

AN ABSTRACT OF THE THESIS OF

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Title: THE EFFECT OF AGE, SEX AND EYE-HAND COORDINATION
ON THE ABILITY TO PREDICT THE READINESS OF
ELEMENTARY STUDENTS TO LEARN AN EFFECTIVE
DENTAL FLOSSING TECHNIQUE

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The purpose of this study was to investigate the relationships between age, sex, eye-hand coordination, the time it takes individuals to learn how to manipulate dental floss between all of their teeth, and the time it takes individuals to learn how to effectively clean their teeth with dental floss.

The subjects consisted of 117 elementary students from two schools in Lebanon, Oregon. Twenty-eight eight year olds, 27 ten year olds, 32 nine year olds, and 30 eleven year olds were selected from Queen Anne's and Santiam Schools. The second and fourth grade classes were selected from Santiam School, while the third and fifth grade classes were chosen from Queen Anne's School.

The eye-hand coordination skills of the student were examined by using a speed and accuracy marble manipulation test called the Moore Eye-Hand Coordination Test. The scores on the test not only indicated each individual's eye-hand coordination ability, but also helped differentiate the students within the sample population so that

they could be compared to other groups of elementary students.

A student's ability to manipulate the dental floss between all of the teeth was determined by direct observation. Examiners observed the students while they attempted the flossing techniques and noted whether they could manipulate the floss between all of the interproximal surfaces.

The amount of plaque left on one and one-half millimeter wide sections of 12 predetermined surfaces of six teeth was measured by the Flossing Performance Index. Plaque buildup was rated from zero to three, zero indicating no plaque formation while a score of three indicated that the plaque covered the entire one and one-half millimeter wide section. To pass the Flossing Performance Index a student would have had to achieve at least a 50 percent reduction in plaque from a pretest rating, and a score of 13 or less on the same index. Each student was required to practice the flossing technique until he could pass the Flossing Performance Index.

Four general hypotheses were considered: Hypothesis I: There is a significant relationship between age and eye-hand coordination, flossing manipulation skill, and flossing effectiveness, Hypothesis II: There is a significant relationship between sex and eye-hand coordination, flossing manipulation skill, and flossing effectiveness. Hypothesis III: There is a significant relationship between eye-hand coordination and flossing manipulation skill, and flossing effectiveness. Hypothesis IV: Age, sex and eye-hand coordination scores, separately or in combination, are good predictors of flossing manipulation skill and flossing effectiveness.

Two null hypotheses were also tested. Hypothesis V: There is no significant difference between males and females at the eight, nine, ten, and eleven year old age levels in regard to eye-hand coordination, flossing manipulation skill, and flossing effectiveness. Hypothesis VI: There is no significant difference between any of the four age groups (eight, nine, ten, and eleven year olds) in reference to eye-hand coordination, flossing manipulation skill, and flossing effectiveness.

In summary, the following conclusions were made:

1. Eye-hand coordination, sex and age are related to the time it takes a student to learn how to manipulate dental floss between all of the teeth, and the time it takes a student to learn how to effectively floss his or her teeth.
2. Eye-hand coordination and age are the most critical variables in relation to the time it takes a student to learn how to manipulate dental floss between all of the teeth, and the time it takes a student to learn how to effectively floss his or her teeth.
3. The variables of eye-hand coordination, sex and age will not predict, at the 95 percent level of confidence, the exact number of days it takes a student to learn how to manipulate dental floss between all of the teeth, and the time it takes a student to learn how to effectively floss his or her teeth.
4. All eight, nine, ten and eleven year old elementary students in this investigation were able to learn how to effectively clean their teeth with dental floss within ten, seven, six, and five days, respectively.

5. Hypotheses II and IV were rejected while hypotheses I and III were not rejected. Null hypothesis V was rejected for the eight year olds on the time it took students to learn how to manipulate floss between all of the teeth, and for eleven year olds on eye-hand coordination, and on the time it took students to effectively clean the teeth with dental floss. Null hypothesis VI was rejected only for the following age groups: eight and nine, eight and ten, eight and eleven, and nine and eleven.

The Effect of Age, Sex and Eye-Hand Coordination
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THE EFFECT OF AGE, SEX AND EYE-HAND COORDINATION ON THE ABILITY TO PREDICT THE READINESS OF ELEMENTARY STUDENTS TO LEARN AN EFFECTIVE DENTAL FLOSSING TECHNIQUE

INTRODUCTION

Dental authorities have been experimenting and researching a wide variety of instruments that have proven to be of some benefit in the limitation of dental disease. Dental floss, an oral hygiene tool tested by C. C. Bass and S. S. Arnim in clinical studies, has been found to be effective in controlling periodontal disease, and is believed to be of help in the prevention of dental caries (6) (4).

Periodontal disease is a destruction or infection of the supporting tissues of the teeth, whereas dental caries is an infection leading to cavities and pulp destruction beneath the hard surfaces of the teeth. Periodontal disease is most often a degenerative disease, but often it can be prevented early in life. The most prevalent form of the disease results from progressive accumulation of bacterial plaque, a mixture of microorganisms and mucinous substances found in saliva, along the gum line and on the teeth (39).

Dental floss has been found to be effective in removing this plaque and thus also in irradiating some factors causing dental disease. Because floss has been found to be effective in helping clean the mouth, the teaching of flossing techniques to elementary school children should aid in the battle against dental disease.

A major problem associated with the introduction of a program that would train elementary school students to use dental floss involves

the determination of the age level where one can first begin teaching the new concept. Dental authorities suggest that the earlier students learn how to use dental floss, the sooner they will be able to remove plaque and thus keep their teeth free of dental disease. Research groups in several states have had dental hygienists and dentists teaching the flossing technique to the various classes at the elementary school level. Dental authorities, however, continue to disagree as to the appropriate time to begin teaching the use of dental floss. The Dental Hygiene Department at the University of Oregon Dental School has decided to experiment with a flossing program at the fifth grade level, and a task force of dentists in San Antonio, Texas are doing research concerning dental flossing at the elementary level, K-6. After a two year pilot study, the dentists in San Antonio recommended modifying the flossing program for grades K-2 due to limited manual dexterity exhibited by the students.

Dental personnel have not determined when students are ready to learn a flossing technique nor when they will have the ability to become effective flossers within predetermined amounts of time. The investigator of this study believed that eye-hand coordination would be the major variable which would determine an individual's readiness to learn the technique. The Sign Test was used to analyze the data from the standardized Moore Eye-Hand Coordination Test. It revealed that eight, nine, ten, and eleven year old children have significantly different times for the test, at the .01 level of significance, and that there is an inverse relationship between time and age. If a student's eye-hand coordination is well developed, then

he may be able to master the flossing technique in less time than a person with poorly developed eye-hand manipulatory skills.

Age and sex were also believed to be major variables in determining an individual's flossing readiness. Age should give a relative idea of an individual's physical, mental and emotional maturation. Sex differences could be apparent due to the varying experiences that male and female children have.

