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The Effect of Compression Stockings and Foot Exercises on Venous Blood Velocity

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THE EFFECT OF COMPRESSION STOCKINGS AND FOOT EXERCISES ON VENOUS BLOOD VELOCITY

by

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A Thesis in Partial Fulfillment
of the Requirements for the Degree
of Master of Science in the Field of Nursing

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Each person whose signature appears below certifies that this thesis in his opinion is adequate, in scope and quality, as a thesis for the degree of Master of Science.

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CHAPTER I

INTRODUCTION TO THE STUDY

Need for Study

Pulmonary embolism is a frequent cause of death or a major contributing factor to mortality following surgery (Kakkar, 1970), long periods of bed rest (Gibbs, 1957), or medical disease (Morrell, 1963). Forty-six percent of pulmonary emboli originate from some stage of thrombophlebitis in the venous system of the lower extremities (Meltzer, 1970, p. 138). Contrary to medical investigator's and practitioner's wishes, there is a "rapidly increasing incidence of deep-vein thrombosis" (Laufman, 1969, p. 489). With increasing age and life expectancy of the population and longer survival of critically ill patients, the problems of thrombophlebitis are becoming more urgent.

Prevention, a vitally important aspect of every treatment program of thrombophlebitis, is almost entirely the nurse's responsibility (Storlie, 1969, p. 125). Common measures which are considered prophylactic because they are aimed at increasing blood velocity include leg and foot exercises and compression stockings (Burrell, 1969, p. 31; Smith, 1972, p. 402). However, prophylaxis against this potential killer has not clearly moved beyond the experimental stage and there remain questions regarding the effectiveness of these presently employed methods in reducing vein thrombosis (Flanc, 1969; Rosengarten, 1970, 1971).

Summarizing the problems of diagnosis and treatment of deep-vein thrombosis, N. L. Browse concludes with this statement: "There are very many years of hard work between today's empirical approach and an effective method of prophylaxis for all patients..." (Browse, 1972, p. 151).

Statement of Problem

Since nurses carry out and often initiate these preventive measures, it seems appropriate that they should contribute to the scientific basis affecting decisions for their actions. The problem considered in this study was: Do pressure gradient stockings and foot exercises increase the venous blood velocity in active women ages 40-60 and 60-80?

Purpose of Study

The purpose of the study was to evaluate the effect of two nursing actions, specifically compression stockings and foot exercises, on the venous velocity of recumbent subjects. It was also hoped the findings would be useful in providing information about a methodology available for nurses to use in research or aid in nursing assessment and thereby contribute to patient care.

Hypothesis

Compression stockings of optimal pressures reduce the total cross-sectional area of the venous system, thereby increasing the velocity of the blood returning from the lower leg. Therefore, it was hypothesized that a sustained increase in blood velocity should be seen when the stockings were on and a decrease when removed.

Exercise causes the muscles of the leg to contract and squeeze the blood from the venous system. However, if the arterial system is adequate, almost immediate filling will occur. It was hypothesized that two minutes of foot exercise would cause a short-term increase in the venous velocity.

Definitions

venous blood velocity: The forward motion of red blood cells in the venous blood returning from the lower extremities to the heart.

pressure gradient stockings: Knee-length elastic stockings which exert a pressure that decreases from the distal to proximal end of the stocking. Knee length T.E.D. (Kendall trademark) seamless nylon anti-embolism stockings will be used.

foot exercises: Maximal dorsiflexion and plantar flexion of the foot thirty times a minute for two minutes.

active: Less than ten hours a day spent in bed.

Assumptions

For this study the following assumptions were made:

1. The probe over the right femoral vein picked up changes in the venous vascular system below that point.

2. Subjects were relaxed by the end of the baseline period and thus had a minimal amount of vessel change due to stress.

Limitations

There were several specific limitations to this study. They were:

1. The subjects were asked to remain in the same position for two and one-half hours so the doppler probe position would remain correct. This was uncomfortable, thus they tended to readjust their position and displace the probe causing inaccuracies in the recording.

2. The anatomical location, angle, and proximity of the femoral artery to the femoral vein varies in each subject due to bone structure, vessel structure, and muscle and subcutaneous tissue; therefore, ideal doppler probe placement was sometimes impossible.

3. Doppler ultrasound measures only qualitative, not quantitative, changes in venous velocity.

4. The number of subjects with acceptable strip chart recordings of the venous velocity was too small for statistical analysis.

Nurses play a prime role in carrying out interventions such as compression stockings and exercise aimed at increasing venous blood return to prevent thrombophlebitis. The merit of these actions is still being investigated. The purpose of this study is to add additional information to this pool of knowledge by recording with the doppler flowmeter the effect of knee-high compression stockings and foot exercises on subject's venous velocity measured at the femoral vein.

CHAPTER II

REVIEW OF THE LITERATURE

Methods of prophylaxis in thrombophlebitis depend on a knowledge of the etiology of deep-vein thrombosis. Little progress has been made in this area since 1886 when Rudolf Virchow, a pioneer in the study of cellular pathology, hypothesized that changes in the blood, its flow, and the vessel container were the causitive factors in thrombophlebitis (Browse, 1972). Consequently, investigators have assumed that changes from normal in any of these three areas will influence the formation of thrombi. The following studies cited relate mainly to the relationship among foot exercise, compression stockings, velocity, and thrombophlebitis.

Relationship of Compression Stockings to Velocity

Considerable attention has been focused on the role compression stockings play in decreasing blood stasis. The variables in evaluating this interaction are the measurement tool, pressure of compression, length of compression; e.g., full length versus knee length, position of the subject, and the amount of time the elastic compression is in effect.

Stanton (1949), using dye injections, showed a decrease from 21.78 seconds to 11.38 seconds in the foot-to-femoral vein time with 20 mm Hg. external pressure from the instep to upper third of the thigh. The X-rays taken at the same time indicated the veins to be well filled with diodrast and measurably decreased in diameter during the period of local compression. Twenty millimeters of mercury pressure did not alter the distribution of dye between the superficial and deep-venous system but accelerated flow in both. Increasing the pressure as high as 35mm Hg. did not produce further increases in the velocity of blood flow.

Twenty years later, using a radioactive isotope as the indicator for the mean blood velocity between the foot and groin, Makin (1969) found significantly greater velocity in the leg compressed below the knee with Tubigrip stockings as compared to the control leg without stockings. However, in looking at the comparison of velocities in Table II on page 371 of his article, if one subject of the thirteen with an atypically high value was excluded from the mean calculation, the difference between the control and Tubigrip is not nearly as impressive. The external pressure exerted on the calf by the stocking was measured via a small bag filled with saline attached to a manometer. It varied with the leg circumference though the mean pressure of Tubigrip on seven subjects was 13.82 mm Hg.

Paulsen's studies (1954) supported the two previous ones. Also using isotopes and foot-to-groin circulation timing, he concluded that the rate of venous flow on a horizontal limb is increased by elastic compression below the knee. He used elastic bandages and did not measure the pressure exerted. When the limb is elevated and elastic compression is applied, the circulation time is further diminished.

In twenty-one subjects, Meyerowitz (1964) measured the blood velocity with 10 mm Hg. of compression with ^{131}I. He found an increase in velocity except in four subjects who showed a decrease and three who indicated no change. Evaluating the effect of inflatable plastic splints on blood flow by isotopes led Ginsberg (1968) to recommend 20-25 mm Hg. of external pressure and Campion (1968) not more than 30 mm Hg.

Questions such as the following led investigators to examine blood velocity with direct measuring techniques. How accurate is a comparison of the transit time of an indicator to flow velocity? Is the velocity of the indicator increased by injection? How informative is data if the leg with diminished velocity cannot be included in the statistics since the dispersal of dye does not reach the groin for assessment? Another aspect to consider with short-term wearing of compression stockings for a foot-to-groin timing in seconds is that the pressure might cause an initial surge and then be too tight causing reduced arterial inflow and reduced venous return.

Direct venous pressure readings in a tributary of saphenous vein in the foot were taken while elastic bandages were in place below the knee and with pressure gradient knee-high stockings. With compression between 16-26 mm Hg. at the instep and 10-16 mm Hg. at the popliteal fossa, no significant difference on the venous pressure was noted and the hemodynamics of the lower leg were not adversely affected. From the accompanying phlebograms, it was concluded that there was a reduction of venous pooling with the elastic compression and an enhancement of popliteal and femoral vein filling (Hunsi, 1968, 1970, 1971). However, the phlebograms indicating venous pooling were taken during a Valsalva maneuver. To say that compression stockings effected quicker venous return and better filling following a Valsalva, when it had already been demonstrated that they caused no change in the hemodynamics of the leg, is underestimating the normal circulatory compensatory mechanisms following a Valsalva. Furthermore, the venous system, being a capacitance system, may exhibit large changes in volume without any significant internal pressure changes (Attinger, 1969).

Spiro (1970), in animal and human studies of venous flow rate measured by an electromagnetic flowmeter, concluded that the optimal pressure for enhancing flow was 5-12 mm Hg. but may vary from patient to patient depending on adipose tissue, existence of varicose veins, and other disease. A study of a below-the-knee compression splint indicated increased flow in both limbs at five millimeters of mercury pressure. Higher pressures resulted in gradual increase in the control limb and decrease in the experimental limb (Spiro, 1970).

Sabri, an investigator from the same institution, duplicated the experiment one year later. After testing dogs and nine patients undergoing surgery, he reported a very small nonsignificant increase in venous flow with an external pressure of five millimeters of mercury pressure, and a reduction of venous flow as well as vascular conduction with high external pressures of 15 mm Hg. or more (Sabri, 1971). A suggestion was that for maximal effect of venous flow, external pressure should approximate intervascular pressure.

