THE EFFECTS OF FATIGUE ON VIGILANCE IN SAILING

by

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ABSTRACT

The Effects of Fatigue on Vigilance in Sailing. Twelve male subjects were tested to determine if increasing amounts of physical fatigue are related to the attention paid to sail trim during sailing. A sailing simulator was used to determine if fatigue, either mental or physical, caused vigilance to vary while the subject was sitting on the side deck, hiking or hiking with weight. Each subject responded to 45 windshifts by adjusting the main sheet to provide proper sail trim for three separate sessions, each one being fifteen minutes long. Telltale deflection was videotaped to provide a vigilance score with deflection time starting when the telltales lifted and ending when adjustment of the sail stopped. Five fitness tests, number of sit-ups in one minute, percent body fat, isometric strength in the hiking position, isometric endurance in the hiking position and maximum oxygen uptake were administered on a separate day to determine if fitness scores were related to vigilance capacity. It was found that neither mental nor physical fatigue caused a decrease in vigilance over the fifteen minute test session. There was a learning effect associated with the apparatus as mean vigilance score for each successive sailing simulator session decreased regardless of the treatment used. Only one of the physical fitness tests was related to vigilance capacity as maximum oxygen uptake values were inversely correlated with mean vigilance scores. Subjects with high aerobic capacity were faster at responding to windshifts, thus supporting the use of a large aerobic component in dry land fitness programs.

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CHAPTER 1

INTRODUCTION

Vigilance and attention are critical components of performance for sports requiring fine motor co-ordination and tracking skills. When activities which require high levels of concentration are undertaken for extended periods of time, a variety of factors can affect performance. Consequently, the greater the capacity of the competitor to integrate all of the required aspects of the sport while still maintaining a high degree of vigilance, the longer he will be able to perform effectively and efficiently. Sports like this are 'open' skills and performance in them can be directly attributed to adaptability and, in certain instances, concentration level.

Sailing is a sport which requires vigilance for success. An individual competing in a sailing race will determine the course which he must follow in his attempts to finish first. Although the permutations and combinations are infinite, the best path to sustain maximum boat speed will be determined by the course other competitors sail, the current wind direction and any subsequent changes that may occur during the race. A good sailor will concentrate on sail trim and respond quickly and appropriately to wind shifts in order to obtain the greatest sustained boat speed.

A major factor affecting vigilance and ultimately performance, is physical fatigue. The type of fatigue regularly associated with vigilance is that which affects the central processing mechanism relating to the ability for continuous attention. Vigilance diminishes with time regardless of the physical state of an individual. General fatigue which is not specific to the muscle groups used in performance of the required task may, contribute to a decrease in vigilance. Bodily fatigue is a performance variable and its effect on vigilance should be reflected by a performance decrement.

Competitive sailing requires a variety of physical skills and abilities including endurance and strength, as moderate and heavy wind conditions require high physical work capacity and the ability to sustain high levels of exertion. Maintainance of optimum boat speed remains important and physical fatigue contributing to decreased concentration on sail trim will result in a decrease in boat speed. Concentration on sail trim could affect a competitive sailor's chances of winning. Bodily fatigue during a race would detract from performance through its effect on vigilance.

STATEMENT OF THE PROBLEM

The purpose of this invèstigation was to determine if increasing levels of physical fatigue are related to decreasing levels of attention on sail trim during sailing. The investigation was designed to determine how vigilance performance is affected during the course of a sailing competition.

Subproblems

The subproblems are:

1. To determine what effect fatigue will have on vigilance during a simulated sailing task.

2. To determine how performance on a simulated sailing task is related to varying levels of personal fitness.

DEFINITION OF TERMS

Vigilance. The concentration required in the experiment is a vigilance capacity known as selective attention. It is the ability to perform a task in the presence of distracting stimulation without significant loss in efficiency. This is identical to the concentration required in competitive sailing.

Fatigue. The fatigue referred to in this experiment is physical fatigue. Although there is a 'mental fatigue' connected with vigilance tasks, the fatigue effect is independent of that process.

Hiking. The position used for the experiment was that assumed by a centreboard sailor during strong winds. Both the hip and ankle were fixed at approximately ninety degrees and the angle at the knee was between zero and ninety degrees depending on the height of the subject and personal preference. The spinal column was straight and the head fixed in the normal position. The muscles used to maintain this position include, the anterior leg muscles for the ankle, the quadriceps for the knee, the psoas and abdominal groups for the hip and the sterno-cleido-mastoid for the head (Soria, 1970). In order to maintain the hiking position the instep of each foot was hooked under a strap in the centre of the boat and the subject sat out over the side. The torso was outside the gunwale of the boat at all times during the experiment. Minor position adjustments were allowed as some movement occurs during a race.

Windshift. Although natural windshifts vary greatly in velocity and magnitude, a standardized set of mechanically produced windshifts were used for this study. Each shift was ten degrees in magnitude with the direction of the windshift determined randomly. Each windshift was of sufficient magnitude that it could be easily detected.

Deflection Time. Deflection time was the time required for the subject to return the sail to proper trim. For a windshift where the wind moved aft, deflection time started as soon as the leeward telltale started to flutter and stopped when the subject finished letting out the sail. For a windshift where the wind moved forward, deflection time commenced when the sail started to luff or flap just aft of the mast and ended when the subject finished pulling in the sail.

Telltales. The telltales were pieces of black wool six inches in length placed on the sail with small sections of number material. One was placed on either side of the sail eight inches from the mast and three feet from the tack.

Physical Fitness Components. The physical fitness components were five fitness tests administered to the subjects prior to the testing. The tests used measured: the number of sit-ups in one minute, percent body fat, muscular strength in the hiking position, muscular endurance in the hiking position and aerobic capacity.

DELIMITATIONS

Sailing is an 'open' task whereas this investigation was conducted in a simulated environment which produced a 'closed' task. The results obtained were taken from dinghy sailors and should generalize to competitors of similar calibre. The subjects were only tested in the 'reaching' portion of the race. This is one of many situations that might arise in competition. However, sail trim is important in all parts of a race and vigilance performance in one portion of a race should generalize to all parts of competitive sailing.

ASSUMPTIONS AND LIMITATIONS

Because it was impossible to effectively control wind direction and velocity, testing was conducted on a simulated model indoors. Although every effort was made to ensure that the results were representative of the actual task, the boat was stationary and not subject to the forward or sideways motion associated with sailing. Only the bottom third of the sail filled with wind properly and although none of the subjects experienced difficulty in sailing the simulator, the sail's appearance was not identical to that found in the racing situation.

The major limitation was the degree of reliability of the experimenter. As an observer of the videotapes containing the responses presented by the subjects, his reaction time and concentration could have unintentionally biased results. The acuity of the video-tape machine may also have affected the results. However, only one experimenter analysed videotapes and it is assumed that error on the part of the experimenter was constant error.

SIGNIFICANCE OF THE STUDY

The study provided insight into the effects of fatigue for vigilance tasks of this nature. Prior to this experiment, very little research had been conducted related to sailing and none had dealt with sailing and vigilance. Substantiation of the hypotheses would indicate what performance decrements might be expected in competition. The importance of particular elements of training programs would be substantiated by the results of the vigilance performance tests.

HYPOTHESES

The hypotheses are:

1. Vigilance decreases will occur during fifteen minutes of simulated sailing regardless of the level of exertion.

2. Physical fatigue will further decrease efficiency during fifteen minutes of the vigilance task.

3. Each of the five physical fitness components is directly correlated with vigilance performance.

Chapter 2

REVIEW OF SELECTED LITERATURE

From the outset of research attempts into information processing, one important part of human response capabilities which has been examined is vigilance. Vigilance can be described as a high state of readiness to perform adaptive and purposive acts (Deese, 1955). A definition as broad as the one provided by Deese is of importance in that it enables one to determine which information processing tasks have vigilance components. Stroh (1971) classified vigilance tasks according to the rate of stimuli presentation. He considered rates below 60 per hour to be recognition tasks while rates above 60 per hour required continuous discrimination. Both vigilance capacities are dependent on the ability to maintain attention.

Vigilance decreases with time on task (Mackworth, 1964). Decay in attention occurs rapidly, often within the first three minutes and Haider and Dixon (1961) found vigilance decreased between the second and tenth minute on their tests. Further vigilance decreases are expected after the tenth minute with the rate of decrease depending on the task and a variety of experimental factors (Buck, 1966; Faulkner, 1962; Adams, Humes and Stenson, 1962; Mackworth,1964).

There are a number of factors which may affect vigilance performance as they affect the subject's response characteristics by providing variability in the stimulation. Consequently, the schedule used for stimulus presentation can have a large effect as vigilance increases when the number of stimuli per hour increases (Holland, 1958, Mackworth, 1964,1970), the interval between stimuli also affects vigilance as increased predictability enables a subject to spend more time resting, thus increasing vigilance capacity (Baker, 1959). However, predictability is usually low in a true vigilance task and response time may actually increase if distractions are presented to a subject attempting to attend or if expectancy creates a false impression of the stimulus presentation schedule (Mackworth, 1979).

Motivation may increase vigilance as Fraser (1953) found that having the experimenter present in the room decreased response time. It appears that many forms of feedback will be important as knowledge of results also increases vigilance performance (Mackworth, 1970). Knowledge of results in practice trials but not during testing is also beneficial as it improves vigilance scores (Adams, and Humes, 1963). It seems apparent that a learning effect is possible in vigilance tasks as the subject's scores are improved by increased familiarity with the activity.

Although vigilance decrements have been found within testing sessions there is no difference in vigilance between sessions (Adams, Humes and Stenson, 1962). Rest allows the capacity for continuous attention to recover (Mackworth, 1964) so the longer the rest period, the greater the restoration of vigilance capacity (McCormack,1958). Rest can take a number of forms as it may be a break between sessions, rest periods within sessions or periods in a test session where attention is not required because of the predictability of the testing schedule.

INFORMATION PROCESSING IN VIGILANCE

Responding to a stimulus during a vigilance task is a form of information processing. Stroh (1971) categorized stimuli that are attended to as; large, novel, involving movement, fulfill a need, interest the individual and conforming to expectancy. Although the stimuli provided in a vigilance task may not have all of the above characteristics they embody at least one of them. Typically, an individual will respond when a discernable change occurs in whatever is being monitored. The actual processing of stimuli and the production of a response depends on the receiving and processing of information and the production of a response. Jerison (1967) stated that a vigilance task has three phases: the observing response phase, the sensory activity phase and the detection indicating phase. In a typical vigilance task a stimuli is received, processed and acted upon (Treisman, 1969).

Detection in a vigilance task is dependent on the information presented. Many factors can influence detection in continuous attention including the intensity, mode and complexity of the stimuli. Broadbent and Gregory (1963) found that the intensity of the stimuli is important as uncertainty may occur with low intensity stimuli. Small increases or decreases may change response rate drastically, especially if the intensity levels being used are near the threshold level (Broadbent and Gregory, 1963). The mode of stimulation may affect vigilance performance as certain forms of information may be more familiar and the corresponding response generated faster (Deutsch and Deutsch, 1967). If two stimuli are mixed, vigilance scores may increase as the requirement for filtering forces the individual to process more information (Mackworth, 1970). In cases such as this, the increased complexity of the task requires that the individual discriminate more in the decision making process. Someone searching for a certain stimulus will respond faster when it is easy to recognize the appropriate stimulus rather than having to distinguish between two or more very similar ones (Shriffin and Schneider, 1977).

Filtering often occurs when one is attending. Treisman and Riley (1967) found that the chief effect of attention in tasks using competing verbal messages was to limit perception of the secondary message rather than to restrict responses or memory. Attention has no effect on perception and it will not interfere with short-term memory provided attention is concentrated on one source of stimuli. The ability to receive and process information in a vigilance task is unaffected when stimulation level remains constant. Should additional stimulation which is of great enough importance that it requires a response be provided then vigilance scores will decrease because of the increased information processing required.

THE EFFECTS OF AROUSAL ON VIGILANCE PERFORMANCE

There has been very little research examining arousal level in vigilance performance. Stroh (1971) found that electr-encephalogram (EEG) activity levels increased during the last tén minutes of a one-hour testing session. Infrequent stimulation also increases arousal levels as electro-myogram (EMG) readings increased in subjects receiving fewer stimuli

(Stern,1966). Vigilance performance also diminishes with less frequent stimulation. However, arousal level is not considered a causative factor in this relationship. Motivation is a very important factor as it has a large effect on arousal level for many tasks.

PHYSICAL FATIGUE IN INFORMATION PROCESSING

Schmidt (1969) classified physical fatigue as a performance variable rather than a learning variable. This view has been supported by others including Alderman (1965) who found that although an individual may not perform the given task as effectively in a fatigued condition, learning will still occur provided there is not complete decay of the appropriate technique. Performance may decrease if massed practice causes fatigue which is specific to the task performed. Using different forms of exercise, Phillips (1963), found that although learning progressed, arm fatigue would decrease arm performance while lower body fatigue would not. Both speed and accuracy decrease as local fatigue affects performance (Alderman, 1965). Related to this, Meyers (1969) found that reaction time is unaffected while movement time increases with localized physical fatigue.

For proper learning to occur, fatigue must be accommodated. Practice will increase performance levels when the individual can manage to practice the skill even under fatigue conditions (Marischuk and Kuznetsov, 1973). Related to this, moderate and related warm-up did not affect performance as any fatigue created was accommodated (Phillips, 1963). Phillips also found that heavy non-related warm-up did improve performance although no explanation was provided.

The hiking position assumed during a sailing race is a static one dependent upon isometric strength. Isometric contractions have certain fatigue charateristics most of which relate to the blood flow in the muscle contracted. When a muscle is contracted to an amount exceeding 15% of maximum voluntary contraction (MVC) blood flow is often not enough to accommodate continued work (Muller, 1932). Tensions below 15% of MVC do not produce fatigue (Rohmert, 1961). Blood flow through contracting muscle tissue is occluded to varying degrees for tensions between 30 and 70% of MVC (Humphreys and Lind, 1963). The fatigue created is directly related to blood occlusion as fatigue occurs more rapidly with increased percentage of MVC (Lind and McNicol, 1967). Although there is some variation between muscle groups, fatigue occurs in the same basic fashion for all isometric contractions. One important variable in isometric work is motivation level. Ischemia leads to anaerobic work and lactate build-up and an athlete must be highly motivated to endure the pain associated with optimum performance (Clarke, Hellon and Lind, 1958).