Statement of the Problem

In order to predict when an individual or class is ready to learn how to use dental floss, information must be obtained that shows the relationships between age, sex, eye-hand coordination ability, time it takes to floss between all of the teeth, and the time it takes to learn how to effectively clean the interproximal surfaces of the teeth. This study was designed to determine whether or not age, sex, and the Moore Eye-Hand Coordination Test results could be used to predict the number of days it takes students to learn how to manipulate floss between all of the teeth, and whether these same variables could predict the time, in days, it takes students to learn how to effectively clean the interproximal surfaces of the teeth with dental floss.

More specifically, the following hypotheses were formulated as major considerations in this study:

1. There is a significant relationship between age and the following three factors: a) eye-hand coordination (X_1), b) the time it takes an individual to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1), and c) the time it takes an individual to learn how to effectively clean the interproximal surfaces of the teeth with dental floss (Y_2).
2. There is a significant relationship between sex and factors X_1 , Y_1 and Y_2 .
3. There is a significant relationship between eye-hand coordination and Y_1 and Y_2 .
4. Age, sex and eye-hand coordination scores, separately or in combination, are good predictors of Y_1 and Y_2 .

The following null hypotheses were also major considerations in this study:

5. There is no significant difference between males and females at the eight, nine, ten and eleven year old age levels in any of the three factors including X_1 , Y_1 and Y_2 .
6. There are no significant differences between any of the four age groups; eight, nine, ten and eleven year olds, in X_1 , Y_1 and Y_2 .

In order for an individual to effectively clean his teeth with dental floss (Y_2) he would have had to pass the Flossing Performance Index Test. The test was considered passed when the student:

1) was able to manipulate the floss into all the interproximal spaces, and 2) was able to achieve at least a 50 percent reduction from the pretest rating on the test and a score of 13 or less on the same index.

An F-test of variance was used to determine whether or not there were significant relationships in hypotheses one through three. Linear regression analysis was used to determine whether or not hypothesis number four was a valid assumption. Finally, multiple t-tests were used to determine whether or not there were significant differences in null hypotheses five and six.

Definition of Terms

Unwaxed Dental Floss

Dental floss is a textile fiber which is rolled into a thread and used to remove bacterial colonies, food and other debris caught between the teeth. Several companies produce floss which is waxed, but only a few produce the thin unwaxed type which is reportedly better for removing plaque (41).

Exposing Tablets or Wafers

Exposing tablets or wafers contain erythrosine dye (F.D.C. Red #3) and are used to stain the microbial masses adhering to the teeth. Four to ten wafers can be dissolved in one ounce of plain water and applied to the teeth by a pledget of cotton or an individual can chew the wafer and swish it about in the mouth for at least one-half minute (5).

Plaque

Plaque is a tooth substrate or oral flora composed of micro-organisms, exfoliated cheek cells, and mucinous substances in saliva. Plaque is known to cause decalcification of the teeth at a pH of 5. Specific kinds of bacteria are especially active in forming plaque. The bacteria come in contact with sucrose and produce gummy substances called dextrins which enables plaque to stick to the teeth. The bacteria act on sugars to produce acids which in turn break down the enamel. Bacteria will begin producing acids within a few seconds after a person eats any food which contains sugars (34). The feltlike consistancy of the plaque helps maintain the acid condition even with the sometimes alkaline influence of the saliva.

Calculus (tartar)

Calculus is a substance formed due to the mineralization of dental plaque. It is considered one of the most important causes

of periodontal disease since it irritates the gum tissue and provides a foothold for the development of dental plaque.

Interproximal

This is a dental term referring to the areas in between the teeth.

Mesial

When referring to teeth, the mesial areas are those portions of the teeth found nearest the oral opening.

Distal

When referring to teeth, the distal areas are those portions of the teeth farthest removed from the oral opening.

Basic Assumptions

In this study the following assumptions were made:

1. The Flossing Performance Index Test would indicate an individual's flossing skill.
2. The flossing procedures outlined by dental authorities and used in this study were effective in getting rid of plaque.
3. The numbers of students used in the experimental groups were sufficient in size to get significant data for meaningful statistical interpretation.

4. The Moore Eye-Hand Coordination Test (MEHCT) is a valid and reliable test for eye-hand coordination.
5. Age, sex and eye-hand coordination are critical variables that affect a person's ability to learn the flossing technique.
6. The control of factors such as socioeconomic class, I.Q., and family history were not necessary.

Limitations of the Study

The investigation reported in this study was subject to the following limitations:

1. The study was limited in numbers of subjects to 117 elementary students from Lebanon, Oregon.
2. The study was limited by its student composition. Second and fourth grade students were chosen from Santiam School while the third and fifth grade students were chosen from Queen Anne's School.
3. The study was limited to the use of the Moore Eye-Hand Coordination Test due to the lack of valid and reliable eye-hand coordination instruments available for the second through the fifth grade levels.
4. The study was limited by the eye-hand coordination scores exhibited by the students.

5. The study was limited by its inability to control the possibility of the interaction effects of testing, where a pretest might influence a student's sensitivity to the instruction of flossing over that of individuals not in the study.
6. The study was limited by its inability to control the reactive effects of experimental arrangements, which limits generalizations made about flossing instruction given to individuals in a nonexperimental setting.

Importance of the Study

Dental disease is considered one of the most wide spread chronic diseases that afflicts man. Stoll, in 1967, reported that 50 percent of all two year olds have one or more cavities and at age five years they have three or more decayed primary teeth. Fourteen percent of the five year olds will have cavities in their first molars. He stated that at age 16 the average youth has seven decayed, missing, or filled teeth and less than four percent of high school pupils are free of dental disease (48). There is a sharp increase in the amount of caries in the 15 to 19 age group and the greatest of all caries incidence is in the 15 to 25 year old age group (16). A study in the early 1960's in Kingston, New York indicated that the DMF (diseased, missing, and filled teeth) rate was 2.3 for six to nine year olds, 7.0

for 10 to 12 year olds, 11.7 for 13 to 14 year olds and 16.5 for 16 year olds (48).

Wheatley and Hallock, (52, p, 342, 343) reported:

The American Dental Association has indicated that the total number of cavities resulting from dental caries in children's teeth is so high (285 million is the nationwide figure) that if all the dentists practicing now were to devote all their time to children they could not hope to be able to fill all the cavities.

Stoll (48, p. 47) states:

That less than 2 percent of the population live their entire life span without some form of dental disease or disability is a known fact.

A report on the dental caries incidence among selected groups of people in the State of Oregon helped point out the extent of dental crisis in Oregon. The subjects were 582 freshmen students at Oregon State College who were residents of Oregon. All of the counties in Oregon except for Grant and Wallowa were represented. Most of the students were from Multnomah, Marion, Benton and Linn Counties. The DMF rate for the 582 freshmen students was 13.22 which was considerably higher than the DMF (Diseased, Missing, and Filled teeth) rate of about 8.0 in similar groups examined in Hagerstown, Maryland and San Francisco (25).

