GATORADE'S Gx SWEAT PATCH.

PRECISIONHYDRATION

THE Gx PATCH: WHAT IS IT?

- WEARABLE MICROFLUIDIC SWEAT PATCH WHICH MEASURES REGIONAL SWEAT CHLORIDE CONCENTRATION AND SWEAT RATE
- DESIGNED FOR THE LEFT VENTRAL FOREARM

TWO MICROFLUIDIC CHANNELS:

- MICROCHANNEL 1: SWEAT RATE (ORANGE DYE)
- MICROCHANNEL 2: SWEAT CHLORIDE CONCENTRATION (PURPLE DYE)
- DIGITAL IMAGE CAPTURE WITH A SMARTPHONE ALLOWS RAPID RESULTS
- DEVELOPED ALGORITHMS WHICH ESTIMATE WHOLE BODY SWEAT RATE AND CHLORIDE CONCENTRATION BASED ON THE COLOUR AND VOLUME OF SWEAT

PRECISIONHYDRATION

THE PREVIOUS RESEARCH...

J Appl Physiol 107: 887–895, 2009.
First published June 18, 2009; doi:10.1152/japplphysiol.00197.2009.

Comparison of regional patch collection vs. whole body washdown for measuring sweat sodium and potassium loss during exercise

Lindsay B. Baker, John R. Stofan, Adam A. Hamilton, and Craig A. Horswill
Gatorade Sports Science Institute, Gatorade Research and Development, Barrington, Illinois

Submitted 20 February 2009; accepted in final form 17 June 2009

BAKER ET AL., 2009

Normative data for regional sweat sodium concentration and whole-body sweating rate in athletes

LINDSAY B. BAKER[1], KELLY A. BARNES[1], MELISSA L. ANDERSON[1], DENNIS H. PASSE[2] & JOHN R. STOFAN[1]

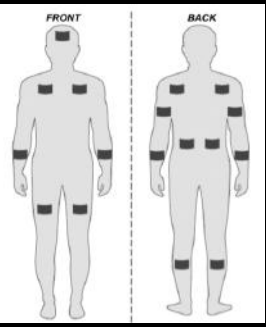
[1]*Gatorade Sports Science Institute, Barrington, IL, USA and* [2]*Scout Consulting, LLC, Hebron, IL, USA*

BAKER ET AL., 2016

Body map of regional vs. whole body sweating rate and sweat electrolyte concentrations in men and women during moderate exercise-heat stress

Lindsay B. Baker, Corey T. Ungaro, Bridget C. Sopeña, Ryan P. Nuccio, Adam J. Reimel, James M. Carter, John R. Stofan, and Kelly A. Barnes
Gatorade Sports Science Institute, Barrington, Illinois

Submitted 21 September 2017; accepted in final form 1 February 2018



BAKER ET AL., 2018

PRECISIONHYDRATION

THE PREVIOUS RESEARCH...

Exercise intensity effects on total sweat electrolyte losses and regional vs. whole-body sweat [Na^+], [Cl^-], and [K^+]

Lindsay B. Baker[1] · Peter John D. De Chavez[2] · Corey T. Ungaro[1] · Bridget C. Sopeña[1] · Ryan P. Nuccio[1] · Adam J. Reimel[1] · Kelly A. Barnes[1]

BAKER ET AL., 2019

THE PREVIOUS RESEARCH...

Cross-validation of equations to predict whole-body sweat sodium concentration from regional measures during exercise

Lindsay B. Baker[1] | Ryan P. Nuccio[1] | Adam J. Reimel[1] | Shyretha D. Brown[1] | Corey T. Ungaro[1] | Peter John D. De Chavez[2] | Kelly A. Barnes[1]

BAKER ET AL., 2020

THE PURPOSE OF THIS STUDY WAS TO DETERMINE THE VALIDITY OF PUBLISHED EQUATIONS IN PREDICTING WHOLE BODY SWEAT SODIUM CONCENTRATION FROM REGIONAL MEASURES WHEN APPLIED TO A NEW DATA SET

I.E. ARE THE REGRESSION EQUATIONS STILL VALID IN A DIFFERENT SET OF PEOPLE

THE Gx RESEARCH...

SCIENCE ADVANCES | RESEARCH ARTICLE

APPLIED SCIENCES AND ENGINEERING

Skin-interfaced microfluidic system with personalized sweating rate and sweat chloride analytics for sports science applications

Lindsay B. Baker[1]*, Jeffrey B. Model[2,3,4], Kelly A. Barnes[1], Melissa L. Anderson[5], Stephen P. Lee[2,3,4], Khalil A. Lee[5], Shyretha D. Brown[1], Adam J. Reimel[1], Timothy J. Roberts[5], Ryan P. Nuccio[1], Justina L. Bonsignore[5], Corey T. Ungaro[1], James M. Carter[6], Weihua Li[2,3,4], Melissa S. Seib[2], Jonathan T. Reeder[3,4,7], Alexander J. Aranyosi[2,3,4], John A. Rogers[2,3,4,8,9,10,11]*, Roozbeh Ghaffari[2,3,4,8,11]*

Advanced capabilities in noninvasive, in situ monitoring of sweating rate and sweat electrolyte losses could enable real-time personalized fluid-electrolyte intake recommendations. Established sweat analysis techniques using absorbent patches require post-collection harvesting and benchtop analysis of sweat and are thus impractical for ambulatory use. Here, we introduce a skin-interfaced wearable microfluidic device and smartphone image processing platform that enable analysis of regional sweating rate and sweat chloride concentration ($[Cl^-]$). Systematic studies ($n = 312$ athletes) establish significant correlations for regional sweating rate and sweat $[Cl^-]$ in a controlled environment and during competitive sports under varying environmental conditions. The regional sweating rate and sweat $[Cl^-]$ results serve as inputs to algorithms implemented on a smartphone software application that predicts whole-body sweating rate and sweat $[Cl^-]$. This low-cost wearable sensing approach could improve the accessibility of physiological insights available to sports scientists, practitioners, and athletes to inform hydration strategies in real-world ambulatory settings.

