

Monitoring physical impact and recovery of pancreatic cancer treatment using consumer wearable health data: A case report

DIGITAL HEALTH
Volume 9: 1–4
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DOI: 10.1177/20552076231177127
journals.sagepub.com/home/dhj



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Abstract

Consumer wearables health data may reflect the impact of pancreatic cancer and its treatment on cardiorespiratory fitness and the subsequent recovery after treatment. The patient is a 65-year-old male treated for borderline resectable pancreatic cancer. Treatment consisted of four courses of FOLFIRINOX neoadjuvant chemotherapy, a Whipple procedure with a right hemicolectomy and venous segment resection, and eight courses of adjuvant FOLFIRINOX chemotherapy. Physical activity and moderate to vigorous physical activity declined after the onset of symptoms, increased in the weeks before surgery, declined after surgery and then gradually recovered during and after adjuvant chemotherapy. Estimated VO_2 max remained stable during neoadjuvant chemotherapy, sharply decreased after surgery and then gradually recovered. Heart rate at rest increased and heart rate variability decreased after the onset of symptoms reaching their highest and lowest values after surgery. Both gradually returned to baseline seven months after the last course of chemotherapy. The physical impact of pancreatic cancer and its treatment and recovery was in this case reflected on consumer wearable health data. Seven months after the last chemotherapy recovery was close to baseline values.

Keywords

cancer, rehabilitation, chemotherapy, surgery, physical fitness

Submission date: 15 September 2022; Acceptance date: 4 May 2023

Introduction

Pancreatic cancer is an impactful type of cancer that requires intensive treatment. The treatment includes surgery if possible combined with (neo)adjuvant chemotherapy or chemoradiotherapy. Sufficient cardiorespiratory

fitness is a prerequisite for the initiation of treatment and may improve treatment outcomes.¹ At the same time treatment, surgery as well as chemotherapy, may reduce cardiorespiratory fitness. Physiologic variables, including physical activity (PA), can be measured using consumer

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wearables like smartwatches. However, although promising for many years, these data are until now rarely used to monitor the impact or recovery from cancer treatment.²

The purpose of this case study is to illustrate the impact and recovery of pancreatic cancer treatment by consumer wearable health data.

Case report

The patient is a 65-year-old male diagnosed with borderline resectable pancreatic cancer (first author CPvds). The first symptoms, consisting of stomach complaints after evening dinner and 10 kg weight loss in about two weeks developed in November 2020. In December 2020, he was diagnosed with pancreatic cancer. In January '21 neoadjuvant FOLFIRINOX chemotherapy was started, consisting of four courses with an interval of two weeks. End of March '21 a Whipple procedure with a right hemicolectomy and venous segment resection was performed. The pathology report revealed aR0, pT3N2M0 pancreatic ductal adenocarcinoma. After an uneventful postoperative course, discharge followed on the seventh postoperative day. Adjuvant FOLFIRINOX chemotherapy was started four weeks after discharge and consisted of eight courses with doses adjustment of the last two courses. Complications occurred with a delay in chemotherapy: *Escherichia coli* sepsis infection which was treated with antibiotics (end of May '21), cholangitis due to hepatojejunostomy obstruction (September '21) which was treated by endoscopic dilatation with placement of two stents, and

leukopenia in October '21. Adjuvant chemotherapy was completed in November '21. Written informed consent to publish the data was obtained. Since the first author describes his own data, no ethical approval was considered indicated.

The following health data were retrieved from a smartwatch (WatchOS 8.7, Apple watch series 3, Apple Inc Cupertino CA USA):

- PA in kcal/day.
- Moderate to vigorous physical activity (mvPA) in min/day, the total number of minutes with an exercise intensity equal to brisk walking or higher.
- Heart rate at rest (HRrest) in beats/min was recorded each day. HRrest directly reflects cardiac function but also underlying processes including autonomic nervous regulation. A lower resting heart rate is considered a better health indicator.
- Heart rate variability (HRV) expressed as SD of beat-to-beat measurement in milliseconds. HRV reflects neurocardiac regulation and its underlying processes including psychological stress. A higher heart rate variability is considered as a better health indicator.^{3,4}
- Estimated maximal oxygen uptake (est.VO₂max), maximal oxygen uptake is estimated based on heart rate during walking or running⁵ and expressed as ml/kg/min.