Baird and Kelly (7, p. 1, 4) reported:

Based on examinations conducted during 1960 to 1962 on a probability sample of the adult population, an estimated 20 million men and women had lost all of

their natural teeth. Excluding the 20 million edentulous adults, there were approximately 91 million others who had on the average 18 decayed, missing, and filled (DMF) teeth. Among these persons, moreover, about one half had gingivitis, or inflammation of the gums, and approximately one-third had destructive periodontal disease.

Kelly, Van Kirk, and Garst (31) state:

To summarize recent survey findings, periodontal disease can be depicted as increasing in prevalence and severity with age, oral uncleanliness and descending socioeconomic status. In the final analysis, establishing oral cleanliness and maintaining it have for decades been mainstays in the successful treatment of periodontal disease.

The mean Simplified Oral Hygiene Index, estimated from nearly 90 million men and women was 1.5. OHI-S scores of greater than 3.0 were found in about one-eighth of all persons, indicating serious neglect. As individuals became older the oral hygiene became worse. This was probably due to the continuing deposition of calculus. Among adults of all ages, 18 to 79, and with incomes less than \$2,000 per year, the greatest mean OHI-S score per person was 2.6 (31).

Analysis of several dental health programs currently in operation indicate a need for new approaches to dental health education, and the means whereby these approaches can be evaluated. Seattle's Head Start program enrolled 420 children in 28 classrooms of the Seattle public schools in 1967. Peterson (42, p. 698) states:

The average cost for dental treatment per child in 1967-68 was \$57, and for 1968-69, \$76. The cost of providing dental treatment for the children in the

Seattle Head Start program was nearly three times the cost of providing medical treatment.

In New York State three and one-half million people are potentially eligible for Medicaid, and in 1970 it was reported that a good percentage were now obtaining the services of Medicaid paid dentists. A recent study found that 47 percent of the dental patients on Medicaid had not been seen by a dentist for a minimum of three years. Patients obtaining dental aid were about equally divided between children and adults, but the cost of dental care has been two to four times as great for adults as for children (8).

Health authorities throughout the world have demonstrated the need for better dental health for all people and not solely for those individuals from low socioeconomic groups. Comments from several leaders in the field of dental health will help to emphasize this universal need. Dr. Majorie Young, Associate Professor in the Department of Health Services Administration, School of Public Health, Harvard, and consultant to the Commission on Dental Practice of the International Dental Federation (56, p. 2) states:

Prevalence data on dental caries and periodontal disease from all parts of the world substantiate the almost universal need for effective comprehensive dental health education programmes.

Although countless numbers of dental health information and instruction programmes in schools and other settings have been carried on for decades in many countries, using a broad spectrum of dental health materials, up to now

there has been a disappointing improvement in dental health status and relevant behavior.

Public health officials point out the need for dental health programs which will be based on new concepts of dental disease prevention. Dunning (16, p. 1, 2) states:

Prevention takes on a new meaning, where manpower is obviously insufficient to render all needed restorative care. The test of any public health measure now becomes, 'how much will it do for the fellow who can't afford private care?'

Green and Vermillion, dental research scientists who are interested in new concepts relative to oral hygiene (23, p. 188) state:

It seems the challenge is how to achieve optimal oral hygiene in population groups in the face of limited manpower supply, difficulties experienced even by apparently well-motivated people in maintaining optimal conditions of oral hygiene, and a total lack of concern, on the part of many, about oral hygiene and periodontal disease.

A realistic focus for some future research may be to identify procedures and materials that individuals of all ages can use themselves, in their homes, for preventing accumulation of plaque and hard deposits on the dentition, and to develop a means of motivating people to adopt practices for self-assistance in preventing and controlling periodontal disease.

Green and Vermillion also explained that schools have a role to play in helping shape children's dental health behavior. They state (23, p. 192):

Effective dental health practices should be established early in the life of every child, and although we do not know exactly how to do this, sociologic research is providing some new insights that ultimately should show the way.

In summary, dental health authorities suggest that emphasis should be placed upon research concerning the early prevention of dental disease. Investigations are necessary due to a limited supply of dental personnel, the lack of motivation and proper habit formation of individuals, the thousands of people who cannot afford dental care, and because of the increase in prevalence of the disease among all individuals. Thus, a study investigating the ability of elementary students to learn dental techniques seems appropriate.

At the elementary level, programs have to be developed to reach the greatest amount of students in the least amount of time with the best dental hygiene procedures possible. Research points to the fact that the most economical, least time consuming, most convenient, and yet effective means of personal oral hygiene known today involves the use of fluoride, dental floss, exposing tablets and a soft tooth brush (52) (6) (10).

While many of the present dental authorities are using fluorides, exposing tablets and soft toothbrushes, very few are teaching the use of dental floss. One of the main problems associated with the incorporation of dental floss into dental hygiene programs, and which was a major concern of this investigation, involves the question of the age level where the dental technique can first be taught. The technique would have to be learned with a minimum amount of time spent on instruction for it would be impractical for schools if the learning of

the technique was too time consuming.

Students of particular age levels will also have different abilities in eye-hand coordination, and it may take weeks to determine how fast an individual can learn how to floss effectively. Thus, it seems likely that it would be important to find an eye-hand coordination test that would predict the time necessary to learn an effective flossing technique. The use of the Moore Eye-Hand Coordination Test in this investigation was an attempt to find such a predictive instrument.

The statistical analysis of the results of the study analyzed the various times it took 117 youngsters to learn how to floss effectively and determined the differences and relationships between students of different ages, sexes and eye-hand coordination abilities. Elementary teachers will be able to use these results to help determine whether or not their students are ready to learn how to use dental floss in the specific amount of time that he or she can allocate to a dental flossing program.

The study's results may also be useful to companies who manufacture flossing aids since they need to know the age levels of children who have difficulty in manipulating floss. Once grade or age levels are determined, then dental health authorities can include flossing aids into their dental health programs at respective grade levels.

To help summarize the importance of this study, since very few publications mention this specific area, dentists and hygienists were requested to relate to the investigator their feelings concerning the project. Dr. Sumter S. Arnim of the University of Texas Graduate School of Biomedical Sciences states (2):

I think you have chosen an excellent study for investigation, one that needs study, is vitally important and holds much promise for rewarding results to all concerned.

Dr. Merrill G. Wheatcroft of the University of Texas Dental Branch, Houston, Texas states (54):

I am not aware of research regarding the age that children can floss and brush adequately. We recently completed five films, one which was titled 'Care of Children's Teeth.' In this film we stated, "It is not known at what age children can clean their own teeth.

There is a real need for what you are doing. Especially so since there are preventive programs being initiated in grade schools. If we are ever going to accomplish control of dental caries we have to start with children.

Miss Jennifer Day, Assistant Professor, Department of Dental Hygiene, University of Oregon Dental School, Portland, Oregon states (13):

This letter is to confirm my support of your projected dental health program. I am not aware of any published research measuring the manual dexterity of school-age children necessary for flossing.

