Characteristics of intensity-based physical activity according to gait ability in people hospitalized with subacute stroke: a cross-sectional study

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ABSTRACT. Objective: Gait ability may be related to the level of intensity-based physical activity in people who have experienced a stroke; however, this relationship has not been explored in previous studies. This study aimed to investigate the characteristics of intensity-based physical activity according to gait ability and to explore the factors related to different intensity physical activity. Method: Eighty hospitalized participants with subacute stroke were assigned to three groups based on their gait ability: group 1 (n = 28) could walk independently with a maximal gait speed (MGS) of more than 0.9 m/s; group 2 (n = 11) could walk independently with a MGS of less than 0.9 m/s; group 3 (n = 41) could not walk independently. Light-intensity physical activity (LIPA) and moderate-to-vigorous physical activity (MVPA) were measured for 12 hours using an accelerometer (OMRON, HJA350-IT) for 7 consecutive days and were calculated throughout three time periods (daytime, non-therapy time, or therapy time). Results: In each time period, a two-way ANOVA showed an interaction between the groups and intensity-based physical activity (p < 0.05). Bonferroni post hoc test showed a significantly higher LIPA in groups 1 and 2 compared with group 3 in daytime or non-therapy time. In contrast, group 1 showed a significantly higher MVPA compared with group 2 and 3 for each time period. Conclusion: During daytime and non-therapy time, the results suggested that gait independence is related to LIPA rather than gait speed, and gait speed and gait independence is related to MVPA.

Key words: subacute stroke, hospital, light-intensity physical activity, moderate-to-vigorous intensity physical activity, gait ability

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These results of previous studies revealed that people with stroke show low values of LIPA and MVPA, and MVPA tend to be low compared with LIPA. On the other hand, little is known about the amount of intensity-based physical activity in people with subacute stroke who received post-acute rehabilitation. In Japan, Kaifukuki rehabilitation ward provides intensive rehabilitation for people with subacute stroke who required post-acute rehabilitation, no study has been done to clarify the characteristics of intensity-based physical activity at the Kaifukuki rehabilitation ward in people with subacute stroke. In other country, one recent study revealed that people hospitalized with subacute stroke performed approximately 22 minutes of moderate and 1 minute of vigorous activity during the daytime (9 am to 4:30 pm). It has potential that people hospitalized with subacute stroke show low LIPA and MVPA as well as the results of previous reports. However, in subacute stroke, characteristics of intensity-based physical activity including LIPA is still unknown. Clarifying the characteristics of LIPA and MVPA is required to discuss the treatment strategy of improving daytime physical activity in hospital more concretely.

Furthermore, the characteristics of intensity-based physical activity may differ according to severity of disability. There are no reports which investigated the amount of intensity-based physical activity in people hospitalized with subacute stroke according to the severity of disability. Additionally, little is known about which disabilities are related to intensity-based physical activity in people hospitalized with subacute stroke according to the severity of disability. In particular, the gait ability attracts as an important factor related to the amount of physical activity in the people with chronic stroke. Walking is one of major activities of daily living in hospitalized people with subacute stroke, and is comparable to activities with a wide range of intensity from LIPA to MVPA. Concretely, walking at a higher gait speed involves a higher intensity of physical activity. Thus, people with stroke who are unable to walk at a high gait speed may not be able to perform sufficient MVPA. In contrast, LIPA commonly involves standing activities, such as light walking and standing to perform self-care tasks. People with stroke who are unable to walk independently may not be able to perform sufficient LIPA. Therefore, we hypothesized that people with subacute stroke in the Kaifukuki rehabilitation ward may show different characteristics of intensity-based physical activity depending on their gait speed and level of gait independence, which could be related to the amount of MVPA and LIPA, respectively. In addition, in people hospitalized with subacute stroke, increased therapy including physical therapy or occupational therapy and additional exercise during non-therapy times contributed to the recovery of post-stroke disabilities. From the perspective of risk management of adverse events, such as falling or a cardiac event, there are limited activities that can be performed during non-therapy time. Intensity-based physical activity during therapy and non-therapy time may show different characteristics; however, this has not been established.

