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Assessing the use of partial body weight measures for liveweight prediction

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Paper

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Statement

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Evaluation of partial body weight for predicting body weight and average daily gain in growing beef cattle

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ABSTRACT: Information on body weight and average daily gain (ADG) of growing animals is key not only to monitoring performance, but also for use in genetic evaluations in the pursuit of achieving sustainable genetic gain. Accurate calculation of ADG, however, requires serial measures of body weight over at least 70 days. This can be resource intensive and thus alternative approaches to predicting individual animal ADG warrant investigation. One such approach is the use of continuously collected individual animal partial body weights. The objective of the present study was to determine the utility of partial body weights in predicting both body weight and ADG; a secondary objective was to deduce the appropriate length of test to determine ADG from partial body weight records. The dataset used consisted of partial body weights, predicted body weights and recorded body weights recorded for 8,972 growing cattle from a range of different breed types in 35 contemporary groups. The relationships among partial body weight, predicted body weight and recorded body weight at the beginning and end of the performance test were determined and calculated ADG per animal from each body weight measure were also compared. On average, partial body weight explained 90.7 ± 2.0% of the variation in recorded body weight at the beginning of the postweaning gain test and 87.9 ± 2.9% of the variation in recorded body weight at its end. The GrowSafe proprietary algorithm to predict body weight from the partial body weight strengthened these coefficients of determination to 95.1 ± 0.9% and 94.9 ± 0.8%, respectively. The ADG calculated from the partial body weight or from the predicted body weight were very strongly correlated ($r = 0.95$); correlations between these ADG values with those calculated from the recorded body weights were weaker at 0.81 and 0.78, respectively. For some applications, ADG may be measured with sufficient accuracy with a test period of 50 days using partial body weights. The intended inference space is to individual trials which have been represented in this study by contemporary groups of growing cattle from different genotypes.

Key words: live weight, performance test, prediction, real-time data capture, test length

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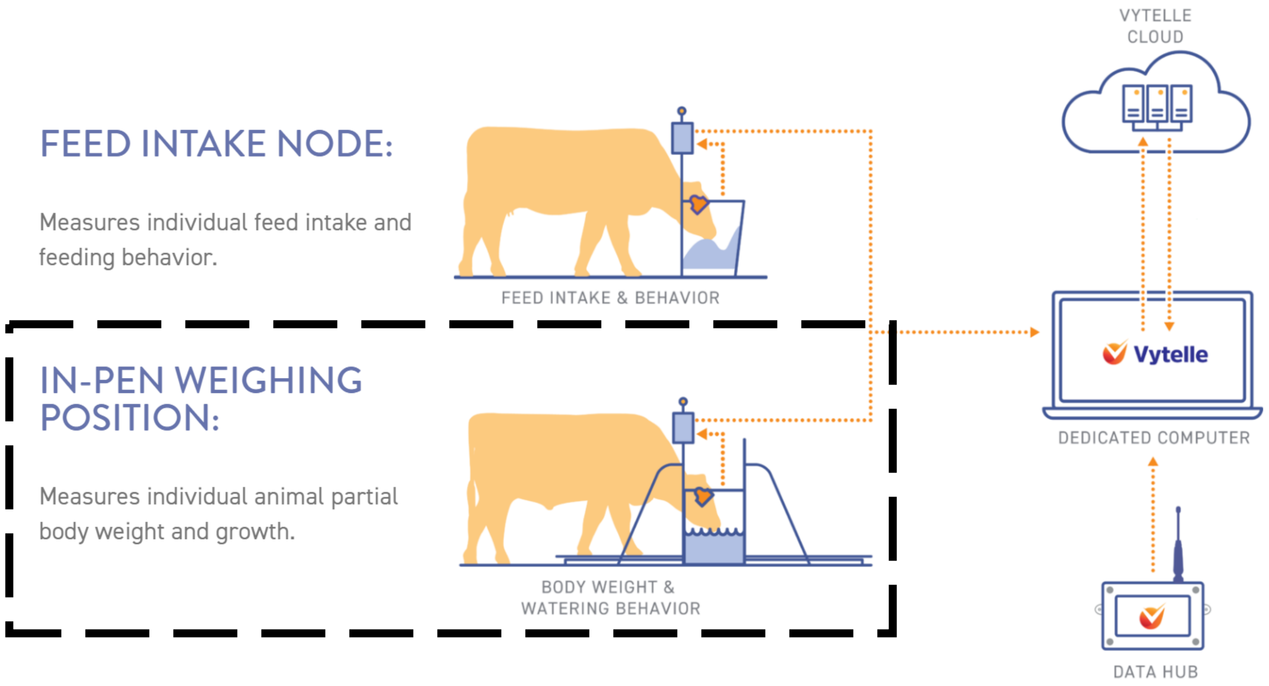
1

Background

- GrowSafe Beef / Vytelle Sense – In pen weighing
- Vytelle invitation for an independent look at the data
- MacNeil recruited some interested parties
- Data and partial funding from Vytelle



Objectives

1. Determine the utility of partial body weights in predicting both body weight and ADG
2. Determine the appropriate length of test for predicting ADG from daily measures of partial body weight.

Frequent weight recording

- May increase accuracy of liveweight records and ADG
- Shorten test period
- Management uses
- Less stress on animals
- Less labour and need for human animal interaction
- Experimental applications

Data

- Data request for relevant data
  - Performance test groups over multiple years
  - Different locations, breed types, diverse as possible
  - Need partial weights, predicted and measured weights
  - Different CG size (min=3)
- ~9k animals, 35 CGs, 2016-2020
- CG size 4 – 123 with test length 63d to 175d
- *Bos indicus*, *Bos taurus africans*, *Bos taurus*, crosses and composite bulls and heifers
- Start, end and in-between recorded weights (min. 4 weights/test), daily average partial weights and predicted daily weights

Analysis (objective 1)

