Protocol

Activity tracking in elderly patients after operative treatment of proximal femur fractures

Acronym

ACTProFem

Summary

Elderly patients commonly suffer from proximal femoral fractures. These injuries are associated with a high mortality, however, objective tools to observe the recovery process are lacking. Physical activity is recognized as the key for the recuperation process. Therefore, we hypothesize that activity trackers can reliably monitor the early postoperative follow-up and be utilized as this missing instrument. Standardized step counts are recorded using wearables and analyzed in association with factors characterizing patient's general and current health, epidemiology, and biochemical parameters. Minute-by-minute data are the basis for the development of a management-suited reporting system. This can facilitate signaling of personal treatment demands and progress of recovery. Data obtained by the used trackers enable a subgroup analysis of patients with femoral neck fractures, comparing two different standardized treatment methods in two different centers. The regular use of wearables can be part of an individualized treatment coordination in future and add a safety feature.

Introduction

Proximal femoral fractures are common in elderly patients and are associated with a high mortality of around 25-30% within the first year [1]. This is determined by a variety of factors as co-morbidity and age, which cannot or only partially be altered [2]. An influenceable key factor for a successful re-integration into normal life is the recovery of mobility. If patients succeed to regain their physical activity, they have a higher chance to survive. Unfortunately, an increased age is often accompanied by a decrease of mental capabilities, which makes it difficult to correctly assess the true health and physical status of these elderly patients. Therefore, typical questionnaires as the Oswestry Disability Index [3] or the Euroqol 5D [4] have limited capacities to evaluate this population. Activity trackers that are also known as step counters or wearables have recently been obtained growing interest for surveillance of motion and physical action and have been successfully validated in young people [5]. They were found to be reliable tools for activity measurements, although differences between various manufacturers were found [6]. Until now, a validation for older people and for postoperative monitoring is lacking. Since clinical trials in the elderly are in need of objective evaluation parameters, which can easily be obtained and are not dependent on an active cooperation, activity trackers appear to be ideal tools for this special population. We hypothesize that wearables are able to monitor activity in the elderly and supply personalized information about the need of training and the degree of recovery. Therefore, these devices add a safety feature by controlling individual needs. The level of physical performance is very different comparing young and active with elderly people. This makes it necessary to validate the suitability of activity trackers for this population and to adjust the categories for e.g. low, middle or high activity. In future, activity trackers offer the possibility for an objective evaluation of different operative treatment options that aim to increase mobility, which is in line with personalized concepts and resources oriented therapies.

Hypothesis

Commercially available step counters are a suitable tool for the assessment of postoperative activity in elderly patients after a fracture of the proximal femur.

Early results

For a feasibility study we included 16 patients (age 71±18 years, ASA 2.6±1.8, BMI 24±2.4), who underwent a hip- and fracture associated operation (AO localization 31, 32 or 6). Exclusion criteria were ISS≥16, wound infections, and colonization with multiresistent bacteria. Additionally, we included 4 young and healthy control individuals (age 37±13 years, ASA 1.0±0.0, BMI 20.5±2.4). The local Ethical board approved the study. Activity was monitored for 10 hours per normal working day using a Fitbit flex™ bracelet, which was worn at the non-dominant arm. Perioperative measurements were done 2±1 days and 8±2 days after surgery. There was a statistically significant difference between the daily activity of the postoperatively monitored patients (25 measurements) and the control persons (7 measurements) (680±1724 steps vs. 12,285±5,999 steps, p=0.002, figure 1).