VIGILANCE IN SAILING

A competitive dinghy racer sailing at an advanced level of competition requires a high level of physical fitness as an average race at a major regatta will require three to four hours of heavy exertion and an individual with high endurance capacity will be more able to produce the work required. The hiking position is physically taxing and it requires high muscular endurance to maintain it for long periods of time (Putnam, 1979). Ischemia can occur in the abdominal muscles and quadriceps with continued hiking. Performance is affected as recovery sessions may be required during a race. Decreases in agility and increases in movement time would also be products of physical fatigue. A tired sailor makes mistakes and the effects can be seen in performance (Street, 1975). It is evident that fatigue plays a large part in competitive sailing especially in heavy winds. Much of the effect is manifested in the work capacity of the individual and the results that fatigue have on hiking ability although the ability to process information may be hindered as well.

Chapter 3

METHODS AND PROCEDURES

Subjects

The subjects (12) were club sailors from the greater Vancouver area. All subjects were active, centreboard boat sailors who raced at the club level in high performance, one design racing dingys during the year prior to the testing. Some of the subjects have been national champion in their respective class and all subjects had sailed in a national championship. Only males between the age of 18 and 38 were tested. Testing was conducted prior to the competitive season although some of the subjects had been active during the offseason. Obese individuals or those training for other sports were excluded.

Apparatus

The apparatus utilized had two sections: a sailing simulator and physical testing apparatus.

Sailing Simulator. The equipment used was of the experimenter's own construction. Appendix 1 contains photographs giving front, rear and side views of the apparatus. The simulator had six components: a sail boat, a wind generating machine, a track for the wind machine, a vision occluding barricade, a digital clock and a video-tape system. The boat employed was of the laser class, i.e., a 14 foot single-handed boat with centreboard. Lasers have a cat rig and there is no standing rigging for the single sail. The boat was secured in a frame so that it sat upright and did not move when the subject hiked.

Appendix 1 contains a diagram of the frame. The frame supported the boat on both gunwales at the front and back of the cockpit. There was also a positioning piece coming up in the centreboard case. The frame held the boat two inches off the ground and leaning five degrees to port. This five degree angle of heel was used as it is within the two to eight normally experienced when sailing a laser and it also facilitated setting of the sail. The boat was secured and it did not move when the subject assumed the hiking position.

The sail was flown in the normal fashion. The telltales were affixed to the sail three feet from the tack of the sail and eight inches back from the mast. Appendix 1 contains a diagram showing telltale positioning. The position of the sail was controlled by the subject using the normal mainsheet (rope) configuration found on the laser. A 'stock' mainsheet was used and one of the purchases was removed from the system to decrease friction. Use of one to one on the mainsheet rather than the normal two to one meant that less rope needed to be used whenever the sail position was adjusted. Elasticized rope, which was used to pull out the end of the boom, was tied to an eye placed in the floor making it easier to let out the sail.

The tiller extension (steering apparatus) was held in the left hand and the mainsheet was held in the right hand. The subjects sat facing the port side of the boat and sailed as if on starboard tack.

The wind generating apparatus was situated on a track opposite the starboard forward section of the laser. It produced wind with a velocity of approximately eight miles per hour. Appendix 1 contains photographs showing side and back views of the wind generating apparatus. The fan blade used in the apparatus was a six-blade, truck fan blade thirty-two inches in diameter which was mounted on the end of a drive shaft secured by the framework of the apparatus. Two electric motors, one one-half of a horse power and the other one-third of a horse power were used to turn the drive shaft. The motors turned at 1725 rpm and the gearing used was 2:1 giving the fan blade a speed of 862.5 rpm.

The centre of the fan blade was 65 inches off the ground and the blade was tilted backwards at an angle of 14 degrees. The wind produced by the fan was directed at the sail through a large vertical aperture 72 inches high and 12 inches wide. The opening was tilted backwards at an angle of four degrees. Both the opening and fan blade were aimed above horizontal because of the height (20 feet) of the laser sail. The bottom of the aperture was 52 inches above the ground and the centre of the fan blade was 60 inches from the outside extremity of the aperture. Fourteen 'louvres' were placed in th aperture, sectioning it into fifteen three inch sections in the horizontal plane. This was done to ensure that the wind leaving the aperture was parallel and that there would be little turbulence when the wind contacted the sail. A plastic bellows was attached to the frame holding the fan blade and the inside portion of the aperture to direct all of the wind produced through the aperture.

The whole wind generating apparatus was placed on a small dolly which had four caster type wheels. The dolly was square with the distance between any two adjoining wheels being 18 inches. The wheels of the dolly ran on a track which traced the arc through which the wind generating apparatus was moved. Appendix 1 contains pictures showing the track and how the dolly wheels ran along the arc. There were two curves, one each for two of the wheels as the two closer to the sail transcribed a smaller arc. The track was mounted on a four foot by eight foot sheet of plywood and it covered approximately 55 degrees. There were four stations marked on the outside curve, each being 19 inches or 10 degrees apart.

The dolly was positioned under the wind generating machine so that the centre of the fan blade was 10 inches in front of the outside curve and eight inches behind the inside curve. The radius of the outside curve was 98 inches making the focal point 28 inches beyond the outside opening of the aperture. The track was placed on the ground so that the outside opening of the aperture was 24 inches from the mast. This placed the focal point for the wind four inches behind the mast or four inches in front of the telltales. Because of the way both the laser and the aperture were tilted, the mast and and aperture diverged at an angle of nine degrees and the focal point was not in the same position on the sail further above the ground.

An eight foot by eight foot vision occluding barricade was used to prevent the subject from seeing the wind generating apparatus. Appendix 1 contains a diagram of the barricade. It was placed on the starboard side of the boat at the forward border of the cockpit. It extended out over the deck of the boat making it impossible for the subject to see anything opposite the forward portion of the starboard side of the laser. An extension lamp was attached to the frame and directed at the sail to provide additional light.

The digital clock was placed on a stand on the port side of the boat 62 inches off the ground and 18 inches from the mast. Appendix 1 contains photographs showing the clock. It was a model 54517-A Clock/Counter produced by the Lafayette Instrument Company of Lafayette Indiana. The display of the clock was electronic, producing five illuminated digits, each one inch in height.

The video-camera system was placed opposite the port side of the boat so that the clock and telltales were in the viewing field. Appendix 1 contains photo-graphs of the video tape apparatus. The camera lens was 110 inches from the mast and 60 inches off the ground. The camera used was a Sony AVC-3400 Video Camera. Recordings were made on V-30H Sony Videotapes using an AV-8400 Sony Auto Threading Portable Videocorder and an AC1000 Sony Color Power Adaptor. Tapes were analysed using a Shibaden SV-510U Video Taperecorder and an RFU-62FW Sony Video Monitor.

<u>Physical Fitness Testing Apparatus.</u> The equipment used for the physical fitness testing was from the John M. Buchanan Fitness Centre at the University of British Columbia. The stopwatch used for timing one minute speed sit-ups was an MDSI 3 Hydrospeed Trilite. The skin fold calipers used for fat testing were John Bull calipers produced by British Indicators Limited.

Isometric strength testing was done using a hiking bench of the experimenter's own construction and a Cybex strength testing system. Appendix 2 contains pictures of the strength testing apparatus. The hiking bench was 33 inches high, 24 inches wide and 18 inches deep with the depth being the same as the width of a laser sidedeck. The hiking strap was adjustable and it attached 22 inches from the top of the hiking bench. A Cybex Isokinetic System (Serial Number C30310) was used for recording the subjects' hiking strength. This apparatus had three parts, including a Cybex II Isokinetic Dynamometer, a Cybex II Speed Selector and a Cybex II Dual Channel Recorder.

Maximum oxygen uptake values were calculated using a Beckman Metabolic Measurement Cart. Heart rates were monitored during the treadmill test with an Exerstress Display Cardioguard 4000 made by Del Mar Avionics. Subjects ran on a treadmill produced by Quinton Instruments of Seattle, Washington.

Procedures

The experiment was conducted in two parts. The first section is concerned with the testing of human response on a sailing simulator and the second deals with the relationship of the selected physical fitness capacities to the subjects' performance on the simulator.

Sailing Simulator Testing. Each subject came in for testing four times. Three of the sessions were with the sailing simulator as subject responses were recorded under three different experimental conditions. The independent variable was the type of fatigue produced by the position used while sailing the simulator. The positions were: sitting on the sidedeck of the laser, the hiking position and the hiking position while wearing a weight jacket which equaled five percent of body weight.

All subjects received all three treatments and a balanced design was used to eliminate any learning effect. Table 3.1 contains the order of treatments for each subject.

Table 3.1

Order Of Treatments For Subjects

SUBJECT	SITTING	HIKING	WITH WEIGHT
1,7	SESSION 1	SESSION 2	SESSION 3
2,8	SESSION 1	SESSION 3	SESSION 2
3,9	SESSION 2	SESSION 1	SESSION 3
4,10	SESSION 2	SESSION 3	SESSION 1
5,11	SESSION 3	SESSION 1	SESSION 2
6,12	SESSION 3	SESSION 2	SESSION 1

Prior to the first session, each subject was introduced to the equipment. This introduction included a full explanation of the function of each piece of apparatus and a demonstration of how the simulator operated. During the briefing, the wind generating apparatus was activated and windshifts in each direction were demonstrated as well as the appropriate response for each type of shift. Subjects then received two practice trials, one for each type of response. If the subject was required to hike for that session the subject was provided with the opportunity to adjust the hiking strap.

The three sessions consisted of 45 windshifts or trials. Each windshift was 10 degrees as the wind generating apparatus was moved from one position to another along the track. The forward outside wheel of the dolly was used to indicate the position of the wind generating apparatus. The four positions on the track provided wind which struck the mast at the following angles: position 1 - 68 degrees, position 2 - 78 degrees, position 3 - 88 degrees and position 4 - 98 degrees. The pattern of windshifts followed was the same for all three sessions with the wind generating machine starting in position 2. Each session lasted 15 minutes with one trial scheduled for each 20 second period in the session. The first 10 seconds of each 20 second period was used as a recovery period with the windshift occurring anywhere between the 10th and 19th second of the interval. The shortest time period between shifts was 11 seconds while the longest was 29 seconds. Both the pattern and time intervals for the trials were generated from a table of random numbers. Table 3.2 contains the interval, time and direction of each shift and the change in location of the wind generating apparatus for each trial. Subjects were informed prior to the first session of the protocol used for the timing and direction of each shift.

Before each session started subjects were asked if they had any questions. They were then told to assume the appropriate position and to take hold of the tiller and mainsheet. The positioning of the barricade was checked to ensure that it prevented the subject from viewing the wind generating apparatus. Both the clock and video-tape machine were started and finally, the wind machine was turned-on ten seconds prior to the start of the test session.

Table3.2

Time Interval, Windshift Direction And Position Change Of The Wind Machine For Each Trial

SHIFT	TIME	INTERVAL	DIRECTION	POSITION
1	00:10	10	FORWARD	2-1
2	00:31	21	AFT	1-2
3	00:58	27	FORWARD	2-1
4	01:19	21	AFT	1-2
5	01:32	13	FORWARD	2-1
6	01:56	24	AFT	1-2
7	02:14	18	AFT	2-3
8	02:33	19	FORWARD	3-2
9	02:56	23	AFT	2-3
10	03:16	20	FORWARD	3-2
11	03:33	17	AFT	2-3
12	03:54	21	AFT	3-4
13	04:10	16	FORWARD	4-3
14	04:37	27	FORWARD	3-2
15	04:59	22	AFT	2-3
16	05:11	12	FORWARD	3-2
17	05:31	20	FORWARD	2-1
18	05:57	26	AFT	1-2
19	06:18	21	AFT	2-3
20	06:39	21	FORWARD	3-2
21	06:50	11	AFT	2-3
22	07:13	23	FORWARD	3-2
23	07:34	21	AFT	2-3
24	07:58	24	AFT	3-4
25	08:15	17	FORWARD	4-3
26	08:35	20	AFT	3-4
27	08:53	18	FORWARD	4-3
28	09:15	22	AFT	3-4
29	09:39	24	FORWARD	4-3
30	09:58	19	FORWARD	3-2
31	10:10	12	AFT	2-3
32	10:33	23	AFT	3-4
33	10:59	26	FORWARD	4-3
34	11:12	13	FORWARD	3-2
35	11:34	22	AFT	2-3
36	11:51	17	FORWARD	3-2
37	12:10	19	FORWARD	2-1
38	12:31	21	AFT	1-2
39	12:52	21	FORWARD	2-1
40	13:13	21	AFT	1-2
41	13:36	25	FORWARD	2-1
42	13:52	16	AFT	1-2
43	14:17	25	AFT	2-3
44	14:30	13	AFT	3-4
45	14:57	27	FORWARD	4-3

During each test session the experimenter stationed himself beside the wind generating apparatus on the opposite side from the barricade. It was the responsibility of the experimenter to create windshifts by moving the wind machine from station to station. The time of each windshift was posted on the side of the apparatus as well as the type of movement required. The experimenter created each windshift by moving the wind generating apparatus to the predetermined locations. It took approximately one second for each such movement of the wind machine.

Sailing Simulator Data Recording. The dependent variable for the first part of the experiment was the deflection time. There were two distinct responses which were used in the sailing simulator testing. For each trial, it was possible for the subject to either pull-in or let-out the mainsheet. Pulling in the mainsheet made the angle between the sail and the boat more acute. This was the correct response for a windshift which moved the wind direction forward or towards the bow of the boat. Letting out the mainsheet increased the angle betweeen the sail and boat. This response was appropriate for windshifts where the wind moved aft or towards the stern of the boat.

Video tapes were analysed on a Shibaden video taperecorder because of the 'pause' mode available with that piece of apparatus. Videotapes were viewed the same day as recording occurred, usually immediately after the session with the simulator. Because of the angle of the video-camera the wind generating apparatus could be seen at all times. This indicated to the experimenter when a windshift was going to occur and what type of shift it would be. The experimenter stopped the taperecorder as soon as the sail responded to the change in wind direction. As the clock ran continuously a reading of elapsed time to the hundredth of a second could be taken from the monitor. The experimenter stopped the taperecorder a second time when the subject finished adjusting the position of the sail. Another reading was taken from the clock and deflection time was determined by subtracting the first reading from the second.

