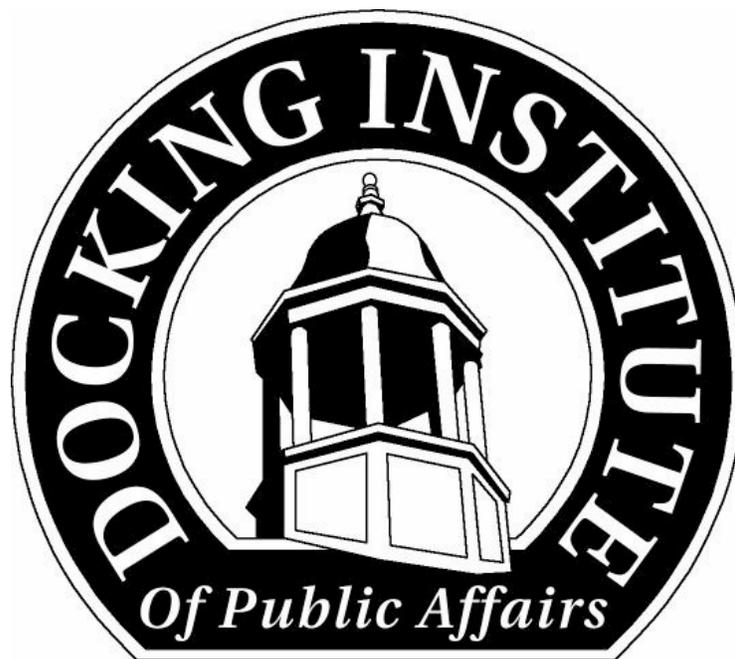# Evaluation Study of the Hays Medical Center Vital Signs In-Home Tele-Monitoring System Intervention for Chronic Obstructive Pulmonary Disease and Congestive Heart Failure Patients
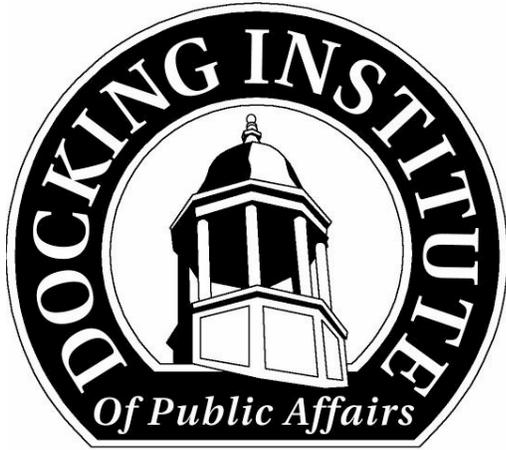

Fort Hays State University
600 Park Street
Hays, Kansas 67601

Fort Hays State University
600 Park Street
Hays, Kansas 67601-4099
Telephone: (785) 628-4197
FAX: (785) 628-4188
www.fhsu.edu/docking

The staff of **the Docking Institute of Public Affairs** and its **University Center for Survey Research** are dedicated to serving the people of Kansas and surrounding states.

If you have questions or comments, and/or need assistance, please do not hesitate to contact our staff.

Brett A. Zollinger, Ph.D.
Director

Trevor Steinert, M.S.S.
Research Scientist

Jean Walker
Special Events Coordinator

Preston Gilson, Ph.D.
Senior Policy Fellow

Michael S. Walker, M.S.
Research Scientist

Joyce Wolfe, M.S.
UCSR Manager

Jodie Wear-Leiker
Administrative Assistant

Ted Bannister, M.S.
Policy Fellow

Evaluation Study of the Hays Medical Center Vital Signs In-Home Tele-Monitoring System Intervention for Chronic Obstructive Pulmonary Disease and Congestive Heart Failure Patients

Report Prepared by

Preston Gilson, Ph.D.
Senior Policy Fellow

Ted Bannister, M.S.
Policy Fellow

Michael Walker, M.S.
Research Scientist

Brett Zollinger, Ph.D.
Director

The Docking Institute of Public Affairs
Fort Hays State University
600 Park Street
Hays, Kansas 67601

Executive Summary

The Docking Institute of Public Affairs conducted a multi-method evaluation research study of an NTIA funded telemedicine project. The project's primary goal was **to test the effectiveness of a new technology configuration and application to reduce post-hospital complications and readmissions of recently dismissed, high-risk hospital patients.** For this project, high-risk patients are those with chronic pulmonary obstructive disease and/or congestive heart failure (COPD/CHF). The patients chosen for the study were judged "moderately" ill. That is, patients with "mild" or "severe" COPD/CHF were excluded from the study. The general health pattern for patients with chronic obstructive pulmonary disease (COPD/CHF) is that there is an overall decline in health as the disease progresses. Patients being treated for this condition and living within a twenty-mile radius of a regional hospital in a very rural area of a Great Plains state, Kansas, were randomly assigned to a treatment group and a control group. The "treatment" in this project was the use of an in-home Health Monitoring System (HMS). The project began during March, 2001 and continued through July, 2002.

Three primary project outcomes were assessed:

Outcome 1: Reduce the health costs of high risk and/or medically fragile, recently dismissed hospital patients.
Result: Non doctor-related targeted (COPD/CHF related) and total health care costs were lower among the treatment group than among the control group on average. In addition, costs among the treatment group were higher at the baseline of the study than at the end of the study. However, results with regard to doctor costs were mixed when comparing the treatment group to the control group and the baseline to the study period data. Higher clinic (doctor) costs may be a positive result. Outcome 1 was partially achieved given these findings.

Outcome 2: Reduce the rates of hospital readmission for high-risk patients with a chronic disease.
Result: Rates of hospitalization among the treatment group were lower than that of the control group. Furthermore, rates of hospitalization among the treatment group remained the same between the baseline period and the study period, while the rates of hospitalization among the control group increased between these two time periods. Outcome 2 was achieved.

Outcome 3: Enhance the quality of life of high risk and/or medically fragile patients with chronic disease.
Result: Structured and unstructured interviews with patients in the study reveal higher perceived quality of life among the treatment group members due to their involvement in the study. Satisfaction with overall health care was higher among treatment group members than among control group members. Furthermore, satisfaction with overall health care increased among the treatment group patients over the course of the study. Vital statistics data show no decrease in health among the treatment group members during the study period, and this may be interpreted as enhancing the quality of life among a group of patients with a chronic health condition. Outcome 3 was achieved.

In addition to the above stated project outcomes, other aspects of the project were assessed, including, whether the daily collection of vital statistics data through the in-home monitoring system could predict acute COPD and/or CHF related episodes, the project costs per patient, and unanticipated quality of life consequences for treatment group patients. The Docking Institute's independent evaluation concludes that:

_ Neither the HMS-collected vital statistics nor the patient self reported well-being data collected over the phone on a daily basis were predictive of acute incidents of COPD/CHF. It is clear that HMS does not increase the prediction of acute incidents for COPD/CHF patients.

_ The treatment group showed no measurable decline in the level of health during the study period. This suggests that there may be some benefits associated with HMS for COPD/CHF patients.

_ On a per patient basis the costs for project equipment (in-home monitoring system and computers at the hospital office) averaged $4,129 over the eighteen-month study period.

_ Total monthly labor costs for monitoring technicians and the network analyst was $2,723.

_ About $70 per month was spent in transportation cost traveling to patient homes for equipment repair/maintenance.

_ In order for this approach to COPD/CHF treatment to be cost-benefit efficient the benefits need only exceed either $8,501 in a three-year period or $5,581 in a one year period on a per patient basis.

- Home monitoring reduces hospital costs. The treatment group's targeted (COPD/CHF related health care) costs were 87% of the control group's. Furthermore, when outliers are removed, the treatment group's targeted costs as a percentage of the control group's targeted costs drops to 76%.

- During the pre-study period the treatment group's costs are significantly higher (246% higher for targeted costs, and 140% higher for total costs) than the control group's, increasing the confidence in the assertion above that during the project period, the treatment group's medical costs seem to have been lowered in association with use of the HMS.

- Comparing the treatment group's medical costs during the 17-month study period to it's costs in the 17-month period prior to the project, targeted costs were 66% lower during the study period than the pre study period. Total medical costs were 81% lower.

- The medical costs for the control group were actually much higher during the study period compared to the pre-study period (161% higher for targeted costs and 165% higher for total costs).

- Among those patients needing hospitalization related to targeted (COPD/CHF) problems during the study period, the typical treatment patient had one less hospital visit, and spent four fewer days in the hospital than the average control group patient. In contrast, during the pre-study period, treatment patients had an equal number of visits to and spent two more days in the hospital than the average control group patient.

- The average treatment group patient spent nine fewer days in the hospital than the average control group patient when considering all medical problems during the study period. In contrast, during the pre-study period, treatment group patients had two more visits and spent two more days in the hospital than the average control group patient.

- On average treatment group patients spent the same number of days in the hospital during the pre-study and study periods, while control group patients showed longer hospital stays during the study period than the pre-study period.

- During the project, the average treatment group patient spent slightly more ($56) on COPD/CHF-related doctor costs and visited their doctor two more times than the control patient. However, they spent $1,152 less than the unmonitored control patient and visited the doctor three fewer times related to total health problems during that same period.

- Mixed results were found with regard to doctor visit costs. The treatment groups targeted costs dropped 15% from the pre-study to the study period, and their total doctor costs dropped by 11%. The control group's targeted costs dropped even more, by 38%, however this group's total doctor costs increased between the pre-study and study periods by 13%.

- Survey and personal interview data show members of both the control group and treatment group are generally satisfied with the medical care that they receive.

- The treatment group's satisfaction with health care increased over the study period, while the control group's satisfaction declined.

- In addition, the Home Monitoring System finds overwhelming support from users, and this support increased from early in the project to the end of the study.

- Treatment group patients enjoyed and perceived a benefit from the daily personal contact with HMS staff members. While it is beyond the scope of the current research to examine this further, it would seem that the personal daily telephone contacts and periodic personal visits afforded the treatment group with needed social interaction and stimulation.

- Survey and personal interviews also found that the HMS involvement provided a strong sense of "health ownership."

Section One
Daily Patient Data for the Treatment Group

Introduction

      The purpose of this study was to determine the efficacy and cost efficiency of in-home monitoring of patients with chronic obstructive pulmonary disease. The general health pattern for patients with chronic obstructive pulmonary disease (COPD/CHF) is that there is an overall decline in health as the disease progresses. Thus, our first hypothesis was that the home monitoring system (HMS) would facilitate earlier intervention and so postpone or slow this overall decline in health. The second hypothesis was that acute incidents of COPD/CHF are preceded by predictable changes or patterns in either vital statistics or patient well-being data. The third hypothesis is that in-home monitoring of COPD/CHF patients is cost efficient. That is, that the benefits of the HMS are greater than the costs.

<u>Methodology</u>

Because of the small sample size our methodology is quite simple and our results are tentative. Sophisticated statistical methods have limited value with sample sizes under 25. We follow the general approach suggested by Tukey in <u>Exploratory</u> <u>Data</u> <u>Analysis</u>. All of the time specific data for each Treatment patient is graphed on a single timeline. The purposes of this graphical approach are to get a feel for the data and to observe any potential relationships between one event and another.

Table 1.1 – Classification of Study Participants

	Selected	Withdrew	Died	Studied
Treatment	29	4	2	23
Control	17	0	1	16

Patients with CPOD in a small western Kansas community were recruited to participate in the HMS study. Patients were randomly assigned to either the Treatment or Control group. But, an insufficient number of patients were recruited to balance the sizes of the Treatment and Control groups and at the same time utilize all the monitoring equipment that was available for the study. Thus, the decision was made to utilize all the monitoring equipment despite the fact that the Treatment group is almost 50 percent larger than the Control group. However, in numbers the difference is only seven individuals.

<u>Data</u>

Daily patient data for the treatment group were collected on regular business days from the time the patient joined the study until the completion of the study.   The completion dates for the treatment group patients were spread over a couple of weeks due to the time required to collect the in-home monitoring system equipment from each patient's home. The data were collected both by machine and by human interaction. The machine data were transmitted to Hays Medical Center computers by ordinary telephone lines. Each patient was also contacted by one of two staff persons each day by telephone to answer a short subjective questionnaire about the patient's general state of health. A 1 to 5 scale was used for each question for ease of understanding by the patients. The questionnaire is located in Appendix IV. The staff person entered the patient's responses into a computer database at the time of the telephone interview.

<u>Results</u>

Neither the vital statistics nor the patient well-being data were predictive of acute incidents of COPD/CHF. Given the data that were collected it is clear that the HMS does not increase the prediction of acute incidents for COPD/CHF patients. (Some of the monitoring equipment did not perform satisfactorily and its use was discontinued during the study.) However, the treatment group showed no measurable decline in the level of health during the study period. This suggests that there may be some benefits associated with the use of the HMS for COPD/CHF patients. The data analysis for the Treatment group patients is presented in the following graphs.

Graph 1.1 – T1 Composite Data
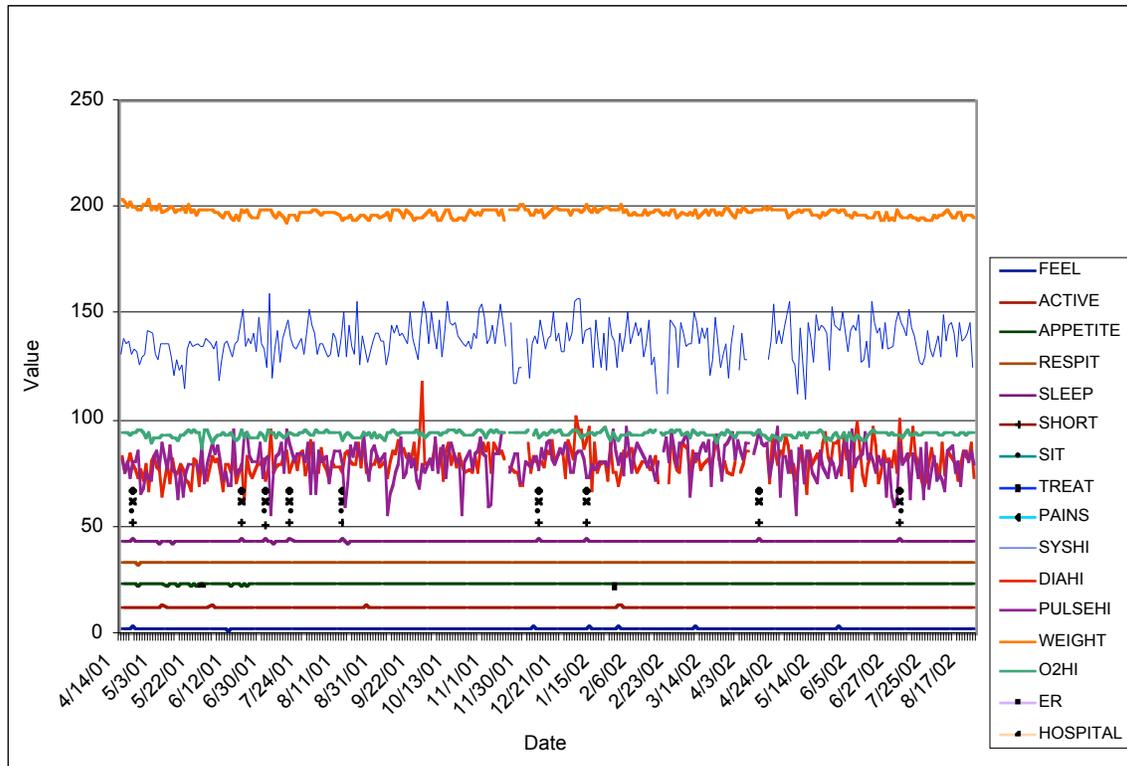
Graph 1.1 shows the vital statistics, well-being data, and medical chart events during the study period for treatment group patient 1 (T1). Composite data charts were constructed for each of the patients in the treatment group. The

vital statistics data values are the recorded values. The well-being data was transformed to separate the responses to the questions. Because the same 1 to 5 scale was used for each question the responses would have graphed on top of each other. The transformation was accomplished by simply adding a constant to each response. In much the same way the medical chart events were assigned arbitrary values for purposes of graphical presentation.

Table 1.2 – Statistical Measurements for T1

MEASURE	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	137.0887	80.9386	80.6087	197.0132	93.4233
Standard Error	0.5232	0.4105	0.4727	0.1088	0.0689
Median	137	81	82	197	94
Mode	136	76	84	198	94
Standard Deviation	8.9561	7.0266	8.1741	1.8907	1.1926
Sample Variance	80.2113	49.3729	66.8162	3.5746	1.4222
Kurtosis	0.1982	2.3821	0.4280	0.1442	2.6920
Skewness	-0.1876	0.6655	-0.6392	0.2540	-0.8532
Range	49	56	41	11	10
Minimum	110	62	56	192	87
Maximum	159	118	97	203	97

Table 1.2 shows the simple statistical parameters for the machine-collected vital statistics data. SYSHI is the measured systolic blood pressure. DIAHI is the measured diastolic blood pressure. PULSEHI is the measured pulse rate. WEIGHT is the measured weight. And, O2HI is the measured blood oxygen level. The distributions are essentially normal, bell-shaped distributions, although for some variables there is minimal skewness. The blood pressure and pulse readings showed greater variability than the weight and O2 readings. It seems likely that some of the outliers are erroneous readings. However, except for weight readings, these outliers were not deleted. The individual variable distributions are shown in Graphs 1.2 through 1.6.

Graph 1.2 – Distribution of Systolic Readings for T1
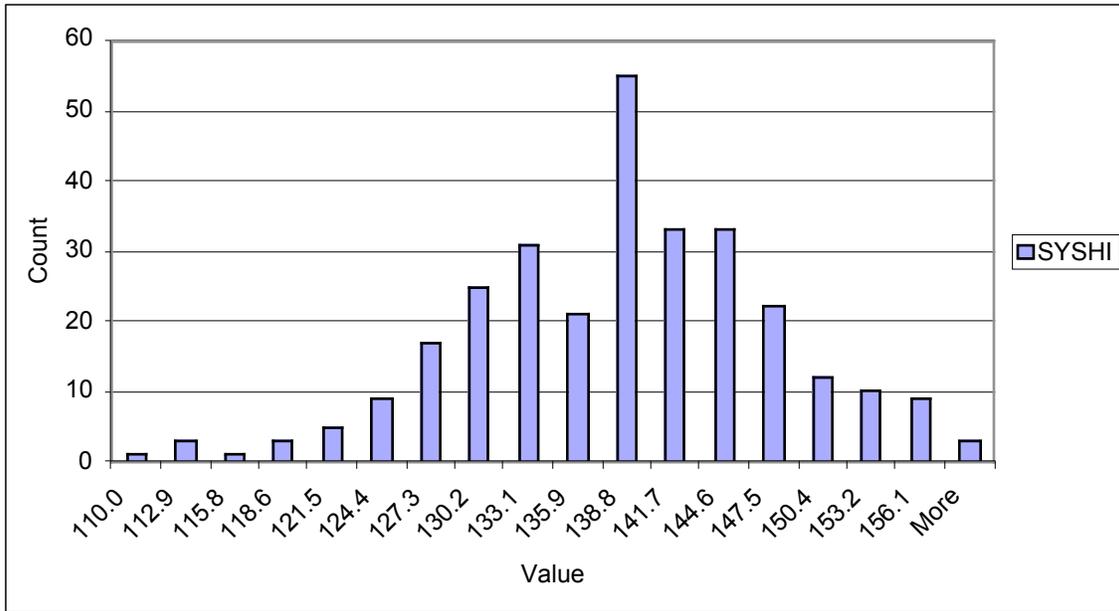

