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Produced by the NASA Center for Aerospace Information (CASI)
User's Instructions for the Cardiovascular Walters Model

This model is a combined, steady-state cardiovascular and thermal model. It was originally developed for interactive use by Dr. R. F. Walters, Department of Human Physiology, School of Medicine, University of California, Davis, California. The model has been converted to batch mode simulation for the Sigma 3 computer. The purpose of the model is to compute steady-state circulatory and thermal variables in response to exercise work loads and environmental factors. During a computer simulation run, several selected variables are printed at each time step. End conditions are also printed at the completion of the run.

R. C. Croston, Ph.D.
PROGRAM DESCRIPTION

A. IDENTIFICATION

Program Name - WALTERS
Programmer - R. C. Croston, GE/MSC, Houston
Date of Issue - April 6, 1972

B. GENERAL DESCRIPTION

This model is a combined, steady-state cardiovascular and thermal model. It was originally developed for interactive use by Dr. R. F. Walters, Department of Human Physiology, School of Medicine, University of California, Davis, California. The model has been converted to batch mode simulation for the Sigma 3 computer.

C. USAGE AND RESTRICTIONS

Machine and Compiler Required - XDS Sigma 3 and ANSI FORTRAN
Peripheral Equipment Required - Card reader and line printer.
Approximate amount of memory required - 2,465 hexadecimal

D. PARTICULAR DESCRIPTION

Equations Used and Derivations - See final report of Contract NAS9-11657, Modification 2C.
Definition of Terms Used - Terms are defined in the referenced math model and in the following descriptions of input and output variables.
Detailed Description - The mathematical model is summarized here by a functional block diagram, Figure 1. The purpose of the model is to compute steady-state circulatory and thermal variables in response to exercise work loads and environmental factors. During a computer simulation run, several selected variables are printed at each time step. End conditions are also printed at the completion of the run.

E. DESCRIPTION OF INPUT

Control and Program Cards - (begin in card column 1)

:JOB
:ASSIGN SI=14 (026 Keypunch Code)
:ASSIGN F:5=3
:ASSIGN F:6=4
:FORTRAN
COMBINED STEADY-STATE CIRCULATORY AND THERMAL MODELS

FIGURE 1.

WALTERS MODEL FUNCTIONAL BLOCK DIAGRAM
(SOURCE DECK)

:END
:LOAD
:$LOAD 256,,O
:$MP
:END
:SEQ

(DATA DECK)

:END

Program Cards - Listed at the end of this document.

Data Cards - (Card columns, format, name definitions)

Columns 1-10, 11-20, etc., 8 parameters per card for a 8F10.0 format of the following list of required input data:

AVCOR 0.138   RESTING A-V DIFF, CORONARY
AVBR 0.069   RESTING A-V DIFF, BRAIN
AVMR 0.067   RESTING A-V DIFF, MUSCLE
AVSKIN 0.010   RESTING A-V DIFF, SKIN
AVOTH 0.035   RESTING A-V DIFF, "OTHER"
AVRSPR 0.040   RESTING A-V DIFF, RESPIRATORY MUSCLES
AVRMSX 0.165   MAXIMUM A-V DIFF, MUSCLE
AVRSMX 0.060   MAXIMUM A-V DIFF, RESPIRATORY MUSCLE
EFRESMX 0.80   MAXIMUM EFFICIENCY, ARM MUSCLE
EFLEGMX 0.80   MAXIMUM EFFICIENCY, LEG MUSCLE
PCTWLG 0.25   WEIGHT PERCENT, LEG MUSCLE
PCTWAR 0.15   WEIGHT PERCENT, ARM MUSCLE
PCTARS 0.05   WEIGHT PERCENT, RESPIRATORY MUSCLE
PCTWCU 0.015   WEIGHT PERCENT, CORONARY MUSCLE
PCTWIM 0.035   WEIGHT PERCENT, INACTIVE MUSCLE
STOPTM 71.0   STOP TIME FOR LENGTH OF EXPERIMENT (min)
TINC 10.0   TIME AT WHICH VARIABLES ARE INCREMENTED (min)  (fixed)
F. DESCRIPTION OF OUTPUT

