

Continual Screening of Patients using mHealth: The Rolling Score Concept applied to Sleep Medicine

C. Zluga^{1,*}, R. Modre-Osprian¹, P. Kastner¹, G. Schreier¹

¹AIT Austrian Institute of Technology GmbH, Safety & Security Department, Assistive Healthcare Information Technology, Graz, Austria

*Contact: claudio.zluga.fl@ait.ac.at



Sleep Apnea – A Co-Morbidity of Heart Failure

 One or more pauses in breathing during sleep

2 Types

- Obstructive sleep apnea (OSA)
- Central sleep apnea (CSA)

- Heart failure
 - Sleep Apnea remains undetected



European Heart Journal, 2015 1117 patients



Motivation

- Screening and diagnosis
 - Standardized questionnaires (Sensitivity and Specifity)
 - Polysomnography

- Independent risk factor for progression and development of heart failure¹
 - Risk assessment
 - > mHealth-based telemonitoring



¹Mechanisms and Clinical Consequences of Untreated Central Sleep Apnea in Heart Failure Costanzo M.R. et. al, Journal of the American College of Cardiology 65(1) (2015), 72-84



Risk Assessment



Health Data Center



Standardized Questionnaires





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The Rolling Score





The Rolling Score Concept





Feasibility Study

- 10 healthy volunteers
- Demographic data:
 - Average age (Min/Max): 29,1 (23/33) years
 - Gender proportion (m/f): 7/3

Informed Consent

- Duration: 29 days (Dec.2015 Jan.2016)
- Equipment:
 - Smartphone with mHealth application (Android)
 - Sleep Tracker Withings[®] Pulse O_X
- **Compliance** of 75% necessary





Concept Implementation







Rolling Score Questionnaire

Category C	Number of Items <i>I</i>	Category Č (Number of Items <i>I</i>)	Number of Items Ĩ	Time Schedule ti
Snoring	1/5*	Snoring (8)	4	Mon.
Observed	1	Snoring (8)	4	Mon.
Sleep Disturbances	9	Sleep Disturbances (8)	8	Tue.
Sleep Medication	1	Sleep Medication (1)	1	Wed.
Daytime Somnolence	1/3/2*	Daytime Somnolence (6)	4	Thu.
Sleep Latency	2	Weekly Quantifiable (5)	5	Fri.
Sleep Duration	1	Weekly Quantifiable (5)	5	Fri.
Sleep Efficiency	2**	Weekly Quantifiable (5)	5	Fri.
Blood Pressure	2	Monthly Quantifiable (4)	3	Every 28 th after start
BMI	1	Monthly Quantifiable (4)	3	Every 28 th after start
Neck size	1	Monthly Quantifiable (4)	3	Every 28 th after start
Sleep Quality	1	Sleep Quality (1)	1	Every 28 th after start
Age/Gender	2	Age/Gender (2)	2	At start

* Order: STOP-BANG/BQ/PSQI ** One item of category *Sleep Duration* for *GSi* calculation necessary



The Rolling Score

Rolling Score of Subject 09



Average relative difference between RS and standardized score

$$\Delta_{\text{rel}} = \frac{1}{n} \frac{\sum_{k=1}^{n} |GSk - End \, Scorek|}{mSR} * 100 \, [\%] \qquad \begin{array}{c} \text{n} \dots \text{ \# of observations} \\ mSR \dots \text{ max. Score Range} \end{array}$$



The Rolling Score



Mean, standard deviation and Δ_{rel} of joined and single GSi and End Score, * joined questionnaires

	101 -				
	GS*	GS	End Score	$\Delta_{ m rel}$ *	$\Delta_{ m rel}$
BQ	0.4 <u>+</u> 0.5	0.4 <u>+</u> 0.5	0.5 <u>+</u> 0.5	3.3%	3.3%
STOP BANG	0.4 <u>+</u> 0.8	0.4 <u>+</u> 0.8	0.4 <u>+</u> 0.8	0.0%	0.0%
PSQI	4.7 <u>+</u> 2.2	3.9 <u>+</u> 2.3	4.5 ±2.1	6.7%	6.7%



Quantification of Items

- Differences in Sleep Parameters between subjective estimations and objective measurements
- One subject excluded from analysis

Parameter	Mean	Standard Deviation	Min	Max
Sleep Latency [min]	11.6	± 20.0	0.8	96.8
Sleep Duration [h]	0.8	± 0.8	0.0	3.5
Sleep Efficiency [%]	9.1	± 5.4	2.9	20.8



Merging

PSQI - Assessment period of 1 month

During the past week [...]?

Algorithm - Arithmetic Mean





Discussion

- Differences between the Rolling Score and the Standardized Global Score (≤ 10%)¹ showing promising results in the context of a feasibility study
- Small temporal variances

Sources:

- "Intraobserver-Variabilities" of certain categories
- **Granularity** of the scoring system
- Subject was **uncertain** in regards to the respond
- Expected Bias: Sensor data may had an influence on the answers of corresponding items



Conclusion

- New risk assessment approach "The Rolling Score Concept"
- > Deviations of scores are in a **reasonable range** (\leq 10%)
- General validation must be performed to confirm the diagnostic benefit

Outlook

- > Application of *Rolling Score Concept* to heart failure patients
- Substitution of items by sensor data and mapping measurements to scoring system by specific algorithm
- Application to other standardized questionnaires