THE PREDICTION VALUE OF THE WETZEL GRID AND BASAL METABOLISM STANDARDS FOR GIRLS OF SOUTHERN ARIZONA TWELVE AND THIRTEEN YEARS OF AGE

by

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An increase in basal metabolism which occurs at about the tenth year in girls living in various parts of the country has been observed by a number of investigators. It is believed by some to reach a maximum at puberty and to diminish to an adult level at eighteen years. Topper and Mulier (1932) are one of several groups of workers of the opinion that it is coincident with physiological rather than chronological age. Others have failed to find any such increase.

The basal metabolism of one group of southern Arizona girls has been investigated in this laboratory by Thompson, Cox, and Ridgway (1948). The study was, however, limited to the postpuberty age and demonstrated a sharp drop from fourteen to eighteen years at which time the adult level was reached. This adult level was observed to be much lower than that of northern states. When compared with that reported from midwestern states for the eighteenth year these workers found a diminishing trend with increasing mean annual temperature.

PROBLEM

Because no investigation had been made of girls in the early adolescent years living in the subtropical climate of the southwest it seemed desirable to study this group. For purposes of extending the data of the older group ages selected were twelve and thirteen years. Such data have now been observed and evaluated in terms of standards of reference which have been widely used throughout the country.

METHOD

The basal metabolisms of fifty-three presumably normal girls twelve and thirteen years of age have been determined between November 1947 and December 1948. No data were collected during the summer months of May through September. Forty-one of these subjects were born and reared in southern Arizona. Twelve born elsewhere had lived an average of eleven and a half years each in southern Arizona. Taken at random from a nearby junior high school, all were of the white race from middle class homes. None had a record of having had thyroid therapy.

The subjects were given written instructions (Appendix A) on procedure to stress the importance of their being in basal condition. Subjects arrived by car and were taken by elevator to the laboratory. They were given a thirty minute rest previous to the test. Benedict and Crofts (1925) have demonstrated that after a subject has dressed and taken a ten minute walk basal metabolism can be determined after a thirty minute rest. They found no statistically significant increase under these conditions before and after the exercise. No tests were made preceding or following scheduled examinations. The tests were made during the menstrual cycle provided the subject was rested and comfortable. The reports in the literature containing data which justify this procedure have been fully discussed by Ridgway (1947).

The Benedict-Roth closed circuit apparatus was used to measure oxygen consumption. A three minute test for tightness was made before each determination. Two 8-to-10-minute tests were made on each of two or more mornings following each other as closely as possible. No preliminary tests were made. Subjects returned for further testing until oxygen consumption in cubic centimeters per minute from either of the tests on a given day agreed within 5% of that on another day.

Oral temperature was taken each morning and repeated until a constant value was obtained. No test was given if there was evidence of fever. A pulse count was taken for a full minute three times each morning and averaged to determine the pulse for the day. Average barometric pressure was 701 millimeters and average room temperature 78^{o}F.

Oxygen consumption was expressed in terms of calories by assuming the respiratory quotient to be 0.82 with the calorie value of one liter of oxygen as 4.825. For method of calculation using Carpenter's tables see Appendixes B and C and Ridgway for interpolation of factors of barometric pressures from 700 to 710 mm. Surface area was computed from the height-weight formula of DuBois as cited by Carpenter (1939).

Calculation of oxygen consumption per minute, calories per twenty-four hours, calories per hour, and calories per square meter per hour were calculated by each of four methods commonly used in clinical and research laboratories. These are: (1) the average of all values agreeing within five per cent of one accepted as a base line on at least two mornings, (2) the average of all accepted tests, (3) results from the first test only, and (4) the average of accepted tests on the first morning. Coefficients of correlation with age were obtained using weighted means of the present study together with those of Ridgway for the years fourteen through eighteen. Because Ridgway observed a highly significant negative correlation with age by means of each of the first two methods of evaluation, the last two methods having a correlation which was just barely significant, coefficients were derived in this study for only the first two.

Deviations were calculated from each of four standards: Harris-Benedict, Dreyer, Mayo Foundation and Wetzel grid (1941, 1944). Derivations of the first three standards have been fully discussed by DuBois (1936), Sherman (1946), and Willard (1942).

The Wetzel grid, in addition to providing a new basal metabolism standard, introduces a method for evaluating physical development. For this purpose heights and weights of the fifty-three subjects together with eight others for whom no basal metabolisms were determined were taken each month between October 1947 and February 1949 except in summer. Weights were recorded as nude after deduction for indoor clothing; heights as the agreement of two measurements without shoes. Individual heights, weights and ages were plotted to find (1) channel,

(2) developmental level, (3) nutritional grade, (4) channel course, (5) auxodrome progress, (6) developmental ratio, (7) maturity rating and, (8) deviation of actual basal metabolism from grid prediction. Physical status for a given date was evaluated by means of the channel and developmental level. Identification of channel and approximation of direction and rate of advance for most of the cases for a period from six to eight years preceding this study were obtained by referring to Tucson elementary and junior high school records.

RESULTS

Physical data of fifty-three subjects twelve and thirteen years of age are shown in Table I, pages 9 and 10. Average ages were 12.56 and 13.63 years. Average pulse rates were 78 and 72 for the 12 and 13 year old subjects with a range from 52 to 96. Average body temperature of the subjects was 98.2°F. with a range of 97.1°F. to 98.8°F.

Actual basal metabolism of each subject compared with four predictions is given in Tables II-A and II-B, pages 11 and 12. Values in all tables II to IX, inclusive, are based upon the average of tests agreeing within five per cent of one accepted as a base line unless otherwise stated.

Tables III-A and III-B, pages 13 to 16, give the basal energy expenditure of each subject in terms of oxygen per minute, calories per twenty-four hours, calories per hour, and calories per square meter per hour by each of the four methods of evaluation of individual tests.

Table IV, page 17, shows the actual mean calories for each year when derived by each of the four methods of evaluation of individual tests. Data of Ridgway are included which were reported from this laboratory on similar subjects 14 through 18 years of age.

Mean deviations from the standards according to age with and without regard to sign are given in Table V-A, page 18. Ranges in deviations from the Mayo Foundation standard of the 53 cases in the present study are shown in Table V-B. They range from -25.37 to + 7.79 per cent; the Harris-Benedict -19.29 to + 14.60; and Dreyer -21.31 to + 13.44.

Table VI, page 19, shows the distribution of cases in this study with respect to agreement with three of the standards. When compared with the Mayo Foundation, 65.4 and 48.2 per cent of the cases in the 12th and 13th year, respectively, fall below the ten per cent deviation and 34.6 and 26.0 per cent, respectively, below fifteen per c ent; Harris-Benedict, 23.1 and 14.8 per cent of the cases, respectively, below ten per cent but only 3.8 and 7.4 per cent, respectively, below fifteen per cent; Dreyer, 15.4 and 18.6 per cent, respectively, below t en per cent with 0.0 and 7.4 per c ent, respectively, below fifteen per cent.

TABLE I

Physical Data of Subjects

No.	Age	Weight Kg.	Height Cm.	Surface Area Sq.m.	Grid D.L.*	Channel	Auxodrome	Av. pulse rate/ min.
1	12.10	48.88	155.8	1.456	136	A2	15	86
2	12.15	45.11	161.8	1.449	130	B1	15	87
3	12.16	49.68	160.6	1.502	138	A1	2	85
4	12.22	36.92	150.2	1.260	108	M	67	66
5	12.26	44.45	156.8	1.408	127	B1	15	80
6	12.32	32.00	138.3	1.110	92	M	82	87
7	12.35	63.27	165.1	1.696	162	A4	2	66
8	12.41	52.59	154.5	1.496	143	A3	2	88
9	12.45	36.32	154.0	1.275	108	B3	82	91
10	12.46	53.93	161.2	1.561	147	A1	2	92
11	12.48	35.63	145.6	1.210	104	M	67	64
12	12.52	41.98	162.6	1.410	123	B3	67	65
13	12.52	30.84	139.5	1.210	89	M	82	78
14	12.58	44.00	157.6	1.406	127	B1	15	76
15	12.60	53.64	166.5	1.591	147	M	2	79
16	12.60	40.15	161.6	1.378	118	B3	67	96
17	12.69	49.74	168.6	1.556	140	B2	15	74
18	12.70	52.83	163.4	1.561	145	M	2	87
19	12.74	51.72	161.4	1.531	143	A1	2	72
20	12.83	56.45	161.4	1.588	151	A3	2	79
21	12.83	58.37	159.8	1.602	154	A4	2	79
22	12.84	46.00	156.7	1.439	131	M	15	65
23	12.84	42.57	157.0	1.386	123	B1	67	70
24	12.89	46.64	158.7	1.450	132	M	15	82
25	12.94	47.32	158.9	1.462	134	M	15	60
26	12.96	44.88	165.7	1.468	130	B3	15	77
27	13.06	35.55	154.0	1.260	105	B3	82	94
28	13.09	82.68	165.9	1.906	186	A7	2	70
29	13.16	45.23	157.5	1.423	129	M	67	80
30	13.29	44.86	157.1	1.417	128	B1	67	61
31	13.46	44.60	160.1	1.433	129	B1	67	76
32	13.50	42.09	151.4	1.341	121	A1	67	62
33	13.52	54.28	167.6	1.608	148	M	15	64
34	13.52	44.28	162.0	1.442	128	B2	67	72
35	13.57	68.28	174.3	1.826	171	A1	2	60
36	13.58	47.73	163.4	1.495	135	M	15	74
37	13.58	46.81	153.2	1.416	131	A1	67	71

