**Comparison of MRI-derived Cardiac Power with and without Deep Learning Acceleration**

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1. **Introduction**

Cardiac power at rest and in exercise can provide useful diagnostic information across a range of cardiovascular pathologies. Historically, this informative metric could only be quantified invasively, limiting its clinical use. However, a recent method derives cardiac power non-invasively using volumes derived from cardiac MRI (CMR) [1]. This method has been tested and validated at rest [2], but further work is needed to develop this method for use during exercise.

1. **Description of the problem**

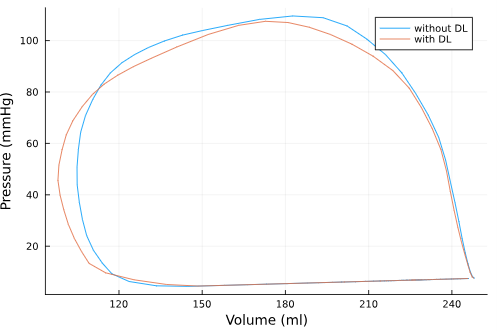
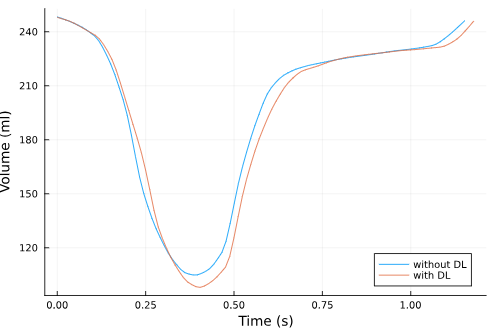
Data acquisition during exercise is complex; motion within the MRI scanner can cause artefact in the acquisitions, leading to low-quality or unusable results. Exercise within the bore of the scanner is possible using a compatible supine cycle ergometer, but testing by this group has revealed the acquisition is still affected by artefact. Furthermore, it has been shown in the literature that acquisition longer than four seconds after the cessation of exercise causes significantly different end-systolic and end-diastolic volumes (ESV and EDV, respectively) [3]. To overcome this, the acquisition process can be accelerated using deep learning software which under-samples the k-space to reduce the scan time. The uncertainty in the volumes and cardiac power calculated using this accelerated method remains to be quantified. In this work we will compare the cardiac power at rest for one participant as a case study, both with and without a commercial deep learning algorithm to quantify the inherent uncertainty of the deep learning acceleration of left-ventricular power.

1. **Related work**

The foundation for the non-invasive cardiac power quantification is by Seemann et al. who use a 0D elastance model to relate the volume to the pressure in the chamber [1]. This method was optimised by previous work in this group to validate the choice of elastance model used [4].

1. **Solution to the problem**

A single participant (28 year old male) was used as a test case. CMR was performed on a 1.5-Tesla Siemens Signa Artist system (Siemens Healthineers AG, Erlangen, Germany) and analysed using Research software, MASS, (Geest, Leiden). Brachial systolic and diastolic pressure were also collected using a sphygmomanometer. Short-axis stacks were taken at rest, once with the deep learning acceleration, sonic DL (Siemens Healthineers AG, Erlangen, Germany), and once without. All other parameters were unchanged. The corresponding pressure was recovered using a double cosine elastance as previously described [4]. The cardiac power was derived from the area of a plot of the pressure-volume loop. See Fig 1.



**Fig.1. (Left)** time-series volume **(Right)** pressure-volume loops for the case study participant. Blue traces denote data derived without sonic DL, red denote the results when deep learning acceleration was used.

HR and cuff pressure were similar during both acquisitions, indicating the participant was in the same physiological state. The difference between HRs in both acquisitions was 1.1 bpm (2.1%) and the difference in the estimated end-systolic pressure was 2.1 mmHg (1.9%) for this participant.

Volumes were also closely aligned between the two methods. The difference in ESV was greater than the difference in end-diastolic volume but still within acceptable limits (ESV, 6.8 ml (6.5%); EDV, 0.2 ml (0.1%)). The resulting cardiac power was therefore similar between the two volume acquisitions, with a difference of 0.01J (0.64%).

1. **Conclusions and future work**

This case study suggests that using deep learning acceleration has little impact on the accuracy of the acquisition. These results are limited, as they were tested for one healthy volunteer at rest, but are promising for future testing of patients and in the exercise state, where the length of acquisition would be obstructive without deep learning acceleration.

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