**Graph 1.3 – Distribution of Diastolic Readings for T1**
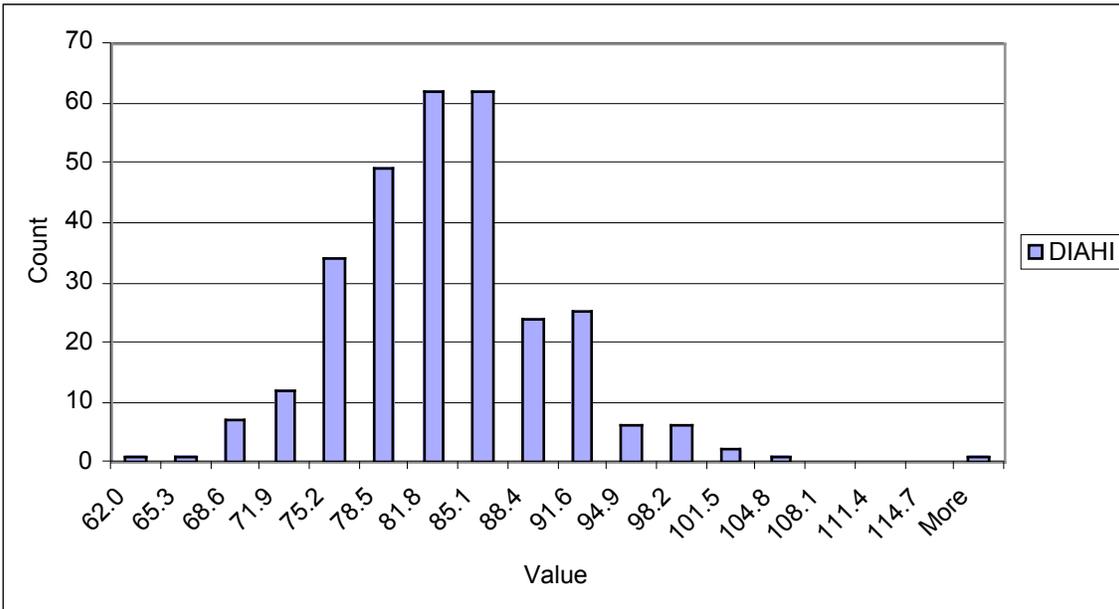
Graph 1.4 – Distribution of Pulse Readings for T1
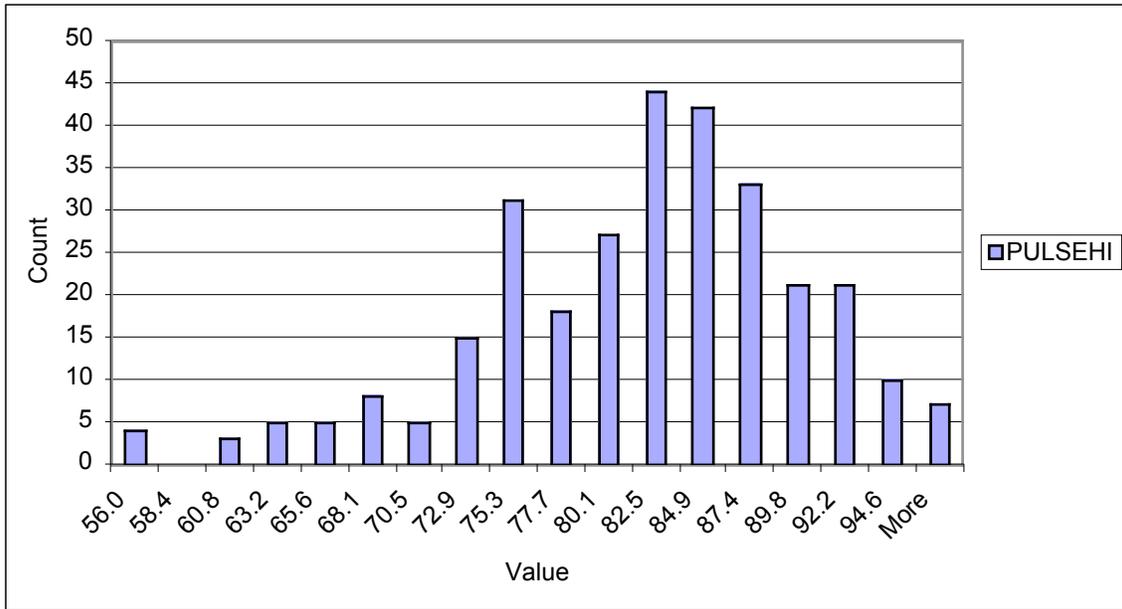
Graph 1.5 – Distribution of Weight Readings for T1
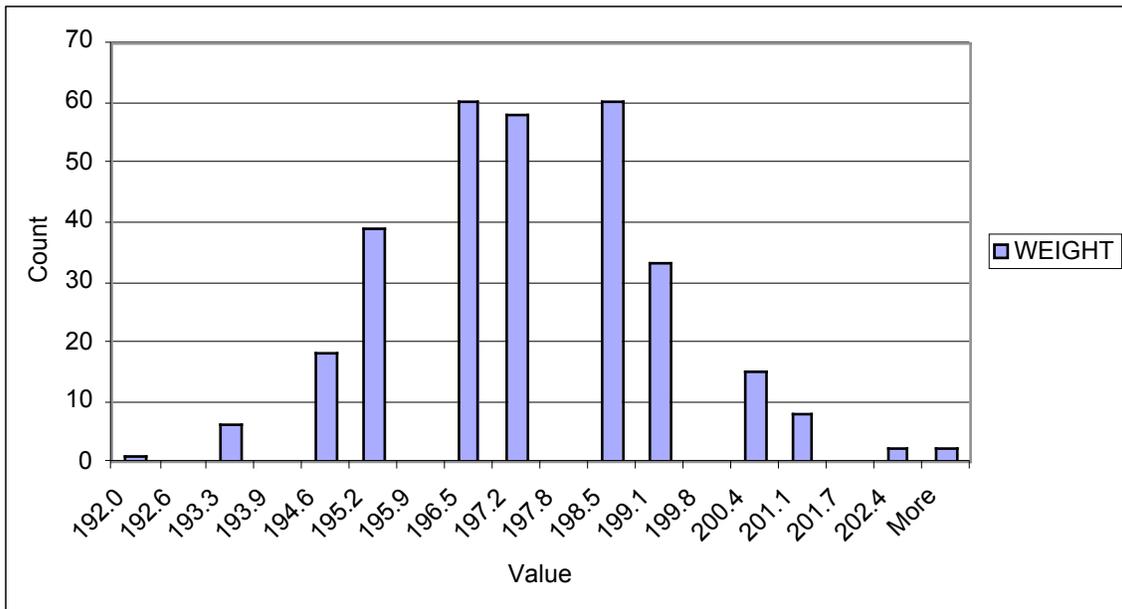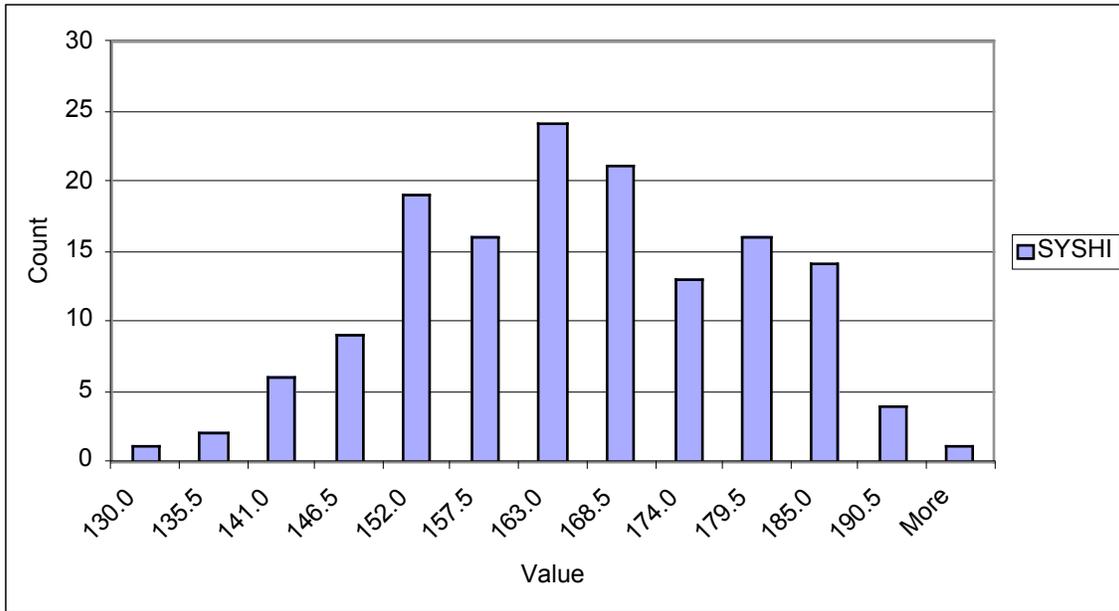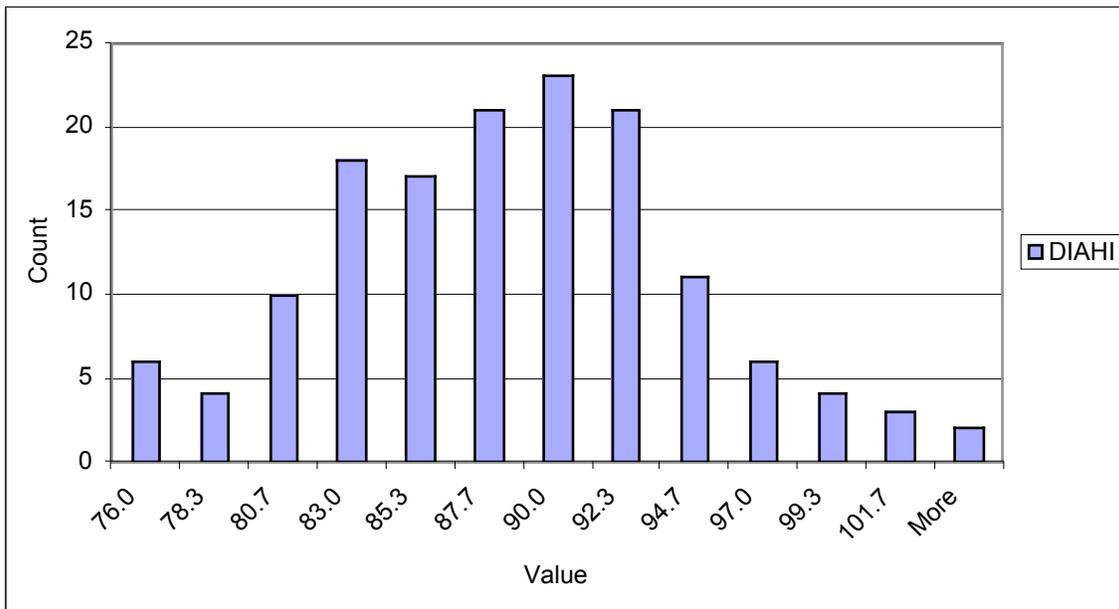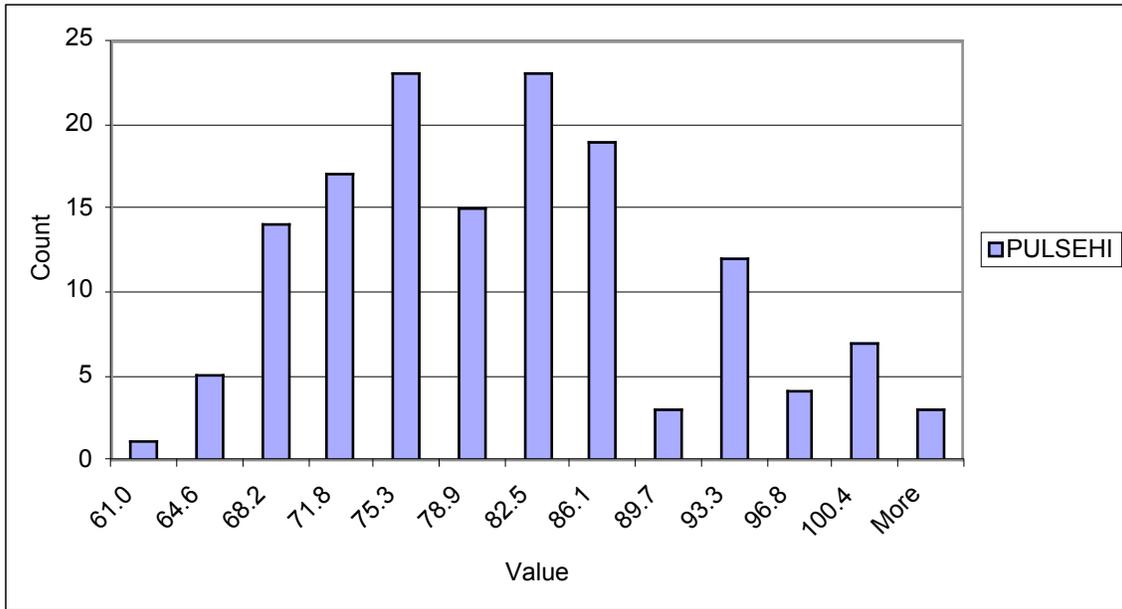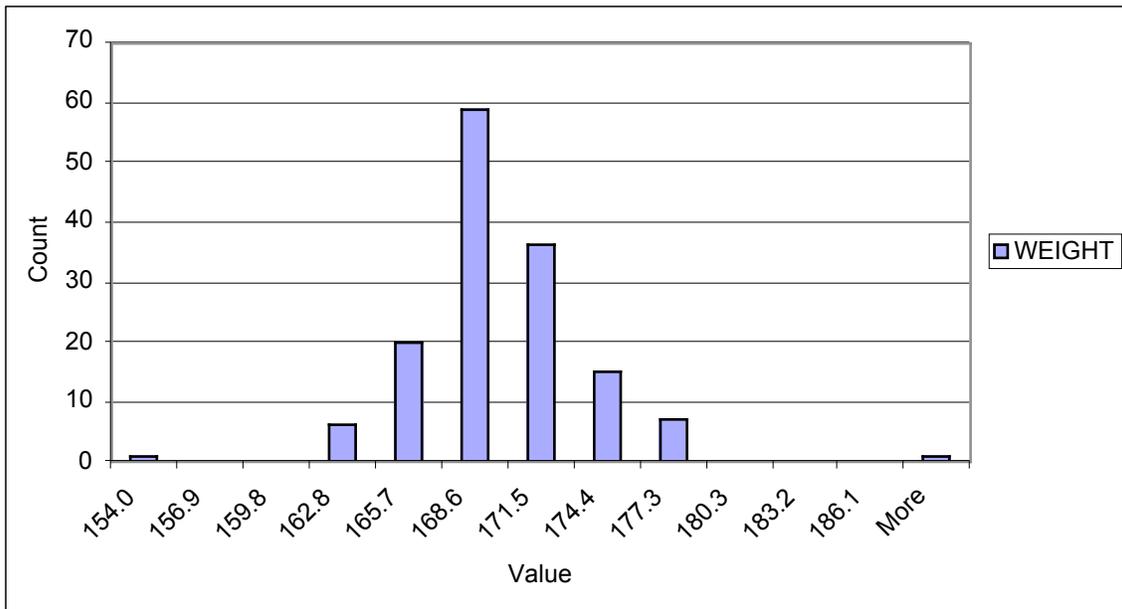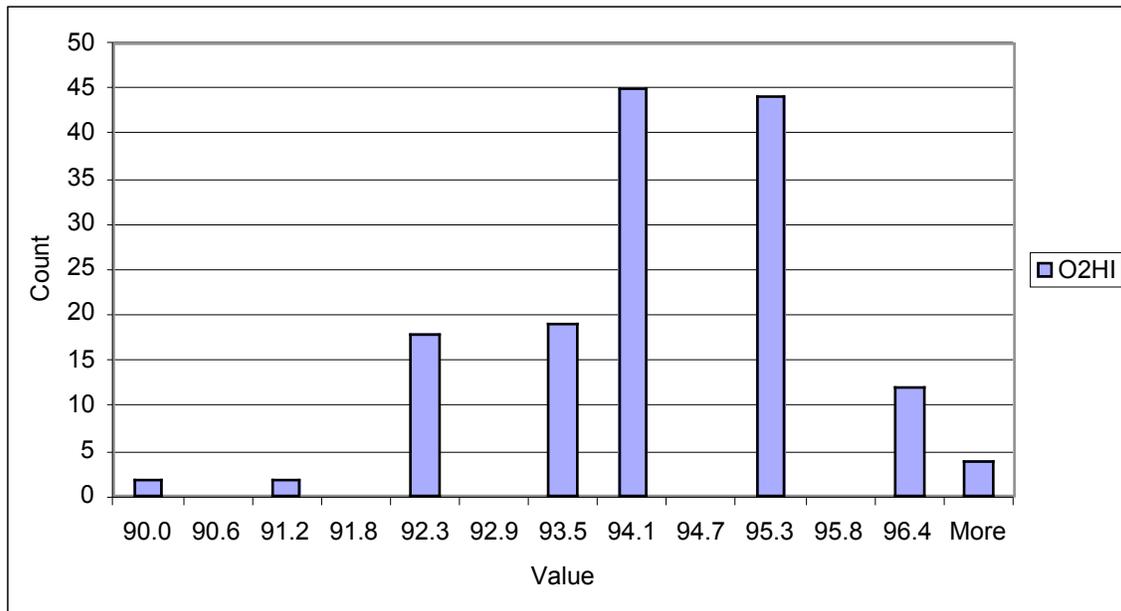
Graph 1.6 – Distribution of O2 Readings for T1
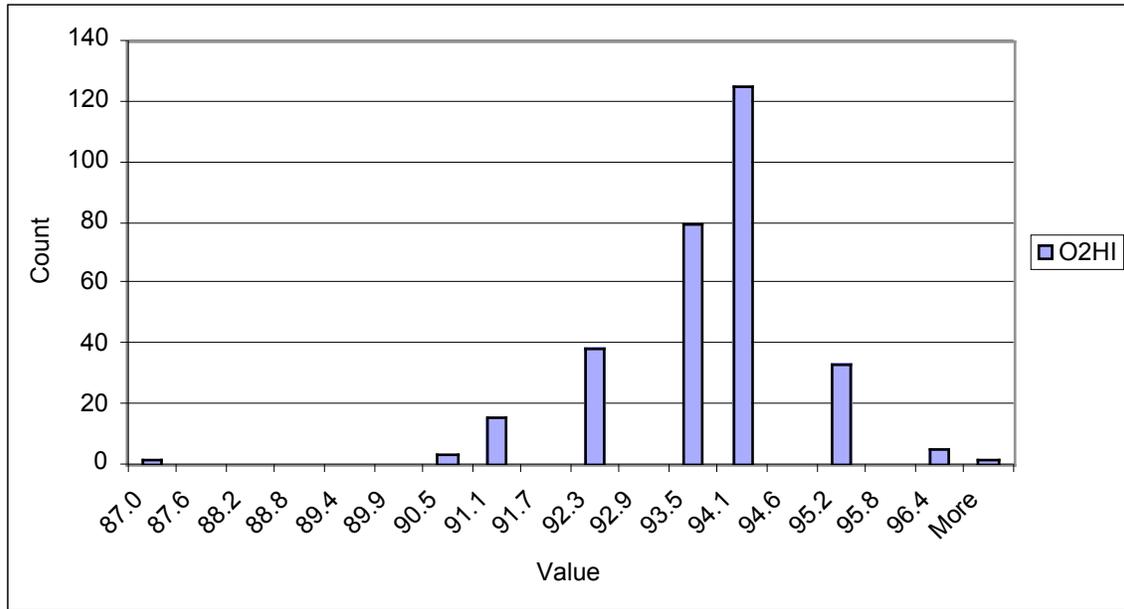
The following graphs (1.7 through 1.138) and tables present the data associated with the remaining treatment group patients (T2 through T23). Except for minor differences in values, the patterns of the variables for each treatment group patient are remarkably similar to those of the other treatment group patients.

Graph 1.7 – T2 Composite Data
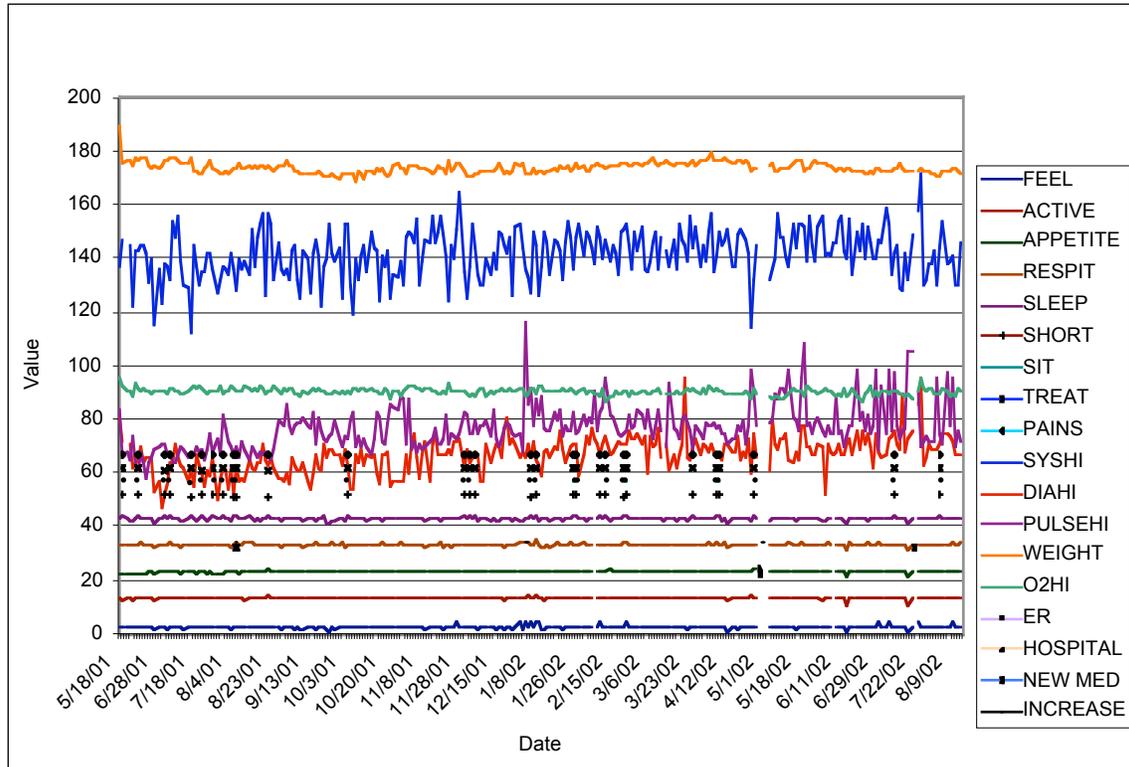
Table 1.3 – Statistical Measurements for T2

MEASURE	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	141.7465	67.0563	77.0246	174.3077	90.8421
Standard Error	0.5391	0.3956	0.4984	0.1224	0.0725
Median	142	67	76	174	91
Mode	145	67	78	173	91
Standard Deviation	9.0853	6.6660	8.4138	2.0698	1.2246
Sample Variance	82.5433	44.4350	70.7916	4.2839	1.4996
Kurtosis	0.3380	2.2525	2.5062	7.7918	0.9002
Skewness	-0.2786	0.3155	1.2291	1.3353	-0.0312
Range	60	49	58	20	8
Minimum	112	47	58	169	87
Maximum	172	96	116	189	95

