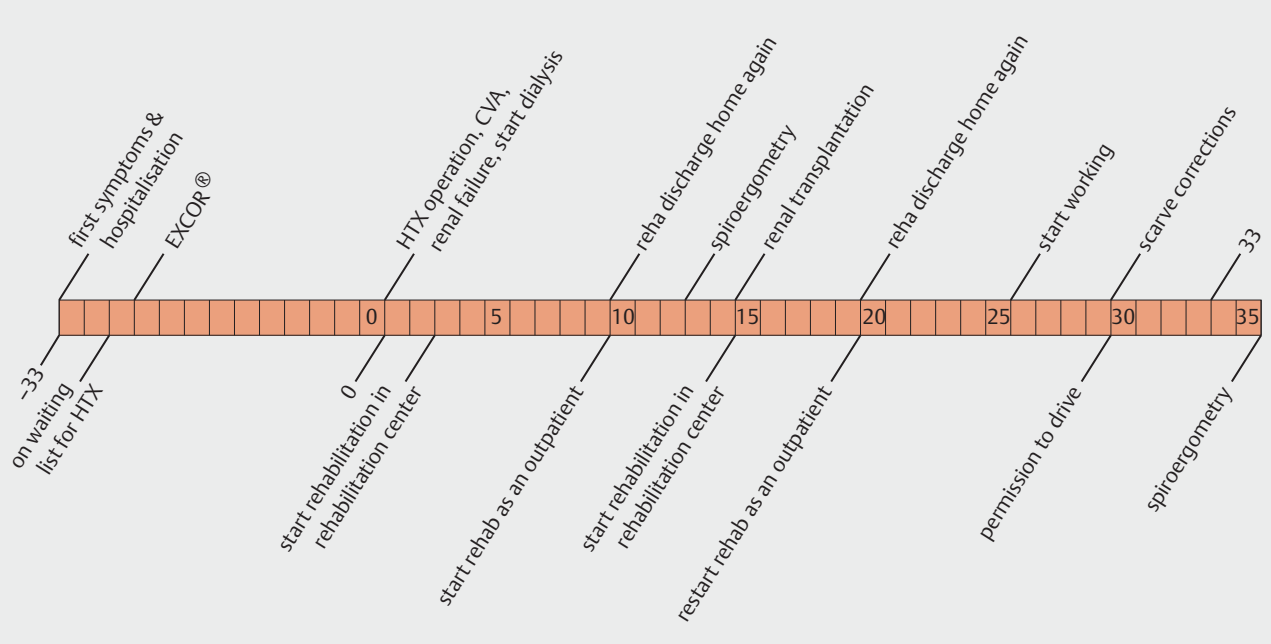
RPS = repetitions per second.

One year after the patient had started his endurance training, the heart response had significantly changed (▶ **Tab. 2,** ▶ **Fig. 3**). The heart rate at training onset was higher (86 beats/min) due to less medication (beta blocker), peak heart rate was 135, and heart rate reserve rose from 32 to 49 beats/min. The patient tolerated more training load due to the tremendously growing effect on activity and recovery (time).

During the following year the patient's quality of life further improved and he was able to drive a (slightly adapted) car and return to work as a structural draughtsman (▶ **Fig. 4**). In this period therapy was reduced and the weekly endurance programme's intensity was increased leading to the following improvements: VO_2max rose up to 36.40 ml/kg/min), peak heart rate (170 beats/min), heart rate variability, heart rate reserve (81 beats) and reaction of the heart rate on activity and recovery significantly. The spiroergometry was measured exactly in the same place and under the same circumstances as 2 years ago. The patient scored his quality of life with 70/100. The recorded recovery reaction after (sub)maximal training load of 1 minute was documented within the amount of 30 seconds (▶ **Tab. 3,** ▶ **Fig. 5**).



▶ **Fig. 3** Heart rate during interval training after 1 year. (Quelle: M. Kandel; graf. Umsetzung: Thieme Gruppe).