To provide the information to discuss the treatment strategy to enhance the amount of intensity-based physical activity during whole daytime, non-therapy time, or therapy time in the people hospitalized with subacute stroke, the purpose of this study was to investigate the characteristics of intensity-based physical activity according to gait ability and the factors related to different intensities of physical activity at the Kaifukuki rehabilitation ward in people with subacute stroke.

Method

Study design

This study had a cross-sectional design with a convenience sample and was conducted based on the Strengthening the Reporting of Observational Studies in Epidemiology guidelines to standardize the study.

Participants

The study enrolled 80 participants with subacute stroke (defined as the time from stroke, ranging from 7 days to 6 months) from a Kaifukuki rehabilitation ward. The participants were included in the study if they met the following criteria: first stroke (ischemic or hemorrhagic); stable overall medical condition after stroke onset; able to walk with or without physical assistance or with a walking aid or lower limb orthosis; able to manage an accelerometer by themselves; and sufficient cognitive ability to provide informed consent. The rehabilitation program comprised conventional physical therapy (including exercise for range of motion, muscle strength, postural balance, transferring, and walking), occupational therapy (including exercises for ADL, such as using the bathroom, grooming, dressing, and bathing), and speech therapy (including dysphagia and aphasia), with a total therapy time of approximately 180 minutes per day. All participants provided written informed consent. This study was approved by the ethical committee of Kyorin University of Health Sciences (approval number: 28-9).

Information regarding participant characteristics including age, gender, time since stroke, type of stroke, and paretic side was collected from the medical records of all participants. The participants’ functional independence was assessed by the Functional Independence Measure (FIM). The FIM assesses 18 items related to ADL on a 7-point scale ranging from 1 (total assistance) to 7 (com-
from bodily movement during ADL with high accuracy, accelerometer can estimate metabolic equivalents (METs) based on Cohen’s criteria. Thus, in this study, larger effect size was chosen for main effect of physical activity from hospitalization with subacute stroke during sitting, standing, and walking activities in people. Accelerometer can also provide a valid estimation of METs, with coefficient > 0.8 over seven days of measurement).

Power analysis revealed minimum of 7 participants in each group would be required to detect a significant interaction effect. Additionally, alpha err and beta err were set at 0.05 and 0.2, respectively.

Gait ability measurement

To assess gait ability, functional ambulation category (FAC) and maximal gait speed (MGS) were determined by the primary physical therapist. The validity and reliability of the FAC and MGS have been reported in people with stroke, and classifies gait ability on six levels according to the amount of physical support required, with scores ranging from 0 (non-functional ambulator) to 5 (independent ambulator). The MGS assesses the participant’s gait speed over a 10-m walkway using a stopwatch.

Physical activity measurement

Physical activity was measured using the Active Style Pro HJA.350-IT with triaxial accelerometer (OMRON, Kyoto, Japan), which is designed to be attached to a waist belt [size 74 × 46 × 34 mm; weight approximately 60 g; and sensitivity 0.003 – 6 G force (1 G = 9.807 m/s²)]. The accelerometer can estimate metabolic equivalents (METs) from bodily movement during ADL with high accuracy and has good test-retest reliability for intensity-based daytime physical activity measurement (intraclass correlation coefficient > 0.8 over seven days of measurement). The accelerometer can also provide a valid estimation of METs during sitting, standing, and walking activities in people hospitalized with subacute stroke.

Based on a previous study, all participants wore the accelerometer on a waist belt on their paretic during the daytime, between 7:00 am and 7:00 pm, except during bathing, for 7 consecutive days. To ensure wearing the accelerometer, the staffs confirmed wearing accuracy or not at morning, night and therapy time every day. LIPA was defined as 1.6-2.9 estimated METs and MVPA as ≥3 estimated METS. The number of minutes of LIPA and MVPA during the daytime and non-therapy time was calculated from the METs data every 60 s over the 12-h period. The daytime, excluding therapy time (physical therapy, occupational therapy, and speech therapy), was set as non-therapy time, and the total minutes of LIPA and MVPA during therapy time and non-therapy time were calculated for 7 consecutive days (therapy time LIPA, therapy time MVPA, non-therapy time LIPA, and non-therapy time MVPA).