The doppler ultrasonic flowmeter has also been utilized to add data concerning the effects of compression of the extremities as a means of increasing venous velocity. During the induction of anesthesia, the subjects wearing tubular compression stockings maintained their previous blood velocity while those in the control group experienced a reduction from 41 cm. per second to 16 cm. per second (Makin, 1970). Since the doppler is a qualitative rather than exact quantitative measuring tool, it is hard to understand how the investigator got readings in centimeters per second. Sigel (1973) reports sustained increased venous velocity for up to thirty minutes following the removal of thigh-length compression stockings that had been on for thirty minutes. During three hours of compression on four subjects, the velocity increased twenty percent above baseline as measured by the doppler ultrasonic flowmeter. This is close to the fifteen percent increase in femoral venous velocity observed by Sabri (1971) with a full-length stocking. After Sigel's report of being able to keep a constant baseline over a three-hour period, the doppler was welcomed as a tool for paramedical researchers since it is completely noninvasive.

Consideration of the results of investigations of venous velocity and the realities common in hospitals with the use of elastic compression helped determine portions of the methodology for this study. Of the technologies available for use, the electromagnetic flowmeter would have had the least opportunities for error and yet anesthesia and surgery would have been required for its use. The doppler flowmeter was chosen for use during this experiment because we wanted to approximate the circumstances of patients on the wards wearing compression stockings who were not anesthesized. The amount of pressure exerted by the stocking is debatable but it seems that the majority of investigators cite values between five millimeters of mercury pressure and 20 mm Hg. as being effective in increasing velocity. The length of the stocking has varied, but only Hunsi (1970) has made a definite recommendation for knee-high compression since all the veins in the lower leg converge upon the popliteal and compression at that site may retard venous drainage. All the studies reviewed have been done on subjects in the recumbent position which is thought to contribute to venous stasis (McLachlin, 1960). This is the position patients in the hospital maintain most of the time while wearing the stockings for reasons other than venous disorders.

Relationship of Exercise to Velocity

Studies dealing with the effect of exercise on blood velocity have not been as numerous as those testing other interventions. Those that have been done indicate the short-term effect produced by exercise.

From Browse's work (1952), it was concluded that calf blood flow establishes its resting level within one hour after exercise as measured with a venous occlusion plethysmograph. Exercise in this experiment consisted of the daily ward routines in ambulatory preoperative patients and was not strictly regimented. No difference in the resting blood flow was noted after twelve hours bed rest compared to one hour's rest.

Monitoring the blood flow of the hand following one minute of squeezing a rubber bulb connected to 25 mm Hg. of counterpressure once every second indicated that peak flow occurred during the immediate post-exercise period, in fact, within five seconds, then diminished to pre-exercise level within two to three minutes (Greenberg, 1972). His measurement device was an electrocapacitance plethysmograph. These results coincided with Beaconsfield's (1954) earlier investigations on the lower limbs where the blood flow returned to normal three and one-half minutes after exercise. He had his subjects contract their calves for two minutes, twelve times per minute, with eight-pound weights on the foot. Blood flow through the muscle increases intermittently during relaxation when the blood flows through dilated vessels and decreases during the contractive phases.

Flow rates measured with ^{24}Na injected at the foot and timed to the groin doubled following two minutes of vigorous dorsiflexion and plantar flexion compared to resting in supine position (Wright, 1952). After ten minutes on the ergometer, an increase in the clearance of ^{24}Na was definitely noted (Chant, 1972). It is important to keep in mind, however, that the lower limb is drained by a plexus of veins rather than a single vein. Measurement of the time taken for the tracer to travel from a superficial vein in the foot to the groin provides only a relationship of the venous flow to the cross-sectional area at different levels of the limb.

Not only is the calf muscle pump thought to increase mean blood flow, but it also changes the pulsatile blood flow. Sabri (July, 1971) investigated the effects of dorsiflexion at ± 15 degrees about the vertical varying between 24-50 times per minute for two minutes. His subjects were anesthesized and undergoing vein surgery which conveniently exposed the femoral veins for the electromagnetic flowmeter. The sixty percent increase he found in arterial and venous blood flow was accompanied by an increase in the pulsatility up to ten times the basal value. Roberts (1971), performing additional experiments also with anethesized patients and using a flowmeter, varied the rate and degree of dorsiflexion and plantar flexion. With the degree fixed and the rate varying between 24-50 times per minute for two minutes, it was noted that in the experimental limb greater increases in flow and pulsatility are produced as the rate of flexion increases. Flow changes in the control limb remained independent of the experimental limb. Holding the rate of flexion constant and increasing the angle showed a similar result. Continuing the exercise for thirty minutes instead of two showed a sustained increase in flow. With operative exercises, the mean femoral vein flow increased by thirty-five percent and pulsatility fourfold.

Studying the compression forces transmitted by the ankle pump under stretchable and nonstretchable leg supports indicated that the nonstretchable is more effective. The ankle pump loses almost all its effectiveness if the leg is covered by elastic materials (Lippman, 1971).

In summary, the literature supports the view that exercise without stretchable support does increase blood velocity proportional to the rate and amplitude of the flexion. The effects vary from subject to subject possibly because of the varying degree of valular incompetence. As long as flexion is maintained, an increase in flow will be sustained. The peak flow time reported is immediately post-exercise.

Relationship of Compression Stockings and Exercise to Thrombophlebitis

Reports on the clinical results of compression stockings and exercise in reducing thrombophlebitis are varied. Using clinical methods alone as diagnostic tools for detecting thrombophlebitis, there was a conflict with some saying benefit was obtained from compression stockings (Sharnoff and Rosenburg, 1964; Makin, 1969) and some not (Blodgett, Beattie, 1946; Powers, 1949). However, in the last six to seven years, studies have indicated that less than fifty percent of patients with thrombosis have clinical symptoms and some with suggestive clinical symptoms are without thrombosis (Flanc, 1968; Rosengarten, 1970).

With ^{125}I fibrinogen to help diagnose the thrombi, Rosengarten (1970) concluded that in the age group over forty years of age compression stockings had no value. Twenty-five patients in the experimental group who wore Tubigrip stockings for fourteen days or until discharge pre and post-operatively were evaluated. Both the experimental and control groups had eight patients with thrombi in the calf.

Sabri and Roberts (1971) concluded that exercise reduces thrombophlebitis. When their patients were given ^{125}I, scanned pre-operatively, given continuous exercises at fifty cycles per minute at ± 20 degrees about the vertical, and then scanned frequently post-surgically, a significant reduction in thrombosis occurred in the control leg versus the experimental one. They concluded that a diminution of pulsatility of venous flow may be the initiating factor for thrombosis.

Following surgery, patients forty years and over were placed on a regime of elevating the foot of the bed nine inches, elastic stockings, and leg exercises. There was no significant reduction in thrombophlebitis when the experimental group was compared to the control; however, in the 61-80 age group, the incidence of thrombosis was forty-six percent in the control group compared to twenty-nine percent in the experimental group (Flanc, 1969). When Tsagogas (1971) utilized the same interventions on post-surgical patients over forty years of age, he found a significant reduction of thrombophlebitis compared to his control group. In his studies he obtained venograms on the patients pre-operatively and excluded any that had venous diseases, whereas Flanc did not do this and may have had some patients included in his study who had thrombophlebitis pre-operatively.

In conclusion, it is encouraging that the more recent studies have shown preventive actions such as compression stockings and exercise are achieving the end results desired, namely a reduction in thrombophlebitis. This indicates that continued research into the effects of each action should be pursued to determine the optimal role each can have.

CHAPTER III

METHODOLOGY

This was an exploratory study to test the feasibility of using the doppler flowmeter to measure the effect of compression stockings and foot exercises on the venous velocity of the right leg in female subjects. A room was chosen for data collection which had a low noise level, adequate facilities, and was convenient for the subjects. The study had four main parts: pre-baseline, baseline, effect of stockings, and effect of exercise.

Prior to starting data collection, the research design was approved by the Loma Linda University Advisory Committee on Human Experimentation (Appendix A).

Sample

The population consisted of two groups, women aged 40-60 and women 61-80, meeting certain stated criteria. A convenience sample consisted of volunteer subjects from the community who were briefly interviewed regarding their health status. Those who were in stated good health and met the following criteria were included in the study.

1. No broken or missing limbs.
2. Oral temperature at time of experiment 97.6 to 98.6 degrees F.
3. No history of varicose veins or vein ligations.
4. Weight $\pm$20 pounds of normal (see Appendix B).

5. Not taking anticoagulants or estrogen medication.

6. Hematocrit normal range of 37-47 percent.

7. Non-smokers.

The preceding criteria were adopted to reduce as many variables in the study as possible.

Pre-baseline Period

Before beginning the baseline period of data collection with the doppler flowmeter, the subject was given a complete explanation of the purpose of the study and the order of events to follow. A consent form (Appendix C) was then signed and witnessed before proceeding. The weight and height of the subject were recorded.

The subject was then asked to lie supine on the bed and her radial pulse and oral temperature were taken. Temperature has an inverse effect upon blood viscosity, while the viscosity varies directly with hematocrit (Selkurt, 1971, p. 242). Therefore, the subject's hematocrit was determined after obtaining blood by a finger prick with a sterile disposable blood lancet. The methodology for obtaining the blood sample followed that outlined by Wintrobe (1961) and the blood specimen was centrifuged for five minutes in a Readacrit Centrifuge, Clay Adams.