The following variables are printed on the line printer. A sample printout is shown in Figure 2.
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<td>6.311</td>
<td>196.4</td>
<td>16399.5</td>
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<td>335.0</td>
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<td>6166.2</td>
<td>59.9</td>
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</tbody>
</table>

**SUMMARY OF CONDITIONS AT TIME OF STOP**

* **ENVIRONMENT**
  - **TAIR** = 23°F
  - **HUMIDITY** = 0.5 PCT
  - **ATM PRESS** = 760.0
  - **AIR SPEED** = 0.2
  - **LEG WORK** = 33.5 ML 02/MIN
  - **ARM WORK** = 13.4

* **BLOOD STATUS**
  - **BODY TEMP** = 98.6
  - **SKIN TEMP** = 98.6
  - **VENTILATION** = 6166.2
  - **O2 UPTAKE** = 246.6
  - **CAROTID OUTPUT** = 4945.7
  - **HEART RATE** = 59.3

* **OXYGEN DEBITS**
  - **CORONARY** = 0.4
  - **LEG** = 11.5
  - **ARM** = 0.0
  - **LEG RATE** = 2.386 ML 02/MIN
  - **ARM RATE** = 0.0
C. **INTERNAL CHECKS AND EXITS**

Exit - A normal exit gives end conditions and a stop.

H. **INDEPENDENT SUBROUTINES**

None

I. **SYSTEM SUBROUTINES**

No special subroutines.

J. **COMPLETION OR FINAL CHECKOUT DATE**

April 6, 1972.

K. **PROGRAM LISTING**
C****
HUMAN PERFORMANCE MODEL
C****
DEPARTMENT OF HUMAN PHYSIOLOGY
C****
SCHOOL OF MEDICINE
C****
UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA 95616
C****
R. F. WALTERS AND J. C. WILCOX
C****
THIS IS HPMOD II+07 GE VERSION
C****
1/27/72 BY VJMAKES
C****
REAL X(50), Y(50), INCTH, MXCOR, MAXX, MAXY, MINX, MINY
REAL MLEG, MARM, MRESP, MOCOR, MINMX, MMRSP
INTEGER A(68), PLE(6), ALFA
LOGICAL FIRST, GDFK
REAL CNTL(16), TOTAL(125), PRVAL(50), NAME(125), OUT(45), IN(5), IN(10)
REAL CON(65), OUTNAM(45), PNRAM(50), INNAME(5), CONNAME(65)
DIMENSION WK(150)