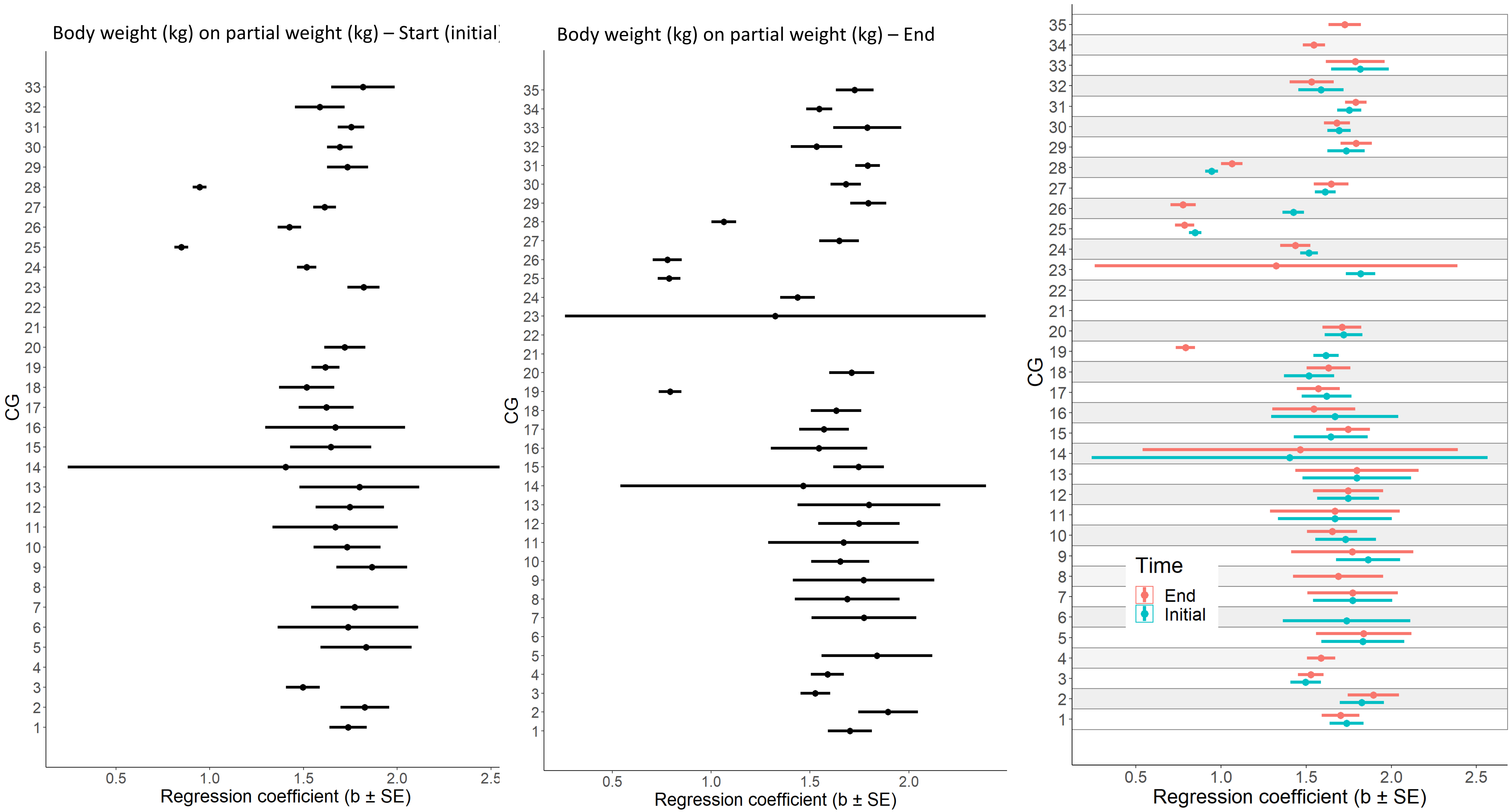
- Partial body weight, predicted body weight, recorded body weight at the start of test and body weight at the end of test
  - Differences, correlations and regressions
- ADG estimated (regression for each animal) from partial body weight, predicted body weight, recorded body weight at the start of test
  - Differences, correlations and regressions
- Mixed model to estimate CG specific parameters

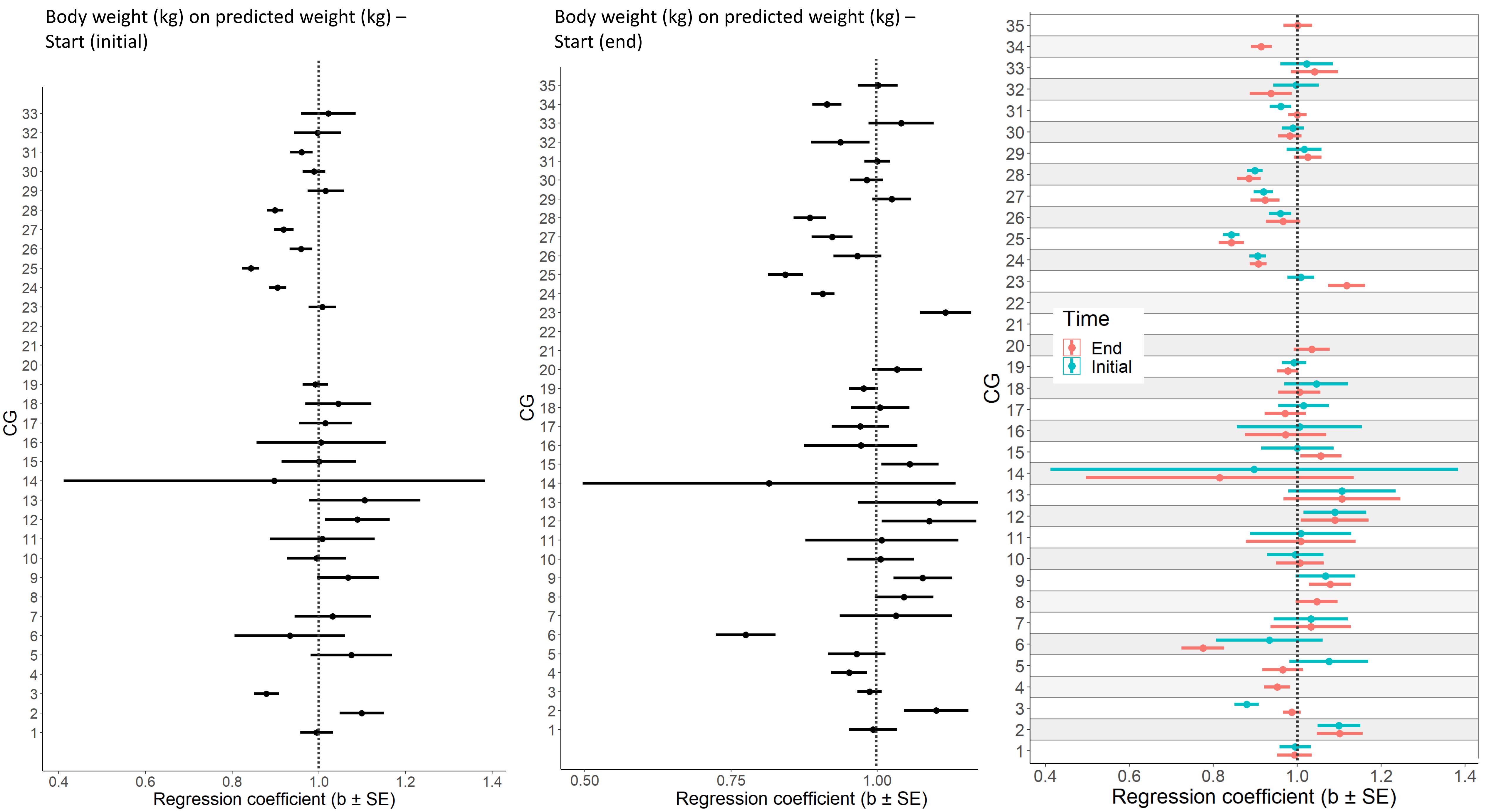
Partial, predicted and actual weight at start & end of test -