In order to insure maximum dorsiflexion and plantar flexion later in the experiment, the subject's foot was placed in an adjustable box (Figure 1) which could be set for

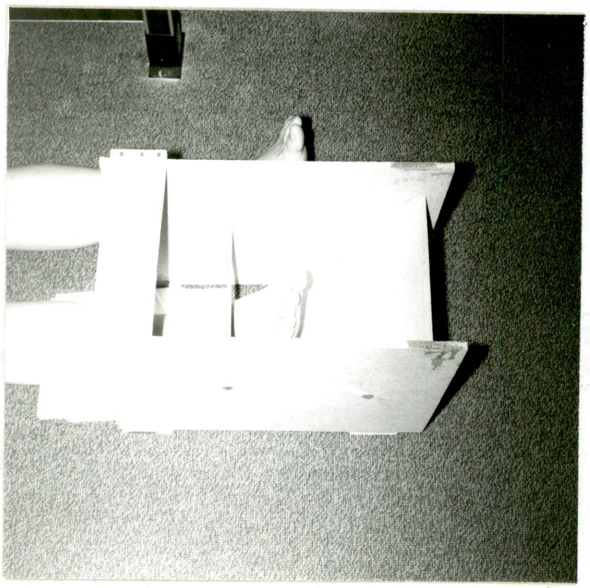


Figure 1

Adjustable Box for Determining Subject's
Maximum Dorsiflexion and Plantar Flexion

each individual.

Based on the measurements of the calf circumference and length of the leg from the popliteal space to the floor, a T.E.D. stocking was selected from the company's fitting chart (Appendix D). To test the compression stocking for the actual pressure exerted at the upper foot, calf, and top of the stocking, a specially designed balloon and mercury manometer similar to that used by Sigg (1968) was designed (Figure 2a, 2b). If the pressure was between 10-15 mm Hg. at the foot, diminished at the calf, and even less at the end of the stocking below the knee, then the compression stocking was considered acceptable. If there did not seem to be a pressure gradient, a next larger or smaller size was tried depending on the pressure reading obtained. If no pressure gradient could be determined with various size stockings, the size recommended by the manufacturer according to the subject's measurements was used. Since Sigel (1973) used thigh length stockings with the doppler to test velocity, it was thought that in using knee length stockings a comparison as to their effectiveness could be made.

The last step in the pre-baseline period was to locate the femoral vein in the groin area with the doppler flowmeter probe and tape it in place. The velocity of venous flow toward and away from the probe was recorded. To determine a baseline point for later calculations of change,

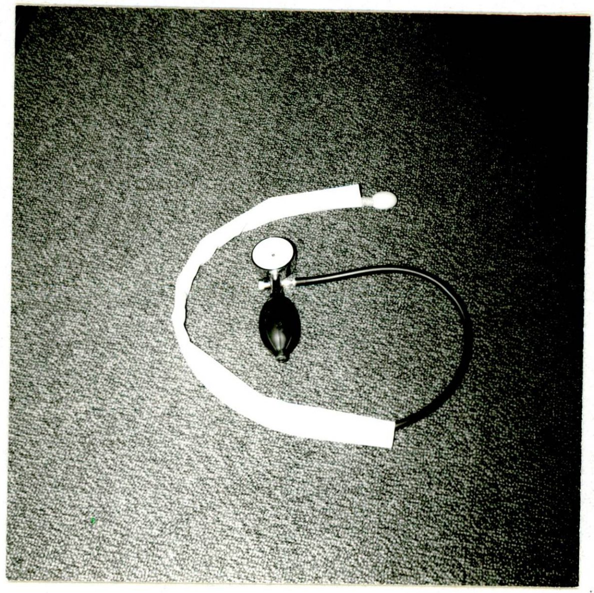


Figure 2a

Balloon and Mercury Manometer Used for Measuring the External Pressure Exerted by the Stockings

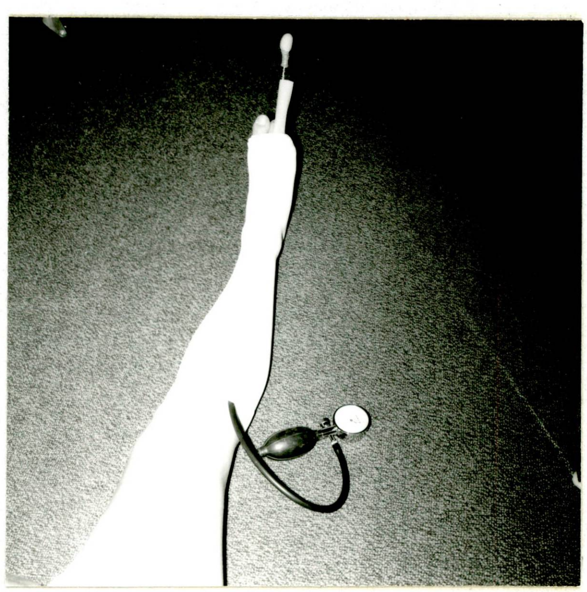


Figure 2b

Balloon and Mercury Manometer in Place Under Stocking Prior to Testing Pressure a pressure cuff on the thigh was inflated until the venous flow was occluded.

Baseline Period

The baseline period was one-half hour lying supine on a bed with no exercise. At minutes 1, 5, 15, and 30 a one-minute strip of venous velocity was recorded from the doppler. After 30 minutes the patient's pulse rate was recorded and right calf circumference measured. The flowmeter recordings were made only on the right leg of each subject.

Exercise Period

At the beginning of the exercise period, a one-minute strip of venous velocity was recorded. The subject then did two minutes of dorsiflexion and plantar flexion to the degree determined during the pre-baseline period. To standardize the rate, a sound was recorded on the tape recorder that regulated the exercise at thirty complete dorsiflexion and plantar flexions per minute. The venous flow velocity was recorded during the exercises and for two minutes following. After this period of monitoring, a one-minute strip was recorded at 10, 15, 20, and 30 minutes. The circumference of the lower leg was measured and pulse taken immediately following the exercise and at the end of thirty minutes.

Stockings and Stocking Removal Period

The next portion of the methodology involved the application and removal of the compression stockings. Following a one-minute strip recording, the stockings of a predetermined size were applied to both legs and a one-minute velocity strip recording was taken immediately afterwards. Stockings were applied to both legs since, in Spiro's work (1970), the control limb had a mean increase in flow when the pressure was increased on the experimental limb. A procedure similar to that after exercise was followed. A one-minute strip was recorded at 5, 15, and 30 minutes and the leg circumference and pulse taken at 30 minutes. The subjects were alternately assigned to do the exercise then stocking sequence or vice versa with the odd-numbered subjects doing the exercise first and the even-numbered subjects having stockings applied first. After the stockings were removed, strip chart recordings were taken at 5, 15, and 30 minutes and the last pulse and leg circumference were taken at 30 minutes (see Appendix E for data collecting sheet).

Instrument for Measurement

The doppler flowmeter model 806 was used for detecting venous velocity changes. A piezo-electric crystal driven by an oscillator emits a nine megahertz ultrasonic signal which is directed transcutaneously through the skin and tissues overlying the femoral vein. The ultrasonic beam is reflected from the moving blood particles. A receiving crystal in the probe detects the backscattered signal which is mixed with the transmitter frequency to produce a frequency spectrum in the audible range. The change in frequency is proportional to the flow velocity and a shift can be heard as a change in an audible sound, shown as a deflection on a dial, or recorded as a written graphic display. In this experiment an audible sound was heard in earphones worn by the investigator as a graphic recording was made of the velocity with a strip chart recorder, Linear Instruments Corporation, model 112. The flowmeter is battery operated and there is no penetration of the skin with use of the transcutaneous probe. In this study the flat doppler probe, with a transmitting and receiving crystal angled at 30 to 45 degrees from the perpendicular, was applied over the femoral vein at the inguinal ligament and taped.

This method of assessing venous velocity has been accepted as simple, safe, and sensitive. The accuracy of the technique is better than clinical appraisal in the diagnosis of venous occlusion (Sigel, 1968) and matches radiographic descriptions well (Evans, 1969; Gosling, 1971). Sigel (1973) reported keeping a constant flow velocity baseline over a three-hour period with this instrument.

CHAPTER IV

RESEARCH FINDINGS

Analysis of Data

The effect of compression stockings and foot exercises on the venous blood velocity, as measured by the doppler flowmeter in a group of fourteen female subjects, is reported in this section. The analysis will be descriptive for the most part with statistical analysis where appropriate.

Sample

Fourteen women were admitted to the study meeting the sample criteria already outlined. Six were in the 40-60 age group with a mean age of 50 and eight in the 61-80 age group with a mean age of 74. However, after reviewing the recorded data, all but five subjects were excluded from the analysis for reasons that will be discussed.

In order to understand why certain data were discarded, it is necessary to recognize the normal femoral venous velocity wave (Figure 3a). It is influenced mainly by two factors: respiration and natural pulsations which emanate from the heart (Essex, 1954; Nippa, 1971). Inspiration causing increased intraabdominal pressure slows down venous return momentarily. This is reflected by a drop in the venous wave. With decreased abdominal pressure upon expiration, there is an increase in the velocity in the femoral vein seen by a peak in the venous wave form. The small amplitude pulsations throughout the reading are either a retrograde pulsation along the vein from the heart or due to the rhythmic compression of adjacent arteries.