Statistical analysis

Continuous variables were expressed as the mean ± standard deviation, and were tested for normality using the Shapiro-Wilk test. Categorical variables were expressed as frequencies. To assess the characteristics of intensity-based physical activity, the 80 participants were assigned to three groups based on gait ability, as follows (Figure 1): group 1 (n = 28) could walk independently with good MGS of more than 0.9 m/s; group 2 (n = 11) could walk independently with a MGS slower than 0.9 m/s; and group 3 (n = 41) could not walk independently. We used an MGS of 0.9 m/s as a cutoff-point because it is used as a predictive value for independent community walking in people with stroke.

To compare the characteristics among groups, one-way ANOVA, chi-square, and Kruskal-Wallis tests were carried out. Two-way ANOVA (3 groups × 2 physical activity levels) and Bonferroni post hoc tests were carried out for each physical activity period (total daytime physical activity, therapy time physical activity, non-therapy time physical activity).

To investigate the relationship between gait ability and daytime physical activity, a logistic regression analysis was carried out with two models after setting the dependent variables as differences of groups which were categorized based on gait independence and MGS, and calculating the
odds ratio (OR) and 95% confidence intervals (95% CI). First, daytime LIPA and daytime MVPA were entered into regression model which was set the differences of gait independence [0: group 3 (could not walk independently), 1: group 2 (could walk independently with a MGS slower than 0.9 m/s)] as dependent variable (Model 1). Second, in participants who could walk independently, daytime LIPA and daytime MVPA were entered into regression model which was set differences of MGS [0: group 2 (MGS slower than 0.9 m/s), 1: group 1 (MGS of more than 0.9 m/s)] as dependent variables (Model 2). The Hosmer - Lemeshow test was performed for all logistic regression models to assess goodness of fit.

All analyses were performed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA). The threshold for significance was \( p < 0.05 \).

### Results

**Participant characteristics**

Participants’ characteristics are summarized in Table 1. All participants accomplished all outcome measurements. There were no significant differences in age, gender, time since stroke, or type of stroke among the three groups. FAC and FIM scores differed significantly among the three groups.

**Daytime physical activity**

In all participants, daytime LIPA and daytime MVPA were 143.9 ± 57.0 (range: 43.7 - 286.9) minutes and 16.5 ± 21.8 (range: 0.3 - 142.3) minutes, respectively. The two-way ANOVA demonstrated significant main effects for the two intensity-based physical activities (\( F = 335.3, \text{df} = 1, p < 0.001 \)) and three groups (\( F = 17.9, \text{df} = 2, p < 0.001 \)), and a significant interaction effect (\( F = 4.4, \text{df} = 2, p < 0.05 \)). The results of Bonferroni post hoc tests shown in Figure 2. Bonferroni post hoc tests demonstrated that daytime LIPA was significantly higher than daytime MVPA in each group (\( p < 0.001 \)) and daytime LIPA in groups 1 (172.3 ± 57.0 minutes) and 2 (170.5 ± 43.2 minutes) was significantly higher than in group 3 (117.3 ± 54.4 minutes). The difference in daytime LIPA between groups 1 and 2 was not significant. In contrast, there were no significant differences in daytime MVPA between groups 2 (8.9 ± 12.5 minutes) and 3 (7.2 ± 7.6 minutes), but daytime MVPA in group 1 (33.2 ± 28.4 minutes) was significantly higher than in groups 2 and 3.

