ORIGINAL ARTICLE

Accelerometry-Based Activity Spectrum in Persons With Chronic Physical Conditions

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ABSTRACT. van den Berg-Emons RJ, Bussmann JB, Stam HJ. Accelerometry-based activity spectrum in persons with chronic physical conditions. Arch Phys Med Rehabil 2010;91: 1856-61.

Objectives: (1) To give an overview of the impact of a variety of chronic physical conditions on accelerometry-based levels of everyday physical activity and to identify high-risk conditions; and (2) to compare these objectively assessed activity levels with the levels estimated by rehabilitation physicians.

Interventions: Not applicable.

Design: Cross-sectional study.

Setting: Participant's home environment.

Participants: Patients (n=461) with 18 chronic physical (sub)conditions and able-bodied subjects (n=96).

Main Outcome Measures: We summarized data on the level of everyday physical activity as objectively measured with an accelerometry-based activity monitor. Thirty-one rehabilitation physicians filled in a questionnaire designed to obtain their estimates of the level of physical activity in patients with the various conditions.

Results: Only 4 of the studied conditions had normal activity levels (≥90% of the able-bodied level). Persons with transtibial amputation (vascular), spinal cord injury, and myelomeningocele (wheelchair dependent) had the lowest levels of activity, less than 40% of the able-bodied level. In general, rehabilitation physicians were aware of the inactive lifestyles, but considerably underestimated the magnitude of inactivity in the high-risk conditions.

Conclusions: This is the first study to provide an objectively assessed activity spectrum in a variety of chronic physical conditions. We hope this study will increase the awareness of health professionals as to which chronic physical conditions are at increased risk for an inactive lifestyle, and will contribute to adaptation of patient management accordingly.

Key Words: Activities of daily living; Chronic disease; Life style; Rehabilitation.

REGULAR PHYSICAL ACTIVITY throughout life is important for maintaining a healthy body[1]. Nevertheless, 60%[2] of the global population fails to achieve the minimum physical activity recommendations.[3-5]

Persons with a chronic physical condition are at greater health risk due to inactivity than able-bodied persons because they are often restricted in performing normal everyday activities such as walking, housekeeping, gardening, shopping, and participating in sports.[6,7]

Health benefits of regular physical activity include weight loss or maintenance, improvement in physical fitness (aerobic capacity, muscle mass), and lower risks of hypertension, diabetes, cardiovascular disease, and some forms of cancer, as well as improvement in quality of life[1,8]

Besides the increased health risk, an inactive lifestyle in persons with a chronic physical condition compounds the effects of the physical condition itself and restricts functional ability and, therefore, personal independence.[9,10] Thus, it could be expected that promotion of physical activity would be an important issue in the management of persons with a chronic physical condition. However, physical activity and its promotion are often a neglected area in PM&R. A reason for this might be that PM&R physicians are not aware of the impact of chronic conditions on the level of everyday physical activity.

Although population-based surveys have consistently demonstrated that persons with chronic conditions are less likely to be physically active compared with able-bodied persons,[10] the existing volume of objective research on physical activity in persons with a chronic condition is small. An important reason for the small volume of objective research may be the complexity of activity measurements in persons with chronic physical conditions: such persons have lower levels of activity (insensitivity of measures), have deviating patterns of movement, and may use assistive devices.[11] Moreover, many different devices have been used to assess physical activity, and most devices have been applied in only one or a few conditions, making comparisons between studies and conditions difficult.

However, 2 decades ago, the development of an accelerometry-based AM was started. Extensive validation procedures have shown that the device provides objective and valid data on postures and physical activities during daily life, both in able-bodied persons and persons with deviating patterns of movement (including wheelchair-dependent persons).[12,13] Over the years, we have performed, and reported on, studies that included measurements with the AM in several chronic physical conditions and in able-bodied persons. In all these studies the hardware and the analysis software were basically the same, which allows comparison between different chronic conditions.

The aims of the present study were (1) to give an overview of the impact of a variety of chronic physical conditions on

List of Abbreviations

AM	activity monitor
CRPS-1	complex regional pain syndrome type 1
PM&R	physical medicine and rehabilitation

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accelerometry-based levels of everyday physical activity and to identify high-risk conditions; and (2) to compare the objectively assessed levels of physical activity in such persons with the levels of physical activity estimated by rehabilitation physicians.

METHODS

Participants

In separate studies, each with its own inclusion and exclusion criteria (table 1), we assessed levels of everyday physical activity in a total of 461 patients (49% men) with 18 chronic physical (sub)conditions. In 3 patient groups (congestive heart failure, CRPS-1, myelomeningocele), we pooled data on activity levels from samples that were measured in separate studies (but with same inclusion and exclusion criteria). All patients were known in a Dutch (university) hospital or rehabilitation center, most of them situated in the west or central region of The Netherlands. Patients were ambulatory or (partly) dependent on a manual wheelchair, and ages ranged between 7 and 81 years.