Six of the fourteen subjects were disqualified from the main data analysis because of interferring arterial pulsations which became so large they obscurred the typical pattern of the venous velocity tracings (Figure 3b). Two subjects were deleted because even with high pressures on the cuff, the pressure could not be maintained long enough to cause a decrease in the venous sound and relative occlusion of the vein. This minimum flow recording was needed for comparisons throughout the study (Figure 3c). The third reason for exclusion occurred in only one subject who was very nervous. That was a wandering baseline (Figure 3d). Of the five qualifying subjects, two were in the 40-60 age group and three in the 60-80. The mean age was 66.

Treatment of the Data

In order to assign some numbers to the velocity changes that took place, a mean of the venous velocity waves was calculated for each one-minute strip recording. This was done by finding the upper and lower lines on the graph paper where 50 percent or more of the peaks touched, then taking the mean for the area between. Example:

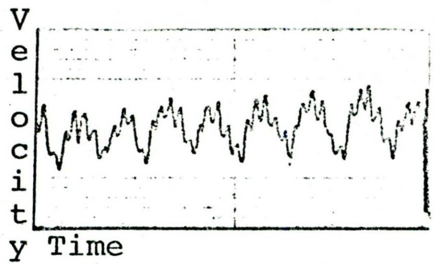


Figure 3a

Normal Velocity Wave Form

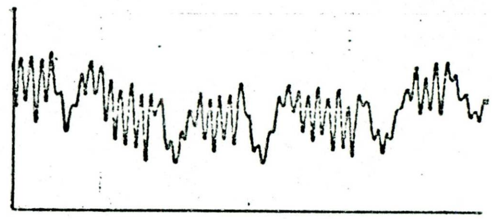
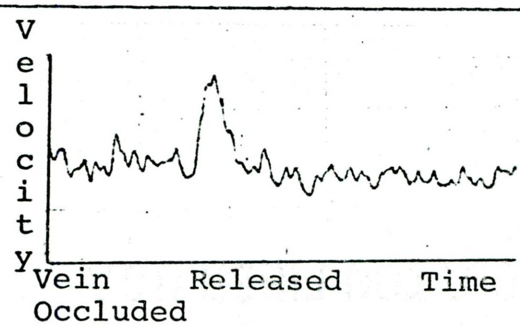


Figure 3b

Arterial Interference



Time Scale:

⟷

15 Seconds

Figure 3c

Cuff Not Able to Occlude Vein

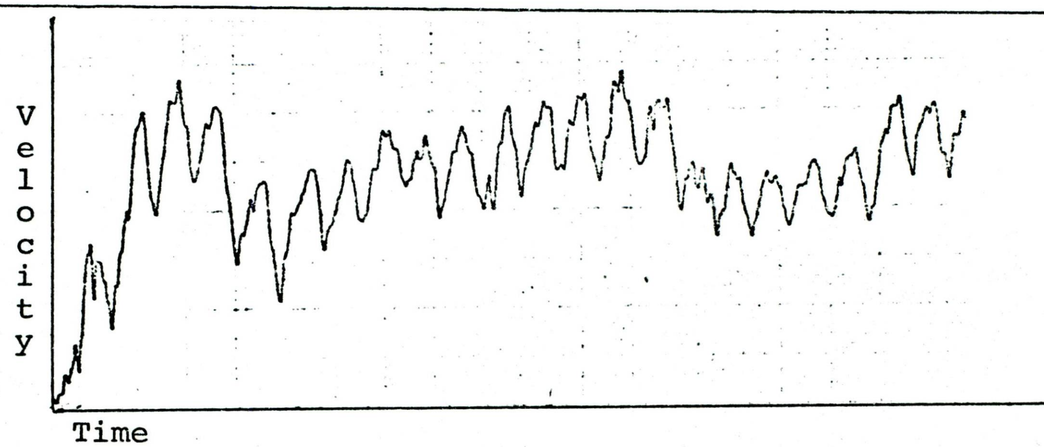


Figure 3d

Wandering Baseline

Figure 3

Femoral Venous Velocity Wave Variations
All Time Scales Recorded at Four-Inches Per Minute

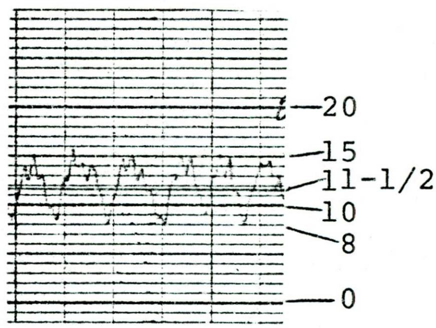


Figure 4

Mean Velocity of Femoral Venous Waves

On the strip excerpt, the electrical baseline of the machine determined 0 on the graph paper. The peaks are at 15 and the troughs are at eight. The mean of this segment would be 11.5 indicated by the heavy line. However, in this subject the vein was occluded at six, so 11.5-6 = 5.5 which would be the mean velocity of this strip. For each subject the electrical mean remained zero but the value of vein occlusion (Z) varied (see Table I).

Four one-minute strips were averaged for the main baseline value of each subject. These values represent the mean velocity above the occluded vein level. All values stated in following portions of the study were explained as plus or minus the baseline value. A one-minute strip was taken prior to exercise and then five following. These five were averaged and evaluated in relation to the baseline value. Before applying the stockings, a one-minute strip was taken, then four at different time intervals following stocking

TABLE I

Vein Occlusion Values for Five Subjects

Subject	Electrical Baseline	Occluded Vein Value
B_7	0	2.5
A_5	0	2
B_6	0	3
B_3	0	5
A_1	0	6
Mean	0	3.7

application. The mean was calculated from the four readings, averaged, and compared to baseline. The identical procedure was followed in analyzing the stocking removal section. Table II indicates the values obtained from the recorded blood velocities in five subjects. Figure 5 indicates the means for the group of five subjects during each period of the experiment.

A strip chart recording taken during the entire period of data collection was too long to be included in the record, but fifteen-second strips extracted from the main data collection periods are in Figure 6. This subject had good probe placement and femoral venous velocity waves. The exercise exerpt is not typical but refer to Figure 7 for typical configuration.

Effect of Exercise

When considering the effect of exercise on blood velocity in the group as a whole, the amount of increase was not significant. Two subjects showed an increase, two no change, and one was less than baseline.

Comparing the mean velocity right after exercise, which according to the literature should be the peak flow (Beaconsfield, 1954; Greenberg, 1972), to the baseline value, we find an increase in three subjects and decrease in two. Seven minutes after finishing the dorsiflexion and plantar flexion, the values had increased over the prior immediate

TABLE II

Comparison of Venous Velocity Changes

Subject	Baseline	Exercise		Stocking		Stocking Removed	
		1 min prior	mean (end)	1 min prior	end	1 min prior	end
B_7	5	-1.5	-1	-1.5	0	1.5	2.5
A_5	13	8.5	0	-2	1		-1
B_6	5	0	5	3.5	3	4.5	5
B_3	7	0	0	-1	-1	-2.5	-1.5
A_1	4.5	-2.5	6.5	8	8.5	5.5	2.5
Means	6.9	.9	2.1	2	2.3	1.8	1.5
Baseline & Mean		7.8	9.0	8.9	9.2	8.7	8.4