Graph 1.8 – Distribution of Systolic Readings for T2
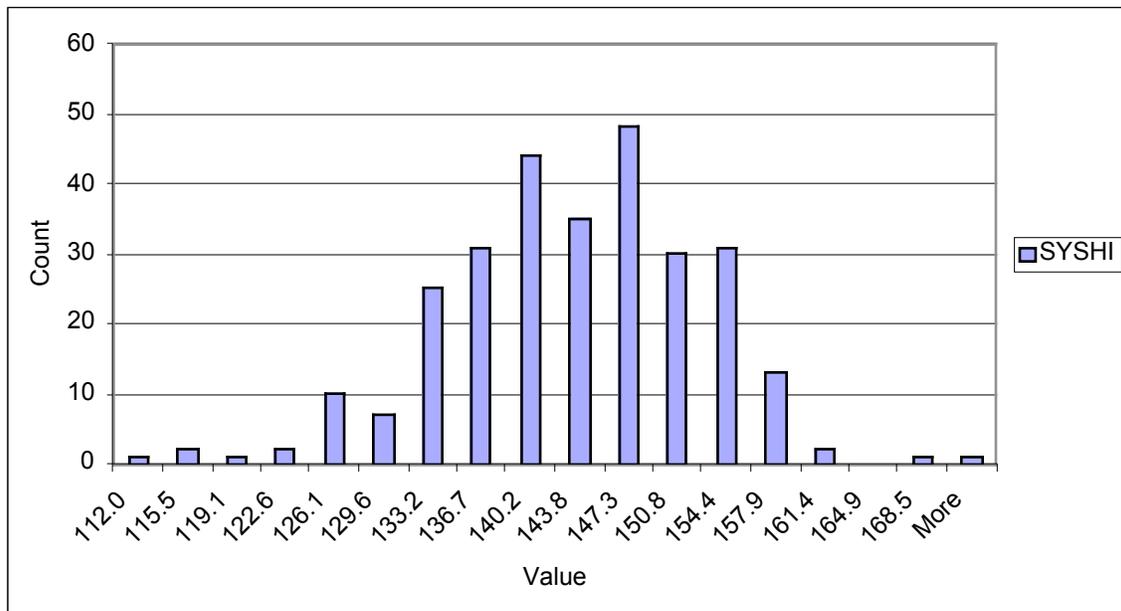
Graph 1.9 – Distribution of Diastolic Readings for T2
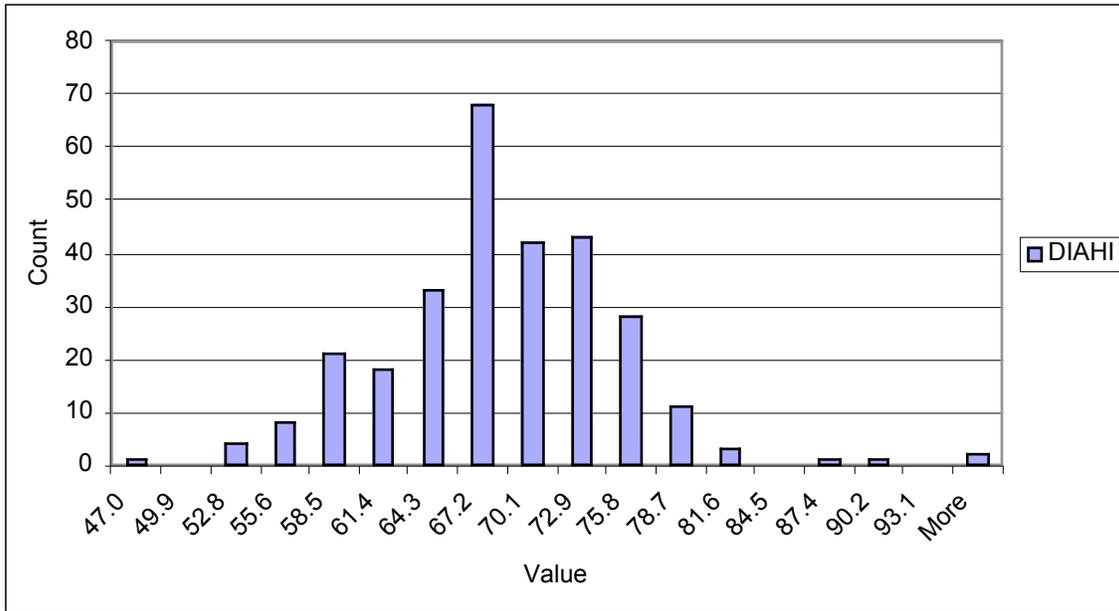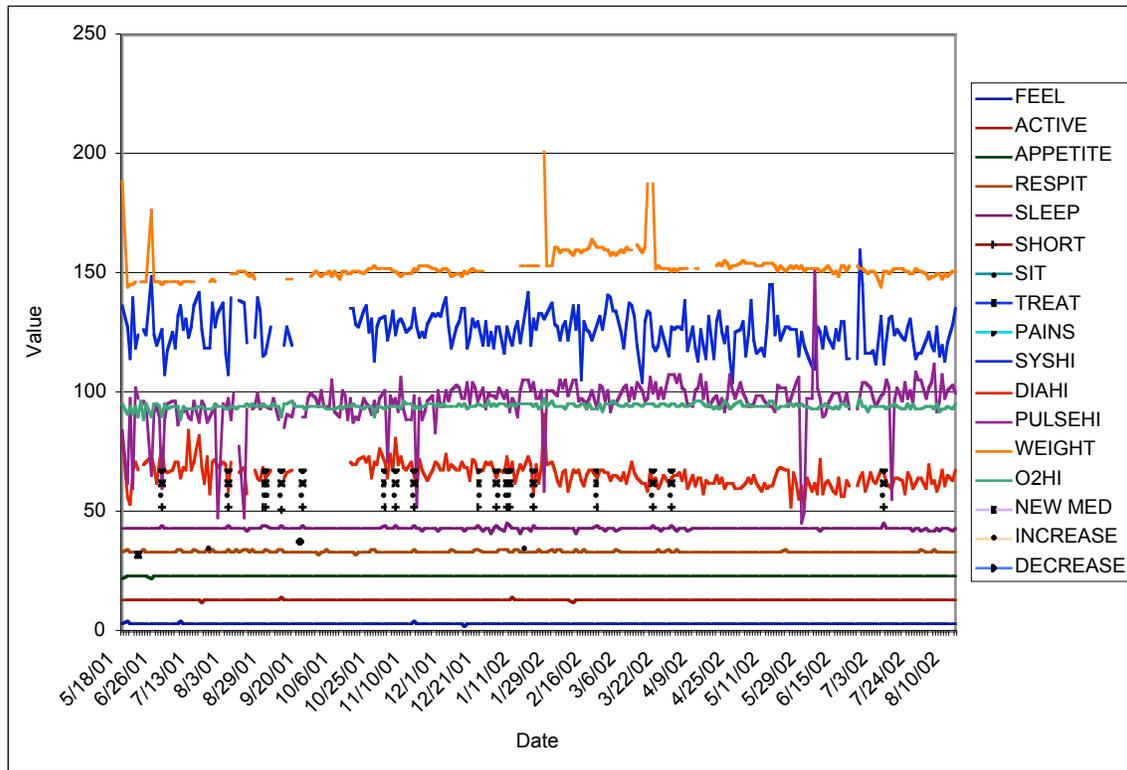

Graph 1.10 – Distribution of Pulse Readings for T2
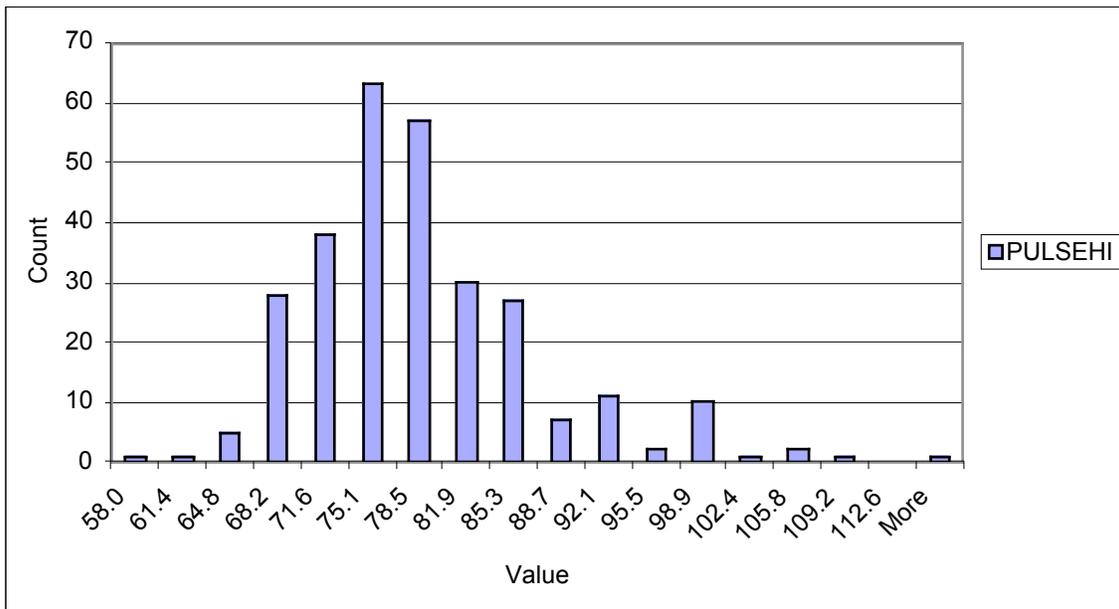
Graph 1.11 – Distribution of Weight Readings for T2
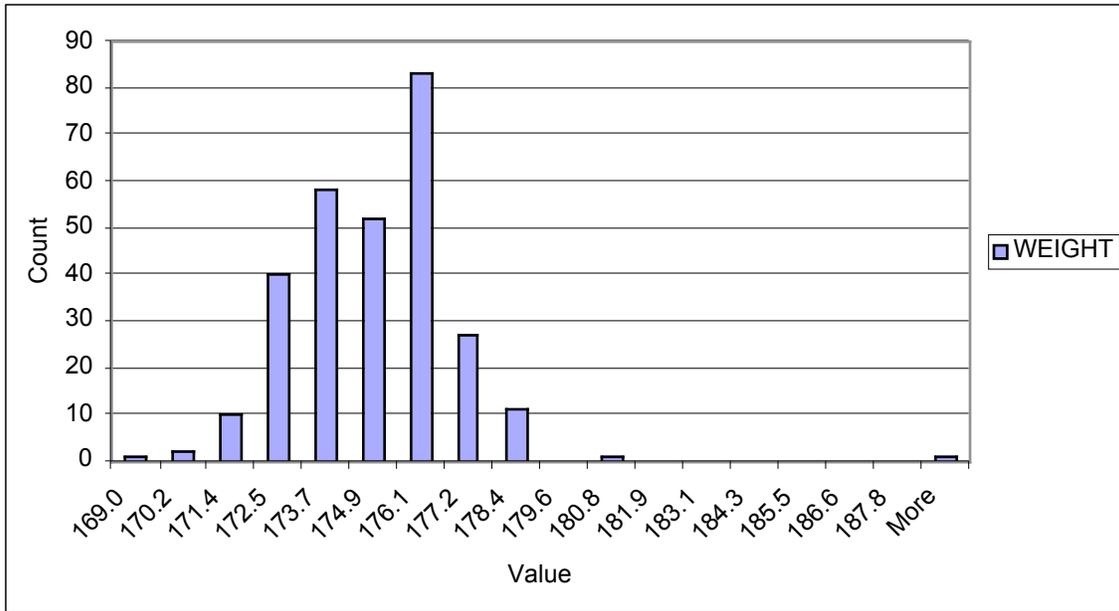
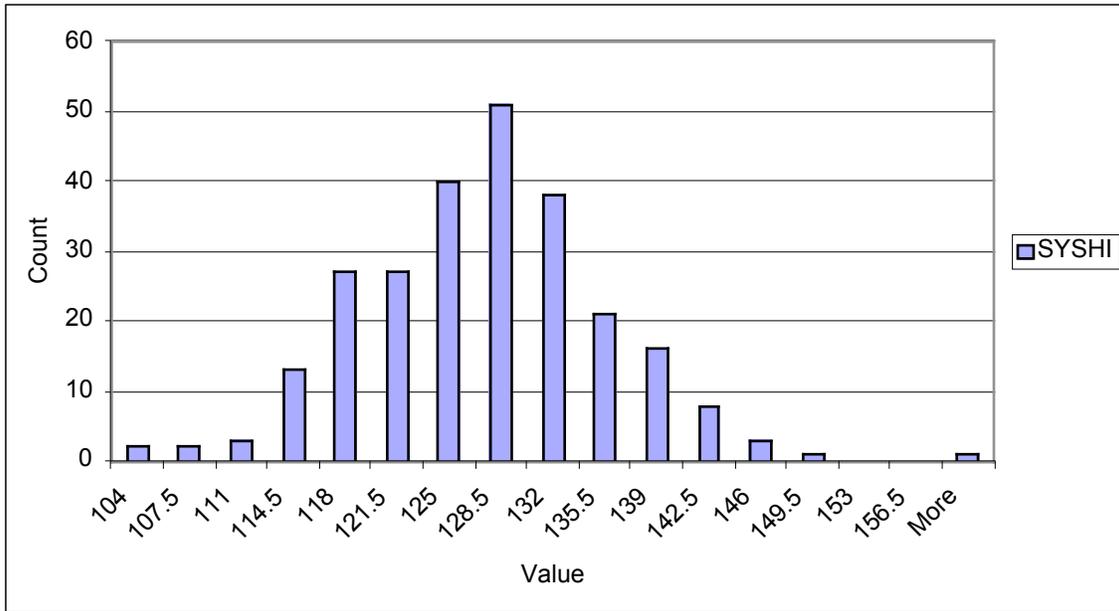**Graph 1.12 – Distribution of O2 Readings for T2**
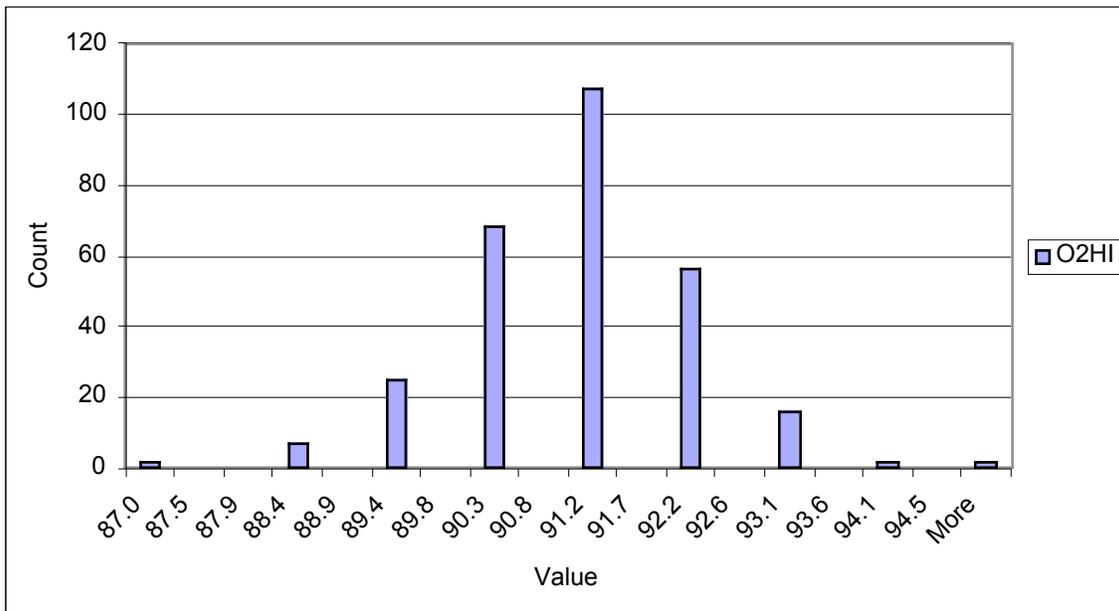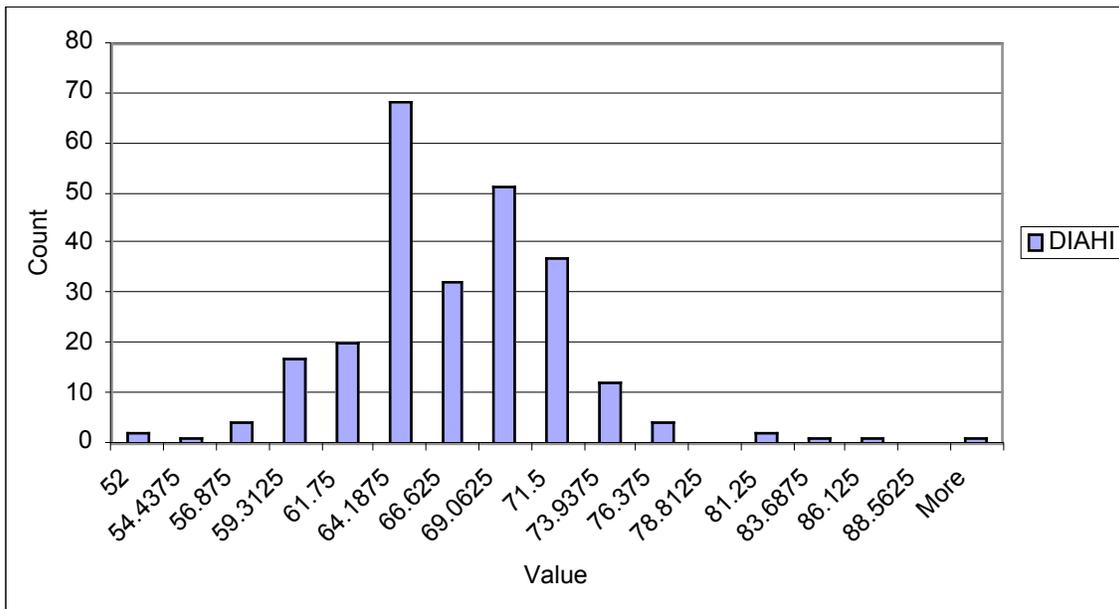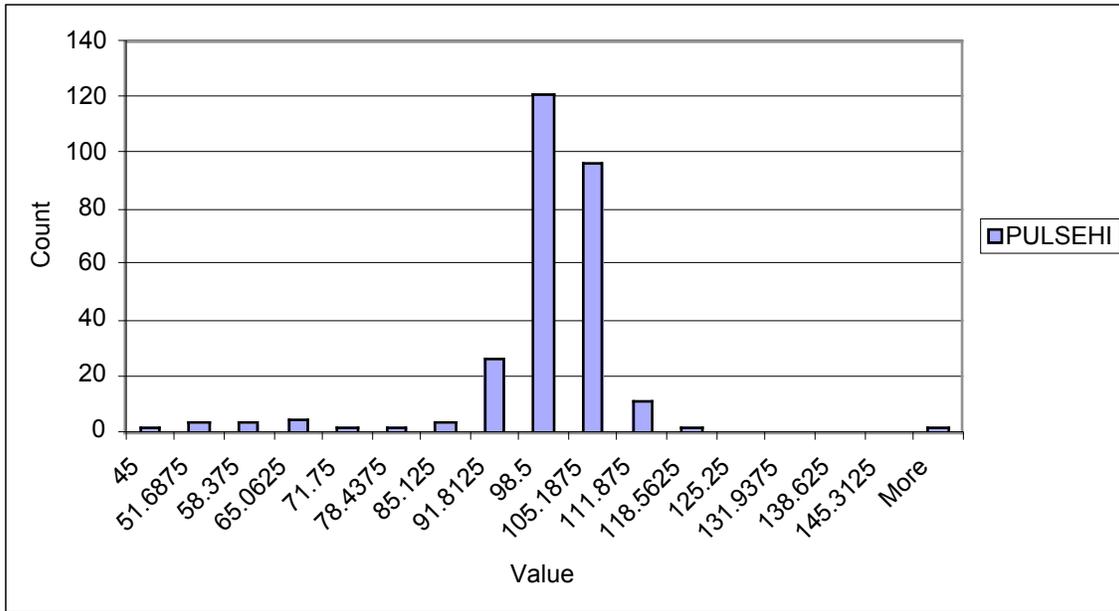
Graph 1.13 – T3 Composite Data
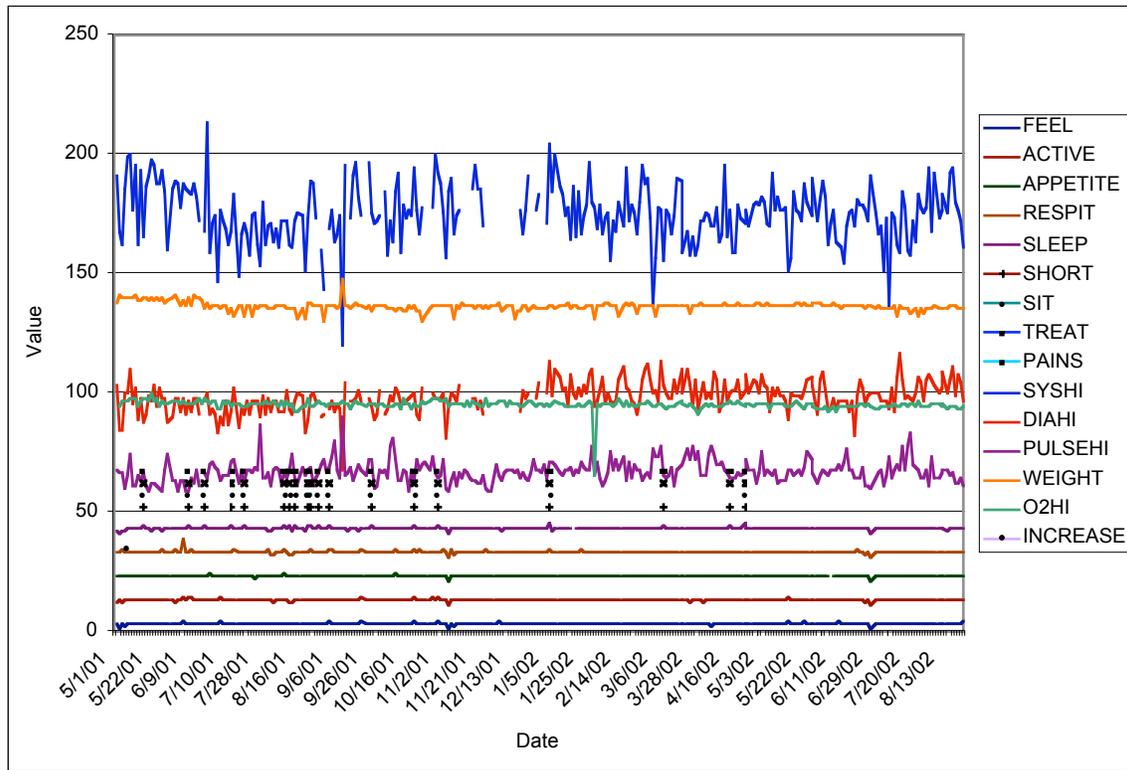
Table 1.4 – Statistical Measurements for T3

MEASURE	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	175.2246	98.0211	66.8268	136.2638	94.6765
Standard Error	0.7360	0.3652	0.2670	0.1125	0.1152
Median	175	98	66	136	95
Mode	172	96	66	137	95
Standard Deviation	12.4255	6.1649	4.6707	1.9717	2.0155
Sample Variance	154.3931	38.0066	21.8158	3.8877	4.0622
Kurtosis	1.3594	2.1147	2.7780	4.6998	154.5769
Skewness	-0.3609	-0.3868	1.1193	0.3672	-10.4297
Range	93	49	32	18	35
Minimum	120	67	58	130	65
Maximum	213	116	90	148	100