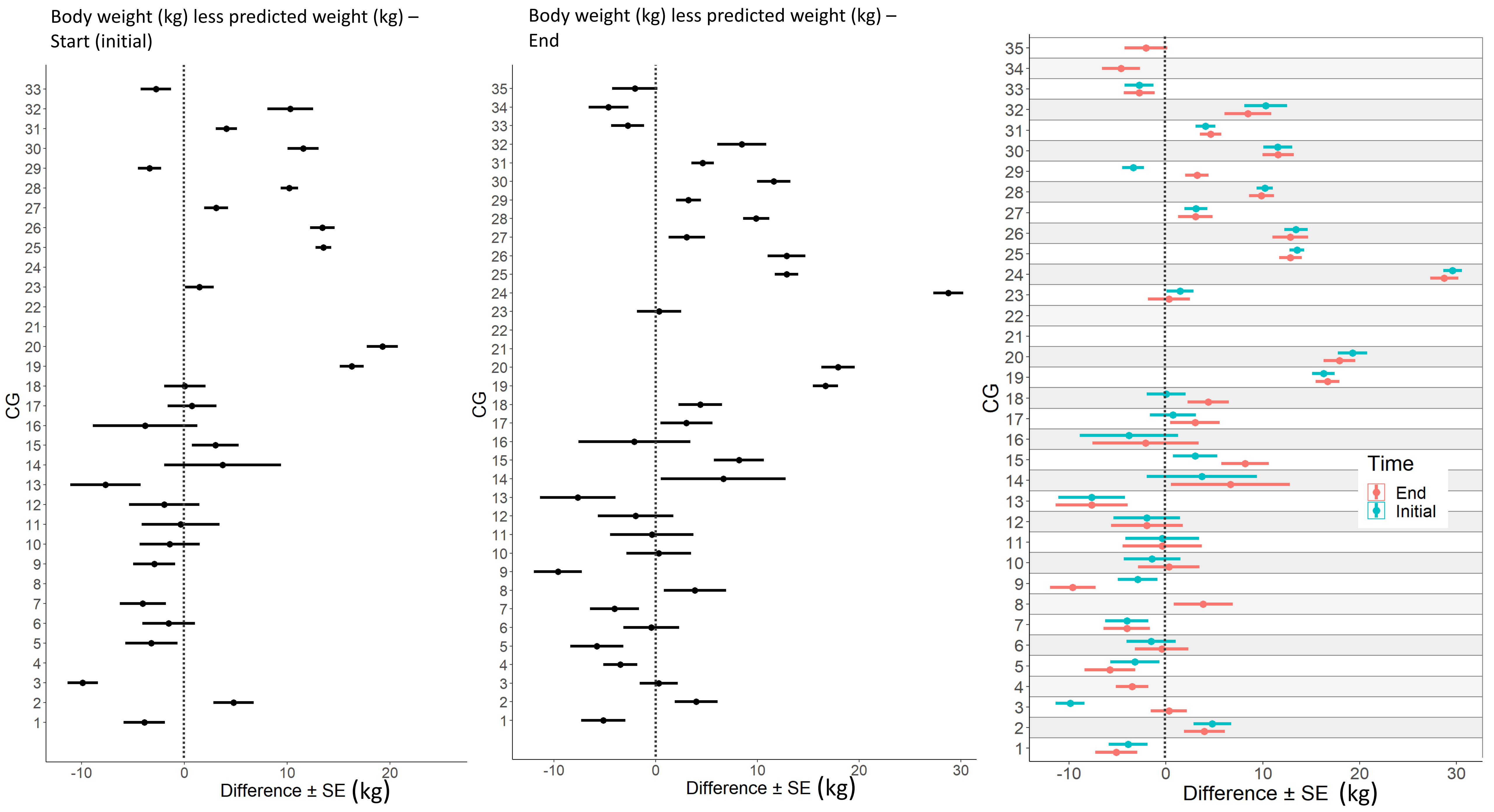
r, b, & differences

Results

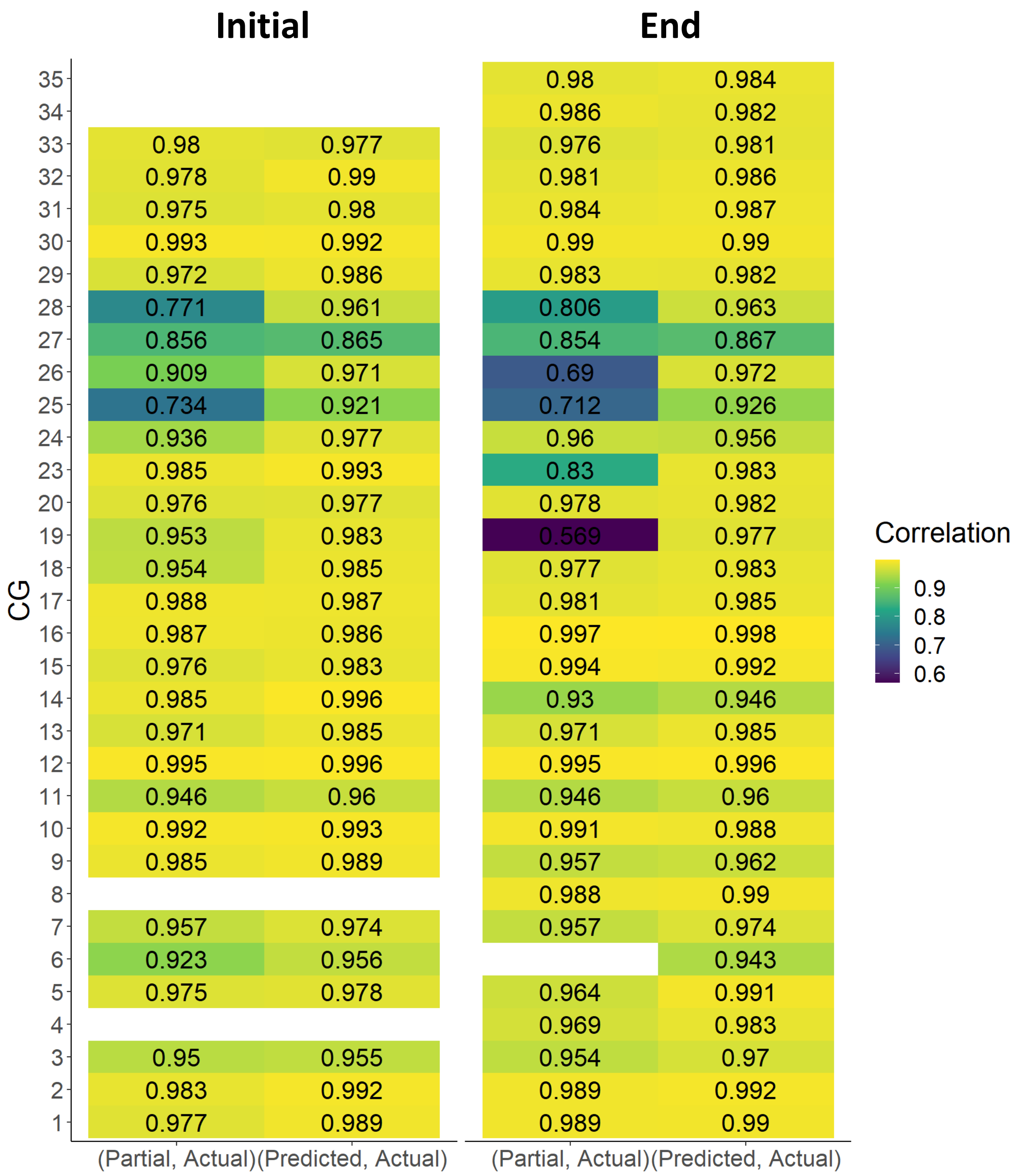
		Partial body weight		Predicted body weight			
CG	N	b ± SE	r_1	b ± SE	b = 1.0	r_2	Difference (kg)
1	32	1.738 ± 0.100	0.977	0.995 ± 0.0376	ns	0.989	−3.91 ± 2.01†
2	34	1.827 ± 0.129	0.983	1.099 ± 0.0510	†	0.992	4.78 ± 1.95*
3	43	1.497 ± 0.090	0.950	0.879 ± 0.0291	**	0.955	−9.91 ± 1.48**
5	20	1.833 ± 0.243	0.975	1.075 ± 0.0937	ns	0.978	−3.22 ± 2.55
6	20	1.737 ± 0.374	0.923	0.933 ± 0.1272	ns	0.956	−1.54 ± 2.55
7	26	1.773 ± 0.233	0.957	1.032 ± 0.0882	ns	0.974	−4.05 ± 2.23†
9	31	1.864 ± 0.188	0.985	1.067 ± 0.0708	ns	0.989	−2.94 ± 2.04
10	15	1.732 ± 0.178	0.992	0.995 ± 0.0677	ns	0.993	−1.44 ± 2.94
11	9	1.669 ± 0.334	0.946	1.008 ± 0.1205	ns	0.960	−0.39 ± 3.79
12	11	1.747 ± 0.182	0.995	1.089 ± 0.0748	ns	0.996	−1.98 ± 3.43
13	11	1.798 ± 0.319	0.971	1.106 ± 0.1279	ns	0.985	−7.68 ± 3.43*
14	4	1.404 ± 1.162	0.985	0.897 ± 0.4856	ns	0.996	3.72 ± 5.69
15	25	1.645 ± 0.216	0.976	1.000 ± 0.0861	ns	0.983	3.01 ± 2.28
16	5	1.669 ± 0.373	0.987	1.005 ± 0.1489	ns	0.986	−3.83 ± 5.09
17	23	1.621 ± 0.146	0.988	1.015 ± 0.0606	ns	0.987	0.73 ± 2.37
18	33	1.517 ± 0.147	0.954	1.045 ± 0.0759	ns	0.985	0.03 ± 2.01
19	97	1.617 ± 0.074	0.953	0.992 ± 0.0291	ns	0.983	16.27 ± 1.16**
20	56	1.720 ± 0.110	0.976	1.048 ±0.0442	ns	0.977	19.26 ± 1.52**
23	33	1.820 ± 0.086	0.985	1.008 ± 0.0314	ns	0.993	1.46 ± 1.40
24	70	1.517 ± 0.052	0.936	0.905 ± 0.0198	**	0.977	29.61 ± 0.96**
25	114	0.849 ± 0.037	0.734	0.843 ± 0.0196	**	0.921	13.53 ± 0.76**
26	44	1.425 ± 0.063	0.909	0.959 ± 0.0262	ns	0.971	13.42 ± 1.21**
27	47	1.612 ± 0.061	0.856	0.919 ± 0.0228	**	0.865	3.09 ± 1.17**
28	91	0.946 ± 0.037	0.771	0.899 ± 0.0188	**	0.961	10.20 ± 0.85**
29	102	1.735 ± 0.110	0.972	1.016 ± 0.0419	ns	0.986	−3.39 ± 1.13**
30	57	1.693 ± 0.068	0.993	0.989 ± 0.0261	ns	0.992	11.55 ± 1.51**
31	123	1.754 ± 0.071	0.975	0.960 ± 0.0255	ns	0.980	4.09 ± 1.03**
32	26	1.587 ± 0.132	0.978	0.997 ± 0.0543	ns	0.990	10.30 ± 2.23**
33	58	1.817 ± 0.169	0.980	1.022 ± 0.0629	ns	0.977	−2.78 ± 1.49†


