The MoveMonitor will enable you to easily assess the physical activity status of your patients. With one small device, worn in an elastic strap on the lower back, you will be able to measure your patients’ physical activity for up to 7 days. The MoveMonitor consists of a hardware unit, the acquisition software, and one or more chosen analysis modules, supplied through our web service.

**DYNAPORT**

The hardware of the MoveMonitor consists of a small and light casing containing a tri-axial accelerometer, a rechargeable battery, USB connection, and raw data storage capability on a Micro-SD card.

**DYRECTOR**

The acquisition software Dyrector will help you prepare the device and gather the acceleration data. Raw data are stored on your local computer in preparation for the automated analysis via our online web portal.

**WEB SERVICE**

Our web service processes your measurements as soon as your data are received. Outcome parameters are calculated and stored in a database in order to generate longitudinal reports. Specific reports can be sent to different stakeholders.

**MODULES**

The core function of the MoveMonitor is the detection of activity types, such as: lying; sitting; standing; locomotion (walking and shuffling), and the transitions between posture and motion. More specific information can be gathered by using the analysis modules: Energy Expenditure; Physical Activity Recommendations; Fall Detection and Sleep Movements.
In general

The DynaPort consists of a small and light case containing a tri-axial accelerometer, a rechargeable battery, an USB connection, and raw data storage on a Micro-SD card. The used accelerometer has a DC response to the Earth’s gravitational field, and uses a seismic or a proof mass suspended by a spring structure in a case. This sensor responds to both slow and fast changes in acceleration. These favorable features for posture and motion detection are reasons for us to use seismic accelerometers.

Technical specifications

<table>
<thead>
<tr>
<th>General</th>
<th>85 x 58 x 11.5 mm (incl. rubber ring: 106.6 x 58 x 11.5 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>55 grams</td>
</tr>
<tr>
<td>Sample frequency</td>
<td>100 Hz</td>
</tr>
<tr>
<td>Storage medium</td>
<td>MicroSD (min 1Gb required for one week of data storage)</td>
</tr>
</tbody>
</table>

**Power**

<table>
<thead>
<tr>
<th>Battery type</th>
<th>Lithium polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery lifetime</td>
<td>204 hours in data storage mode (7 days of measurement + 7 days in standby)</td>
</tr>
</tbody>
</table>

**Triaxial Accelerometer Characteristics**

<table>
<thead>
<tr>
<th>Sensor range</th>
<th>±2g or ±6g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor resolution</td>
<td>±1mg at ±2g, ±3mg at ±6g</td>
</tr>
</tbody>
</table>

**Other Features**

- Internal clock for time and date registration
- LED indication about system status
- USB connector for charging and communication

**Acceleration Sensor**

Inclination, indicated by the amount of gravity measured, provides information about the angle of the sensor surface compared to the horizontal plane. The inclination and acceleration of body segments reveal information about posture and motion of a person. The sensor has a selectable full scale of ±2g or ±6g and is capable of measuring acceleration over a bandwidth of 640 Hz for all axes. The resolution is 1mg in the 2g range and ±3mg in the ±6g range. The sample frequency has been set to 100Hz.
**MEASUREMENTS WERE FOUND TO BE HIGHLY REPRODUCIBLE IN A SHAKING DEVICE (COEFFICIENT OF VARIATION < 3.1%), AS WELL AS IN WALKING IN A GROUP OF FIFTY-FIVE CHILDREN (12-17 YEARS) (INTRA-OBSERVER INTRACLASS CORRELATION COEFFICIENT 0.93-0.98).**

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**FEATURES**

**AUTOMATIC START - STOP AND INTERNAL CLOCK**
Since it is possible to pre-program the initiation date and time of the measurement, the DynaPort can be given or sent to the patient without the need of interaction with the researcher or caregiver.

**USB CONNECTOR**
The USB connector is used for installing the patient- and measurement ID, start and stop programming, updating of the firmware, and charging the DynaPort.