THE RESEARCH HAD PREVIOUSLY FOCUSSED ON VALIDATING THE ABSORBENT PATCHES.

THIS NEW PAPER AIMED TO VALIDATE THE USE OF THE GX PATCH.

BAKER ET AL., 2020

WHAT THEY DID.

PRIMARY OBJECTIVE:

TO DETERMINE THE VALIDITY OF A SKIN-INTERFACED WEARABLE

BAKER ET AL., 2020

WHAT THEY DID.

TRIAL 1	TRIAL 2 (A + B)	TRIAL 3
• FIELD TESTING • Gx PATCH vs. ABSORBENT PATCH DURING ON-FIELD/COURT SPORTS TRAINING	• LABORATORY TESTING • **TRIAL 2A:** Gx PATCH vs. ABSORBENT PATCH + WHOLE-BODY WASHDOWN • **TRIAL 2B:** TEST-RETEST RELIABILITY	• A COMBINATION OF FIELD AND LAB TESTING • DEVELOPMENT OF WHOLE-BODY SR + SWEAT CHLORIDE PREDICTION MODELS
n = 43	n = 45	n = 312

BAKER ET AL., 2020

PRECISIONHYDRATION

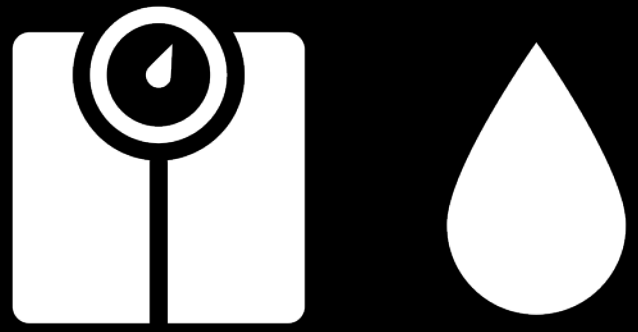
EVERY TRIAL:

SWEAT COLLECTION:

SWEAT COLLECTED FROM THE RIGHT FOREARM BY AN ABSORBENT PATCH AND THE LEFT FOREARM WITH THE GX PATCH

BAKER ET AL., 2018

WHOLE-BODY SWEAT RATE:



CALCULATED FROM THE DIFFERENCE IN PRE- AND POST-EXERCISE BODY MASS DIVIDED BY EXERCISE DURATION*

CHEUVRONT & KENEFICK., 2017

SWEAT ANALYSIS/HANDLING:

ABSORBENT SWEAT PATCHES WERE HANDLED THE SAME WAY:

- REMOVED WHEN MODERATELY SATURATED
- CENTRIFUGED AND ANALYSED IN THE SAME WAY

PRECISIONHYDRATION

EVERY TRIAL:

REGIONAL SWEAT RATE:

mg per cm^2 per minute

1. THE MASS OF SWEAT ABSORBED IN THE PATCH (TO THE NEAREST 0.001G)
2. THE PATCH SURFACE AREA
3. THE DURATION THE PATCH WAS ON THE SKIN

WHAT DID THEY DO?

TRIAL 1

- FIELD TESTING
- Gx PATCH vs. ABSORBENT PATCH DURING ON-FIELD/COURT SPORTS TRAINING

n = 43

TRIAL 2 (A + B)

- LABORATORY TESTING
- **TRIAL 2A:** Gx PATCH vs. ABSORBENT PATCH + WHOLE-BODY WASHDOWN
- **TRIAL 2B:** TEST-RETEST RELIABILITY

n = 45

TRIAL 3

- A COMBINATION OF FIELD AND LAB TESTING
- DEVELOPMENT OF WHOLE-BODY SR + SWEAT CHLORIDE PREDICTION MODELS

n = 312

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PRECISIONHYDRATION

TRIAL 1

FIELD TESTING

VS.

- N = 43 (15 MALES, 28 FEMALES)
- FIVE SPORTS: TENNIS, SOCCER, LACROSSE, BASKETBALL, AND TRACK AND FIELD
- 22-34°C, 50-82% RH
- PATCH TIME ON SKIN WAS 39 TO 112 MIN

OBJECTIVE: TO COMPARE THE GX PATCH TO THE ABSORBENT PATCH RESULTS FOR REGIONAL SWEAT RATE AND SWEAT CHLORIDE CONCENTRATION IN FIELD TRAINING – DO THEY GIVE SIMILAR RESULTS?

PRECISIONHYDRATION

CORRELATIONS (PEARSON'S).

- PEARSON'S CORRELATIONS IS A MEASURE OF THE STRENGTH AND DIRECTION OF ASSOCIATION THAT EXISTS BETWEEN TWO VARIABLES
- ATTEMPTS TO DRAW A LINE OF BEST FIT THORUGH THE DATA OF TWO VARIABLES AND THE *r* VALUE INDICATES HOW FAR AWAY ALL THE DATA POINTS ARE FROM THIS LINE OF BEST FIT
- VALUE CAN RANGE FROM -1 TO 1

Correlation Coefficient Value (*r*)	Direction and Strength of Correlation
-1	Perfectly negative
-0.8	Strongly negative
-0.5	Moderately negative
-0.2	Weakly negative
0	No association
0.2	Weakly positive
0.5	Moderately positive
0.8	Strongly positive
1	Perfectly positive