TABLE I (continued)

Physical Data of Subjects

No.	Age	Weight Kg.	Height Cm.	Surface Area Sq.m.	Grid D.L.*	Channel	Auxedrome	Av. pulse rate/ min.
38	13.60	47.13	156.2	1.442	133	A1	67	67
39	13.60	43.00	161.6	1.416	125	B2	67	82
40	13.61	42.80	154.4	1.371	123	B1	82	64
41	13.67	47.82	165.4	1.511	136	B2	67	76
42	13.68	61.95	161.8	1.658	160	A4	2	72
43	13.70	41.66	161.1	1.397	122	B2	82	52
44	13.74	51.00	149.5	1.445	139	A4	67	78
45	13.85	58.46	161.8	1.618	154	A3	15	64
46	13.86	39.00	161.7	1.360	116	B4	82	72
47	13.86	55.64	164.8	1.604	150	A1	15	68
48	13.87	45.54	160.4	1.448	130	B1	67	88
49	13.88	47.18	155.2	1.434	133	M	15	75
50	13.90	43.84	163.6	1.443	127	B2	67	68
51	13.95	35.63	155.5	1.270	106	B3	82	71
52	13.96	42.41	163.6	1.420	124	B3	82	88
53	13.98	38.63	154.5	1.310	114	B2	82	78

* Developmental level

TABLE II-A

Actual Basal Metabolism of Girls Twelve Years Of Age Compared With Standard Prediction Values

No.	Date Mo. yr.	Av. oxygen consumed cc./min.	Cal./ 24 hrs.	Cals./ sq.m./hr.	Deviation from predictions expressed in per cent: Harris-Benedict	Dreyer	Mayo	Wetzel Grid
1	Dec.1947	185.9	1291	36.93	-4.65	-8.31	-16.60	-3.08
2	Mar.1948	205.0	1424	40.93	+7.23	+5.32	-7.56	+8.90
3	Jan.1948	215.4	1496	41.49	+9.20	+5.50	-6.30	+11.64
4	Jan.1948	171.5	1192	39.41	-2.93	-2.46	-11.00	-1.48
5	Jan.1948	212.5	1476	43.73	+12.50	+10.07	-1.24	+14.32
6	Dec.1947	169.6	1178	44.22	+1.64	-1.92	-0.14	+3.33
7	Feb.1948	225.6	1567	38.48	+3.91	-1.88	-13.10	+8.29
8	Nov.1948	204.0	1417	39.50	+2.31	-2.61	-10.79	+3.96
9	Apr.1948	157.8	1096	35.82	-10.82	-9.35	-19.11	-9.42
10	Feb.1948 Mar.1948	201.3	1398	37.35	-0.85	-5.02	-15.65	+1.52
11	Feb.1948	156.2	1085	37.41	-10.03	-9.36	-15.52	-8.82
12	Mar.1948	193.1	1342	39.67	+3.38	+3.38	-8.97	+5.25
13	Feb.1948	139.6	970	33.39	-15.63	-12.84	-23.37	-13.70
14	Jan.1948	189.8	1318	39.08	+0.76	-0.75	-10.32	+2.09
15	Apr.1948	185.7	1290	33.78	-8.96	-12.06	-22.49	-6.72
16	Dec.1947	190.4	1322	40.00	+3.44	+4.18	-8.22	+5.34
17	Dec.1947	196.0	1362	36.44	-1.52	-3.47	-16.39	+0.88
18	Nov.1948 Dec.1948	202.5	1407	37.58	+0.28	-3.23	-13.77	+2.55
19	Jan.1948	206.0	1431	38.92	+3.10	-0.42	-10.69	+4.98
20	Mar.1948 Apr.1948	221.2	1537	40.33	+7.18	+2.40	-7.46	+10.18
21	Apr.1948	233.7	1624	42.23	+12.15	+6.42	-3.10	+15.10
22	Nov.1948	177.0	1230	35.58	-7.09	-9.22	-18.35	-6.18
23	Apr.1948	207.8	1444	43.39	+11.76	+10.82	-0.44	+13.25
24	Mar.1948	188.0	1306	37.52	-2.10	-4.18	-13.91	-0.68
25	Apr.1948	173.4	1204	34.35	-10.22	-12.31	-21.17	-8.92
26	May 1948	189.6	1317	37.38	-0.98	-1.50	-14.22	+0.76
Average		192.2	1335	38.65	+0.12	-2.03	-11.92	+2.05

TABLE II-B

Actual Basal Metabolism of Girls Thirteen Years Of Age Compared With Standard Prediction Values

					Deviations from predictions expressed in per cent			
No.	Date Mo. yr.	Av. oxygen consumed cc./min.	Cals./ 24 hrs.	Cals./ sq.m./hr	Harris-Benedict	Dreyer	Mayo	Wetzel Grid
27	Oct. 1948	171.1	1188	39.31	-2.46	-	-8.36	-0.75
28	Apr. 1948 May 1948	234.5	1630	35.59	-3.66	-9.99	-17.04	+4.82
29	Feb. 1948	204.2	1418	41.57	+7.66	+5.90	-3.10	+8.90
30	Nov. 1948	184.8	1284	37.79	-2.13	-3.53	-11.91	-0.84
31	Oct. 1948	204.8	1423	41.35	+8.29	+7.40	-3.61	+9.29
32	Oct. 1948	210.2	1460	45.38	+14.60	+13.44	+7.79	+15.14
33	Jan. 1948	209.4	1454	37.70	+2.32	-0.55	-10.45	+5.36
34	Oct. 1948	194.4	1350	39.05	+2.66	+2.27	-7.24	+4.24
35	Nov. 1948	204.5	1421	32.42	-9.32	-13.30	-22.99	-4.63
36	Nov. 1948	180.3	1253	34.89	-7.18	-8.54	-17.12	-5.58
37	Feb. 1948	153.6	1067	31.42	-19.29	-21.31	-25.37	-18.61
38	Dec. 1948	193.8	1347	38.93	+1.21	-1.02	-7.53	+2.04
39	Nov. 1948	197.2	1370	40.31	+5.22	+5.38	-4.25	+6.70
40	Mar. 1948	176.0	1223	37.20	-4.90	-5.63	-11.63	-4.08
41	Jan. 1948	198.3	1378	37.98	+1.77	+0.58	-9.78	+3.45
42	Jan. 1948	213.9	1486	37.39	+0.27	-4.68	-11.19	+3.40
43	Apr. 1948	156.7	1088	32.50	-15.52	-14.79	-22.80	-14.46
44	Jan. 1948	184.0	1278	36.88	-5.68	-9.62	-12.40	-4.98
45	Dec. 1947	216.7	1506	38.77	+4.00	-0.33	-7.90	+6.73
46	Jan. 1948	190.1	1320	40.47	+4.60	+6.88	-3.87	+5.94
47	Nov. 1947	178.7	1242	31.59	-12.96	-15.73	-24.97	-10.84
48	Dec. 1947	202.6	1407	40.52	+6.43	+5.40	-3.75	+7.65
49	Nov. 1947	180.6	1255	36.56	-5.50	-7.58	-13.16	-4.92
50	Dec. 1947	174.8	1214	35.10	-7.46	-7.18	-16.63	-5.96
51	Nov. 1947	175.2	1217	39.96	-	+3.22	-5.08	+1.24
52	Nov. 1947	194.6	1352	39.70	+4.16	+5.13	- 5.70	+5.62
53	Nov. 1947	171.9	1194	37.99	-4.02	-2.77	-9.76	-3.32
Average		191.0	1326	37.72	-1.37	-2.63	-11.15	+0.43