Graph 1.14 – Distribution of Systolic Readings for T3
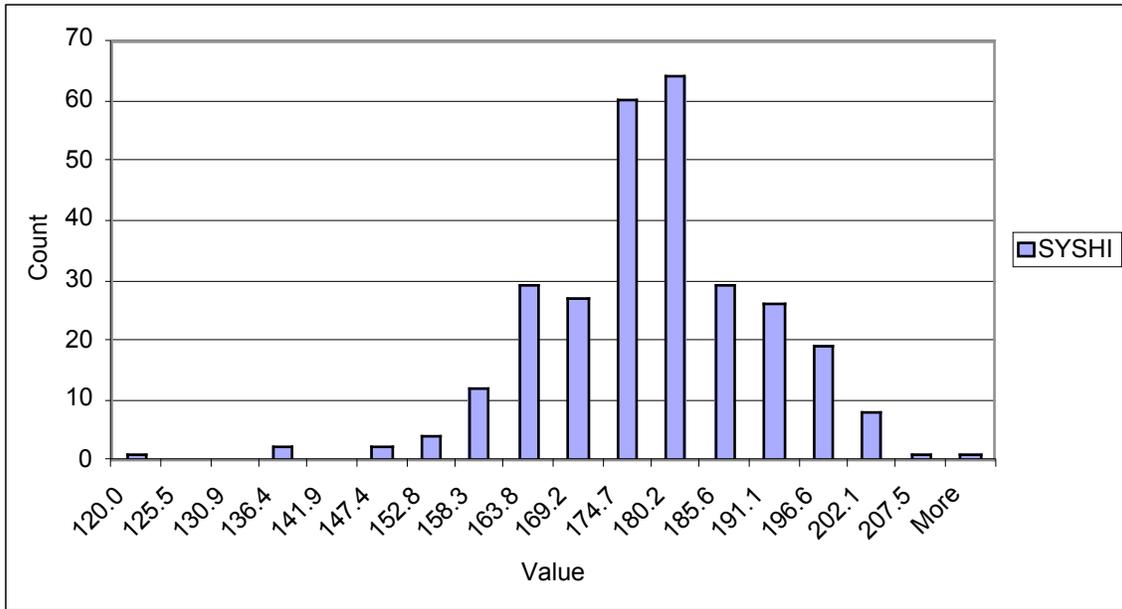

Graph 1.15 – Distribution of Diastolic Readings for T3
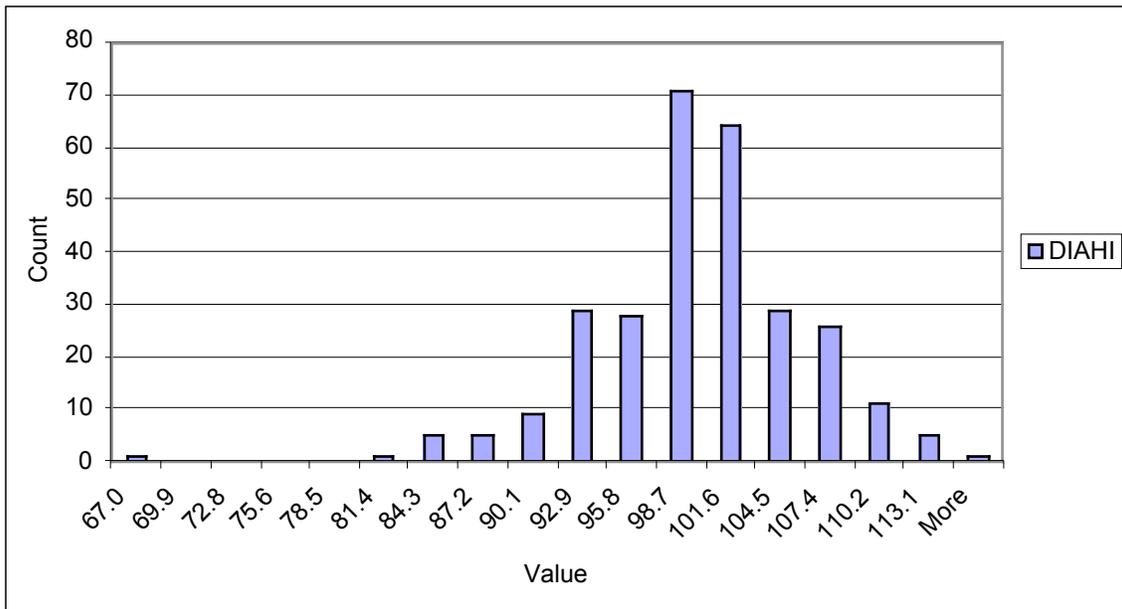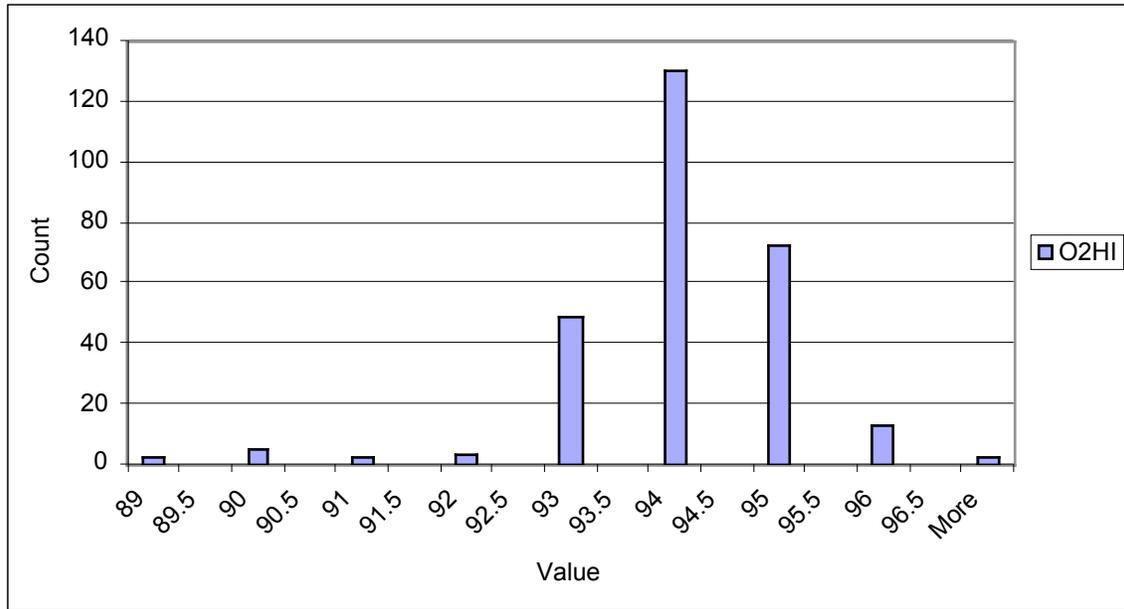
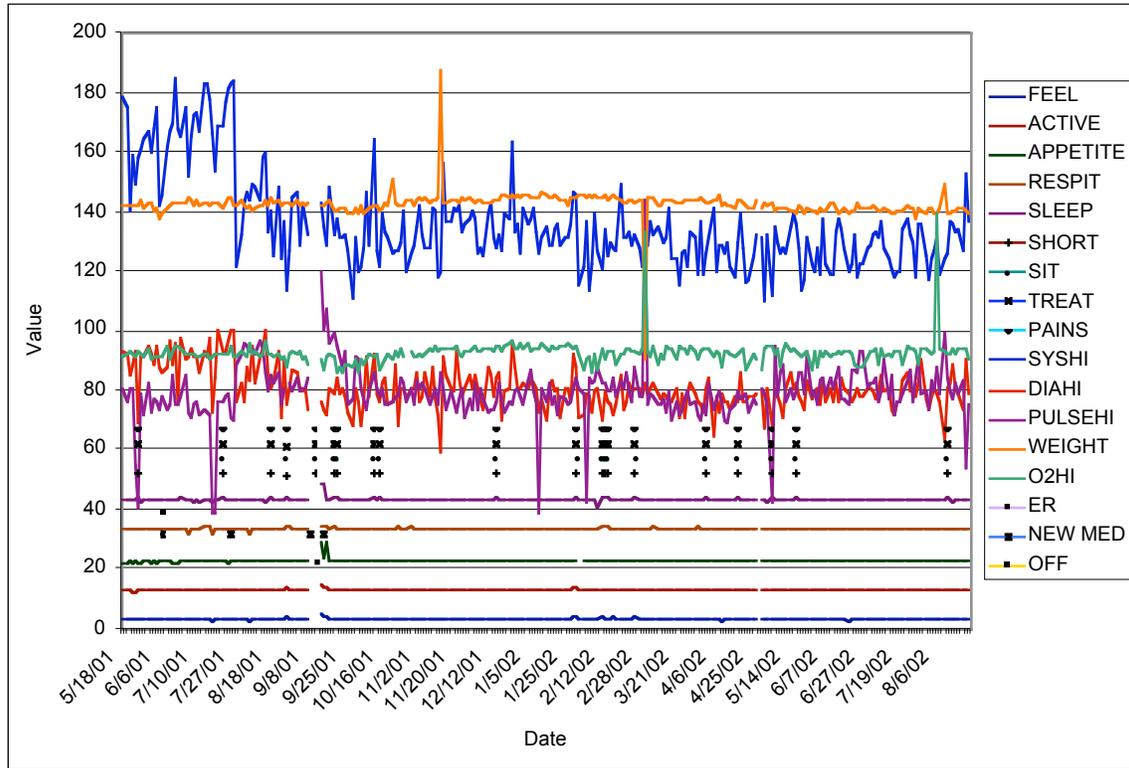**Graph 1.16 – Distribution of Pulse Readings for T3**
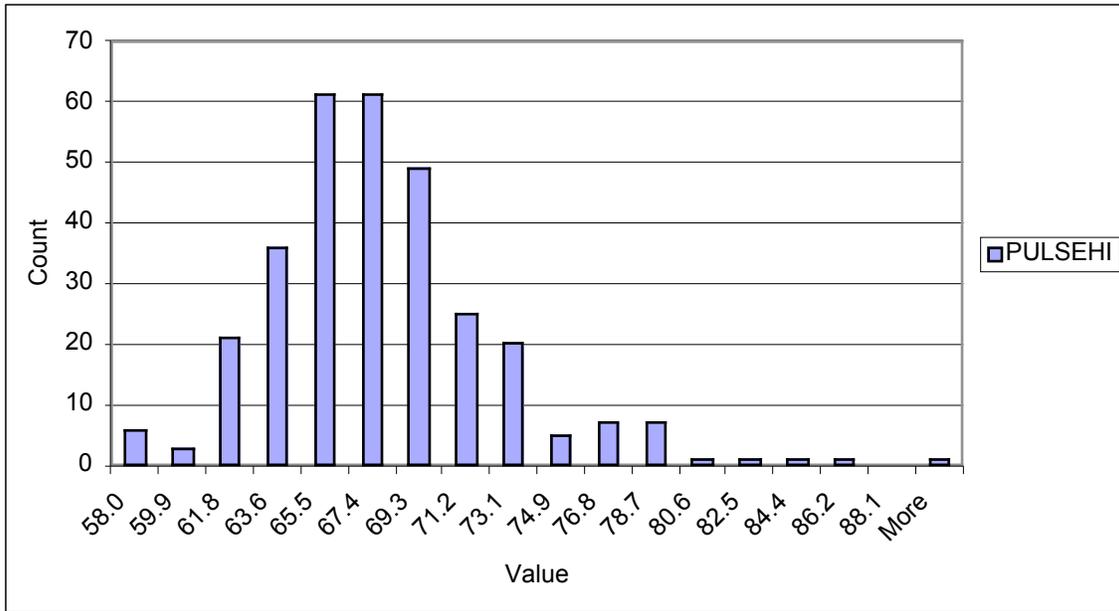
Graph 1.17 – Distribution of Weight Readings for T3
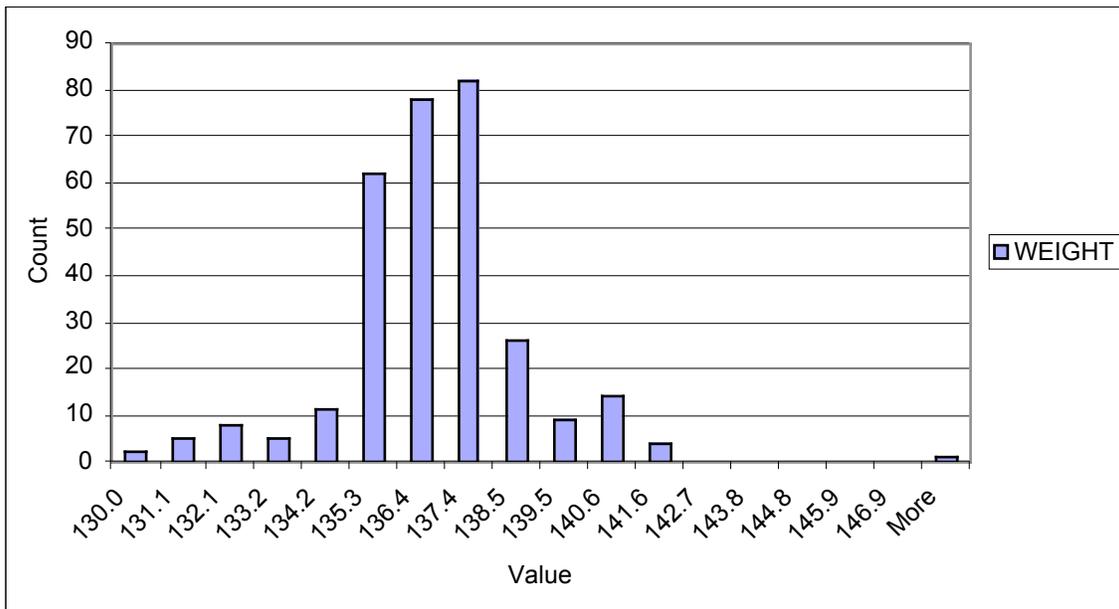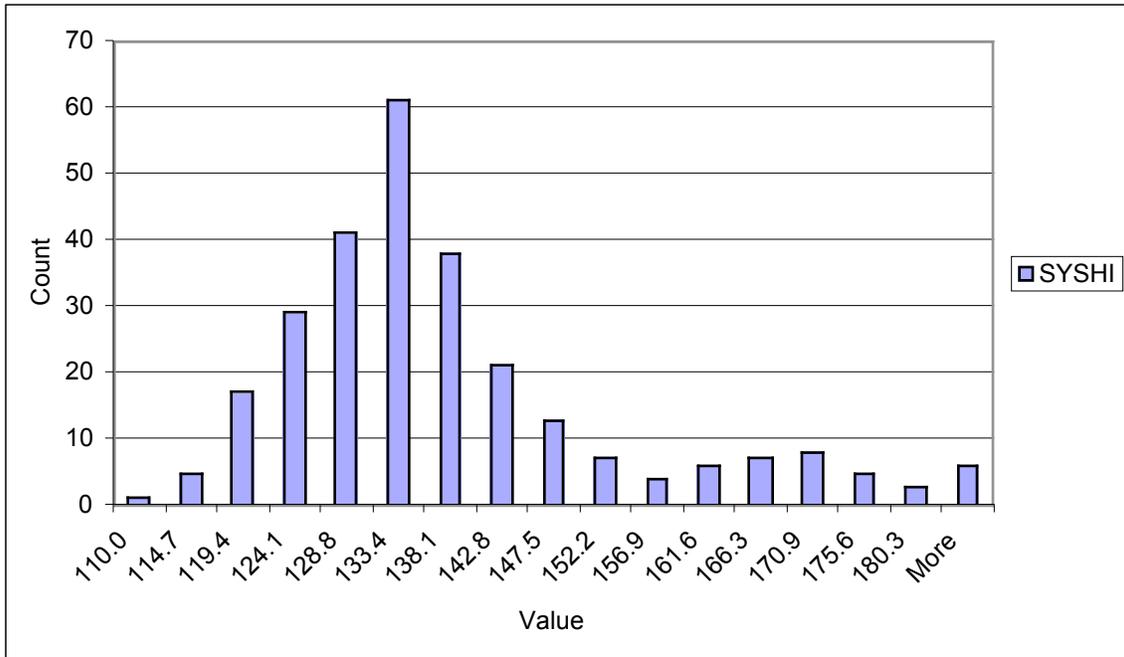
Graph 1.18 – Distribution of O2 Readings for T3
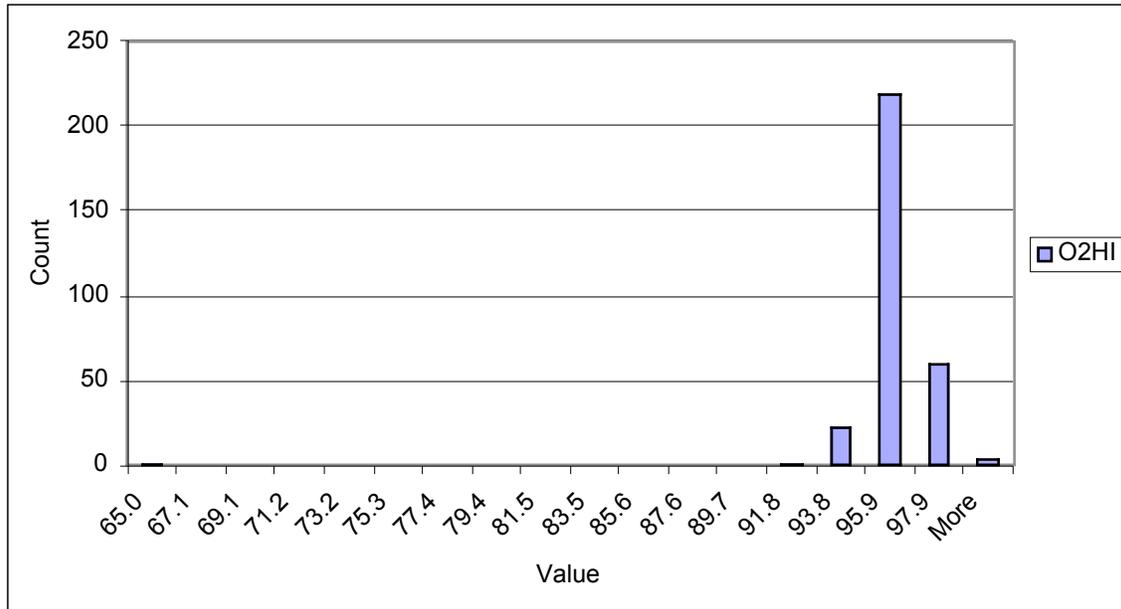
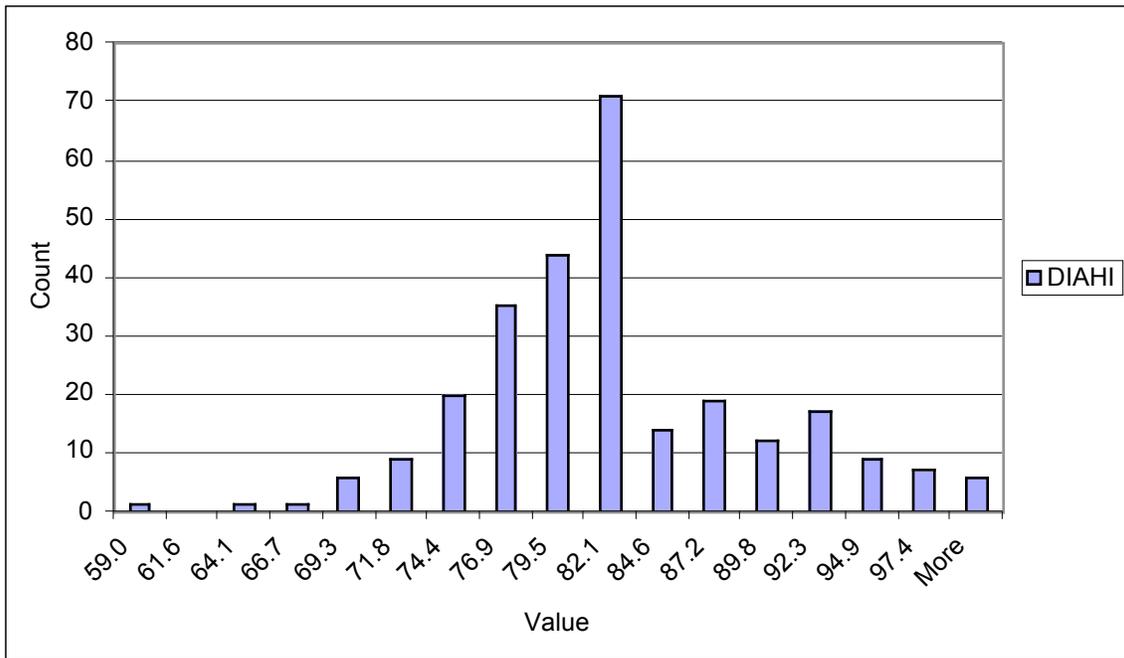**Graph 1.19 – T4 Composite Data**
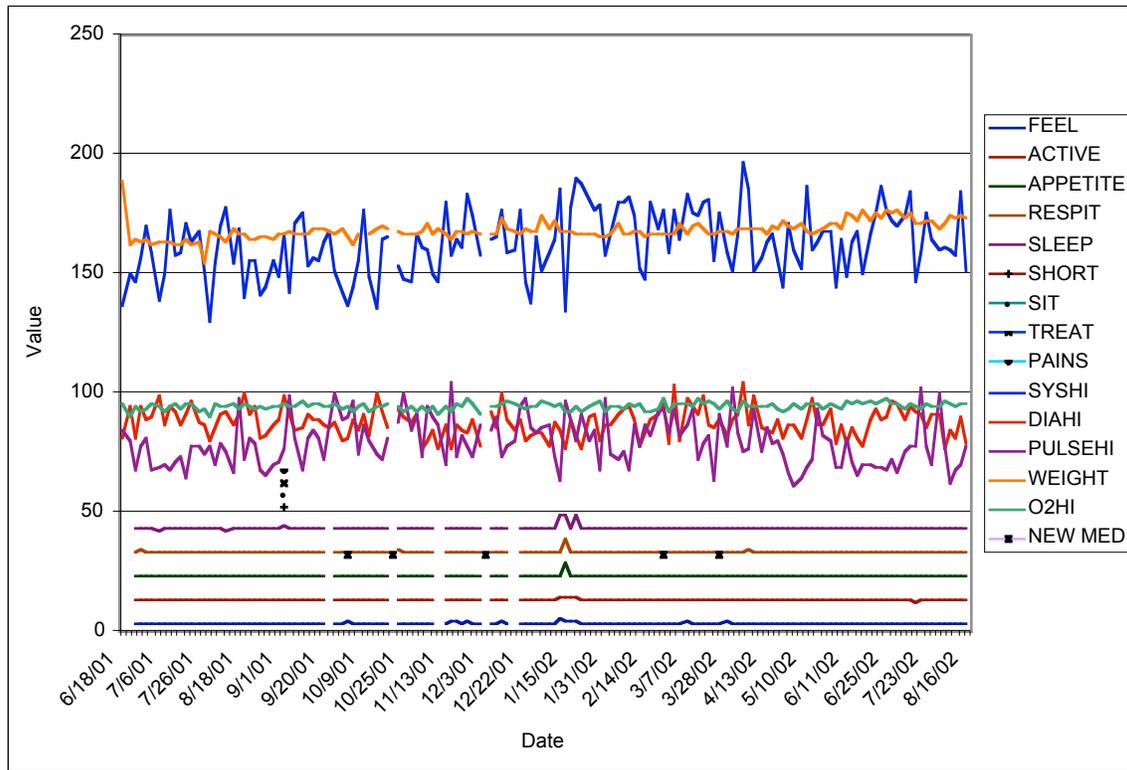
Table 1.5 – Statistical Measurements for T4

