Poster-ID: PT-07-011

Automation of an assessment of patients following hip arthroplasty

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BACKGROUND

Currently, approximately 1.71 billion people worldwide require rehabilitation from musculoskeletal disorders - and the number is increasing [1]. In times of severe staff shortages, responding to the increased importance of individualization and the call from researchers for biomechanical data to support functional assessment and Patient Reported Outcome Measures (PROMS) will be a major challenge [2,3]. Monitoring the changes during rehabilitation is a time-consuming process mostly without digital support. Since assessment is a highly standardized procedure, it holds great potential for automation.

The objectives of the study are to test the feasibility of a digital automated assessment in patients following hip arthroplasty and whether biomechanical data add value to a functional assessment in this patient population.

METHODS

Subjects

22 patients following total hip arthroplasty (9f + 13m , 59.9±5.9 yrs; 175.0±8.7 cm; 81.5±14.2 kg; 20.2±6.2 days post-operative; HOOS: pain 64.5±13.8, symptoms 69.1±12.6, ADL 67.9±12.8, quality of life 39.3±26.5) had been tested during their stay in a rehabilitation clinic (Medical Park Bad Wiessee St. Hubertus).

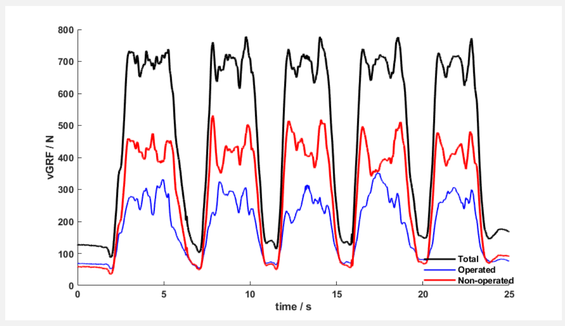


Fig.1 vGRF during the 5STS for the operated and non-operated limb of a representative participant

Assessment

The five times Sit-to-Stand Test (5STS) as functional assessment and the Hip Osteoarthritis Outcome Score (HOOS) as a PROMS were automatically collected.

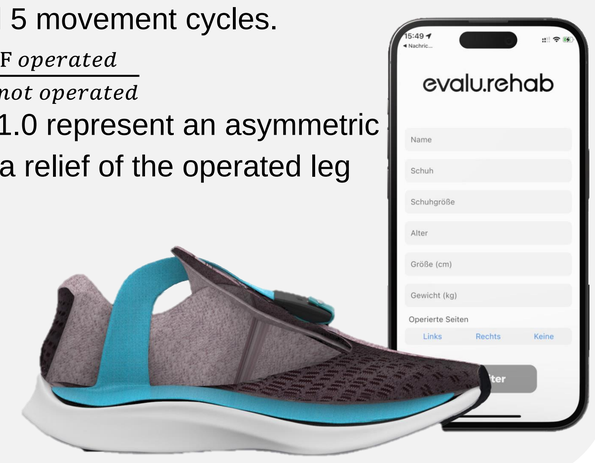
Assessment Devices

The assessment was performed with an android-based application developed specifically for the study (alpha version, evalu.rehab, elmatrix GmbH; device: Lenovo Tablet K10).

Vertical ground reaction forces (vGRF) were collected directly by the application connected to measurement insoles (200 Hz, loadsol, Novel GmbH). Additionally, vGRF were simultanously measured with two force plates (1000 Hz, Contemplas, Contemplas GmbH) to test for validity.

Data processing

- A self written matlab algorithm (Matlab, R2021b, The Mathworks, Inc.) detected the start and and end of the 5STS movement cycles and calculated the total duration of the 5STS and the mean symmetry index (SI) for all 5 movement cycles.
- $\mathrm{SI} = \frac{\mathrm{vGRF}\ operated}{\mathrm{vGRF}\ not\ operated}$
- Values < 1.0 represent an asymmetric load with a relief of the operated leg



RESULTS

100% of patients were able to complete the assessment on their own. Due to insufficient data quality, 16 datasets were used for analysis. Mean ± SD of the SI (0.79 ± 0.09) and 5STS-Time (13.2 ± 3.6 s) estimated from the application data were comparable to those of the force plate (0.78 ± 0.10 and 13.2 ± 3.3 s, respectively) with a mean difference of - 0.01 for the SI and - 0.06 for the 5STS time.