TABLE III-A

Basal Energy Expenditure of Subjects

	Oxygen / minute (c.c.)				Calories / 24 hours			
No.	5%	All Av.	1st Test	1st A.M.	5%	All Av.	1st Test	1st A.M.
1	185.9	217.4	190.8	254.4	1291	1510	1326	1768
2	205.0	210.0	224.9	215.0	1424	1459	1562	1494
3	215.4	221.1	238.3	227.8	1496	1536	1656	1582
4	171.5	171.5	173.8	172.8	1192	1192	1208	1200
5	212.5	207.8	210.7	202.2	1476	1444	1464	1404
6	169.6	169.6	167.1	167.9	1178	1178	1160	1166
7	225.6	222.0	224.1	208.4	1567	1542	1556	1448
8	204.0	210.9	231.7	219.3	1417	1465	1610	1524
9	157.8	160.8	169.5	161.6	1096	1118	1178	1123
10	201.3	204.7	214.9	209.0	1398	1422	1493	1452
11	156.2	152.8	156.3	157.8	1085	1062	1086	1096
12	193.1	205.8	226.8	210.3	1342	1430	1576	1461
13	139.6	142.4	138.5	138.3	970	989	962	961
14	189.8	187.2	188.6	190.9	1318	1300	1310	1326
15	185.7	187.7	193.6	188.8	1290	1304	1345	1312
16	190.4	195.7	203.3	194.8	1322	1358	1412	1354
17	196.0	193.9	193.1	190.3	1362	1348	1342	1322
18	202.5	206.2	204.8	211.1	1407	1432	1422	1466
19	206.0	202.5	204.6	198.2	1431	1406	1421	1377
20	221.2	217.8	218.4	228.1	1537	1514	1518	1584
21	233.7	241.6	235.1	231.8	1624	1678	1634	1610
22	177.0	177.0	176.9	177.0	1230	1230	1229	1230
23	207.8	208.0	209.3	233.8	1444	1445	1454	1624
24	188.0	195.0	209.8	196.9	1306	1355	1458	1368
25	173.4	176.5	185.7	180.3	1204	1226	1290	1253
26	189.6	191.8	161.9	159.4	1317	1332	1125	1108
27	171.1	185.2	210.6	190.0	1188	1286	1463	1320
28	234.5	254.0	240.6	244.8	1630	1765	1672	1700
29	204.2	212.2	223.8	214.6	1418	1474	1554	1491
30	184.8	188.6	200.0	194.2	1284	1310	1390	1349
31	204.8	201.8	207.6	205.3	1423	1402	1442	1426
32	210.2	217.8	221.8	216.7	1460	1514	1540	1506
33	209.4	209.4	214.7	212.4	1454	1454	1492	1476
34	194.4	194.0	183.2	186.5	1350	1348	1272	1296

TABLE III-A (continued)

Basal Energy Expenditure of Subjects

	Oxygen / minute (c.c.)				Calories / 24 hours			
No.	5%	All Av.	1st Test	1st A.M.	5%	All Av.	1st Test	1st A.M.
35	204.5	214.0	230.7	217.8	1421	1487	1602	1514
36	180.3	180.3	179.5	178.7	1253	1253	1248	1242
37	153.6	155.6	161.4	157.9	1067	1081	1122	1097
38	193.8	198.0	187.5	188.5	1347	1376	1302	1310
39	197.2	199.3	194.3	197.6	1370	1385	1350	1373
40	176.0	176.0	178.7	176.3	1223	1223	1242	1225
41	198.3	232.2	334.0	264.6	1378	1613	2320	1838
42	213.9	207.8	218.2	214.2	1486	1444	1516	1488
43	156.7	153.6	156.1	156.6	1088	1067	1084	1088
44	184.0	179.1	185.4	184.0	1278	1244	1288	1278
45	216.7	211.5	172.5	195.7	1506	1470	1198	1360
46	190.1	187.0	192.3	185.1	1320	1299	1336	1286
47	178.7	187.7	202.8	188.6	1242	1304	1408	1310
48	202.6	209.8	203.0	202.2	1407	1458	1410	1404
49	180.6	182.4	175.1	175.6	1255	1268	1216	1220
50	174.8	178.0	187.3	180.0	1214	1237	1301	1251
51	175.2	182.4	174.3	176.4	1217	1267	1211	1226
52	194.6	197.6	206.8	199.1	1352	1373	1436	1384
53	171.9	167.8	155.6	163.8	1194	1166	1081	1138

TABLE III-B

Basal Energy Expenditure of Subjects

	Calories / hour				Calories / square meter / hour			
No.	5%	All Av.	1st Test	1st A.M.	5%	All Av.	1st Test	1st A.M.
1	53.78	62.92	55.24	73.62	36.93	43.21	37.93	50.56
2	59.30	60.80	65.07	62.20	40.93	41.96	44.90	42.92
3	62.32	64.03	68.99	65.94	41.49	42.63	45.93	43.90
4	49.65	49.65	50.34	50.04	39.41	39.41	39.95	39.71
5	61.55	60.14	61.01	58.56	43.73	42.73	43.34	41.60
6	49.08	49.08	48.33	48.57	44.22	44.22	43.54	43.75
7	65.28	64.30	64.83	60.32	38.48	37.90	38.22	35.55
8	59.10	61.07	67.11	63.49	39.50	40.82	44.85	42.43
9	45.66	46.54	49.05	46.78	35.82	36.51	38.47	36.68
10	58.29	59.24	62.18	60.50	37.35	37.95	39.84	38.77
11	45.26	44.24	45.29	45.66	37.41	36.56	37.43	37.74
12	55.93	59.54	65.64	60.89	39.67	42.23	46.56	43.18
13	40.41	41.22	40.10	40.05	33.39	34.06	33.13	33.10
14	54.94	54.16	54.58	55.27	39.08	38.53	38.83	39.31
15	53.74	54.31	56.08	54.64	33.78	34.14	35.25	34.34
16	55.12	56.64	58.89	56.44	40.00	41.10	42.74	40.96
17	56.70	56.17	55.93	55.09	36.44	36.10	35.94	35.41
18	58.65	59.66	59.26	61.13	37.58	38.21	37.96	39.15
19	59.60	58.65	59.22	57.36	38.92	38.31	38.68	37.47
20	64.06	63.04	63.22	66.03	40.33	39.69	39.80	41.58
21	67.64	69.98	68.03	67.14	42.23	43.70	42.47	41.92
22	51.20	51.20	51.18	51.20	35.58	35.58	35.57	35.58
23	60.14	60.20	60.59	67.66	43.39	43.43	43.71	48.81
24	54.40	56.50	60.74	56.97	37.52	38.95	41.89	39.28
25	50.22	51.10	53.74	52.19	34.35	34.94	36.76	35.69
26	54.88	55.54	46.87	46.12	37.38	37.83	31.93	31.42
27	49.53	53.64	60.98	55.00	39.31	42.57	48.40	43.65
28	67.85	73.50	69.68	70.84	35.59	38.57	36.56	37.16
29	59.14	61.46	64.76	62.12	41.57	43.19	45.51	43.65
30	53.54	54.58	57.90	56.26	37.79	38.52	40.87	39.71
31	59.26	58.44	60.08	59.39	41.35	40.79	41.94	41.46
32	60.86	63.04	64.24	62.71	45.38	47.01	47.90	46.77

TABLE III-B (continued)

Basal Energy Expenditure of Subjects

	Calories / hour				Calories / square meter / hour			
No.	5%	All Av.	1st Test	1st A.M.	5%	All Av.	1st Test	1st A.M.
33	60.62	60.62	62.14	61.52	37.70	37.70	38.66	38.26
34	56.32	56.20	53.06	53.95	39.05	38.96	36.80	37.41
35	59.20	62.00	66.81	63.04	32.42	33.95	36.59	34.52
36	52.19	52.19	51.95	51.71	34.89	34.89	34.74	34.58
37	44.48	45.08	46.72	45.68	31.42	31.84	33.00	32.27
38	56.14	57.30	54.25	54.55	38.93	39.74	37.61	37.83
39	57.06	57.69	56.29	57.18	40.31	40.75	39.76	40.38
40	51.00	51.00	51.71	51.06	37.20	37.20	37.72	37.25
41	57.39	67.26	96.68	76.58	37.98	44.51	63.97	50.69
42	61.99	60.14	63.16	62.04	37.39	36.27	38.09	37.42
43	45.41	44.48	45.23	45.38	32.50	31.84	32.37	32.48
44	53.30	51.83	53.68	53.30	36.88	35.87	37.15	36.88
45	62.71	61.25	49.95	56.64	38.77	37.87	30.87	35.01
46	55.03	54.10	55.69	53.62	40.47	39.78	40.96	39.44
47	51.71	54.31	58.74	54.58	31.59	33.94	36.71	34.11
48	58.68	60.74	58.80	58.56	40.52	41.95	40.61	40.43
49	52.28	52.82	50.73	50.88	36.56	36.93	35.46	35.57
50	50.64	51.50	54.19	52.10	35.10	35.69	37.55	36.10
51	50.76	52.82	50.49	51.08	39.96	41.59	39.76	40.23
52	56.38	57.18	59.84	57.63	39.70	40.26	42.14	40.58
53	49.77	48.54	45.08	47.44	37.99	37.05	34.42	36.21

TABLE IV

Mean Calories According to Age

Age	No. Cases	Oxygen consumed cc./min.	Cals./ 24 hrs.	5% Check	All Av.	No.	First Test	No.	First A.M.
12*	26	192.2	1335	38.65	39.26	26	39.83	26	39.64
13*	27	191.0	1326	37.72	38.49	27	39.48	27	38.52
14**	23	194.2	1349	36.22	36.80	22	37.26	22	36.63
15**	23	188.2	1307	34.37	34.71	21	36.16	22	34.70
16**	24	183.7	1276	33.12	33.20	24	33.51	24	32.94
17**	25	184.6	1282	32.12	32.29	21	34.33	24	33.33
18**	36	171.3	1190	31.21	31.58	34	32.43	36	31.73

