Daily activity and functional performance in people with chronic disease: A cross-sectional study

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Abstract: The aim of this study was to describe the physical activity profiles, in patients with stroke, Parkinson’s disease, multiple sclerosis and rheumatoid arthritis and to investigate the association between physical activity and functional performance. Physical activity profiles were conducted using tri-axial accelerometers and functional performance was examined by the “Six-Spot Step Test” and the “Timed Up and Go”. Patients daily performed 5896 ± 3176 steps with an average cadence of 88.3 ± 11.1, 368 ± 418 inclined walking steps and 50 ± 16 sit-stand transfers. Daily activity was modestly explained by functional performance. The activity profiles showed a large variance in activity parameters and results suggest that activity parameters and the two functional performance tests are different constructs.

Subjects: Physiotherapy and Sports Medicine; Disability; Chronic Diseases; Behavioral Medicine

Keywords: accelerometers; multiple sclerosis; Parkinson’s disease; rheumatoid arthritis; stroke

ABOUT THE AUTHORS
The research activities of our group are focused on monitoring of physical activity and functional performance in real life settings. Our study of daily physical activity includes monitoring of steps, inclined walking steps, sit-stand transfers, walking cadence, collected using tri-axial accelerometers. This method allows us to get an unbiased and objective measurement of daily physical activity. Our target population includes patients with chronic and progressive disease, such as stroke, Parkinson’s disease, Multiple sclerosis, Rheumatoid arthritis, and patients with musculoskeletal pathology of the lower extremities. The work in this paper addresses an important issue between physical activity and functional performance, which may explain two different constructs of patient behavior and capability. When monitoring status of a disease or change after an intervention, the clinicians in collaboration with the patients therefore have to decide which construct is most important to measure.

PUBLIC INTEREST STATEMENT
The preservation of walking abilities and being able to move freely around in the community can have a high impact on the quality of life. Patients with chronic or progressive disease may be affected in daily physical activity and functional performance. However, different characteristics of physical activity among patients with different disease severity and the relation to functional performance are not very well investigated. Knowledge of physical activity and relation to physical performance may guide clinicians in the choice of relevant assessment tools and help patients in rehabilitation. In our study, we investigated the physical activity profiles of patients with stroke, Parkinson’s disease, multiple sclerosis and rheumatoid arthritis and the association between physical activity and functional performance. Our findings suggest that daily physical activity and physical function may be two different constructs; one showing what one actually does in real life and the other what one is able to perform at the moment.
1. Introduction

The preservation of walking abilities and being able to move freely around in the community have a high impact on the quality of life (Vagetti et al., 2014). Moreover, to overcome future costs of a rapidly increasing elderly population and the expected higher disease burden, it is crucial that patients with chronic or progressive disease maintain independent mobility and are physical active.

In Denmark, patients with chronic or progressive diseases, such as stroke, Parkinson’s disease, multiple sclerosis or rheumatoid arthritis are entitled to free of charge physiotherapy treatment specified by strict criteria defined by the Ministry of Health. The total cohort of patients with chronic disease receiving free of charge physiotherapy in Denmark counts 43 different diagnoses and includes 68,000 patients with yearly costs of approximately 700 million kroner (reports from the Danish regional health authorities, 2017). Stroke, Parkinson’s disease, multiple sclerosis or rheumatoid arthritis account for more than half of these costs and are therefore of special interest. The purpose of the free of charge physiotherapy settlement is to increase/maintain physical function or to delay the loss of physical function within this group of patients, depending on the type and severity of the disease.

Accelerometer-based activity monitoring is frequently used in research for measuring real-life physical activity and lower body functioning (Fini, Holland, Keating, Simek, & Bernhardt, 2015; Grimm & Bolink, 2016). There are now commercial, consumer-grade devices including accelerometers available such as step-counters, watches or smartphones. But the accuracy of such devices seems too low and their clinical validity is unproven in functionally limited populations for application in the clinical assessment of these populations. However, also research-grade devices and analysis methods with clinically validated accuracy levels in functionally limited populations have become assessable with regards to cost and user-friendliness.