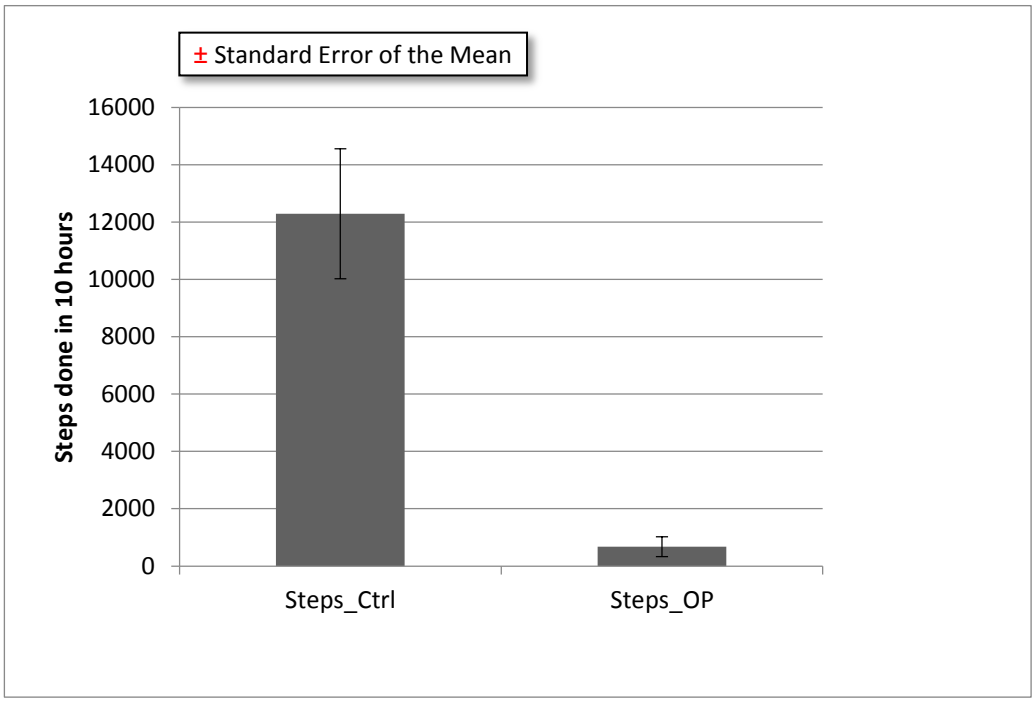


Figure 1: Comparison of the daily activity of healthy control individuals (Steps_Ctrl) and patients after a hip-associated operation (Steps_OP). Noticeable is the large difference between the activity levels.

Although we found a statistically significant correlation between the time elapsed after the operation and the daily steps made or length of walked distance (p=0.03), the average step counts made 2 or 8 days post surgery failed to reach a statistically significant difference (p=0.07, figure 2).