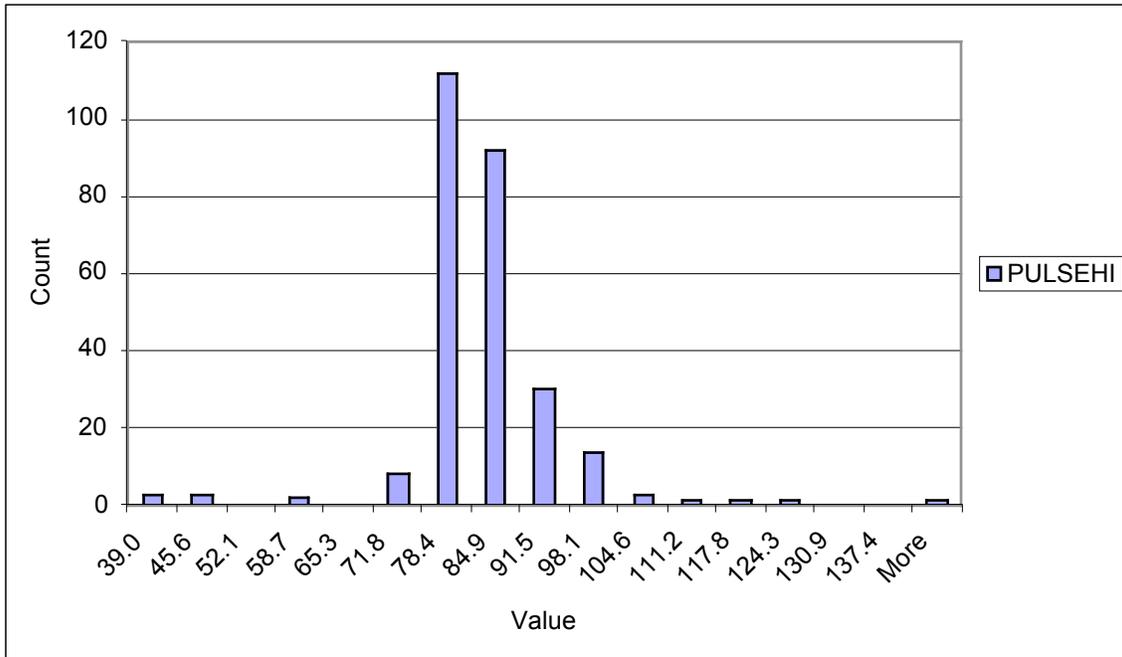| MEASUREMENT	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	162.5205	87.3151	79.1712	168.1517	94.0753
Standard Error	1.1233	0.5019	0.8212	0.3218	0.1126
Median	163	87	78	168	94
Mode	159	86	70	167	94
Standard Deviation	13.5729	6.0649	9.9227	3.8754	1.3599
Sample Variance	184.2237	36.7828	98.4601	15.0185	1.8495
Kurtosis	-0.5872	-0.1627	-0.4420	5.8281	0.2559
Skewness	-0.0092	0.2593	0.4840	0.9695	-0.4384
Range	66	28	43	35	7
Minimum	130	76	61	154	90
Maximum	196	104	104	189	97

**Graph 1.20 – Distribution of Systolic Readings for T4**

**Graph 1.21 – Distribution of Diastolic Readings for T4**

**Graph 1.22 – Distribution of Pulse Readings for T4**

Graph 1.23 – Distribution of Weight Readings for T4

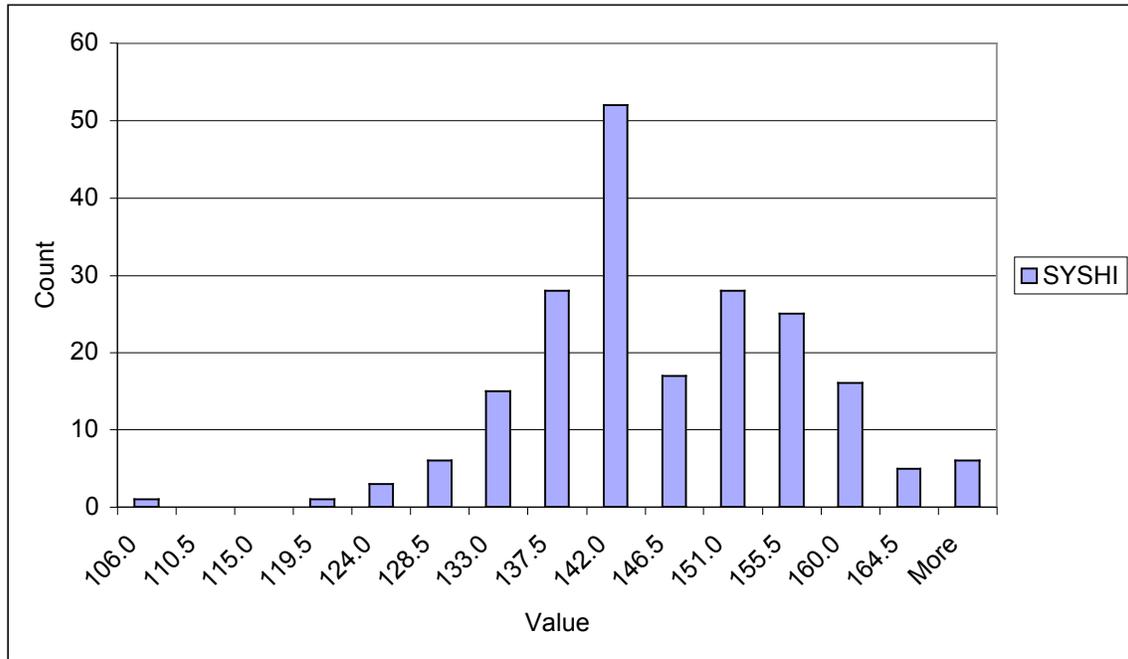**Graph 1.24 – Distribution of O2 Readings for T4**
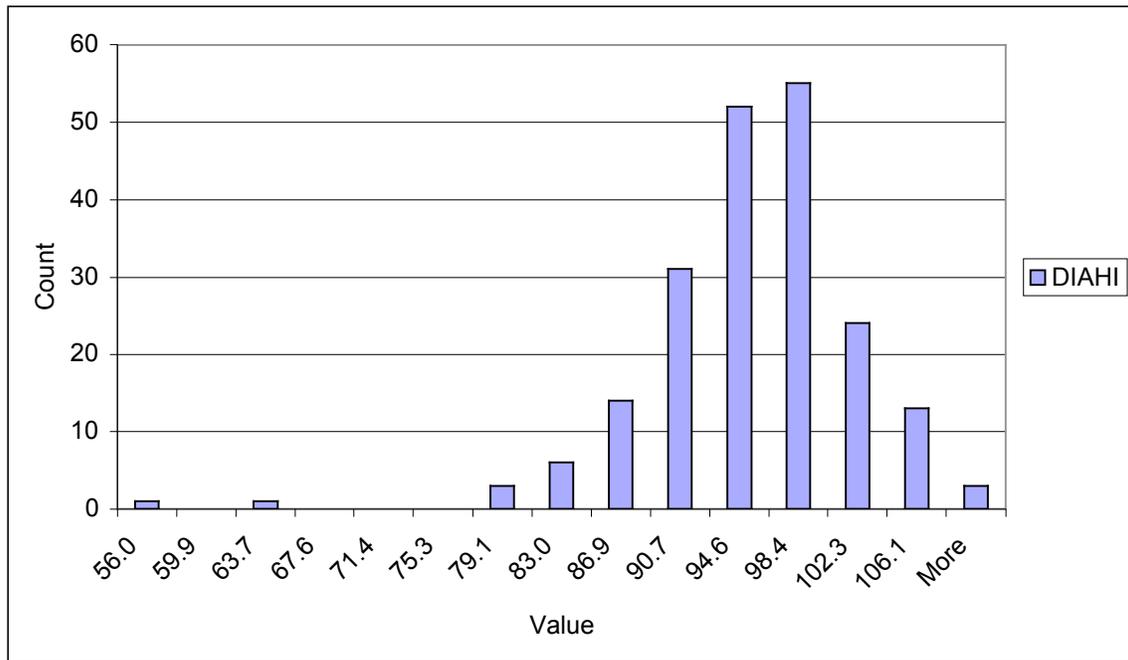
Graph 1.25 – T5 Composite Data

Legend: FEEL, ACTIVE, APPETITE, RESPIT, SLEEP, SHORT, SIT, TREAT, PAINS, SYSHI, DIAHI, PULSEHI, WEIGHT, O2HI, NEW MED, INCREASE, DECREASE

Table 1.6 – Statistical Measurements for T5

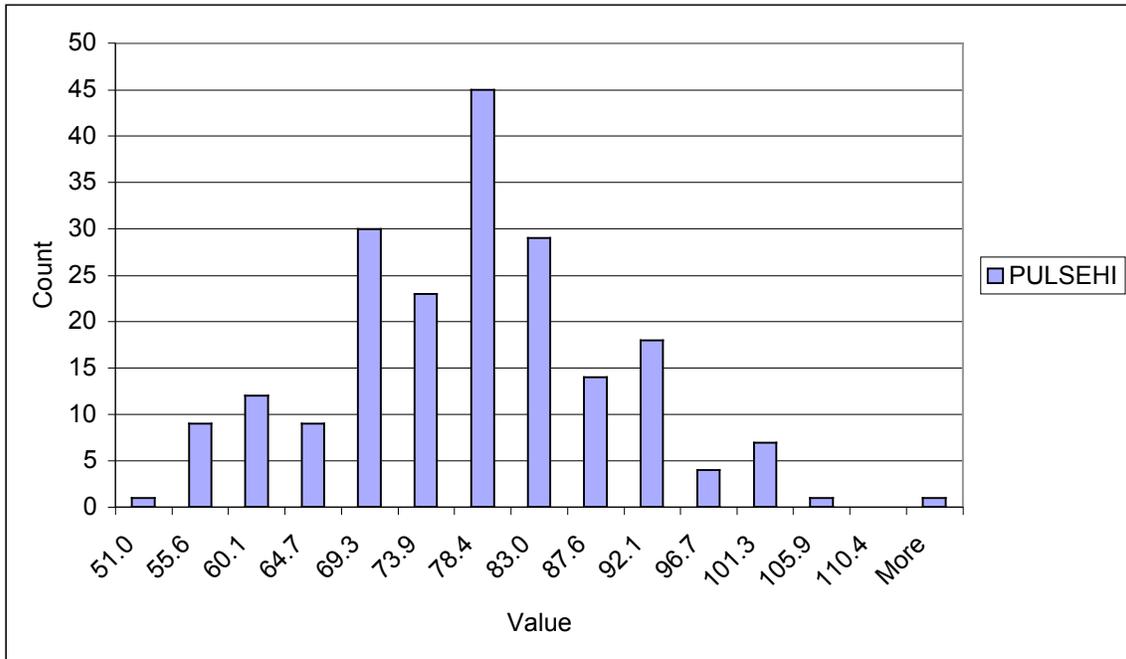| MEASUREMENT	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	125.9328	65.6482	95.7721	152.6234	94.0468
Standard Error	0.5211	0.3277	0.6445	0.4255	0.0675
Median	126	66	97	151	94
Mode	127	62	101	151	94
Standard Deviation	8.2884	5.2128	10.6289	6.5779	1.1247
Sample Variance	68.6978	27.1734	112.9737	43.2694	1.2650
Kurtosis	0.7722	2.5505	10.8667	21.5128	4.6285
Skewness	0.2259	0.6527	-1.9456	3.9003	-1.3193
Range	56	39	107	57	8
Minimum	104	52	45	144	89
Maximum	160	91	152	201	97

**Graph 1.26 – Distribution of Systolic Readings for T5**

**Graph 1.27 – Distribution of Diastolic Readings for T5**

Graph 1.28 – Distribution of Pulse Readings for T5

Graph 1.29 – Distribution of Weight Readings for T5
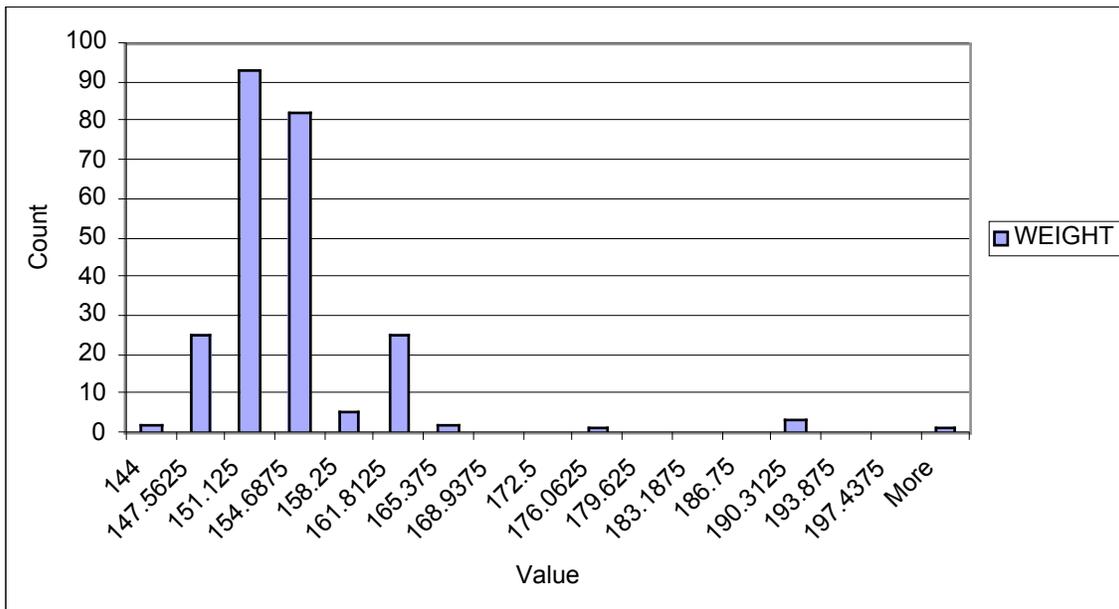
Graph 1.30 – Distribution of O2 Readings for T5

Graph 1.31 – T6 Composite Data

Legend: FEEL, ACTIVE, APPETITE, RESPIT, SLEEP, SHORT, SIT, TREAT, PAINS, SYSHI, DIAHI, PULSEHI, WEIGHT, O2HI, ER, NEW MED, OFF

Y-axis: Value
X-axis: Date

Table 1.7 – Statistical Measurements for T6

MEASUREMENT	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	136.1360	81.0625	79.5904	142.5772	92.5092
Standard Error	0.9529	0.4264	0.6165	0.2827	0.2642
Median	132	81	79	143	92
Mode	131	81	75	144	92
Standard Deviation	15.7161	7.0329	10.1481	4.6629	4.3486
Sample Variance	246.9962	49.4610	102.9835	21.7431	18.9101
Kurtosis	1.2896	0.3927	10.7444	89.1487	75.1488
Skewness	1.2871	0.4267	0.2501	-2.0957	7.4335
Range	75	41	105	97	53
Minimum	110	59	39	90	86
Maximum	185	100	144	187	139

