Objectives. To evaluate whether an automated computer-based algorithm for digital phonocardiogram (PCG) interpretation could detect systolic murmurs and differentiate innocent from abnormal murmurs, thus being capable of supporting large scale screening systems for structural heart disease in childhood.

Methods
A. Database:
- Retrospective study including anonymized PCGs obtained from 820 children, (age 1-14yrs) either during school screening program (S.P) or during their visit in a pediatric cardiology outpatient clinic (P.C).
- In each case 3-5 recordings were obtained (apical, lower and upper left sternal border) by using a commercial digital stethoscope allowing for 3-lead ECG and PCG channel simultaneous recording.
- PCGs have been off-line labelled by an expert pediatric cardiologist as corresponding to absence of a murmur (A), presence of innocent murmur (I.M) or of abnormal systolic murmur (A.M).
- All P.C cases and all S.P cases with abnormal murmurs had confirmatory echocardiographic evaluation data, ranging from normal to a wide range of CHD.

B. Automated PCG analysis:
- Recordings with unacceptable noise were manually removed.
- ECG channel R peaks and an envelope-based detection algorithm were used to define the systolic interval. Fig.1
- Following band-pass filtering of PCG signals a classification scheme using Support Vector Machines have been used. Fig. 2
- System training was performed by a dataset of 450 subjects with I.M (n=329) and A.M (n=121).
- Sensitivity (Sens.) and specificity (Spec.) in detecting: 1) the presence of a murmur and 2) of an abnormal murmur has been estimated in various scenarios.

Results
783 cases (95%) with 2677 recordings of acceptable quality have been analyzed. They represented cases with absence of murmur (A =256), innocent murmur (I.M =352) or abnormal murmur (A.M=175).

Presence vs absence of murmur
Performance in detection of systolic murmur (against murmur’s absence)
- In complete database (S.P+ P.C)
  - Sensitivity 93%
  - Specificity 88%

Abnormal vs Innocent murmur
Performance in detection of an abnormal murmur (against innocent) Fig.3
- A. In complete database (S.P+ P.C)
  - Sensitivity 95%
  - Specificity 35%
- B. In school obtained database (S.P)
  - Sensitivity 84%
  - Specificity 72%

Conclusions
Automated PCG classifiers could serve as useful means in supporting pediatric cardiac auscultation interpretation. Further software developments and large prospective studies could allow for cost-effective heart disease screening systems in childhood.

Authors declare that there is no conflict of interest