BERN UNIVERSITY OF APPLIED SCIENCES

Today, many tasks call for interdisciplinary solutions. In order to better address these requirements, the Bern University of Applied Sciences (BFH) aims to concentrate and strengthen its competencies in specific areas based on established research groups. The BFH centres offer answers to current and future social and technological issues. They are unique in Switzerland due to their set-up and holistic approach.

For example, the BFH Centre for Technologies in Sports and Medicine combines the research and development activities of various institutions: two research institutes from the field of engineering and information technology collaborate with the Health Division and the Swiss Federal Institute of Sport. Thus, engineers can work together with medical doctors, health and physiology specialists, as well as sports coaches to achieve the common goal of sharing expertise with industrial partners and expediting innovation.

In addition to bringing together experts, linking research and education is an important concept of the BFH. Many of the lecturers are simultaneously engaged in research. And the latest discoveries and methods are incorporated and actively implemented in teaching - especially in the context of semester papers and projects. Thus, students often contribute to the development of marketable products, particularly in cooperation with business partners and spin-off companies.

This practice-oriented education prepares students both at bachelor's and master's levels to become outstandingly qualified specialists and executives in the industry. People who are already working can take their careers one step further with continuing education, for example, with the new program in Digital Health.

Medtech is an important branch of industry for Switzerland and has been able to grow steadily in recent years. The BFH is ready to further contribute to this positive development by providing the industry with well-trained professionals and close cooperation in the field of research and development. The Bern University of Applied Sciences is well connected as member of the Medical Cluster and the Competence Centre for Medical Technology – and a valuable partner in the region Mittelland, as well as throughout Switzerland and internationally.

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Research Profile

The Institute for Rehabilitation and Performance Technology IRPT uses methods and technologies from sports and exercise physiology to improve rehabilitation outcomes for people after accidents or illness. The IRPT specialises in the areas of cardiopulmonary and neurological rehabilitation after stroke or spinal cord injury, feedback control for physiological systems, as well as automation and control of training equipment. The IRPT collaborates closely with Swiss companies and rehabilitation clinics, thus ensuring that research results can be quickly and directly applied for the benefit of patients. A growing number of projects funded by the Swiss National Science Foundation (SNSF) and Innosuisse support basic research, transfer of knowledge into industry, and the development of innovative products. The IRPT team consists of research assistants, Ph.D. students, postdocs, and a group of bachelor and master project students. The team members have varied backgrounds in electrical, mechanical and bio-mechanical engineering, human movement sciences, physiotherapy, and rehabilitation medicine. The IRPT is located in Burgdorf (Canton of Bern) on the campus of the Department of Engineering and Information Technology of Bern University of Applied Sciences.

Rehabilitation Engineering

The interdisciplinary research of the Rehabilitation Engineering Group focuses on neural control of movement in clinical populations with neurological deficits resulting from spinal cord injury, stroke, or other causes. By combining rehabilitation technology and cognitive performance feedback, the group's goal is to reinforce the patient's volitional drive and to exploit the central nervous system's lifelong capacity for plasticity, regeneration, and repair. This approach promotes cardiopulmonary and musculoskeletal health and supports an environment in which positive neurological adaptations can occur. The work harnesses multidisciplinary expertise in engineering, neurosciences, sports and exercise science, and medicine. This allows professionals to address prevention and management of the progressive secondary complications of spinal cord injury, stroke, and a wide range of further neurological conditions; this approach promotes neurological recovery for improved motor control, sensation, and autonomic function.


IRPT rehabilitation robotics lab.

The Rehabilitation Engineering Group develops new technical devices and extends the functionality of existing products. Recent developments include novel rehabilitation devices for adults and children with neurological impairments, based upon dynamic leg-press technology (collaboration with Dynamic Devices AG).

The group also develops recumbent cycling systems for people with complete lower-limb paralysis. These systems use functional electrical stimulation (FES) of the paralysed muscle groups. The IRPT teamed with the Swiss Paraplegic Centre (Nottwil) to participate in the FES Bike Race at Cybathlon 2016. Team IRPT/SPZ won the bronze medal at this event.

