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Exophthalmometry: A comparison study employing the Hertel exophthalmometer and the Corneal Reflection pupilometer

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Exophthalmometry: A comparison study employing the Hertel exophthalmometer and the Corneal Reflection pupilometer

Abstract

The project was designed to determine if there was any correlation at the 0.05 level of significance between exophthalmometry as performed using methodology developed with the Corneal Reflection Pupilometer, as compared with that gathered via the standard Hertel technique. Using 540 measurements with each device, we found that a 0.8mm measurement difference between the two methods is not statistically different. The standard error measurement with the CRP was 0.0368 mm when compared with Hertel readings on an identical population while disregarding no subjects. The data interpretation shows a very high coefficient of determination indicating inter-instrument agreement. The fact that the Hertel device is considered the yardstick of exophthalmometry and assumes an accuracy level to within 2 mm taken to extension indicates that the CRP is as accurate and reliable when used in the prescribed fashion.

Degree Type

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Master of Science in Vision Science

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Alfred Furie

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Optometry

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EXOPHTHALMOMETRY

A Comparison Study
Employing the Hertel Exophthalmometer and
The Corneal Reflection Pupilometer

Original Research Conducted By:
Larry Scheele and Ric Peterson

Under the Advisement of:
Alfred Furie, O.D.

To Be Completed
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Pacific University
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Forest Grove, Oregon 97116

A Thesis Accomplished in
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Degree Requirements for
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HERTEL/CRP EXOPHTHALMOMETRY THESIS

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Pacific University is responsible for facilities used during the data gathering and processing. Our respective families are due a hearty thanks for their tolerance and moral support. A general note of gratitude is also extended to the many who became subjects and/or unofficial advisors and to all the coffee companies of the world for their obvious participation.

ABSTRACT

Hertel/CRP Exophthalmometry

The project was designed to determine if there was any correlation at the 0.05 level of significance between exophthalmometry as performed using methodology developed with the Corneal Reflection Pupilometer, as compared with that gathered via the standard Hertel technique. Using 540 measurements with each device, we found that a 0.8mm measurement difference between the two methods is not statistically different. The standard error measurement with the CRP was 0.0368 mm when compared with Hertel readings on an identical population while disregarding no subjects.

The data interpretation shows a very high coefficient of determination indicating inter-instrument agreement. The fact that the Hertel device is considered the yardstick of exophthalmometry and assumes an accuracy level to within 2 mm taken to extension indicates that the CRP is as accurate and reliable when used in the prescribed fashion.

INTRODUCTION

Exophthalmos is a condition whereby the globe(s) extends excessively from what is anatomically normal. A number of anomalous conditions have exophthalmos as a major diagnostic finding . It may be significant with respect to instances of eye tumors, hormonal imbalances, and/or ocular trauma, among others.

This proposal is structured on a new method for the measurement of exophthalmos. This project is simply a new application for the Silor Corneal Reflection Pupilometer commonly found in today's optometric practice. Historically, the Hertel Exophthalmometer has been the standard to which all other methods have been compared. It is employed in this study as well. Through the use of this instrument application, another technique has been developed to accurately detect and record the amount the eye extends from normal position relative to the zygomatic bone at the temporal aspect of the orbit.

This is an original application with no known previous research having been accomplished according to the manufacturer and distributor of the Corneal Reflection Pupilometer. The literature search revealed no relevant material in exposition of this concept.

The CRP has long been used as a measure of vertex distance, which is the distance from the front of the eye(cornea) to the spectacle lens ocular surface. With this same positioning format, measuring from the zygomatic bone at the outer edge of the orbit to the apex of the cornea, the accuracy of the CRP is expected to be very similar to that of the Hertel.

METHODS

SUBJECTS:

The subject population included 270 patients. All were randomly selected i.e. no special screening process was performed to "weed out" patients in any manner. Ages ranged from the very young (5 to 6 years old) to the elderly (70 to 80 years old). Both males and females participated in this study. Patients were all drawn from the Portland, Oregon metropolitan area.

METHODS AND MATERIALS:

Each patient was placed in a comfortable sitting position facing a 5 millimeter round target approximately 3 meters directly in front of him/her. The patient was first measured with the Hertel Ophthalmometer in the standard manner by one of the investigators. Immediately after the Hertel measurement, he/she was remeasured with the Corneal Reflection Pupilometer (CRP). The CRP is introduced from the side of the patient. The measurement baseline in the viewing window of the CRP is aligned at the anterior aspect of the zygomatic bone. Our measurement therefore will be from this zygomatic bone to the front of the eye (corneal apex). The sliding hairline indicator of the instrument is then moved tangent to the apex (front) of the cornea in profile. The apparatus is set at infinity and a distance in millimeters can be read directly from the scale for recording. This data was then organized by comparing each measurement from the Hertel, with the same eyes measured using the Corneal Reflection Pupilometer.

The problem of parallax is minimal with a proper placement angle. This is achieved when the patient's pupil, as viewed through the instrument, first approaches its minimum subtense. A frontal illumination of approximately 25 foot candles is sufficient to allow proper alignment when darkly pigmented irides are involved.