A study concerned with instructing groups in flossing will also be helpful. Presently, as we discussed, most oral hygiene instruction on flossing is done on a one-to-one basis. Some offices currently spend five and one-fourth hours on one patient to enable that person to control his own plaque. If classrooms of 30 children can be instructed in flossing, this would be a great time saver.

Dr. Norman O. Harris, University of Puerto Rico Dental School, San Juan, Puerto Rico writes (26):

First, let me congratulate you for looking into preventive dentistry techniques. Great emphasis is needed to use the tools we have today to accomplish a better job in oral health delivery.

Dr. Herbert Brilliant, formerly of the University of Pennsylvania, and now practicing in the area of periodontics, states (9):

I want you to know that you have my personal support for this type of research and of the entire dental profession as well. Information of this type is terribly important and badly needed if we are to make any sense of presenting a worthwhile and workable concept in Preventive Dentistry.

Dr. John D. Suomi, Chief, Community Applications Section, Preventive Practices Branch, Division of Dental Health, Department of Health Education and Welfare, Bethesda, Maryland, states (49):

In my opinion, research projects related to flossing by children are very much needed. Recently, great emphasis has been placed on the need to floss if one is to clean thoroughly the proximal surfaces of teeth. Toothbrushing alone, although very helpful in removing bacterial plaque on the facial and lingual surfaces of teeth, is not effective in cleaning between the teeth. The need for flossing is emphasized by most dentists who are preventively oriented. Plaque has been implicated in dental

caries and periodontal disease etiology. Plaque control programs are becoming the in thing, so to speak. Very little, however, is known about the ability of children to use floss. It is often assumed that they are unable to use floss properly. Your proposal will attempt to shed some light on this question and is to be commended.

In summary, research and personal communication have demonstrated that it is important to find ways to prevent dental disease early in life. In addition, it has also been explained that it is necessary to determine when individuals are ready to master effective oral hygiene procedures. Effectiveness will depend upon readiness. Therefore, the importance of this investigation is that it will help enable professional personnel to determine when children among the eight, nine, ten and eleven year old age groups are ready to master the technique of dental flossing.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Dental floss, which has been used by some dentists and dental researchers for over a century, has just recently been incorporated into modern oral hygiene programs. Floss can be maneuvered into the interproximal spaces, the spaces between the teeth, and it has been demonstrated that floss, with the proper manipulation, will remove oral debris and plaque from these areas.

Swenson, writing about the interdental area, states (50, p. 733):

Many positive factors can contribute to changes in the interdental area, the most common of which are calculus and bacterial plaque. The interdental area is not satisfactorily cleaned with a toothbrush and requires the use of interdental cleansing devices.

Sumter S. Arnim, of the University of Texas Graduate School of BioMedical Sciences, points out that if one removes the bacterial organisms causing tissue destruction, the connective tissue will remain unharmed. Healthy tissue is found in certain sites in all the autopsy specimens, irrespective of age, when no microbial masses are present. It was found in patients at the University of Texas that tissue would grow back and heal if bacterial material was removed (4, p. 271).

Arnim also reports that the microbial matter that adheres to the teeth is semi-transparent and resembles the tooth in color.

Cavities are formed underneath the microbial films that are especially hard to get to with a toothbrush. Just a couple of days will develop an extensive colony of bacterial plaque and calculus which will be harder than ever to get rid of. The plaque will grow best in the hidden areas between the teeth, near the gumline and in the fissures of the tooth surface (3, p. 3).

Thus, the purpose of the dental floss is to rid the interproximal spaces of disease causing plaque. This can be accomplished only if flossing takes place at least once every day. Theilade (51, p. 111) explains:

The plaque may, under certain not yet fully elucidated circumstances, become mineralized and is subsequently termed dental calculus. The mineralization may start 24 hours after the first deposition of plaque. In humans, plaque seems to be a prerequisite for the deposition of calculus.

Furthermore, Theilade and Schroeder (51, p. 43) state:

Recent research in dental calculus has shown that the deposition of dental deposits is the most important cause of periodontal disease. The only practical way to avoid the detrimental effects of calculus deposition is for the patient to carry out effective oral hygiene daily.

Calculus is formed by impregnation of dental plaque or materia alba with calcium phosphate crystals. The time necessary for the transformation of the soft matrix into hard, mature calculus containing at least 75 to 80 percent inorganic materials is about 12 days for calculus formers.

The Role of Plaque

Gjeramo and Flotra (22) have reviewed the dental literature and have come to the following conclusions concerning the role of plaque in dental disease:

Bacterial plaque is now considered to be the dominant etiological factor in marginal periodontitis (Lovdal, et al., 1958; Shei, et al., 1959; Green, 1963; Ash, et al., 1964; Brandtzaeg and Jamison, 1964a; Loe, et al., 1965; and Waerhaug, 1967). Clinical evidence are given that gingivitis can be prevented, and often successfully treated by improving the oral hygiene (Brandtzaeg and Jamison, 1964b; Loe, et al., 1965; Lindhe and Koch, 1967; and Gjeramo, unpublished). Furthermore, several investigations show that gingival conditions are worst in the interdental areas, the areas least accessible to ordinary brushing (Lovdal, et al., 1958; Loe, et al., 1965; Lindhe and Koch, 1967).

In 1969 Loe (34) published an article concerning the etiology and prevention of periodontal disease. Within the article he describes the role of dental plaque and its affect on gum tissue and bone. He explains that shortly after a polished tooth surface is exposed to saliva a pellicle one micron thick begins to form. Simultaneous with, or soon after its formation, bacteria begin to colonize the cervical portion of the pellicle. Separate colonies unite and adhere to the tooth in a matter of a few hours.

The microorganisms present consist mostly of gram-positive cocci and short rods innitially, but within 24 to 48 hours these organisms increase in number and gram-negative cocci and short rods appear. After two or three days of plaque formation, filaments and

fusiforms are seen. A ten day old plaque had enormous amounts of the types of bacteria already mentioned plus vibrios and spirochetes. At 14 days the gram-positive cocci and small rods account for only about 50 percent of the total flora, gram-negative cocci and small rods approximately 30 percent, filaments approximately eight percent, fusobacteria eight percent, vibrios and spirochetes approximately two percent each. At the end of two weeks the bacteria flora in plaque on the surface of the tooth above the gingiva remains fairly constant.

Loe continued to report that within the plaque matrix a relatively sparse substance made up of proteins exists. This substance is formed by combining the material split off from the salivary glycoproteins and the polysaccharides produced extracellularly by oral streptococci. This extracellular polysaccharide can only be made by microorganisms if sucrose is present in the oral cavity. This suggests that if sucrose were eliminated from the diet the plaque's composition and abundance would be altered. However, generally the presence or absence of cervical plaque on the necks of the teeth is relatively independent of the passing of foodstuffs through the mouth. With a standard diet of course bread, ample fruit and vegetables, young, healthy individuals with complete dentition, normal gingiva, salivation, occlusion, and mastication build up increasing amounts of plaque on the teeth if cleansing is abolished. Plaque is clinically demonstrable in less than 24 hours

and even excessive chewing of fibrous food between meals does not prevent its formation. 'Self-cleansing' of teeth is an illusion, for individuals who consume fibrous foods for a week without using other artificial cleansing devices will have their teeth loaded with plaque.