Graph 1.32 – Distribution of Systolic Readings for T6

Graph 1.33 – Distribution of Diastolic Readings for T6

**Graph 1.34 – Distribution of Pulse Readings for T6**

Graph 1.35 – Distribution of Weight Readings for T6
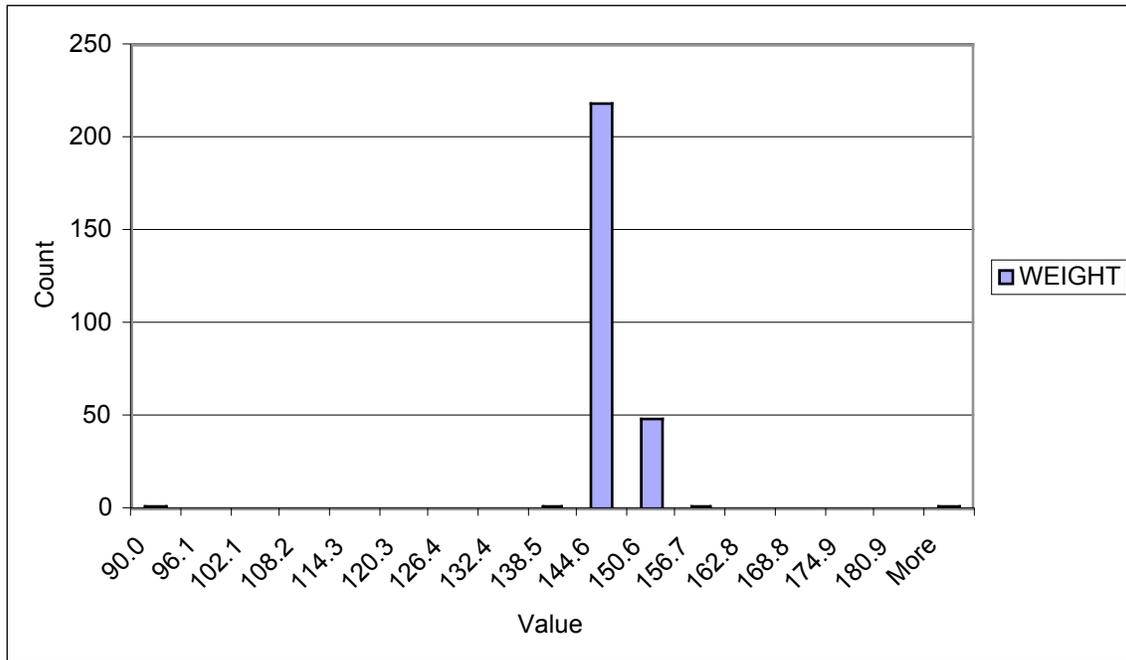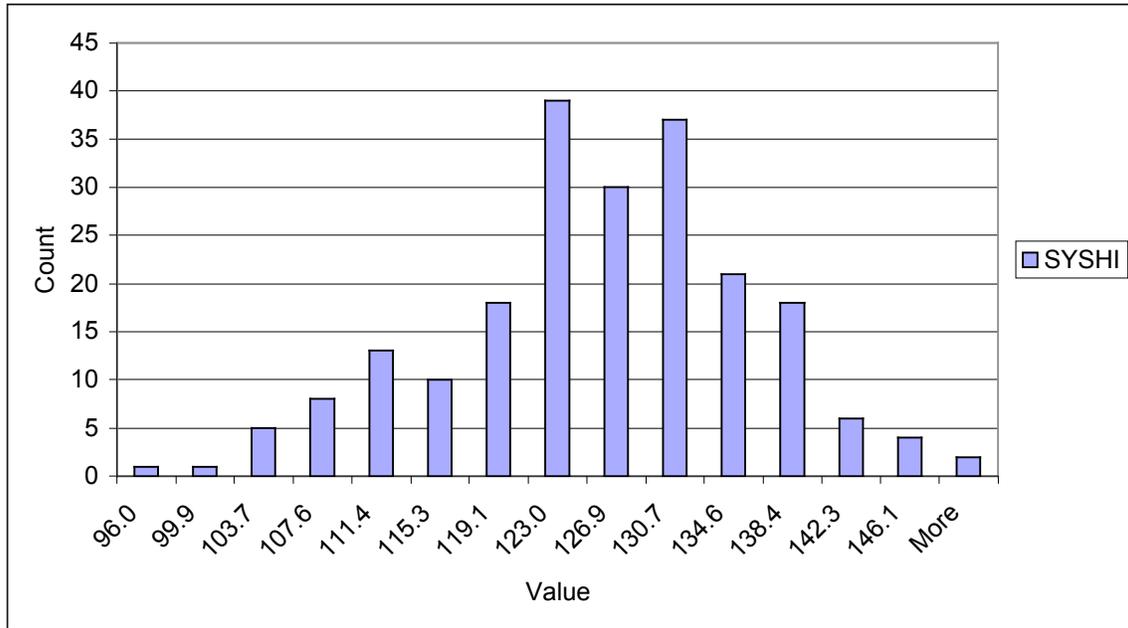
Graph 1.36 – Distribution of O2 Readings for T6
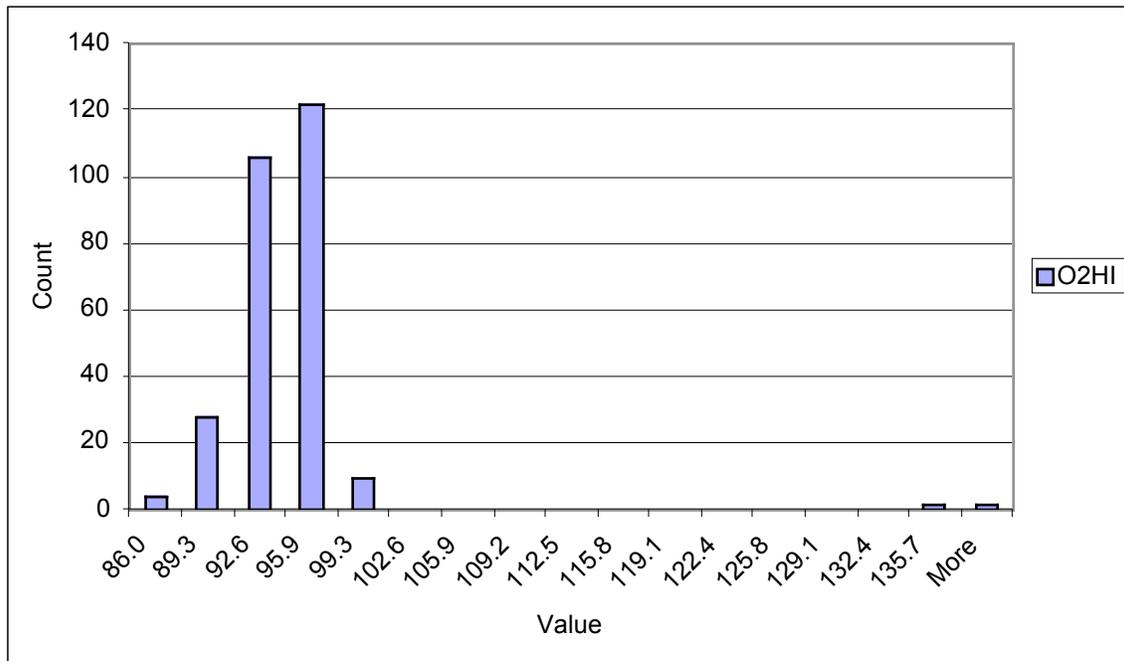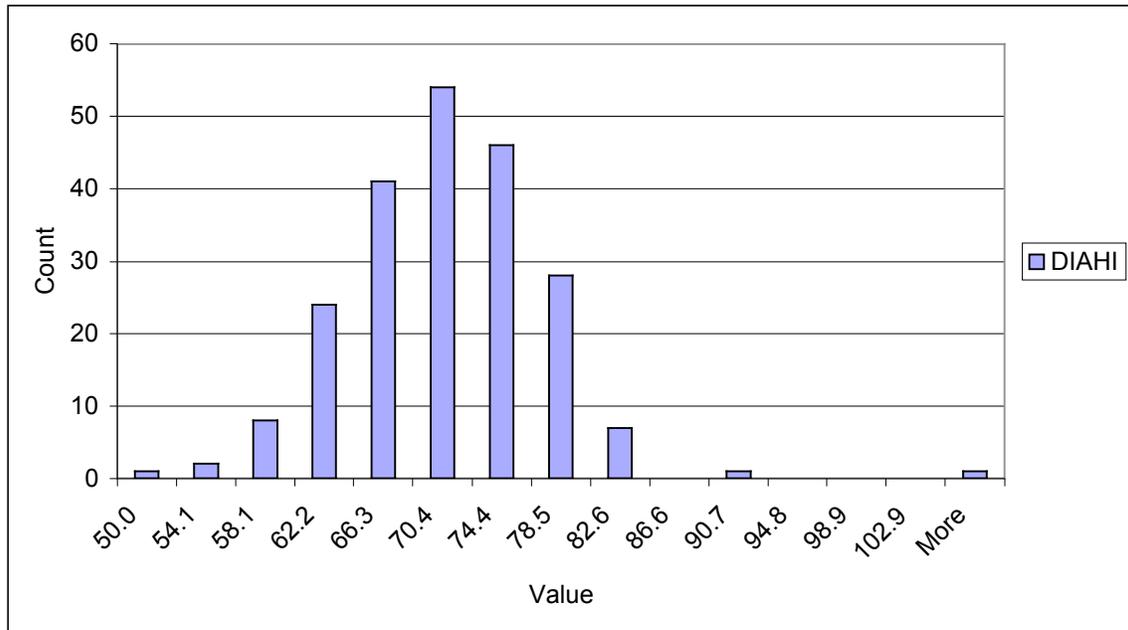
Graph 1.37 – T7 Composite Data
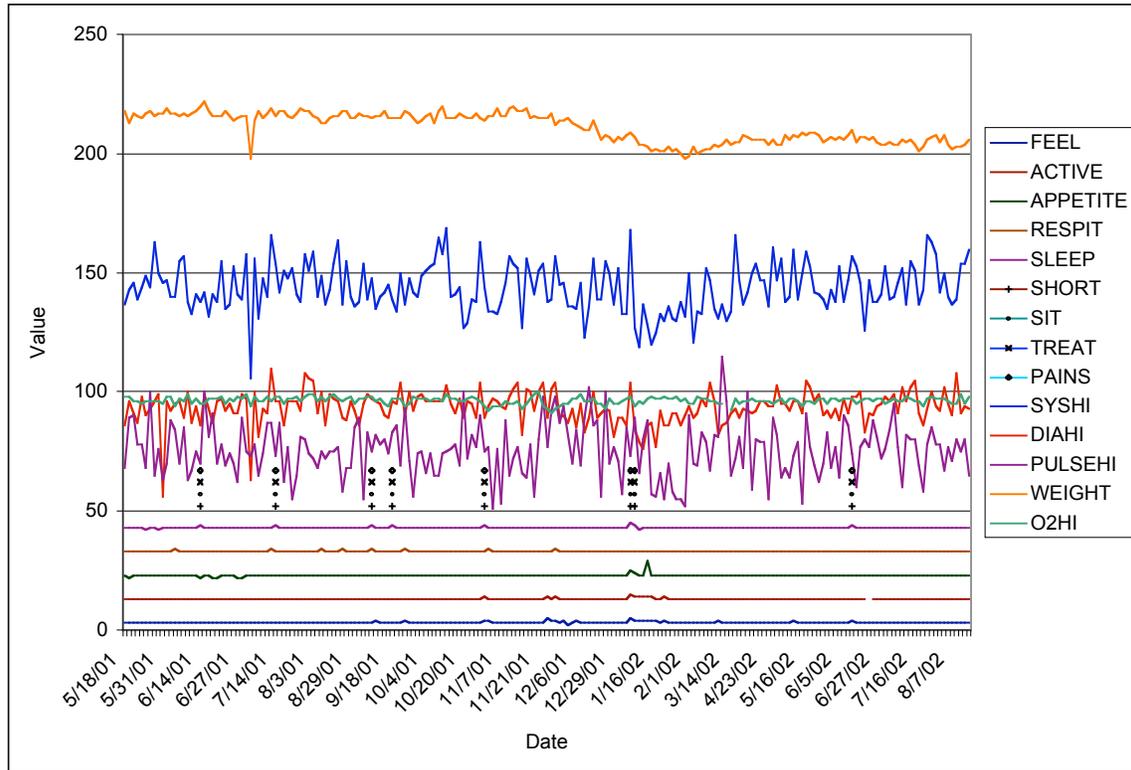
Table 1.8 – Statistical Measurements for T7

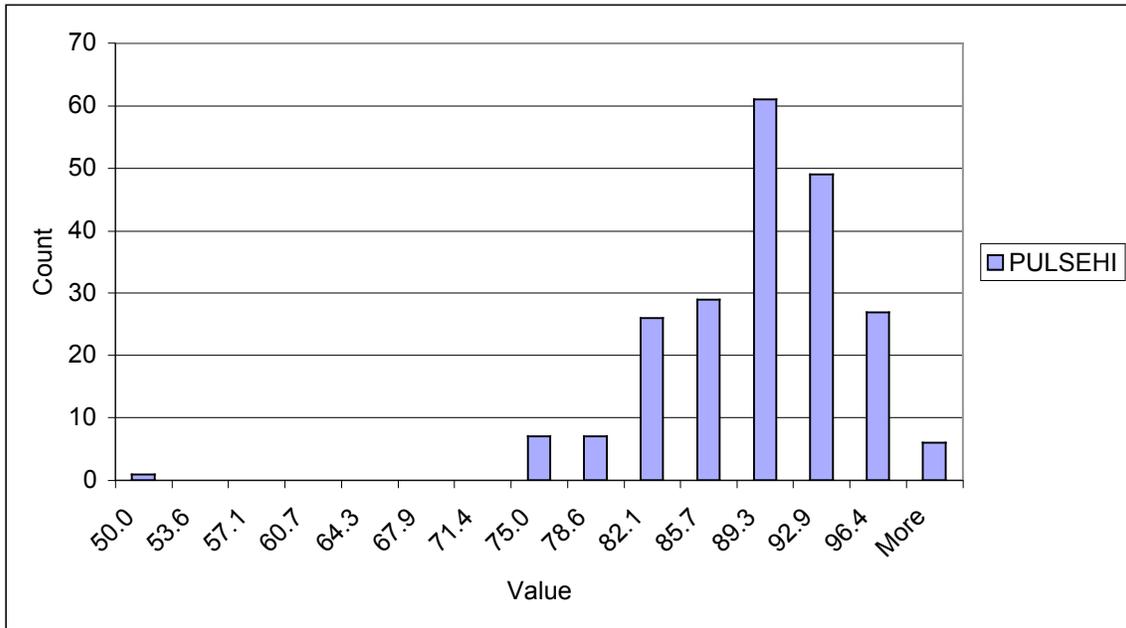| MEASUREMENT	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	143.8128	93.4286	75.4532	211.0739	96.3069
Standard Error	0.7266	0.4769	0.8006	0.4202	0.1025
Median	142	94	75	213	96
Mode	138	96	77	216	97
Standard Deviation	10.3524	6.7954	11.4062	5.9876	1.4575
Sample Variance	107.1727	46.1768	130.1005	35.8509	2.1242
Kurtosis	0.2663	5.5949	0.1543	-1.3074	0.7297
Skewness	-0.0157	-1.2108	0.2220	-0.2999	-0.5080
Range	63	54	64	24	9
Minimum	106	56	51	198	91
Maximum	169	110	115	222	100

**Graph 1.38 – Distribution of Systolic Readings for T7**

**Graph 1.39 – Distribution of Diastolic Readings for T7**

**Graph 1.40 – Distribution of Pulse Readings for T7**

Graph 1.41 – Distribution of Weight Readings for T7
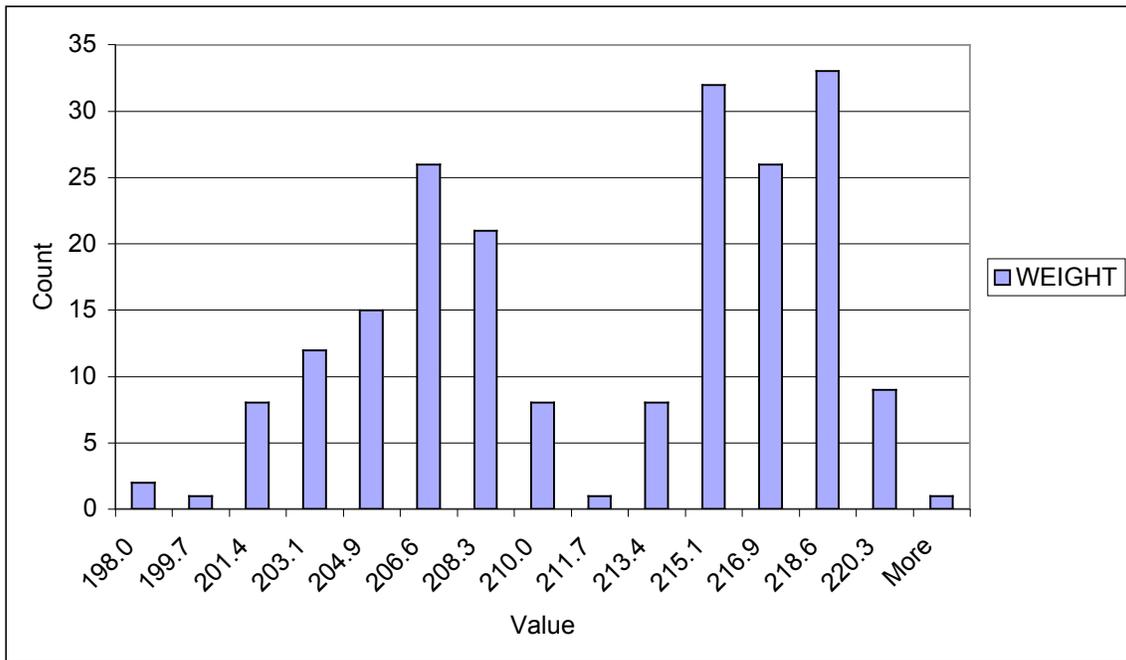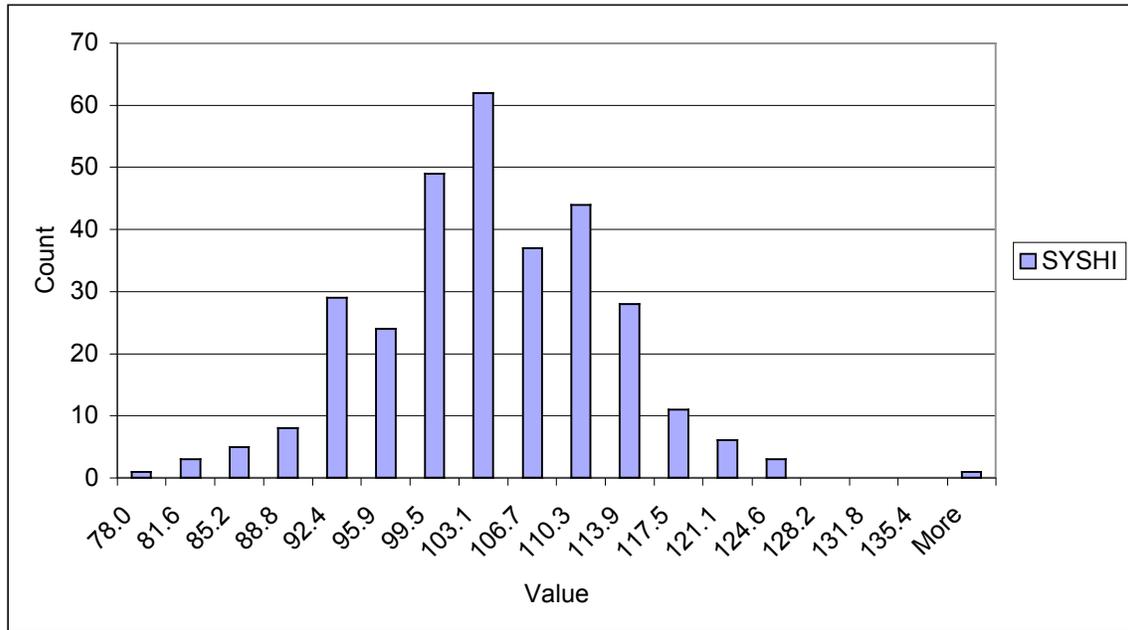
Graph 1.42 – Distribution of O2 Readings for T7
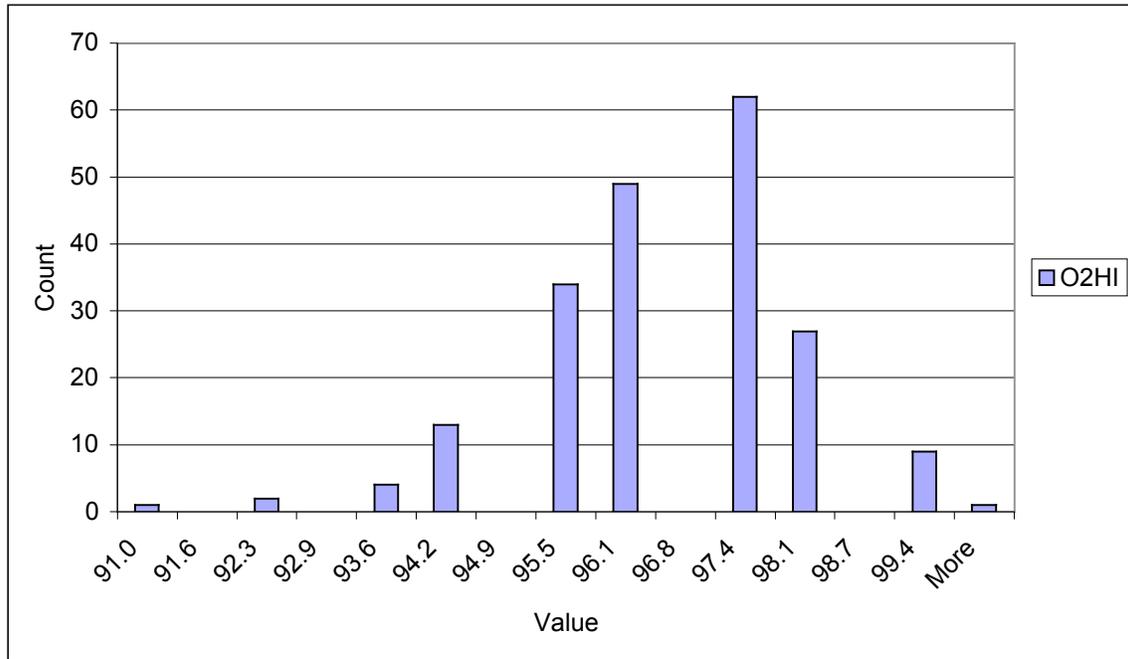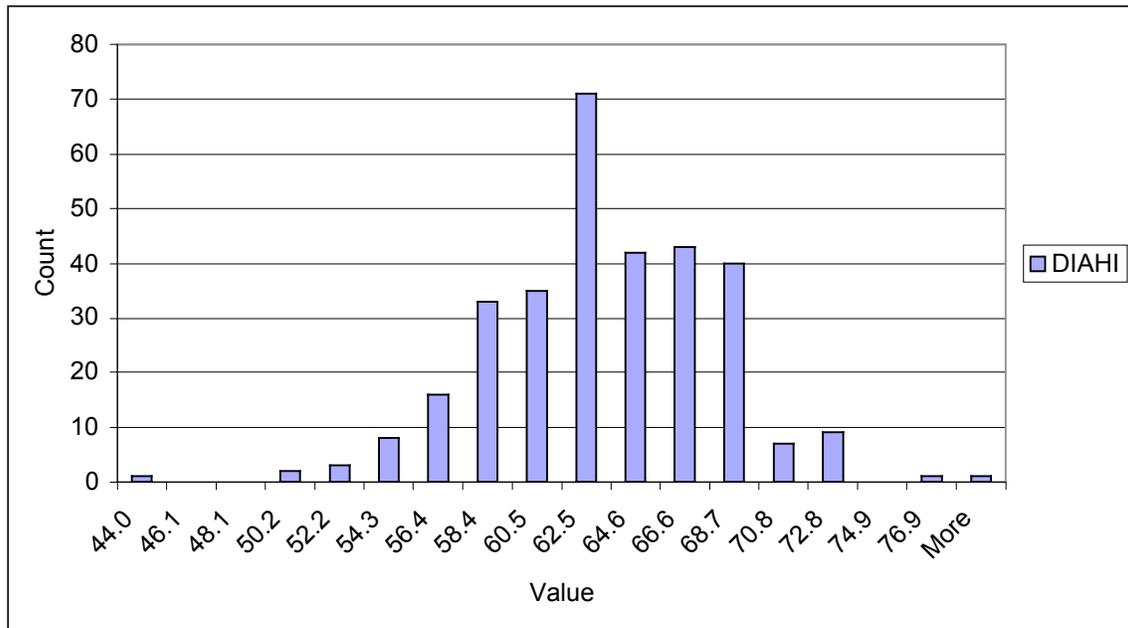
Graph 1.43 – T8 Composite Data
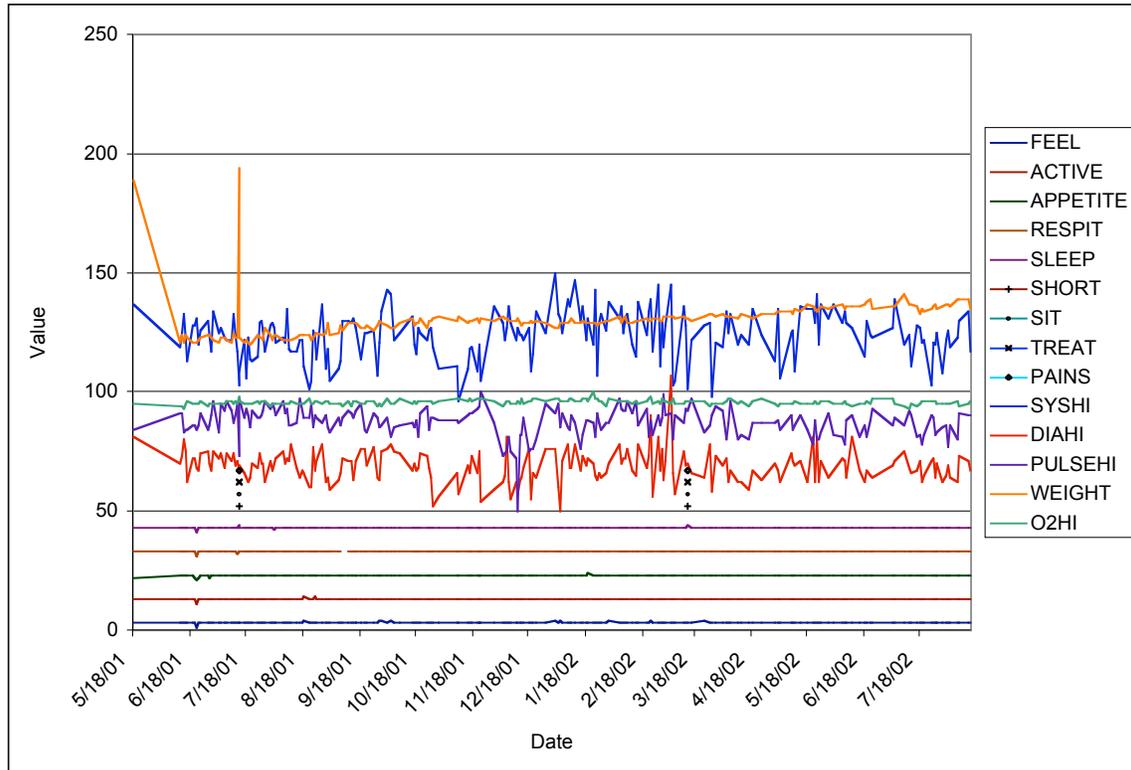
Table 1.9 – Statistical Measurements for T8