Mean values of the above-mentioned measures per month are displayed over a period of two years, June '20 until June '22 covering:

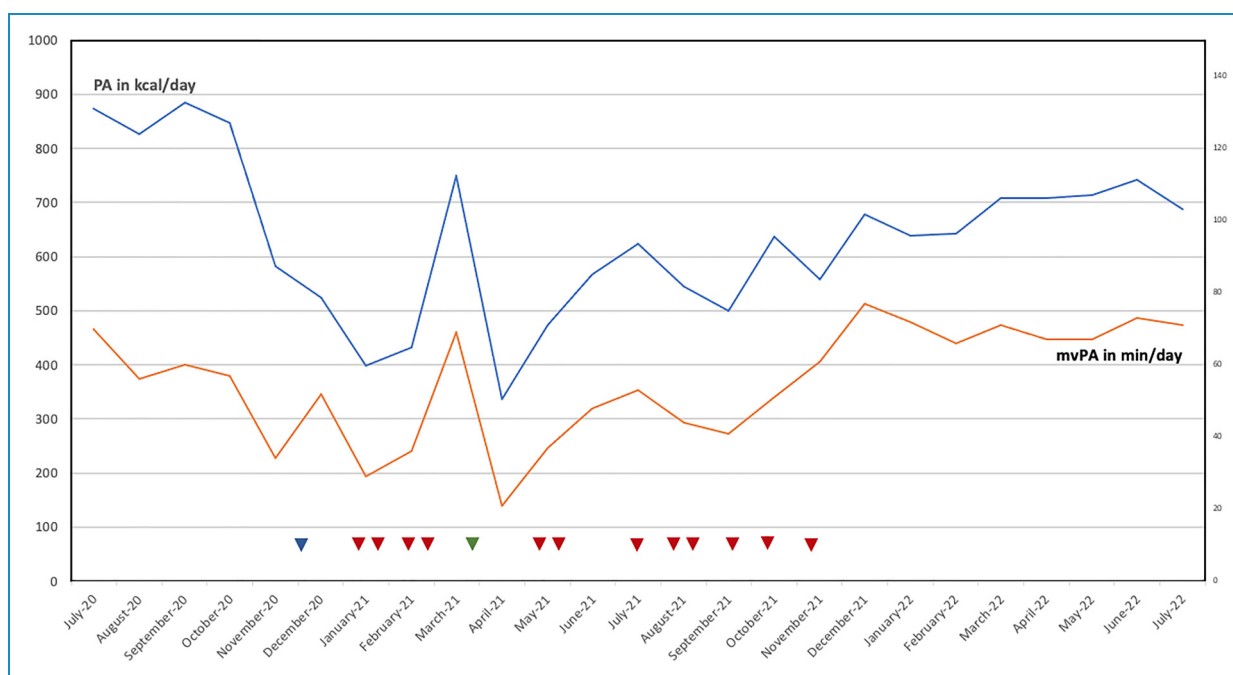


Figure 1. Physical activity (PA) and moderate to vigorous physical activity (mvPA). ▼: diagnosis; ▼: chemotherapy FOLFIRINOX course; ▼: surgery.