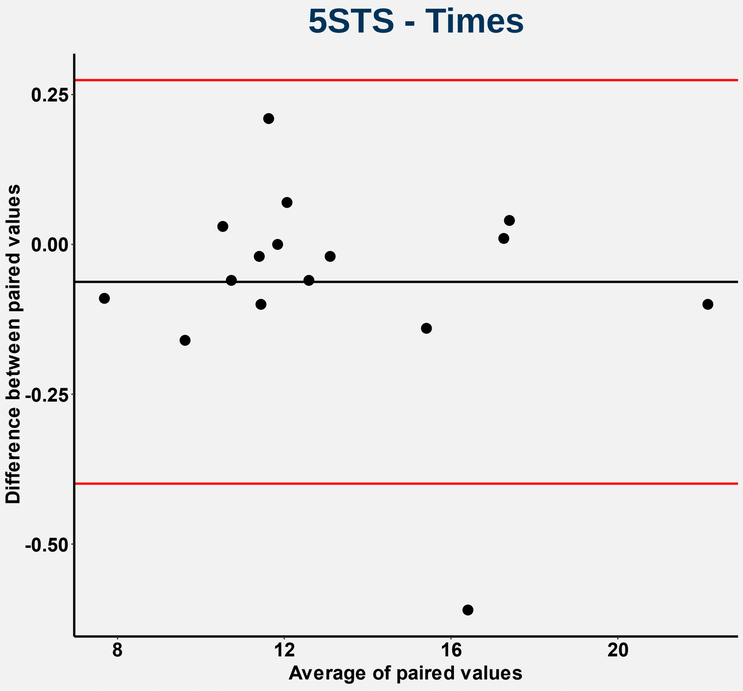


Fig.2 Bland-Altmann comparison of the 5STS times measured by force plate and the application; black line = mean differences (- 0.06); red lines = limits of agreement (- 0.4.; 0.27);

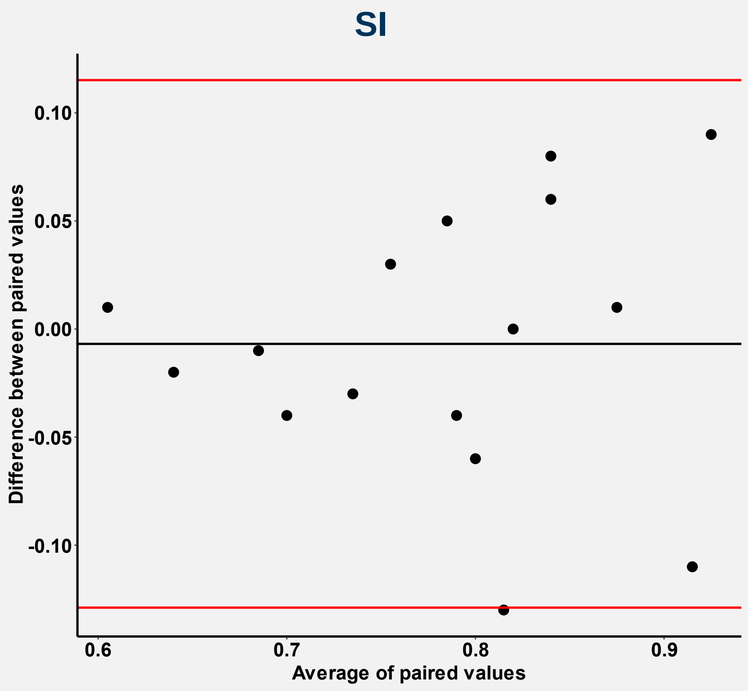


Fig.3 Bland-Altmann comparison of symmetry indices measured by force plate and the application; black line = mean differences (- 0.01); red lines = limits of agreement (-0.13;0.12);

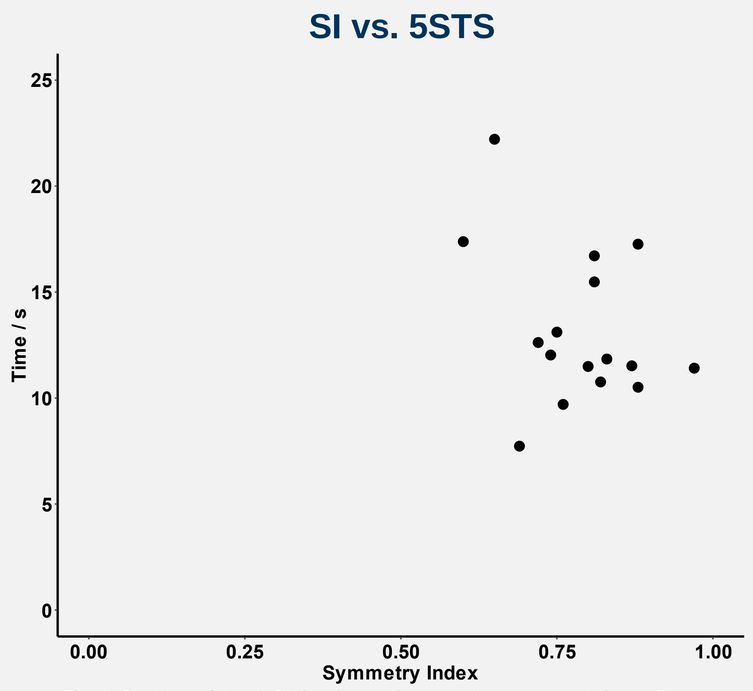


Fig.4 Scatter plot of SI in dependence of movement time. Pearson correlation coefficient showed no correlation between movement time and quality of movement (r = - 0.32, p > 0.23);

DISCUSSION

Using automated orthopedic assessment in combination with biomechanical devices shows great potential, especially for functional assessment. Comparing the two systems, the results showed good agreement and an absence of a systematic error for 5STS – Time and SI. The lack of correlation between the 5STS – Time and the SI outlines the necessity of collecting biomechanical parameters when checking the functional condition of patients. SI has been shown to be task-specific and seems to become an important parameter in documentation of orthopedics rehabilitation progress [2,3,4]. In the future, automation of functional assessments including biomechanical parameters can additionally improve the ability of the therapists to individualize the therapy in a time saving process.

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