Performance-based tests such as the six-spot step test (SSST) and timed up and go (TUG) are clinical tests used to evaluate performance status and change of performance over time in patients with chronic disease. The SSST is less used but a promising tool for assessment of functional performance (Nieuwenhuis, Tongeren, Van Sorensen, & Ravnborg, 2006). The SSST has been validated and shown to address several important domains including limb dexterity, postural stability in one-leg stance, dual tasking and cognitive capacity during walking in several neurological populations (Brincks, Callesen, Dalgas, & Johnson, 2019; Lindvall, Anderzén-Carlsson, Appelros, & Forsberg, 2018; Sandroff, Motl, Sosnoff, & Pula, 2015). The TUG test has previously been correlated to the number of daily steps measured with accelerometer-based activity monitoring in patients with multiple sclerosis (Weikert et al., 2012). Furthermore, the TUG test has been shown to be sensitive in the prediction of falling, but the TUG test may lack the ability to monitor challenges of, e.g., balance and cognitive tasks, which may influence the activity of daily living.

In clinical settings with chronic diseases, such as the Danish free of charge physiotherapy settlement, it is necessary to have reliable and valid assessment tools to monitor the status of disease and change after interventions. Chronic and progressive diseases may have a wide range of activity behaviours and functional performance levels both within individuals in the specific diseases and between diseases. The characteristics of physical activity behaviour among patients with different chronic diseases and severity and the relation to performance-based tests, such as the SSST and TUG test are not very well investigated. More knowledge of physical activity behaviour and relation to physical performance may guide the clinicians in the choice of relevant assessment tools for individual patients in rehabilitation.

Hence, the aims of the study were to 1) describe the physical activity profiles (quantified by the number of daily steps, inclined walking steps, sit-stand transfers and walking cadence) in patients with stroke, Parkinson’s disease, multiple sclerosis and rheumatoid arthritis and 2) investigate the association between physical activity profiles with the two performance-based tests; the SSST and the TUG.
2. Materials and methods

2.1. Study design
The current study applied an observational cross-sectional design to assess physical activity profiles and performance-based function in a cohort of patients with chronic and progressive diseases.

2.2. Participants
Patients were recruited from a cohort of patients who previously had participated in a survey performed in physiotherapy outpatient clinics in June 2018. Patients who made consent to be contacted for further investigation of physical activity were invited to participate in physical activity monitoring from August to October 2018. Inclusion criteria were ≥18 years old, and one of the following diagnoses: stroke, Parkinson’s disease, multiple sclerosis and rheumatoid arthritis. Exclusion criteria were not able to rise from a chair without help from another person, not cognitively able to fill out a questionnaire or not able to read or speak Danish.

The study was conducted in accordance with the declaration of Helsinki and all participants gave written and verbal informed consent. The study was approved by the Danish Data Protection Agency (j.nr. 1-16-02-757-17) and by the Central Denmark Region Committee on Biomedical Research Ethics (request: 56/2018). Data on functional performance in the sub-groups of Parkinson patients were reused from a previous study (Brincks, Jørgensen et al., 2019).

2.3. Free of change physiotherapy
Patients are referred to the Danish free of charge physiotherapy settlement by their general practitioner or a medical specialist. The specific criteria for receiving treatment or training in the settlement include (i) having one of the 43 diagnoses defined by the Danish Health Authority (Sundhedsstyrelsen, 2019), (ii) having a severe physical disability, defined as “a person who cannot manage her- or himself indoors for 24 h without help or aids for daily personal living”, and iii) having a prognosis that the disease will last more than 5 years. Furthermore, patients with a progressive disease, defined as “an abnormal function of the sensor-motoric system or nervous system”, are eligible to receive training in a team-based approach. The latter group covers patients with less severity.

The settlement holds more than 68.000 patients. Stroke, Parkinson’s disease, multiple sclerosis and rheumatoid arthritis represent the four largest groups and stands for more than half of the population. These four diseases may cover a wide range of functional levels across patient diagnosis, which we generically report by the modified Rankin Scale questionnaire (mRS-9Q) (Patel et al., 2012). The free of charge physiotherapy settlement therefore provide a population with inter-patient variability which optimizes the settings to investigate associations of the physical activity and performance-based function.

2.4. Physical activity measures
Parameters of daily physical activity (daily steps, inclined walking steps, sit-stand transfers, walking cadence) were collected using tri-axial accelerometers (AX3, Axivity Ltd., Newcastle, UK). These parameters were chosen to provide different aspects of physical activity, such as the amount of walking, general mobility and level of physical activity.