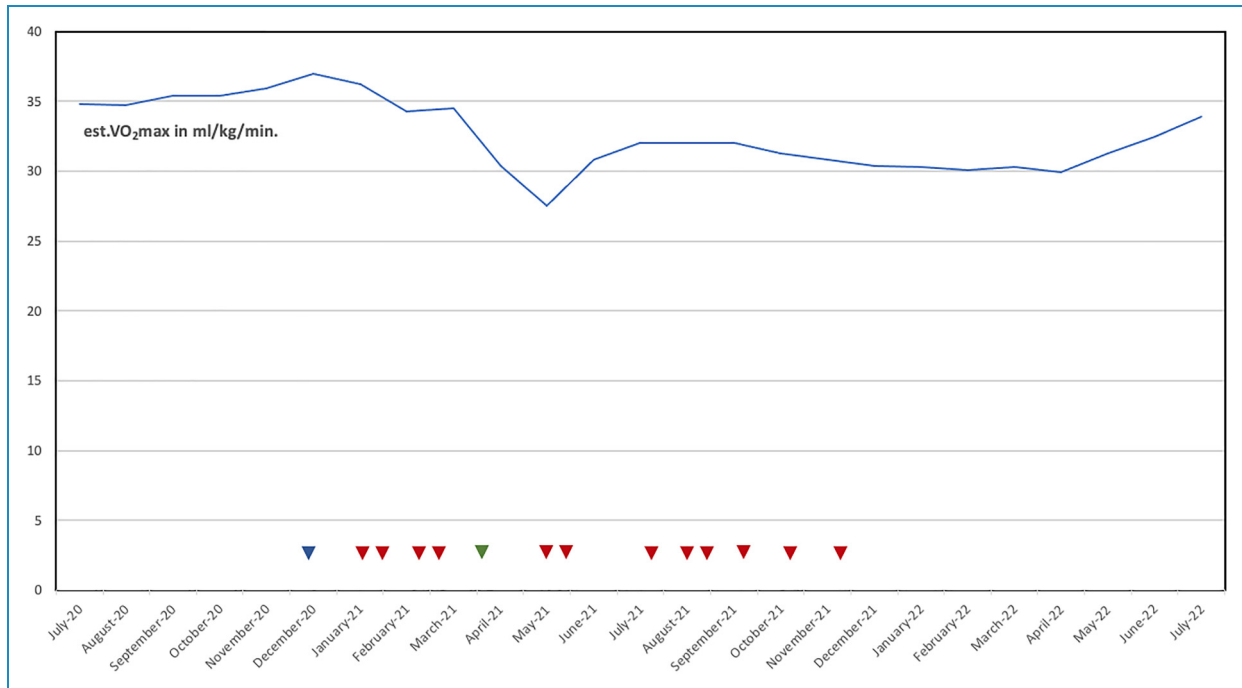


Figure 2. Estimated maximal oxygen uptake (est. VO₂max). ▼: diagnosis; ▼: chemotherapy FOLFIRINOX course; ▼: surgery.

- baseline period July '20–October '20
- symptom period end of November '20–December '20
- treatment period January '21–November '21
 - neoadjuvant chemotherapy January '21–February '21
 - surgery end of March '21
 - adjuvant chemotherapy May '21–November '21
- recovery period December '21–July '22

The smartwatch was worn almost every day, except seven days peri surgical. PA and mvPA declined after the onset of symptoms in November '20, increased in March '21 (without chemotherapy and before surgery), then declined after surgery and then gradually increased; mvPA increased above baseline values after the end of treatment (Figure 1).

Est.VO₂max remained stable from baseline until surgery the end of March '21, then decreased, recovered somewhat in May '21–June '21 and remained stable from July '21 until March '22 and recovered until baseline from April '22 to July '22 (Figure 2). In March '22, iron supplementation of 200 mg was prescribed for persistent low Hb (around 6.2 mmol/L), in April twice a week, and in May once a day. Hb increased to 7.0 mmol/L in July '22 and was accompanied with a gradual increase in est.VO₂max.

HRrest was stable in the baseline period, then an immediate increase in HRrest was seen from the onset of symptoms, and during neoadjuvant chemotherapy, reaching a peak after surgery and then slowly decreased reaching baseline values in June '22 (Figure 3).

HRV was also stable during the baseline period and decreased directly after the onset of symptoms, neoadjuvant

chemotherapy with the lowest values in the period after surgery, with a gradual recovery toward baseline values in June 2022 (Figure 3).

Discussion

This case report illustrates that the impact and recovery of pancreatic cancer treatment is reflected on consumer wearable health variables. The onset of symptoms is accompanied by changes in HRrest, HRV, PA and mvPA. The pattern of HRrest and HRV is very similar but in an opposite direction, HRrest increased while HRV decreased after the onset of disease and initiation of treatment. A possible explanation is that in both measures the same underlying processes are reflected possibly autonomic nervous activation. Another explanation may be that HRV is influenced by heart rate in the sense that HRV decreases because of an increased heart rate and vice versa, so-called cycle length dependence.⁶