Loe suggests that the rate of plaque formation may be influenced by the amount and characteristics of saliva, ill fitting dental restorations, and crowded teeth. It has been claimed that calculus and faulty restorations cause gingival irritation, but it is now clear that the plaque covers the calculus and restorations and it is the plaque that causes the irritation.

The organisms in plaque do not enter the gingival tissue, but damage and irritate the gum tissue by excreting pathogenic enzymes and toxins. The following are produced by the plaque flora: hyaluronidase and beta glucuronidase from streptococci and diphtheroids, phenolsulfatase from fusobacteria, chondrosulfatase from diphtheroids, and collagenase from Bacteroides melaninogenicus.

Endotoxins extracted from bacteria, bacterial antigens, and bacterial metabolites such as ammonia, hydrogensulfide, etc. all probably contribute to gingival irritation and tissue destruction.

No one particular organism can be accused of causing gingival inflammation and generally the oral flora is not considered pathogenic. However, when the bacteria accumulate and increase in number they collectively work together to cause gum disease. Clinical gingivitis

becomes apparent after about a week of plaque build up and it is well documented that inflammatory changes are well under way before spirochetes appear in abundance (34).

Effectiveness of Dental Floss

It is clear that oral debris, including plaque, must be removed. Dental floss has proven to be very inexpensive, easily adaptable and quite effective in removing oral debris. Manhold, Manhold and Weisinger (35, p. 71), studying the efficiency of dental floss in removing grams of oral debris on the teeth of 25 randomly selected subjects, state:

Specifically, brushing and twice rinsing alone removed a total of 17.02 grams while the use of floss resulted in an additional clearance of 13.58 grams.

Mohammed and Monserrate studied the removal of dental plaque by floss in 104 patients who practiced good oral hygiene. They found through examination of pre and post test photographs taken of the oral cavity after the plaque on the teeth was stained with erythrosine disclosing tablets, that, following the use of dental floss, almost all of plaque which remained after toothbrushing was removed. Mohammed and Monserrate state (37, p. 420):

The actual amount of plaque removed by the use of dental floss was approximately 25 percent of the total plaque present in these subjects before toothbrushing. However, its removal is believed to be quite significant clinically because so much of the plaque which remained after toothbrushing was in

particularly vulnerable areas; i. e., in the interproximal and cervical areas.

In 1969 Keller (30) compared the effectiveness of various cleansing devices, including: a dentifrice was compared with water; handbrushes compared to electric brushes; synthetic bristles compared to natural bristles; and vertical motion electric brushes compared with horizontal motion brushes. Also, the effects of floss, water jets and water rinses were studied. Keller found that brushing with a dentifrice was more effective than water in removing interproximal plaque. He also found that water jets or flossing techniques were good supplements to the toothbrush for cleansing the proximal surface.

Keller and Manson-Hing (30, 402) continued to determine the effectiveness of various cleansing devices and compared the following oral hygiene tools:

- 1) Horizontal electric brush, with dentifrice
- 2) Vertical electric brush, with dentifrice
- 3) Elliptical electric brush, with dentifrice
- 4) Handbrush, natural bristle, with dentifrice
- 5) Handbrush, synthetic bristle, with dentifrice
- 6) Handbrush, synthetic bristle, with dentifrice plus dental floss
- 7) Handbrush, synthetic bristle, with dentifrice plus water jet

The dentifrices used were:

- 1) Colgate
- 2) Crest
- 3) Gleem
- 4) Pycopay Powder

The patients brushed the experimental areas of the teeth for ten seconds in all seven treatments. In the sixth treatment the subjects flossed the interproximal area for five seconds after brushing. In the seventh treatment the water jet was aimed at the interproximal space on the tongue side for five seconds and on the cheek for five seconds after brushing.

The results showed that treatment number 6 had mean percents which were far greater than any of the other techniques used; and that treatment number 7 was consistently higher in mean percents than any of the remaining techniques. Keller and Manson-Hing (30, p. 403) state:

1. The data is quite conclusive that the best way to cleanse the proximal surfaces of posterior teeth is through the use of a handbrush and dentifrice followed by the use of dental floss.
2. The next best cleansing method is the use of a handbrush and dentifrice followed by an intermittent water jet.
3. There is no advantage to be gained by using electric brushes instead of handbrushes. In addition, no advantage could be found between the various actions of electric brushes.
4. Natural and synthetic bristles showed similar cleansing effectiveness.
5. All dentifrices as used in this study removed similar amounts of plaque; however, when compared, one dentifrice showed a statistically significant difference (Colgate).

Keller and Manson-Hing completed a second study involving the following cleansing devices:

1. Waxed Floss
2. Unwaxed Floss
3. Teflon Yarn
4. Rubber Pick
5. Balsa Pick

In the first three treatments the experimental tooth area was flossed for five seconds by the examiner using a plastic floss holder. The rubber pick was used for five seconds on the cheek side and 5 seconds on the tongue side of the tooth's interproximal area. The balsa pick or 'stim-u-dent' was only applied to the cheek side of the tooth's interproximal area since it could not be applied to the tongue side. Keller and Manson-Hing stated the following results (30, p. 404, 405):

Note that the percentages of plaque removed for treatments No. 1, 2, and 3 are consistently greater than the percentages of plaque removed for treatments No. 4 and 5 using the five measuring systems. The use of waxed and unwaxed floss or teflon yard was much more effective than either the rubber pick or balsa pick. The results were significant at a level of less than .01 by all methods of measurement. When the use of the waxed and unwaxed floss were compared with the use of telfon yarn, the flosses were more effective for removing plaque from the proximal surface. One can see from Table 5 when waxed and unwaxed floss were compared, no significant difference was noted by any of the measuring systems. When wood and rubber picks were compared, no significant differences were discernible by any of the measuring systems. However, it must be remembered that our subjects were young healthy individuals with normal embrasures that did not permit much penetration of the picks into the interproximal space. This finding may not be applicable to persons with periodontal breakdown and large interproximal spaces.

Gjeremo and Flotra (22) evaluated the effect of dental floss as compared with toothpicks in interdental cleaning. They used dental students at the Dental Faculty, University of Oslo, Norway, in the age groups of 20 to 30 years. The gingival conditions of the students were very good with no signs of periodontium destruction. Plaque and gingivitis scores were recorded according to the Plaque Index (Silness and Loe 1964) and the Gingival Index (Loe and Silness, 1963).

The investigators made the following conclusions:

1. Toothpicks are no more effective than an ordinary toothbrush in removing plaque from the lingual or tongue sides of the interproximal areas.
2. Toothbrushes or toothpicks have less effect on the interproximal surfaces than does dental floss.
3. Dental floss is almost twice as time consuming as the use of toothpicks.