The accelerometer was mounted on the lateral thigh using adhesive tape. Data from the accelerometers were collected at 100 Hz. Patients were instructed to wear the accelerometer continuously for 7 days and 24 h per day. In some patients, the accelerometer was removed during the day, and shorter wear-time occurred in the beginning and at the end of the measurement period. Data on days where the total daily weartime was less than 12 h were excluded. Furthermore, patients with less than 3 days of wear-time were excluded from the analyses (Motl et al., 2007).

Accelerometer data were post-processed using a previously described algorithm (MATLAB (Mathworks, Natick, MA, USA)) (Lipperts, Laarhoven, Senden, Heyligers, & Grimm, 2017), validated for healthy participants (Grimm & Bolink, 2016), in patients with orthopedic pathology of the lower extremities (Lipperts et al.,...
and for impaired, slow-walking patients (Van Laarhoven et al., 2016). It has previously been used in various populations including, e.g., knee arthroplasty patients (Schotanus, Bemelmans, Grimm, Heyligers, & Kort, 2017) and patients with hip diseases (Kierkegaard et al., 2019) during post-operative recovery from the in-hospital period to full rehabilitation reflecting a wide range of functional capacity, patient of various stages of osteoarthritis from mild to end-stage (Sliepen, Mauricio, Lipperts, Grimm, & Rosenbaum, 2018) as well as healthy subjects (Daugaard et al., 2018). The algorithm was semi-automated and calibration was performed in each individual through manual selection of representative periods of normal walking (level walking). This approach ensured a reliable detection of physical activity in a wide range of different walking patterns (Lipperts et al., 2017). Waken hours were defined by subtracting nocturnal rest (which include sleep and awake periods, e.g., going to the toilet at night). Nocturnal rest was classified from the first evening time point where the accelerometer axis changed from repeating disruptions to the thigh being in a constant horizontal plane, similar to algorithmic principles described elsewhere to measure nocturnal rest periods using accelerometers. There is evidence in the literature that higher age (Hennegrave et al., 2018), male gender and higher body mass index (Chen et al., 2015) negatively affect the number of daily steps. For adjustment of possible confounders, we, therefore, collected data on age, gender and body mass index.

2.5. Performance-based tests
The SSST (Nieuwenhuis et al., 2006) in brief consists of a lane with six circles, spaced 3 m ahead and half a meter to the sides, one where the patient starts and five where blocks (wooden blocks of 4 cm height and 8 cm in diameter) are placed in the centre of these circles. All blocks had to be displaced by being kicked entirely out of their circle. Otherwise, the test was considered invalid, and a new test was performed after a short rest. If more than one attempt to kick the block out of the circle was needed this was accepted. If the test was misunderstood or inadequately conducted another test run was performed following a short rest. The full test consists of four successful runs including two rounds for each leg, starting with two runs for the dominant leg. Mean time of these four runs was calculated and served as the test result. Initially, all patients were verbally and visually instructed by the assessor. Next, all patients completed one SSST to avoid a potential learning effect between trials, which is likely to occur (Lindvall et al., 2018). Time recording started when the first foot was lifted from the starting circle and time was stopped again when the last block was kicked out of the last circle.

The TUG test was performed with the patient seated on a chair (Podsiadlo & Richardson, 1991). From this position, the patient rises and walks 3 m on an even surface as fast and safe as possible to a marked spot, where a 360° turn is performed, and then walks back to the chair. The test is timed with a stopwatch and stopped when the patient is seated in the chair again. The fastest time of three test runs is recorded as the result.

2.6. Statistical analysis
Physical activity and performance-based tests were reported with descriptive statistics. Associations between daily activity parameters and performance-based tests were assessed with scatterplots and linear regression. Underlying assumptions for linear regression were checked for each model by residual scatterplots and residuals versus fitted value plots. Right-skewed data were logarithmically transformed to achieve normal distributions. The associations were reported in both an unadjusted and an adjusted model. Confounders in the adjusted model were age, gender, body mass index. The adjusted model was used for the interpretation of the results. Data are presented as mean (M), standard deviation (SD), effect size ($R^2$), root mean square (RMS), 95% prediction intervals (PI) and p-value ($P$) with a significance level of $P = 0.05$. For data analysis we used Stata (StataCorp. 2013. Stata: Release 13. Statistical software. College Station, TX: StataCorp LP).