* Data of present investigator

** Data of Ridgway

TABLE V-A

Mean Deviation from Standards

Age Yrs.	With regard to sign: Mayo	Harris-Benedict	Dreyer	Without regard to sign: Mayo	Harris-Benedict	Dreyer
12*	-11.92	+0.12	-2.03	11.92	5.95	5.73
13*	-11.15	-1.37	-2.63	11.75	6.05	7.01
14**	-11.89	-3.50	-5.76	12.70	7.50	5.38
15**	-13.64	-7.22	-8.57	13.64	8.04	9.03
16**	-13.96	-9.72	-10.81	13.96	10.08	11.25
17**	-12.68	-9.81	-10.70	13.93	11.67	12.56
18**	-14.93	-14.29	-14.57	14.93	14.29	14.57

TABLE V-B

Percentage Range of Deviation from Standards

Age	Mayo	Harris-Benedict	Dreyer
12*	-23.37 to -0.14	-15.63 to +12.50	-12.84 to +10.82
13*	-25.37 to +7.79	-19.29 to +14.60	-21.31 to +13.44
14**	-20.93 to +7.62	-13.86 to +21.22	-17.54 to +16.57
15**	-25.93 to +0.01	-22.19 to + 7.44	-24.29 to +5.21
16**	-22.62 to +0.01	-18.00 to + 4.17	-19.14 to +5.37
17**	-26.44 to +12.51	-23.92 to +18.55	-25.67 to +18.39
18**	-21.72 to -5.97	-22.96 to -4.82	-22.32 to -5.30

* Data of present investigator

** Data of Ridgway

TABLE VI

Distribution of Cases With Respect
To Agreement With Three Predictions *

Deviation %	Mayo Foundation Cases	%	Harris-Benedict Cases	%	Dreyer Cases	%
			Age 12			
0-3	3	11.5	10	38.4	8	30.8
0-5	4	15.4	15	57.6	13	50.0
0-7	5	19.2	15	57.6	17	65.4
0-10	9	34.6	20	76.9	22	84.6
0-15	17	65.4	25	96.2	26	100.0
0-20	23	88.4	26	100.0	26	100.0
0-25	26	100.0	26	100.0	26	100.0
0-30	26	100.0	26	100.0	26	100.0
			Age 13			
0-3	0	0.0	8	29.6	7	25.9
0-5	5	18.5	14	51.8	10	37.0
0-7	7	25.9	18	66.6	16	59.2
0-10	14	51.8	23	85.2	22	81.4
0-15	20	74.0	25	92.6	25	92.6
0-20	23	85.2	27	100.0	26	96.3
0-25	26	96.3	27	100.0	27	100.0
0-30	27	100.0	27	100.0	27	100.0

* Without regard to sign

Table I, pages 9 and 10, gives grid data concerning developmental level, channel, and auxodrome for the subjects in this study. Tables II-A and II-B, pages 11 and 12, give the per cent deviation of actual metabolism from the grid. Table VII, page 21, gives the distribution of cases of the two studies together in per cent above and below grid calories.

Figure I, page 22, a scatter diagram of the combined cases, shows wide overlapping of developmental levels and age from twelve through eighteen years. Appendix D shows the grid as used for each subject.

The snapshots of the subjects illustrate the type of physique found in each channel. The developmental levels ranged from 89 to 186 and the channels A7 to B4. Plates I-A and I-B illustrate channels A4, A1, M, B1, B2 and B3 when subjects are arranged in order of increasing developmental level but not necessarily increasing height. Plates II-A, II-B and II-C illustrate channels with the subjects in Plate I-A and I-B rearranged in order of increasing height but not necessarily increasing developmental level. Plate III illustrates subjects of the same developmental level in channels A4, A2, A1, M, B1, and B2. Plate IV illustrates subject in channel A7.

TABLE VII

Cases in Per Cent Above and Below Grid Calories

5% Check

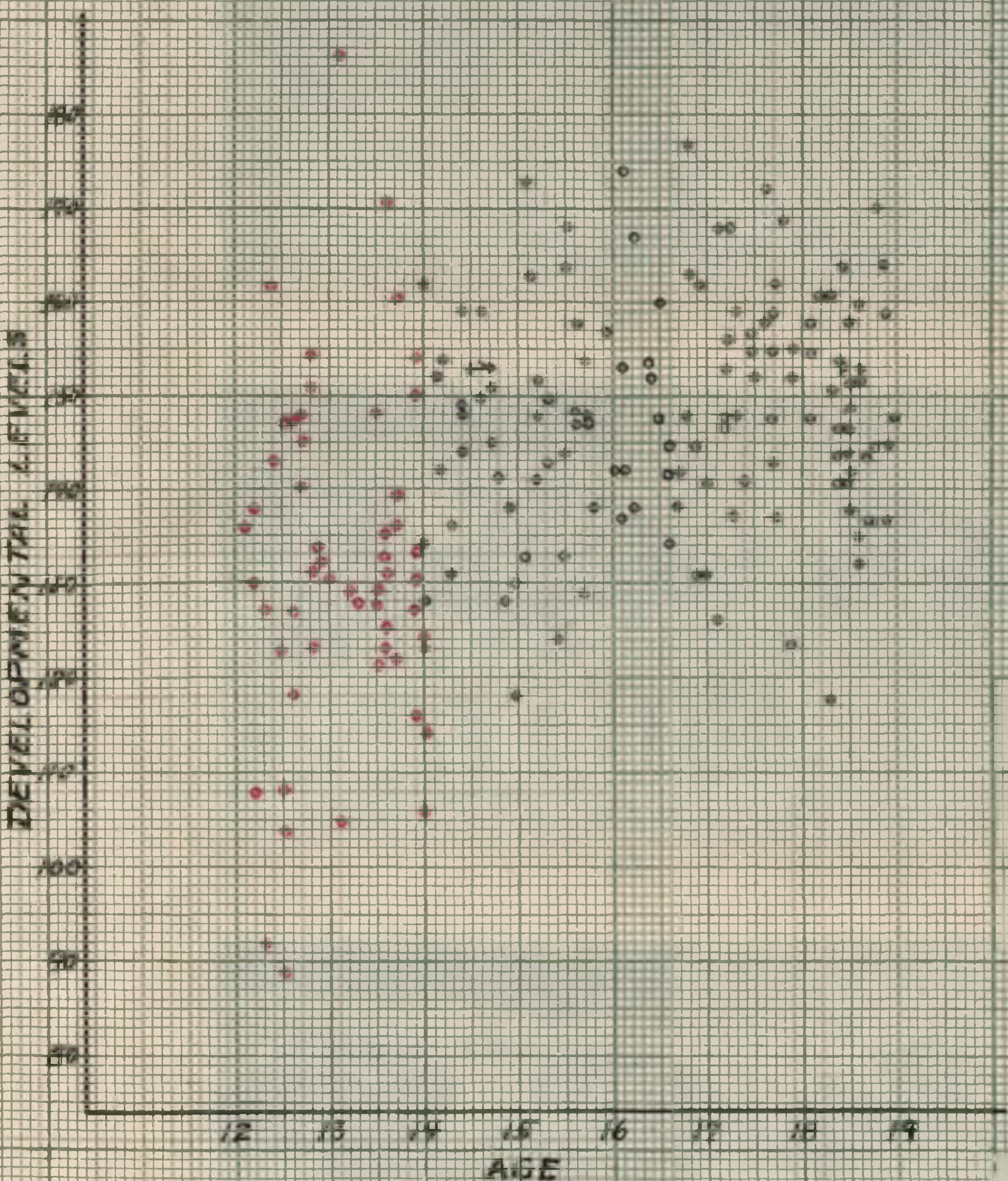
Age Yrs	Total Cases	+5%	-5%	+7%	-7%	+10%	-10%	+12%	-12%	+15%	-15%
12*	26	34.6	23.0	26.9	15.4	19.2	3.8	11.5	3.8	3.8	0.0
13*	27	33.3	18.5	14.8	11.1	7.4	11.1	3.7	7.4	3.7	3.7
14**	23	21.7	39.1	17.4	39.1	13.0	21.7	8.7	8.7	4.3	0.0
15**	23	8.7	52.2	4.3	39.1	0.0	30.4	0.0	13.0	0.0	4.3
16**	24	0.0	75.0	0.0	54.2	0.0	41.7	0.0	29.2	0.0	8.3
17**	25	4.0	64.0	4.0	60.0	4.0	60.0	4.0	48.0	4.0	36.0
Total	148	11.4	41.8	8.8	33.8	6.8	25.6	4.0	16.8	2.0	8.1