Physical Fitness Testing. Prior to the sailing simulator testing, all subjects were given a physical fitness evaluation. The tests administered permitted an evaluation of general fitness and some specific physical capacities required in sailing. After recording age and weight, five separate fitness scores were obtained. They included: the number of bent-knee sit-ups accomplished in one minute, percent body fat, isometric strength in the hiking position, isometric endurance in the hiking position and an evaluation of maximum oxygen uptake.

Only one trial was administered for the sit-up testing. Subjects were encouraged to warm-up by stretching or light exercising although no practicing was allowed. The subjects feet were secured by the experimenter who counted the number of sit-ups accomplished out loud and informed the subject when 15 seconds remained in the test period. All sit-ups were done with the knees bent and the hands clasped behind the neck. They were only counted if the sit-up started with the shoulder blades touching the floor and ended with the elbows touching the thighs.

The percent body fat evaluation was conducted using six skin-fold measurement locations; triceps, subscapular, chest, suprailiac, abdomen and front thigh measures were taken with skin-fold fat calipers. Each measurement was replicated three times and the averages of the six scores were summed for use in the following equation (Yuhasz, 1965).

Sum of Six Skinfolds (mm) x .097 + 3.64 = Percent Fat

Isometric strength and endurance in the hiking position were both evaluated using the cybex equipment. The hiking bench constructed by the experimenter was placed next to the Cybex. The subjects sat on the bench in the hiking position using the hiking strap on the bench to fix the feet. The angle at the hip was constant for all subjects as the height of the dynamometer was adjusted so that the hip joint was opposite the pivot point of the dynamometer arm. The arm was set 30 degrees below vertical and it was 13 inches long for all subjects. Each subject placed the end of the arm on his sternum and attempted to push the arm back vertical.

Each of the two strength trials consisted of a one second maximal exertion against the arm. The single endurance trial was maximal although subjects maintained the maximum pressure they were capable of on the arm until the experimenter told them to stop. Results for the strength trials were recorded in pounds and are an expression of the force exerted on the arm. The better of the two trials was accepted. A fatigue curve was drawn for the endurance measure as the force exerted diminished with time. The score recorded was the time required for the force exerted to decrease to 50 percent of the original maximum value. Endurance scores were recorded in seconds.

Maximum oxygen uptake values were determined by direct treadmill evaluation. Each subject ran on the treadmill while measurements were taken from the expired air. The protocol used had three distinct phases. After attachment of the heart rate monitoring apparatus, each subject warmed-up by walking on the treadmill at three mph for 10 minutes. The breathing apparatus was not used during this period as the subject acclimatized himself to the treadmill and other novel aspects of the testing situation.

The exercise portion of the test started with the treadmill running at seven mph and zero grade. For each successive minute during exercise, the grade of the treadmill was increased one degree. Subjects ran until maximum uptake was achieved. This was determined through constant evaluation of the subjects' heart rate, oxygen uptake level and fatigue level. Oxygen uptake values were obtained from the Beckman every 30 seconds throughout the exercise session. The breathing apparatus was worn for the whole execise period.

A five minute recovery period was also provided for the subjects. They walked on the treadmill at three mph until their metabolic rate returned well below maximal levels. Heart rate was the only variable monitored during recovery.

Results for all five of the physical fitness test were presented to the subjects immediately after the testing session.

Experimental Rationale And Controls

Because testing was done on a simulator, a number of controls were used to counter the effect of intervening variables. All of the subjects tested were highly skilled individuals who had little difficulty producing the appropriate response. Randomization in the time interval and direction for each stimulus was used to prevent anticipation from skewing results. Order of treatments was balanced to ensure that the results were a product of vigilance and unaffected by learning.

The basic premise of the experiment was to determine if physical fatigue caused decreases in vigilance. Decreased attention on sail trim would be manifested by diminished boat speed and decrements in performance. Work capacity related to this as high fitness levels could diminish the effects of fatigue. The experiments were designed to indicate if fatigue decreased vigilance and if physical fitness affects vigilance capacity.

Experimental Design

For Experiment 1, the design was a 2-way repeated measures design repeated on both factors. The independent variable was the amount of fatigue produced by sailing the simulator. The dependent variable was the deflection time. A total of 135 trials were recorded with each subject receiving 45 trials on three separate days. The project is a 3X45 factorial experiment repeated on both factors.

Experiment 2 was a correlation analysis using a total of nine variables. The variables used were the five physical fitness test scores, the means for each of the three sessions with the simulator and the mean for all 135 trials. The multiple correlation analysis yielded co-efficients for the 46 possible comparisons of variables.

Data Analysis

Data analysis was done in two sections. For experiment 1, a two-way repeated measures analysis of variance (ANOVA) repeated on both variables was calculated using computer program BMD:P2V. For experiment 2, a correlation analysis was calculated using computer program Simcort.

Test Of Hypothesis 1. Hypothesis 1 predicted that vigilance decreases with time regardless of physical fatigue. Examination of the trials factor in the 3X45 ANOVA indicated if there was significant difference between trials. A graph of the mean scores was then used to determine if vigilance decreased or increased.

Test Of Hypothesis 2. Hypothesis 2 predicted that physical fatigue further decreased vigilance. The comparison for the independent variable (amount of fatigue) indicated if significant difference existed between the treatments for all 45 trials. The interaction of the independent variable and the trials factor indicated if a significant difference existed for one section of the test sessions.

Test Of Hypothesis 3. Hypothesis 3 predicted that high physical fitness scores would be inversely correlated with vigilance scores. High negative correlation between a physical fitness test and deflection time would have indicated that individuals high in that fitness capacity had better vigilance.

Chapter 4

RESULTS AND DISCUSSION

A representative vigilance score was obtained by calculating the mean of all trials. As there was no missing data and no trials were discarded the score obtained represents 135 trials for each of the 12 subjects. The subjects' raw data for Experiment 1 is presented in Appendix 3. The mean score for Experiment 1 was 2.53 seconds.

The physical fitness test results also had no missing data. Table 4.1 contains the scores for each fitness test as well as the age and weight for each subject. Results for Experiment 2 are for single trial evaluations and the data from the physical fitness tests was not reduced prior to the correlation analysis.

Table 4.1

Physical Fitness Test Results For Experiment 1

SUBJECT	AGE	WEIGHT	SIT-UPS	%FAT	STREN	END	MVO2
		KG	#/MIN		LBS	SEC	ML/KG
GS	21	77.8	40	11.2	87	33.8	50.6
DH	38	82.0	39	10.3	116	16.4	42.4
PL	23	72.0	61	9.9	178	25.0	48.0
RT	26	77.5	50	7.9	126	12.0	47.3
MF	19	77.5	40	7.7	136	43.0	53.1
BL	27	65.8	37	9.9	83	11.0	54.8
DW	19	77.5	67	9.1	111	40.0	52.8
JH	26	74.0	50	13.4	83	20.0	36.2
RB	18	87.0	46	8.9	124	22.0	33.2
JT	22	71.0	48	7.9	126	32.0	47.6
MK	19	70.0	45	8.9	111	15.0	38.1
MC	18	80.5	42	9.4	102	36.0	50.3

RESULTS AND DISCUSSION OF THE PREPLANNED COMPARISONS OF THE HYPOTHESES

Experiment 1

Hypothesis 1. It was expected that 'mental' fatigue resulting in a decrease in vigilance would occur over the fifteen minute test session. The 3X45 ANOVA with the trials factor being the last variable indicated that there was significant difference between trials. The results of the 3X45 ANOVA are contained in Table 4.2. The trials factor is highly significant with an alpha level of <.001, however, the standard deviations for each trial are high (see Appendix 4). The mean deflection times were graphed for the 45 trials to determine if trends existed in the data. Figure 4.1 indicates that there is no systematic increase in deflection time scores, consequently, the high variability in the data makes it impossible to state that vigilance decreased over time for experiment 1. Because of the high variabliity in the data, blocking was used to section the results into small blocks which could more readily be compared. The computer program BMD:P2V was again used to analyse the data. Table 4.3 lists the ANOVAs calculated for the vigilance scores from Experiment 1 using blocking designs of various sizes.

The blocking factors only had significance when the number of trials was low. The blocking factor was significant for nine blocks of five trials (.048) and fifteen blocks of three trials (.002). The results for the trials and blocking factors for each ANOVA appear in Table 4.4.

Table 4.2

Analysis Of Variance Table For Experiment 1

SOURCE	SS	df	ms	F	P
SUBJECTS	190.22	11	17.29		
CONDITIONS	.12	2	.06	.04	.963
SxC	34.51	22	1.57		
TRIALS	97.20	44	2.21	2.36	<.001
SXT	452.95	484	.94		
CXT	72.82	88	.83	1.02	.422
SXCXT	781.89	968	.81		
	10333.11	1619			

For both cases where the blocking factor was significant, the variability in the trials factor for the 3X45 design has been transfered to the blocking factor. The mean scores for the blocks show that there is no real trend and that the difference between blocks is caused by fluctuations in the data. It is interesting to note that the scores tend to stabilize near the end of the test sessions. Both Figure 4.1 and the means for the blocks indicate that the range of scores is greatly diminished. Table 4.6 contains the significance levels of interactions for the blocks of trials used in the analysis for Experiment 1. The mean scores shown in Table 4.5 confirm the results indicated by Figure 4.1. The deflection time did not increase and there was no decrease in vigilance for Experiment 1. Hypothesis 1 is therefore rejected and the null hypothesis accepted.

Hypothesis 2. The second hypothesis predicted that the physical fatigue produced by one or both of the treatments used in the sailing simulator testing would decrease vigilance. This change could be manifested in two ways as deflection time would either be greater for the complete session or only for a portion of it. This relationship was examined by the conditions factor in the 3X45 ANOVA and the interaction of conditions and trials

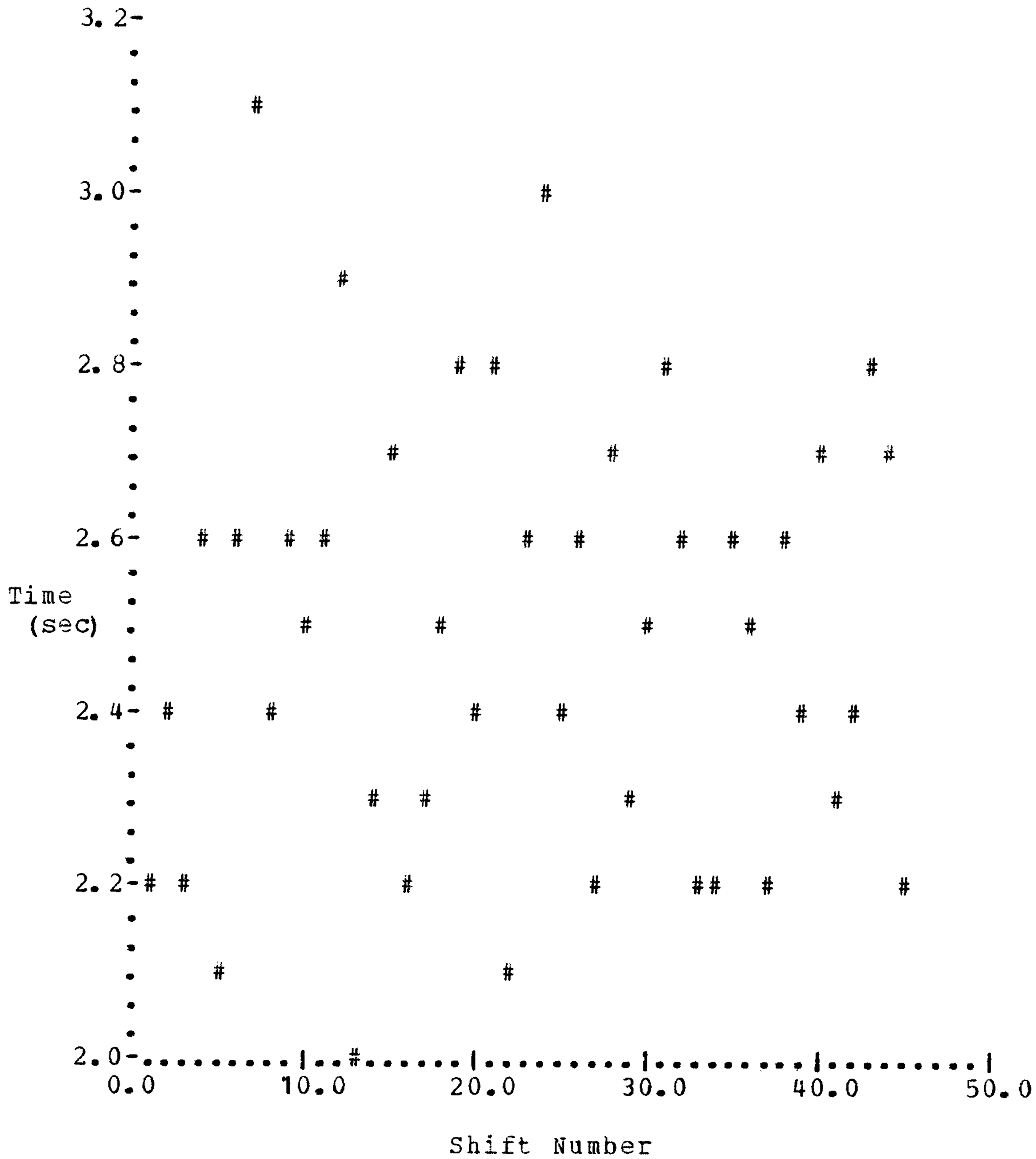

Figure 4.1 Graph of Mean Deflection Time and Trials.

for the same analysis (see Table 4.2). The conditions factor had an alpha level of .963 indicating that no difference existed between any of the three treatments for the full 45 trials. The interaction of conditions and trials was insignificant, demonstrating that the relationship between treatments did not change for any part of the 45 trials. Figure 4.2 shows the

Table 4.3

Analyses Of Variance Calculated For Sailing Simulator Vigilance Scores

BLOCKS	# OF TRIALS	DESIGN
5	9	3x5x9
9	5	3x9x5
3	15	3x3x15
15	3	3x15x3

Table 4.4

Results For Analyses Of Variance Using Blocking For Experiment 1

DESIGN	BLOCKS	P	TRIALS	P
3x15x3	15	.002	3	.521
3x3x15	3	.903	15	.351
3x9x5	9	.048	5	.570
3x5x9	5	.596	9	.378

Table 4.5

Mean Scores For Blocks Used In Experiment 1

DESIGN	3x15x3	3x9x5	3x5x9	3x3x15
# of blocks	15	9	5	3
trials/blk	3	5	9	15
1	2.32	2.34	2.46	2.52
2	2.46	2.66	2.49	2.54
3	2.72	2.55	2.58	2.51
4	2.74	2.49	2.50	
5	2.37	2.62	2.51	
6	2.38	2.49		
7	2.72	2.51		
8	2.59	2.50		
9	2.44	2.51		
10	2.51			
11	2.55			
12	2.46			
13	2.46			
14	2.47			
15	2.61			

scores for the three conditions for each trial. The high variability of the results is undoubtedly a factor in the significance levels obtained from the ANOVA.