To determine the impact of the chronic physical condition on physical activity, we compared the levels of everyday physical activity in the persons with chronic conditions with age and sex-specific values as retrieved from a reference sample. This reference sample consisted of 96 able-bodied subjects between the ages of 8 and 82 years (50% men) who had been measured with the same AM and the same measurement procedures. The reference sample was a random sample and representative for the Dutch population. There was a wide range in profession, socioeconomic status, education, living situation, and activity level.

Studies were approved by the Medical Ethics Committee of Erasmus Medical Center, the other hospitals involved, or both. Written informed consent was obtained from all subjects.

Objective Measurement of Physical Activity

The rationale for the AM sensor configuration, the subsequent steps of the signal analysis, and the method of activity detection have been described in detail.[12] The AM is based on long-term ambulatory monitoring in daily life of postures (lying, sitting, standing), physical activities (walking, including climbing stairs and running; cycling; wheelchair propulsion, including handcycling; and general [noncyclic] movement), and transitions between postures. In ambulatory subjects we used 4 ADXL202 uniaxial piezoresistive accelerometers[a,b] (size 1.5×1.5×1cm). One accelerometer was attached to each thigh (while standing the accelerometers are sensitive to movement in the anteroposterior direction), and 2 accelerometers were attached to the skin over the sternum (while standing 1 accelerometer is sensitive to movement in the anteroposterior direction and 1 in the longitudinal direction). In subjects who (partly) depended on a manual wheelchair, 1 additional sensor was attached to each wrist. The accelerometers were connected to the AM[b] (size 15×9×3.5cm, weight 500g; or size 15×9×4.5cm, weight 700g), which was worn in a padded bag around the waist. Accelerometer signals were stored digitally on a PCMCIA flash card[b] with a sampling frequency of 32Hz. Except in the studies of chronic benign pain, CRPS-1, Guillain-Barré syndrome, and stroke (24-h measurement on a weekday), the measurements with the AM were performed during 2 randomly selected consecutive weekdays (48-h measurement). In all studies the measurements were performed in the subjects' home environment. To avoid measurement bias, we explained the principles of the AM only after the measurements were taken. All subjects agreed with this procedure. We instructed the subjects to continue their ordinary daily life, including sports and therapy; however, subjects were not allowed to swim or take a bath or shower during the monitoring period. After the measurements, we asked the subjects to indicate whether the measurement days had been representative for them (eg, with regard to illness, participation in sports). In case they indicated a nonrepresentative measurement, we excluded the measurement from analysis.

Data were downloaded onto a computer for analysis[12] by the Kinematic Analysis part of the Vitagraph Software package.[b] AM data were calculated per day (24-h period). In subjects who had a 48-hour measurement, the data were averaged over the 2 measurement days because there were no differences between the first and second 24-hour periods. In each patient group we assessed (1) the "duration of physical activities," which is a composite measure consisting of the separately detected activities of walking, wheelchair driving, cycling, and general movement, and expressed this as a percentage of a 24-hour period; and (2) the "percentage subnormal," which is the average duration of physical activities in the patients divided by the average duration of physical activities in able-bodied age-mates (= norm level) × 100.

Estimates by Rehabilitation Physicians

To obtain insight into how well rehabilitation physicians estimate the levels of physical activity of persons with chronic physical conditions, we developed a questionnaire for this purpose. We described the essential characteristics (eg, age, sex, inclusion and exclusion criteria) of each patient group that we had measured with the AM. We defined the level of physical activity as the duration of the day that the subjects perform physical activities such as walking, wheelchair driving, and cycling, as well as noncyclic activities having a moderate intensity (eg, gardening, cleaning), to conform to the activity detection procedure of the AM. We set the physical activity level of able-bodied age-mates as the norm level (=100%). We aimed to have the opinions of 30 rehabilitation physicians and therefore asked 40 Dutch rehabilitation physicians to score at which proportion of the norm they considered each patient group to be active (patients with no deficits in physical activity would be scored as 100% of the norm). The rehabilitation physicians were not involved in the AM studies. We also asked the physicians to indicate how experienced they were with each particular patient group (large, moderate, or little experience).

Thirty-one (78%) of the 40 rehabilitation physicians completed the questionnaire. They were from (university) hospitals (n=7, 22%), rehabilitation centers (n=21, 68%), or from both (n=3, 10%). The average ± SD years of experience as a rehabilitation physician was 11.4±8.0. Ten (32%) of the rehabilitation physicians had experience in treating children, 17 physicians (55%) in treating adults, and 4 physicians (13%) had experience in both age groups.

Concerning a particular condition, we used only those scores of physicians who had at least "moderate" experience with that condition, and we only compared the physicians' estimations with the AM when at least 10 physicians had at least moderate experience with that condition. For liver transplant patients, patients with Prader-Willi syndrome, and patients with congestive heart failure, fewer than 10 physicians had the minimum requisite experience with the physical condition; therefore we made no comparison between the AM and the physicians' estimates for those conditions.