Body weight (kg) on partial weight (kg) – Start (initial)
Body weight (kg) on partial weight (kg) – End
CG
Regression coefficient (b ± SE)
Time
End
Initial


Body weight (kg) on predicted weight (kg) – Start (initial)
Body weight (kg) on predicted weight (kg) – Start (end)
CG
Regression coefficient (b ± SE)
Time
End
Initial



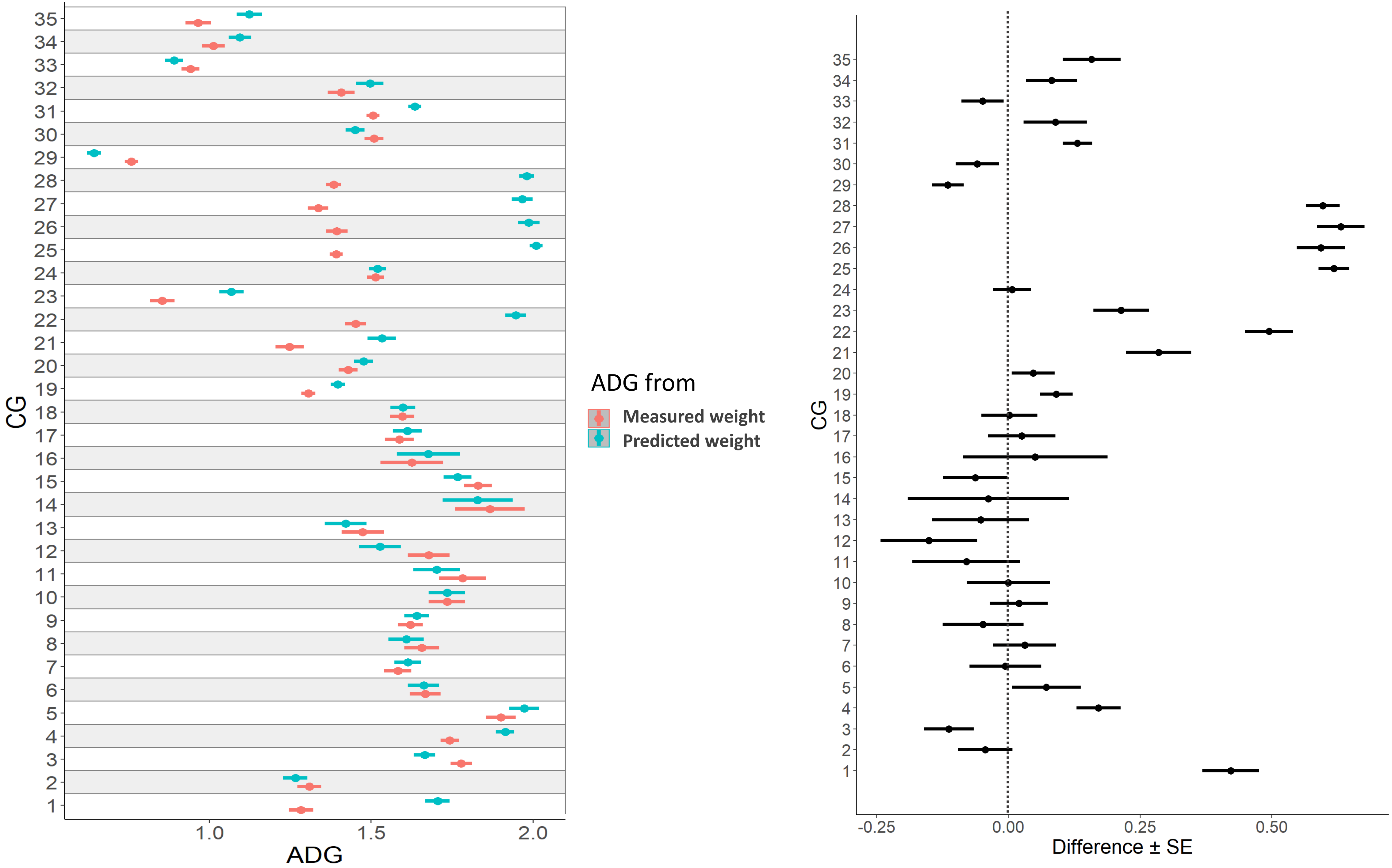
Body weight (kg) less predicted weight (kg) – Start (initial)
Body weight (kg) less predicted weight (kg) – End
CG
Difference ± SE (kg)
Time
End
Initial


Initial
End
CG
35 34 33 32 31 30 29 28 27 26 25 24 23 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
0.98 0.977
0.978 0.99
0.975 0.98
0.993 0.992
0.972 0.986
0.771 0.961
0.856 0.865
0.909 0.971
0.734 0.921
0.936 0.977
0.985 0.993
0.976 0.977
0.953 0.983
0.954 0.985
0.988 0.987
0.987 0.986
0.976 0.983
0.985 0.996
0.971 0.985
0.995 0.996
0.946 0.96
0.992 0.993
0.985 0.989
0.957 0.974
0.923 0.956
0.975 0.978
0.95 0.955
0.983 0.992
0.977 0.989
0.98 0.984
0.986 0.982
0.976 0.981
0.981 0.986
0.984 0.987
0.99 0.99
0.983 0.982
0.806 0.963
0.854 0.867
0.69 0.972
0.712 0.926
0.96 0.956
0.83 0.983
0.978 0.982
0.569 0.977
0.977 0.983
0.981 0.985
0.997 0.998
0.994 0.992
0.93 0.946
0.971 0.985
0.995 0.996
0.946 0.96
0.991 0.988
0.957 0.962
0.988 0.99
0.957 0.974
0.943
0.964 0.991
0.969 0.983
0.954 0.97
0.989 0.992
0.989 0.99
(Partial, Actual) (Predicted, Actual)
(Partial, Actual) (Predicted, Actual)
Correlation
0.9
0.8
0.7
0.6