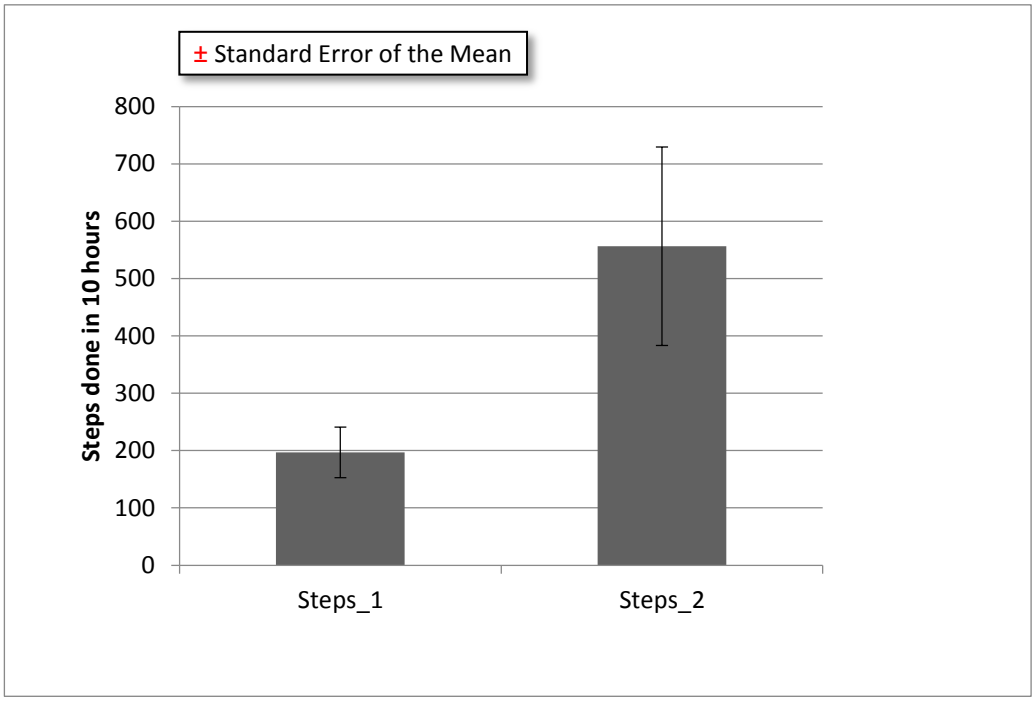


Figure 2: Comparison of the daily activity of patients (n=9) 2 days (Steps_1) or 8 days (Steps_2) after a hip-associated operation. Although there is a clear trend, the difference did fail to reach statistical significance.

Furthermore, the number of minutes with slight activity was 8 days after surgery significantly higher compared to 2 days (p=0.032). In contrast to the postoperative period, all other monitored parameters as co-morbidity (ASA), age, pain level (VAS), body mass index, and preoperative mobility status did not correlate with activity levels. But when the pain level was higher than 3, the activity was significantly diminished 8 days following the operation (p=0.042).

Protocol

Questions to answer:

1.) Are step counters a suitable tool to monitor postoperative activity of elderly patients after fracture treatment of the proximal femur?
2.) How can activity categories as 'low', 'middle', or 'high' be defined in this population based on a minute-by-minute analysis?
3.) Are there other predictors of postoperative activity as co-morbidity, age, pain level, body mass index (BMI), or the preoperative mobility status?
4.) Is this method suitable to compare different treatment standards?

Ad Q1) Until now, three different tracker types (Fitbit flex [San Francisco, Ca, USA], Misfit shine [Burlingame, CA, USA], Axivity [Newcastle upon Tyne, UK]) have been preliminary tested at three different locations (ankle, wrist, and femur). The activity of patients with proximal femoral fractures was recorded using protocols recording different activities, which were then classified as 'no' (bedrest night-time), 'low' (bedrest or activities in the bed at day-time), 'middle' (activities in a chair including transfer), and 'high' [physiotherapy). These records were correlated to the amount of steps or accelerator potentials. E.g. the Misfit tracker at the ankle detected 'high' activity events with a 91% and middle activity events with an 83% likelihood. The number of real steps made during physiotherapy highly significantly correlated with the steps recorded (R^2=0.999), but was slightly

overestimated by about 20%. The accelerator potentials measured with the Axivity tracker were analysed based on the calculation of the Signal Vector Magnitude (SVM) and the Cut-points using Metabolic Equivalent of Task (METS) as suggested by van Hees et al. [1]. Due to the very low intensity of physical activity, the thresholds were adapted using a statistical cluster method, which was confirmed by a discriminance analysis. The resulting calculated activity levels correlated highly statistically significantly with the real activity levels (R^2=0.70). The data acquired until now in 10 patients showed that there is a plausible increase in activity with time after an operation. The tools appears to be suitable for monitoring of postoperative recovery providing an objective parameter; however, the data also indicated the need for verification. Based on the preliminary results, a power analysis demonstrated that the number needed to treat in order to gain statistical significance with an 80% power is 48 patients. The step counts are the primary outcome criterion of this study, but we need to add additional validated instruments to verify step counting and further time points. This allows to prove reliability and to obtain middle or even long-term data. Because of its simplicity and importance the Euroqol 5D [4] was chosen, which is in line with patient's priorities as pain and disability [7]. This is supplemented by the Barthel disability index [8]. This score was positively evaluated in our group as a predictor regarding mortality, need to change the residential status and loss of independent walking ability based on pre-fracture levels. The preliminary data have shown that there is an enormous activity difference between the normal control population and elderly patients. In conclusion, a more appropriate group, which defines the adequate standard for normality, is needed. Therefore, elderly patients suffering from a distal radius or forearm fracture, who are treated in the hospital, are included as a control group. Assuming an activity twice as high as seen in patients with proximal femur fractures and considering a similar variance, a power analysis demonstrated that the number needed to monitor in order to gain statistical significance with an 80% power is 15 patients (2-sided confidence interval 95%).