The blocking used to test Hypothesis 1 substantiated the results of the 3X45 ANOVA. The treatments effect is the same for all of the analyses and none of the interactions between treatments and blocks of treatments and trials is significant for any of the ANOVAs calculated. The interaction values for the ANOVAs calculated using blocking appear in Table 4.6. The only alpha level to approach significance is that of the interaction of treatments and blocks for the 3X9X5 design as the p value is .053. However, this is not a product of a systematic trend in the data and it can be accounted for by the high variability in the scores. The results of the data analyses contradict the second hypothesis and the null hypothesis is again accepted for Hypothesis 2.

<u>Experiment 2</u>

<u>Hypothesis 3.</u> Because it was possible that the three sessions on the sailing simulator would be different, means for the three sessions were used separately in a correlation analysis. The mean scores for each subject are presented in Table 4.7.

High inverse correlation between the mean deflection time for the simulator sessions and scores for all of the physical fitness tests except percent body fat were expected. Percent body fat should have the inverse relationship as high body fat is not desirable. The matrix of the correlation analysis is presented in Appendix 5. Only three of the five correlations

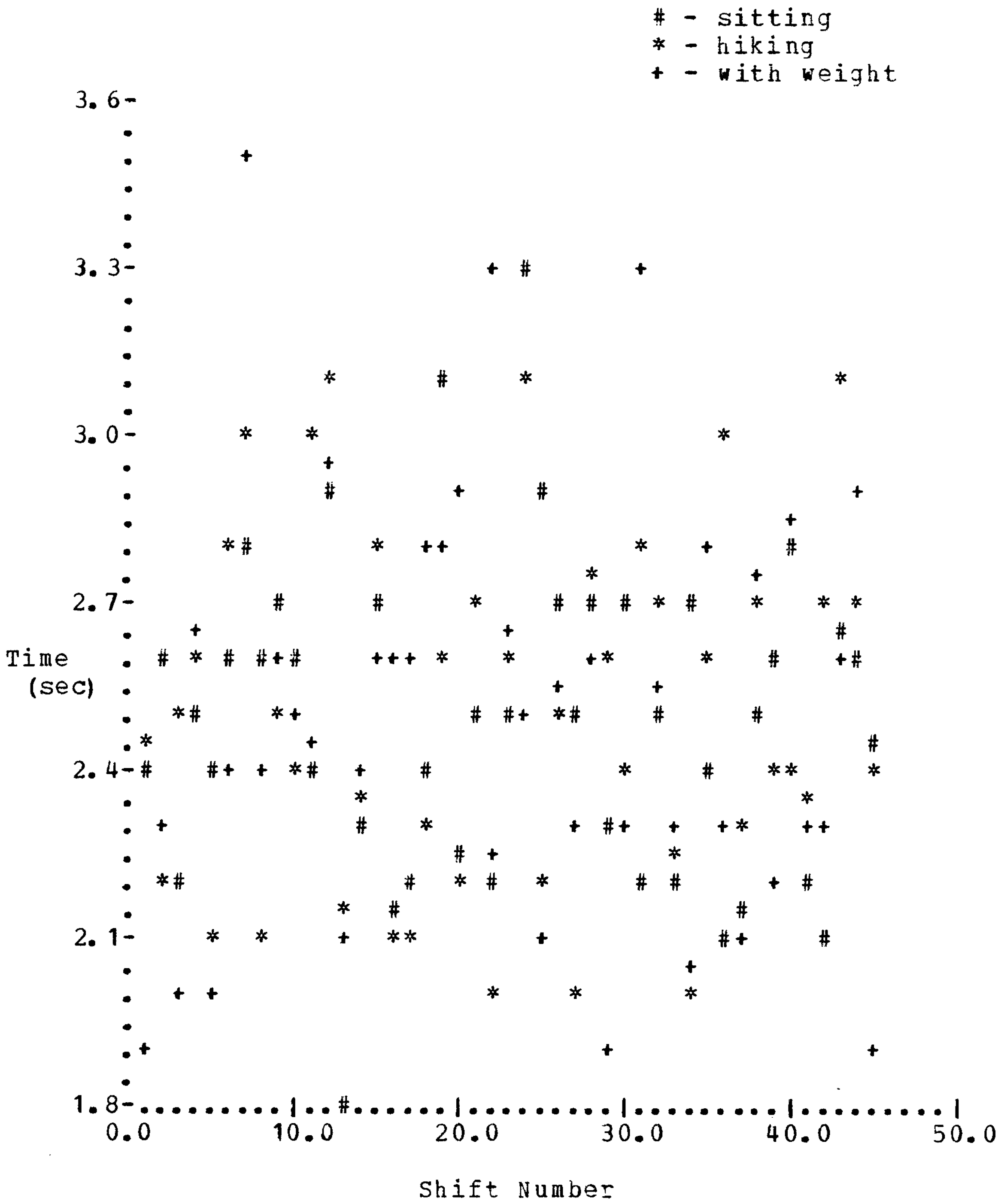

Figure 4.2 Mean Scores for Sitting, Hiking and Hiking With Weight.

showed a moderate relationship. Maximum oxygen uptake was inversely correlated with the means for sitting (-.625), hiking (-.802), hiking with weight (-.599) and the grand mean (-.730). The speed sit-ups and percent body fat had no relationship with

Table 4.6

Significance Levels Of Interactions For Analyses Of Variance Using Various Blocking Designs

DESIGN	INTERACTION	P
3x15x3	treat x blocks	.168
3x15x3	treat x trials	.878
3x3x15	treat x blocks	.156
3x3x15	treat x trials	.170
3x9x5	treat x blocks	.053
3x9x5	treat x trials	.159
3x5x9	treat x blocks	.208
3x5x9	treat x trials	.945

Table 4.7

Subject Means And Standard Deviations For Sitting, Hiking And Hiking With Weight

SUBJECT	SITTING		HIKING		WITH WEIGHT	
	X	SD	X	SD	X	SD
GS	2.24	.80	2.07	.62	2.11	.67
DH	2.56	1.02	2.40	.73	2.60	.83
PL	1.86	.58	2.23	.70	1.86	.75
RT	2.65	.84	2.61	1.19	2.95	1.54
MF	2.19	.60	2.51	.77	2.41	.71
BL	2.46	.75	2.34	.73	2.47	.81
DW	2.16	.43	2.28	.63	2.28	.67
JH	3.43	1.75	3.28	1.34	3.03	1.40
RB	2.72	1.09	3.09	1.80	2.63	.77
JT	2.94	.97	2.72	.79	2.56	1.02
MK	2.66	.66	2.86	.75	3.03	1.23
MC	2.48	.78	2.03	.63	2.35	.91

vigilance scores as only one correlation was above .300. The two isometric measurements showed very weak correlations as strength was correlated at -.490, -.090, -.551 and -.468. However, correlations this low account for very little of the variability in the data sets and the strength measures cannot be described as inversely correlated with vigilance.

Maximum oxygen uptake is inversely correlated with vigilance as the deflection time was lower for subjects with higher aerobic capacity. The validity of the relationship can be questioned in light of the fact that neither Hypothesis 1 nor Hypothesis 2 was accepted. There is no physical or mental fatigue causing a decrease in vigilance for the sailing simulator experiment. Physical fitness has a beneficial effect counteracting fatigue as it postpones its onset. Consequently, it is difficult to conclude that a physical fitness capacity is related to a performance variable which is not affected by fatigue. It is definitely possible that the correlation between maximum oxygen uptake and mean deflection time is spurious. However, the relationship does exist and Hypothesis 3 is accepted for maximum oxygen uptake and rejected for the other four physical fitness tests.

Analysis For A Learning Effect

On examination of Figures 4.1 and 4.2 it seemed apparent that a distinct pattern had appeared in the first portion of the graph of deflection time and trials. All three of the treatments had similar undulations in the curves for the first 15 to 20 trials. Deflection time increases quite dramatically for trials seven and twelve and then immediately decreases on the subsequent trial. A similar increase occurs on trial 24, although the fluctuation in the mean score is not as marked. Table 3.2 indicates that trials seven and twelve are the first instances where the wind generating apparatus is moved to positions three and four respectively. The increase in deflection time is a product of the presentation of a new stimulus. The subsequent drop in deflection time can be accounted for through consideration of the subjects' expectations. In both instances, the next windshift is the inverse of the previous one and this is undoubtedly something which the subject expects. Windshift 24 represents the second time that position four is presented to the subjects and a similar effect may have occurred, although it is not as marked. The large fluctuations in the mean scores for the first portion of the sessions appears to be a product of the pattern used. This is substantiated by the increase in stability seen in the later trials as the means for blocking, especially blocks of five trials, show very little variation near the end of the sessions.

With the fluctuations in the data being produced by the windshift pattern employed, the data was restructured to test for a learning effect. The ANOVA for treatments indicated that there was no difference between sitting, hiking and hiking with weight. Because of this, the sessions were re-ordered and analysed according to the order of presentation. High fluctuations in the first but not the second and third sessions would be an indication of a learning effect. Figure 4.3 contains a graph of deflection time and trials for the three sessions.

The same repeated measures analysis of variance used in Experiment 1 was then calculated for the re-organized data. Table 4.8 contains the ANOVA table for a 3X45 repeated measures analysis repeated on both factors.

The ANOVA indicates that there is significant difference (p=.017) between the sessions. The mean deflection times for the

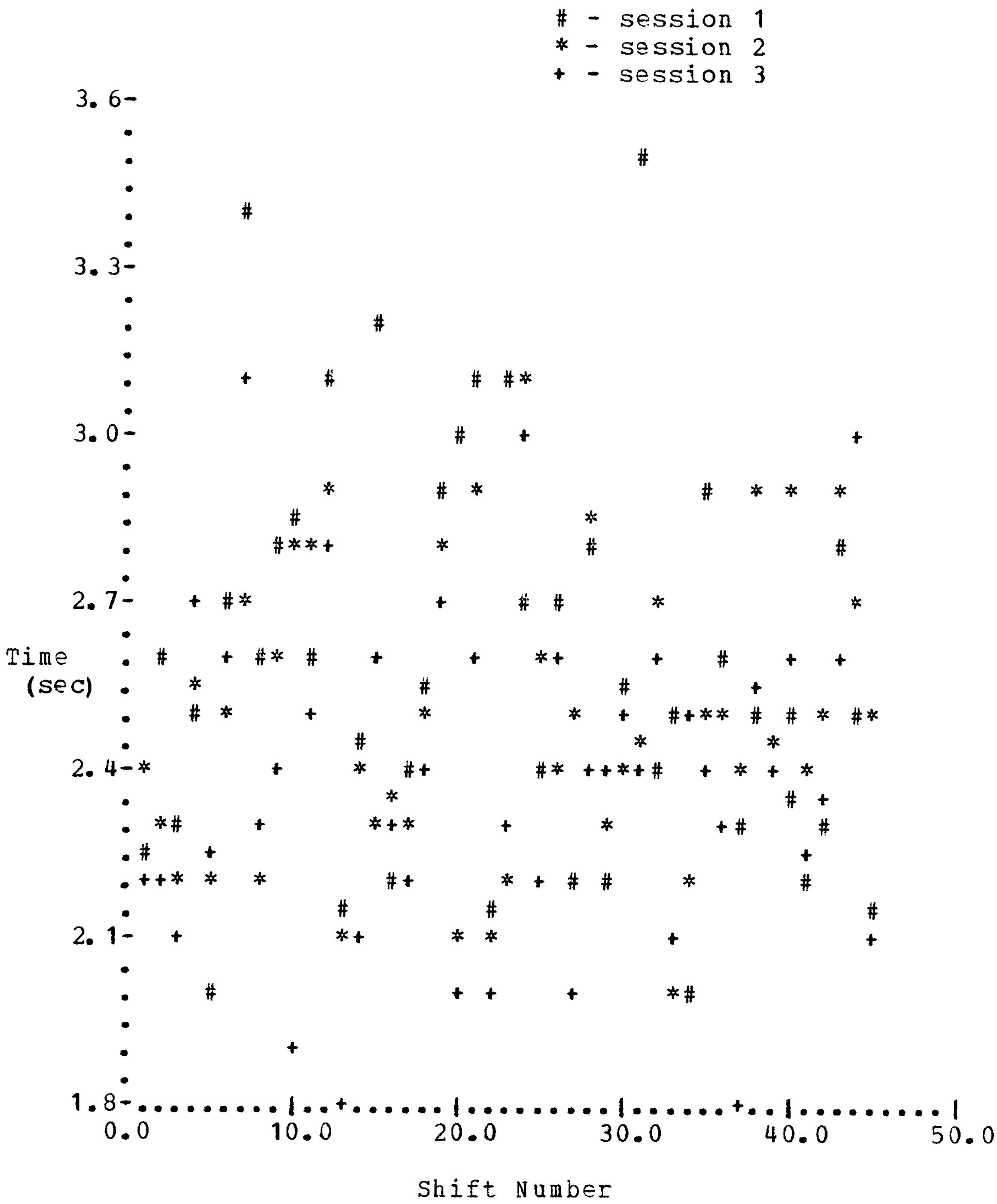

Figure 4.3 Mean Scores by Order of Sessions by Trials

session are: session 1 - 2.62 seconds, session 2 - 2.53 seconds, session 3 - 2.42 seconds. Clearly a learning effect has occurred as mean deflection time has decreased with each successive session. The graph shows certain trends when the curves for the three sessions are compared. There are more large errors in

Table 4.8

Analysis Of Variance Table For Learning Effect

SOURCE	SS	df	ms	F	P
SUBJECTS	190.22	11	17.29		
CONDITIONS	10.75	2	5.37	4.95	.017
SxC	23.88	22	1.09		
TRIALS	97.20	44	2.21	2.36	<.001
SXT	452.95	484	.94		
CXT	54.98	88	.62	.76	.952
SXCXT	799.73	968	.83		
	10333.11	1619			

session one than in either session two or three. The amount of variability decreases a large amount in the third session and this increase in consistancy is the major reason for the drop in the mean score. Familiarization with the apparatus and the stimuli presented appears to have produced the decrease in mean deflection time. It is also possible that subjects may have been more successful in anticipating shifts during later sessions because of their increasing familiarity with the pattern and time intervals used.