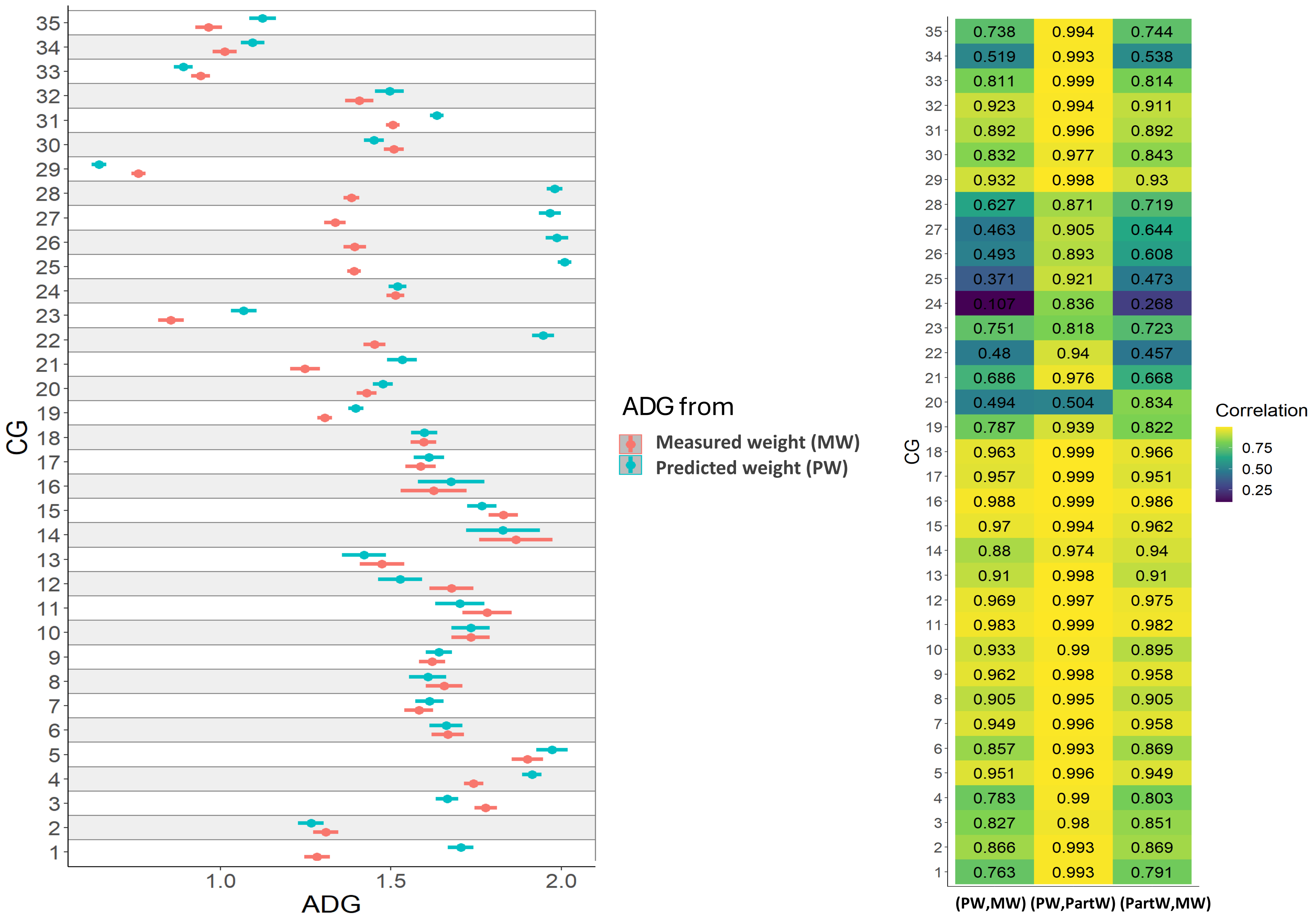
Results

- Start of test
  - partial weight explained 73-99.5% of measured weight
  - predicted weight explained 87-99.6% of measured weight
- End of test
  - partial weight explained 57-99.7% of measured weight
  - predicted weight explained 87-99.8% of measured weight
- Algorithm does improve coefficient of determination, reduces SE
- Statistically different coefficients (for prediction) means a constant doesn’t work (previous studies)
  - Algorithm uses more accurate tailored coefficients