Traditionally, a two millimeter margin of error has been noted as expected reasonable accuracy via Hertel methodology. The CRP was realistically expected to be within these standard allowances. Random error was minimized by close experimental condition controls. Possible significant factors of variability are related to individual differences between instruments. The Hertel uses a mechanical touch alignment whereas the CRP method is visual in nature. This introduces another variable, that of the degree of orbital soft tissue blanketing the point of reference. This is principally of two types, orbital fat and dermatochalasis. With adequate experience, either is easily compensated for with a preliminary palpation of the area.

DISCUSSION

Exophthalmometry is a technique employed as a diagnostic tool to determine if there is a proptosis and/or difference in the extension of the eyes. Anomalous conditions such as in thyroid dysfunction or trauma employ exophthalmometry in the testing regime for differentiation and confirmatory measures.

The Silor Corneal Reflection Pupilometer is a widely distributed device with previously noted application in measuring the distance between the apex of the cornea and spectacle lens or frame (vertex distance). The method for measuring the exophthalmic eye was modeled after this operation.

The Hertel Exophthalmometer has long been the prevailing method by which a globe displacement has been quantified. It is for this reason that this device was selected as the baseline in this study.

A total of 540 determinations were made with both apparatus and the tabulated findings subjected to a statistical analysis. A random t-test for dependant samples on subjects taken while disregarding no candidates and a Pearson coefficient of correlation (r) were performed. The level of significance was set at the 0.05 level on a two-tailed test.

The comparison of the two measurements accomplished during this endeavor proved to be of high statistical significance. Because the samples are from the identical group of subjects, there is inherently a homogeneity of variance.

The coefficient of determination derived from the Pearson r shows a value of 0.7724. This demonstrates that the two instruments are in agreement with respect to the findings.

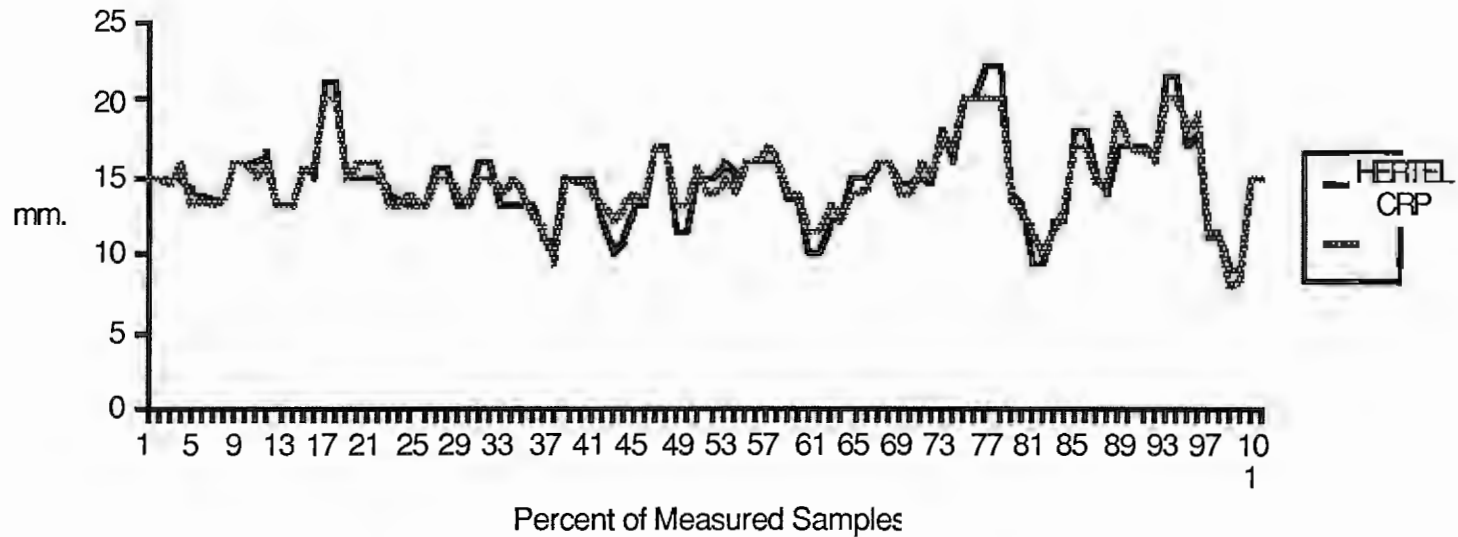
The standard error measurement was 0.368 mm on a sample size of

540. This is relatively insignificant when compared with the acceptable range of 2 mm on the Hertel. In reality, as much as a 0.8 mm difference at the 0.05 level between findings has not proven statistically significant. For all intents and purposes the instruments can be considered as being equal when used in the manner described in this study.

It should be noted that as in any newly acquired skill, there is a need to practice and hone the measurement technique with both apparatus. The authors are now equally confident in either approach.

