# Leveraging the Human Digital Twin for Perioperative Monitoring of Pediatric Patients- An Early Case Study

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**Introduction:** The Internet of Medical Things (IoMT) connects patient devices with healthcare systems such as the electronic medical record (EMR). Wearable tracking devices such as Fitbit can contribute data to the IoMT, giving clinicians more information about a patient's baseline physiological levels known as a ***human digital twin*** **(HDT)**. This can then allow comparisons after an illness, treatment, or surgery and give a measure of how long it takes to restore the patient to a good level of daily physical function. It could lead to a precision medicine personalized post-operative recovery plan. A digital twin is an ultrahigh fidelity mathematical model of a system constructed from all available information. For medicine, the system is the human body. The available information might include fitness tracker metrics, EMR information, radiological imaging, genomics and exposomics- the non-genetic exposures that contribute to health, such as environmental pollution, weather, diet and psychosocial behaviors. This case study demonstrates an early use of the HDT to track a patient's recovery from major scoliosis surgery.

**Methods:** The patient wore a Fitbit Charge 3 device for several weeks prior to his posterior spinal fusion procedure, and 5 months postoperatively. A Fitbit app account was created and anonymously linked to Fitabase, a data collection platform which de-identifies and collects data from the Fitbit app in near real-time. From the Fitabase server, the patient's heart rate (HR), step count, active minutes, and sleep data were available to the clinical team. This data was used to establish the patient's preoperative HDT, identify post-surgery variability, and determine when the patient regained or exceeded their HDT baseline. This study is approved by the JHACH Institutional Review Board.

**Results:** The patient was an 18-year-old white, non-Hispanic male, who was otherwise well. He was compliant with both wearing the device and regularly syncing it to the Fitbit app. The measured baseline HDT and time for each metric to recover postoperatively are reported in table 1. Five months after surgery, he now exceeds his preoperative HDT by over 800 steps per day.

| Metric | Baseline Human Digital Twin | Postoperative time to return to baseline |
|---|---|---|
| Mean daily step count | 4471 steps | 7 weeks |
| Resting heart rate | 52 bpm | 19 weeks |
| Daily moderate or very active movement | 18 minutes | 10 weeks |
| Mean nightly sleep duration | 7 h 26 m | 3 weeks |
| Nightly restless sleep | 22 minutes | N/A |

**Table 1: Patient's baseline Human Digital Twin (HDT) and time taken to recover.** Postoperative restless sleep was initially lower than baseline HDT but increased for several days when the acute prescriptions for diazepam and oxycodone were stopped.

**Discussion:** This case study demonstrates an early use of wearable technology to create a HDT that was used to track trends in recovery after major surgery. The Fitbit is a relatively inexpensive wearable consumer grade device that has been demonstrated to be the most accurate of commercially available fitness trackers[1] and therefore has potential clinical utility as a trend monitor. The measured elements of the patient's HDT varied considerably in their time to return to baseline- from 3 weeks for sleep to 19 weeks for resting heartrate. We can also measure the potential benefit of the surgery- the patient is now more active than his preoperative HDT as evidenced by an increased daily step count, perhaps as a result of increased $FEV_1$ and improved mobility.

**Conclusion:** The observations demonstrated in this single patient report reveal the start of the future potential of the HDT. With further study and the recording of many HDTs, it may be possible to use machine learning to discover new trends. We could predict delayed recovery or the early onset of postoperative complications, thereby allowing earlier intervention and improved patient outcomes.

**Reference:**

1.Case MA, Burwick HA, Volpp KG, Patel MS. Accuracy of Smartphone Applications and Wearable Devices for Tracking Physical Activity Data. *JAMA.* 2015;313(6):625-626.