3. Results

3.1. Patients
From a previous survey, a total of 169 of 223 patients with chronic and progressive disease were eligible and gave consent to be contacted for an extended examination of physical activity. Of these 115 patients were able to be contacted and made final consent to be enrolled in this study.
Of the 115 patients, six had no physical activity monitored (two lost their device and four had no data recorded) and 10 patients wore the accelerometer for less than 3 days. Ninety-nine patients with valid activity data wore the accelerometer for mean 6.5 days (SD 1.54). Characteristics of the 99 eligible patients are reported in Table 1.

Ten patients were retrospectively excluded while they could not perform the SSST and the TUG without assistive walking devices and they were represented as a separate cluster on the scatter-plots compared to the rest of the patients and therefore acting as outliers in the regression analysis. The physical activity profile of the patients is reported in Table 2.

### Table 1. Characteristics at inclusion of 99 patients with one of the following diagnoses; stroke (ST), Parkinson’s disease (PD), multiple sclerosis (MS) and rheumatoid arthritis (RA)

|                      | All, n = 99 | ST, n = 22 | MS, n = 28 | PD, n = 34 | RA, n = 15 |
|----------------------|-------------|------------|------------|------------|------------|
| Age (SD):            | 62.4 (11.6) | 65.1 (10.8)| 56.3 (8.8) | 67.9 (7.8) | 57.3 (17.0)|
| Sex, n (%):          |             |            |            |            |            |
| Male                 | 40 (41.2%)  | 10 (45.5%) | 6 (21.4%)  | 22 (68.8%) | 2 (13.3%)  |
| Female               | 57 (58.8%)  | 12 (54.5%) | 22 (78.6%) | 10 (31.3%) | 13 (86.7%) |
| Time since onset disease (SD): |           |            |            |            |            |
| Years                | 10.5 (8.6)  | 8.1 (5.2)  | 12.4 (7.6) | 6.7 (5.5)  | 18.5 (13.1)|
| Residence status, n (%): |            |            |            |            |            |
| Living alone         | 15 (15.2%)  | 4 (18.2%)  | 3 (10.7%)  | 5 (14.7%)  | 3 (20.0%)  |
| Living with someone  | 84 (84.8%)  | 18 (81.8%) | 25 (89.3%) | 29 (85.3%) | 12 (80.0%) |
| Education, n (%):    |             |            |            |            |            |
| No education         | 11 (11.5%)  | 3 (14.3%)  | 3 (10.7%)  | 3 (9.4%)   | 2 (13.3%)  |
| Short (<2.5 years)   | 10 (10.4%)  | 3 (14.3%)  | 2 (7.1%)   | 3 (9.4%)   | 2 (13.3%)  |
| Medium (2.5–4 years) | 59 (61.5%)  | 11 (52.4%) | 18 (64.3%) | 21 (65.7%) | 9 (60.0%)  |
| Long (> 4 years)     | 11 (11.5%)  | 4 (19.0%)  | 2 (7.1%)   | 4 (12.5%)  | 1 (6.7%)   |
| Other                | 5 (5.2%)    | 0 (0.0%)   | 3 (10.7%)  | 1 (3.1%)   | 1 (6.7%)   |
| Work/study status, n (%): |         |            |            |            |            |
| Working              | 10 (10.1%)  | 0 (0.0%)   | 3 (10.7%)  | 5 (14.7%)  | 2 (13.3%)  |
| Flex job             | 13 (13.1%)  | 1 (4.5%)   | 8 (28.6%)  | 3 (8.8%)   | 1 (6.7%)   |
| On pension           | 69 (69.7%)  | 20 (90.9%) | 15 (53.6%) | 26 (76.5%) | 8 (53.3%)  |
| Other                | 6 (6.0%)    | 1 (4.5%)   | 1 (7.2%)   | 0 (0.0%)   | 4 (26.7%)  |
| Self-reported function (mRS-9Q), n (%): |         |            |            |            |            |
| 0: No symptoms       | 6 (6.1%)    | 0 (0.0%)   | 3 (10.7%)  | 3 (8.8%)   | 0 (0.0%)   |
| 1: No significant disability |       |            |            |            |            |
| 2: Slight disability | 10 (10.1%)  | 2 (9.1%)   | 3 (10.7%)  | 5 (14.7%)  | 0 (0.0%)   |
| 3: Moderate disability| 43 (43.4%) | 12 (54.5%) | 8 (28.6%)  | 14 (41.2%) | 9 (60.0%)  |
| 4: Moderately severe disability | 31 (31.3%) | 6 (27.3%)  | 12 (42.9%) | 9 (26.5%)  | 4 (26.7%)  |
| 5: Severe disability | 0 (0.0%)    | 0 (0.0%)   | 0 (0.0%)   | 0 (0.0%)   | 0 (0.0%)   |
| Use of assistive walking device, n (%): |         |            |            |            |            |
| Yes                  | 27 (27.3%)  | 9 (40.9%)  | 12 (42.9%) | 3 (8.8%)   | 2 (13.3%)  |
| No                   | 72 (72.7%)  | 13 (59.1%) | 16 (57.1%) | 31 (91.2%) | 12 (80.0%) |