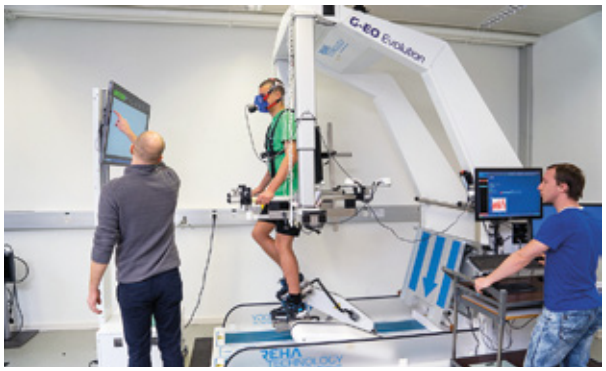
Team IRPT/SPZ at the FES Bike Race, Cybathlon 2016.

The functionality of existing robotics-assisted rehabilitation devices, including gait-rehabilitation robots and tilt tables, has been extended to facilitate application for cardiopulmonary rehabilitation. This involves biofeedback of patient

effort, volitional control of mechanical work rate, together with automatic feedback control of physiological outcome variables including heart rate, oxygen uptake, and metabolic work rate. A key feature of the group's work is the employment of methods from sports and exercise physiology and the adaptation of these protocols to the rehabilitation setting. Working closely with key clinical collaborators, these approaches are applied in the clinic for rehabilitation of people with various neurological problems, including stroke and spinal cord injury.

The following selection of research and clinical projects gives an overview of the spectrum of research activities of the Rehabilitation Engineering Group:

- Cardiopulmonary rehabilitation of stroke patients using robotics-assisted treadmill exercise (RATE)
- Active control and neurological stimulation of the ankle joint during RATE
- Cardiopulmonary rehabilitation of patients with incomplete spinal cord injury or stroke using a robotics-assisted tilt table
- Rehabilitation tricycle incorporating FES



Cardiopulmonary rehabilitation with the G-EO System end-effector gait-rehabilitation robot.

The IRPT has an excellent infrastructure for research including a dedicated research lab within the Reha Rheinfelden. Robotics-assisted devices include exoskeleton (Lokomat, Hocoma AG) and end-effector (G-EO System, Reha Technology AG; Lyra, medica Medizintechnik GmbH) gait rehabilitation robots, a robotics-assisted tilt table (Erigo, Hocoma), and an adaptive leg robot (Allegro, Dynamic Devices AG). The institute also has modern cardio-respiratory monitoring systems.

Sports Engineering

The Sports Engineering Group focuses on interdisciplinary research on advanced feedback control methods for treadmill and cycle-ergometer automation, and on basic research in the area of physiological heart rate variability (HRV). The work builds on multidisciplinary expertise in engineering and sports and exercise science. This research deals mainly with high-end performance, but many of the methods have also been translated successfully into activities of the Rehabilitation Engineering Group for application in patients with neurological deficits.

IRPT sports engineering lab

The group has developed feedback-control algorithms that allow exercise intensity to be specified for training and testing via automatic regulation of heart rate, oxygen uptake, or metabolic work rate. In each case, a target profile for the controlled variable is selected. During the exercise, treadmill speed and slope, or cycle work rate, are automatically adjusted so that the target response is achieved. High-precision, automatic-positioning algorithms for the treadmill have also been developed. This allows users to select their own walking or running speed, while the feedback control continuously adjusts treadmill speed to maintain a reference position.

The following selection of research and development projects gives an overview of the spectrum of research activities of the Sports Engineering Group:

- Investigation of the characteristics of heart rate variability, dynamics, and control during exercise
- Feedback control of heart rate, oxygen uptake, or metabolic work rate during treadmill and cycle-ergometer exercise
- Automatic position control for walking and running on a treadmill
- Automatic control of position and physiological variables while cycling on a treadmill

The IRPT labs in Burgdorf are equipped with high-performance treadmill (Venus, h/p/cosmos sports and medical gmbh) and cycle ergometer (LC7, Monark Exercise AB) technology. Various position-monitoring sensors, including ultrasound and laser, and a real-time communication protocol give complete control over the treadmill through a computer. The institute also has modern cardio-respiratory monitoring systems for on-line breath-by-breath monitoring, ECG recording, and HRV analysis.