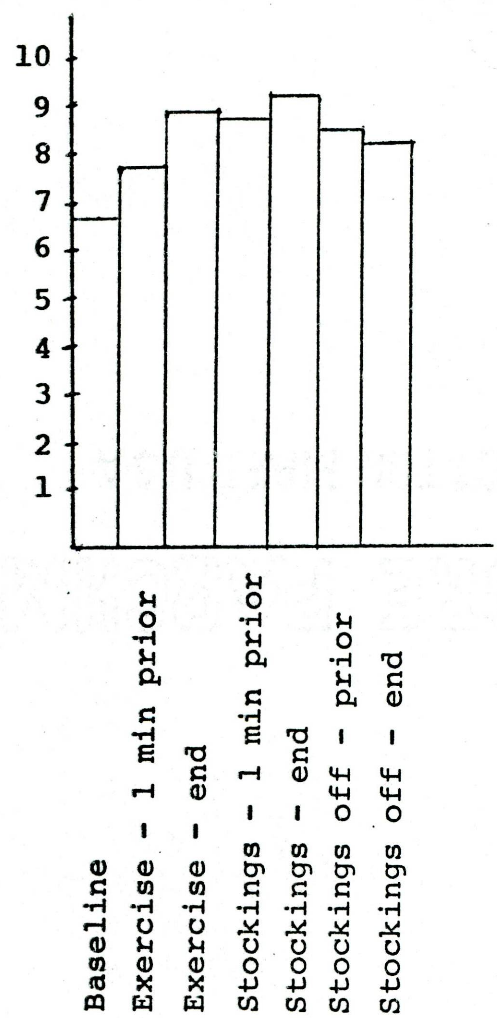


Figure 5

Comparison of the Mean Velocities of Five Subjects

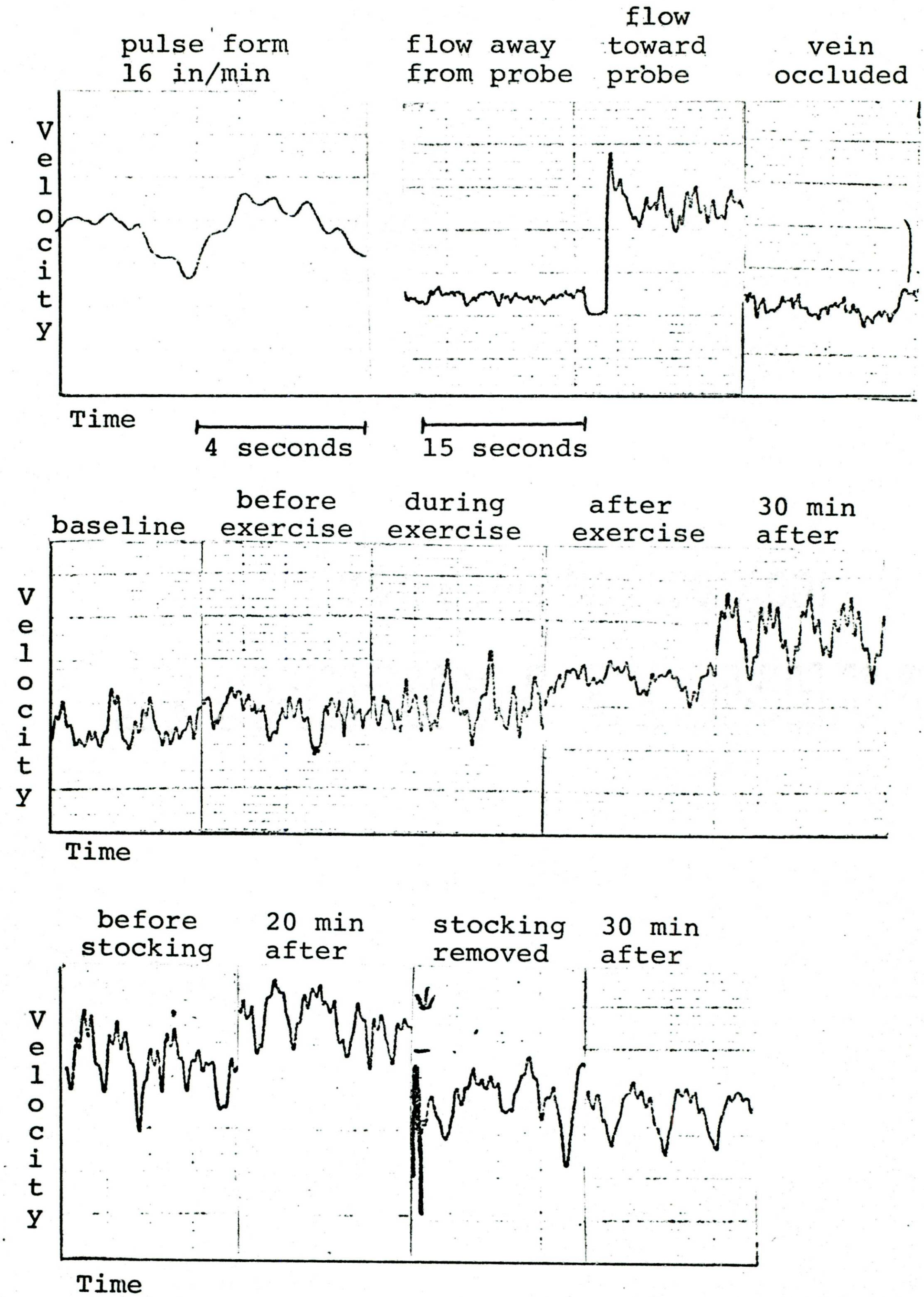


Figure 6

Femoral Vein Velocity Changes Over a Two-Hour Period on Subject A_1

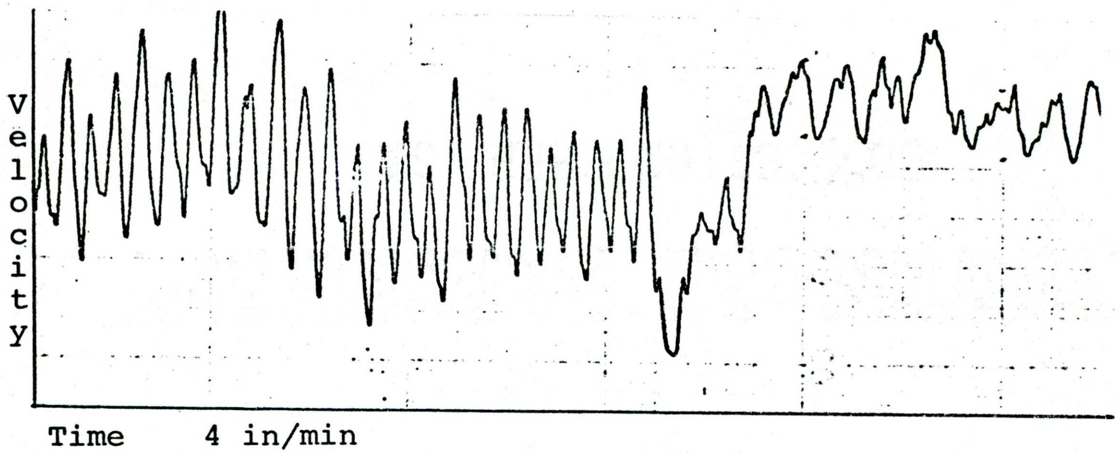


Figure 7

Venous Velocity Wave During Exercise

post-exercise samplings except in one instance where there was a sharp decrease. At the end of the thirty-minute exercise period, values for all subjects but two were equal with baseline or below it.

During the two-minute period of exercise, the mean velocity did not increase. The pulse waves changed configuration becoming narrower and increased in amplitude (Figure 7). Following the two-minute exercise period, there was a five to fifteen second lull before the velocity increased. Of the total fourteen patients studied, a number of them stated they could not have gone on exercising any longer. Most stated the upper part of their leg just above the ankle felt tight and three subjects experienced cramping.

Effect of Stockings

An overall look at the effect of the stockings on the velocity for this group of five indicated a nonsignificant increase over the baseline. Taken individually, three of the five subjects indicated an increase, one a decrease, and one no change.

The first minute after application of the stockings two subjects showed an increase in velocity, two remained the same, and one decreased when compared to the one-minute strip before application. The tracings of the two subjects who showed an initial increase changed by the end of the stocking section. The velocity in one had continued to increase and the other's mean velocity had decreased in the latter half of the application period. The two that indicated no immediate effect remained the same, and the subject with the initial decrease indicated an increase in the mean velocity. While the stocking was on, the velocity wave remained almost identical to baseline period with no decrease in the effect of respiration of the velocity tracing. Nor was the cardiac effect increased as reported by Sigel (1973).

The methodology, when proposed, designed that the stockings would have a pressure of 10-15 mm Hg. at the instep and five millimeters of mercury pressure at the top of the stocking. However, in testing the pressure with a balloon and mercury manometer on twelve subjects, only four had that low a pressure reading at the instep. One subject had a stocking with a pressure gradient effect on the leg which started with 26 mm Hg. at the instep. The remainder of the subjects varied with most of their values higher than the proposed pressures. Table III indicates the pressures recorded from the stockings recommended by the manufacturer according to calf circumference and leg length.

Removal of the stockings did not seem to effect the mean velocity significantly. When comparing the values indicating the effect of stockings with the mean values for the stocking application period, we found three subjects whose velocity decreased and two who showed an increase.

TABLE III

External Pressure Exerted by Compression Stocking as Measured by a Balloon and Mercury Manometer

Subject	Foot	Calf	Top of Stocking
'A_1	16*	12	12
A_2 no data			
A_3	20	14	14
A_4	22	16	14
A_5	18	16	16
A_6	14	18	16
B_1	12	16	12
B_2 no data			
B_3	14	12	12
B_4	16	24	22
B_5	26	24	24
B_6	20	20	16
B_7	26	24	22
B_8	14	16	14

* Measurements in mm Hg.

' Subjects A - 40-60 age group
Subjects B - 61-80 age group

Statistical analysis of the effect of exercise and application of compression stockings by a t-test yielded p-values too high to fall within the .05 significance level. However, they were close enough to lead one to speculate that with a larger sample, several of the relationships might be significant. The effect of exercise and stockings when compared to baseline had about the same p-value.

Leg Circumferences

Table IV indicates the changes in calf circumference in millimeters for each subject. The difference between the end of the baseline and immediately following exercise was a significant decrease at the .05 level. From immediately after exercise until the end of the exercise period, the t-value showed the change to be nonsignificant. The value expressing the decrease in circumference from the end of the exercise period until the end of the thirty minutes with the stockings on was highly significant at the .01 level. The increase in circumference from when the stockings were on to thirty minutes after removal was also highly significant at an .01 level.