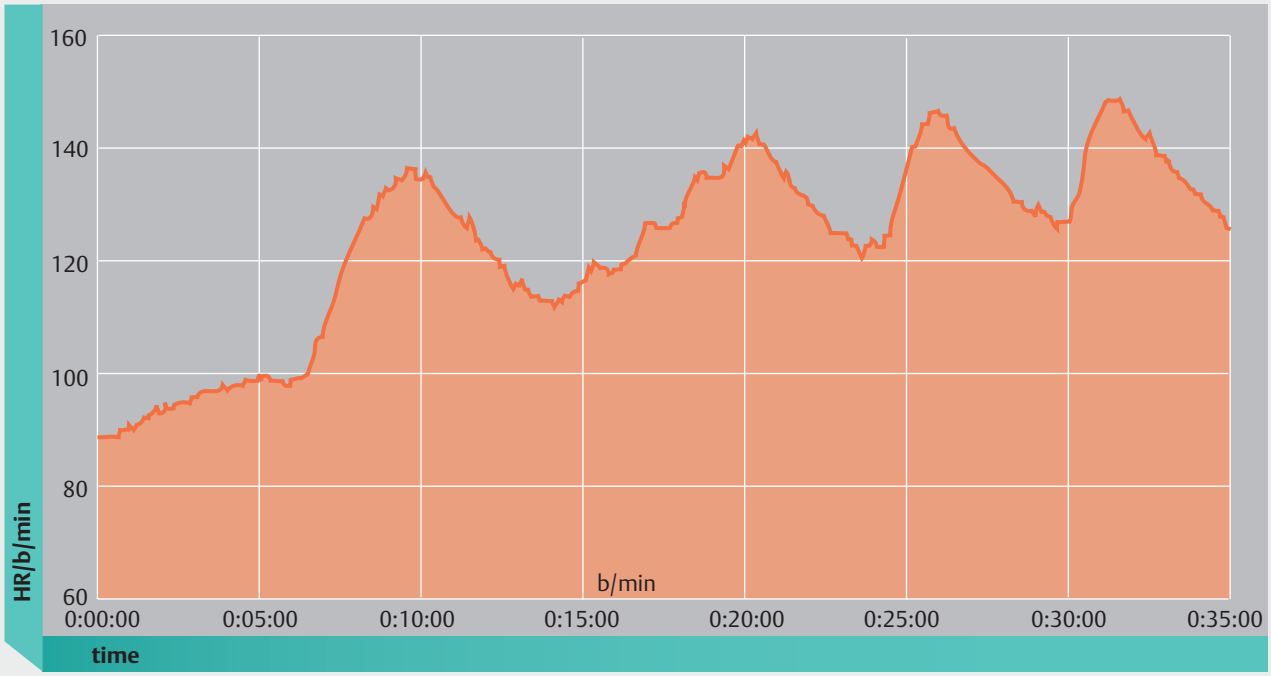


▶ **Fig. 4** Events timeline of the patient's health problem (months). (Quelle: M. Kandel; graf. Umsetzung: Thieme Gruppe).

Discussion

The young patient had multiple severe complications following HTX with tremendous impact on the rehabilitation process. Additional barriers were distress due to external factors like conflicts with authorities of transportation, insurance and finance. The results revealed the difficulties with transferring research knowledge into clinical practice. Despite these problems it was possible to implement a high intensity exercise programme.

The American College of Sports Medicine (ACSM; [2]) and the American Heart Association (ASA; [9]) recommend exercises with



▶ **Fig. 5** Heart rate during interval training after 2 years. (Quelle: M. Kandel; graf. Umsetzung: Thieme Gruppe).

▶ **Tab. 3** Example of interval training 2 years later.

exercise	performance
treadmill walking	5 min 4.5 km/h (warm-up)
crosstrainer	1 min 100 watts/RPS 70 2 min 130 watts/RPS 70 1 min 100 watts/RPS 70 4 min rest
cycling	4x (1 min 210 watts/30 sec rest) RPS 80 4 min rest
stepper	120 min (step 5/10) 4 min rest 120 min (step 5/10)
rest	4 min

RPS = repetitions per second.

an intensity of 50 to 90 % of VO_2max which is rather imprecise. One reason for this is uncertainty and disagreement of how to improve the VO_2max in patients after HTX [20]. VO_2max does not only depend on the cardiac output (stroke volume × heart rate) but also on muscular oxygen uptake.

Most of these limiting factors seem to best improve by implementing high intensity training (even stroke volume; [20]). Heart rate recovery effects within seconds after training indicate the initiating reinnervation of the transplanted heart [12]. Although there exist non-invasive methods to prove reinnervation [4] these were not used in this case.

The patient responded very well to the high intensity exercise programme and made enormous progress during the 2 years of rehabilitation. He became independent of financial and social support and his quality of life vastly improved. Cardiovascular performance parameters rose to the level of slightly below average trained healthy subjects ([1], 25 percentile of peak oxygen uptake in healthy men).

This case report yet shows that rehabilitation after HTX predominantly depends on the individual subject. Not only is it difficult to establish standard guidelines for rehabilitation after HTX but also to implement them into practice. Physiotherapists must pay attention to all ICF domains including personal and environmental factors as wells as the pathophysiological history of HTX in order to supervise and guide the individual patient to independency and a high quality of life.

Conclusion

Not every rehabilitation after HTX will possibly be as successful as portrayed in this case study of a young patient with pronounced motivation, active coping strategy and training experience as a competitive swimmer. However, the results may illustrate the prospects of a individually adjusted rehabilitation programme despite existing severe complications.

Conflict of Interest

The authors declare that they have no conflict of interest.

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