**Non-therapy time physical activity**

In all participants, non-therapy time LIPA and non-therapy time MVPA were 85.1 ± 46.2 (range: 15.0 - 208.4) minutes and 6.8 ± 12.6 (range: 0.1 - 57.4) minutes, respectively. The two-way ANOVA demonstrated significant main effects for the two intensity-based physical activities (\( F = 286.6, \text{df} = 1, p < 0.001 \)) and three groups (\( F = 19.0, \text{df} = 2, p < 0.001 \)), and a significant interaction effect (\( F = 11.8, \text{df} = 2, p < 0.001 \)). The results of Bonferroni post hoc tests shown in Figure 3. Bonferroni post hoc tests demonstrated that non-therapy time LIPA was significantly higher than non-therapy time MVPA in each group (\( p < 0.001 \)), and non-therapy time LIPA was significantly higher in groups 1 (114.4 ± 42.6 minutes) and 2 (101.1 ± 31.8 minutes) than in group 3 (60.8 ± 38.3 minutes). In contrast, non-therapy time MVPA in group 1 (13.0 ± 19.6 minutes) was significantly higher than in groups 2 (5.0 ± 6.7 minutes) and 3 (3.0 ± 2.1 minutes).

**Therapy time physical activity**

In all participants, therapy time LIPA and therapy time MVPA were 58.7 ± 21.9 (range: 14.6 - 121.4) minutes and 9.5 ± 12.0 (range: 0 - 57.4) minutes, respectively. The two-way ANOVA demonstrated significant main effects for the two intensity-based physical activities (\( F = 257.4, \text{df} = 1, p < 0.001 \)) and three groups (\( F = 4.8, \text{df} = 2, p < 0.05 \)), and a significant interaction effect (\( F = 5.1, \text{df} = 2, p < 0.05 \)). The results of Bonferroni post hoc tests shown in Figure 4. Bonferroni post hoc tests demonstrated that therapy time LIPA was significantly higher than therapy time MVPA in each

### Table 1. Participant characteristics

|                      | Group 1 (n=28) | Group 2 (n=11) | Group 3 (n=41) | \( p \) |
|----------------------|---------------|---------------|---------------|------|
| Age, years           | 59.6±12.1     | 67.6±14.8     | 65.1±14.0     | 0.147-|
| Gender, men/women, number | 15/13         | 5/6           | 26/15         | 0.492-|
| Time since stroke, day | 54.3±18.2     | 57.6±14.7     | 61.5±17.5     | 0.276-|
| Type of stroke, ischemic/hemorrhage, number | 16/12 | 6/5 | 22/19 | 0.960-|
| Functional ambulation category, 1/2/3/4/5, number | 0/0/0/14/14 | 0/0/0/11/0 | 14/19/8/0/0 | <0.001-|
| Functional independence measure, point | 118.3±6.4 | 111.8±8.3 | 78.4±21.8 | <0.001-|

Values are mean ± standard deviation or number. The threshold for significance was \( p < 0.05 \).

- One-way analysis of variance
- Chi-squared test
- Kruskal-Wallis test

Shapiro-Wilk test: age were normal in all groups (\( p > 0.05 \)), time since stroke was non-normal in group 2 (\( p < 0.05 \)).

Bonferroni post hoc tests shown in Figure 3. Bonferroni post hoc tests demonstrated that non-therapy time LIPA was significantly higher than non-therapy time MVPA in each group (\( p < 0.001 \)), and non-therapy time LIPA was significantly higher in groups 1 (114.4 ± 42.6 minutes) and 2 (101.1 ± 31.8 minutes) than in group 3 (60.8 ± 38.3 minutes). In contrast, non-therapy time MVPA in group 1 (13.0 ± 19.6 minutes) was significantly higher than in groups 2 (5.0 ± 6.7 minutes) and 3 (3.0 ± 2.1 minutes).
The threshold for significance was $p<0.05$.

* $p<0.05$ † $p<0.001$

Shapiro-Wilk test: daytime LIPA in group 1 and 2 were normal ($p>0.05$), daytime LIPA in group 3 were non-normal ($p<0.001$), daytime MVPA in all groups were non-normal ($p<0.001$).