It was noted throughout the study that the venous velocity was affected by various actions of the subject. These could be noted by a change in the pulse amplitude. The common ones were: laughing and talking (Figure 8a), coughing and deep breathing (Figure 8b), moving other extremities

TABLE IV

Changes in Calf Circumference on 13 Subjects

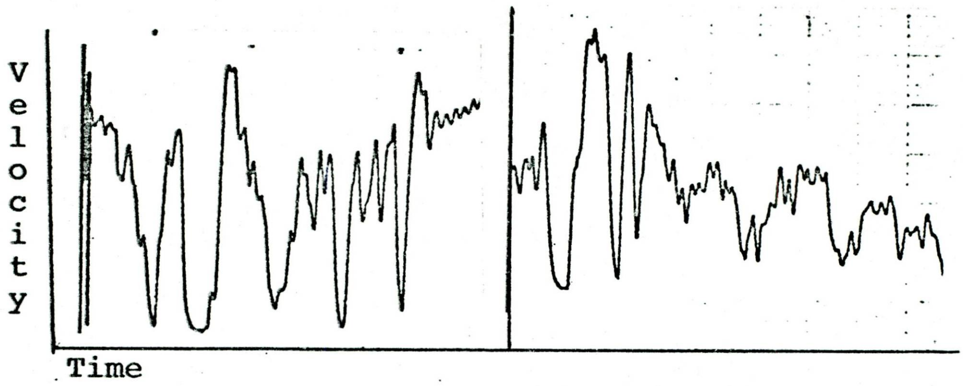
Subject	B E_1	E_1 E_2	E_2 S	S SR
A_1	+1*	-4	-4	0
A_2	-9	+5	-3	-2
A_3	-2	0	-10	+10
A_4	-2	+3	-5	+6
A_5	0	+2	-6	+4
A_6	-2	-2	-2	+6
B_1 not accurate				
B_2	+1	-3	-6	+6
B_3	-1	+3	-2	+1
B_4	-4	0	-6	+9
B_5	-1	0	-9	+16
B_6		+4	-9	+11
B_7		-4	-8	+2
B_8	-4	-1	-7	+4
Mean	-1.91	+0.230	-5.91	+5.615

* Changes indicated are in millimeters

B = baseline
E_1 = two minutes after exercise
E_2 = end of exercise section
S = end of stocking section
SR = end of stocking removal section

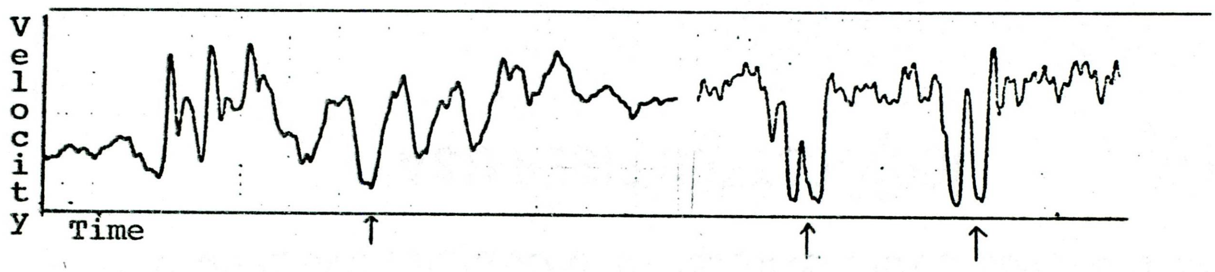
Subjects A - 40-60 age group

Subjects B - 61-80 age group



Laughing and Talking in Two Different Subjects

Figure 8a



Deep Breathing and Coughing in Two Subjects

Figure 8b

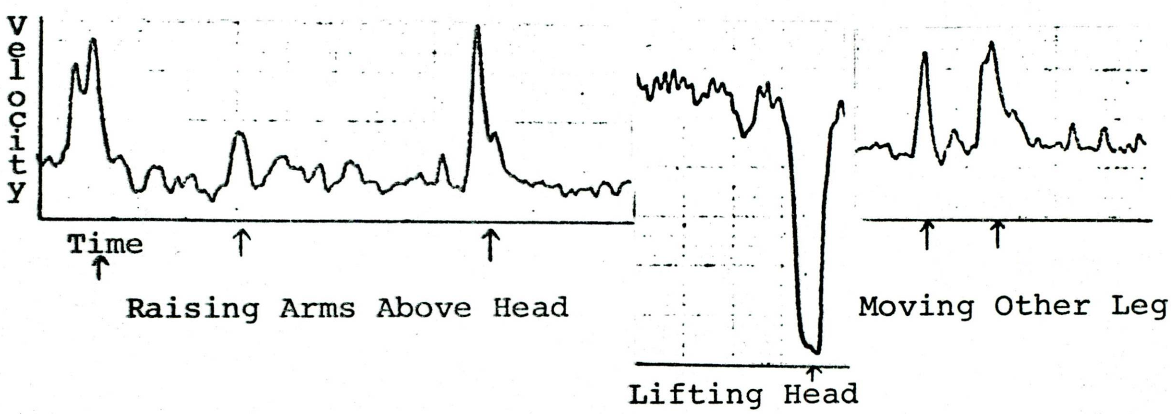
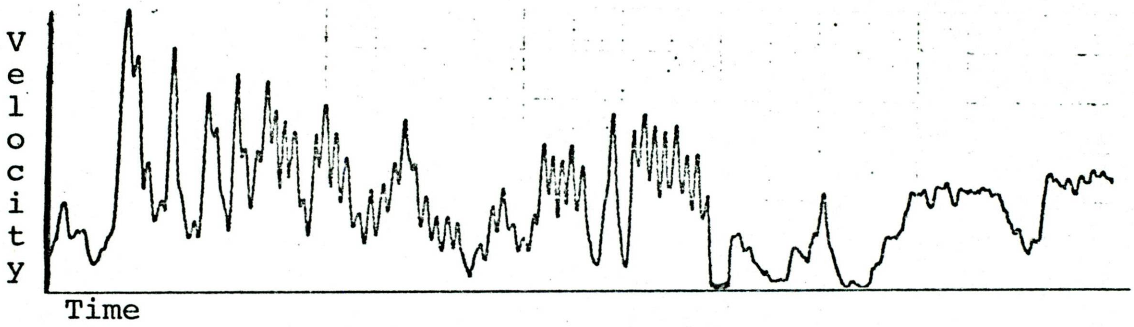


Figure 8c

Figure 8

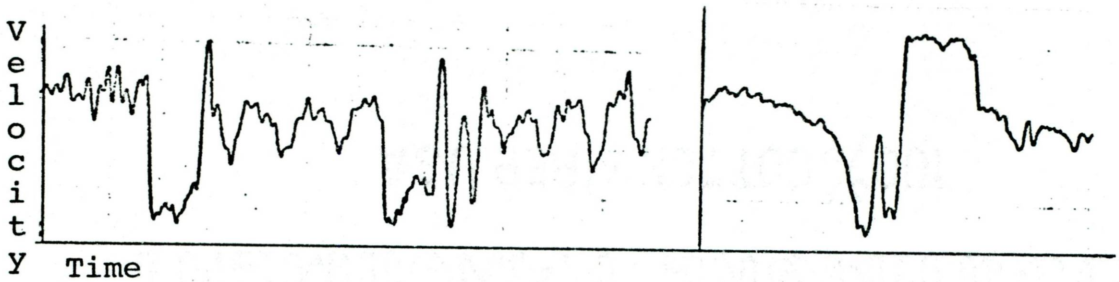
The Influence of Common Actions on Venous Velocity
Paper Speed - Four Inches Per Minute

(Figure 8c), tightening abdominal muscles (Figure 8d), performing a Valsalva maneuver (Figure 8e), moving with pain (Figure 8f), and applying the stockings (Figure 8g).



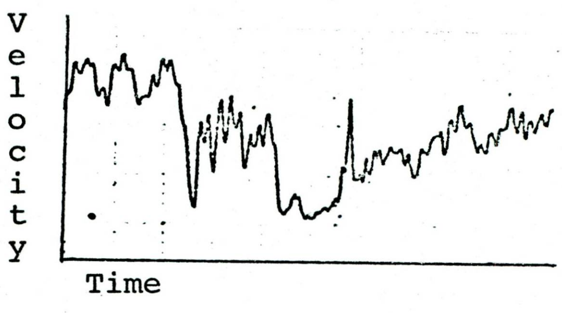
Tightening Abdominal Muscles

Figure 8d



Valsalva Maneuver in Two Subjects

Figure 8e

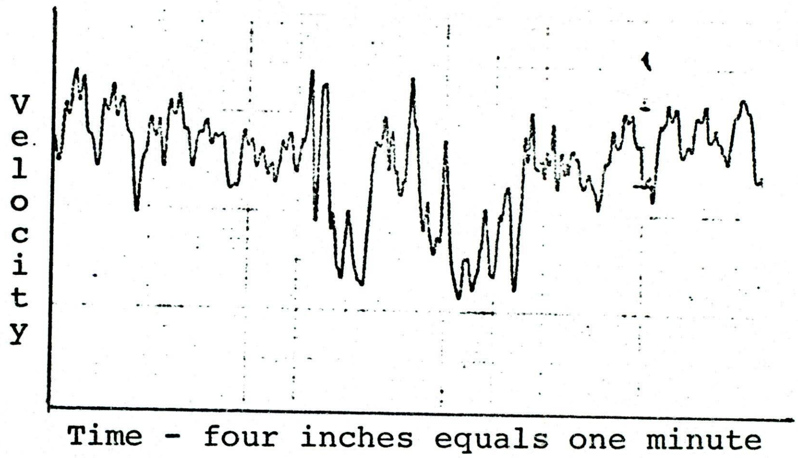


Experiencing Pain in Arms

Figure 8f

Figure 8 (Cont'd)

Influence of Common Actions on Velocity
Paper Speed - Four Inches Per Minute



Application of Stockings

Figure 8g

Figure 8 (Cont'd)

Influence of Common Actions on Velocity
Paper Speed - Four Inches Per Minute

CHAPTER V

DISCUSSION OF RESULTS

The following discussion attempts to not give answers but possible explanations of the results witnessed from the pilot study with a relatively new data collecting instrument on a relatively old problem.

The question posed at the beginning of the study was: Do exercise and compression stockings increase the venous blood velocity in the lower extremities? It was hypothesized that they would have a positive effect; however, the results showed a variety of changes which did not make a conclusive stand on the effects possible. In order to understand the results, the method of measuring change and the physiological interactions in the subject must be reviewed.