During the course of this investigation, several other applications of the CRP have been discussed. Among the more promising are the determination of strabismic angles, and the acquisition of measurements during the contact lens fitting process. These remain for future investigation.

HERTEL/CRP DATA GRAPH



Hertel/CRP EXOPHTHALMOMETRY

STATISTICAL SUMMARY

	Sum Hertel	7907
	Average Hertel	14.6425926
	Sum CRP	7877
	Average CRP	14.587037
	Sum Of Differences	471
	Average of Differences	0.87222222
	Sum Of Dif Squared	805
	Standard Dev. squared	0.73132344
	Standard Deviation	0.85517451
	Standard Error of dif.	0.03683497
	Test statistic	23.6791868
Pearson	Product-moment Correlation	
	sum of (CRP)(Hertel)	118102.875
	sum of Hertel squared	119307
	sum of CRP squared	117703.75
	Pearson r	1492113.5
		2.8823E+12
		1697723.5
	r =	0.87889076
	Coefficient of Determination	0.77244897

Hertel /CRP EXOPHTHALMOMETRY

	A	B	C	D	E	G	H
1	Hertel	CRP	Hertel Squared	CRP Squared	Hertel(CRP)	Difference	Dif Squared
2	15	15	225	225	225	0	0
3	15	15	225	225	225	0	0
4	15	14.5	225	210.25	217.5	0.5	0.25
5	15	16	225	256	240	1	1
6	14	13	196	169	182	1	1
7	14	13.5	196	182.25	189	0.5	0.25
8	13.5	13	182.25	169	175.5	0.5	0.25
9	13.5	13.5	182.25	182.25	182.25	0	0
10	16	16	256	256	256	0	0
11	16	16	256	256	256	0	0
12	16	15	256	225	240	1	1
13	16.5	16	272.25	256	264	0.5	0.25
14	13	13	169	169	169	0	0
15	13	13	169	169	169	0	0
16	15.5	15.5	240.25	240.25	240.25	0	0
17	15	15.5	225	240.25	232.5	0.5	0.25
18	21	20	441	400	420	1	1
19	21	20	441	400	420	1	1
20	15	15	225	225	225	0	0
21	15	16	225	256	240	1	1
22	15	16	225	256	240	1	1
23	15	16	225	256	240	1	1
24	14	13	196	169	182	1	1
25	13.5	13	182.25	169	175.5	0.5	0.25
26	13	14	169	196	182	1	1
27	13	13	169	169	169	0	0
28	15.5	15	240.25	225	232.5	0.5	0.25
29	15.5	15	240.25	225	232.5	0.5	0.25
30	13	14	169	196	182	1	1
31	13	13	169	169	169	0	0
32	16	15	256	225	240	1	1
33	16	15	256	225	240	1	1
34	13	14	169	196	182	1	1
35	13	15	169	225	195	2	4
36	13	14	169	196	182	1	1
37	13	12.5	169	156.25	162.5	0.5	0.25
38	11	11.5	121	132.25	126.5	0.5	0.25
39	10.5	9.5	110.25	90.25	99.75	1	1
40	15	15	225	225	225	0	0
41	14.5	15	210.25	225	217.5	0.5	0.25
42	15	14	225	196	210	1	1
43	12	13	144	169	156	1	1
44	10	12	100	144	120	2	4
45	11	13	121	169	143	2	4
46	13	14	169	196	182	1	1
47	13	13.5	169	182.25	175.5	0.5	0.25
48	17	17	289	289	289	0	0

Hertel /CRP EXOPHTHALMOMETRY

	A	B	C	D	E	G	H
49	17	16.5	289	272.25	280.5	0.5	0.25
50	11.5	13	132.25	169	149.5	1.5	2.25
51	11.5	13	132.25	169	149.5	1.5	2.25
52	15	15.75	225	248.0625	236.25	0.75	0.5625
53	15	14	225	196	210	1	1
54	16	15	256	225	240	1	1
55	15	14	225	196	210	1	1
56	16	16	256	256	256	0	0
57	16	16	256	256	256	0	0
58	16	17	256	289	272	1	1
59	16	16	256	256	256	0	0
60	13.5	14	182.25	196	189	0.5	0.25
61	13.5	14	182.25	196	189	0.5	0.25
62							
63	Hertel	CRP	Hertel Squared	CRP Squared	Hertel(CRP)	Difference	Dif Squared
64	866.5	873.75	12761.25	12906.5625	12812	40.25	43.8125