The trials effect is significant for the ANOVA but that was expected as the results are identical for those reported in the treatments ANOVA. The graph shows only random variation in the trials. Blocking similar to that used in Experiment 1 was utilized to examine the interaction of session and blocks. The results for the interaction appear in Table 4.9. None of the interactions approach significance indicating that the difference between sessions is constant throughout the session.

The learning that occurred during the sailing simulator testing may have been produced by a number of factors. The pattern used for the windshifts created high scores for certain trials during the first session. Each time a new position was

Table 4.9

Significance Levels Of Interactions For Analyses Of Variance Using Blocking In Learning Effect Analysis

DESIGN	INTERACTION	P
3x15x3	order x blocks	.437
3x15x3	order x trials	.823
3x3x15	order x blocks	.920
3x3x15	order x trials	.765
3x9x5	order x blocks	.870
3x9x5	order x trials	.515
3x5x9	order x blocks	.582
3x5x9	order x trials	.686

introduced during testing, the deflection time increased dramatically. This occurred to a lesser extent in subsequent sessions. Familiarity with the pattern used, positions possible and the time intervals used between shifts contributed to learning. Additional practice trials using all four possible positions and a more extensive introduction to the experiment may be required to remove the learning effect.

Reliability Analysis

The standard deviations displayed in Appendix 4 indicate that the error range for the deflection time scores was quite high. Reliability analysis was attempted to determine if the high standard deviations are a correct representation of the deflection time scores or if they are a product of the data analysis technique.

The video-tape for one session was re-analysed three times. The 45 scores for the three sessions were then used in a correlation analysis using computer program Simcort. Raw data for the reliability study appears in Appendix 6. The correlation analysis yielded six co-efficients of correlation which were used to indicate if the data analysis system was reliable. The results were correlations of .490, .727, .680, .775, .641 and .798, which are not the high positive values which would have been representative of reliability in the data analysis techniques.

The methods used for obtaining the raw data used in Experiment 1 did not prove to be completely reliable. This less than desired reliability increases the subject by sessions error term in the analysis of variance and had the effect of reducing the power of the analysis, consequently, an error may occur as a significant difference between sessions will be negated by the high error term. However, the extremely low value for the probability (.963) indicates very clearly that there is no difference between sessions and that rejection of hypothesis 2 is correct. This is substantiated by the analysis for a learning effect. Although the error term is inflated by poor reliability, there is still significant difference between sessions when they are analysed according to order of presentation. This indicates that the power of the analysis was strong enough to overcome the error due to poor reliability. The finding of a learning effect and the rejection of hypothesis 2 is therefore valid.

Experiment 2 is also affected by poor reliability as mean values from experiment 1 are used in the correlation analysis in experiment 2. The use of a mean value overcomes the error caused by low reliability. Three of the values used are means for 45 trials and the fourth is the average value for all 135 trials. The vigilance scores used for each subject in the correlation analysis are valid because they are means for such a large number of trials. The results of experiment 2 are valid and the treatment of Hypothesis 3 is correct.

Summary Of Hypotheses

The results from both Experiment 1 and Experiment 2 are mixed. Hypothesis 1 and 2 were not accepted and this does not support the findings of Mackworth and others. The third hypothesis is accepted for one of the five physical fitness tests and this substantiates the basic theory used in training for sports requiring physical exertion.

Testing of the two hypotheses in Experiment 1 indicated that no fatigue, be it physical or mental, occurred during testing. A number of factors contributed to this. It is probable that the fifteen minute sessions may not have been long enough or strenuous enough for vigilance to be affected. The inter-stimulus interval may also have been too short for testing vigilance performance accurately. The simulator used reduced the number of variables that the subject had to consider while sailing. The fatigue effect may have been reduced as the subjects did not have to contend with the motion of the boat. The simulator did not require as much upper body work as a race does and the attempt at simulating heavy weather sailing may not have been successful. A learning effect occurred and it may have been a factor in the absence of a vigilance effect. Attempts at replicating sailing have limited the effectiveness of the experimental controls and all of these factors should be considered in future research of this nature.

The analysis for Experiment 2 is partially dependent upon the results of Experiment 1. All of the considerations produced in Experiment 1 will then have some bearing on Hypothesis 3. Maximum oxygen uptake is inversely correlated with deflection time scores as vigilance is better for subjects with higher uptake values. The reliability of the data from Experiment 1 is the only factor which can detract from this relationship. The other physical fitness tests did not show any relationship to vigilance performance. This may be a product of the tests themselves as they may not be applicable for examining fitness levels of competitive sailors. Because the maximum oxygen uptake measure only examines aerobic capacity it is clear that the physical fitness test results obtained cannot be used for prediction of performance on the simulator. None of the tests administered gives a comprehensive measure of sailing skill.

Chapter 5

SUMMARY AND CONCLUSIONS

Summary

The purpose of this investigation was to determine what effect fatigue had on vigilance in sailing. The fatigue complex was divided into physical and mental fatigue components for the investigation. Ability to maintain sail trim was used to measure vigilance performance on a sailing simulator. Mechanically produced wind shifts were presented to subjects and the time required to respond to and correct for each shift was recorded. The hypotheses stated that the deflection time would increase with fatigue and that the effect could be attributed to either a mental or a physical component. The investigation was also designed to determine if physical fitness was related to vigilance performance.

Two separate experiments were performed to achieve this purpose. Experiment 1 consisted of three 15 minute sessions of simulated sailing. Each session had different physical requirements for the subjects as they sailed sitting on the side-deck, hiking and hiking with weight. Forty-five windshifts were presented in a random pattern using a varying interval in each session. The experimental task was a simple two-choice response as the mainsheet was either eased or pulled to let the sail out or pull it in. Deflection time started with the incidence of the windshift on the sail and stopped when the subject had completed the required mainsheet adjustment.

Experiment 2 examined the relationship between five selected fitness components and vigilance performance. The selected components were: number of sit-ups in one minute, percent body fat, muscular strength in the hiking position, muscular endurance in the hiking position and maximum oxygen uptake. The results of the five physical fitness tests were used with the mean deflection time values for the three sessions and the grand mean in a correlation analysis to determine which fitness characteristics related to vigilance performance.

Conclusions

The conclusions arrived at as a result of the investigation were:

1. Mental fatigue did not occur and vigilance did not decrease over the fifteen minute testing period.

2. Physical fatigue did not affect vigilance performance. The treatments used for the three sessions produced no difference in deflection time scores.

3. A learning effect occurred as deflection time scores decreased with each subsequent session.

4. Four of the physical fitness parameters, number of sit-ups in one minute, percent body fat, muscular strength in the hiking position and muscular endurance in the hiking position, showed

no relationship with vigilance performance.

5. Maximum oxygen uptake is inversely correlated with deflection time scores. It appears that individuals with higher aerobic capacity have better vigilance while sailing as they react to and adjust for windshifts faster.

6. Training programs for sailing should include a large aerobic component as vigilance is a factor in maintainance of optimum boat speed.

Suggestions For Further Research

Because of the problems encountered in this investigation it is recommended that certain aspects of the design be considered in further research. The reliability of the video-tape analysis technique must be ensured. Removal of the human component in the tape analysis is probably required. An electronic device which measures telltale deflection would provide the desired reliability. Other factors could be changed to enhance further research attempts ,e.g., the wind velocity should be increased and the inter-stimulus interval should also increase, the testing sessions should be lengthened as the effects of fatigue are not manifested in the first fifteen minutes of sailing. If deemed appropriate, other variables could be added to the procedures, e.g., a requirement that the subject balance the boat or that the tiller be adjusted rather than the sail could be incorporated. One important addition to the design would be practice trials as all possible windshifts should be demonstrated prior to each session. This would be a major step in eliminating the learning effect. Most of the difficulties encountered are a product of attempts at simulation and methods for on-the-water testing should be investigated.

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APPENDIX

Figure A 1.