**TAMPERING RESISTANT**
The design accommodates ‘witness of tampering’ to facilitate identification of devices where collected data may require further investigation. The opening of the Micro SD reader and the USB connector can be covered with a sticker.

**ONE WEEK OF DATA STORAGE**
The lithium polymer battery included in the housing allows for a full week of continuous monitoring and 7 days stand-by time. If the device is not worn this is detected automatically.

**SENSOR LOCATION**
The accelerometer is attached to an elastic strap and positioned on the lower back at the height of the second lumbar vertebra (which was used as an approximation of the body’s centre of mass). This location and the fact that a strap holds the device securely in place guarantee a high reproducibility of signals.

**RAW DATA STORAGE**
Output data of the raw signals is not summarized by any proprietary processing, allowing researchers increased control over data processing stages. The ability to reanalyze the original raw data demonstrates the flexibility of raw accelerometry.

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**REPRODUCIBILITY**

Measurements were found to be highly reproducible in a shaking device (coefficient of variation < 3.1%), as well as in walking in a group of fifty-five children (12-17 years) (intra-observer intraclass correlation coefficient 0.93-0.98).\(^1\)

PHYSICAL ACTIVITY

IN GENERAL

Being physically active is increasingly being acknowledged as a way to diminish or prevent disability. Objective and accurate information about the physical activities in a patient’s daily life is of fundamental importance for research as well as for clinical practice. Furthermore, the reports of the results improve feedback to the patient, which facilitates education and self-management. The MoveMonitor offers you a range of Analysis Modules to make this possible. You can add as many Modules as desired. The Module ‘Physical Activity’ forms the basis for this concept.

METHOD

Digital data is analyzed and expressed in terms of body posture (such as lying down, sitting or standing), locomotion (walking and shuffling) and movement parameters (such as movement duration, intensity and frequency). The high resolution raw acceleration data lends itself to a pattern recognition approach that uses logical algorithms for the classification of types of activity. Lying can be identified from the orientations of the trunk. Sitting and standing can be identified by the pattern of transitions between activities. Locomotion is identified by intensity and frequency of cyclic movements.

OUTCOMES

Types of activity form the basis of the MoveMonitor and are presented in a Numerical report, a Summary report or in a Day-to-Day report. The numerical report is an event list, with cumulative event number, start time, end time, and activity type. The summary report shows the average of the complete measurement. The day-to-day report presents day totals and activity distributions per day in 20 minute bouts.

Transitions are defined as a change in type of activity. The number of transitions between all types of activities are calculated and summarized in a table in the graphical reports.

For each period of walking that is detected, the amount of steps is determined and shown in the numerical report. In the summary report the total amount of steps and the average amount of steps per walk period are shown.
**VALIDITY**

It was concluded that the DynaPort MiniMod provides information on habitual physical activity. The parameters are useful as outcome measures and for self-monitoring of daily activities in physical activity intervention studies for COPD. The MiniMod is a very accurate instrument for detecting postures, walking and steps [1]. The DynaPort MoveMonitor is a practical and valuable method for objectively evaluating gait and postures [2]. This triaxial monitor system is a practical and valuable tool for objective, continuous evaluation of walking and postures in patients with mild to moderate PD [3].

3. Dijkstra, Kamsma, Zijlstra. This triaxial monitor system is a practical and valuable tool for objective, continuous evaluation of walking and postures in patients with mild to moderate PD. Arch Phys Med Rehabil Vol 91, August 2010.
ENERGY EXPENDITURE

IN GENERAL

The energy expenditure (EE) of a man or woman over a whole day is often divided into different components and can be individually determined. These are: basal metabolic rate (BMR), diet induced thermo genesis (DIT), and physical activity (PA) see Figure 1. The rates of EE during physical activity vary depending on intensity, duration, the frequency of the activity, and on the body mass and fitness of the person performing the activity. There is currently a trend towards decreased physical activity during work time, which means that physical activity EE during leisure time is becoming more important in determining total EE. Thus, physiology, behavior, and lifestyle play major roles in determining energy expended in activity.