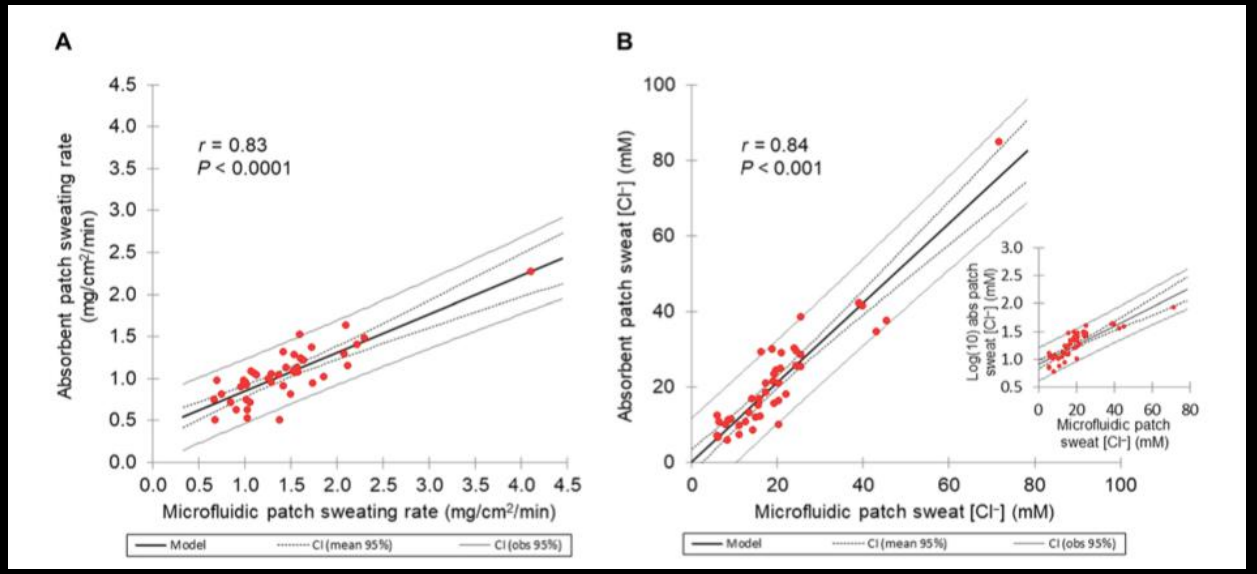
TRIAL 1

FIELD TESTING

VS.

RESULTS:

- GX PATCH WAS SIGNIFICANTLY CORRELATED WITH THE ABSORBENT PATCH FOR BOTH REGIONAL SWEAT RATE (r = 0.83) AND SWEAT CHLORIDE CONCENTRATION (r = 0.84)

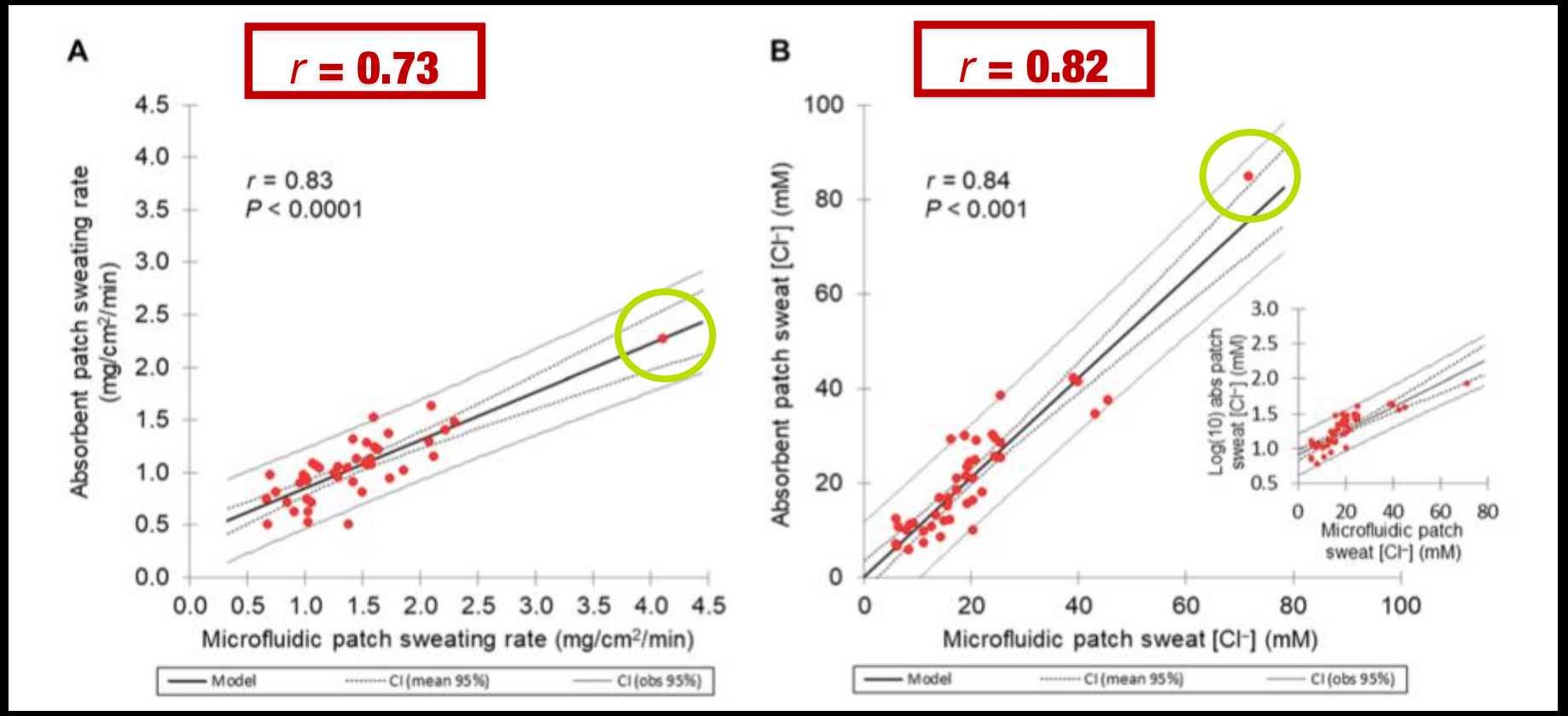


PRECISIONHYDRATION

TRIAL 1

FIELD TESTING

VS.



ONE OUTLIER DATAPOINT – WHEN REMOVED CORRELATIONS REMAINED STATISTICALLY SIGNIFICANT

PRECISIONHYDRATION

TRIAL 1

FIELD TESTING

VS.