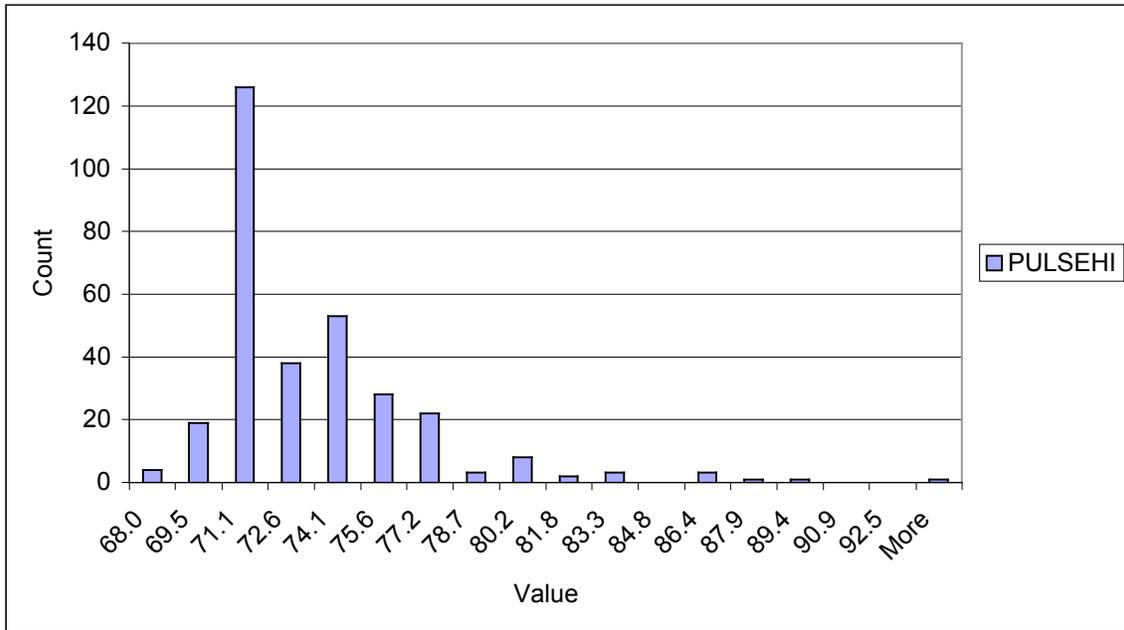| MEASUREMENT	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	124.0235	68.7230	87.1925	129.9577	95.5869
Standard Error	0.6747	0.4562	0.4103	0.5262	0.0648
Median	125	69	88	130	96
Mode	122	71	90	129	95
Standard Deviation	9.8476	6.6583	5.9886	7.6801	0.9458
Sample Variance	96.9759	44.3333	35.8637	58.9841	0.8945
Kurtosis	0.1119	4.7596	6.2037	37.7356	1.6658
Skewness	-0.2958	0.8092	-1.3734	4.8205	0.4732
Range	54	57	50	74	7
Minimum	96	50	50	120	93
Maximum	150	107	100	194	100

**Graph 1.44 – Distribution of Systolic Readings for T8**

**Graph 1.45 – Distribution of Diastolic Readings for T8**

Graph 1.46 – Distribution of Pulse Readings for T8

Graph 1.47 – Distribution of Weight Readings for T8
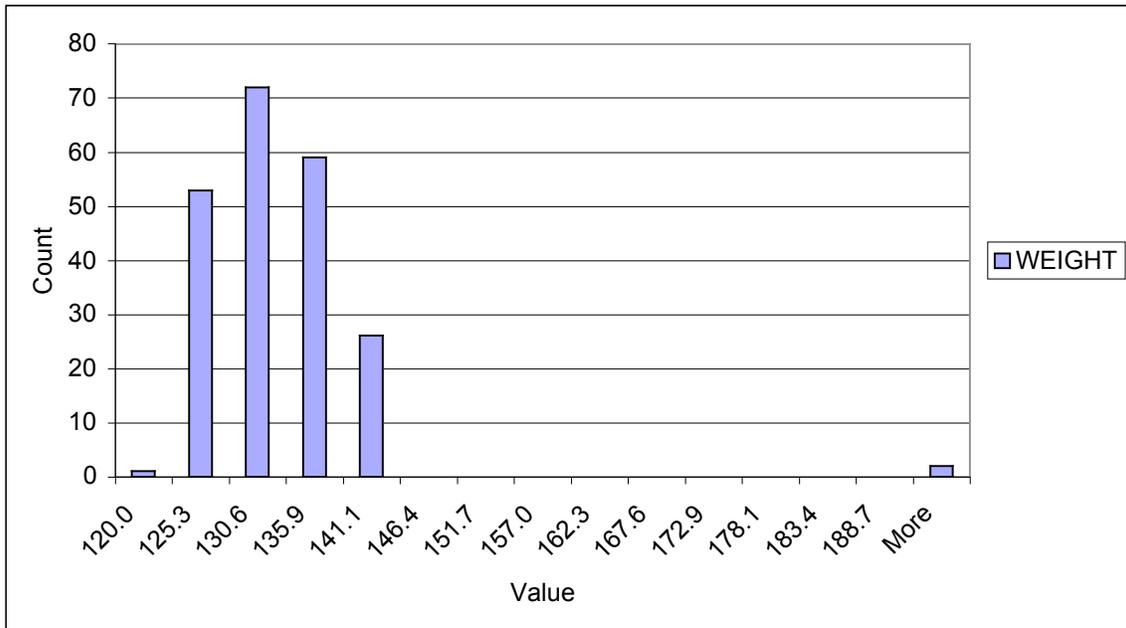
Graph 1.48 – Distribution of O2 Readings for T8
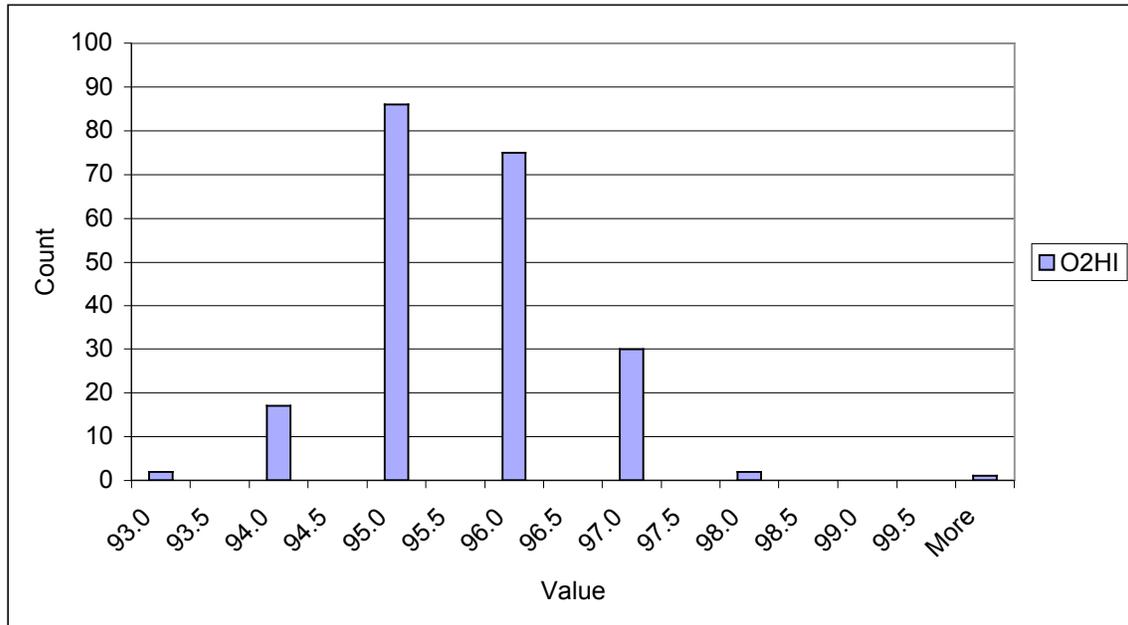
Graph 1.49 – T9 Composite Data
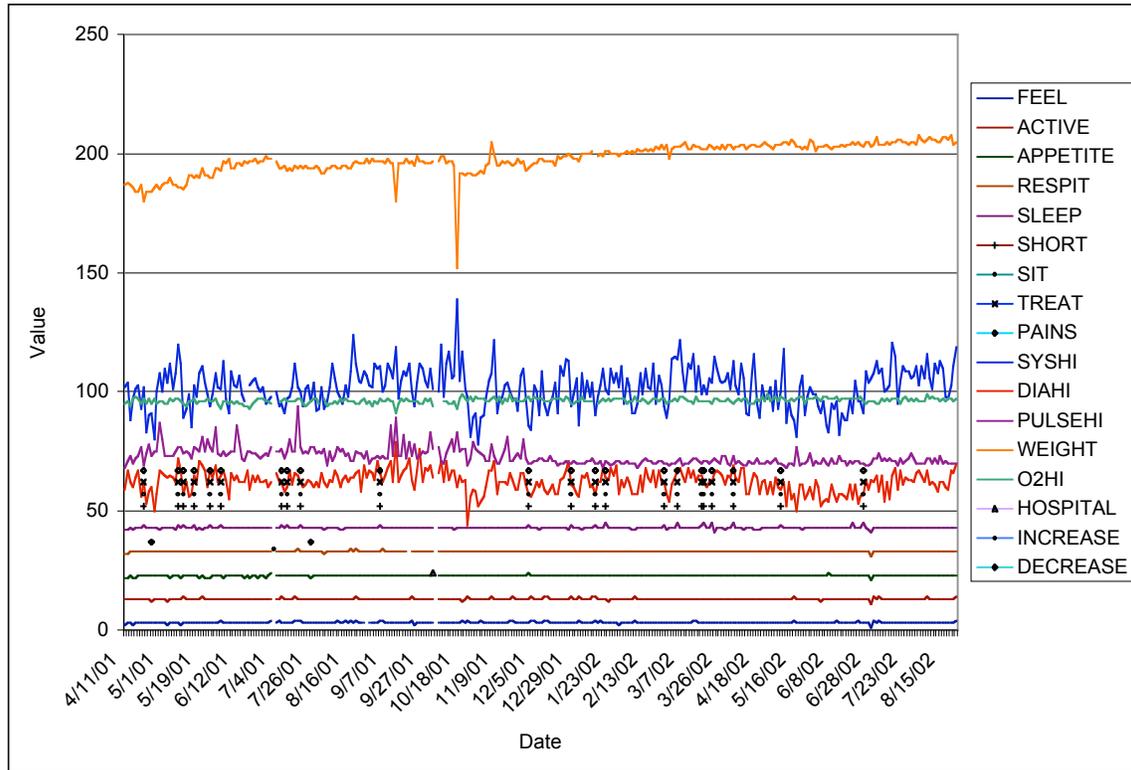
Table 1.10 – Statistical Measurements for T9

MEASUREMENT	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	101.8810	62.2692	72.6827	198.0772	96.2630
Standard Error	0.4931	0.2577	0.2007	0.3553	0.0610
Median	102	62	72	198	96
Mode	103	62	70	204	96
Standard Deviation	8.6953	4.5524	3.5456	6.2651	1.0703
Sample Variance	75.6084	20.7247	12.5710	39.2521	1.1456
Kurtosis	0.6311	0.8779	6.9834	8.6421	1.9062
Skewness	0.1112	-0.1854	2.1518	-1.7321	-0.5403
Range	61	35	26	56	8
Minimum	78	44	68	152	91
Maximum	139	79	94	208	99

Graph 1.50 – Distribution of Systolic Readings for T9

Graph 1.51 – Distribution of Diastolic Readings for T9

Graph 1.52 – Distribution of Pulse Readings for T9
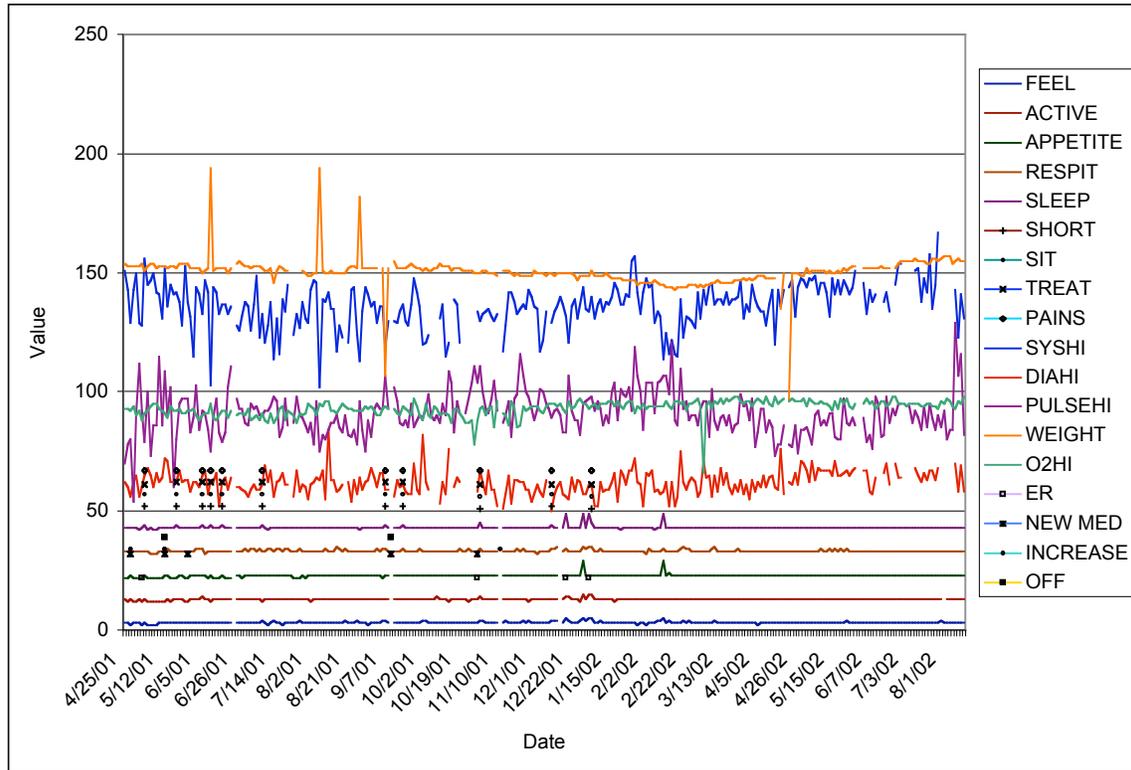

Graph 1.53 – Distribution of Weight Readings for T9
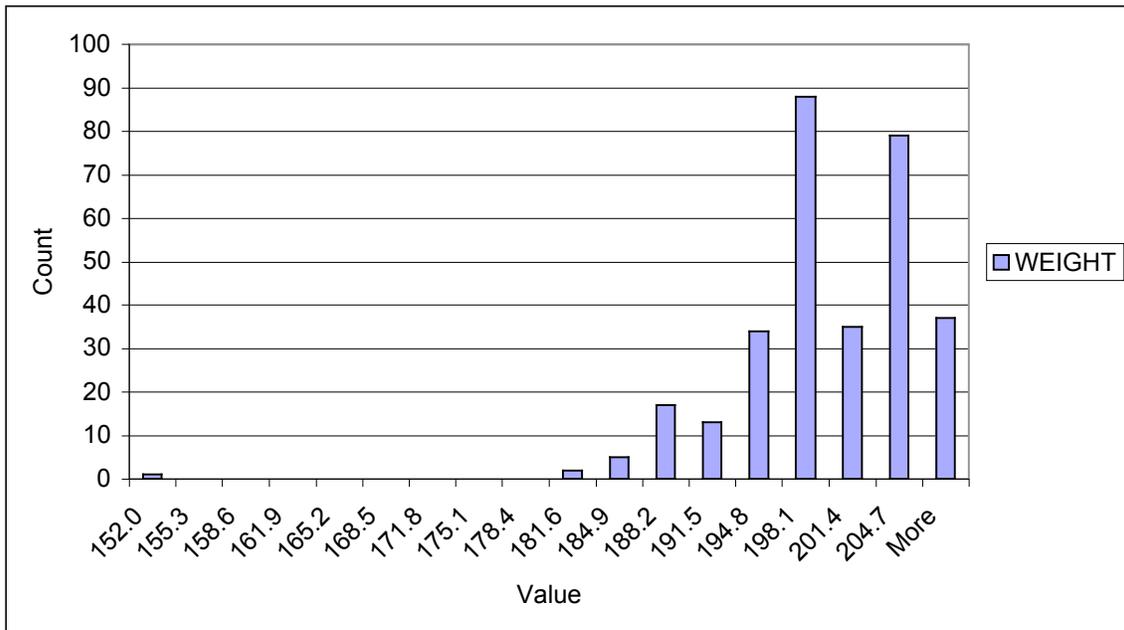
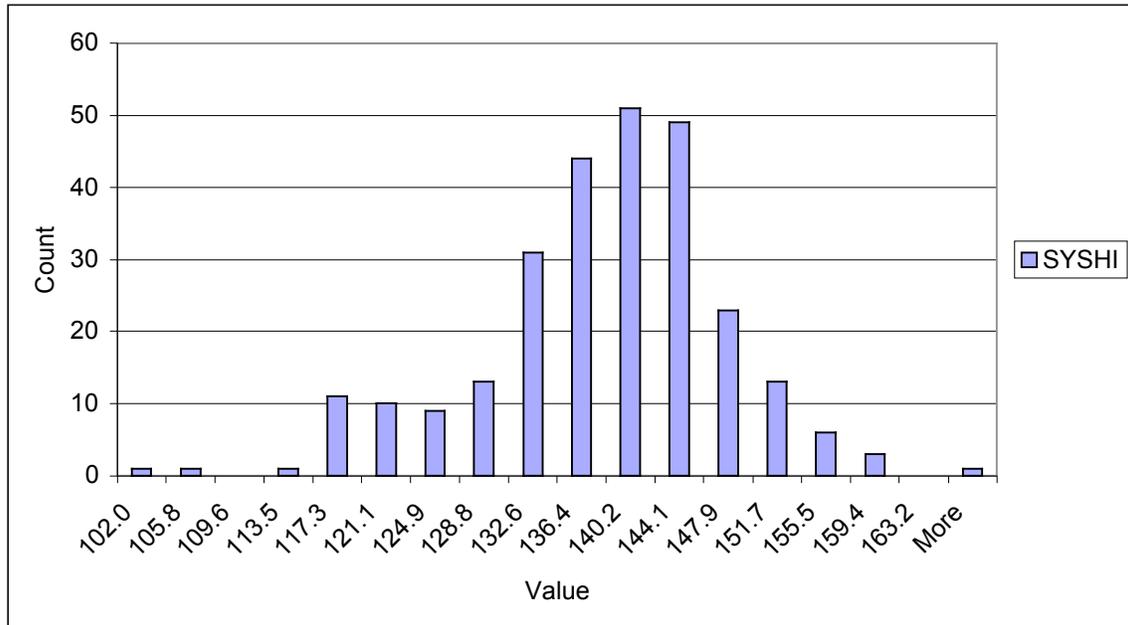**Graph 1.54 – Distribution of O2 Readings for T9**
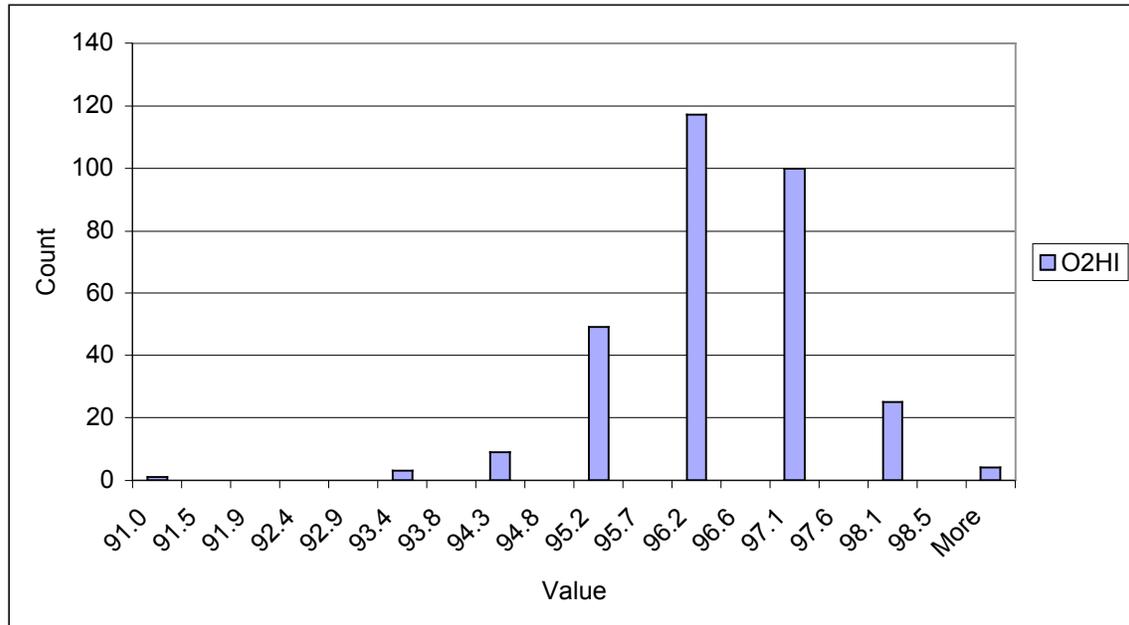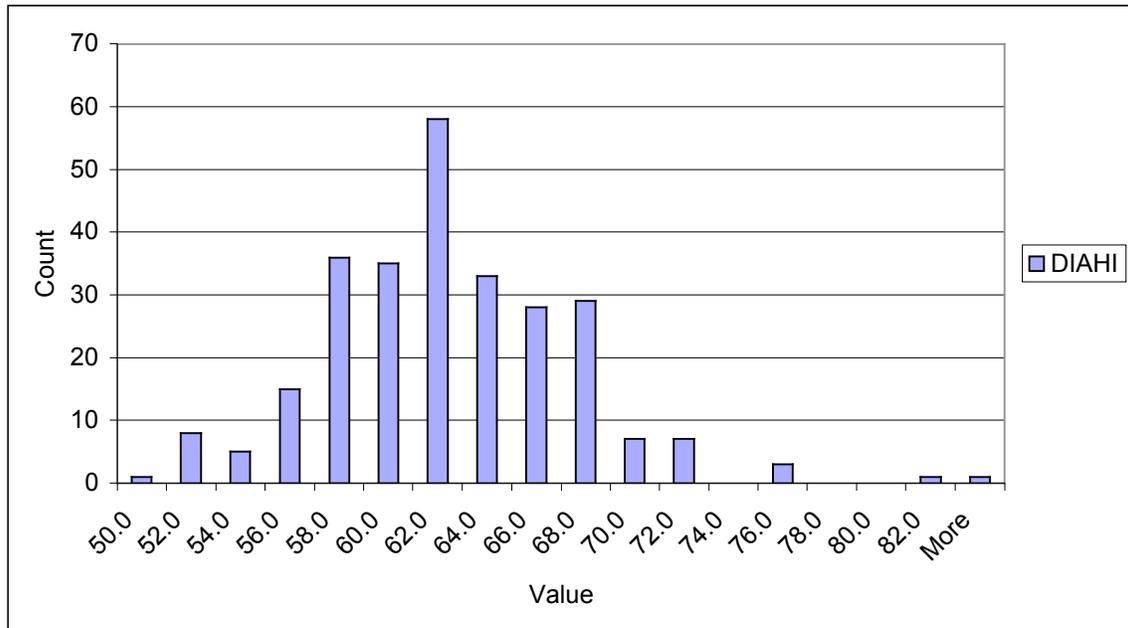
Graph 1.55 – T10 Composite Data