Ad Q2) The idea behind this question is to establish a management-suited reporting system, which may easily identify patients in need for more intense assistance and support ('low' activity) or others that can help themselves and are ready for discharge ('high' activity). The providers of the trackers support users by an internet based interface that primarily was and is used for monitoring and storage of step counts. Based on published algorithms, additional features as activity calories are reported. But this is limited to summaries for every 5 or 15 minutes. However, recorded minute-by-minute activity data can facilitate a definition of categories that fit the activity level of patients after operative treatment of proximal femoral fractures. This is possible applying the statistical methods of a discriminance and a cluster analysis. For attainment of this data, programming of scripts to interact with the manufacturer's API environment is necessary. The providers included in this study offers common interfaces that support the acquisition of minute-by-minute data. The grouping variable for the discriminance analysis needs still to be determined and will be chosen
dependent on the quality of correlation to the activity.

Ad Q3) Monitored co-factors with a likely influence on physical activity in patients after operative treatment of proximal femur fractures are co-morbidity (ASA - physical status according to the American Society of Anesthesiologists), age, pain level (visual analog scale -VAS) [9], body mass index (BMI), and preoperative mobility status (no mobility, need for support, age appropriate). Our preliminary data suggest a strong importance of an adequate pain management. These factors are supplemented by the documentation of the pre- and postoperative serum hemoglobin, C-reactive protein levels and albumin, the number of days at an intensive care unit (ICU), by the allowed weight bearing (partial or full), total days of stay in the hospital and the differentiation of the implant (osteosynthesis or arthroplasty). Additionally, patients need to answer the Euroqol 5D questionnaire, which is a validated instrument and reflects country specific quality of life. Furthermore, the Barthel disability index is evaluated reflecting the overall functional status in the elderly. Sit to Stand status

preoperatively and at the 6 month follow-up, is used as a proxy for sarcopenia. The Orientation Memory Concentration (OMC) test is administered at baseline and 6 month follow-up – to check the validity of the patients answers to the questionnaires.

Ad Q4) A subgroup analysis can provide valuable information about this. We planned the inclusion of two centers, the Departments of Orthopedics and Trauma Surgery in Odense, Denmark and in Freiburg, Germany. Femoral neck fractures, a relevant subgroup of proximal femoral fractures, are standardized treated in Odense with a posterior approach and a non-cemented hemiarthroplasty and in Freiburg with an anterolateral approach and a cemented hemiarthroplasty. The subgroup analysis correlates with a two-arm-two-center cohort trial. Activity tracking in association with the other monitored parameters facilitates a comparison of short- and middle term results within the study. This is not the primary outcome criterion; therefore, the study is not powered for this subgroup analysis. If the validation part shows promising results showing reliability of the method and the acquired preliminary data reflect feasibility, these preliminary results facilitate the planning of this trial including calculation of the necessary statistics.

Inclusion criteria

- Existence of a proximal femoral fracture including the locations AO 31 and 32 (intervention group, n=48 in each center)
- Or existence of fracture of the upper extremity including the locations AO 11, 12, 13, 21, 22 and 23 (control group, n=15 in each center)
- Age ≥ 65 years
- Being able to read and understand Danish or German
- Informed consent