Shapiro-Wilk test: non-therapy time LIPA in group 1 and 2 were normal ($p>0.05$), non-therapy time LIPA in group 3 were non-normal ($p<0.001$), non-therapy time MVPA in all groups were non-normal ($p<0.001$).

group ($p<0.001$), and there was no significant difference in therapy time LIPA among the three groups (group 1: $57.9 \pm 22.2$ minutes, group 2: $69.4 \pm 21.0$ minutes, group 3: $56.4 \pm 21.6$ minutes). In contrast, therapy time MVPA in
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Figure 4. Bonferroni post hoc tests in therapy time intensity-based physical activity

The threshold for significance was $p < 0.05$.

* $p < 0.05$ † $p < 0.001$

Shapiro-Wilk test: therapy time LIPA in all groups were normal ($p > 0.05$), therapy time MVPA in group 1 were normal ($p < 0.001$), therapy time MVPA in group 2 and 3 were non-normal ($p < 0.001$).

Table 2. The relationships between differences of gait ability and daytime physical activity

| Model 1 (n=52) | | Model 2 (n=39) |
|----------------|----------------|----------------|
| Dependent variables | Differences of gait independence (0: group 3, 1: group 2) | Differences of maximal gait speed (0: group 2, 1: group 1) |
| Independent variables | OR | 95% CI | p | OR | 95% CI | p |
| Daytime LIPA | 1.018 | 1.004 - 1.031 | 0.011 | 1.012 | 0.993 - 1.031 | 0.207 |
| Daytime MVPA | 0.990 | 0.916 - 1.071 | 0.809 | 1.124 | 1.036 - 1.221 | 0.005 |
| Hosmer-Lemeshow test | $\chi^2=45.965, p=0.597$ | $\chi^2=31.740, p=0.671$ |

The threshold for significance was $p < 0.05$.

For Model 1, the dependent variables were differences of gait independence (0: group 3, 1: group 2), and the independent variables were daytime LIPA and daytime MVPA; For Model 2, the dependent variables were differences of gait speed (0: group 2, 1: group 1), and the independent variables were daytime LIPA and daytime MVPA.

The relationships between differences of gait ability and daytime physical activity

The results of binomial logistic regression analysis are summarized in Table 2. The Model 1 and 2 fitted the data (Model 1: $p > 0.05$, $\chi^2 = 45.965$ Model 2: $p > 0.05$, $\chi^2 = 31.740$). Model 1 results showed that only daytime LIPA (OR = 1.018, 95% CI = 1.004 - 1.031, $p < 0.05$) was significantly related to differences of gait independence.

Model 2 results showed that only daytime MVPA (OR = 1.124, 95% CI = 1.036 - 1.221, $p < 0.01$) was significantly related to differences of gait speed.

Discussion

This study investigated the characteristics of intensity-
based physical activity according to gait ability and the factors related to different intensities of physical activity in people hospitalized with subacute stroke. The results revealed that the characteristics of intensity-based physical activity differed according to gait ability, and the relationships between gait ability and amount of intensity-based physical activity. To the best of our knowledge, this is the first study to verify the characteristics of intensity-based physical activity according to gait ability and factors related to different intensities of physical activity in people hospitalized with subacute stroke.

The amount of LIPA during daytime, non-therapy time, and therapy time was significantly higher than the amount of MVPA in all groups. LIPA was defined as 1.6-2.9 estimated METs, which is comparable to standing activities with light effort such as standing while reaching, stepping in place, and slow walking. These activities are frequently performed by hospitalized people during ADL such as toileting, grooming, dressing, transfer maneuvers, and walking along short corridors. In contrast, MVPA, defined as ≥3.0 estimated METs, which is comparable to walking at a relatively high gait speed, walking around obstacles, carrying objects, and running. Opportunities for participating in MVPA in the hospital environment may be limited.