Sailing Simulator Testing Apparatus

Front View of Sailing Simulator

Side View of Sailing Simulator

Rear view of Sailing Simulator

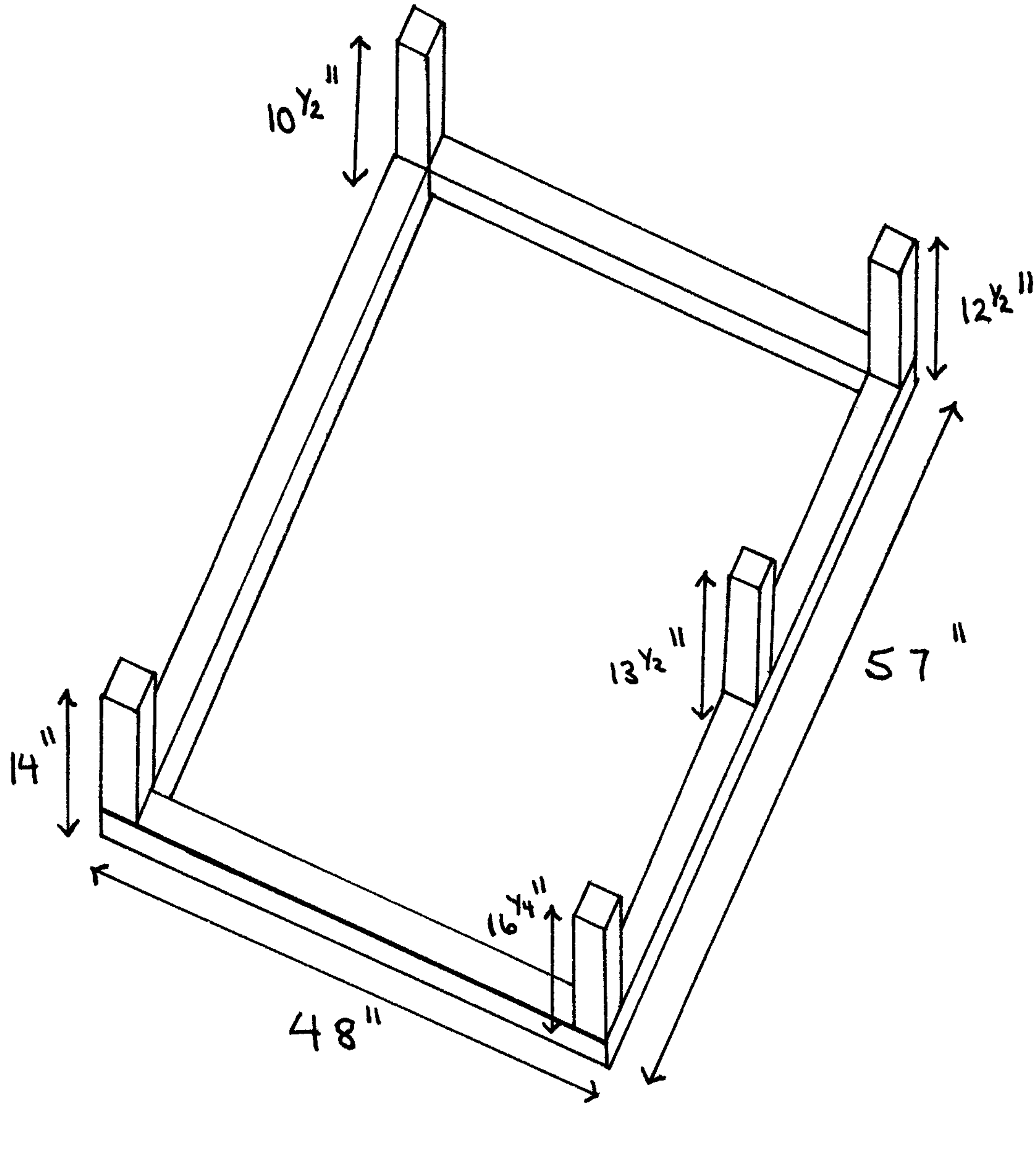


Diagram of Laser Frame

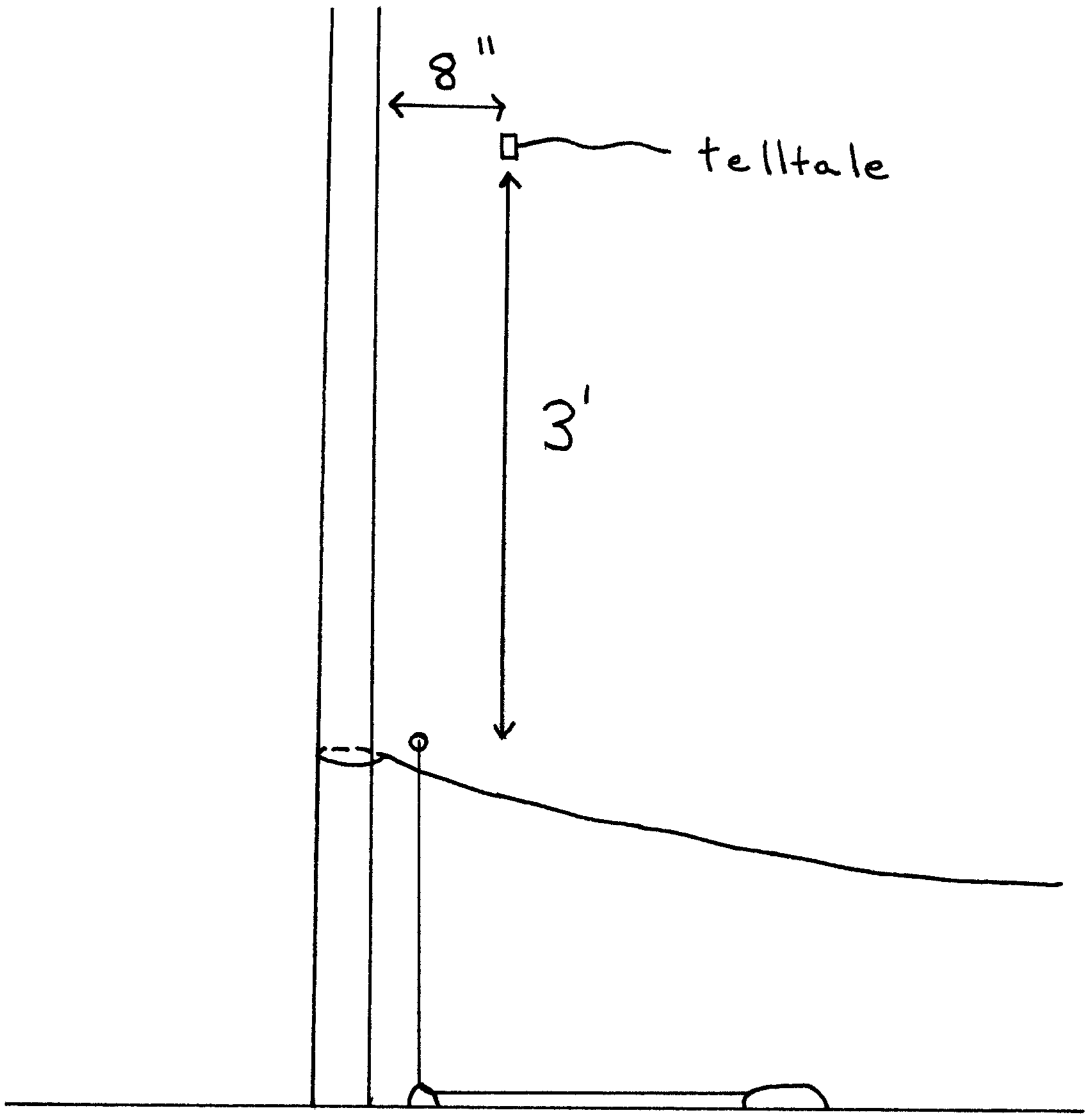
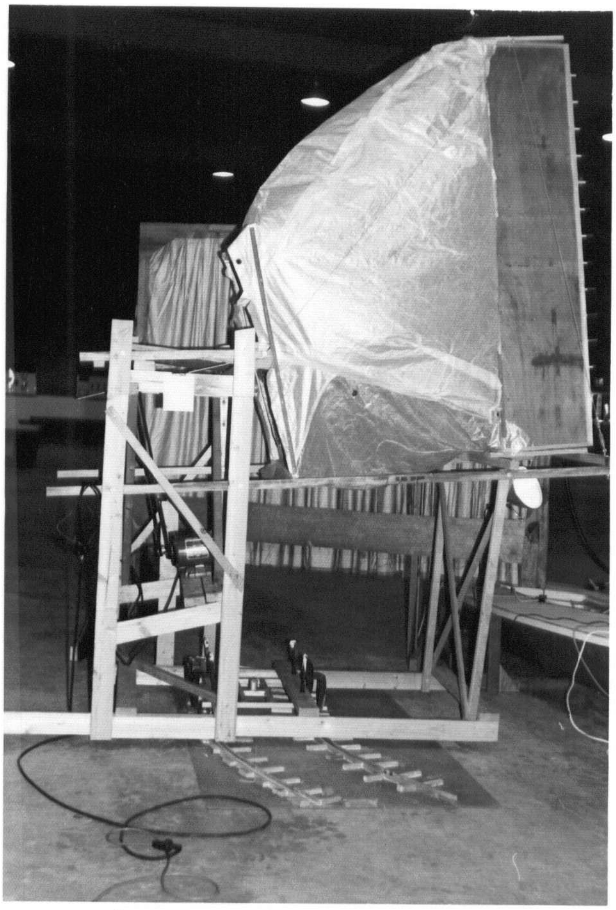
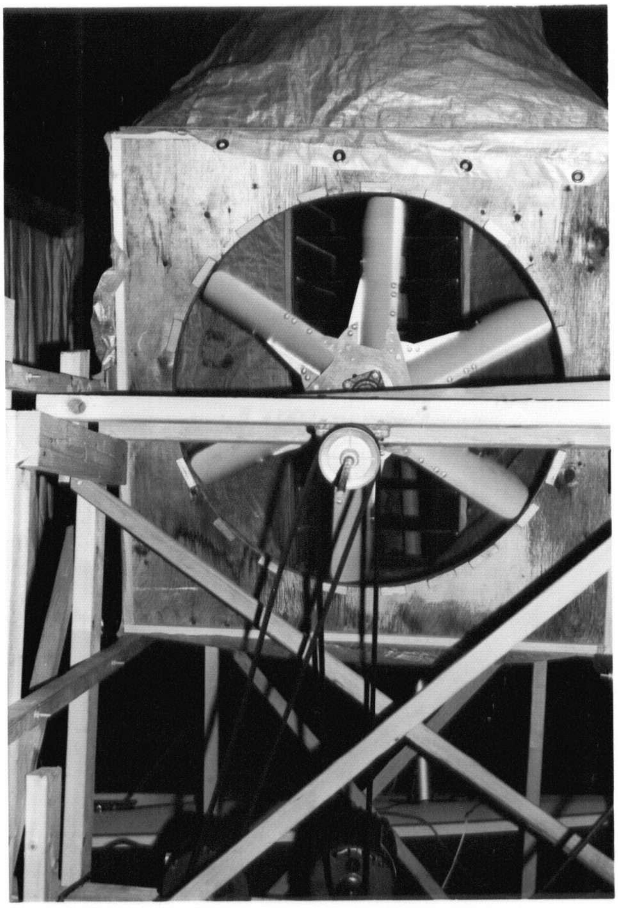


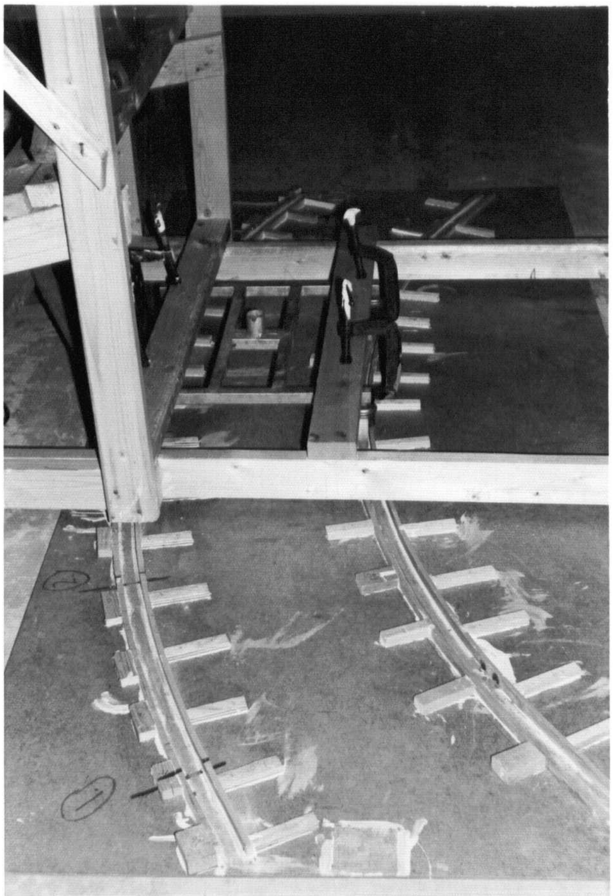
Diagram Showing Telltale Positioning



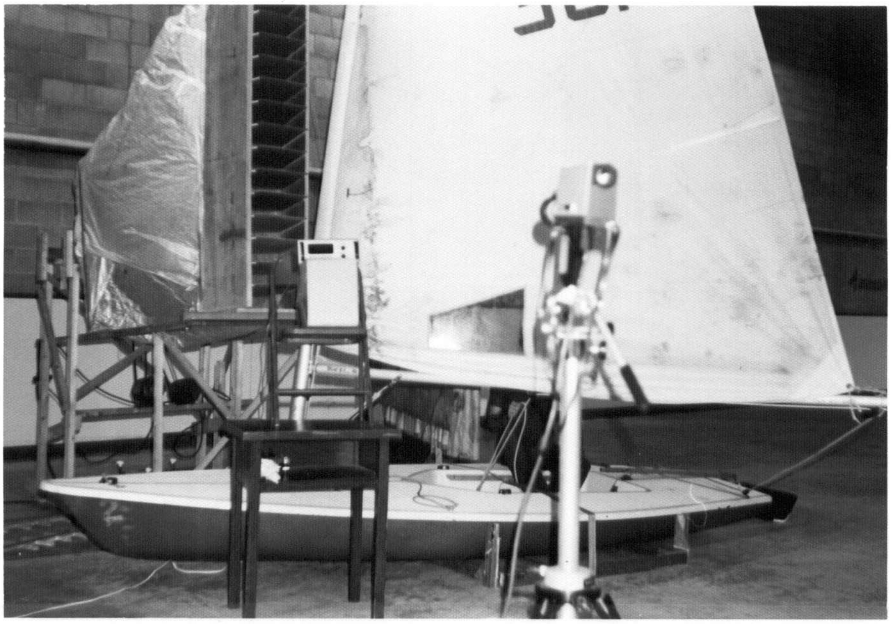
Side View of Wind Machine



Rear View of Wind Machine



The Track and Dolly Used For Creating Windshifts



Videotape System Used For Recording Telltale Activity

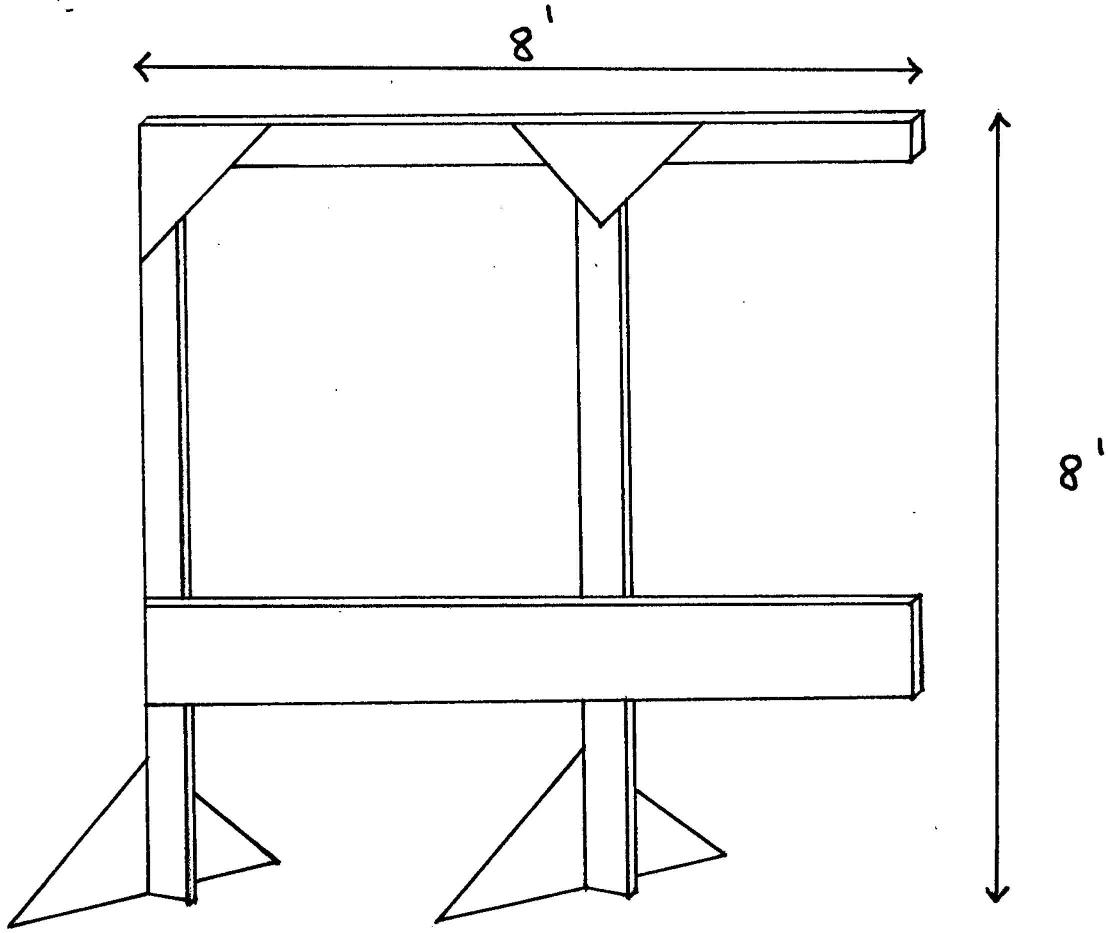
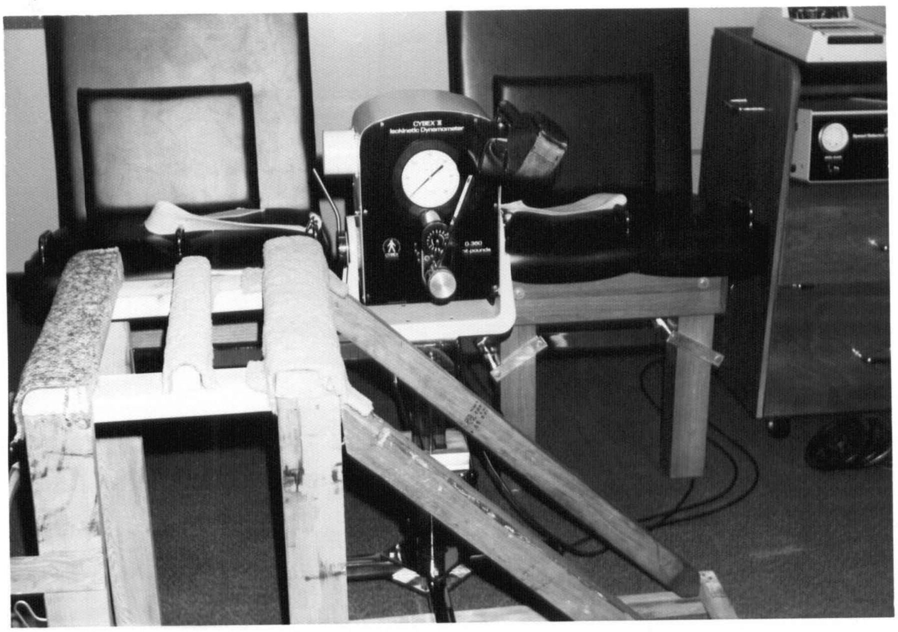


Diagram of the Vision Occluding Barricade

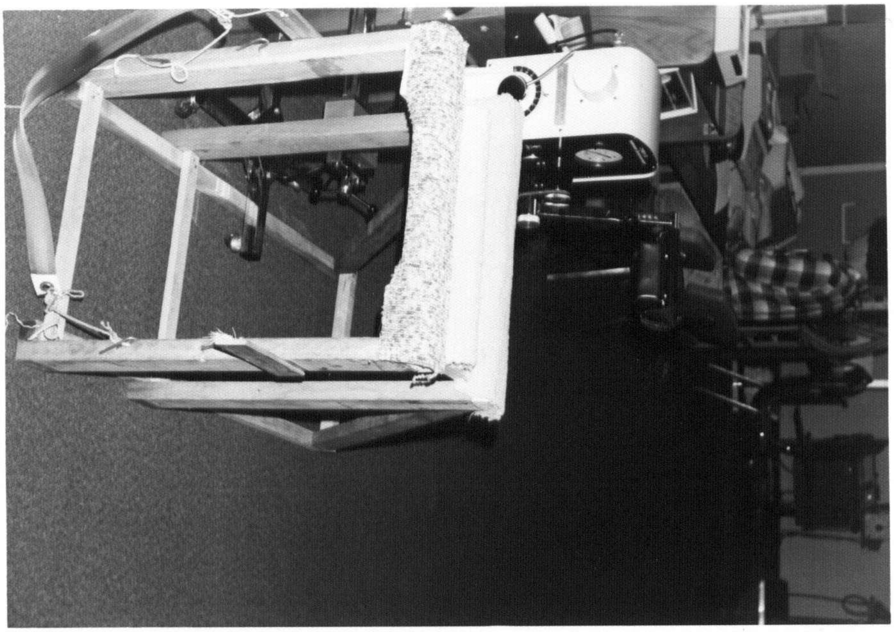
Figure A 2.