Instrument of Measurement

The doppler ultrasonic flowmeter has been used for collecting data over an extended period of time. Makin (1970) used a flat probe tilted at a 45 degree angle to record the velocity in patients undergoing surgery with an example showing a tracing for a four-hour time span. The very slow paper speed used in Makin's study makes it difficult to evaluate the venous wave configurations to determine if they are solely venous. However, in an exerpt of 120 seconds, the venous waves do not resemble either those exemplified in Sigel's study (1973) or the results from this one. It must be kept in mind that these were patients undergoing anesthesia and had respiration maintained manually when the recordings were taken. Makin reported no difficulty in locating or maintaining his recordings in any of the twenty-seven subjects. Sigel's (1973) femoral vein tracings more nearly resembled those found in the categorized "good" samples of this study. In his ten subjects he found the baseline could be kept constant enough over a three-hour period and reported the changes in flow velocity as percents of the baseline.

The probe position is one of the most important parts of the technique. In this study of fourteen subjects, there were only three whose venous velocity sounds could be picked up clearly without extra pressure on the probe. Even when the probe was taped in place, a slight movement of the subject's other leg or upper extremities seemed to bring in arterial pulsations and change the position of the vein so the probe no longer yielded a maximum flow velocity tracing. Since the veins were deep and pliable with the surrounding muscles and adipose tissue above, it was felt that a sensitive probe situated on the skin could easily become repositioned over a period of time so the ultrasonic waves no longer hit the moving red blood cells at the optimum 45 degree angle. In some subjects it took up to half an hour to obtain a good velocity tracing from the femoral vein.

Arterial sounds kept interferring. In all but three subjects, the probe was taped over the vein, pressure was applied until the vein was occluded, then eased off until the sound and recordings on the dial of the doppler were maximum.

From this study it was found that subjects vary as to the ease with which the femoral vein blood velocity can be recorded transcutaneously. In those persons in whom it is located easily, taping the probe on the skin above the vein does not guarantee an optimal reading for a long period of time, and pressure on the probe may be necessary to obtain a maximal reading. It is possible that the results of this study were affected by the problems encountered with the probe placement. A majority of the subjects studied were not included in data analysis because of a large amount of arterial interference making the sample size too small to provide conclusive results.

The Effect of Stockings

The reported 15-20 percent increases in blood velocity in the femoral vein with the use of thigh-length stockings were considered significant by other workers (Sabri, 1971; Sigel, 1973). Comparing mean velocity values in this study of the stocking period to baseline of the five subjects analyzed, two ($^{B}6$, $^{A}1$) showed such increases. However, in $^{B}6$'s case, removal of the stocking increased the velocity even more, in fact equal to the amount that exercise had affected it.

The rate of venous flow varies in relation to other functions of the circulatory system. It changes with pressure gradient, vessel radius, viscosity of the blood, or length of the vessel (Selkurt, 1971, p. 240-244). Reasons why all subjects did not show an increase in velocity with application of the compression stockings may be explained by the way the stockings affected the other components of the flow relationship.

It was hypothesized that with the application of stockings, the velocity would be increased due to a reduction in the total cross-sectional area of the venous system in the leg. The five subjects included in the comparison of velocities had pressures under the compression hose which ranged between 14-26 mm Hg. at the instep to 12-22 mm Hg. at the top of the stocking. Few of the stocking pressures indicated a distinct pressure gradient. With the significant decrease in calf circumference that occurred when the stockings were on (Table IV), it would seem that a decrease in the cross-sectional area had occurred. Since the velocity did not change in all cases, one might propose that the site of measurement should have been the popliteal and not the femoral vein. It is possible that the venous system in a thigh without compression could accommodate the increased flow and rate, thus resulting in no change in velocity at the femoral vein. In Sigel's experiment (1973) where an increase was shown with stockings of thigh length, the readings were taken two inches above the stocking, not thirteen to eighteen inches above as in this study.

An alternative explanation as to why no increase in the velocity was seen in some subjects is that the stockings were too tight. As shown by Sabri (1971), external compression above 15 mm Hg. reduces the femoral arterial flow. With a decrease in blood flow into the leg proportional to the amount of external pressure, there would not be any velocity change.

In two instances ($^{A}1$, $^{A}5$) where the velocity was increased with the application of stockings, it was reduced at the end of their removal. In subjects $^{B}6$ and $^{B}7$, removal of the stocking increased the velocity which supports the idea that compression stockings may be beneficial on some legs and useless or even harmful on others. In the subjects where removal of the stockings did increase the velocity, the velocity value was higher than baseline. This could be due to the fact that the stockings caused arterial compression and a reactive hyperemia occurred after their removal.

One group of investigators focused upon the importance of the amplitude of the venous velocity wave rather than the mean velocity being the important factor in preventing thrombus formation (Roberts, 1971; Sabri, 1971). In Sigel's (1973) work, the respiratory peak-to-peak effect was diminished which he interpreted to indicate increased venous tone from compression of tissue around the vessel and less ability of the thoracic and abdominal pressures to cause fluctuations in femoral vein velocity. The abdominothoracic pump mechanism is one of the major aids to venous return (Selkurt, 1971, p. 365). In this study the stockings were only on the lower leg; therefore, changes in the thoracic and abdominal pressures would still affect the femoral flow resulting in little or no change in the pulse form. Certain actions such as coughing, laughing, moving extremities, and deep breathing did increase the velocity wave amplitude while they had no effect on the mean velocity (Figure 8).

The Effect of Exercise

From the other studies (Browse, 1952; Greenberg, 1972), one would expect that the mean end exercise value would approximate baseline. In two subjects ($^{A}1$, $^{B}6$) who showed mean values of the exercise period increased over the baseline, one subject had the probe taped in position and needed no pressure to obtain maximal response. Possibly during exercise the position of the vein changed. The one-minute tracings of $^{B}6$ had arterial pulsations in the strips from E15 and E30 which could make the mean velocity of the readings higher.

There was an immediate increase in the mean velocity just after exercise but it did not remain elevated. During vigorous activity of both the calf and thigh, Ludbrook (1966) found about fifteen percent of the blood which entered the thigh was expelled and sixty-five percent of that which entered the calf. Since there was little thigh movement, one could expect a portion of the sixty-five percent to leave the lower extremity and affect the velocity reading at the femoral. Possibly if the reading could have been made at the popliteal vein, more of a change would have been noted.

The most effective rate for exercise is once every second (Roberts, 1971). In this study some subjects could have exercised faster and others would have become uncomfortable. The subjects in Roberts' study were unconscious and not doing active exercises. In the sample group of this study, the venous velocity wave changed to a more peaked narrow form during exercise and in three the amplitude doubled. One reason for the lack of effectiveness in the two who did not show change was that during the exercise, they flexed their knees or moved their hips. Even though they practiced the correct procedure before the experimental period started, by the time they were asked to exercise they had forgotten how to do it. Exercise did increase the mean velocity initially after completion as was hypothesized.

CHAPTER VI

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

Thromboembolism continues to hamper the progress of patient recovery. Nurses are responsible for helping prevent thromboembolism with actions which are aimed at increasing the blood velocity from the lower extremities. Common measures would include compression stockings and foot exercises. However, there still remain questions regarding the effectiveness of the presently employed methods in reducing deep-vein thrombosis. This study attempted to add some insight to the problem of whether knee-length compression stockings and foot exercises increase the venous blood velocity in active women age 40 to 80.

There are reports in the literature of increased changes in velocity as a result of compression. Yet there is not a consensus on how much external pressure is the most effective. This is partially due to the many types of compression stockings used and the different available technologies for measuring change. Although it is known that exercise causes an immediate increase in velocity, investigative work is being done to define the optimal rate and degree.

Fourteen subjects met the population criteria and comprised a convenient sample for this study. Data collection was conducted on each subject for a minimum of two and one-half hours. It was in four parts: pre-baseline period, baseline period, exercise period, and application and removal of stockings. At frequent intervals one-minute strip recordings of the subject's venous velocity were taken with a doppler ultrasonic flowmeter. The transcutaneous probe was taped over the femoral vein.

The results of the study were based on the data from five of the fourteen subjects. The others were deleted from analysis mainly because of poor velocity readings due to arterial interference.

When considering the effect of exercise on the blood velocity, it was found that immediately after the completion of maximum dorsiflexion and plantar flexion for two minutes, the velocity for each person was increased above the one-minute strip taken before the exercise. However, all the mean values of the exercise period, except for one subject, were equal with baseline or below it.

An overall look at the effect of the stockings on velocity for the group of five indicates a nonsignificant increase over the baseline period. Taken individually, three of the five subjects showed an increase, one a decrease, and one no change. The external pressure exerted by the stocking did not fall within those values proposed as necessary for an optimal pressure gradient, even though the manufacturers call them pressure-gradient stockings.

Removal of the stockings did not seem to change the immediate mean velocity significantly. When comparing the mean values for the stocking application period with those for the stocking removed period, it was noted that the velocity had decreased in three subjects and increased in two. One possible explanation discussed for the increase in the two subjects was that pressures were higher than recommended during the stocking application, causing a decrease in arterial inflow.

Other situations such as laughing, coughing, deep breathing, and movement of the upper extremities caused an increase in velocity mementarily by increasing the velocity pulse amplitude.

Conclusion

Due to the small sample, the two hypotheses could not be accepted or rejected based on statistical analysis. With the application of pressure-gradient compression stockings, a sustained increase in velocity with a decrease upon removal was hypothesized. This occurred in two of the five subjects.