DATA NCONT/16/, NOUT/50/, NIN/13/
DATA CNTL/TS/, ITPRNT/, WLEG/, INKHI/, TAIR/, RHUM/, PRESS/,
+ TINC/, PPOS/, VAI/, RSET/, GO/, HELP/, TITLE/, STOP/, WHATS/
DATA KYES/KNDX/, END/, MNT, INHEND/
DATA OUTNAME/, TIME/, VD2/, VY/, THR/, CO/, TB/, DBR/, DTM/
C****
C0000 WRITE (3) PRVAL
C NRECS=NRECS+1
C**** FIRST CHECK TO SEE IF STOP, PRINT, OR OTHER HALT PRINTS REACHED
IF (ISTART.NE.0) GO TO 4001
C WRITE (6,1144) (PRNAM(IPR11),I=1,1PR)
1144 FORMAT (1H ,$3X$4(4,1X))
WRITE(6,601)
601 FORMAT(1H TIME, VM2, V, HR, CA, TB) 153
*,1(€SKIN) 181
READ(S10)TPRNT 185
READ(S27)IK 186
27 FORMAT(1H,B5,00,2F10.0)) 187
ISTART= 188
+001 IF (TIME.LT.STRPTIM) GO TO 4010
C WRITE (6,2002)
C+002 FORMAT (1H STOPTIME EXCEEDED, DO YOU WISH PLOT (Y/N)?) 191
C READ(5,900) A11 192
C IF (A11.EQ.1YES) GO TO 4005 193
C+003 WRITE (6,2004)
C+004 FORMAT (1H DO YOU WISH TO RESTART (Y/N)?) 195
C READ(5,900) A11 196
C IF (A11.EQ.1YES) GO TO 526 197
GO TO 5000 198
C 199
C+005 REMOVED PLOTTING ROUTINE
C+010 IF (TIME.LT.STRPTIM) GO TO 4020
PRRTIM=TIME*TPRNT 202
203
C +START=ISTART+1
C IF (1START.LT.10) GO TO +0105
C WRITE (6,1144) (PRNAM(IPR11),I=1,1PR) 205
C +START=1
C0105 WRITE (6,2012) (PRVAL(IPR11),I=1,1PR) 206
C CHANGED VARIABLE OUTPUT
C+015 WRITE(6,2012) TIME, VM2, V, HR, CA, TB, TS\N 208
+012 FORMAT (1H,F8.16F9.1) 211
C**** TEMPORARY CONTINUE OPTION 212
C IPR=0 213
C CALL TTREAD(A,ALFA,FP,IND,IPT) 214
C IF (IND.NE.0) GO TO 1006 215
C**** END OF TEMPORARY SECTION 216
C 217
C REMOVED VARIABLE INCREMENTING SECTION 218
C 219
+020 TIME=TIME+0 220
IF (TIME.KL.1START)26,25,25 221
25 $LEGAL=MK(1START-1)+85-23*82LEGAL 222
ISTART=ISTART-2 223
26 CONTINUE 224
C**** START EXECUTION LOOP
C**** RESPIRATION RATE
C050 VM=BTAT/TS/UPTEKE 226
C WRITE (6,111) V 227
11 FORMAT (1H VM,F10.1) 228
C**** BRAIN
C028=228+TS 230
C**** INACTIVE MUSCLE 231
C****
C**** SKIN OXYGEN CONSUMPTION

C**** RESPIRATORY COMPARTMENT

C**** CALCULATE TOTAL NON-RSP O2 CONSUMPTION

IF (PCSRAD + LE + 0.1) PCRAO = 0

C**** 02RSP = 02RSP + PCRAO

C**** 02RSP = 02RSP + AAVPSM

C**** WRITE (6a, 10) 02LEG, 02ARM, 02COR, 02RSP, O2FST

C**** 10 FORMAT ( 012, 02ARM, COR, 02RSP, O2FST)

C**** HEAT BALANCE PORTION OF MODEL

C**** CONTINUE

C**** WRITE (6a, 14) HTOT, HTBR, HTE, HTL, HTC, HTS, HTP, HT08, HT8

C**** 14 FORMAT (1, HT08, HT8)

C**** 15F10.5, 1AF10.5

C**** CALCULATE VAPOR PRESSURE AT BODY TEMPERATURE

C**** WRITE (6a, 27) HTOT, HTBR, HTE, HTL, HTC, HTS, HTP, HT08, HT8

C**** HTE, HT8

C**** HEAT LOSS FROM SKIN BLOOD FLOW

C**** WRITE (6a, 30) HSKIN

C**** 9 FORMAT (1, HSKIN, 0.85, HSKIN)

C**** NOTE: OTHER WAYS TO CALCULATE SKIN T. IS THIS BEST

C**** WRITE (6a, 33) WBSK

C**** 10 FORMAT (10, 8.405, 1235, 513, 273.1, 0.85, 0.85)

C**** CALCULATE HEAT LOSS THROUGH SWEATING

C**** IF (HT8 + HTR) GO TO 4150

C**** IF (HT8 + HT) GO TO 4150

C**** "DTSW = TBSW + 0.3"

C**** DTSW = 0.3"