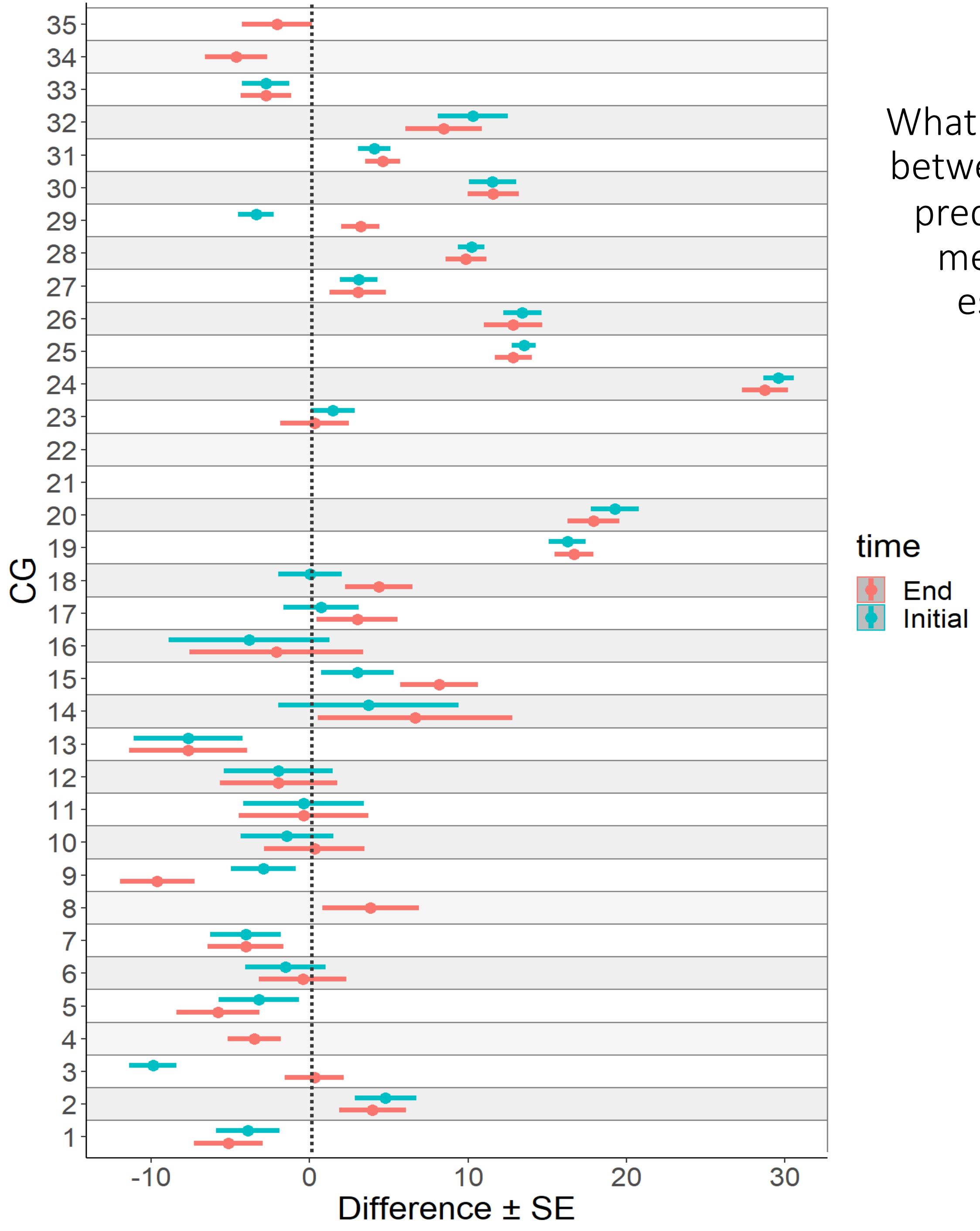
Average Daily Gain



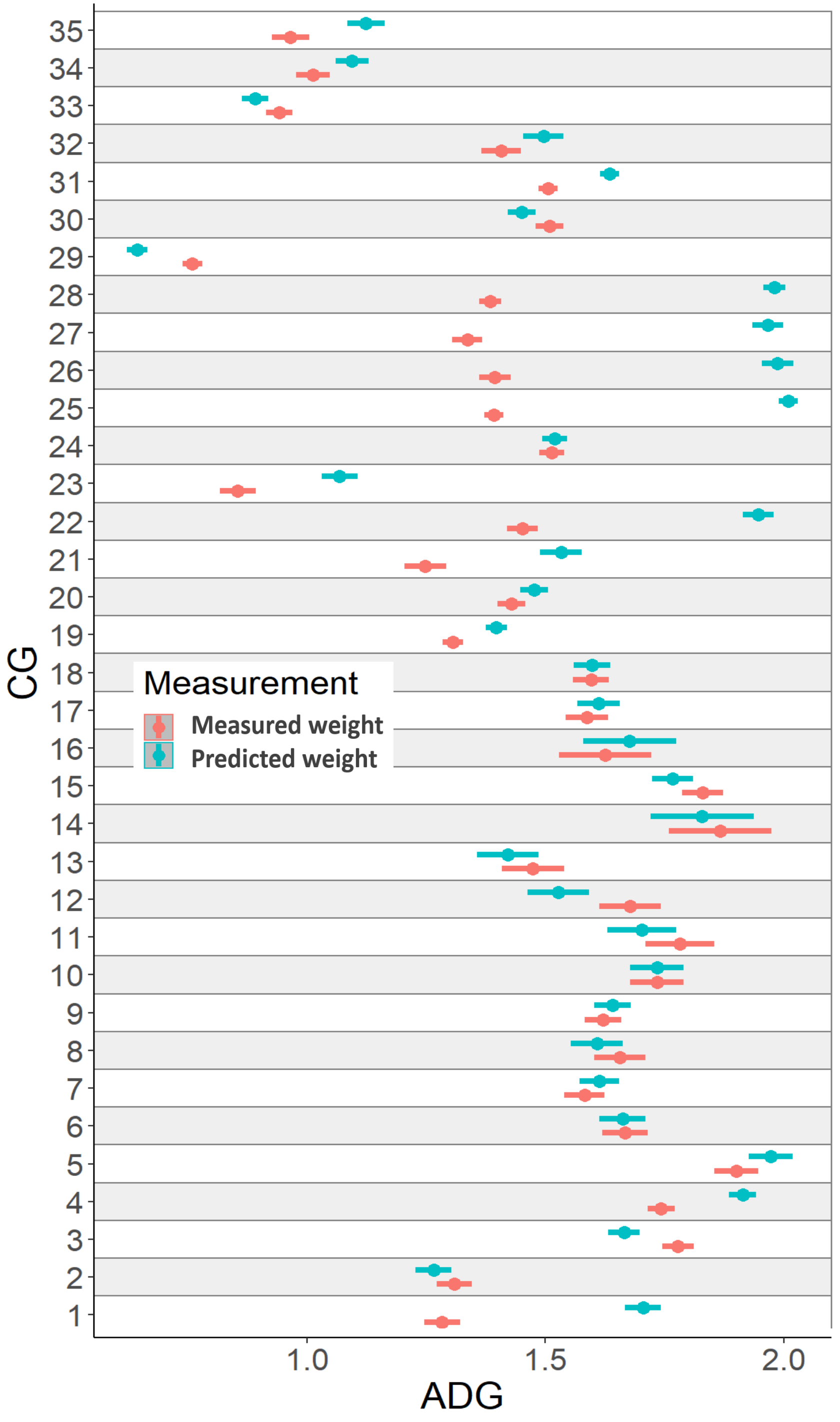
CG
ADG
1.0
1.5
2.0
ADG from
Measured weight
Predicted weight
CG
Difference ± SE
-0.25
0.00
0.25
0.50