RESULTS:

- GX PATCH WAS SIGNIFICANTLY CORRELATED WITH THE ABSORBENT PATCH FOR BOTH REGIONAL SWEAT RATE (r = 0.83) AND SWEAT CHLORIDE CONCENTRATION (r = 0.84)
- THE GX PATCH'S REGIONAL SWEAT RATE WAS SIGNIFICANTLY HIGHER THAN THAT OF THE ABSORBENT PATCH:
  1.42 ± 0.6 (GX) VS. 1.04 ± 0.33 mg/cm^2 per minute (P < 0.0001)
- NO DIFFERENCE BETWEEN SWEAT CHLORIDE CONCENTRATION BETWEEN GX AND ABSORBENT PATCH (21.4 ± 14.1 VS. 20.0 ± 12.4 mM, P = 0.11)

Mean ± SD

PRECISIONHYDRATION

WHAT DID THEY DO?

TRIAL 1

- FIELD TESTING
- Gx PATCH vs. ABSORBENT PATCH DURING ON-FIELD/COURT SPORTS TRAINING

n = 43

TRIAL 2 (A + B)

- LABORATORY TESTING
- **TRIAL 2A:** Gx PATCH vs. ABSORBENT PATCH + WHOLE-BODY WASHDOWN
- **TRIAL 2B:** TEST-RETEST RELIABILITY

n = 45

TRIAL 3

- A COMBINATION OF FIELD AND LAB TESTING
- DEVELOPMENT OF WHOLE-BODY SR + SWEAT CHLORIDE PREDICTION MODELS

n = 312

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PRECISIONHYDRATION

TRIAL 2 LAB TESTING 2A

- N = 45
- SUBJECTS CYCLED FOR 90-MIN ON AN ERGOMETER AT MODERATE INTENSITY IN A CLIMATE-CONTROLLED CHAMBER (32°C, 25-50% RH)
- WHOLE BODY WASHDOWN (WBW) USED TO MEASURE WHOLE BODY SWEAT SODIUM AND CHLORIDE CONCENTRATION
- AD LIBITUM 6% CHO-ELECTROLYTE DRINK CONSUMED

VS.

VS.

TRIAL 2 LAB TESTING 2A

OBJECTIVE i): TO COMPARE THE GX PATCH TO THE ABSORBENT PATCH RESULTS FOR REGIONAL SWEAT RATE AND SWEAT CHLORIDE CONCENTRATION IN THE LAB

OBJECTIVE ii): TO DETERMINE THE RELATIONSHIP BETWEEN THE GX PATCH AND WHOLE-BODY SWEAT RATE AND SWEAT CHLORIDE CONCENTRATION (AS GIVEN BY WBW)

VS.

VS.

PRECISIONHYDRATION

TRIAL 2 LAB TESTING 2A

BETTER CORRELATIONS THAN IN THE FIELD (AS WOULD BE EXPECTED)

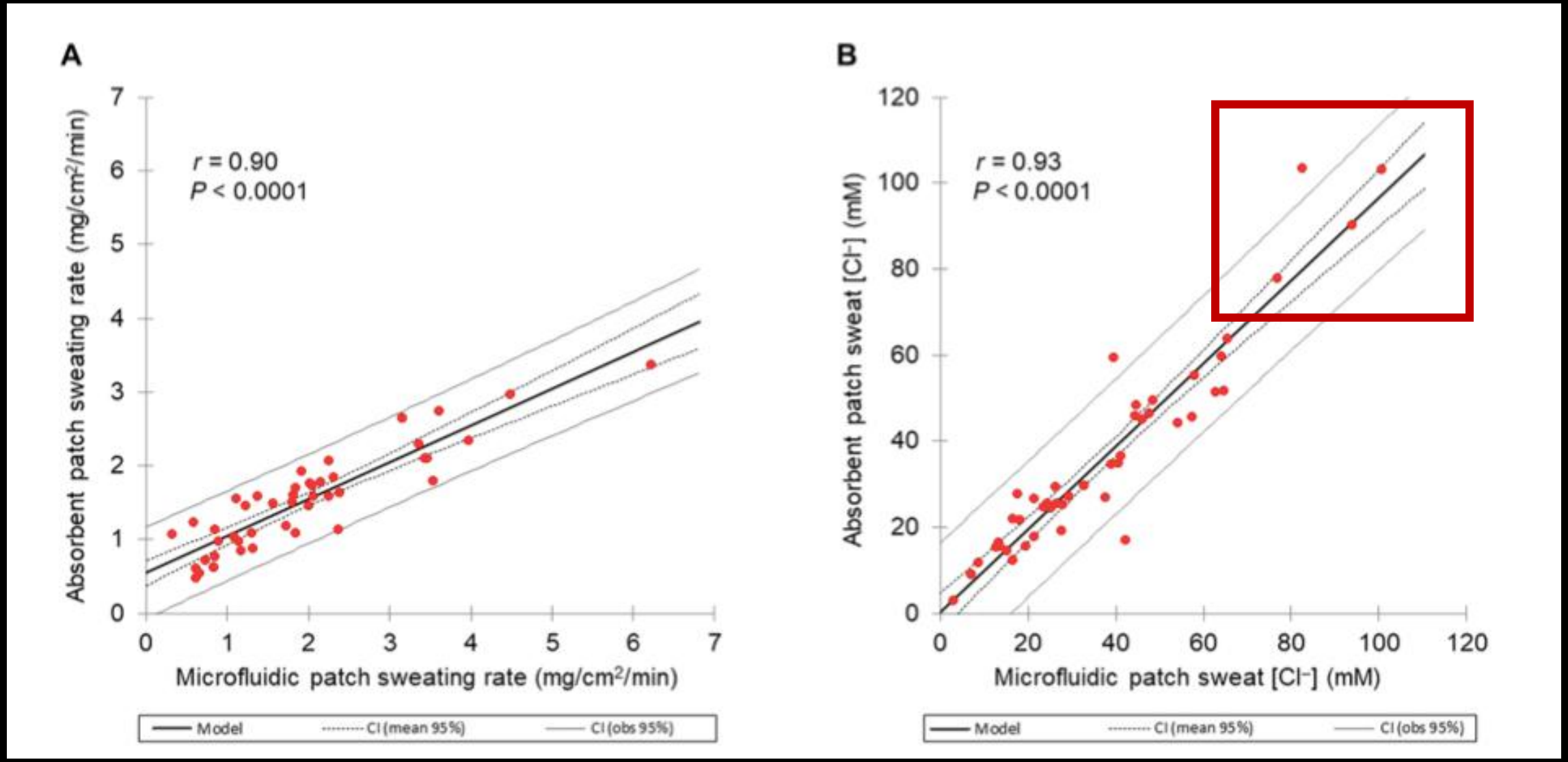
RESULTS:

- GX PATCH SIGNIFICANTLY CORRELATED WITH THE ABSORBENT PATCH FOR BOTH REGIONAL SWEAT RATE (r = 0.90) AND SWEAT CHLORIDE CONCENTRATION (r = 0.93)
- THE GX SWEAT RATE WAS SIGNIFICANTLY HIGHER THAN THAT OF THE ABSORBANT PATCH (1.99 ± 1.22 VS. 1.55 ± 0.68 mg/cm^2 per min)
- NO DIFFERENCE BETWEEN THE GX PATCH AND THE ABSORBENT PATCH IN SWEAT CHLORIDE (37.8 ± 23.3 VS. 36.7 ± 23.7 mM)

VS.

= SAME FINDINGS AS THOSE IN THE FIELD

PRECISIONHYDRATION

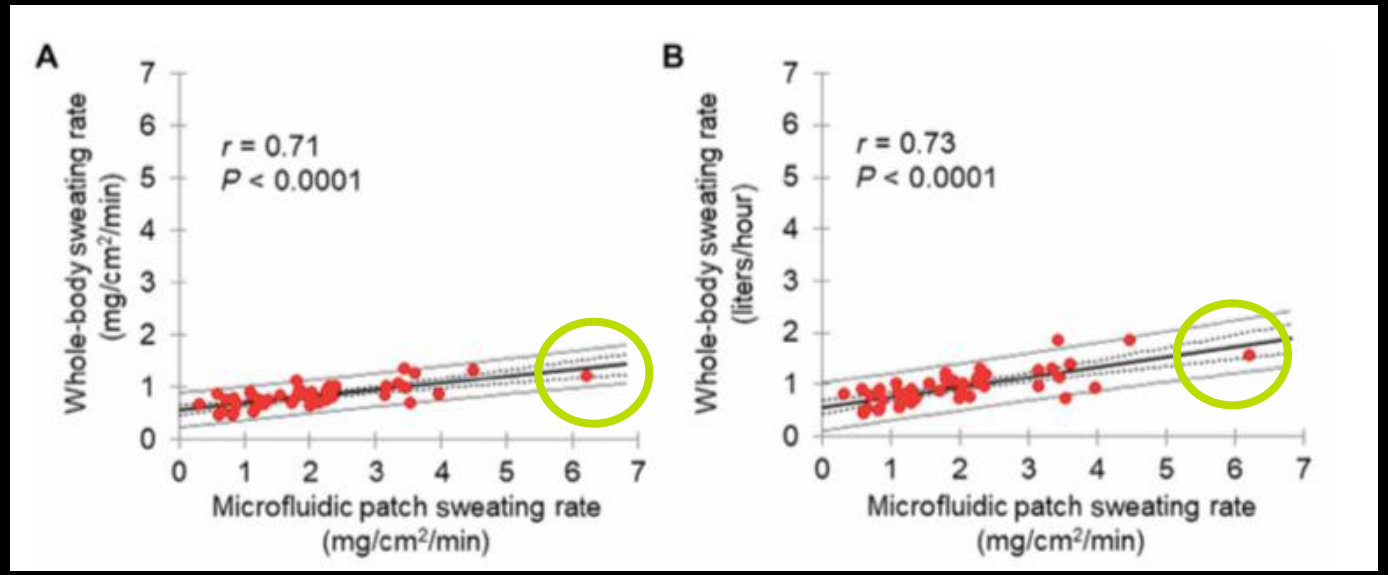


TRIAL 2 LAB TESTING 2A

RESULTS – WBW vs. Gx PATCH

WHOLE BODY SWEAT RATE (CALC. FROM BODY MASS CHANGE)

- WHOLE BODY SWEATING RATE DATA ARE EXPRESSED IN BODY SURFACE AREA (NORMALISED) (mg/cm² per minute) VS. GX PATCH SWEAT RATE (LEFT)
- AND EXPRESSED IN ABSOLUTE TERMS (L/h) VS. GX PATCH SWEAT RATE (RIGHT)



WHEN OUTLIER REMOVED (VERY HIGH GX PATCH SR) IS REMOVED, CORRELATIONS REMAIN SIG. $r = 0.70$, $r = 0.71$

PRECISIONHYDRATION

TRIAL 2 LAB TESTING 2A

RESULTS – WBW vs. Gx PATCH

WHOLE BODY SWEAT RATE (CALC. FROM BODY MASS CHANGE)

THIS DATA SUGGESTS THAT THE CORRELATIONS ARE SIMILAR BETWEEN THE GX PATCH AND WHOLE BODY SR REGARDLESS OF WHETHER OR NOT THE DATA IS NORMALISED TO BODY SURFACE AREA SO L/H CAN BE USED.

