Topic: Gait and Independence: Investigating the Relations between Gait Parameters, Barthel Index, and Hospitalization in Patients with Sarcopenia

Functional independence in activities of daily living (ADL) significantly impacts a person's quality of life (QOL). Sarcopenia is a disease that describes the loss of muscle mass. It is an age-related adverse muscle change that affects the architecture and composition of muscles [1, 2]. The reduced muscle strength in patients with Sarcopenia leads to an increased risk of falls, a decrease in gait speed, restrictions in ADL, functional dependency, and a reduction in QOL [2–4]. With the disease progression and increase in functional dependencies, patients often require to be hospitalized. Sarcopenia is mostly common among elderly adults but can also occur earlier in life [5–7]. Sarcopenia also leads to a decrease in gait speed [3]. Since no cure exists, patients with Sarcopenia often require to be hospitalized and usually undergo physical therapy and rehabilitation during their stay [8].

One of the physical disability measurements is the Barthel index (BI). BI is an assessment with ten items including gait-related activities such as walking, stair ambulation, and transferring from a (wheel-)chair to bed and return [9]. The sub-scores are weighted and scored based on their perceived importance. The full score of 100 points stands for maximum independence. The BI is widely used in hospitals and rehabilitation centers due to its good clinical utility: little staff training, quick and easy administration, and low cost [10]. With the BI containing key physical and self-care items, it is commonly used for admission and discharge planning of hospitalized patients [10]. However, BI is a score rated by the patient or a professional and therefore is a subject measure of the patient's condition [9–11].

Therefore, a more objective, standardized, and generalizable approach to mobility assessment in clinical settings is needed [12]. A practical solution for an objective assessment of BI is instrumented gait analysis. Wearables can track and assess a person's mobility over a period of time and can be used in a variety of environments, including clinical and home settings. Inertial measurement units (IMUs) are small, lightweight devices that can objectively measure gait. Previous research has demonstrated the utility of IMUs in stroke patients to assess gait in terms of gait parameters such as spatiotemporal, frequency, complexity, and asymmetry features, enabling close monitoring of the gait of post-stroke recovery [13].

It is of interest to consider the relation between the BI and IMU-derived gait parameters, to ultimately support the healthcare professionals in making important therapy decisions, such as hospitalization, the length of stay (LOS) in rehabilitation, and the necessary physiotherapy. The objectivity of IMUs results in a more convenient and precise therapy and rehabilitation. Monitoring (potential) patients remotely can prevent falls and injuries by determining the suggested time for rehabilitation.

Chang et al. found that gait-related BI sub-scores are associated with gait speed and stance time [14]. Their linear regression analysis indicated a weak correlation, with R^2 values ranging from 0.096 to 0.181. Consequently, their approach lacks robustness in predicting the BI from the specified gait parameters [14]. Other studies show a negative correlation between the LOS and the BI ensuring that in neurological rehabilitation the

BI on admission predicts the LOS [15–17]. However, no statements were made regarding the BI on discharge. A study on neurological and orthopedic patients demonstrated a correlation between BI subscores and the total score at discharge ($R^2 = 0.636$ and $R^2 = 0.622$, respectively) [18].

This thesis aims to explore the changes in gait parameters at admission and discharge as well as their correlation with the overall BI score and its sub-scores. Additionally, factors such as gait parameters and BI scores influencing the LOS will be analyzed. Here, LOS is calculated as days between the date of gait assessment on admission and the date of gait assessment on discharge. This work will also develop a model to estimate the LOS based on gait metrics obtained from IMU data, BI (sub-)scores, and demographic characteristics to identify patients who are at higher risk for a longer rehabilitation period and to facilitate resource allocation and discharge planning.

The dataset for this study was recorded at AGAPLESION hospitals in Hamburg and Frankfurt am Main, Germany. It contains foot-worn IMU data of standardized two-minute walks (TMWs) and Timed Up and Go (TUG) tests of 174 patients with Sarcopenia and their BI assessed by health care professionals at admission and discharge as well as hospital data such as demographic data, the reason for admission, disease, and documentation of falls. The problem mentioned above regarding the subjectivity of the BI appears in our data set: for 20 patients, several consecutive BI assessments were performed by different evaluators on the same day, yielding different results. As the data is not complete for all patients, the dataset is split into sub-groups, i.e. 1) patients with IMU data on admission and discharge as well as BI (n = 58), 2) patients with IMU data and BI data on admission (n = 110) and discharge (n = 84).

The proposed work consists of the following tasks:

- Literature and patent research on the BI assessment and its correlation with gait analysis data. The relation between the gait and LOS and the effects of hospitalization and rehab in patients with Sarcopenia on the spatiotemporal gait parameters.
- Data cleaning and extracting gait parameters. Divide the cleaned dataset into subgroups according to available data as specified above. Extract spatiotemporal gait parameters from IMU data using the gaitmap library [19] for the TMW. Additionally, the time of the performed TUG tests will be extracted.
- Statistical analysis of the total BI score and the gait-related sub-scores BI at the time of admission with the time of discharge. Additionally, we do the same analysis for the gait parameters to investigate the gait changes at the time of admission and discharge. We will perform the mentioned tasks both on subgroups 1 and 2.
- Measure the correlations between gait parameters obtained from IMU data with the individual sub-scores as well as the total score of the BI. In this analysis, we will investigate if changes occur in gait parameters during rehabilitation and if so, how they correlate with the changes in the BI.
- Since the time of the gait recordings does not always align with the time of the recorded BI, we will define time frames based on the time distances of these two tests for different patients and correlate their gait parameters with their BI. Comparing the results between the correlations will show how gait changes within those time frames.

- Investigate the correlations between the LOS and influencing factors such as gait parameters and BI scores.
- Find a predictive model to estimate the LOS based on the influencing factors such as the gait parameters and BI using machine learning models including random forest (RF).
- If time allows, designing a classification model to differentiate between the time of admission and discharge based only on the gait of the patients. In this model, the spatiotemporal gait parameters from the TMW and the time of the TUG will be used. In the methodology of this part, several classification models such as SVM, RF, and other models will be used and their results will be compared to each other. It should be noted this part is not mandatory and upon completion, it has an extra point.

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