The amount of daytime LIPA was approximately 172.3, 170.5, and 117.3 minutes while daytime MVPA was approximately 33.2, 8.9, and 7.2 in groups 1, 2, and 3, respectively. In a previous study by English et al., people with chronic stroke who could walk independently spent approximately 210 minutes engaged in LIPA and 5 minutes in MVPA per day, which was significantly less than the control participants. The participants who could walk independently in this study (groups 1 and 2) engaged in similar amounts of daytime LIPA and MVPA, except for daytime MVPA in group 1. Although the previous study only collected data in mild stroke participants, their mean gait speed was relatively low (approximately 0.8 m/s, range 0.1-1.6 m/s), comparable to the mean gait speed in group 1 of our study. The participants in group 1 in our study had higher daytime MVPA values than participants in the previous study. These results suggest that even if independent walking is possible, daytime MVPA is not always high in people with subacute stroke with a slow gait speed. Moreover, compared with the study by English et al., participants who could not walk independently in this study clearly showed a lower amount of not only MVPA but also LIPA than participants in the study by English et al. A beneficial treatment strategy is needed to enhance the amount of physical activity according to gait ability in people hospitalized with subacute stroke.

Our results show that participants who could walk independently engaged in significantly more LIPA than participants who could not walk independently during daytime or non-therapy time. On the other hand, there were no significant differences of amount of LIPA during daytime or non-therapy time between group 1 and 2. Furthermore, the results of logistic regression analysis revealed that there was significant relationship between gait independence and daytime LIPA. These results suggest that gait independence is related to the amount of daytime or non-therapy time LIPA. Because participants who could walk independently were able to obtain the opportunities for free-standing activities without physical assistance, and were probably able to engage more amount of LIPA in the hospital. In fact, during therapy time, when physical assistance was always provided for gait, there was no significant difference in LIPA among the participants. It is important to improve the inactive life style as well as to enhance LIPA in people with subacute stroke who cannot walk independently, and treatment to improve the gait independence may be contribute to enhance amount of daytime LIPA. Moreover, collaborative treatment involving caregivers, family members, or nursing staff in non-therapy time would be a useful way to increase opportunity of engaging daytime LIPA in people with subacute stroke who could not walk independently.

Participants who could walk independently with a high gait speed showed significantly higher MVPA values during each period than those who could walk independently with a slow gait speed. Additionally, in participants who could walk independently, the results of logistic regression analysis showed that there was significant relationship between gait speed and daytime MVPA. These results suggest that gait speed and gait independence are related to the overall amount of MVPA. Especially, higher gait speed would be an important factor for making the MVPA, because the energy expenditure of walking increases with gait speed. Although performing 150 minutes or more of moderate intensity physical activity per week is recommended for people with stroke, those with subacute stroke who lacked either gait speed or gait independence were unable to achieve this recommendation. For people with subacute stroke, it is necessary to improve their functions so that activities comparable to MVPA can be carried out, and improving not only gait independence but also gait speed may be a beneficial treatment strategy to enhance MVPA in daily hospital life.

The treatment methods used to enhance physical activity among hospitalized people with subacute stroke should be considered based on an individual’s gait independence and gait speed.

Study limitations

First, a convenience sample was used and the sample size was small, especially in group 2. Furthermore, some physical activity variables analyzed in the two-way ANOVA were non-normality distributed. Thus, caution is
required when interpreting the results for two-way ANOVA. Second, because this was a cross-sectional study, we cannot provide conclusions regarding causal relationships with regard to the factors related to intensity-based physical activity. Third, this study was conducted at a single hospital, and the results may not be generalizable to all people hospitalized with subacute stroke. Further longitudinal studies with larger samples in a multiple hospital setting are required to investigate the causal relationship between gait ability and intensity-based physical activity in people hospitalized with subacute stroke.

Conclusion

We investigated the characteristics and factors related to intensity-based physical activity according to gait ability in people hospitalized with subacute stroke. Among those who could walk independently, participants with a slow gait speed had low levels of MVPA during therapy and non-therapy time, similar to those who could not walk independently. Participants who could not walk independently had low levels of both MVPA and LIPA. We showed that gait independence is related to the amount of LIPA in non-therapy time, and that gait speed and gait independence could be related to the amount of MVPA during therapy and non-therapy time. Strategies to enhance physical activity while taking into account gait ability are necessary for people hospitalized with subacute stroke.

Conflict of Interest: There is no conflict of interest to disclose.

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