Of the 115 patients, six had no physical activity monitored (two lost their device and four had no data recorded) and 10 patients wore the accelerometer for less than 3 days. Ninety-nine patients with valid activity data wore the accelerometer for mean 6.5 days (SD 1.54). Characteristics of the 99 eligible patients are reported in Table 1.
3.2. Six-step spot test and physical activity

The relation between SSST and the physical activity parameters (daily steps, stair-steps, sit-stand transfers and walking cadence) is illustrated in Figure 1. Patients with a need for an assistive walking device during tests are marked with black.

| Table 2. Physical activity profiles of 99 patients with one of the following diagnoses; stroke (ST) Parkinson’s disease (PD), multiple sclerosis (MS) and rheumatoid arthritis (RA) |
|-------------------------------------------------|----------------|----------------|----------------|----------------|
| Average events per day (SD)                     | All, n = 96    | ST, n = 21     | MS, n = 26     | PD, n = 34     | RA, n = 15     |
| Steps level                                     | 5896 (3176)    | 5042 (2913)    | 5453 (2954)    | 7087 (3660)    | 5277 (2017)    |
| Inclined walking steps                          | 368 (418)      | 219 (306)      | 362 (471)      | 481 (461)      | 339 (292)      |
| Sit-stand transfers                             | 50 (16)        | 41 (11)        | 56 (19)        | 50 (15)        | 47 (12)        |
| Average cadence (SD)                            |                |                |                |                |                |
| Steps/minute                                    | 88.3 (11.1)    | 80.6 (14.1)    | 87.0 (9.9)     | 93.5 (8.6)     | 90.0 (6.2)     |
| Average waken hours (SD)                        |                |                |                |                |                |
| hours per day                                   | 15.5 (0.9)     | 15.2 (0.7)     | 15.5 (0.8)     | 15.9 (1.1)     | 15.3 (0.8)     |
| Waken hours as % (SD)                           |                |                |                |                |                |
| Sedentary                                       | 66 (13)        | 70 (13)        | 69 (12)        | 59 (12)        | 67 (10)        |
| Standing                                        | 24 (10)        | 21 (10)        | 22 (8)         | 29 (10)        | 23 (9)         |
| Walking                                         | 9 (4)          | 8 (4)          | 9 (4)          | 11 (5)         | 9 (3)          |
| Other                                           | 0.8 (1.5)      | 0.5 (1.0)      | 0.7 (1.1)      | 1.1 (2.0)      | 0.8 (1.3)      |
| Functional performance, mean (SD)               |                |                |                |                |                |
| Six-spot step test, seconds                     | 10.4 (5.4)     | 15.8 (7.9)     | 10.0 (4.1)     | 8.1 (2.7)      | 8.7 (2.1)      |
| Timed up and go, seconds                        | 8.0 (4.2)      | 11.8 (6.8)     | 7.3 (2.4)      | 6.8 (2.2)      | 6.4 (1.3)      |
Table 3. The association between the Six-Spot Step Test and physical activity (daily steps, inclined walking (Inc. walk.), sit-stand transfers and walking cadence (Walk. cad.). Crude and adjusted (Adj.) results are shown