Physical Fitness Testing Apparatus

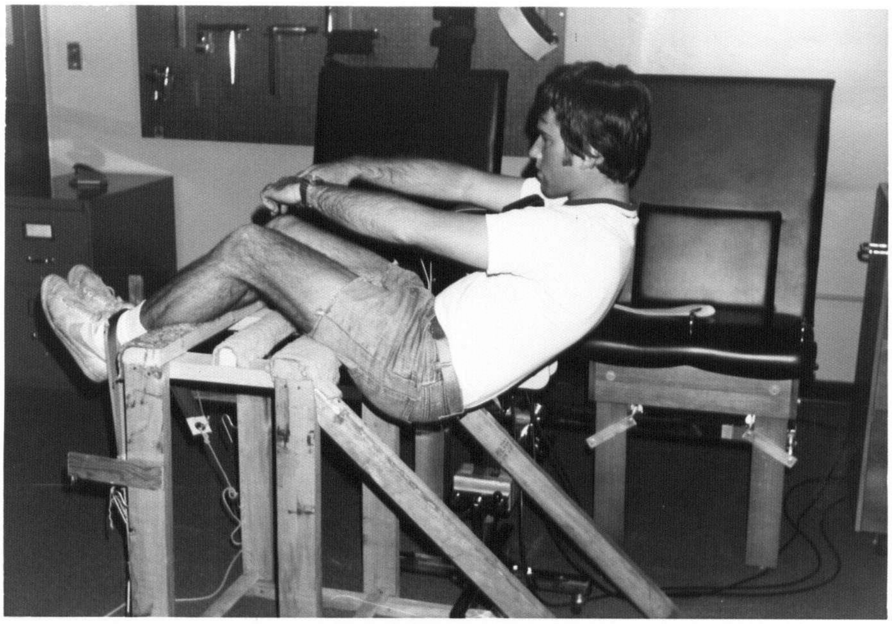
Cybex Dynamometer Recorder



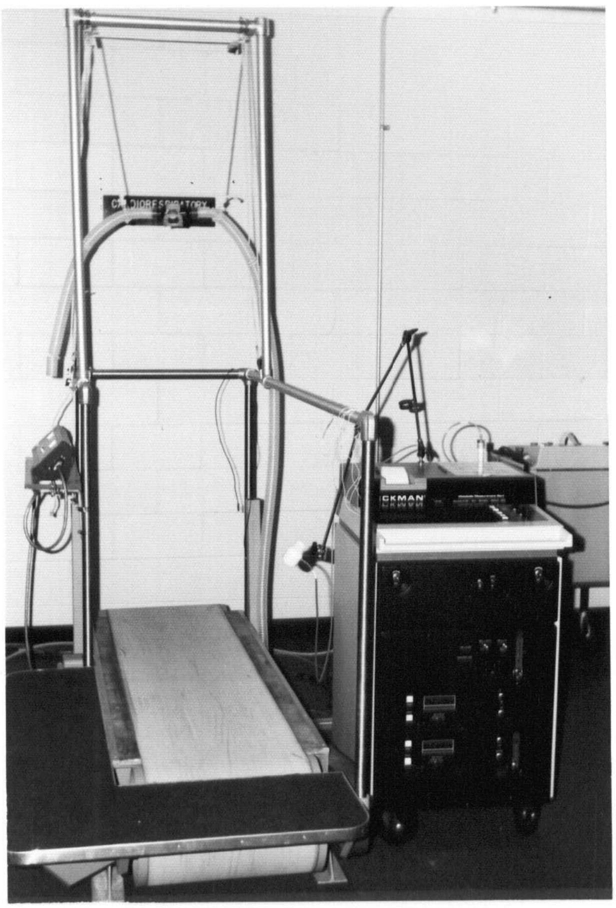
Side View of Strength Testing Apparatus



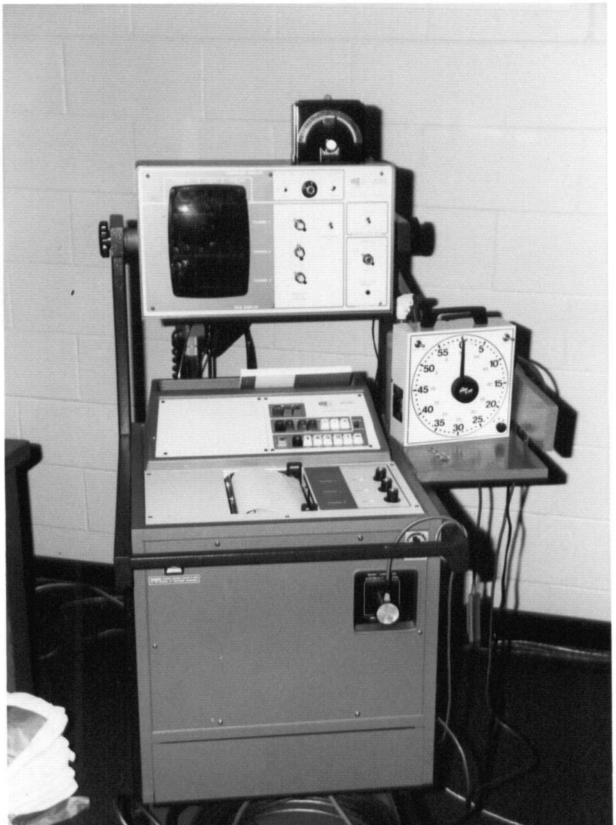
Front View of Strength Testing Apparatus



Side View of Strength Testing Apparatus With a Subject



Treadmill and Beckman Metabolic Measurement Apparatus



Heart Rate Monitor

Table A 3.

Raw Data For Experiment 1.

0.90	1.95	2.25	2.12	1.60	1.40	1.48	2.18	2.34	2.77	2.20	1.37	1.53
0.89	2.93	1.94	2.39	1.58	2.71	2.49	2.20	4.00	2.76	3.86	2.71	2.06
2.05	3.52	1.43	2.59	2.47	2.89	2.74	1.98	2.76	0.73	1.50	2.38	2.74
2.00	1.61	1.44	3.72	4.05	1.54							
3.75	2.77	1.63	1.87	1.97	1.90	2.61	1.65	2.73	1.80	2.60	2.15	1.23
2.55	1.99	1.90	3.25	2.03	2.11	1.86	1.76	1.84	1.94	1.80	1.91	2.45
1.65	1.87	0.60	1.41	1.56	1.61	1.20	1.47	2.20	2.26	1.70	2.81	1.32
2.54	1.60	2.19	2.70	2.55	3.71							
1.24	2.19	1.92	2.50	2.27	1.86	4.05	2.11	2.88	1.49	2.20	2.44	1.29
1.72	2.05	2.09	2.45	2.33	2.50	2.07	1.98	3.94	1.75	2.34	1.19	2.49
2.41	1.86	1.36	0.79	3.30	1.69	1.41	2.05	2.48	1.89	2.00	1.77	1.39
3.16	1.94	1.87	2.09	2.71	1.08							
2.99	2.38	0.92	2.02	2.72	3.30	4.70	2.10	2.96	3.45	1.77	4.53	1.15
1.76	5.09	1.50	1.20	3.31	3.80	1.00	2.70	0.76	4.01	2.60	3.19	2.91
2.01	1.81	2.31	2.74	2.36	2.74	3.97	2.06	2.29	1.56	4.09	1.90	1.72
2.09	2.70	2.29	3.36	2.26	1.91							
2.91	1.85	1.69	2.50	2.29	1.98	3.50	2.74	3.20	2.46	3.98	4.61	1.71
1.91	2.13	1.30	2.49	2.10	2.20	2.36	2.27	1.67	1.50	3.81	2.08	2.07
1.95	2.25	2.53	2.60	2.49	2.01	2.83	1.65	2.06	3.06	1.67	2.57	1.94
2.19	1.40	2.70	3.69	3.59	1.55							
1.55	2.20	1.62	3.35	1.86	1.40	3.60	3.06	2.60	1.60	2.52	6.24	2.50
2.80	2.60	2.90	3.04	2.46	2.82	2.33	2.50	1.56	2.46	2.62	2.30	2.38
2.50	2.65	3.55	1.70	2.29	4.26	3.41	2.07	2.39	1.88	2.70	2.26	2.24
3.06	2.69	2.24	2.97	3.46	1.67							
1.29	2.30	1.56	1.87	1.39	1.95	2.82	1.30	1.87	2.16	2.19	2.46	0.50
1.99	1.85	2.50	1.71	2.21	2.23	0.83	2.34	0.21	1.76	2.67	1.57	2.20
1.86	2.41	2.23	1.30	1.34	1.97	1.64	1.80	1.53	1.67	1.79	2.21	1.96
1.86	2.26	2.03	2.51	2.87	0.64							
1.50	1.90	0.96	2.30	1.26	2.30	2.75	1.57	2.85	2.69	2.10	3.18	1.71
2.27	2.15	1.60	2.76	2.07	2.84	2.31	2.80	1.97	5.17	1.84	2.20	2.56
2.54	2.04	2.04	1.39	3.00	1.90	1.90	1.33	3.26	3.00	1.86	1.97	1.33
2.09	1.82	1.96	2.43	2.24	2.46							
1.79	1.79	1.04	2.09	0.97	1.90	2.26	1.01	2.47	2.10	1.78	3.57	0.94
1.04	3.22	1.60	0.70	2.25	2.30	1.76	1.95	1.53	1.61	1.64	1.70	2.37
2.25	2.39	0.37	3.35	2.30	2.70	1.57	1.57	3.27	0.37	0.62	1.19	1.96
1.79	1.64	2.43	2.21	2.56	1.59							
1.20	2.52	2.40	2.75	3.19	3.60	1.96	3.40	4.44	3.77	2.03	3.64	2.20
3.09	2.63	2.04	1.73	1.43	3.31	2.76	1.46	1.77	2.47	2.94	3.99	3.40
3.76	2.50	3.03	1.74	1.99	2.88	1.91	1.94	2.30	4.06	1.90	2.51	4.15
2.85	2.24	1.66	2.35	2.85	2.66							
1.70	2.37	2.36	3.19	1.35	1.76	2.25	2.33	1.43	1.51	1.77	4.46	2.56
1.95	1.99	2.11	2.70	2.15	2.49	1.66	2.57	2.36	2.55	5.50	2.50	1.66
2.37	2.83	8.14	3.70	2.40	2.13	2.86	1.18	2.21	3.67	3.40	2.83	2.42
3.11	1.40	3.56	2.53	2.31	3.20							
2.00	2.40	4.20	2.59	1.76	3.81	4.14	5.95	2.53	3.33	2.45	2.14	3.75
2.63	4.13	1.10	2.67	2.43	2.46	10.74	2.36	2.61	3.90	2.39	3.69	2.76
3.17	1.95	1.66	2.10	2.31	2.65	4.19	1.51	2.47	4.80	2.14	1.37	2.83
3.07	1.63	3.15	2.70	2.75	1.38							
1.34	2.01	1.10	2.90	2.09	2.11	2.50	2.40	1.69	1.99	2.69	2.69	2.04
2.12	3.26	1.99	1.88	3.03	2.17	3.21	2.34	1.25	2.10	1.90	2.70	2.10