Hertel /CRP EXOPHTHALMOMETRY

	I	J	K	L	M	N	O
1	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
2	10	11.5	100	132.25	115	1.5	2.25
3	10	11.5	100	132.25	115	1.5	2.25
4	12	13	144	169	156	1	1
5	12	12	144	144	144	0	0
6	15	14	225	196	210	1	1
7	15	14.5	225	210.25	217.5	0.5	0.25
8	16	16	256	256	256	0	0
9	16	16	256	256	256	0	0
10	14.5	14	210.25	196	203	0.5	0.25
11	14.5	14	210.25	196	203	0.5	0.25
12	15	16	225	256	240	1	1
13	14.5	15	210.25	225	217.5	0.5	0.25
14	18	17.5	324	306.25	315	0.5	0.25
15	16	16.5	256	272.25	264	0.5	0.25
16	20	20	400	400	400	0	0
17	20	20	400	400	400	0	0
18	22	20	484	400	440	2	4
19	22	20	484	400	440	2	4
20	14	13.5	196	182.25	189	0.5	0.25
21	13	12.5	169	156.25	162.5	0.5	0.25
22	9.5	11.5	90.25	132.25	109.25	2	4
23	9.5	10	90.25	100	95	0.5	0.25
24	12	11.5	144	132.25	138	0.5	0.25
25	12	13	144	169	156	1	1
26	18	17	324	289	306	1	1
27	18	17	324	289	306	1	1
28	15	14.5	225	210.25	217.5	0.5	0.25
29	14	14.5	196	210.25	203	0.5	0.25
30	17	19	289	361	323	2	4
31	17	17	289	289	289	0	0
32	17	16.5	289	272.25	280.5	0.5	0.25
33	16	16	256	256	256	0	0
34	21.5	20	462.25	400	430	1.5	2.25
35	21.5	20	462.25	400	430	1.5	2.25
36	17	18	289	324	306	1	1
37	18	19	324	361	342	1	1
38	11	11.5	121	132.25	126.5	0.5	0.25
39	11	11.5	121	132.25	126.5	0.5	0.25
40	9	8	81	64	72	1	1
41	9	8.5	81	72.25	76.5	0.5	0.25
42	15	15	225	225	225	0	0
43	15	15	225	225	225	0	0
44	20	19	400	361	380	1	1
45	19	19	361	361	361	0	0
46	14	14.5	196	210.25	203	0.5	0.25
47	14	15	196	225	210	1	1
48	12.5	13.5	156.25	182.25	168.75	1	1

Hertel /CRP EXOPHTHALMOMETRY

	I	J	K	L	M	N	O
49	12.5	13.5	156.25	182.25	168.75	1	1
50	16.5	15.5	272.25	240.25	255.75	1	1
51	16	16	256	256	256	0	0
52	14.5	15	210.25	225	217.5	0.5	0.25
53	14.5	15.5	210.25	240.25	224.75	1	1
54	10	11	100	121	110	1	1
55	10	9	100	81	90	1	1
56	15	15	225	225	225	0	0
57	14.5	14	210.25	196	203	0.5	0.25
58	9	10	81	100	90	1	1
59	8.5	9	72.25	81	76.5	0.5	0.25
60	14	13.5	196	182.25	189	0.5	0.25
61	14	14.5	196	210.25	203	0.5	0.25
62							
63	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
64	881	884	13665.5	13611.5	13614.25	43	48.5

Hertel /CRP EXOPHTHALMOMETRY

	P	Q	R	S	T	U	V
1	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
2	20	19	400	361	380	1	1
3	20	19	400	361	380	1	1
4	16	13.5	256	182.25	216	2.5	6.25
5	16	16.25	256	264.0625	260	0.25	0.0625
6	14.5	15	210.25	225	217.5	0.5	0.25
7	14.5	14.5	210.25	210.25	210.25	0	0
8	13.5	13.5	182.25	182.25	182.25	0	0
9	14	14	196	196	196	0	0
10	18.5	18	342.25	324	333	0.5	0.25
11	18.5	19	342.25	361	351.5	0.5	0.25
12	15.5	15	240.25	225	232.5	0.5	0.25
13	15.5	15.5	240.25	240.25	240.25	0	0
14	8	9	64	81	72	1	1
15	8	8.5	64	72.25	68	0.5	0.25
16	16	15.5	256	240.25	248	0.5	0.25
17	16	15	256	225	240	1	1
18	13	13	169	169	169	0	0
19	13	13	169	169	169	0	0
20	13	13	169	169	169	0	0
21	11	10.5	121	110.25	115.5	0.5	0.25
22	13	13.5	169	182.25	175.5	0.5	0.25
23	13	13	169	169	169	0	0
24	11	11	121	121	121	0	0
25	11	12	121	144	132	1	1
26	11	10.5	121	110.25	115.5	0.5	0.25
27	11	9.5	121	90.25	104.5	1.5	2.25
28	17	18	289	324	306	1	1
29	16	16.5	256	272.25	264	0.5	0.25
30	16.5	16.5	272.25	272.25	272.25	0	0
31	16.5	15.5	272.25	240.25	255.75	1	1
32	17	13.5	289	182.25	229.5	3.5	12.25
33	16.5	13.5	272.25	182.25	222.75	3	9
34	12	11.5	144	132.25	138	0.5	0.25
35	12	11.5	144	132.25	138	0.5	0.25
36	17	16.5	289	272.25	280.5	0.5	0.25
37	16	15	256	225	240	1	1
38	16	16.5	256	272.25	264	0.5	0.25
39	17	17	289	289	289	0	0
40	14.5	15	210.25	225	217.5	0.5	0.25
41	14.5	15.5	210.25	240.25	224.75	1	1
42	13	12.5	169	156.25	162.5	0.5	0.25
43	13	12.5	169	156.25	162.5	0.5	0.25
44	15	14	225	196	210	1	1
45	15	14	225	196	210	1	1
46	17	17	289	289	289	0	0
47	19	19	361	361	361	0	0
48	16.5	17	272.25	289	280.5	0.5	0.25