All Averaged

Age Yrs	Total Cases	+5%	-5%	+7%	-7%	+10%	-10%	+12%	-12%	+15%	-15%
12*	26	42.3	23.0	38.4	15.4	26.9	7.6	19.2	3.8	3.8	0.0
13*	27	40.7	22.2	33.3	11.1	18.5	7.4	14.8	7.4	7.4	7.4
14**	23	21.7	30.4	21.7	17.4	17.4	4.3	13.0	0.0	4.3	0.0
15**	23	13.0	38.5	4.3	30.4	4.3	21.7	0.0	13.0	0.0	0.0
16**	24	0.0	70.8	0.0	58.3	0.0	45.8	0.0	29.2	0.0	8.3
17**	25	0.0	76.0	0.0	80.0	0.0	52.0	0.0	48.0	0.0	32.0
Total	148	12.8	41.2	10.8	29.0	6.8	21.6	4.7	16.2	2.0	8.1

* Data of the present investigator

** Data of Ridgway



SCATTER DIAGRAM OF DEVELOPMENTAL LEVELS

o PRESENT INVESTIGATOR

o THOMPSON, COX AND RIDGWAY

FIGURE I

A4

A1

M

PLATE I-A. Channels with increasing developmental level

B1

B2

B3

PLATE I-B. Channels with increasing developmental level

A4

A3

A2

PLATE II-A. Channels with increasing height

A1

M

PLATE II-B. Channels with increasing height

B1

B2

B3

PLATE II-C. Channels with increasing height

PLATE III. Channels A4, A2, A1, M, B1, B2, with same developmental level

A7

PLATE IV. Channel A7, side view

DISCUSSION

It has been demonstrated in Table IV, which shows the combined data of Ridgway and of the present writer, that the means of calories per square meter per hour of the 12 and 13 year old subjects in each case are larger than those of the older subjects. Calories then drop sharply with age with the significantly high coefficient of correlation of $- .997 \pm .0003$ for the method of the 5 per cent check and $- .991 \pm .0008$ for that of averaging all t ests. It should be noted in the present study that data derived by all four methods show a decrease from 12 to 13 years of age. Data of Ridgway, however, show diminishing values foreach year in only the first two methods; the last two showing a marked increase at the seventeenth year.

It should be kept in mind that unusually high and low values which may be obtained by first tests, or even by first mornings, are minimized when a large number of cases are averaged to obtain a representative sampling of a population. For the individual case, on the contrary, failure to find a constant value on successive mornings results in reporting too high a value for the majority of c ases. The writer therefore recommends the use of the five per cent agreement both for group studies and for determining the true basal metabolism of an individual.

The use of a preliminary training period is suggested by Shock (1942) and Young et al. (1941). However, when the 5% check is obtained the writer is of the opinion that the preliminary training period is unnecessary. This has been confirmed by Lewis and coworkers (1943) and by Ridgway.

Yearly mean deviations with regard to sign from the Mayo Foundation standard, Table V-A, are all large and of the same order of magnitude. However there is close agreement between the Harris-Benedict and Dreyer standards and the actual metabolism at 12 and 13 years but as age increases minus deviations become large. This is in agreement with Nalbandov et al. (1938) who, working with Oklahoma children, found that deviations from these two standards were small when they were young but increased as maturity was reached.

All cases in this study, Table VI, were within ± 20% deviation from the Harris-Benedict standard; all in the 12 year group within ± 15% and all in the 13 year group within ± 25% deviation from Dreyer; all in the 12 year group within ± 25% and all in the 13 year group within ± 30% deviation from Mayo Foundation.

Stark (1935) has recommended the Harris-Benedict standard extrapolated in a straight line for use in preadult years. Wang, Kaucher, and Wing (1936) listed in order of preference firstly, the Harris-Benedict and secondly, the Dreyer standards for postpubescent girls. They reversed the order for their prepubescent subjects.

Jenkins (1931) has recommended that control groups be set up according to geographical location for reference to existing standards. Thus characteristic mean deviations of various age groups from these prediction values could be considered in interpreting basal metabolism. A standard should require minimal calculation and yet predict accurately. He suggests that established standards be recommended in preference to the derivation of new ones.

In view of these suggestions and the findings of the present study the writer recommends, that for standards based upon the age classification, the Harris-Benedict or Dreyer standards be used for girls 12 and 13 years of age in this region. This is in agreement with the recommendations of Ridgway for the older group. Unless calculation tables such as those of Carpenter (1939) are available for use with the Harris-Benedict standard, Dreyer would be preferred by many because of its greater simplicity.

Table VIII, page 34, shows studies reported in the literature for similar ages on the basis of calories per square meter per hour. Boothby, Berkson and Dunn (1936) reported highest calories for both the twelfth and thirteenth years. Blunt, Tilt, McLaughlin and Gunn (1926) report results in close agreement with those of MacLeod (1924). Data of Lewis, Duval and Iliff (1943) at Denver are in close agreement with the present study. It follows that in view of this similarity in metabolic rate in two such different geographical regions the warm climate of southern Arizona would seem to have no effect on the ages included in the present study.

Inherent in the grid is a straight line relation between basal metabolism and physical development without regard to age. This has been demonstrated in Table IX, page 35, with actual calories and actual developmental levels with the greatest increase occurring at class interval 120 to 129. Mean deviations from grid calories for each interval fall within + 1.6 and - 7.7%, the smallest occurring at interval 120 to 129. As shown in Tables VI and VII percentages of cases in the 12th and 13th year whose basal metabolism fell within ± 10% and ± 15% deviations from Wetzel's standard were about the same as those of Harris-Benedict and Dreyer. This would seem to indicate that contrary to that claimed by Wetzel a standard based upon age can predict for these subjects as closely as one based upon developmental levels regardless of age. In addition to age, however, the Harris-Benedict standard takes into consideration both weight and height as such and the Dreyer weight only.

TABLE VIII

Comparison of This Study with Other Work

Investigator	Institution	Year	Method of Selection of Data	Age 12 No.	Age 12 Cals./sq.m/hr	Age 13 No.	Age 13 Cals./sq.m/hr
Present Study	Univ. of Arizona	1949	5% check	26	38.6	27	37.7
Boothby, Berkson and Dunn	Mayo Clinic	1936	First test only	27	43.9	17	42.5
Blunt, Tilt, McLaughlin and Gunn	Univ. of Chicago	1926	Av. of values within 5%	18	42.3	15	41.0
Lewis, Duval and Iliff	Univ. of Colorado	1943	First satisfactory test		39.1		37.6
MacLeod	Columbia Univ.	1924		18	41.3	22	41.0
Shock	Univ. of California	1942	Av. of 6 tests on 2 successive mornings		40.4		38.8
Wang, Kaucher and Wing	Univ. of Cincinnati	1936	Av. of 2 lowest tests within 4% on 2 successive days	8	40.1	7	40.0

TABLE IX

Comparison of Actual and Grid Calories

Grid					Indirect Calorimetry							
					5% check				All averaged			
Cases	Intervals of Dev. Level *	Cals. M.*	S.D.*	C.V.*	Cals. M.	Dev. from Grid %	S.D.	C.V.	Cals. M.	Dev. from Grid %	S.D.	C.V.
5	100-109	1202			1156	-3.8			1185	-1.4		
5	110-119	1249			1194	-4.4			1201	-3.8		
21	120-129	1286	11.3±1.7	0.8	1287	+0.1	124.0±18.3	9.6	1307	+1.6	123.8±18.2	9.4
35	130-139	1325	12.8±1.5	1.0	1251	-5.6	105.4±12.0	8.4	1278	-3.5	127.1±14.5	9.9
50	140-149	1372	11.4±1.1	0.8	1267	-7.7	125.8±12.0	9.9	1272	-7.3	108.6±10.4	8.5
42	150-159	1412	12.4±1.3	0.8	1329	-5.9	150.9±15.7	11.4	1339	-5.2	148.1±15.4	11.1
17	160-169	1452	14.0±2.3	1.0	1348	-7.2	118.8±19.4	8.8	1367	-5.8	149.1±24.4	10.9
6	170-179	1495			1391	-7.0			1460	-2.3		

* D.L. Developmental level
M. Mean
S.D. Standard deviation of the mean
C.V. Coefficient of variation

Combined data of present investigator and that of Thompson, Cox and Ridgway (1948)

Table VII, giving the distribution of cases in the combined studies reported from this laboratory in per cent above and below grid calories, demonstrates increasing number of cases having increasing minus deviations up to the 18th year.

When types of body build of 61 cases in the present study were evaluated by the grid, channel distribution showed a positive skew as follows:

A7	A4	A3	A2	A1	M	B1	B2	B3	B4
1	4	3	2	9	16	8	10	7	1

For illustrations of these cases by channels the reader is referred to Plates I to IV, inclusive, pages 23 to 29.

When classified as to auxodrome, 14 of the cases were in the 2%, 18 in the 15%, 19 in the 67%, 10 in the 82% and none in the 98% auxodrome. Considerably more than 67%, e.i. 84%, were in the 2 to 67% auxodrome. Again, when the developmental level attained at the end of the study was compared with the highest level to be reached at cessation of growth in each case as indicated by the auxodrome in question, 82% of the subjects had already made 90% or more of the predicted increase (36% of the cases 95 to 100% or more; 46%, 90 to 94%). Twelve per cent had made 85 to 89% and 6%, 80 to 84% of the predicted increase. Average advance per month by levels was 0.7 for those cases which had reached 95 to 100% of the expected growth, 0.9 for 90 to 94%, 1.0 for 85 to 89% and 1.1 for 80 to 84%.