METHOD

Activity-related energy expenditure (AEE) is difficult to quantify, especially under sedentary conditions. Here, a model was developed using the detected type of physical activity (PA) and movement intensity (MI), based on a tri-axial seismic accelerometer, with energy expenditure for PA as a reference. The relation between AEE (J/min/kg), MI, and the type of PA was determined for standardized PAs as performed in a laboratory, including: lying, sitting, standing, and walking. AEE (J/min/kg) was calculated from total energy expenditure (TEE) and sleeping metabolic rate (SMR), as assessed with indirect calorimetry ((TEE × 0.9) – SMR)[1].

OUTCOMES

**Basal Metabolic Rate (BMR)**
Together with the closely related Resting Metabolic Rate (RMR), the BMR is the minimum amount of energy that a body requires when lying in physiological and mental rest. In many people BMR represents around 60-75% of total EE. The main determinant of BMR is body weight and body composition.

**Diet Induced Thermo genesis (DIT)**
The amount of energy utilized for digestion, absorption and transportation of nutrients. DIT accounts for about 10% of total energy intake for a mixed western diet.

**Activity-Related Energy Expenditure (AEE)**
Physical Activity is the most variable component of EE in humans (see Figure 2) and, after BMR, the second largest component of daily energy expenditure. It includes the additional EE above BMR and DIT due to muscular activity and increased cardio respiratory function.
**VALIDITY**

According to Van Hees et al., the type of physical activity improved the prediction of energy expenditure. A tri-axial seismic accelerometer is a valid tool for estimating energy expenditure related to sedentary physical activities. This is the first study to show a significant relationship between PA monitor output and energy expenditure during sedentary conditions [1].


IN GENERAL

A good night’s rest is essential to quality of life. Insufficient or poor quality sleep may result in drowsiness and loss of concentration, which adversely affects productivity and well-being during the day. After having sleep problems for an extended period of time, existing illness-related problems can worsen or cause extra difficulties for the patient. For patients suffering from Parkinson’s disease, COPD, or from the effects of a CVA these are familiar problems. The Sleep Movements Module of the MoveMonitor classifies movement information during night’s rest.

METHOD

Night’s rest is identified by using the duration and frequency of lying periods. The movement intensity is used to identify transitions during night’s rest. Beginning and end of these transitions can be accurately detected, due to the high resolution of the measurements. Of each transition the magnitude and average velocity are calculated, using the change of inclination of the trunk. Average movement intensity during movement time is calculated.

OUTCOMES

NIGHT’S REST DETECTION

The MoveMonitor activity classification is used to identify the night’s rest. This yields information about the time of going into bed in the evening and getting up in the morning. Any period of lying that lasts longer than 3 hours, which is interrupted for less than 15 minutes, will be detected as night’s rest.

GOING OUT OF BED

If the subject leaves the bed for a short while between going into bed in the evening and getting up in the morning, this is called an ‘out of bed period’. The total amount of ‘out of bed periods’ and the beginning and the end of each period are displayed.

POSTURES

The inclination of the trunk is used to trace the subjects’ postures. The postures ‘left side’, ‘right side’, ‘prone’, and ‘supine’ are detected and are shown in a graph. Besides this, the absolute and relative duration of each posture are displayed.
**MOVEMENT TIME**

By calculating the size of the rotation vector of the DynaPort every movement is detected. Movement Time indicates the percentage of time that movement is detected. Movement Time per minute is also shown in a graph.

**MOVEMENT INTENSITY**

The size of the rotation vector is used to calculate the intensity of all movement periods. The average Movement Intensity per minute is shown in a graph. The average Movement Intensity of all movement periods is displayed.