Hertel /CRP EXOPHTHALMOMETRY

	P	Q	R	S	T	U	V
49	16.5	16	272.25	256	264	0.5	0.25
50	12	11	144	121	132	1	1
51	10.5	11	110.25	121	115.5	0.5	0.25
52	13	13	169	169	169	0	0
53	13	13.5	169	182.25	175.5	0.5	0.25
54	17	17	289	289	289	0	0
55	17	17	289	289	289	0	0
56	13	12	169	144	156	1	1
57	13	12.5	169	156.25	162.5	0.5	0.25
58	16	15	256	225	240	1	1
59	16	16.25	256	264.0625	260	0.25	0.0625
60	18	17.5	324	306.25	315	0.5	0.25
61	17	17.5	289	306.25	297.5	0.5	0.25
62							
63	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
64	883.5	866.5	13430.75	12918.625	13149.75	37	49.875

Hertel/CRP EXOPHTHALMOMETRY

	W	X	Y	Z	AA	AB	AC
1	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
2	17	16	289	256	272	1	1
3	18	16	324	256	288	2	4
4	11	10	121	100	110	1	1
5	10.5	10	110.25	100	105	0.5	0.25
6	11	11	121	121	121	0	0
7	10.5	11.5	110.25	132.25	120.75	1	1
8	11	11	121	121	121	0	0
9	11	11	121	121	121	0	0
10	13.5	13	182.25	169	175.5	0.5	0.25
11	13.5	13	182.25	169	175.5	0.5	0.25
12	15	17	225	289	255	2	4
13	15	18	225	324	270	3	9
14	15	16	225	256	240	1	1
15	15	15	225	225	225	0	0
16	17	17	289	289	289	0	0
17	16	18	256	324	288	2	4
18	14	13	196	169	182	1	1
19	12	11	144	121	132	1	1
20	15	14	225	196	210	1	1
21	15	14	225	196	210	1	1
22	17	16	289	256	272	1	1
23	17	16.5	289	272.25	280.5	0.5	0.25
24	16	16	256	256	256	0	0
25	16	15.5	256	240.25	248	0.5	0.25
26	18	17	324	289	306	1	1
27	18	17	324	289	306	1	1
28	13	14	169	196	182	1	1
29	13	13	169	169	169	0	0
30	14.5	15	210.25	225	217.5	0.5	0.25
31	14.5	16	210.25	256	232	1.5	2.25
32	15	14	225	196	210	1	1
33	15	14	225	196	210	1	1
34	20.5	17	420.25	289	348.5	3.5	12.25
35	19	16.5	361	272.25	313.5	2.5	6.25
36	15	15	225	225	225	0	0
37	15	15	225	225	225	0	0
38	17.5	16	306.25	256	280	1.5	2.25
39	17.5	16	306.25	256	280	1.5	2.25
40	10	12	100	144	120	2	4
41	10	11	100	121	110	1	1
42	16	15	256	225	240	1	1
43	15	15	225	225	225	0	0
44	10	11.5	100	132.25	115	1.5	2.25
45	10	11	100	121	110	1	1
46	15	17	225	289	255	2	4
47	15.5	17	240.25	289	263.5	1.5	2.25
48	18	18	324	324	324	0	0

Hertel /CRP EXOPHTHALMOMETRY

	W	X	Y	Z	AA	AB	AC
49	18	18	324	324	324	0	0
50	16	14	256	196	224	2	4
51	15	14	225	196	210	1	1
52	14	15.5	196	240.25	217	1.5	2.25
53	14	15	196	225	210	1	1
54	11	14	121	196	154	3	9
55	11	13	121	169	143	2	4
56	12	12	144	144	144	0	0
57	11	12	121	144	132	1	1
58	12	13	144	169	156	1	1
59	12	12.5	144	156.25	150	0.5	0.25
60	15	15	225	225	225	0	0
61	14.5	15	210.25	225	217.5	0.5	0.25
62							
63	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
64	862.5	865.5	12804.75	12777.75	12740.75	60	101