Oral Hygiene Frequency

The frequency with which a dental cleansing device should be used and the amount of time that should be spent at each cleansing session varies somewhat from individual to individual. Dr. Ariaudo examined and evaluated 100 patients who had been on recall for varying periods and he found that individuals with the greatest number of plaque free teeth were those who spent the greatest amount of time on oral hygiene. The patients who scored the best on the plaque indexes were those who spent at least 25 minutes a day on oral hygiene,

and worked at the process on at least two different occasions each day. The longest period of time was spent in the evening before retiring. Dr. Ariaudo states (1, p. 310):

Those with better gingival health generally use unwaxed dental floss. It should be emphasized that some people due to digital dexterity are able to achieve good oral hygiene more readily than others, but none seem to do a creditable job in less than 20 minutes a day. To make this time available, it is often suggested that oral hygiene procedures be performed while watching television or reading.

Dr. Sumter S. Arnim, writing about the frequency of oral hygiene practices, states (2, p. 310):

In my opinion, the frequency with which a given patient must carry out effective hygiene procedures in order to maintain gingival health is determined by the length of time required for formation of a community of microbial elements on and between the teeth and gums at those sites where disease begins. An effective oral hygiene procedure prevents the microbial aggregates associated with the initiation of periodontal disease from attaining the thickness, volume and population complexity required to produce the irritating waste products leading to an inflammatory response on the part of the gingiva.

Arnim suggests that an individual can experimentally determine when it is necessary for him to clean his teeth. By completely irradicating the plaque on the teeth and refraining from toothbrushing until the plaque reaches maturity and maximum volume and thickness, an individual can determine when he should use oral hygiene procedures. Arnim explains that the time interval may be as long as 10 days and as short as 3 days.

Arnim writes that most individuals desire to clean their teeth every day, and that some wish to practice oral hygiene more than once a day. He warns that it is easy to brush too much and clean too little.

Dr. John Green (23, p. 311) states:

...teeth should be cleaned thoroughly immediately after every intake of food. But, such an answer has been based in the age-old belief that 'a clean tooth does not decay' and the demonstration that acidogenic microorganisms can, given the proper substrate, lower the pH on the tooth surface in an incredibly short time to a level sufficient to decalcify tooth enamel. In this case, however, the emphasis is on gingival health and the question implies that the respondent should not consider the need for caries control, or the requirements for esthetics or control of breath odor.

.....thorough cleaning of the teeth once every 24 hours should be sufficient for maintaining gingival health if the procedures are, in every sense of the word, effective. If we assume that for oral hygiene procedures to be truly effective they must include the use of tape or floss in addition to brushing so that plaque and debris will be removed from all surfaces of the teeth, including the interproximal surfaces, then the once every 24 hours frequency may be unrealistic for some individuals. Most of us have been unsuccessful in getting some patients to clean the interproximal surfaces thoroughly every day because many people are unwilling to spend that much time on oral hygiene. However, interproximal cleaning probably is the most important part of the oral hygiene procedure and should be promoted vigorously.

An additional important consideration involves the previous concern of many dentists as to whether tissue destruction occurs because of the use of dental floss. A study involving the examination of 46 randomly chosen individuals who used dental floss twice

daily was conducted. Manhold, Manhold and Weisinger (35, p. 72)

state:

There was no evidence of any adverse effect from using the floss during the study. As a result, it was concluded that dental floss may be used routinely with safety.

Arnim (4, p. 267) reports that C. C. Bass developed teaching approaches of oral hygiene including the use of dental floss. Bass found that not only individuals with caries benefited from the program, but also those with periodontal disease showed marked improvement in gum tissue. Those with gum disease that used the program found that the tissues around their teeth improved with time, and that there was much less bleeding and movement of their teeth.

Arnim states (5, p. 8,9):

To date, the only reliable method known for removal of the cause of dental disease is thorough, complete and judicious personal oral hygiene. This means someone must clean all tooth surfaces effectively, often enough, to prevent development and maturation of the periodontal and carious microcosms if the preventive program is to be effective. In other words, bacterial plaques must be located, visualized and disrupted before they reach a thickness, volume and metabolic potential capable of energizing the mechanisms responsible for the creation of lesions known as "tooth decay" and "pyorrhea."

Arnim suggests that individuals use exposing tablets, soft toothbrushes, dental floss, and irrigators in order to keep their mouth free of disease causing plaque. He quotes from L. S. Parmly, a dentist publishing an article on oral hygiene in 1819, to emphasize

that the methods he recommends are not entirely new to dental science (5, p. 5):

A system for prevention of dental disease that really works. 'The first part to be used is the brush ... surfaces are completely freed from all extraneous matter. The second part is the dentifrice polisher for removing roughness, stains ... The third part is the waxed silken thread, which, though simple, is the most important. It is to be passed through the interstices of the teeth, between their necks and the arches of the gums, to dislodge that irritative matter which no brush can remove, and which is the real source of disease. With this apparatus thus regularly and daily used, the teeth and gums will be preserved free from disease...'

Arnim reports on case studies which were completed at the University of Texas Dental Branch. He explains how the individuals followed the above procedures of oral hygiene which resulted in saving some patient's teeth and the irradiation of gum disease in others. One case study involved a 16 year old girl who had 23 carious lesions out of a total of 24 teeth. A dentist advised her that she would have to have most of her teeth removed and replaced by dentures. She was revolted at this prospect and was advised to check with the University of Texas Dental Branch. The dentists at the University of Texas agreed to attempt to help her maintain most of her teeth. After she agreed to refrain from consuming her usual four candy bars and soda pop daily, she was put on a personal oral hygiene program. Arnim (6, p. 384) states:

The carious lesions were opened so she could clean her teeth properly. The carious lesions were opened so she could clean the microbial masses from the cavities. This was done to determine whether she was really interested in saving her teeth and whether she could stop the rampant carious process with simple oral hygiene measures. The changes in the teeth from active lesions to arrested lesions could be noted in a few weeks' time. The changes occurred fastest in those teeth that were easiest to keep clean Those lesions on posterior teeth which she could not clean thoroughly were restored when repeated examinations revealed microbial masses in the cavities. The pulps of two maxillary molars were diseased and these teeth were removed. Several arrested lesions were not restored for approximately one year. In Figure 4A slightly softened white spots can be seen which later remineralized and became hard Lesions shown in Figure 4 D became dark and hard during the first two months. All the lesions have now been restored. Since 1962 the patient has had only one new lesion and this developed on the occlusal surface of one of the maxillary molars.

Arnim also describes several other case studies which indicate the success of dental floss and other oral hygiene tools (6)(5)(3)(4).