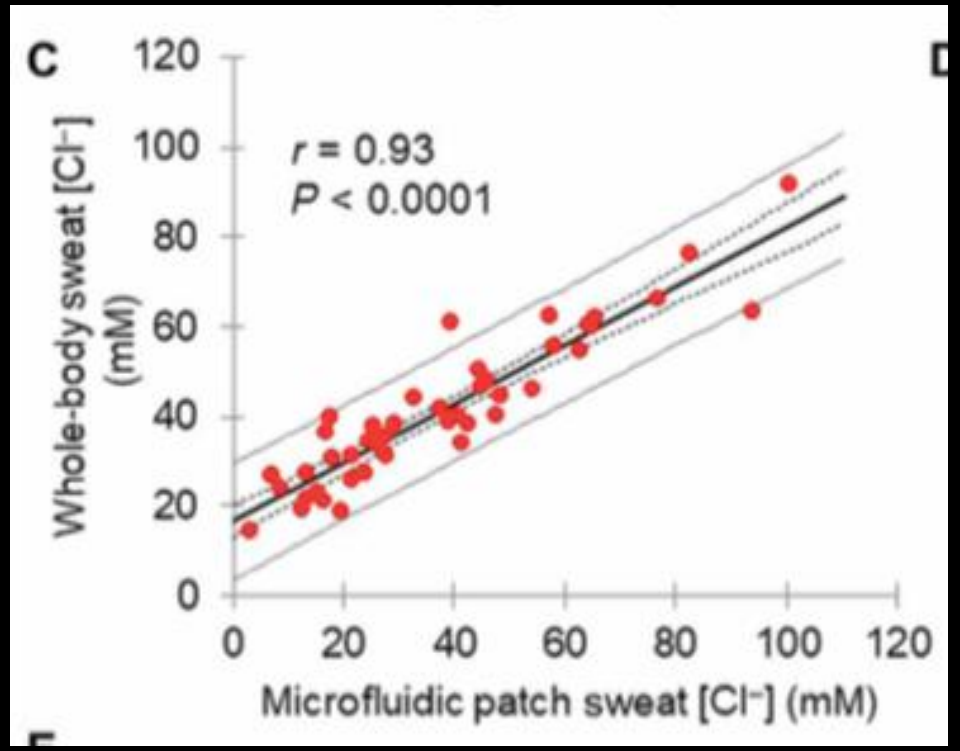
TRIAL 2 LAB TESTING 2A

RESULTS – WBW vs. Gx PATCH

WHOLE BODY SWEAT [Cl^-]

= UNDER LAB CONDITIONS, IT'S A GOOD MATCH r = 0.93

VS.



PRECISIONHYDRATION

TRIAL 2 LAB TESTING 2A

FROM THE PRACTICAL PERSPECTIVE OF HYDRATION SCIENCE, SODIUM IS THE MOST IMPORTANT ELECTROLYTE BECAUSE IT PLAYS A KEY ROLE IN FLUID BALANCE IN THE BODY.

THE GX PATCH MEASURES SWEAT CHLORIDE CONCENTRATION.

THIS RESEARCH HAD TO SHOW THAT SWEAT CHLORIDE CONCENTRATION CORRELATED WITH SWEAT SODIUM CONCENTRATION SO THAT RECOMMENDATIONS ON SODIUM REPLACEMENT COULD BE MADE FOLLOWING THE USE OF THE GX PATCH.

SEE NEXT SLIDE...

TRIAL 2 LAB TESTING 2A

RESULTS – WBW

WHOLE BODY SWEAT [Cl^-] VERSUS WHOLE BODY SWEAT [Na^+]

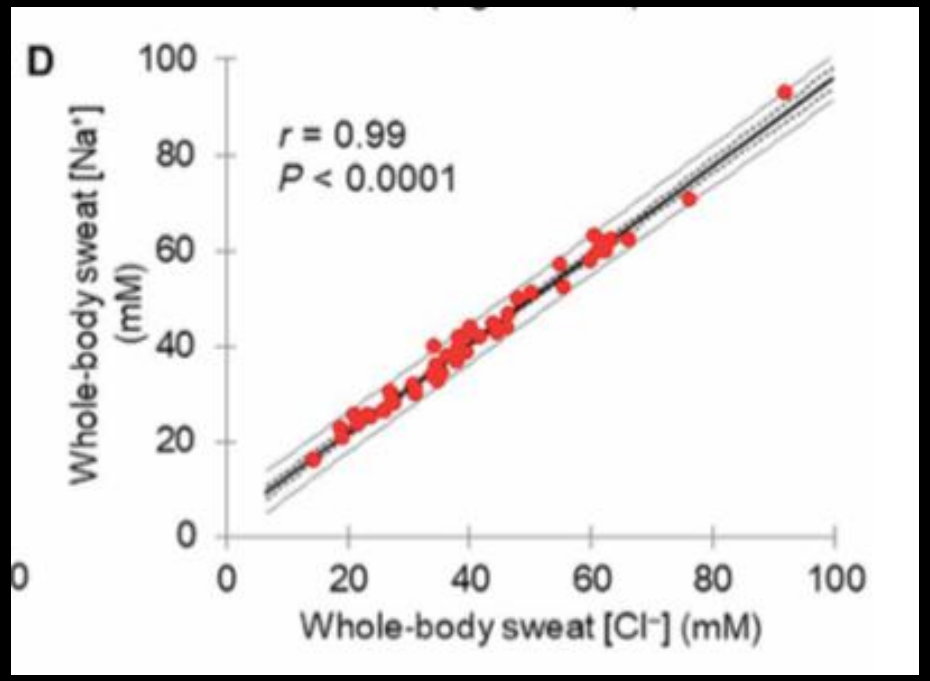
$r = 0.99$

SODIUM: 41.3 ± 16.5 mM

mM to mg = x 23

CHLORIDE: 41.8 ± 15.5 mM

mM to mg = x 35



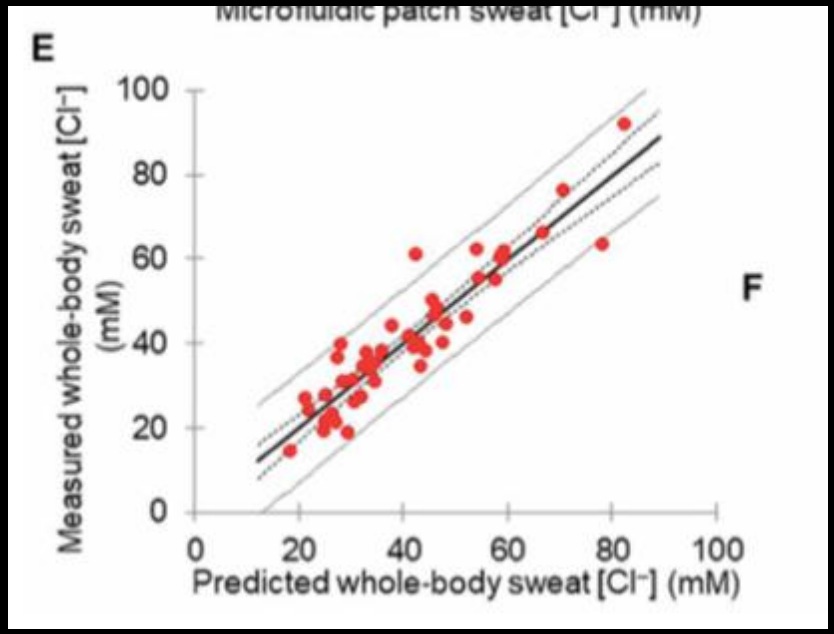
PRECISIONHYDRATION

TRIAL 2 LAB TESTING 2A

RESULTS – WBW vs. GX PREDICTION OF WHOLE BODY CHLORIDE LOSS

MEASURED WHOLE BODY SWEAT [Cl^-] VERSUS PREDICTED WHOLE BODY SWEAT [Cl^-]