Selected Publications

K. J. Hunt and J. Saengsuwan, "Changes in heart rate variability with respect to exercise intensity and time during treadmill running," BioMedical Engineering OnLine, vol. 17:128, 2018 https://doi.org/10.1186/s12938-018-0561-x

F. Chrif, T. Nef, and K. J. Hunt, "Investigation of cardiopulmonary exercise testing using a dynamic leg press and comparison with a cycle ergometer," BMC Sports Sci. Med. Rehabil., vol. 10:5, 2018. https://doi.org/10.1186/s13102-018-0095-3

K. J. Hunt, P. Anandakumaran, J. A. Loretz, and J. Saengsuwan, "A new method for self-paced peak performance testing on a treadmill," Clin. Physiol. Funct. Imaging, vol. 38, pp. 108–117, 2018
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K. J. Hunt and S. Gerber, "A generalised stochastic optimal control formulation for heart rate regulation during treadmill exercise," Systems Science & Control Engineering, vol. 5:1, pp. 481–494, 2017
https://doi.org/10.1080/21642583.2017.1398685

M. Laubacher, E. A. Aksöz, R. Riener, S. Binder-Macleod, and K. J. Hunt, "Power output and fatigue properties using spatially distributed sequential stimulation in a dynamic knee- extension task," Eur. J. Appl. Physiol., vol. 117, no. 9, pp. 1787–1798, 2017
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F. Chrif, T. Nef, M. Lungarella, R. Dravid, and K. J. Hunt, "Control design for a lower-limb paediatric therapy device using linear motor technology," Biomed. Signal Process. Control, vol. 38, pp. 119–127, 2017
https://doi.org/10.1016/j.bspc.2017.05.011

J. Riedo and K. J. Hunt, "Feedback control of oxygen uptake during robotics-assisted end-effector-based stair climbing," Systems Science & Control Engineering, vol. 5:1, pp. 142–155, 2017
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J. Saengsuwan, L. Berger, C. Schuster-Amft, T. Nef, and K. J. Hunt, "Test-retest reliability and four-week changes in cardiopulmonary fitness in stroke patients: evaluation using a robotics-assisted tilt table," BMC Neurology, vol. 16:163, 2016.
https://doi.org/10.1186/s12883-016-0686-0

K. J. Hunt and S. E. Fankhauser, "Heart rate control during treadmill exercise using input-sensitivity shaping for disturbance rejection of very-low-frequency heart rate variability," Biomed. Signal Process. Control, vol. 30, pp. 31–42, 2016.
https://doi.org/10.1016/j.bspc.2016.06.005

O. Stoller, M. Schindelholz, and K. J. Hunt, "Robot-assisted end-effector-based stair climbing for cardiopulmonary exercise testing: feasibility, reliability and repeatability," PloS ONE, vol. 11(2): e0148932, 2016.
https://doi.org/10.1371/journal.pone.0148932

K. J. Hunt, S. E. Fankhauser, and J. Saengsuwan, "Identification of heart rate dynamics during moderate-to-vigorous treadmill exercise," BioMedical Engineering OnLine, vol. 14:117, 2015.
https://doi.org/10.1186/s12938-015-0112-7

O. Stoller, E. D. de Bruin, M. Schindelholz, C. Schuster-Amft, R. A. de Bie, and K. J. Hunt, "Efficacy of feedback-controlled robotics-assisted treadmill exercise to improve cardiovascular fitness early after stroke: a randomised controlled pilot trial," J. Neurol. Phys. Ther., vol. 39, pp. 156–165, 2015
https://doi.org/10.1097/NPT.0000000000000095