Hertel /CRP EXOPHTHALMOMETRY

	AD	AE	AF	AG	AH	AI	AJ
1	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
2	13	14	169	196	182	1	1
3	13	16	169	256	208	3	9
4	12	12	144	144	144	0	0
5	12	12	144	144	144	0	0
6	15	16	225	256	240	1	1
7	15	15	225	225	225	0	0
8	11	12	121	144	132	1	1
9	10.5	12	110.25	144	126	1.5	2.25
10	20	20	400	400	400	0	0
11	19.5	19	380.25	361	370.5	0.5	0.25
12	10	11	100	121	110	1	1
13	10.5	11	110.25	121	115.5	0.5	0.25
14	17	17	289	289	289	0	0
15	16	15	256	225	240	1	1
16	15.5	15	240.25	225	232.5	0.5	0.25
17	15	16	225	256	240	1	1
18	11	13	121	169	143	2	4
19	11	14	121	196	154	3	9
20	10	12	100	144	120	2	4
21	10	12	100	144	120	2	4
22	12	12	144	144	144	0	0
23	12	13	144	169	156	1	1
24	15	17	225	289	255	2	4
25	15	15	225	225	225	0	0
26	13	15	169	225	195	2	4
27	14	14	196	196	196	0	0
28	16.5	16	272.25	256	264	0.5	0.25
29	15	15	225	225	225	0	0
30	11	10	121	100	110	1	1
31	10	11.5	100	132.25	115	1.5	2.25
32	12	13	144	169	156	1	1
33	12	12	144	144	144	0	0
34	12	11	144	121	132	1	1
35	13	12	169	144	156	1	1
36	10	10	100	100	100	0	0
37	10	11	100	121	110	1	1
38	15.5	15	240.25	225	232.5	0.5	0.25
39	15.5	15	240.25	225	232.5	0.5	0.25
40	12	13	144	169	156	1	1
41	12	13	144	169	156	1	1
42	16	15.5	256	240.25	248	0.5	0.25
43	16	16	256	256	256	0	0
44	15	14	225	196	210	1	1
45	15	14	225	196	210	1	1
46	15.5	15	240.25	225	232.5	0.5	0.25
47	16	16	256	256	256	0	0
48	14	14	196	196	196	0	0

Hertel/CRP EXOPHTHALMOMETRY

	AD	AE	AF	AG	AH	AI	AJ
49	13.5	13	182.25	169	175.5	0.5	0.25
50	14	12	196	144	168	2	4
51	14	14	196	196	196	0	0
52	12	11	144	121	132	1	1
53	11.5	11	132.25	121	126.5	0.5	0.25
54	13	13	169	169	169	0	0
55	13	14	169	196	182	1	1
56	16	15	256	225	240	1	1
57	16.5	16	272.25	256	264	0.5	0.25
58	17	17	289	289	289	0	0
59	16.5	15	272.25	225	247.5	1.5	2.25
60	15.5	15	240.25	225	232.5	0.5	0.25
61	15.5	15	240.25	225	232.5	0.5	0.25
62							
63	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
64	820	833	11553.5	11834.5	11658.5	48	71

Hertel /CRP EXOPHTHALMOMETRY

	AK	AL	AM	AN	AO	AP	AQ
1	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
2	12	12	144	144	144	0	0
3	12	12	144	144	144	0	0
4	12	13	144	169	156	1	1
5	12	13	144	169	156	1	1
6	17.5	18	306.25	324	315	0.5	0.25
7	17	17	289	289	289	0	0
8	20.5	18	420.25	324	369	2.5	6.25
9	20.5	17	420.25	289	348.5	3.5	12.25
10	14	15	196	225	210	1	1
11	14.5	15	210.25	225	217.5	0.5	0.25
12	17	15	289	225	255	2	4
13	16	15	256	225	240	1	1
14	14.5	14	210.25	196	203	0.5	0.25
15	13	13	169	169	169	0	0
16	17	15.5	289	240.25	263.5	1.5	2.25
17	16.5	16	272.25	256	264	0.5	0.25
18	23.5	22	552.25	484	517	1.5	2.25
19	23.5	21	552.25	441	493.5	2.5	6.25
20	16	14	256	196	224	2	4
21	16	14	256	196	224	2	4
22	14.5	15	210.25	225	217.5	0.5	0.25
23	14.5	15	210.25	225	217.5	0.5	0.25
24	17	18	289	324	306	1	1
25	16.5	20	272.25	400	330	3.5	12.25
26	13.5	13	182.25	169	175.5	0.5	0.25
27	13.5	13	182.25	169	175.5	0.5	0.25
28	17	16.5	289	272.25	280.5	0.5	0.25
29	15	15	225	225	225	0	0
30	14.5	14	210.25	196	203	0.5	0.25
31	14.5	13	210.25	169	188.5	1.5	2.25
32	17	17	289	289	289	0	0
33	16.5	16.5	272.25	272.25	272.25	0	0
34	16	17	256	289	272	1	1
35	15	16	225	256	240	1	1
36	19	16.5	361	272.25	313.5	2.5	6.25
37	18	17	324	289	306	1	1
38	13	11.5	169	132.25	149.5	1.5	2.25
39	12	10.5	144	110.25	126	1.5	2.25
40	15.5	15	240.25	225	232.5	0.5	0.25
41	15.5	15	240.25	225	232.5	0.5	0.25
42	15.5	16.5	240.25	272.25	255.75	1	1
43	15.5	15	240.25	225	232.5	0.5	0.25
44	14.5	15	210.25	225	217.5	0.5	0.25
45	14	15	196	225	210	1	1
46	17.5	16.5	306.25	272.25	288.75	1	1
47	17.5	17	306.25	289	297.5	0.5	0.25
48	18	17	324	289	306	1	1

