German Air Force Center of Aerospace Medicine

RECORDING HUMAN HEMODYNAMICS DURING PARABOLIC FLIGHTS USING PHOTOPLETHYSMOGRAPHY

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ICASM 2018 “SHARING THE SKY SAFELY“, Bangkok, 11–15 November 2018
INTRODUCTION

PARABOLIC FLIGHTS

➢ Parabolic flights present one of the few possibilities to simulate alternating gravity conditions under laboratory-type conditions.

➢ The special parabolic trajectory allows for approximately 22 seconds of zero-g, preceded and followed by a hyper-g phase.

➢ Parabolic flights are excellent for examining rapid hemodynamic changes in humans under alternating accelerations.

Airbus A300 Zero-G directly before reaching the 0-g phase

Picture: https://bilder.t-online.de/b/61/32/23/90/id_61322390/610/tid_da/
INTRODUCTION

PULSOXIMETRY
Takuo Aoyagi, 1972

PHOTOPLETHYSMOGRAPHY
Hertzmann, 1930s

\[ \text{SaO}_2 = \frac{[O_2 - \text{Hb}]}{[O_2 - \text{Hb}] + [\text{Hb}]} \]
INTRODUCTION

COMPONENTS OF THE PPG SIGNAL

Absorption by venous blood

Absorption by bone and tissue

Diastolic Absorptive Minimum

Systolic Absorptive Maximum

AC Portion

DC Portion

Time
INTRODUCTION

QUANTITATIVE EVALUATION OF THE DC PORTIONS OF THE PULSE WAVE DURING CENTRIFUGE PROFILES

$G_z$

$Pw$ (red) [AU]

$Pw$ (IR) [AU]

$G_{z_{max}}$

$t_0$

$t_{max}$

$\Delta G_{Pw(R)}$

$\Delta G_{Pw(IR)}$

DC portion IR

$\Delta \lg \text{AU} [\text{mV}]$

$\text{time [s]}$

$\text{AEF < 7.02}$

$\text{AEF > 7.02}$

$\ast = p < 0.05$

All figures: © GAF IAM
INTRODUCTION

QUANTITATIVE EVALUATION OF THE AC PORTIONS OF THE PULSE WAVE

Amplitude changes IR Portion [%]

All figures: © GAF IAM
OBJECTIVES OF THE STUDY

- Continuously record the pulse wave during parabolic flights using photoplethysmography;

- derive DC portions ($= \text{PPG}_{DC}$) and AC portions ($= \text{PPG}_{AC}$);

- draw conclusions about blood volume distribution and changes in cardiac contractility.
METHODS

SUBJECTS

✓ N = 26
✓ 11 women, 15 men
✓ Age: 33 ± 9 years (MW±SD)
✓ valid medical
METHODS

EXPERIMENTAL PROCEDURE

Each subject underwent:
31 parabolas including 3 different activity levels:
- no load (NL),
- physical load (PL - 50 W),
- mental load (ML).

Phases of parabolic flight
METHODS

DATA ANALYSIS

$G_z$-Load

$PPG_{AC}$

$PPG_{DC}$
RESULTS

HR [bpm]

NL

ML

PL

PPGDC [AU]

NO LOAD

FLIGHT PHASE

A

B

C

D

E

HR [bpm]

60

80

100

120

140

160

*

*

**

MENTAL LOAD

FLIGHT PHASE

A

B

C

D

E

HR [bpm]

60

80

100

120

140

160

*

*

PHYSICAL LOAD

FLIGHT PHASE

A

B

C

D

E

HR [bpm]

60

80

100

120

140

160

* = p<0.05

Figures: © GAF CAM
RESULTS

CNAP [mmHg]

ML

PL

PPGAC [AU]

* = p<0.05

Figures: © GAF CAM
SUMMARY

➢ The PPG method is an easy-to-use, low-cost method without wearing effects on the test persons.

➢ In flights with alternating accelerations, PPG enables relevant information and noninvasive data generation to describe the instantaneous state of the circulatory system.

➢ Our findings confirm that filtered PPG reflects the changes of blood volume distribution and cardiac contractility known from earlier studies on parabolic flights using other methodological approaches.
THANK YOU VERY MUCH FOR YOUR ATTENTION!