Coefficient of determination (r^2)	0.86
Concordance correlation coefficient	0.92
Root mean square error	6 mM
Mean absolute error	5 mM
Mean absolute percentage error	13%



PRECISIONHYDRATION

TRIAL 2 LAB TESTING 2B

- **TEST-RETEST RELIABILITY = DAY-TO-DAY COEFFICIENT OF VARIATION**
- **THIS IS A NECESSARY STEP IN ANY METHODOLOGICAL VALIDATION PROCESS!**
- **SUBSET OF 12 SUBJECTS (8 MALES, 4 FEMALES)**
- **ON TOP OF TRIAL 2A, COMPLETED TWO ADDITIONAL TRIALS (2-8 DAYS APART, SAME TIME OF DAY)**

VS.

VS.

OBJECTIVE: TO DETERMINE THE DAY-TO-DAY COEFFICIENT OF VARIATION OF THE GX PATCH IN MEASURING REGIONAL SWEAT RATE AND SWEAT CL CONCENTRATION

PRECISIONHYDRATION

TRIAL 2 LAB TESTING 2B

CIRCUMSTANCES KEPT CONSISTENT!

- SUBJECTS WERE ASKED TO CONSUME A CONSISTENT DIET IN THE 48 HOURS PRIOR AND TO AVOID CAFFEINE, ALCOHOL AND VIGOROUS EXERCISE IN THE 24 HOURS PRIOR
- THEY WERE ASKED TO DIRNK 500ML OF WATER 2 HOURS BEFORE THE TRIALS
- URINE SAMPLES WERE COLLECTED FOR URINE SPECIFIC GRAVITY MEASUREMENT
- DIETARY ANALYSIS CONFIRMED THAT ENERGY, FLUID AND SODIUM INTAKE WERE CONSISTENT IN THE 48 HOURS LEADING INTO EACH TRIAL

VS.

VS.

PRECISIONHYDRATION

COEFFICIENT OF VARIATION.

IS THE RATIO OF THE STANDARD DEVIATION TO THE MEAN (GENERALLY EXPRESSED AS A %)

CV = THE STANDARD DEVIATION IS X% OF THE MEAN

A UNITLESS MEASURE WHICH ALLOWS YOU TO COMPARE VARIABILITY BETWEEN DISPARATE GROUPS

THE HIGHER THE COEFFICIENT OF VARIATION, THE GREATER THE LEVEL OF DISPERSION AROUND THE MEAN = THE STANDARD DEVIATION IS RELATIVELY LARGE COMPARED TO THE MEAN

ALTERNATIVELY, THE LOWER THE VALUE OF THE COEFFICIENT OF VARIATION, THE MORE PRECISE THE ESTIMATE

COEFFICIENT OF VARIATION.

IS THE RATIO OF THE STANDARD DEVIATION TO THE MEAN (GENERALLY EXPRESSED AS A %)

CV = THE STANDARD DEVIATION IS X% OF THE MEAN

<10% = VERY GOOD

10-20% = GOOD

20-30% = ACCEPTABLE

>30% = NOT ACCEPTABLE

TRIAL 2 LAB TESTING 2B

RESULTS:

- **SWEAT RATE:** COEFFICIENTS OF VARIATION (CVs) WAS 9% FOR BOTH METHODS (GX PATCH AND ABSORBENT PATCH)
- **SWEAT CHLORIDE CONCENTRATION:** COEFFICIENTS OF VARIATION (CVs) WAS 12% FOR THE GX PATCH AND 13% FOR THE ABSORBENT PATCH
- **WHOLE-BODY SWEAT RATE:** COEFFICIENT OF VARIATION WAS 4% (1.07 ± 0.50 AND 1.09 ± 0.49 L/H)

WHAT DID THEY DO?

TRIAL 1

- FIELD TESTING
- Gx PATCH vs. ABSORBENT PATCH DURING ON-FIELD/COURT SPORTS TRAINING

n = 43

TRIAL 2 (A + B)

- LABORATORY TESTING
- **TRIAL 2A:** Gx PATCH vs. ABSORBENT PATCH + WHOLE-BODY WASHDOWN
- **TRIAL 2B:** TEST-RETEST RELIABILITY

n = 45

TRIAL 3

- A COMBINATION OF FIELD AND LAB TESTING
- DEVELOPMENT OF WHOLE-BODY SR + SWEAT CHLORIDE PREDICTION MODELS

n = 312

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PRECISIONHYDRATION

TRIAL 3 LAB + FIELD TESTING (COMBINATION)

- 312 SUBJECTS (194 MALES, 118 FEMALES – INCLUDING THOSE FROM TRIALS 1+2)
- RANGED FROM RECREATIONALLY ACTIVE TO HIGHLY TRAINED
- LAB (n = 114) AND FIELD (n=198)
- VARIETY OF CONDITIONS: 21 TO 35°C, 25-82% RH

OBJECTIVE: TO DEVELOP A WHOLE-BODY SWEATING RATE PREDICTIVE MODEL

TRIAL 3 LAB + FIELD TESTING (COMBINATION)