Exclusion criteria

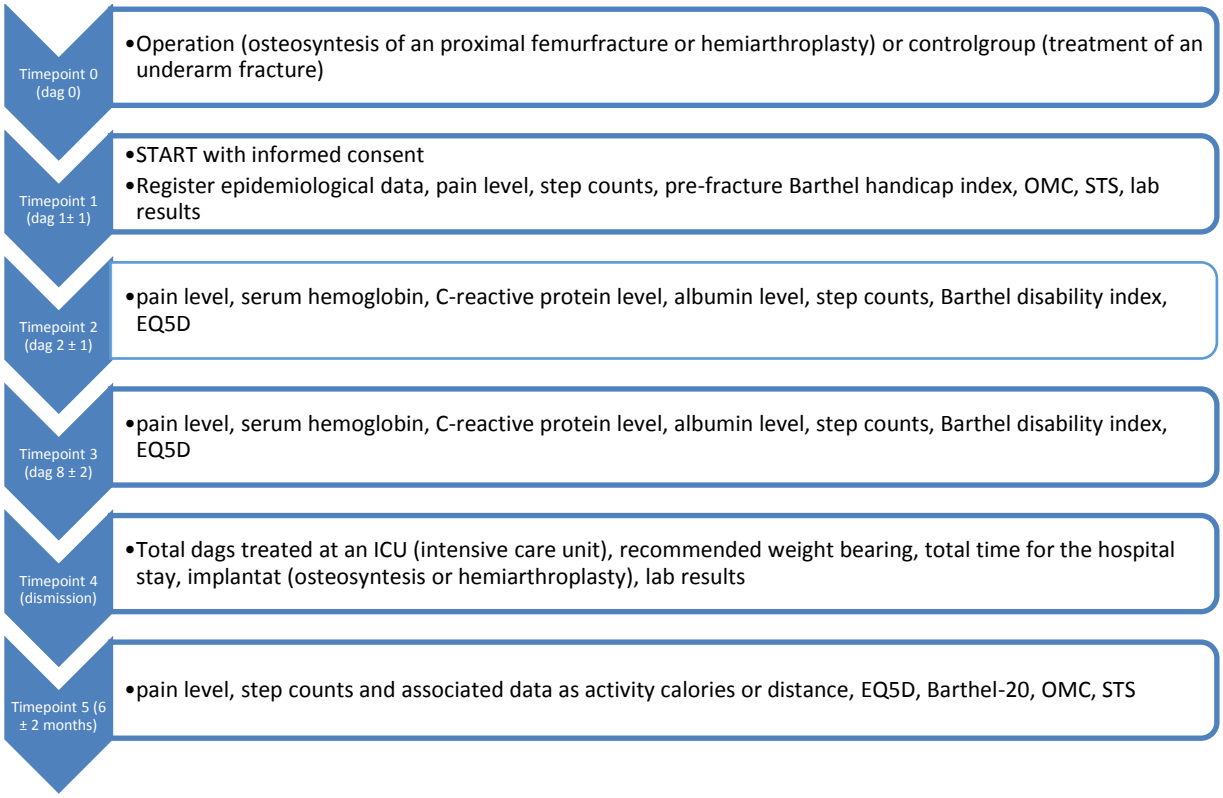
- Open fractures
- Polytrauma
- Known colonization with multiresistent bacteria
- Preoperatively bedridden patients
- Infection of the wound
- Operative revisions because of other reasons

Measurements

Following inclusion of a patient in the study, activity trackers are individualized to the person that is monitored (age, BMI) using the interface provided by the manufacturer. After operation and the informed consent, two different trackers, showing the most reliable results after the validation phase (Axivity at the non-operated femur and Misfit Shine at the same ankle) are used to monitor the postoperative follow-up. For analysis, step counts and accelerators signal vector magnitudes are used, as recently practiced in a pilot group. Read-outs are done using a Bluetooth interface and a smart phone or a normal computer and follow the below specified time schedule. Data downloads are possible using the manufacturer's standard internet platforms. If patients are discharged before the 6th postoperative day, they keep wearing the bracelet and send it back by post. For the 6 months measurement, patients come for the regular control in the outpatient clinic and get equipped with the bracelet. After at least 5 days, they send it back by post [10, 11]. The patients of the control group wear the trackers at the non-dominant side only during their hospital stay. The

epidemiological data and treatment characteristics are monitored once and the scores (EuroQol 5D questionnaire, Barthel handicap index, Orientation Memory Concentration) are monitored during the hospital stay and at the 6 month control.
Recent studies reported important differences between various methods of activity measurement, which were dependent on specific occupations [12]. Although an absolute value for physical activity (steps measured) is not necessary and all included patients have an expected similar spectrum of occupations, the used method for activity tracking shall be controlled for their validity with regard to the specific movement pattern of elderly patients. Therefore, an activity protocol is written for the first 10 patients recording their specific actions in combination with the recorded activity. This is coordinated with the physiotherapy and the nursing staff as follows: 30 minutes bedrest, 30 minutes sitting and mobilization outside the bed, 30 minutes personal hygiene, 30 minutes physiotherapy. The associated activity data should reflect the degree of stress. These activities allow the test of a possible detection threshold. Assuming a 25% difference between the different levels of activity, a standard deviation of 20%, and a 2-sided confidence interval of 95%, the inclusion of 8 patients would provide the necessary power of 80%. During these short periods, the patients wear a second tracker device at the lower leg (ankle).