The Flossing Technique

The flossing technique, in order to be completed properly and effectively, takes a certain amount of physical maturity and fine muscle coordination. Arnim (2), in a personal letter to the investigator of this study, suggests that various methods of manipulating the dental floss should be taught to students so that they can choose the one that best fits their dexterity. A Portland, Oregon dentist, Allen Pike suggests that although flossing may be difficult, it is not impossible

for a child to master. He feels that anyone with the coordination to ride a two wheel bicycle or button clothing should be able to use floss (43). O'Leary and Nabers describe a proper way to use and manipulate the floss and explain which fingers are necessary for the process. O'Leary and Nabers (41, p. 30) state:

Cut off a piece of floss about 3 feet long. Lightly wrap the ends of the floss around your middle fingers... To clean between the upper right back teeth pass the floss over your right thumb and the forefinger of your left hand. The thumb is to the outside of the teeth, and helps hold the cheek back. To clean between the upper left teeth pass the floss over your left thumb and the forefinger of your right hand. Now the left thumb is outside the teeth and the right forefinger is on the inside. To clean between all lower teeth hold the floss with the forefingers of both hands. You will be able to insert the floss gently between all lower teeth with the floss over your forefingers in this position.

O'Leary and Nabers (41, p. 31) describe additional recommended procedures for flossing:

1. The fingers controlling the floss should not be more than one-half inch apart.
2. Do not force the floss between the teeth. Insert it gently by sawing back and forth at the point where the teeth contact each other. Let it slide gently into place.
3. With both fingers move the floss up and down six times on the side of one tooth, and then repeat on the side of the other tooth until the surfaces are "squeaky" clean.
4. Go to the gum tissue with the floss, but not into the gum so as to cause discomfort, soreness, or bleeding.

5. When the floss becomes frayed or soiled, a turn from one middle finger to the other brings up a fresh section.
6. At first flossing may be awkward and slow, but continued practice will increase skill and effectiveness.

The above flossing program has also been described and printed in several state and national publications. Varieties of the flossing techniques vary according to fingers chosen for manipulating the floss between the teeth, the fingers used to stabilize the floss, and the number of strokes necessary to rid the interproximal area of plaque. There has not been any research conducted to determine which methods of flossing are more efficient.

Most flossing procedures, like the one O'Leary and Nabers explained, suggest that the index fingers and thumbs be incorporated into the technique. It might be assumed, therefore, that there should be a positive correlation between finger dexterity and flossing. An individual who has developed fine motor abilities, as long as other variables remain equal, should be able to learn the flossing technique in a shorter period of time than individuals who have undeveloped fine motor coordination.

Eye-Hand Coordination

There have been several studies conducted to determine the relationship between manual dexterity or eye-hand coordination and

the ability to complete physical as well as mental tasks. One research project that is significant to this study was conducted in 1970 by A. J. Roberts. His project used The Moore Eye-Hand Coordination Test and Frostig's Test I.- Eye Motor Coordination Test to estimate a subject's speed and accuracy in coordinating eye-hand activities.

Roberts used these tests to determine whether a kindergarten experience was beneficial to fine-muscle eye-hand coordination abilities. His results showed that first grade students with a kindergarten experience had better eye hand coordination than those without kindergarten experience. Roberts states (45, p. 51):

The main effect of kindergarten experience on fine-muscle eye-hand coordination was significant at the .025 level. This indicates that significant differences in fine-muscle eye-hand coordination, as measured by the EHCT, (Moore Eye Hand Coordination Test) do favor the children who have experienced kindergarten.

Roberts' study shows the significance of training and experience to the development of eye-hand coordination abilities. His study also suggested that girls, in general, develop eye-hand coordination skills at an earlier age than do boys.

Kephart (32) explains that eye-hand coordination is very important when training children to do complex tasks. He suggests that there is a direct relationship between those that exhibit learning problems in elementary classrooms and those that have poor eye-hand coordination.

Deach examined the abilities of children two through six years of age to complete skills of throwing, catching, kicking, striking and bouncing. Deach states (14, p. 287-288):

The major purpose was to discover if there were, at each age level, discrete patterns of performance for each of the skills studied and the course of development these patterns took when viewed in terms of recognized patterns of skillful adult performance.

The results showed that the boys out performed the girls, the boys being about a year ahead of the girls except in the multiple bounce test. High I.Q. seemed to have little influence upon performance. Deach concluded that genetic development of motor skills depended upon the physiological and physical maturation. The complexity of performance patterns increased in time, but individuals of the same age had wide ranging motor abilities.

Ebel (17) points out that motor abilities are predictive of performance of different stages of learning complex perceptual motor tasks. Individuals with a great deal of manual dexterity may more readily learn a specific skill such as the operation of a lathe. Moreover, individuals with a large number of highly developed basic skills can become proficient at a great variety of tasks. Dinkmeyer (15) also finds that an awareness of an individuals physical and mental development leads to a better idea of the approximate time to introduce educational tasks.

Kephart (32) believes that the development of motor coordination must take place if students are to develop writing skills. He observes that eye-hand coordination involves aiming or sighting behavior, and that a child will establish visual and perceptual control first while motor movements develop second.

Hilgard (29) studied the effects of training and practice of basic motor skills on the performance levels of children between the ages of 24 and 36 months. It was recognized through research, that improvement in motor performance is due to both maturation of innate growth factors and to the cumulative effects of experience. Experiments have shown that animals that have been prevented from learning a task, but have not stopped their maturation process, will be able to master the task quickly when they are exposed to it. Hilgard's study showed that children who had practiced buttoning, cutting with scissors, and climbing a ladder were no more advanced than the control group which did not practice these techniques. The experimental group was trained for 13 weeks as compared to a one week training period for the control group.

Hicks and Ralph (28) used the Porteus Diamond Maze to determine the effects of practice on eye-hand coordination in preschool aged children. The practice group had a total of 20 tracings with the preferred hand whereas the control group only completed the maze six times with the preferred hand. The investigators found

that the type of practice given the experimental group was not sufficient enough to get a significantly greater increase in skill than the increase found in the control group. There was a large increase in skill in both groups, but this was attributed to structural maturation and general practice.

There has been many attempts to describe the various components that characterize manipulatory movements. Hempel and Fleishman analyzed the results of 17 manipulative apparatus tests, six printed tests for manual dexterity, and 23 gross physical performance tests. The tetrachoric correlations of the tests were subject to Thurstone's centroid factor analysis. The results of the analysis indicated that the following four factors should be described for the manipulative apparatus tests and printed tests (27, p. 15):

1. Manual Dexterity - the ability to make coordinated and skillful arm-hand movements.
2. Finger Dexterity - the ability to skillfully manipulate objects with the fingers.
3. Arm-Hand Steadiness - the ability to perform precise, steady arm-hand movements, minimizing the factors of speed and strength.
4. Aiming - an eye-hand coordination ability that uses precise visual alignment and motor control to make accurate positioning movements.

Taking into consideration that eye-hand coordination involves a series of different skills, Frostig (19) developed a group of five tests which examined youngsters for five areas of visual perception.

These areas include:

1. Eye-hand coordination where a child is to draw straight and curved lines between increasingly narrow boundaries.
2. Figure-ground perception where the child discriminates between intersecting figures.
3. Perception of form constancy where a child detects squares and circles among other shapes on a page.
4. Perception of position in space where a child must detect a figure that is reversed or rotated in a sequence.
5. Perception of spatial relationships where a child is asked to link dots that would duplicate a given pattern.