|                     | Steps adj. model | Steps adj. model | Inc. walk. adj. model | Inc. walk. adj. model | Sit-stand adj. model | Sit-stand adj. model | Walk. cad. adj. model | Walk. cad. adj. model |
|---------------------|------------------|------------------|-----------------------|-----------------------|----------------------|----------------------|-----------------------|-----------------------|
| \( R^2 \) adj.      | 0.12             | 0.24             | 0.25                  | 0.25                  | 0.11                 | 0.22                 | 0.08                  | 0.06                  |
| F-stat, \( P \)     | \( F(1,87) = 12.87, \) \( P < 0.001 \) | \( F(4,82) = 7.73, \) \( P < 0.001 \) | \( F(1,87) = 30.19, \) \( P < 0.001 \) | \( F(4,82) = 8.23, \) \( P < 0.001 \) | \( F(1,87) = 11.60, \) \( P = 0.001 \) | \( F(4,82) = 7.04, \) \( P = 0.001 \) | \( F(1,87) = 8.62, \) \( P = 0.004 \) | \( F(4,82) = 2.28, \) \( P = 0.07 \) |
| RMS                 | 0.50             | 0.47             | 1.08                  | 1.09                  | 0.26                 | 0.24                 | 0.09                  | 0.09                  |
| Variation range with 95 % \( PI \) | \(-62; 164\) | \(-60; 149\) | \(-88; 735\) | \(-88; 740\) | \(-39; 65\) | \(-37; 59\) | \(-17; 20\) | \(-17; 20\) |

\( F \) = F-statistics \( P \) = p-value, \( PI \) = Prediction interval, RMS = root mean square.
The results of the linear regression between the SSST and physical activity measured as daily steps, steps at inclined walking, sit-stand transfers and walking cadence are reported in Table 3. The SSST was associated to physical activity parameters in such a way that it explained 24%, 25%, 22% and 6% of each of the physical activity parameters in the adjusted model and in general PI reflected a large variation of each association.

3.3. Timed up and go test and physical activity
The relation between TUG and physical activity parameters (daily steps, stair-steps, sit-stand transfers and walking cadence) is visualised in Figure 2.

The linear regression analysis showed that the TUG explained daily steps, inclined walking steps, sit-stand transfers and walking cadence to the same extent as the SSST in both the unadjusted and adjusted model (adjusted for age, gender and body mass index), Table 4. The results of the regression indicated the TUG explained 22%, 21%, 15% and 7% of each of the physical activity parameters in the adjusted model and in general PI reflected a large variation of each association.

4. Discussion
The physical activity profiles of the four groups with chronic or progressive disease revealed a large variance in the real-world walking behaviour and sit-stand transfers both within and between the four groups of patients. The majority of the patients seemed to have a reduced walking behaviour. The SSST and the TUG explained 6-24% of the variation in the selected parameters of physical activity of which the cadence was the parameter with the least association to the performance-based tests.

4.1. Physical activity profiles
Patients were fairly equally distributed on level of self-reported function (mRS-9Q), level of education and in respect to living with a partner; however, some variation in the activity profile did occur along with differences in the use of the assistive walking device and less time since onset of
Table 4. The association between the Timed Up and Go and physical activity (daily steps, inclined walking (Inc. walk.), sit-stand transfers and walking cadence (Walk. cad.)). Crude and adjusted (Adj.) results are shown

| Steps adj. model | Inc. walk adj. model | Inc. walk model | Sit-stand adj. model | Sit-stand model | Walk. cad. adj. model | Walk. cad. model |
|------------------|----------------------|----------------|----------------------|----------------|----------------------|----------------|
| $R^2$ adjusted   | $F(1,87) = 9.57$, $P = 0.003$ | $F(4,82) = 7.10$, $P < 0.001$ | $F(1,87) = 21.1$, $P < 0.001$ | $F(4,82) = 6.71$, $P < 0.001$ | $F(1,87) = 9.90$, $P = 0.002$ | $F(4,82) = 2.51$, $P = 0.09$ |
| $R^2$            | 0.09                 | 0.19           | 0.21                 | 0.21           | 0.06                 | 0.15           |
| RMS              | 0.50                 | 0.67           | 0.71                 | 0.71           | 0.68                 | 0.82           |
| Variation range  | $[-63; 169]$         | $[-60; 152]$   | $[-89; 812]$         | $[-89; 789]$   | $[-40; 67]$          | $[-38; 62]$    |
| $F$-statistics, $P$ = p-value | Prediction interval, RMS = root mean square |
disease. In a study applying the same accelerometer-based method as this study, 171 healthy patients with a mean age of 64 (SD 9.7) years, body mass index of 26.3 (SD 4.8) performed an average of 7477 steps per day (SD 3388) (Daugaard et al., 2018) which is considerably more daily steps than the combined groups of patients in this study who perform 5896 (SD 3176) steps. Engelhard, Patek, Lach, and Goldman (2018) reported an average of 5270 (SD 2217) steps per day among people with moderate multiple sclerosis and 6347 (SD 2961) among people with mild multiple sclerosis. The observation of reduced walking behavior may partly be explained by the selection of people with chronic disease referred to free of charge physiotherapy, which per definition have some degree of functional disability. Interestingly this may not have been captured by the self-reported mRS-9Q where more than half scored 0 to 2 of disability. Part of the reason for this may be that patients with low disability primarily only experience reduced function when exhausted, as seen in multiple sclerosis. Fini et al. (2015) reported an average of 4078 steps per day among patients with stroke in the chronic phase. Opposite to our results in patients with multiple sclerosis, this number of steps lies substantially below the level of our population. It is difficult to say exactly what causes this difference, but free of charge physiotherapy along with possible differences of demographics and different accelerometers and methods within the studies could be some of the reasons.

