Brief Report

Correlations between the step activity monitor and the DynaPort ADL-monitor

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Abstract

Objective. This study was performed to evaluate correlations between the DynaPort activity of daily living monitor and the step activity monitor.

Design. Experimental study with repeated measures.

Background. Physical activity becomes more important to assess quality of life, e.g. after clinical interventions such as joint replacement surgery.

Methods. Nine subjects wore both devices simultaneously for two days. Limitations and technical problems caused by the devices were assessed by a questionnaire. Correlation coefficients were calculated between parameters derived from both instruments.

Results. Only small limitations and problems were reported. Significant correlations were found between the number of steps (step activity monitor) and the percentage of locomotion (DynaPort) ($r = 0.95$), between the number of steps and the physical activity index (DynaPort) ($r = 0.71$) and between the physical activity index and the percentage of locomotion ($r = 0.76$). Wilcoxon-tests between the first and second measurement of each subject did not reveal significant differences but correlation coefficients were poor ($r = 0.16–0.36$).

Conclusions. After one day of simultaneously wearing both devices, the percentage of locomotion can be obtained using only the step activity monitor for additional days. Poor correlations between the first and the second measurements of each subject underline the necessity to record further days to acquire the level of human physical activity.

Relevance

Different devices are available for an objective assessment of patients’ level of physical activity. To minimize the restrictions for patients during the measurements, interactions between different devices should be assessed. We determined correlations between both devices to relate the steps counted by the step activity monitor to parameters of the DynaPort.

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1. Introduction

Assessments of activities of daily living (ADL) become more important to increase knowledge about time spent in different postures and activities. Thus, researchers assess quality of life (Schutz et al., 2001) and measure the effects of their clinical interventions (van Dam et al., 2001) or evaluate trends in the society (Schutz et al., 2001). Depending on the aim of the study, various devices are used which differ with respect to technology, size and mode of expression of activity. If direct observation is not feasible, portable devices may be used instead, such as pedometers or accelerometers. Subjective techniques like surveys, questionnaires or diaries are also used but known to be dependent on patients’ cognitive functioning and their ability to accurately recall intensity, frequency and duration of different activities; consequently, they have only limited applicability (Sirard and Pate, 2001; Tudor-Locke and Myers, 2001). Furthermore, these self-reports have to be quantified and categorised by researchers. This impairs the comparability of different studies. Therefore, objective measurement devices were developed to assess activities of daily living which try to eliminate subjective influences as far as possible.
Pedometers are small and easy-to-use devices, but they are limited in their discrimination of activities and posture. If gait parameters cannot be adjusted, there will be a certain risk of under or overestimating the number of steps (Silva et al., 2002). Uni-axial accelerometers can be placed at different locations and offer customized outcomes. Tri-axial accelerometers or combinations of accelerometers and goniometers worn at defined locations enable explicit assessments of posture and motion but require more space and may interfere with the subjects’ activities (Morlock et al., 2001). It is concluded that no technique is able to quantify all aspects of physical activity. Therefore, different devices should be combined (Schutz et al., 2001; Stråd and Pate, 2001; Trost, 2001). A possible approach would be to assess a one-day-profile of daily living activities with the DynaPort ADL-monitor, a tri-axial accelerometer, and to record additional days with a pedometer, e.g. to get a seven-day-profile of the step activity. In consideration of the step activity, one could compare the day with simultaneous measurements e.g. to a seven-day-period. This could finally lead to a more accurate estimation of activities of daily living as performed by using only the DynaPort. Therefore, the purpose of the present study was to examine the correlations between the tri-axial accelerometer-based DynaPort ADL-monitor and the step activity monitor (SAM) to establish the association between both instruments.

2. Methods

2.1. Subjects

Two female and seven male subjects (Table 1) wore the DynaPort and the SAM simultaneously twice for a single day of different weeks. After demonstrating the DynaPort, adjusting the SAM to individual gait parameters and programming both devices, they were taken home by the subjects. The next morning, the subjects applied the devices and wore them until the evening. Sleeping hours during the night were not assessed. The subjects were free in their activities, but were advised to stop and resume measurements for activities like swimming, playing soccer or while having a shower because the DynaPort is not waterproof. After returning the devices the next day, the subjects filled out a questionnaire including visual analogue scales to estimate technical problems and limitations caused by the DynaPort (0 = none, 5 = many). Subjects were also asked to compare the assessed day to “normal” days. The number of interruptions was also reported in the questionnaire.

2.2. DynaPort ADL-monitor

The DynaPort ADL-monitor (McRoberts BV, Den Hague, The Netherlands) consists of three accelerometers placed at the waist (two sensors, measuring horizontal and vertical acceleration of the trunk) and the left thigh (measuring vertical acceleration). Both waist sensors are integrated into a recording unit which is worn around the waist in a neoprene belt. Data is stored on a PCMCIA flash disc which can be read out in a PC. The leg sensor is connected to the recorder via cable and is worn in a neoprene belt under the clothes. Batteries (3 AA cells) and a 16MB flash disc enable assessments of up to 30 h with a sampling rate of 32 Hz. The DynaPort weighs about 650 g.