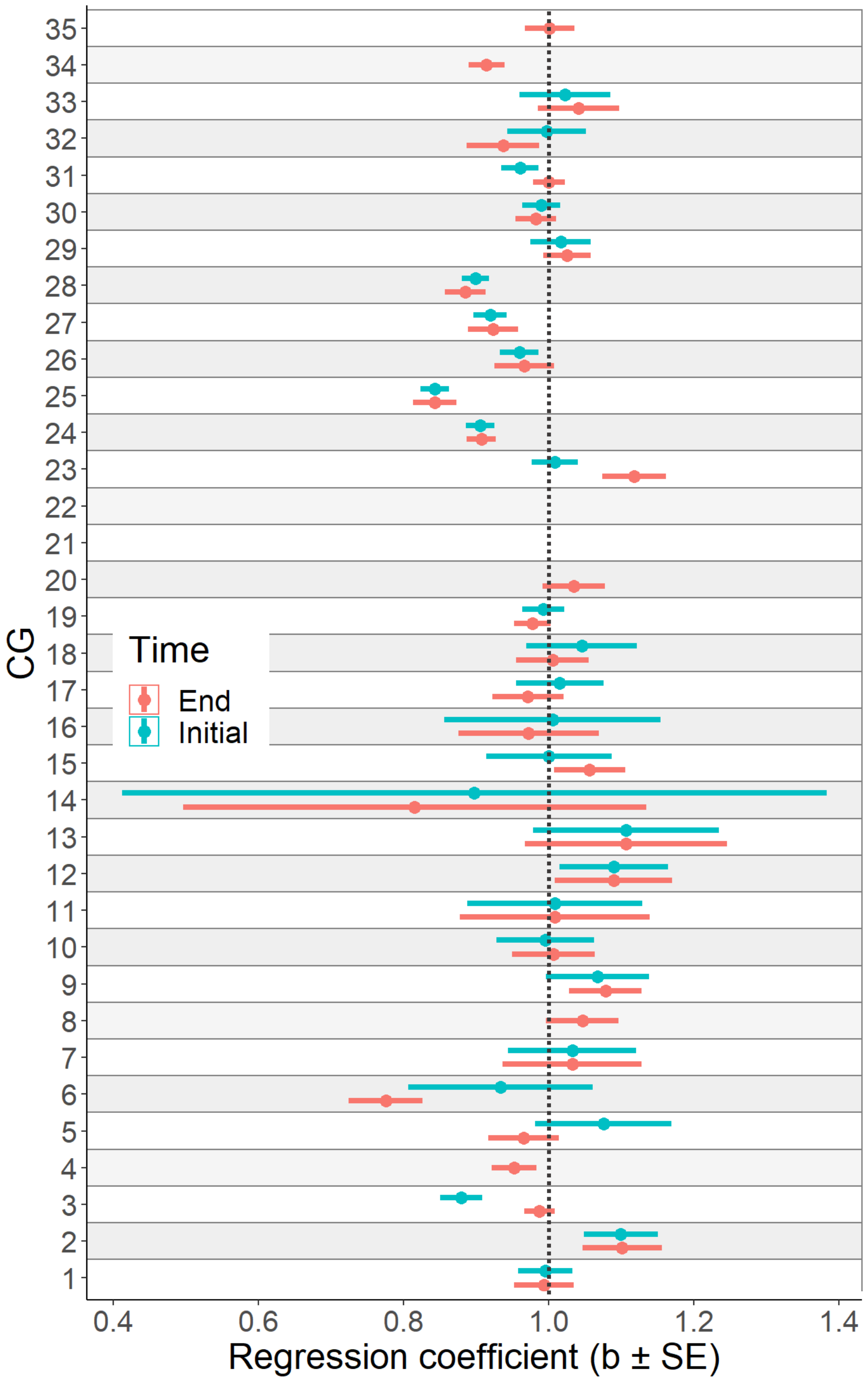


CG
ADG
1.0
1.5
2.0
ADG from
Measured weight (MW)
Predicted weight (PW)
Correlation
0.75
0.50
0.25
(PW,MW) (PW,PartW) (PartW,MW)
35 0.738 0.994 0.744
34 0.519 0.993 0.538
33 0.811 0.999 0.814
32 0.923 0.994 0.911
31 0.892 0.996 0.892
30 0.832 0.977 0.843
29 0.932 0.998 0.93
28 0.627 0.871 0.719
27 0.463 0.905 0.644
26 0.493 0.893 0.608
25 0.371 0.921 0.473
24 0.107 0.836 0.268
23 0.751 0.818 0.723
22 0.48 0.94 0.457
21 0.686 0.976 0.668
20 0.494 0.504 0.834
19 0.787 0.939 0.822
18 0.963 0.999 0.966
17 0.957 0.999 0.951
16 0.988 0.999 0.986
15 0.97 0.994 0.962
14 0.88 0.974 0.94
13 0.91 0.998 0.91
12 0.969 0.997 0.975
11 0.983 0.999 0.982
10 0.933 0.99 0.895
9 0.962 0.998 0.958
8 0.905 0.995 0.905
7 0.949 0.996 0.958
6 0.857 0.993 0.869
5 0.951 0.996 0.949
4 0.783 0.99 0.803
3 0.827 0.98 0.851
2 0.866 0.993 0.869
1 0.763 0.993 0.791

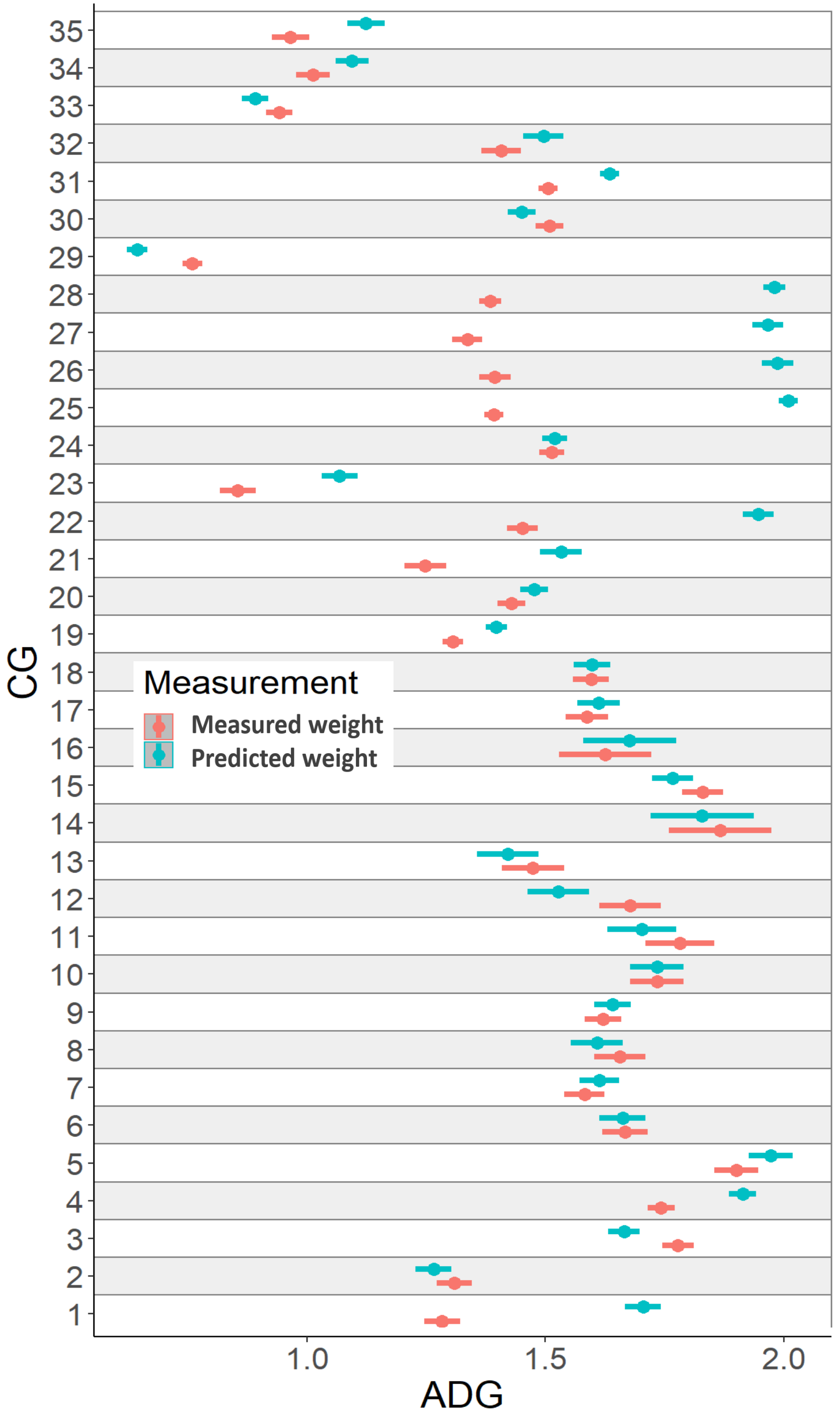


What do differences between actual and predicted weight mean for ADG estimation?





What do variation in regression coefficients for predicting weight mean for ADG estimation?