Hertel /CRP EXOPHTHALMOMETRY

	AK	AL	AM	AN	AO	AP	AQ
49	17	17.5	289	306.25	297.5	0.5	0.25
50	17	15.5	289	240.25	263.5	1.5	2.25
51	17	16	289	256	272	1	1
52	12	12	144	144	144	0	0
53	12	12	144	144	144	0	0
54	18.5	17.5	342.25	306.25	323.75	1	1
55	18.5	18	342.25	324	333	0.5	0.25
56	17	17	289	289	289	0	0
57	16	16	256	256	256	0	0
58	15	16	225	256	240	1	1
59	16	17	256	289	272	1	1
60	15	15	225	225	225	0	0
61	15	14	225	196	210	1	1
62							
63	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
64	951.5	929.5	15460.25	14693.75	15032	55	90

Hertel /CRP EXOPHTHALMOMETRY

	AR	AS	AT	AU	AV	AW	AX
1	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
2	13.5	13	182.25	169	175.5	0.5	0.25
3	13.5	13	182.25	169	175.5	0.5	0.25
4	15	14.5	225	210.25	217.5	0.5	0.25
5	15	14.5	225	210.25	217.5	0.5	0.25
6	12	13	144	169	156	1	1
7	11	13	121	169	143	2	4
8	14	13.5	196	182.25	189	0.5	0.25
9	14	13.5	196	182.25	189	0.5	0.25
10	11	11	121	121	121	0	0
11	12	11.5	144	132.25	138	0.5	0.25
12	14	14	196	196	196	0	0
13	13	14	169	196	182	1	1
14	16.5	16.75	272.25	280.5625	276.375	0.25	0.0625
15	16.5	16	272.25	256	264	0.5	0.25
16	20	20	400	400	400	0	0
17	19	20	361	400	380	1	1
18	16	16	256	256	256	0	0
19	16	16	256	256	256	0	0
20	15	13.5	225	182.25	202.5	1.5	2.25
21	15	14	225	196	210	1	1
22	16	14	256	196	224	2	4
23	16	14.5	256	210.25	232	1.5	2.25
24	20	18	400	324	360	2	4
25	20	19	400	361	380	1	1
26	15	15	225	225	225	0	0
27	15	15	225	225	225	0	0
28	13	13	169	169	169	0	0
29	13	13	169	169	169	0	0
30	15	16	225	256	240	1	1
31	13	15	169	225	195	2	4
32	14	13	196	169	182	1	1
33	14	14	196	196	196	0	0
34	13	13	169	169	169	0	0
35	14	13	196	169	182	1	1
36	17	20	289	400	340	3	9
37	17	20	289	400	340	3	9
38	20	15	400	225	300	5	25
39	20	15	400	225	300	5	25
40	14	14	196	196	196	0	0
41	14	14	196	196	196	0	0
42	15	15	225	225	225	0	0
43	15	15	225	225	225	0	0
44	13.5	14	182.25	196	189	0.5	0.25
45	13.5	14	182.25	196	189	0.5	0.25
46	15	15.5	225	240.25	232.5	0.5	0.25
47	15.5	15	240.25	225	232.5	0.5	0.25
48	14	13	196	169	182	1	1

Hertel /CRP EXOPHTHALMOMETRY

	AR	AS	AT	AU	AV	AW	AX
49	15	13	225	169	195	2	4
50	12	13	144	169	156	1	1
51	12	13	144	169	156	1	1
52	13	15	169	225	195	2	4
53	11	15	121	225	165	4	16
54	15	15	225	225	225	0	0
55	14	13	196	169	182	1	1
56	14	14	196	196	196	0	0
57	14	14	196	196	196	0	0
58	13	12	169	144	156	1	1
59	13	13	169	169	169	0	0
60	17	15	289	225	255	2	4
61	16	15	256	225	240	1	1
62							
63	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
64	885.5	875.75	13364.75	13020.5625	13125.875	57.25	133.5625