1.08	2.04	1.57	1.49	1.48	2.14	2.40	2.85	2.54	2.25	2.10	1.87	2.01
2.13	3.57	1.77	3.57	2.41	1.51							
3.20	2.01	2.06	2.10	1.41	1.89	1.77	2.96	1.89	3.50	2.16	2.70	2.80
1.95	2.37	1.59	2.44	2.66	2.71	2.89	2.75	3.39	2.28	3.16	2.03	1.99
1.67	2.83	3.94	4.86	2.86	2.70	1.39	1.83	4.19	3.97	2.85	1.80	2.21
1.30	2.78	2.66	2.11	2.02	2.10							
3.50	2.48	1.55	2.75	1.55	2.22	2.19	1.72	3.83	1.80	2.28	3.00	2.60
1.55	2.63	2.61	2.01	2.40	3.69	1.71	3.00	1.76	2.79	3.27	1.04	1.90
3.50	2.94	2.09	1.60	3.50	2.64	1.78	1.58	2.65	3.93	2.02	3.03	1.75
1.91	1.81	2.02	2.77	2.49	2.74							
1.92	3.70	2.86	3.11	2.08	3.66	3.79	1.39	3.10	1.80	4.28	2.11	1.48
2.89	2.51	1.02	2.93	2.45	2.51	1.48	2.10	1.70	2.72	3.47	2.12	3.97
2.68	1.89	1.36	2.42	2.89	1.97	2.09	2.70	1.81	1.89	1.93	2.38	2.40
2.44	2.18	2.39	3.67	1.96	2.52							
1.06	2.27	2.57	1.69	2.17	2.34	2.77	1.95	2.50	3.17	3.97	2.25	3.14
1.47	1.53	2.24	1.57	3.37	1.37	2.16	2.06	1.90	1.36	2.98	1.39	2.34
1.36	2.37	1.74	2.70	2.71	3.12	1.66	1.51	3.20	2.31	2.83	3.17	1.51
2.20	2.99	2.98	4.21	2.47	2.87							
1.71	4.50	1.91	2.70	1.78	3.96	2.21	3.57	1.89	2.73	2.00	2.31	2.10
2.14	1.89	1.34	2.20	2.96	1.60	2.25	2.36	3.59	4.19	2.04	1.69	2.54
2.30	2.66	2.26	2.61	3.23	1.70	2.46	1.95	3.80	1.43	1.50	3.31	2.10
3.90	2.01	2.70	1.70	3.64	1.55							
3.02	2.20	2.67	1.99	1.07	1.96	1.93	2.19	2.71	1.79	2.61	2.15	2.09
1.85	2.41	1.90	2.06	2.46	1.97	2.09	3.14	1.64	2.39	2.30	2.50	2.24
1.46	2.14	2.33	1.97	2.30	2.76	1.64	1.77	2.91	1.64	1.79	2.02	2.34
1.60	2.53	1.77	2.31	1.73	2.71							
1.84	1.68	2.83	1.54	1.40	2.36	3.07	2.50	1.87	1.71	2.34	2.75	1.76
2.01	2.90	1.60	1.83	2.00	3.19	1.46	3.41	2.21	2.44	2.91	2.42	2.40
1.76	2.16	2.27	2.96	2.52	2.15	1.64	2.10	2.41	1.75	2.31	1.90	3.19
2.62	1.65	1.73	4.60	2.53	1.84							
1.60	1.56	1.47	2.06	3.33	2.70	1.62	2.36	1.80	2.26	2.12	2.30	2.11
3.04	2.00	3.07	1.86	2.70	1.76	1.79	2.28	1.92	2.13	3.18	1.27	2.59
1.68	2.24	2.03	3.35	2.41	2.33	1.47	3.19	1.95	1.94	1.52	2.61	2.95
1.92	2.03	2.89	1.89	4.84	2.40							
1.91	4.61	2.25	2.57	2.61	3.25	3.30	2.62	2.70	1.83	1.70	5.31	2.70
2.11	2.47	1.98	2.14	2.39	3.80	2.89	4.20	2.50	1.92	2.48	2.09	2.23
3.22	1.77	2.29	2.54	2.25	2.43	2.13	2.13	2.64	2.29	2.10	1.76	1.60
2.78	2.04	2.43	1.76	1.45	1.84							
2.11	2.09	1.96	2.35	1.49	3.50	2.50	1.28	2.97	1.86	2.39	2.20	1.47
1.97	2.43	0.82	1.47	2.06	2.50	1.01	2.47	1.23	2.82	2.64	1.40	2.14
1.62	2.39	1.17	1.63	2.51	2.79	1.53	1.14	2.34	1.94	1.15	2.45	1.35
3.49	1.80	2.29	1.97	2.49	2.09							
1.91	1.95	1.88	2.27	2.14	2.16	1.82	2.06	1.49	3.23	1.92	1.82	1.63
2.43	2.06	1.77	2.60	2.67	2.17	2.50	7.43	1.91	2.00	2.41	1.76	2.76
1.72	2.31	2.35	1.92	3.34	2.39	2.19	2.03	2.69	2.54	2.88	2.63	1.63
2.90	1.64	3.39	2.61	2.57	1.30							
5.50	1.90	2.29	2.27	4.04	2.96	4.09	2.16	4.16	4.59	2.24	2.63	2.73
3.89	2.34	3.84	3.18	3.10	5.65	2.40	2.57	2.02	2.29	7.85	1.45	2.63
3.22	4.64	3.72	8.79	1.75	3.24	2.21	3.76	2.86	2.00	1.59	6.60	4.60
8.36	1.88	2.64	2.54	2.78	2.30							
4.54	3.66	3.89	1.80	2.83	2.43	5.01	2.10	2.87	3.52	7.10	2.13	1.73
4.99	2.65	3.95	2.24	2.15	3.77	3.80	5.47	1.80	3.24	4.04	1.99	2.87
2.64	3.07	2.70	1.50	2.60	2.24	2.14	2.09	3.23	4.48	1.86	4.40	5.96
2.62	2.04	5.34	6.20	3.43	2.31							
1.50	2.13	2.46	3.09	2.92	4.83	7.07	1.08	2.80	1.77	3.34	2.51	1.64
1.67	2.71	6.23	3.26	2.39	5.13	3.37	6.04	1.32	2.53	2.27	2.70	2.43

2.06	2.40	2.74	3.03	2.60	3.87	2.67	1.87	3.78	2.81	1.41	6.24	3.94
3.82	4.17	1.47	4.00	2.52	1.96							
2.63	2.79	2.46	3.24	2.93	2.80	2.62	3.55	2.41	2.82	3.00	2.59	2.24
2.83	2.94	1.73	2.57	2.29	3.00	3.03	2.66	4.43	2.34	2.86	6.37	2.18
4.73	2.78	2.55	2.13	2.90	2.56	2.72	3.09	2.58	2.40	2.70	2.62	3.76
2.38	2.72	2.42	2.29	2.97	6.95							
2.78	2.07	2.97	3.07	2.60	2.54	3.81	2.77	2.55	1.69	1.96	2.51	3.50
2.61	4.14	2.71	1.39	2.92	3.68	1.82	2.30	1.92	2.93	2.78	1.94	2.93
1.95	2.50	1.85	2.81	1.63	4.97	3.86	3.17	2.33	2.77	2.11	2.46	4.52
1.99	3.60	2.37	2.47	3.82	2.21							
1.61	2.27	2.56	2.76	1.70	1.92	2.31	2.42	4.57	3.25	2.44	2.75	1.33
2.68	2.54	3.36	2.69	2.49	2.42	2.20	4.21	2.34	1.99	2.41	1.93	2.74
2.16	2.60	1.71	3.90	2.87	1.54	2.65	2.62	2.15	2.29	2.67	2.52	2.25
2.00	2.06	2.00	2.78	2.05	1.70							
4.17	2.82	2.80	2.74	2.03	2.04	2.34	6.07	2.85	1.92	2.19	2.67	2.34
1.49	2.22	2.21	3.72	2.25	2.63	2.10	2.49	2.82	2.87	2.50	4.53	4.14
1.47	3.10	3.49	1.64	2.20	2.45	1.43	7.13	2.32	2.47	2.15	2.24	1.91
2.44	2.07	2.71	2.01	3.45	2.86							
1.94	1.91	2.76	4.77	4.59	2.90	3.76	1.71	2.61	3.04	1.88	5.77	2.26
2.77	6.30	2.95	1.50	2.26	1.96	2.34	1.80	1.80	2.53	3.28	2.66	4.29
1.91	4.96	1.87	1.9112.09		2.76	3.90	4.43	1.76	2.84	3.10	3.50	1.73
1.90	4.59	2.29	1.86	2.41	2.99							
3.24	2.70	1.81	2.66	2.19	3.85	2.23	1.81	3.18	4.84	3.64	3.09	3.15
3.54	2.04	2.47	2.93	4.33	2.31	2.24	2.14	2.78	2.78	2.87	3.29	2.46
2.26	4.01	1.28	1.23	2.14	2.01	1.63	2.83	2.54	2.17	2.81	2.82	1.67
1.79	3.09	1.60	2.89	2.89	2.32							
2.19	2.76	3.51	3.33	3.54	2.57	2.60	2.10	1.51	2.96	2.17	2.66	1.59
2.96	2.72	2.73	1.49	3.10	3.51	2.50	2.55	3.34	3.07	4.87	2.56	3.07
2.70	3.58	2.19	3.15	2.77	2.44	2.03	1.77	2.35	2.92	2.35	2.09	2.68
2.94	1.71	1.95	2.13	3.46	2.40							
2.46	2.14	4.22	4.19	1.80	3.14	3.26	1.86	2.77	2.16	4.86	2.91	2.13
1.49	3.12	2.45	2.26	2.61	2.68	2.81	3.50	2.96	2.87	2.48	4.33	2.70
2.59	3.51	2.82	1.89	3.45	3.96	2.73	2.25	3.12	4.10	3.62	2.92	1.89
3.03	2.33	2.82	3.01	2.70	1.79							
1.67	2.27	2.13	2.72	1.58	3.39	8.53	2.30	2.16	1.78	2.83	3.04	2.12
3.05	4.36	3.21	4.74	4.15	4.80	2.00	3.56	2.01	3.58	2.91	2.78	3.40
1.93	4.34	2.19	2.94	3.90	3.03	2.00	1.40	3.42	2.24	3.24	3.20	2.02
5.06	3.09	2.60	2.67	2.71	3.27							

Table A 4.

Means and Standard Deviations For Experiment 1.

Siting On The Side Deck

Trial	Mean	Standard Deviation
1	2.42	1.35
2	2.66	.79
3	2.26	.74
4	2.58	.51
5	2.44	.89
6	2.63	.73
7	2.84	.96
8	2.62	1.27
9	2.73	.89
10	2.65	.91
11	2.42	.69
12	2.90	1.09
13	1.88	.65
14	2.32	.83
15	2.78	.82
16	2.12	.70
17	2.25	.74
18	2.47	.59
19	3.11	1.01
20	2.23	.77
21	2.56	.65
22	2.20	1.27
23	2.56	.60
24	3.36	1.62
25	2.98	1.39
26	2.76	.74
27	2.52	1.07
28	2.68	.88
29	2.38	.75
30	2.71	1.99
31	2.23	.51
32	2.54	.39
33	2.24	.68
34	2.75	1.52
35	2.41	.41
36	2.16	.82
37	2.17	.69
38	2.55	1.30
39	2.66	.99
40	2.82	1.79
41	2.29	.53
42	2.12	.41
43	2.69	.70
44	2.69	.76
45	2.49	1.54

Hiking

1	2.48	1.00
2	2.23	.53
3	2.49	.93
4	2.61	1.01
5	2.10	.94
6	2.42	.53
7	3.09	.86
8	2.12	.54
9	2.52	.52
10	2.43	.74
11	3.09	1.61
12	3.14	1.18
13	2.17	.70
14	2.33	.93
15	2.81	1.29
16	2.10	.84
17	2.16	.60
18	2.37	.43
19	2.63	.69
20	2.21	.74
21	2.76	1.01
22	2.09	.58
23	2.64	.98
24	3.10	1.01
25	2.24	.76
26	2.53	.67
27	2.00	.43
28	2.73	.84
29	2.64	1.93
30	2.45	1.05
31	3.32	2.81
32	2.70	.96
33	2.30	.93
34	2.01	.95
35	2.69	.70
36	2.30	.88
37	2.37	.78
38	2.73	.73
39	2.45	1.44
40	2.42	.60
41	2.33	.99
42	2.74	.95
43	3.15	1.30
44	2.71	.57
45	2.43	.64

Hiking With Weight

1	1.94	.70
2	2.37	.74
3	2.05	.80
4	2.63	.37
5	2.00	.63
6	2.83	1.09

7	3.50	2.20
8	2.45	1.32
9	2.68	.87
10	2.51	1.00
11	2.46	.56
12	2.93	1.15
13	2.10	.81
14	2.36	.74
15	2.69	1.83
16	2.65	1.36
17	2.60	.95
18	2.80	.70
19	2.83	1.13
20	2.91	2.50
21	3.32	1.76
22	2.27	.82
23	2.64	.85
24	2.53	.47
25	2.11	.85
26	2.57	.35
27	2.33	.54
28	2.70	.76
29	1.96	.80
30	2.38	.96
31	2.85	.59
32	2.57	.84
33	2.29	.85
34	2.06	.60
35	2.80	.62
36	2.36	1.13
37	2.13	.77
38	2.75	1.29
39	2.23	.71
40	2.87	1.04
41	2.32	.79
42	2.36	.60
43	2.61	.60
44	2.93	.74
45	1.91	.65

Table A 5.

Correlation Matrix For Experiment 2.

	Sit-ups	% Fat	Stren	Endur	maxVO2
Situps	1.0000				
% Fat	-0.0284	1.0000			
Stren	0.4426	-0.4959	1.0000		
Endur	0.2171	-0.2003	0.1453	1.0000	
maxVO2	0.0083	-0.2965	0.0189	0.4412	1.0000
Sitting	-0.2115	0.3425	-0.4904	-0.3811	-0.6252
Hiking	0.0269	0.1532	-0.0899	-0.3814	-0.8022
Weight	-.02211	0.0405	-0.3774	-0.5511	-0.5989
Gnd Mn	-0.1461	0.1951	-0.3459	-0.4679	-0.7296

	Sitting	Hiking	Weight	Grand Mean
Sitting	1.0000			
Hiking	0.7816	1.0000		
Weight	0.8114	0.7626	1.0000	
Gnd Mn	0.9372	0.9157	0.9239	1.0000

Table A 6.

Raw Data For The Reliability Analysis

1	2	3	4
2.46	3.04	2.00	2.30
2.14	5.57	4.42	3.70
4.22	3.83	4.01	3.96
4.19	6.23	4.80	4.13
1.80	1.90	1.86	1.86
3.14	4.00	3.34	3.57
3.26	3.01	3.94	2.78
1.86	2.44	2.41	2.39
2.77	2.77	3.51	2.66
2.16	3.23	1.62	2.20
4.86	2.96	3.18	3.57
2.91	2.51	2.52	2.89
2.13	2.07	1.65	1.88
1.49	4.07	1.85	1.81
3.12	3.03	3.24	3.14
2.45	2.81	2.04	2.74
2.26	3.03	2.25	2.45
2.61	3.03	2.57	2.69
2.68	2.89	2.48	2.89
2.81	3.54	3.24	3.49
3.50	3.45	3.49	2.52
2.96	3.47	3.23	3.45
2.87	2.78	2.87	2.70
2.48	2.79	2.43	2.41
4.33	4.55	4.38	4.62
2.70	3.65	3.68	3.58
2.59	3.37	2.28	2.61
3.51	3.57	4.42	3.21
2.82	2.73	2.61	2.73
1.89	1.98	2.16	1.99
3.45	3.97	4.00	3.36
3.96	3.90	3.36	4.34
2.73	2.11	2.86	2.60
2.25	2.42	2.14	2.16
3.12	2.73	2.76	2.65
4.10	4.00	4.21	4.12
3.62	3.33	3.23	3.57
2.92	2.97	3.35	4.23
1.89	2.30	2.10	1.95
3.03	2.91	2.77	2.95
2.33	2.27	2.20	2.44
2.82	3.49	2.30	3.27
3.01	4.35	2.48	2.34
2.70	3.10	2.78	3.42
1.79	1.73	2.24	2.07

$SIG