It was hypothesized that two minutes of maximum dorsiflexion and plantar flexion would cause a short-term increase in velocity. The strip recordings of each subject's venous velocity indicated this to be true.

Recommendations

Implications for nursing practice: The following are suggestions for nurses who implement the wearing of compression stockings or encourage foot exercises. They are based on the observations made during this study.

1. Accurate measurement of the calf circumference and length for correct size selection is imperative. However, one size of stocking fits each leg a little differently. Compression stockings may not have the desired effects on everyone so complaints by the patient of tingling or discomfort should be investigated for circulatory impairment. The stockings in this study that exerted the optimal pressures did not require a great deal of force to apply.

2. As the activity of the patient increases, the venous blood velocity is increased by phasic fluctuations. Moving of the upper extremities as well as foot exercises will increase the femoral flow velocity.

3. Talking, coughing, deep breathing, and laughing should be encouraged in patients. These cause a surge in the velocity of blood flow.

4. In the operating room during surgery, in the recovery room, and on the floor, nurses should continue exercising the patient's lower extremities until the patient can be responsible for his own exercise. The more often it

is done, the better. An effective rate is 24-50 times per minute if tolerated at the maximum range of motion for each patient.

Implications for further study: The doppler flowmeter is a valuable tool for data collecting, especially for nurses because it is portable and does not require invasive techniques. To improve the methodology of a replicate study, the following changes would be recommended:

1. The subjects should be screened prior to data collecting for valvular competency. This could be done by recording both forward flow velocity and reverse flow at the same time during a Valsalva maneuver (Reagan, 1971).

2. Select only those subjects with the best readings from the probe position and repeat the experiment several times on different occasions.

3. Do sound recordings on a tape recorder and correlate them with the strip recordings for more accurate evaluation of the data.

4. To monitor changes in the venous blood velocity from knee-length stockings, use the popliteal fossa as a probe site. This would eliminate any compensation that might take place in the vessels of the thigh.

5. Design a study to examine the arterial and venous velocity with the application of stockings.

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APPENDICES

APPENDIX A

APPROVAL OF RESEARCH DESIGN BY LOMA LINDA UNIVERSITY ADVISORY COMMITTEE ON HUMAN EXPERIMENTATION

LOMA LINDA UNIVERSITY

DIVISION OF RELIGION

LOMA LINDA, CALIFORNIA 92354

March 13, 1974

Miss Ann Wood
School of Nursing
Loma Linda University
Loma Linda, CA 92354

Dear Miss Wood:

Your research proposal involving the effect of foot exercises and compression stockings on venous blood velocity has been reviewed by the Advisory Committee on Human Experimentation and approved without qualification.

It is understood that if you should change this research project in any significant way you will notify the committee.

Sincerely yours,

Jack W. Provonsha

Jack W. Provonsha, Chairman
Advisory Committee on
Human Experimentation

JWP:mn

APPENDIX B

WEIGHT TABLE

HEIGHT AND WEIGHT TABLE FOR ADULT WOMEN

Desirable Weights for Persons Age 25 and Over[1]

Height (with shoes on) 2-inch heels		Small Frame	Medium Frame	Large Frame
Feet	Inches	lbs.	lbs.	lbs.
4	10	92-98	96-107	104-119
4	11	94-101	98-110	106-122
5	0	96-104	101-113	109-125
5	1	99-107	104-116	112-128
5	2	102-110	107-119	115-131
5	3	105-113	110-122	118-134
5	4	108-116	113-126	121-138
5	5	111-119	116-130	125-142
5	6	114-123	120-135	129-146
5	7	118-127	124-139	133-150
5	8	122-131	128-143	137-154
5	9	126-135	132-147	141-158
5	10	130-140	136-151	145-163
5	11	134-144	140-155	149-168
6	0	138-148	144-159	153-173

[1] Metropolitan Life Insurance Company, New York

(Williams, 1973, p. 655)

APPENDIX C

CONSENT FORM

CONSENT

I have had explained to me the procedures which are to be followed as a part of my participation in this project designed to study increased blood return from the legs. Specific actions which will affect me will be foot exercises, and application of elastic compression stockings.

As a participant, I realize I will have a small amount of blood taken from my middle finger for a Hematocrit test with a sterile disposable stylet. I also understand I will be asked to wear a hospital gown and remain in bed for approximately three hours. The instrument which will measure the blood return will consist of a flat probe sending out sound signals which will be held in position in my upper thigh area by adhesive tape. It will not harm or cause me pain. I understand that measures will be taken to protect my privacy during my participation in this project as well as in reporting results.

By my participation I realize I will be contributing facts which will help medical personnel deal with the problem of blood clotting, a common hospital complication in members of my age group.

In consideration of the foregoing, I do hereby give my free and voluntary consent to participate in the project and procedures which are described above under the direct supervision of Ann Wood R.N. of Loma Linda University. In direct

witness thereof I have signed this consent at Loma Linda, California, on ________________________, 1974.
date

______________________________ ______________________________
Signature Witness

APPENDIX D

INSTRUCTIONS FOR FITTING T.E.D. STOCKINGS

T.E.D. BELOW KNEE STOCKINGS

Instructions for Fitting

Calf Circum.	Length	Size
To 12"	To 16" Over 16"	Small Reg-Length Small X-Length
12 to 15"	To 17" Over 17"	Medium Reg-Length Medium X-Length
15"-17-1/2"	To 18" Over 18"	Large Reg-Length Large X-Length
Over 17-1/2"	To 18" Over 18"	Extra Large, R-Length Extra Large, X-Length

Taken from Kendall Hospital Products Division's brochure on T.E.D. seamless nylon anti-embolism stockings. Thromboembolism the Unpredictable Killer, H-1054

APPENDIX E

DATA COLLECTING SHEET

SUBJECT: ______________________ AGE: ______________________

Pretesting:

1. _______ consent signed
2. _______ height
3. _______ weight _______ frame
4. _______ leg circumference _______ length _______ TED
5. _______ temperature _______ B. P. _______ pulse
6. _______ hematacrit
7. _______ maximum dorsi and plantar flexion
8. _______ test compression _______ mm Hg. upper foot
   _______ mm Hg. calf
   _______ mm Hg. top of stocking
9. _______ find femoral

Baseline:

0-1 min one minute strip
5-6 " "
15 " "
30 " "
_______ pulse
_______ leg measurement (circ)

Stockings:

0-1 min one minute strip
1-2 " stocking on
2-3 " one minute strip
5 " "
15 " "
30 " "
_______ pulse
_______ leg circumference

Remove stocking and take strip at 5, 15, 30 minutes

Foot Exercises:

0-1 min one minute strip
1-3 " exercise with strip
3-5 " strip following exercise
_______ pulse
_______ leg circ.
10 " one minute strip
15 " "
20 " "
30 " "
_______ pulse
_______ leg circ.

_______ END pulse
_______ end leg circumference

LOMA LINDA UNIVERSITY

Graduate School

THE EFFECT OF COMPRESSION STOCKINGS AND FOOT EXERCISES ON VENOUS BLOOD VELOCITY

by

Ann Lee Wood

An Abstract of a Thesis in Partial Fulfillment of the Requirements for the Degree of Master of Science in the Field of Nursing

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August 1974

ABSTRACT

To provide information of the effect of knee length compression stockings and foot exercise on venous blood velocity, an exploratory pilot study was conducted. An additional purpose of the investigation was to evaluate the non-invasive doppler ultrasonic flowmeter as a data collecting tool.

Fourteen volunteer female subjects, ages 40 to 80, met the designated criteria and were tested. During the half-hour baseline period and throughout the study at specified intervals, one-minute venous velocity tracings were recorded at the femoral vein with the doppler flowmeter. The baseline period was followed by two minutes of maximum dorsiflexion and plantar flexion of the right foot. Thirty minutes later compression stockings were applied for half an hour, then removed for thirty minutes. The external pressure exerted by the stockings was measured by a specially designed balloon and mercury manometer prior to starting the baseline recordings.

Only five of the population sample were included in the description of results. The major disqualifying reason was poor venous velocity readings because of arterial interference. However, external pressure values of the stockings and changes in the calf circumference were tabulated on the entire group of fourteen subjects.

Two minutes of exercise caused an immediate increase

in venous velocity in all five subjects but at the end of thirty minutes, all the values but one were equal with baseline or below. The velocity wave changed configuration during dorsiflexion and plantar flexion becoming narrower and of greater amplitude than during baseline. The wave configuration was in phase with the foot movement rather than with the respiratory cycle as during baseline. A significant decrease in the mean measurement of calf circumference occurred between the end of the baseline period and immediately following two minutes of exercise.

After wearing compression stockings thirty minutes, three of the five subjects showed an increase in venous velocity, one a decrease, and one no change when compared to baseline values. The form of the femoral venous velocity wave, while the stockings were in place, remained almost identical in appearance compared to those during baseline with no decrease in the effect of respiration on the pulse wave nor increase of the cardiac affect.

Though the manufacturers indicate their stockings have a pressure gradient, very few of the stockings had that effect when on the subject's legs. The pressure was two to four millimeters of mercury higher than the top of the stocking in the majority of cases. There was a significant decrease in the calf circumference of all the subjects when the stockings were in place.

Removal of the stockings did not result in an immediate decrease in velocity. At the end of thirty minutes, three subject's velocity had decreased and two increased in comparison to the values at the end of the stocking application period. The mean calf circumference after thirty minutes without the stockings was significantly greater than when the stockings were on.

Factors which may have contributed to these results and how they varied from other investigative studies were discussed. Implications for nursing practice and recommendations for further study were made based on the results of this research.