It is of interest to note that Cases No. 34 and No.39 were identical twins. They had developmental levels of 114 and 112, respectively, at the beginning of the study and 130 and 128, respectively, at the end. Each twin, advancing 16 developmental levels in 15 months, averaged 1.1 per month. Both followed channel B2 and the 67% auxodrome throughout the experimental period. Furthermore it was found from their school measurements for ages 6 to 12 years that this identical growth pattern had also been followed during the earlier period. Minor shifts out of channel occurred at the same time in each case.

From the above discussion it is obvious that the group of subjects as a whole is physically more advanced than that which is representative of a whole population as judged by Wetzel. This may be due to the fact that all subjects in the present study were from one school district with middle class homes offering an environment favorable for optimal development. It is likely that these results would be modified were a cross section obtained of the city of Tucson. There would probably be more cases in the retarded auxodromes with a later age at attainment of puberty and lower levels to be reached at maturity with possibly a lower basal metabolism.

When the average basal metabolism of the prepubescent subjects was compared with that of the postpubescent a significant drop was observed in calories per square meter per hour: 39.7 to 35.0. Twelve to six months before puberty the average was 39.2 calories and six to one month, 40.0. One to six months after puberty the average was 38.3; six to twelve months, 36.6; twelve to eighteen months, 36.6; eighteen to thirty-two months, 36.6. When the cases were arranged in this relation to puberty no trend in increasing age was observed.

Topper and Mulier (1932) reported that the increase in basal metabolism during pubescence occurred at different times in individual cases and is more closely coincident with the physiological rather than the chronological age. They report that in those children in whom there is an early basal metabolism increase puberty begins earlier. Talbot (1925) is also of the opinion that there is a closer relation of physiological rather than of chronological age to basal metabolism at puberty. MacLeod (1924) and Talbot, Wilson and Worcester (1937) did not always find a prepubescent rise in metabolism. Wang, Kaucher and Wing (1936) found an average of 40.2 calories per square meter per hour for 18 prepubescent girls and 37.0 for 16 postpubescent girls.

When 48 of the cases were classified according to auxodromes, it was observed that the mean ages of each group at which time the menarche occurred increased with increasing auxodromes as shown in Table X. Eighty per cent of the cases rather than 67% were in the 2 to 67% auxodrome.

Table X

Date of Onset of Puberty

Auxodrome	Mean Age	Cases	Per cent
2%	11.9	7	15
15%	12.3	12	25
67%	12.8	19	40
82%	13.8	10	21

Four subjects in the 67% auxodrome and 3 in the 82% which had not reached puberty were included in these averages by giving the ages as of the date of the termination of the experimental period. Thus the years 12.8 and 13.8, for the 67% and 82% auxodromes, respectively, would be somewhat increased were the exact dates obtainable.

Since the present study was done in Tucson which has an altitude of 2400 feet the question arises as to the effect of altitude on basal metabolism. The reader is therefore referred to the observations on this subject by Thompson, Cox and Ridgway (1948) and Ridgway (1947).

SUMMARY

The basal metabolism of fifty-three southern Arizona girls twelve and thirteen years of age has been determined and discussed on the basis of calories per square meter per hour and total calories per twenty-four hours.

Calories dropped from 38.7 to 37.7 at twelve and thirteen years of age, respectively. When combined with the yearly mean calories of Ridgway as reported from this laboratory for the years 14 to 18, a highly significant negative coefficient of correlation with age was found.

When the cases in the present study were classified into groups according to months before and after puberty, a rise in metabolic rate was observed before puberty and a fall thereafter. In this distribution no correlation with age was found. This increase in metabolic rate appeared therefore to coincide with physiological rather than chronological age.

In comparing these results on 12 and 13 year old subjects with studies reported in the northern states on similar subjects no lowering effect was observed due to the subtropical climate.

Of the standards based upon classification of subjects by age the Harris-Benedict and Dreyer predicted more accurately than did the Mayo Foundation. Yearly mean predictions by these two standards for the 12th and 13th years were in agreement with that determined but minus deviations for all standards became increasingly large by the 18th year.

Fifteen monthly measurements of heights and weights were taken and the subjects classified, together with those of Ridgway, into class intervals of developmental levels. An increase in metabolic rate with increasing developmental level was observed with the greatest increase occurring at interval 120-129.

The percentages of cases whose actual basal metabolism fell within ± 10% and ± 15% deviations from the Wetzel standard based on developmental level were no larger than those from the Harris-Benedict and Dreyer. The conclusion is therefore made that a standard based upon the comparatively new concept of developmental levels regardless of age may predict no more accurately than those based upon age but which take weight and height as such into consideration in one instance and weight only in the other.

When comparing growth in relation to age of these subjects of the southwest with that found by Wetzel in his control group, which lived in northern midwestern states, it was observed that growth in the former was noticeably advanced. However selection of subjects in the present study was of necessity limited to only one district of the city of Tucson which was of good socioeconomic status. The present investigator suggests that for critical comparison selection of subjects, although continuing to be limited to those of the white race, be made more representative by obtaining an adequate cross section of the population.

APPENDIX A

Information for the Subject

1. Eat a light dinner the evening before the test and take no other food until after the test.

2. Retire early, not later than 10:00 P.M.

3. The morning of your test dress leisurely. Come with the least activity possible to the door facing Herring Hall, the south wing of the Agricultural Building. Someone will be there to take you to the laboratory by elevator.

4. The operator will request you to remove your shoes and loosen any tight clothing before you lie down.

5. You will be given one-half hour's rest before the test is started. Remain quiet and relaxed during this time.

6. Avoid unusually strenuous exercise the preceding day.

7. If you contract a cold, or for any reason are unable to keep your appointment, please call 3030 extension 255.

APPENDIX B

Interpolation of Table 43, Carpenter (1) (1939) from 20.0°C. to 28.0°C. and 690 to 700 mm. Barometric Pressure

Factors for reduction of saturated volumes to 0°C. dry and 760 mm. pressure

	Barometric Pressure (mm.)									
Temp. °C	690	691	692	693	694	695	696	697	698	699
20.0	.8240	.8252	.8264	.8276	.8288	.8300	.8314	.8328	.8342	.8356
20.1	.8236	.8248	.8260	.8272	.8284	.8296	.8310	.8324	.8337	.8351
20.2	.8232	.8244	.8256	.8268	.8280	.8292	.8306	.8319	.8333	.8346
20.3	.8228	.8240	.8252	.8264	.8276	.8288	.8301	.8315	.8328	.8342
20.4	.8224	.8236	.8248	.8260	.8272	.8284	.8297	.8310	.8324	.8337
20.5	.8220	.8232	.8244	.8256	.8268	.8280	.8293	.8306	.8319	.8332
20.6	.8216	.8228	.8240	.8252	.8264	.8276	.8289	.8302	.8314	.8327
20.7	.8212	.8224	.8236	.8248	.8260	.8272	.8285	.8279	.8310	.8322
20.8	.8208	.8220	.8232	.8244	.8256	.8268	.8280	.8293	.8305	.8318
20.9	.8204	.8216	.8228	.8240	.8252	.8264	.8276	.8288	.8301	.8313
21.0	.8200	.8212	.8224	.8236	.8248	.8260	.8272	.8284	.8296	.8308
21.1	.8196	.8208	.8220	.8232	.8244	.8256	.8268	.8280	.8292	.8304
21.2	.8192	.8204	.8216	.8228	.8240	.8252	.8264	.8276	.8288	.8300
21.3	.8188	.8200	.8212	.8224	.8236	.8248	.8260	.8272	.8284	.8296
21.4	.8184	.8196	.8208	.8280	.8232	.8244	.8256	.8268	.8280	.8292
21.5	.8180	.8192	.8204	.8216	.8228	.8240	.8252	.8264	.8276	.8288
21.6	.8176	.8188	.8200	.8212	.8224	.8236	.8248	.8260	.8272	.8284
21.7	.8172	.8184	.8196	.8208	.8220	.8232	.8244	.8256	.8268	.8280
21.8	.8168	.8180	.8192	.8204	.8216	.8228	.8240	.8252	.8264	.8276
21.9	.8164	.8176	.8188	.8200	.8212	.8224	.8236	.8248	.8260	.8272

APPENDIX B (continued)

Interpolation of Table 43, Carpenter (1) (1939) from 20.0°C.