**TRANSITIONS**

Each rotation of more than 10 degrees is called a transition. Each transition is classified in one of four classes: small shifts, medium shifts, large shifts, and extra large shifts. For every class the frequency, average velocity, and average duration are shown.

**REPORTS**

Each rotation of more than 10 degrees is called a transition. Each transition is classified in one of four classes: small shifts, medium shifts, large shifts, and extra large shifts. For every class the frequency, average velocity, and average duration are shown.

**VALIDITY**

This analysis is based on the activity classification of the MoveMonitor which is validated [1] and the high reproducibility of the DynaPort accelerometer [2]. The validation study of the Sleep Movement module is submitted for publication.

PA RECOMMENDATIONS

IN GENERAL

The average Energy Expenditure (EE) of males and females over a whole day is decreasing. This decrease in physical activity raises major health concerns. The majority of the adult population is either inactive, or only occasionally engaged in light activity. Only a small percentage of men and women achieve the moderate activity guidelines. Most are either sedentary or are only moderately active on an irregular basis. Half of all adults believe they are active enough to stay fit. In terms of intensity and duration, new strategies are being developed for the promotion of physical activity.

<table>
<thead>
<tr>
<th>MODERATE ACTIVITY</th>
<th>VIGOROUS ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message</td>
<td>30 minutes of moderate activity on most days.</td>
</tr>
<tr>
<td>Definition</td>
<td>Activity that raises your heart rate and leaves you a little out of breath.</td>
</tr>
<tr>
<td>Examples</td>
<td>Brisk walking, dancing, gardening, golf, bowling</td>
</tr>
<tr>
<td></td>
<td>30 minutes of vigorous activity, 3 times a week.</td>
</tr>
<tr>
<td></td>
<td>Activity that leaves you sweaty and out of breath.</td>
</tr>
<tr>
<td></td>
<td>Running, cycling, football, tennis, exercise class.</td>
</tr>
</tbody>
</table>

METHOD

The PA RECOMMENDATION module calculates energy expenditure (METs) using the acceleration of body movements. Please see the Energy Expenditure flyer for more information about this method. These outcome values will be compared with some widely used recommendations or custom guidelines. The activity level thresholds are editable and can be chosen to be absolute, or relative to patient fitness.

OUTCOMES

Metabolic Equivalent of Task (MET)

A physiological concept expressing the energy cost of a physical activity as a multiple of Basal Metabolic Rate (BMR). By convention, 1 MET is considered as the resting metabolic rate obtained during quiet sitting.

MET-minutes

The duration of physical activity in minutes above moderate intensity. A 4 MET activity expends 4 times the energy used by the body at rest. If a person performs a 4 MET activity for 30 minutes, he or she has done $4 \times 30 = 120$ MET-minutes of physical activity. A person could also achieve 120 MET-minutes by performing an 8 MET activity for 15 minutes.

Physical Activity Guidelines

Physical Activity Guidelines describe the types and amounts of physical activity that offer substantial health benefits to young, adult and elderly people. Several well-known guidelines are implemented (e.g. ACSM and NNGB), and the compliance with these guidelines is assessed.
**Absolute Intensity**

Physical Activity recommendations use absolute aerobic intensity in terms of METs. According to the ACSM thresholds for adults [1]:

- Light-intensity activities are defined as 1.1 MET to 2.9 METs.
- Moderate-intensity activities are defined as 3.0 to 5.9 METs.
- Vigorous-intensity activities are defined as 6.0 METs or more.

**Relative Intensity**

Intensity can also be defined relative to fitness. In this case the intensity is expressed in terms of a percentage of a person’s aerobic capacity reserve. Relatively intensive activities are used in recommendations for older adults and adults with functional limitations that affect movement ability. Relative moderate intensity is defined as 40 to 59 percent of aerobic capacity reserve. Relative vigorous intensity is defined as 60 to 84 percent of aerobic capacity reserve [2].

**Reports**