Survey about the scheduled data acquisition



For patient identification the CPR (PIZ) number is used.

Time-point 0 (Day 0): operation (osteosynthesis of the proximal femur or hemiarthroplasty)
Time-point 1 (Day 1±1): informed consent, age, sex, BMI, ASA classification, time between injury and operation, STS, pain level, serum hemoglobin, C-reactive protein level, albumin level, step counts, prefracture Barthel disability index, OMC.
Time-point 2 (Day 2±1): pain level, serum hemoglobin, C-reactive protein level, albumin level, step counts, Barthel disability index, EQ5D
Time-point 3 (Day 8±3): pain level, serum hemoglobin, C-reactive protein level, albumin level, step counts, EQ 5D, Barthel disability index

Time-point 4 (Day of discharge): total days at an ICU, allowed weight bearing, total days of clinical stay, implant (osteosynthesis or arthroplasty), complications, serum hemoglobin, C-reactive protein level, albumin level
Time-point 5 (6±1 months, this time point allows the discrimination between fracture healing and non-union and therefore reflects a relevant middle-term outcome): pain level, step counts, Euroqol 5D questionnaire, Barthel disability index, OMC, STS

Inclusion in the study and the measurements at the first 4 time-points are carried out in the hospital. For time-point 5 an established cooperation with the local homecare ensures that the patients can further be observed if they do not reach an activity level allowing a consultation in the outpatient clinic.

Data management and statistics

REDCap™ (Research Electronic Data Capture), a secure application for online surveys and databases, facilitates data management. Odense University Hospital is an institutional partner of REDCap, which was especially designed for biomedical research and fulfills all necessary safety features. This is supported by the OPEN initiative (Odense Patient data Explorative Network). Normally distributed numeric data sets are compared using the paired Student's t–test. Otherwise or in case of non-numeric data, nonparametric tests determine the significance of difference. For correlations, Spearman ρ is calculated. Category definitions are facilitated by a discriminant and a cluster analysis as recently shown [13]. Incidences are compared using the chi square test.

Risk evaluation

There is no risk associated with wearing a step counter. These products are widely used in the normal population, are not invasive, but add useful information, which may be used as an additional safety feature.

Informed consent

The information about the planned study and the monitoring of step counts is carried out between day 0 and day 2 of the protocol and includes a dialog about sense and background of the clinical trial. A 12 hour period is calculated before starting the measurement, but at any time point it is possible for the patients to withdraw their agreement. Responsible for the informative dialog is the trial leader, who may delegate this to a study nurse or the undergraduate, who accounts for study logistics and is involved in all parts of the trial. The person giving the information is responsible for an undisturbed atmosphere and sufficient time. The basis for the information are the written patient information and the form for participant agreement.

Financing

Grants for financing were approved by the Jeppe Juhl Mindelegat and the OUH pregraduat pulje 2016. The included patients do not receive gratuities.

Future prospects

Individual activity tracking in association with a management-suited reporting system is a step towards personalized medicine using objective parameters, which do not depend on mental status. This is especially important considering the target group of elderly patients. This can be further developed by using wearables for identification, which allows the connection to an electronic

medical record. This may further facilitate tailored distribution of resources, increase patient safety, save documentation time and support coordination of treatment or rehabilitation.

Cooperation

Jens Lauritsen, Department of Orthopaedics and Traumatology, Odense University Hospital, Sdr. Boulevard 29, 5000 Odense C and Associate Professor, Dept. of Clinical Medicine, University of Southern Denmark (statistical expertise, Barthel index validation, cooperation with the 'Kommune Odense')
Kaywan Izadpanah, Department of Orthopedics and Trauma Surgery, Albert-Ludwigs University Medical Center Freiburg, Hugstetter Str. 55, 79106 Freiburg, Germany (data acquisition)
OPEN (Odense Patient data Explorative Network)
The pilot study was carried out in Freiburg and approved by the local Ethical board. Local funding for study support is requested.

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Appendix

Barthel disability index, Euroqol 5D