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Using hybrid models to predict blood pressure reactivity to unsupported back based on anthropometric characteristics

Key words: Blood pressure (BP), Principal component analysis (PCA), Forward stepwise regression, Artificial neural network (ANN), Adaptive neuro-fuzzy inference system (ANFIS), Least squares support vector machine (LS-SVM)

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Motivation

- The unsupported back of the participant during BP measurement is responsible for a spurious overestimation of BP, termed ‘BP reactivity to an unsupported back’.

- Overestimation of BP may lead to inappropriate antihypertensive treatment, which exposes individuals unnecessarily to potential adverse side effects and increases health care cost.

- Inaccurate labeling leads to increased perception of disease and absenteeism from work.

Methods

- To determine the accurate value of BP reactivity due to unsupported back in normotensive and hypertensive participants, the effect of anthropometric characteristics (age, height, weight, body mass index, arm circumference) influencing BP, was taken into account.

- Multi-collinearity among anthropometric characteristics was eliminated using PCA, and new uncorrelated variables or principal components (PCs) obtained from PCA were used as input variables in subsequent analysis.

Methods (Con'd)

- PCA-based forward stepwise regression (PCA-SWR), PCA-based ANN (PCA-ANN), PCA-based ANFIS (PCA-ANFIS), and PCA-based least squares support vector machine (PCA-LS-SVM) models were developed for the prediction of BP reactivity to an unsupported back.

- The prediction performance of the developed models was assessed using the coefficient of determination (R^2), root mean square error (RMSE), and mean absolute percentage error (MAPE).

Major results

- There is no statistically significant difference between SBP measurements of a supported and an unsupported back (p=0.0759 for normotensive participants and 0.1157 for hypertensive participants).

- We found a significantly higher DBP, p<0.001, in all participants.

- The value of Pearson's correlation coefficient greater than 0.6 revealed the existence of multi-collinearity between pairs of anthropometric characteristics.

Major results (Con'd)

- Bartlett's sphericity test verified the applicability of PCA. The value of χ^2 was 231.012 (normotensive participants) and 119.480 (hypertensive participants) with a degree of freedom of 10 and $p<0.0001$.

- The overall KMO index was computed as 0.63 for normotensive and 0.75 for hypertensive participants, which indicates that the sample size is enough to apply PCA .

Major results (Con'd)

- Out of five PCs, only the first four PCs (PC1–PC4), explaining more than 5% of total variation, were retained for further analysis.

- The selected PCs explained 99.8% and 98.04% of the total variations in normotensive and hypertensive participants, respectively.

- Component loadings after varimax rotation give an indication of the extent to which the original variables are influential in forming new variables.

Major results (Con'd)

- Weight and BMI were the characteristics having the highest correlations with PC1 and height had the highest correlation with PC2.

- Comparisons of the statistical indices of the four models as shown in Table 6 revealed that the PCA-LS-SVM model has the highest value of R^2 and lowest value of RMSE and MAPE for prediction of BP reactivity to an unsupported back in normotensive participants.

Major results (Con'd)

Table 6 Statistical indices for different models

Model	R^2 (%)		RMSE		MAPE (%)	
	Normotensive	Hypertensive	Normotensive	Hypertensive	Normotensive	Hypertensive
PCA-SWR	45.22	32.60	1.6842	2.3954	29.20	29.90
PCA-ANN	71.86	66.71	0.5421	0.5862	24.80	18.30
PCA-ANFIS	80.75	82.67	0.4954	0.4686	11.20	5.92
PCA-LS-SVM	98.49	95.95	0.1243	0.2013	3.01	2.90

R^2: coefficient of determination; RMSE: root mean square error; MAPE: mean absolute percentage error

Conclusions

- An unsupported back during BP measurement causes a significant rise in DBP.
- Performance comparison of PCA-SWR, PCA-ANN, PCA-ANFIS, and PCA- LS-SVM revealed the potential capability of the PCA-LS-SVM model in predicting BP reactivity to an unsupported back.
- The results of this study may provide valuable reference for researchers and engineers who apply hybrid models for the prediction of biological variables.
- The results are helpful in physicians' diagnosis and they are also good for the prevention of hypertension in clinical medicine.