Table 1.11 – Statistical Measurements for T10

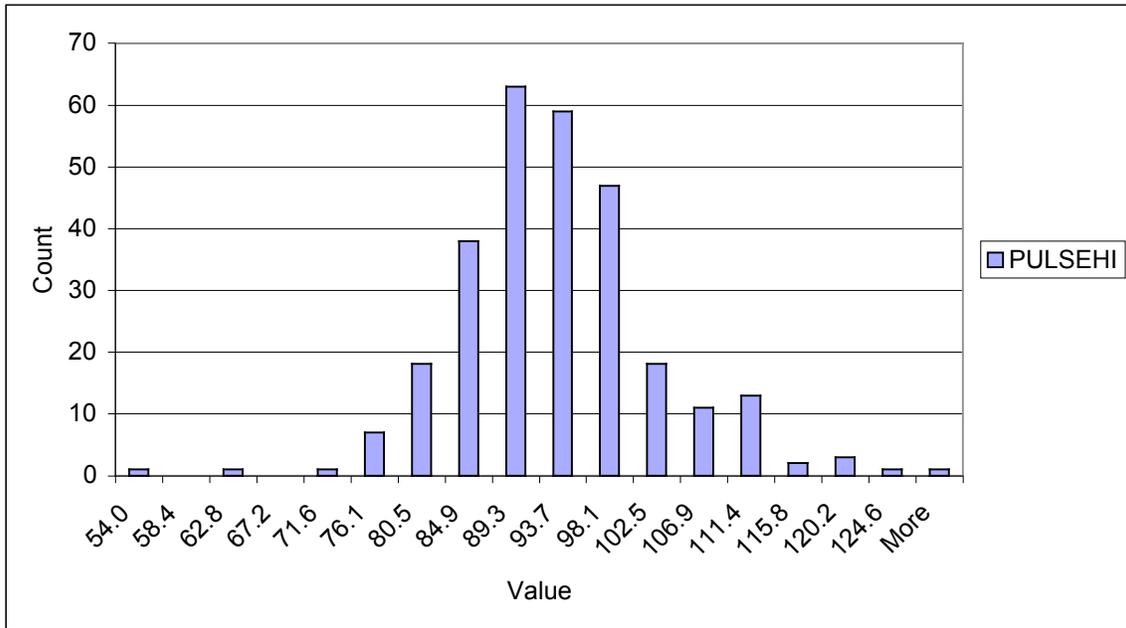| MEASUREMENT	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	136.3483	61.9888	91.0317	150.5816	93.1354
Standard Error	0.5855	0.3046	0.5624	0.3927	0.1918
Median	137	62	90	151	94
Mode	137	62	90	152	94
Standard Deviation	9.5678	4.9770	9.4780	6.5941	3.2555
Sample Variance	91.5436	24.7705	89.8329	43.4826	10.5983
Kurtosis	0.9261	1.8443	1.7894	36.7309	17.2082
Skewness	-0.5145	0.6193	0.3802	-0.7162	-2.6893
Range	65	34	75	98	32
Minimum	102	50	54	96	66
Maximum	167	84	129	194	98

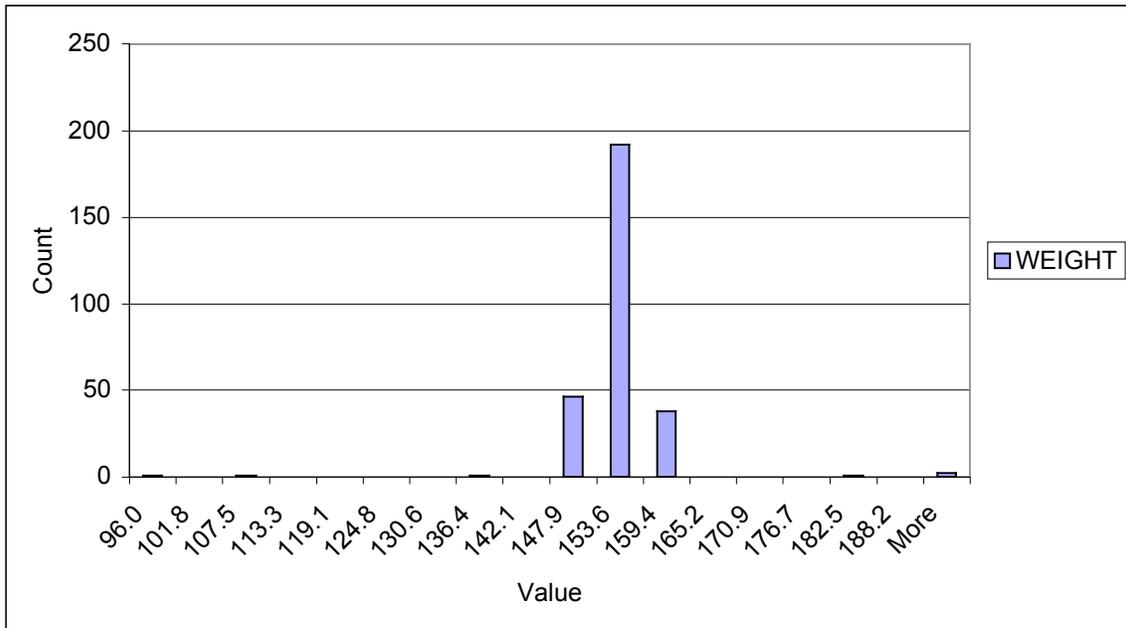**Graph 1.56 – Distribution of Systolic Readings for T10**

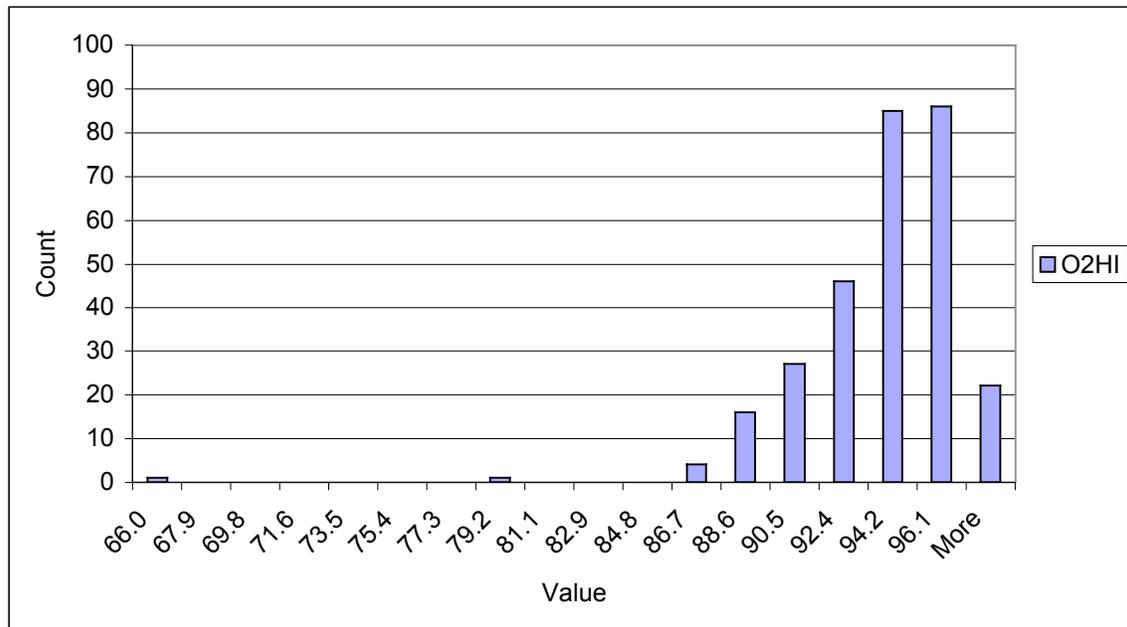**Graph 1.57 – Distribution of Diastolic Readings for T10**

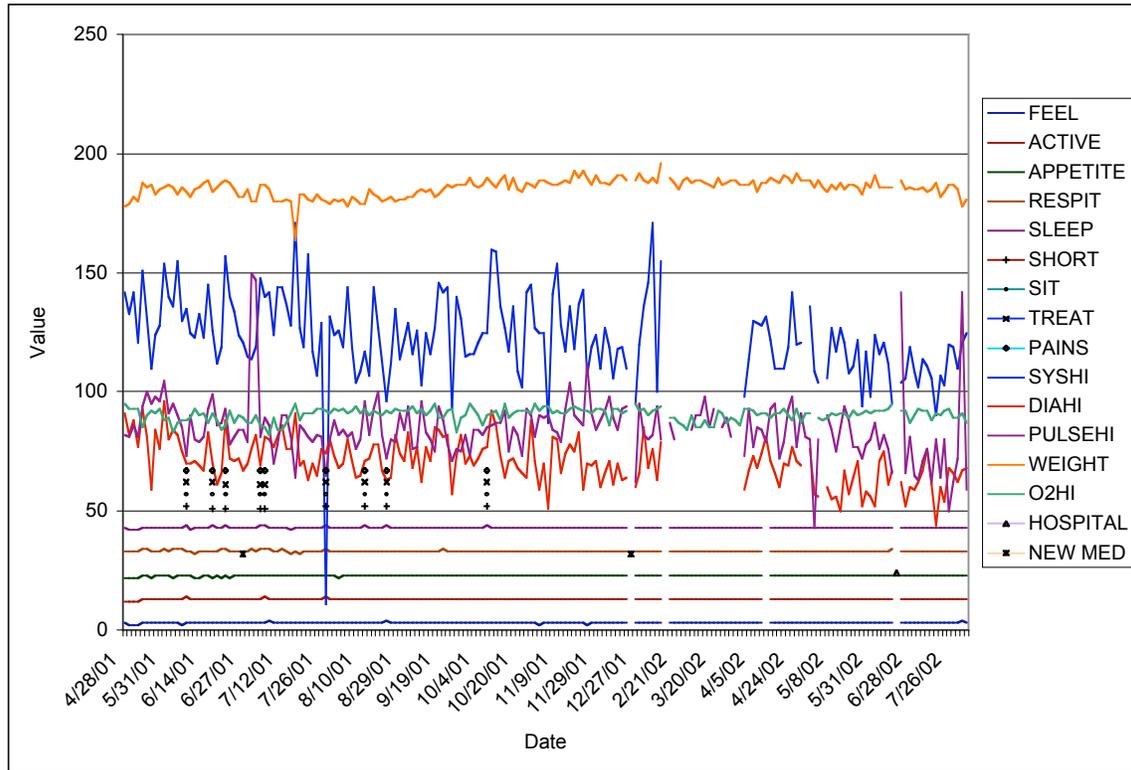**Graph 1.58 – Distribution of Pulse Readings for T10**

Graph 1.59 – Distribution of Weight Readings for T10

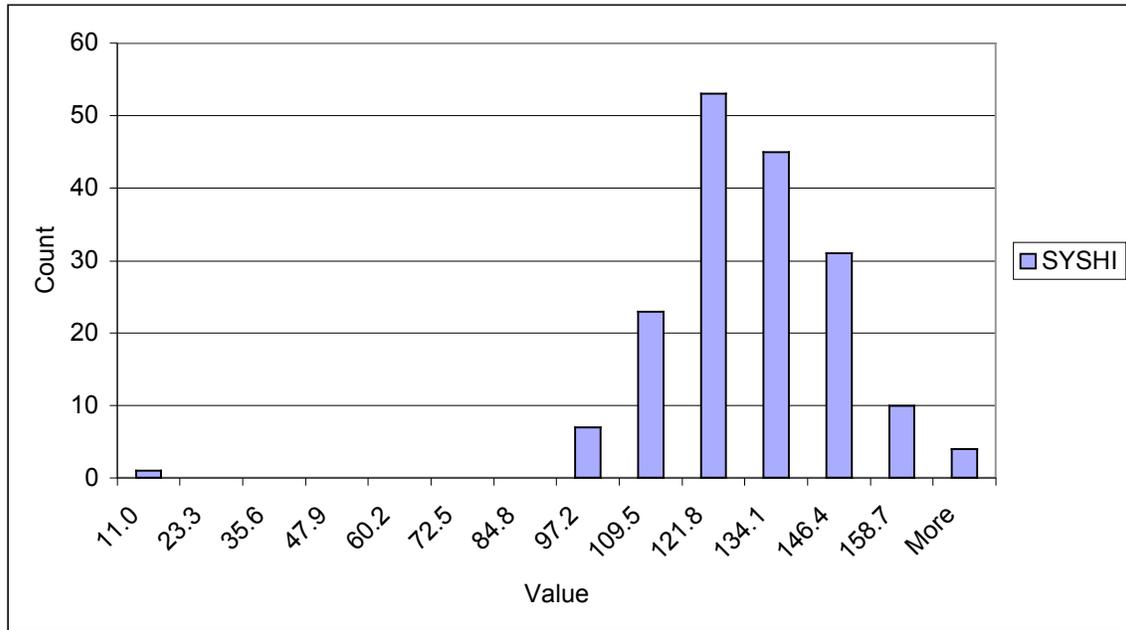**Graph 1.60 – Distribution of O2 Readings for T10**

**Graph 1.61 – T11 Composite Data**

Table 1.12 – Statistical Measurements for T11

| MEASUREMENT	SYSHI	DIAHI	PULSEHI	WEIGHT	O2HI
Mean	123.6034	70.8218	84.5405	185.7277	90.4526
Standard Error	1.3872	0.7162	0.9730	0.2757	0.1981
Median	122.5	71	84	186	91
Mode	119	71	80	187	92
Standard Deviation	18.2984	9.4470	13.2341	3.8099	2.7305
Sample Variance	334.8303	89.2455	175.1410	14.5150	7.4554
Kurtosis	7.4652	-0.0842	8.6413	4.5240	0.2642
Skewness	-1.0138	0.0326	1.7309	-1.1320	-0.7983
Range	160	52	107	32	13
Minimum	11	44	43	164	82
Maximum	171	96	150	196	95

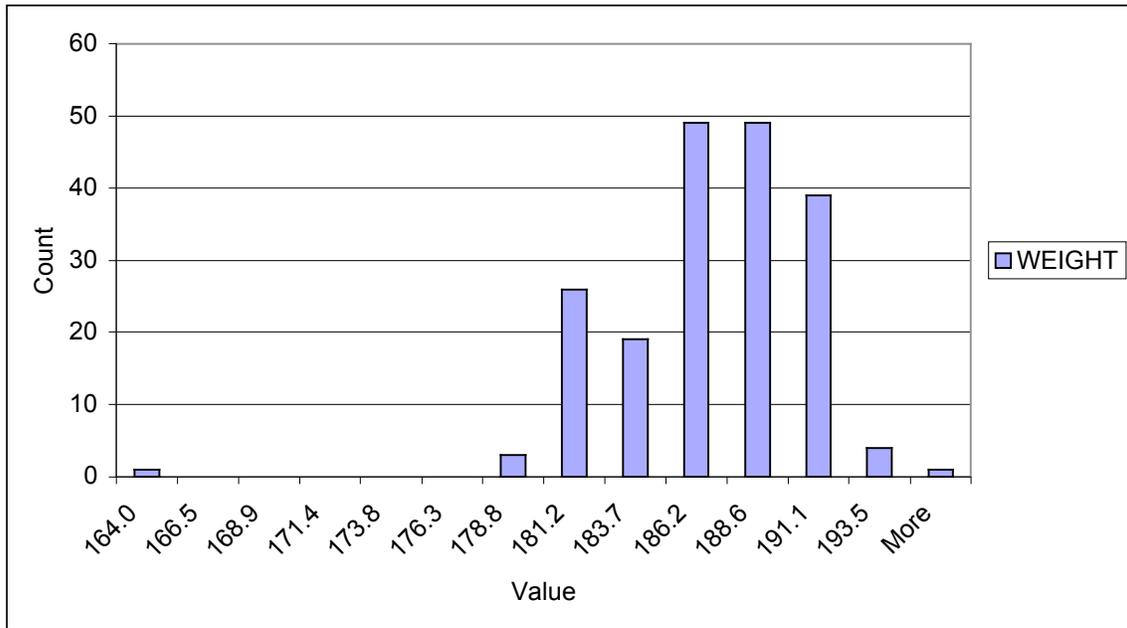**Graph 1.62 – Distribution of Systolic Readings for T11**

Graph 1.63 – Distribution of Diastolic Readings for T11
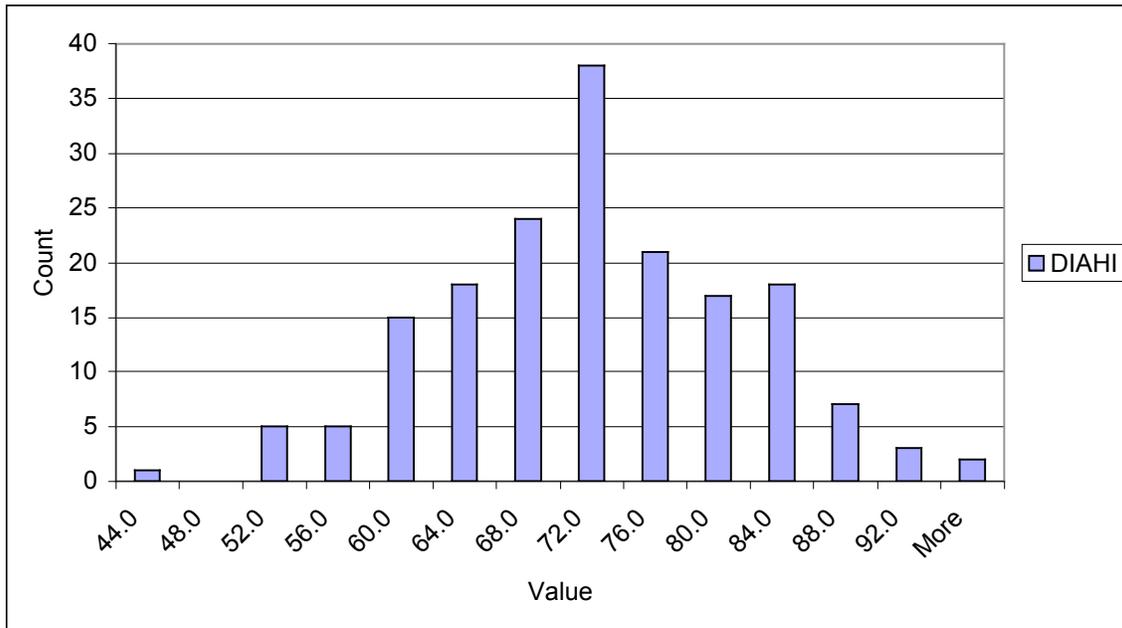
Graph 1.64 – Distribution of Pulse Readings for T11
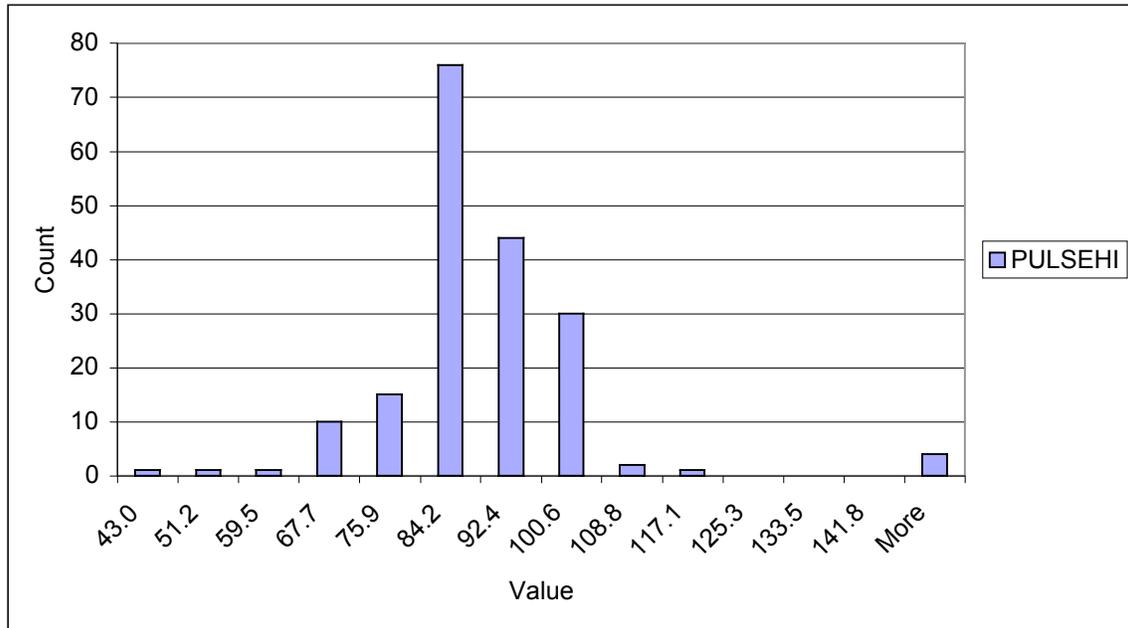
Graph 1.65 – Distribution of Weight Readings for T11

Graph 1.66 – Distribution of O2 Readings for T11