Hertel /CRP EXOPHTHALMOMETRY

	AY	AZ	BA	BB	BC	BD	BE
1	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
2	16	16	256	256	256	0	0
3	16	16	256	256	256	0	0
4	10.5	11.5	110.25	132.25	120.75	1	1
5	10.5	12	110.25	144	126	1.5	2.25
6	15	13	225	169	195	2	4
7	15	14	225	196	210	1	1
8	14	18	196	324	252	4	16
9	15	18	225	324	270	3	9
10	16	14	256	196	224	2	4
11	16	15	256	225	240	1	1
12	16	14	256	196	224	2	4
13	16	13	256	169	208	3	9
14	17	17	289	289	289	0	0
15	17	17	289	289	289	0	0
16	11	9.5	121	90.25	104.5	1.5	2.25
17	11	9.5	121	90.25	104.5	1.5	2.25
18	17	13	289	169	221	4	16
19	17	14	289	196	238	3	9
20	15	15	225	225	225	0	0
21	14	15	196	225	210	1	1
22	15	14	225	196	210	1	1
23	14	14	196	196	196	0	0
24	16	14	256	196	224	2	4
25	16	14	256	196	224	2	4
26	13	14	169	196	182	1	1
27	14	14	196	196	196	0	0
28	21	19	441	361	399	2	4
29	20.5	19	420.25	361	389.5	1.5	2.25
30	14	12	196	144	168	2	4
31	14	12	196	144	168	2	4
32	15	12	225	144	180	3	9
33	15	12	225	144	180	3	9
34	16	16	256	256	256	0	0
35	15	16	225	256	240	1	1
36	16	17	256	289	272	1	1
37	16	17	256	289	272	1	1
38	13	13	169	169	169	0	0
39	13	13	169	169	169	0	0
40	14	14	196	196	196	0	0
41	13	14	169	196	182	1	1
42	12	13	144	169	156	1	1
43	12	13	144	169	156	1	1
44	15	14	225	196	210	1	1
45	13	14	169	196	182	1	1
46	13	12.5	169	156.25	162.5	0.5	0.25
47	13	12.5	169	156.25	162.5	0.5	0.25
48	16	15	256	225	240	1	1

Hertel /CRP EXOPHTHALMOMETRY

	AY	AZ	BA	BB	BC	BD	BE
49	15	15	225	225	225	0	0
50	16	15	256	225	240	1	1
51	16	15	256	225	240	1	1
52	15	14	225	196	210	1	1
53	15	14	225	196	210	1	1
54	17	16	289	256	272	1	1
55	16	16	256	256	256	0	0
56	19	17	361	289	323	2	4
57	18	16	324	256	288	2	4
58	15	20	225	400	300	5	25
59	15	18	225	324	270	3	9
60	14	15	196	225	210	1	1
61	12	15	144	225	180	3	9
62							
63	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
64	895.5	874.5	13626.75	13020.25	13228.25	82	190.5

Hertel /CRP EXOPHTHALMOMETRY

	BF	BG	BH	BI	BJ	BK	BL
1	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
2	15	16	225	256	240	1	1
3	15	15	225	225	225	0	0
4	10	13	100	169	130	3	9
5	11	13	121	169	143	2	4
6	17	16	289	256	272	1	1
7	17	15	289	225	255	2	4
8	11	13	121	169	143	2	4
9	11	11	121	121	121	0	0
10	12	13	144	169	156	1	1
11	11	11	121	121	121	0	0
12	14	15	196	225	210	1	1
13	13	14	169	196	182	1	1
14	13	13	169	169	169	0	0
15	13	14	169	196	182	1	1
16	15	15	225	225	225	0	0
17	15	15	225	225	225	0	0
18	16	15	256	225	240	1	1
19	16	15	256	225	240	1	1
20	12	15	144	225	180	3	9
21	12	15	144	225	180	3	9
22	15	15	225	225	225	0	0
23	15	15	225	225	225	0	0
24	12	13	144	169	156	1	1
25	12	12	144	144	144	0	0
26	16	15	256	225	240	1	1
27	15.5	15.5	240.25	240.25	240.25	0	0
28	15.5	15	240.25	225	232.5	0.5	0.25
29	15.5	15.5	240.25	240.25	240.25	0	0
30	13	15	169	225	195	2	4
31	14	15	196	225	210	1	1
32	16	16	256	256	256	0	0
33	15.5	16	240.25	256	248	0.5	0.25
34	15	14	225	196	210	1	1
35	15	14	225	196	210	1	1
36	17.5	17	306.25	289	297.5	0.5	0.25
37	17.5	17	306.25	289	297.5	0.5	0.25
38	13	14	169	196	182	1	1
39	13	14	169	196	182	1	1
40	16	14	256	196	224	2	4
41	16	15.5	256	240.25	248	0.5	0.25
42	13	14	169	196	182	1	1
43	13	14	169	196	182	1	1
44	13	14	169	196	182	1	1
45	13	13.5	169	182.25	175.5	0.5	0.25
46	15	14	225	196	210	1	1
47	14	15	196	225	210	1	1
48	14	15	196	225	210	1	1

Hertel /CRP EXOPHTHALMOMETRY

	BF	BG	BH	BI	BJ	BK	BL
49	15	15	225	225	225	0	0
50	12	12	144	144	144	0	0
51	12	12	144	144	144	0	0
52	15	14	225	196	210	1	1
53	16	14	256	196	224	2	4
54	17	16	289	256	272	1	1
55	17	17	289	289	289	0	0
56	16	16	256	256	256	0	0
57	16	15.5	256	240.25	248	0.5	0.25
58	20	20	400	400	400	0	0
59	20	20	400	400	400	0	0
60	12	12	144	144	144	0	0
61	11	12	121	144	132	1	1
62							
63	Hertel	CRP	Hertel Square	CRP Squared	Hertel(CRP)	Difference	Dif Squared
64	861	874.5	12639.5	12920.25	12741.5	48.5	76.75

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