In this case, baseline PA and mvPA were relatively high and mvPA reached baseline values prior to surgery which may have contributed to the fast uneventful recovery after surgery and to recovery in general as was demonstrated before.¹ In contrast to HRrest and HRV est.VO₂max changed minimally after the onset of symptoms and during the neoadjuvant chemotherapy possibly because this variable is not immediately affected by disease or because in this case PA and mvPA were sufficient to maintain est.VO₂max. After surgery est.VO₂max decreased with about 20% in May '21. Then est.VO₂max recovered somewhat but remained below baseline values and returned close to baseline values after iron supplementation was

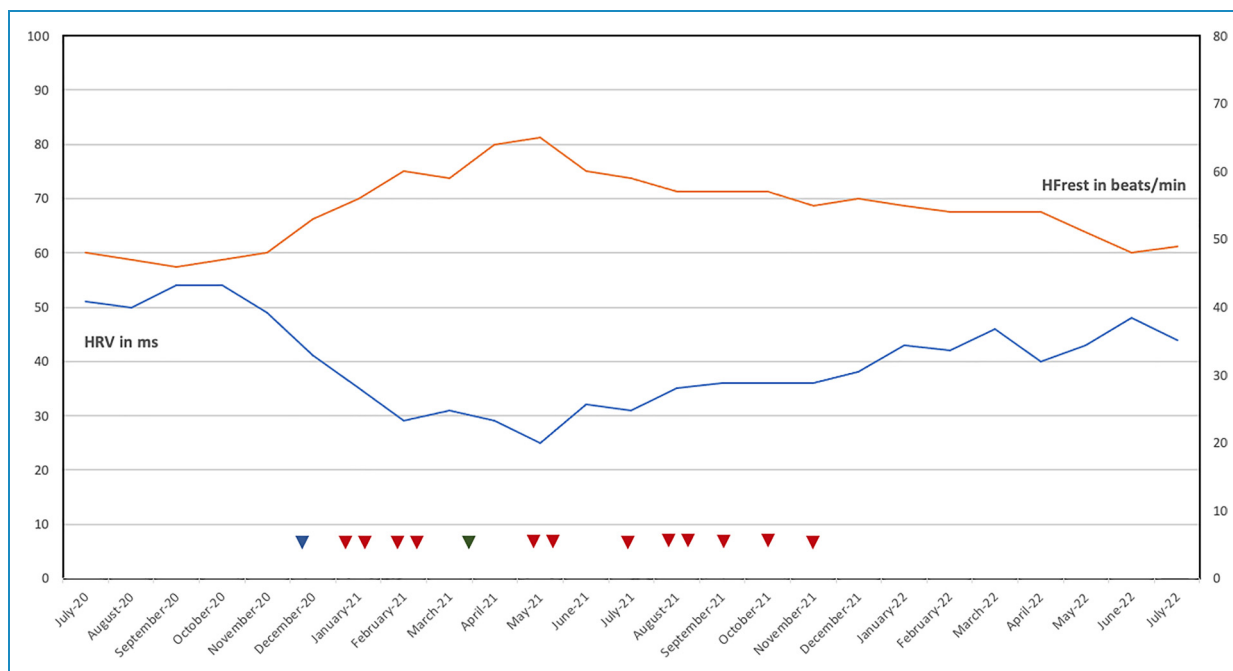


Figure 3. Heart rate variability (HRV) and heart rate frequency at rest (hRrest). ▼: diagnosis; ▼: chemotherapy FOLFIRINOX course; ▼: surgery.

prescribed. Iron deficiency was possibly the reason for incomplete recovery of est.VO₂max.

Overall recovery to baseline values of the health data took about seven months after the last chemotherapy cycle. Insight in the (expected) time to recovery may be valuable for patients in the future

Conclusion

Telemonitoring using wearable health data is technically available for several years but still not widely used. Telemonitoring using consumer health data may give patients and caregivers valuable insight in impact and recovery of cancer treatment. It may have unique advantages namely that personal baseline values before the onset of disease are available and that continuous monitoring is feasible. The clinical meaning of these variables may be complex since various complex underlying processes can be reflected in these variables.


Contributorship: CPvdS researched literature and conceived the study. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Declaration of conflicting interests: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval: Written informed consent to publish the data was obtained. Since in this retrospective descriptive study the first author describes his own data, no ethical approval was considered indicated.

Funding: The author(s) received no financial support for the research, authorship, and/or publication of this article.

Guarantor: CPvdS.

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