Data is read out from disc, processed with special software (DynaScope, version 5, McRoberts BV) and automatically classified with specific algorithms. A detailed report is generated differentiating parameters for posture and motion, e.g. time spent in each position or activity. Motion is subdivided into walking or bicycling, frequencies and number of cycles are provided for each period of walking, but the accumulated number of steps is not calculated. Finally, a physical activity index (PAI) is calculated, ranging from zero to six with lying, sitting and standing being rated as zero, one and two, respectively. Walking and bicycling are not set to fixed values but are calculated taking the intensity into account.

2.3. Step activity monitor

The step activity monitor (Cyma Inc., Seattle, USA) is a miniature device to estimate step activity. It measures 6.5 × 5.1 cm, weighs 65 g and is mounted on the right ankle. The SAM can be adjusted to gait parameters e.g. by editing cadence and sensitivity. This has been shown to result in an accuracy of 97% (Coleman et al., 1999). Depending on the sampling interval and activity level of the patient, the SAM can measure and store data for more than 30 days using a 1-min sampling interval. Data is downloaded via a docking station and processed with special software (StepWatch, version 2.0).

3. Results

One male subject dropped out of the study. The remaining eight subjects completed the measurements, so the results are based on 16 trials.

Subjects wore both devices for 13.9 h (SD: 2.5) per day, the second assessment was performed 21 days (SD:
11) after the first one. The DynaPort quantified the average percentage of motion to 10.1% (SD: 4.9) and calculated an average PAI of 1.3 (SD: 0.2). Only 0.3% of the assessed time could not be attributed to one of the main categories locomotion, standing, sitting and lying (Fig. 1). The SAM counted 11 561 steps per trial (SD: 5649). On average, every other trial was interrupted for a few minutes, problems with restarting the measurements did not occur.

One survey did not return, so the results are based on 15 questionnaires. No limitations were declared twice, minor limitations 11 times and few limitations caused by the DynaPort were mentioned twice. Technical problems were reported within two measurements. Three times, subjects did not classify the assessed days as normal days. One subject went to sleep earlier than usual, one subject expected longer sitting periods in the evening and one subject expected more periods of inactivity because of a jet lag.

Calculation of Spearman-rho showed significant correlations between the number of steps (SAM) and the DynaPort categories percentage of locomotion ($r = 0.95$, $P < 0.01$, Fig. 2), percentage of standing ($r = 0.43$, n.s.), percentage of sitting ($r = -0.61$, $P < 0.05$), percentage of lying ($r = -0.04$, n.s.) and PAI ($r = 0.71$, $P < 0.01$, Fig. 3). PAI was also significantly correlated to the percentage of locomotion ($r = 0.76$, $P < 0.01$). Excluding the assessments of days which were not classified as normal days causes only noteworthy changes to the correlation coefficient of lying ($r = -0.39$, n.s.). To compare the first and the second measurement of each subject, a Wilcoxon signed-rank test was performed but did not reveal significant differences. However, Spearman correlations between the parameters of the first and second measurement were poor ($r = 0.16–0.36$).

4. Discussion

Our main aim was to relate the number of steps received by the SAM to the parameters obtained by the DynaPort for receiving the best estimation of daily life activities with minimal effort and discomfort for the subjects. Both devices were used in different studies before. For example, functional assessment of hip joint replacement was performed with the DynaPort, the activity of patients with total hip arthroplasties was assessed with the SAM. Both devices achieved good results in testing validity and reliability (Resnick et al., 2001; Shepherd et al., 1999; van Dam et al., 2001).

The results of the visual analogue scales regarding limitations and technical problems indicate a higher patient compliance for the DynaPort system compared to previously used activity monitors (Morlock et al., 2001). This could be explained by the smaller size and weight of the DynaPort system, a more convenient placement of the recorder and the capability to record 24 h without changing batteries or storage medium.

The high correlation between the steps counted by the SAM and the percentage of locomotion measured by the
DynaPort underlines the possibility to relate the number of steps to activities of daily living. Therefore, additional step counting validates the percentage of locomotion assessed by a single day of ADL-monitoring with the DynaPort. Accordingly, the percentage of locomotion can be estimated with step counting. Further days of ADL measurements are not required thus the technical demands and limitations are reduced to a lower level. If intensity and percentage of locomotion is being investigated, one day of simultaneous data acquisition with the DynaPort and SAM followed by further days using only the SAM delivers good results.

The lower correlation between the number of steps measured by the SAM and PAI of the DynaPort is explained by the calculation mode of the PAI. Not only locomotion is considered, but also the percentage of lying, sitting and standing. Because these aspects vary and are not assessed by step counting, PAI and steps as well as PAI and percentage of locomotion show a lower correlation. Seasonal effects (Pivarnik et al., 2003) and differences between working days and week-end (Trost et al., 2000) are probable and may cause a variance in time spent in different postures. This point is underlined by the poor correlations between the first and the second measurement of each subject. Assessing activities of daily living by recording data for only one day does not deliver good results, so further days of monitoring are necessary.

5. Conclusion

Both devices are useful for the assessment of physical activity. The DynaPort offers a very detailed outcome and causes only minor limitations in activities of daily living. The SAM reflects the number of steps and causes minimal limitations, if there are any at all. Compared to the DynaPort, evaluation of different postures is not possible.

Regarding the high correlation between the number of steps derived from the SAM and the percentage of locomotion measured by the DynaPort it is possible to estimate the percentage of locomotion for additional days recorded only by the SAM.

The combination of the DynaPort and the SAM offers a sound and efficient estimation of physical activity, trends in the population and the effect of clinical interventions, especially if the lower extremities are affected.

References