to 28.0°C. and 690 to 700 mm. Barometric Pressure

Factors for reduction of saturated volumes to 0°C. dry and 760 mm. pressure

	Barometric Pressure (mm.)									
Temp. C	690	691	692	693	694	695	696	697	698	699
22.0	.8160	.8172	.8184	.8196	.8208	.8220	.8232	.8244	.8256	.8268
22.1	.8156	.8168	.8180	.8192	.8204	.8216	.8228	.8240	.8252	.8264
22.2	.8152	.8164	.8176	.8188	.8200	.8212	.8224	.8236	.8248	.8260
22.3	.8148	.8160	.8172	.8184	.8196	.8208	.8220	.8232	.8244	.8256
22.4	.8144	.8156	.8168	.8180	.8192	.8204	.8216	.8228	.8240	.8252
22.5	.8140	.8152	.8164	.8176	.8188	.8200	.8212	.8224	.8236	.8248
22.6	.8136	.8148	.8160	.8172	.8184	.8196	.8208	.8220	.8232	.8244
22.7	.8132	.8144	.8156	.8168	.8180	.8192	.8204	.8216	.8228	.8240
22.8	.8128	.8140	.8152	.8164	.8176	.8188	.8200	.8212	.8224	.8236
22.9	.8124	.8136	.8148	.8160	.8172	.8184	.8196	.8208	.8220	.8232
23.0	.8120	.8132	.8144	.8156	.8168	.8180	.8192	.8204	.8216	.8228
23.1	.8115	.8127	.8139	.8151	.8163	.8175	.8187	.8199	.8211	.8223
23.2	.8110	.8122	.8134	.8146	.8158	.8170	.8182	.8194	.8206	.8218
23.3	.8105	.8117	.8129	.8141	.8153	.8165	.8177	.8189	.8201	.8213
23.4	.8100	.8112	.8124	.8136	.8148	.8160	.8172	.8184	.8196	.8208
23.5	.8095	.8107	.8119	.8131	.8143	.8155	.8167	.8179	.8191	.8203
23.6	.8090	.8102	.8114	.8126	.8138	.8150	.8162	.8174	.8188	.8198
23.7	.8085	.8097	.8109	.8121	.8133	.8145	.8157	.8169	.8181	.8193
23.8	.8080	.8092	.8104	.8116	.8128	.8140	.8152	.8164	.8176	.8188
23.9	.8075	.8087	.8099	.8111	.8123	.8135	.8147	.8159	.8171	.8183

APPENDIX B (continued)

Interpolation of Table 43, Carpenter (1) (1939) from 20.0°C. to 28.0°C. and 690 to 700 mm. Barometric Pressure

Factors for reduction of saturated volumes to 0°C. dry and 760 mm. pressure

	Barometric Pressure (mm.)									
Temp. C	690	691	692	693	694	695	696	697	698	699
24.0	.8070	.8082	.8094	.8106	.8118	.8130	.8142	.8154	.8166	.8178
24.1	.8066	.8078	.8090	.8102	.8114	.8126	.8138	.8150	.8162	.8174
24.2	.8062	.8074	.8086	.8098	.8110	.8122	.8134	.8146	.8158	.8170
24.3	.8058	.8070	.8082	.8094	.8106	.8118	.8130	.8142	.8154	.8166
24.4	.8054	.8066	.8078	.8090	.8102	.8114	.8126	.8138	.8150	.8162
24.5	.8050	.8062	.8074	.8086	.8098	.8110	.8122	.8134	.8146	.8158
24.6	.8046	.8058	.8070	.8082	.8094	.8106	.8118	.8130	.8142	.8154
24.7	.8042	.8054	.8066	.8078	.8090	.8102	.8114	.8126	.8138	.8150
24.8	.8038	.8050	.8062	.8074	.8086	.8098	.8110	.8122	.8134	.8146
24.9	.8034	.8046	.8058	.8070	.8082	.8094	.8106	.8118	.8130	.8142
25.0	.8030	.8042	.8054	.8066	.8078	.8090	.8102	.8114	.8126	.8138
25.1	.8026	.8038	.8050	.8062	.8074	.8086	.8098	.8110	.8122	.8134
25.2	.8022	.8034	.8046	.8058	.8070	.8082	.8094	.8106	.8118	.8130
25.3	.8018	.8030	.8042	.8054	.8066	.8078	.8090	.8102	.8114	.8126
25.4	.8014	.8026	.8038	.8050	.8062	.8074	.8086	.8098	.8110	.8122
25.5	.8010	.8022	.8034	.8046	.8058	.8070	.8082	.8094	.8106	.8118
25.6	.8006	.8018	.8030	.8042	.8054	.8066	.8078	.8090	.8102	.8114
25.7	.8002	.8014	.8026	.8038	.8050	.8062	.8074	.8086	.8098	.8110
25.8	.7998	.8010	.8022	.8034	.8046	.8058	.8070	.8082	.8094	.8106
25.9	.7994	.8006	.8018	.8030	.8042	.8054	.8066	.8078	.8090	.8102

APPENDIX B (continued)

Interpolation of Table 43, Carpenter (1) (1939) from 20.0°C. to 28.0°C. and 690 to 700 mm. Barometric Pressure

Factors for reduction of saturated volumes to 0°C. dry and 760 mm. pressure

	Barometric pressure (mm.)									
Temp. C	690	691	692	693	694	695	696	697	698	699
26.0	.7990	.8002	.8014	.8026	.8038	.8050	.8062	.8074	.8086	.8098
26.1	.7985	.7997	.8009	.8021	.8033	.8045	.8057	.8069	.8081	.8093
26.2	.7980	.7992	.8004	.8016	.8028	.8040	.8052	.8064	.8076	.8088
26.3	.7975	.7987	.7999	.8011	.8023	.8035	.8047	.8059	.8071	.8083
26.4	.7970	.7982	.7994	.8006	.8018	.8030	.8042	.8054	.8066	.8078
26.5	.7965	.7977	.7989	.8001	.8013	.8025	.8037	.8049	.8061	.8073
26.6	.7960	.7972	.7984	.7996	.8008	.8020	.8032	.8044	.8056	.8068
26.7	.7955	.7967	.7979	.7991	.8003	.8015	.8027	.8039	.8051	.8063
26.8	.7950	.7962	.7974	.7986	.7998	.8010	.8022	.8034	.8046	.8058
26.9	.7945	.7957	.7969	.7981	.7993	.8005	.8017	.8029	.8041	.8053
27.0	.7940	.7952	.7964	.7976	.7988	.8000	.8012	.8024	.8036	.8048
27.1	.7935	.7947	.7959	.7971	.7983	.7995	.8007	.8019	.8031	.8043
27.2	.7930	.7942	.7954	.7966	.7978	.7990	.8002	.8014	.8026	.8038
27.3	.7925	.7937	.7949	.7961	.7973	.7985	.7997	.8009	.8021	.8033
27.4	.7920	.7932	.7944	.7956	.7968	.7980	.7992	.8004	.8016	.8028
27.5	.7915	.7927	.7939	.7951	.7963	.7975	.7987	.7999	.8011	.8023
27.6	.7910	.7922	.7934	.7946	.7958	.7970	.7982	.7994	.8006	.8018
27.7	.7905	.7917	.7929	.7941	.7953	.7965	.7977	.7989	.8001	.8013
27.8	.7900	.7912	.7924	.7936	.7948	.7960	.7972	.7984	.7996	.8008
27.9	.7895	.7907	.7919	.7931	.7943	.7955	.7967	.7979	.7991	.8003
28.0	.7890	.7902	.7914	.7926	.7938	.7950	.7962	.7974	.7986	.7998

APPENDIX C.

Calculation of Basal Metabolism

Ht. cm.	Last food		Name -
			Date -
Wt. lb.	Body temp.	Resp.	Birthday -
			Age for A & DuB. -
Wt. kg.	Bar. T.	B.P.	H & B -
			Grid -
Area	Bar. R.		Dreyer -
			Mayo F. -

	mm diff.	cc.oxygen	Spir.Temp.	Pulse	Test for tightness
I					Temp. beg.
					Temp. end
II					

	I	II	III	IV
Log temp.rise				
Log 37.4	5729	5729	5729	5729
Log A	____	____	____	____
Antilog A				
Spir.diff.,cc	____	____	____	____
oxygen used	____	____	____	____
Log " "				
Log,Table 43	____	____	____	____
Log B				
Minus Log time	7782	7782	7782	7782
Log C				
Corr.oxygen/min.				
	5%	all av.	1st test	1st A.M.
Av.oxygen/min.	____	____	____	____
Cals./24 hrs.,T.14	____	____	____	____
Cals./hr.T.14	____	____	____	____
Log Cals./hr.	____	____	____	____
Minus log area	____	____	____	____
Log D	____	____	____	____
Cals./sq.m./hr.	____	____	____	____

/sq.m.hr.	A. & DuB	Dev.	%	History:
	H & B	Dev.	%	
/24 hrs.	Dreyer	Dev.	%	
	Mayo F.	Dev.	%	
V.C. Dreyer wt.		Dev.	%	
West. S. A.		Dev.	%	
West. Ht.		Dev.	%	

Apparatus: Benedict-Roth

Observers:

APPENDIX D

GRID for Evaluating PHYSICAL FITNESS

in Terms of PHYSIQUE (Body Build), DEVELOPMENTAL LEVEL and BASAL METABOLISM

— A Guide to Individual Progress from Infancy to Maturity —

Name____________________________ No.______________

DATE OF BIRTH________________

DATE	AGE	WT.	HEIGHT	DEV. LEVEL

PHYS. STATUS		A/N/R
CLIN.	GRID	

DIRECTIONS

Plot Wt. & Ht. Read Dev. Level. Plot against Age to secure Schedule & sight on Basal Heat Production.