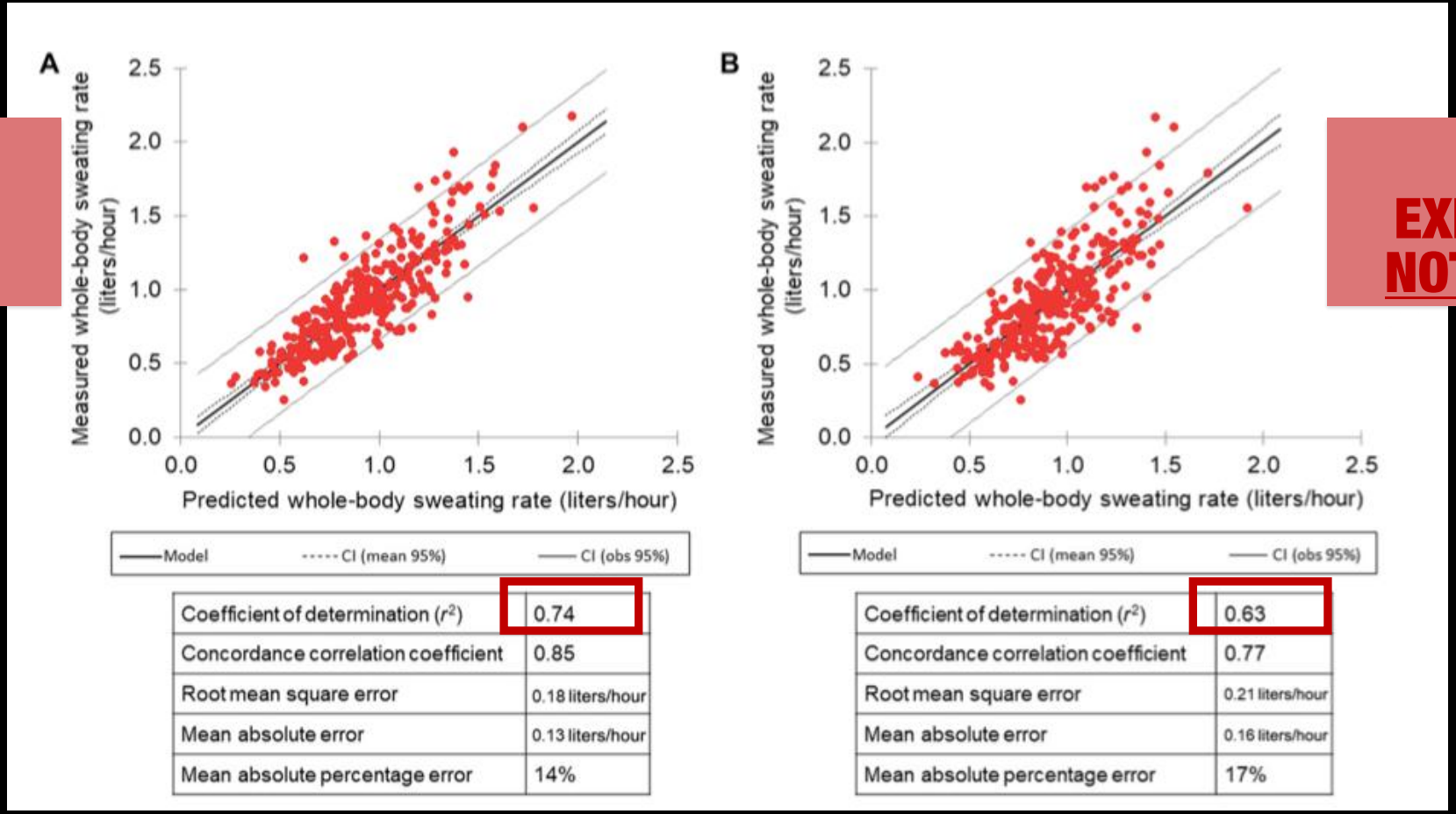
INPUTS INTO THE MODEL INCLUDED:

- GX REGIONAL SWEAT RATE
- SUBJECT CHARACTERISTICS (BODY MASS + SEX)
- ENVIRONMENT – AIR TEMPERATURE
- EXERCISE CONDITIONS – DURATION, SPORT, AND ENERGY EXPENDITURE

PRECISIONHYDRATION

TRIAL 3 LAB + FIELD TESTING (COMBINATION)

ENERGY EXPENDITURE INCLUDED



Coefficient of determination (r^2)	0.74
Concordance correlation coefficient	0.85
Root mean square error	0.18 liters/hour
Mean absolute error	0.13 liters/hour
Mean absolute percentage error	14%

Coefficient of determination (r^2)	0.63
Concordance correlation coefficient	0.77
Root mean square error	0.21 liters/hour
Mean absolute error	0.16 liters/hour
Mean absolute percentage error	17%

ENERGY EXPENDITURE NOT INCLUDED

PRECISIONHYDRATION

FINAL PREDICTION MODELS (FROM THE GX PATCH)

PREDICTED VS. MEASURED (r^2)

SWEATING RATE = 0.74

SWEAT CHLORIDE = 0.86

WHEN ENERGY EXPENDITURE IS INCLUDED IN THE MODEL (0.63 WITHOUT)

= ‘GOOD AGREEMENT’

PRECISIONHYDRATION

FINAL PREDICTION MODELS (FROM THE GX PATCH)

RESULTS SUGGEST THAT THE MEAN ABSOLUTE ERROR OF THE PREDICTION MODELS ARE 0.13 LITERS/HOUR (OR 14%) FOR WHOLE-BODY SWEATING RATE AND 5 MMOL (OR 13%) FOR WHOLE-BODY SWEAT CHLORIDE CONCENTRATION.

PRACTICAL CONSIDERATIONS

- ALL STUDIES HAD SUBJECTS ELIMINATED – PATCH FELL OFF/DELAMINATED, SWEAT DIDN'T PROGRESS FAR ENOUGH INTO THE TUBE, BACKFLOW IN MICROCHANNEL 1
- EXERCISE DURATION IN THE PRESENT STUDIES DIDN'T SURPASS 2 HOURS – RESULTS MAY NOT BE APPLICABLE TO ENDURANCE EVENTS LASTING LONGER

FUTURE RESEARCH

- BROADER ENVIRONMENTAL CONDITIONS
- LONGER EXERCISE DURATIONS
- MORE LOCATIONS – RIGHT FOREARM, OTHER REGIONS OF THE BODY