Only few studies have applied tri-axial accelerometer-based measurements in people with chronic disease (Christiansen et al., 2017; Dobkin, Xu, Batalin, Thomas, & Kaiser, 2011; Hale, Pal, & Becker, 2008; Nozoe et al., 2019), whereas, several studies have used uni-axial accelerometers, pedometers or self-reported physical activity. The daily real-world activity profiles, using tri-axial accelerometers, provided in this study enable comparison with future studies with similar patient populations and methods and may provide more insights of daily physical activity in patients with chronic or progressive disease.

### 4.2. Associations between physical activity and performance-based function

The SSST and the TUG were only to some extent associated with the selected parameters of physical activity, regardless of body mass index, age and gender. Those patients who performed fewest daily steps, inclined walking steps, sit-stand transfers and had the lowest walking cadence had a poorer performance-based function. Moreover, we found that the number of steps and inclined walking steps (steps walked up or downstairs or slopes) was the physical activity parameter most closely associated with both the SSST and the TUG. Both daily walking in normal surroundings and inclined walking requires good balance and muscle strength and thus potentially a difficult task for patients with, e.g., chronic or progressive diseases. Cadence showed the lowest association with the SSST and the TUG which may surprise since cadence has previously been found to be an important predictor of disease progression and as such an important target parameter when measuring disease progression. However, performance-based measures of physical function and accelerometer-based measures of physical activity appear to assess different constructs, and moreover, performance-based tests may not represent patients’ activity performance in the real world. This is supported by the literature showing that the correlation among performance-based measures, self-reported measures and accelerometer-based measures is debated (Jacobsen et al., 2019; Van Der Linden, Hooper, Cowan, Weller, & Mercer, 2014) and it has previously been suggested that walking capacity and physical activity behaviours are separated constructs (Engelhard et al., 2018). As such, accelerometer-based measures of physical activity and performance-based measures of physical function have different abilities and may ultimately be combined to measure different effects in interventions and clinical settings with patients having chronic or progressive disease.

### 4.3. Limitations

We acknowledge certain limitations in our study. First, the sample size was 99 patients divided into four groups with 15–34 patients in each group which may limit the generalization of the physical activity profile and performance-based function to the general populations of the four groups. Second, since this is a cross-sectional study, we cannot comment on causality, but only
on the associations between accelerometer-based physical activity and performance-based function, e.g., we can not conclude that patients with high performance-based function are more physically active. Third, due to the method of recruitment, it is possible that the patients who accepted the study invitation were a selected group of highly motivated people and thus might have a different activity behaviour compared to most people with these four chronic diseases. However, in regard to previous findings in patients with multiple sclerosis, the opposite was found in our population in regard to, e.g., fewer steps taken. Hence, we have to be cautious to generalise the results to all people with either stroke, Parkinson’s disease, multiple sclerosis or rheumatoid arthritis.

4.4. Conclusion

In this study, we provided a physical activity profile of four different patient cohorts with stroke, Parkinson’s disease, multiple sclerosis and rheumatoid arthritis. The activity profiles showed large variance in activity parameters of daily steps, inclined walking steps, sit-stand transfers and walking cadence within patient groups. The association of the physical activity parameters to SSST and TUG was modest and therefore physical activity could only to some extent be explained by the SSST and TUG test.

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Declaration of Interests

No potential conflict of interest was reported by the authors.

Implications for Rehabilitation

- Daily physical activity and physical function are two different constructs; one showing what one actually does in real life and the other what one can perform at the moment.
- The Six-Spot Step Test and Timed Up and Go test are similarly associated with daily physical activity and as such none of these two tests are superior to the other in explaining the daily physical activity.
- When monitoring the status of the disease or change after an intervention, the clinician has to decide which construct is most important to measure.

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