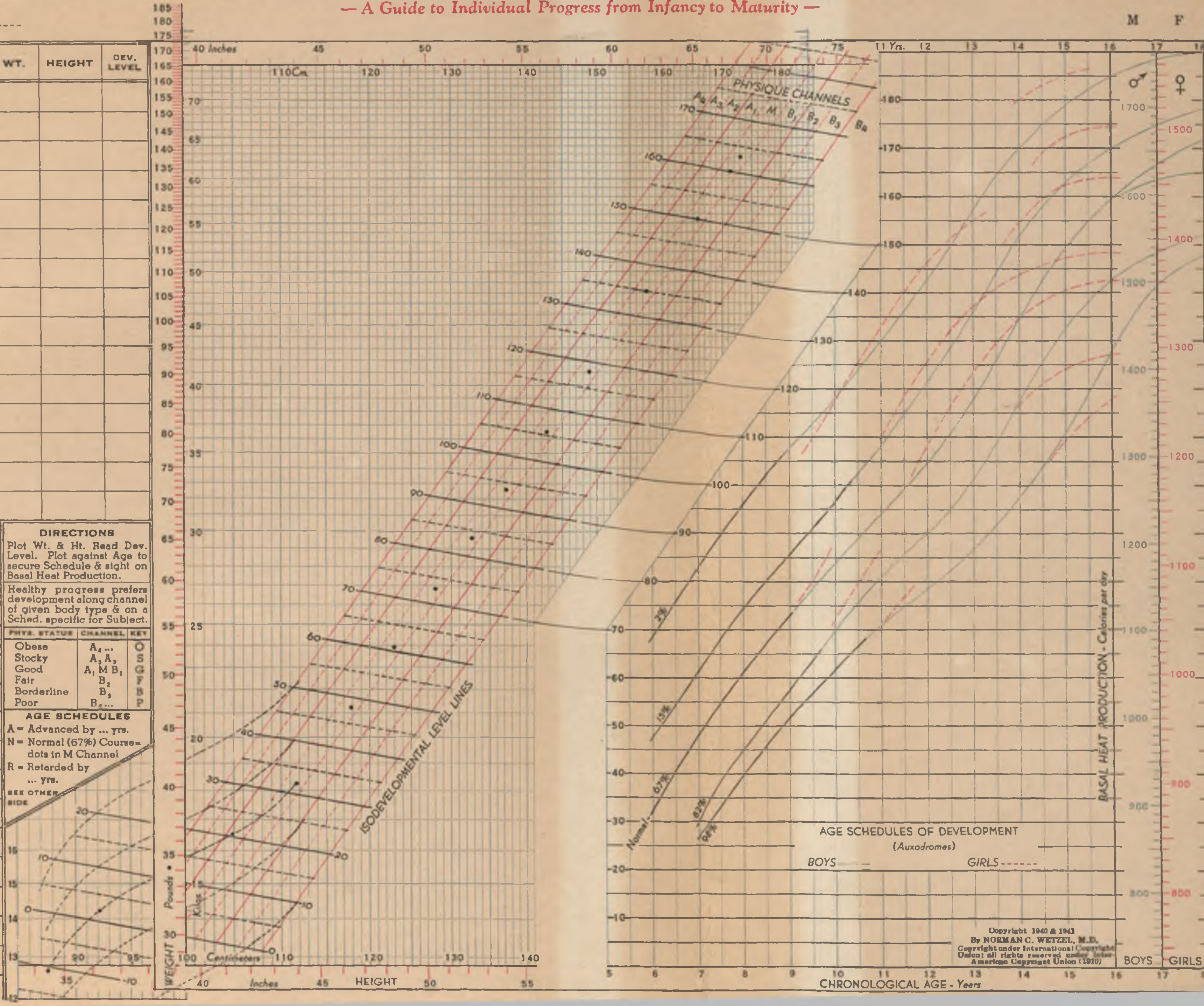
Healthy progress prefers development along channel of given body type & on a Sched. specific for Subject.

PHYS. STATUS	CHANNEL	KEY
Obese	A_4 ...	O
Stocky	$A_3 A_2$	S
Good	A_1 M B_1	G
Fair	B_2	F
Borderline	B_3	B
Poor	B_4 ...	P

AGE SCHEDULES

A = Advanced by ... yrs.
N = Normal (67%) Course = dots in M Channel
R = Retarded by ... yrs.

SEE OTHER SIDE



APPENDIX E

Vital Capacity

Ridgway (1947) from this laboratory reviewed the literature on the subject of vital capacity. Vital capacity as measured for each subject is shown in Table XI, page 50, and compared with three commonly used standards based upon, (1) weight (Dreyer), (2) surface area (West) and (3) standing height (West). A definite trend was observed of increasing vital capacity both with increasing developmental level and with age.

Thompson, Cox and Ridgway (1948) found that West's standard referred to surface area without regard to plus or minus sign predicted the vital capacity more closely than West's standard referred to weight when cases were classified as to age. This standard also predicted more closely than Dreyer's standard referred to weight for each year except the 15th and 20th. The results in the present study on younger subjects are not in agreement with the above. The Dreyer standard based on weight predicted more closely than the other standards for the 12th and 13th years.

TABLE XI

Actual Vital Capacity of Subjects
Compared With Standard Prediction Values

No.	Actual V.C. in L.	West (ht.)	West (s.a.)	Dreyer (wt.)
		Per cent deviations from standards		
		Age 12		
1	2.59	-16.98	-11.00	-5.82
2	2.45	-24.39	-15.52	-4.67
3	2.34	-27.10	-22.00	-15.83
4	3.05	+1.66	+21.03	+37.39
5	2.67	-14.97	-5.32	+4.30
6	2.01	-27.17	-9.46	-3.36
7	2.99	-9.39	-11.80	-8.84
8	2.45	-20.71	-18.06	-15.81
9	2.21	-28.24	-13.34	+0.45
10	2.84	-11.80	-8.97	-4.38
11	2.09	-28.18	-13.63	-3.24
12	2.05	-36.92	-27.30	-15.98
13	1.98	-29.03	-18.18	+1.20
14	2.55	-19.05	-9.25	+0.39
15	3.34	+1.21	+5.03	+12.84
16	2.44	-24.46	-11.59	+3.39
17	3.58	+6.23	+15.11	+28.78
18	3.03	-7.06	-2.88	+3.76
19	2.63	-18.32	-14.05	-8.68
20	2.74	-14.90	-13.84	-9.86
21	2.91	-9.06	-9.06	-5.52
22	2.14	-31.63	-25.69	-18.32
23	2.33	-25.80	-15.89	-5.66
24	2.50	-21.13	-13.79	-5.65
25	3.23	+1.57	+10.62	+20.52
26	2.65	-19.94	-9.56	+3.11
Av. *	2.59	18.34	13.54	9.53
Av.**		-17.52	-9.55	-0.60
		Age 13		
27	1.88	-38.96	-25.40	-12.96
28	3.35	+0.90	-12.08	-16.66

TABLE XI (continued)

No.	Actual V.C. in L.	West (ht.)	West (s.a.)	Dreyer (wt.)
29	2.47	-21.59	-13.03	-4.63
30	2.73	-13.06	-3.53	+6.22
31	2.32	-27.51	-18.88	-9.38
32	2.34	-22.52	-12.69	-4.49
33	3.18	-5.06	-1.24	+6.71
34	2.17	-33.03	-24.65	-14.56
35	3.18	-8.62	-12.88	-9.14
36	2.57	-21.17	-14.05	-4.82
37	2.30	-24.84	-18.73	-13.53
38	2.94	-5.76	+2.08	+10.11
39	2.57	-20.43	-9.18	+3.21
40	2.48	-19.48	-9.48	-
41	2.68	-18.79	-11.26	-0.74
42	2.44	-24.69	-26.51	-24.22
43	2.52	-21.74	-9.68	+3.70
44	2.30	-23.08	-20.42	-19.01
45	3.12	-3.70	-3.70	+1.28
46	2.37	-26.63	-12.86	+2.16
47	2.83	-14.24	-11.56	-6.29
48	3.13	-2.18	+7.93	+20.38
49	2.40	-22.58	-16.08	-10.45
50	3.25	-0.62	+12.84	+28.97
51	2.77	-10.93	+9.05	+28.23
52	2.69	-17.74	-5.28	+9.35
53	2.13	-18.70	-31.07	-7.39
Av.*	2.63	17.35	13.19	10.32
Av.**		-17.29	-10.83	-1.41

* Mean values without regard to sign
** Mean values with regard to sign

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