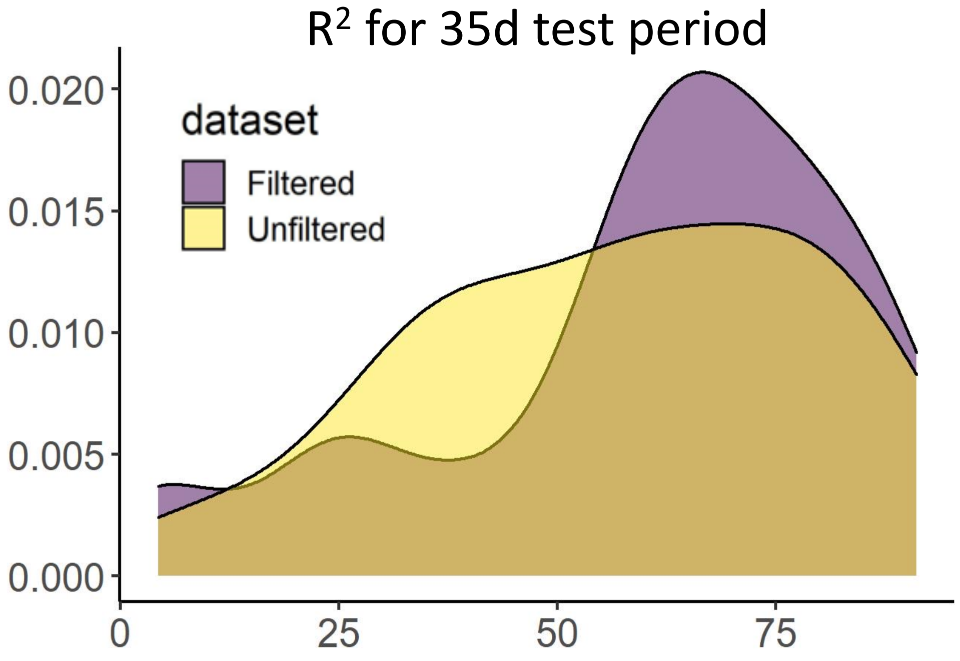
Length of Test

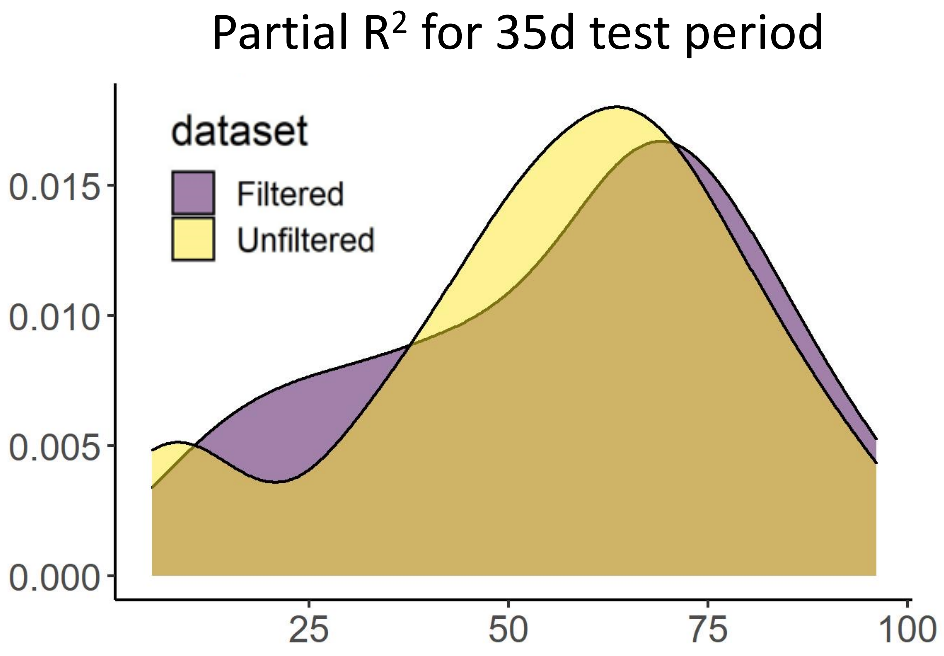
Analysis (Objective 2)

- ADG estimates from short and long test periods
  - Truncate all tests at 70d
  - ADG from partial and predicted weights
  - Completed twice, with and without data edit for abnormal growth rate ($r^2 < 0.9$)
    - 38% of ADG estimated from partial weights $r^2 < 0.90$
- Split the data in two at 35d and at 50d
  - ADG full, ADG early, ADG late
- Regression with ADG full as dependent variable
  - Type 1 SS

Results

- Regress pred. ADG_{part1} on pred. ADG_{full}
  - 2 CGs had an $r^2 > 0.90$
- Include ADG_{part2}
  - 3 CGs had partial $r^2 < 0.10$
- First and second half explained a similar proportior of the variation in ADG_{full}
  - 0.57 and 0.56, respectively
- 66% of CG end weight predictions differed significantly from actual
- Filtering for abnormal growth rates (partial body weight) only retains 62%
- Including all CGs as fixed effects
  - ADG in the first half of the test period explained 51.5% of within CG variance
  - ADG from the latter half explained 33.1% of the within CC variance (after accounting for ADG during the first half of the test)



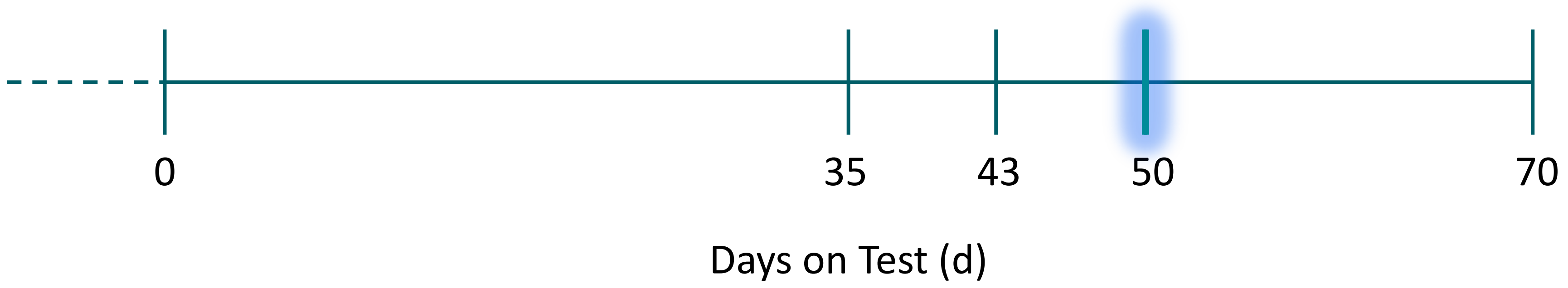


Results

- Repeated with split at 50d
- Mean r^2 and partial r^2 were 0.83 and 0.26, respectively
  - Providing additional ($P < 0.05$) information informing the full-test ADG in 22 CGs
- When edited for abnormal growth rate
  - Mean r^2 and partial r^2 were 0.84 and 0.27, respectively
  - Latter days add more info ($P < 0.05$) for 13 CGs
- Including all CGs as fixed effects
  - ADG in the first half of the test period explained 80% of within CG variance
  - ADG from the latter half explained 2% of the within CG variance (after accounting for ADG during the first half of the test)

Results

- Repeated with split at 43d
- Including all CGs as fixed effects
  - ADG in the first half of the test period explained 68% of within CG variance
  - ADG from the latter half explained 8% of the within CG variance (after accounting for ADG during the first half of the test)
- 50d acceptable shortened test period



Shortened test period

- Not entirely a statistical consideration
- To be as precise as possible, full test length is preferable
  - Plus better chance of testing at a constant age
- Shorter test period has more opportunity of linear growth rates
- More animals tested when capacity or cost/test is limiting
  - Power of test increased for genetic evaluation or experiments
- Shorter the test, any inaccuracy in ADG estimation may be magnified if early and late weights are affected unequally

Conclusions

- Results specific to one proprietary system
- Be cognizant that error also exists in body weights measures
- Predicting full body weight from partial body weight is likely to have acceptable accuracy in most applications
  - CG specific start and end coefficients. Later test can learn from early test
  - there will be some degree of prediction error
- When capacity or cost/test is a limiting factor, 50d test is appropriate
- If the number of animals available is limiting, longer test preferable

Other thoughts

- More frequent measures may present an opportunity to get over chute weight measuring error - gut fill, time of day, scale, user
- Resulting complex data structure tackled with ML (continuous refinement as test progresses)
- Higher chance of capturing that age constant weight
- Partial weights straight into the genetic evaluation

Thank You

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