After testing about 2,000 public school children, Frostig found that the five areas of visual perception developed independently of one another. There was a clear connection between the children's visual perceptual difficulties and their poor classroom adjustment at lower age levels. In the grades above the first elementary level, this high correlation between poor visual perception and poor classroom adjustment diminishes.

Some investigators have evaluated the information known concerning eye-hand coordination and have experimented with some tests to determine their value in estimating an individual's dexterity. As one example, Sloan (46), attempted to modify the Oseretsky Motor Development Scale so that the test items were more adaptable to

American subjects. The 36 item test is designed to test six to 14 year old youngsters for their respective motor developments. The recent Lincoln version of the Motor Development Scale has only tentative norms because of the relatively small sample used to determine them. The test is also limited in that research studies would have to spend several hours testing each individual subject. However, the items on the Motor Development Scale are fairly reliable and valid. In testing for reliability it was found that the subject's performance was fairly consistent through the entire scale. The test is considered valid in its attempt to sample a wide range of 'motor abilities' and in its quality of remaining internally consistent. A subject's score increases with age, which suggests that maturational or learning factors may be important considerations when determining test performance criteria. The scale was developed to determine the motor development of an individual and its relationship to intelligence and social adaptability of an individual. Sloan reported that Oseretsky found that the normal and above average intelligent children often display motor deficiency. The deficiency may be social and/or clinical in regard to implications. Sloan has been able to demonstrate a close relation between intelligence, motor behavior, and social maturity, and he believes that further research with the Lincoln-Oseretsky Motor Development Scale will help confirm his findings.

Eye-Hand Coordination and Intelligence

Cratty (12) states that it has been claimed that central nervous system functioning, including hearing, seeing, and thinking, can be enhanced in normal children if they were to practice simple motor tasks. He believes that this may be partially true, but that it is not always necessary for individuals to practice motor tasks in order to increase their intelligence and perception. Cratty (12, p. 8) states:

Evidence supporting this assumption is forthcoming from the laboratories of Abercrombie and her colleagues who have presented findings that children in late childhood and early teens who have lacked movement attributes from birth (cerebral palsey) perform on an equal level on tests of intelligence and perception with normal children.

However, every educator can attest to the fact that an I.Q. measure does not always correlate directly to classroom success, problem solving ability, creative thinking, and attributes about things intellectual. Certain measures of intellect are related to certain measures of motor ability; however, the two behaviors are not mutually inclusive.

Fretz reinforces Cratty's ideas in a study involving the intellectual visual perception and visual-motor performance of poorly coordinated boys. Fretz (18, p. 69) states:

While the boys performance and verbal I.Q. 's were well within the normal range (103-105) respectively, their Frostig and Bender test scores showed them to be an average of 19 and 13 months retarded, respectively. The differences suggested that 'intelligence' tests were quite independent of visual perception and visual motor tests, despite seeming overlap of tasks as cited above.

Another study conducted by the Van De Riet's (53) showed no significant differences in the visual motor performance between 45 under achieving and 45 normal achieving boys. Thus, Cratty, Fretz, and the Van De Riet's support the hypothesis that visual motor development is not directly correlated with intelligence or achievement in school.

Eye-Hand Coordination and Socioeconomic Status

Knights and Moule (33) used a Motor-Steadiness Battery including the Pencil Maze, Graduated Holes, and the Lafayette Pegboard to get normative data on 184 normal school pupils. The data was taken from the two schools with different socioeconomic status, but the conclusion drawn from a large number of t-tests was that social class is not an important variable affecting the performance of these three tests.

Cohen suggests that pre-school middle class children have more opportunities at home to develop motor coordination than do underprivileged youngsters and states (11, p. 434):

Such probable differences in early home experiences among the groups suggest a need for more developmental programs directed at involving the very young disadvantaged preschooler in situations which will offer him a greater opportunity to differentiate more fully and integrate aspects of the environment.

Gill, Herdtner and Lough (21) investigated perceptual differences in first grade Negro and white lower class and middle class children; and kindergarten, nursery, and first grade middle class children. They found that there was a significant difference between the classes in the ability to perform five of the six specific perceptual tasks. The only subtest where there was not a significant difference was the Visual-motor subtest. Thus, research indicates that socioeconomic status in relation to eye-hand coordination is not an important variable in determining visual-motor performance.

Sex Differences

Sex differences have been ancillary considerations in most of the studies involving eye-hand coordination tests. Gill, Herdtner and Lough (21) found that there was no significant difference between the sexes on their Visual-Motor Subtest. Findings by Moore (38), Stachnik (47) and Sloan (46), however, appear to substantiate the hypothesis that there is a significant difference between the sexes when the factor of speed is considered. The sex difference favors the girls. Therefore, it has not been conclusively established that sex is a significant variable in determining an individual's eye-hand coordination ability. Thus, sex is considered in this flossing investigation to determine its value as a variable.

Summary

Research indicates that plaque is a primary cause of dental disease, and that if plaque were to be completely removed from the teeth, periodontal disease and probably caries would eventually disappear. This research also suggests that dental floss is one of the most effective oral hygiene tools for removing interproximal plaque. However, few experimental studies have determined the precise effectiveness of dental floss and those that have been carried out have involved only small sample populations.

Studies have demonstrated that dental floss is more effective in removing interproximal plaque than toothpicks, water-jets, teflon yarn, rubber picks, and balsa picks.

Dental authorities generally agree that dental flossing practices should be carried out at least once every 24 hours. However, different individuals vary in their rate of plaque buildup and thus some people should floss more often than others.

It is not known what flossing technique is most effective, but it is generally agreed that it may be a combination of the techniques already devised. It is also believed that each individual may be just as effective by incorporating his own technique.

The literature cited in this study indicates that an individual's physical and perceptual maturation can predict his ability to perform complex perceptual motor tasks. An individual's maturation will be

dependent upon heredity as well as experience. However, if a person is not sufficiently mature to handle a particular motor task, training and experience will not greatly accelerate his learning capacities.

Researchers analyzed the results of eye-hand coordination tests and identified categories for the specific types of motor skills. Finger dexterity was described as the ability to skillfully manipulate objects with the fingers. Visual perception involves eye-hand coordination, figure-ground perception, perception of form constancy, perception of position and perception of spatial relationships.

The literature suggests that motor abilities in many cases are quite specific and that correlations between various motor skills show little relationship. It appears that physical maturation is a much more important criterion in determining eye-hand coordination than is intelligence, socioeconomic status or sex. When determining factors that affect the combination of both fine and gross motor skills, however, there may be a close relationship between intelligence, motor behavior and social maturity.

From the literature review it seems necessary to investigate the relationships between sex, eye-hand coordination, age and flossing abilities. Specifically it seems appropriate to determine whether age, sex and specific eye-hand coordination abilities will predict readiness for dental flossing education.

CHAPTER III

DESIGN OF THE STUDY

The purpose of this investigation was to determine the amount of time necessary to educate elementary grade students concerning the manipulatory skills involved in the use of dental floss so that dental authorities could more accurately predict when they should begin teaching students flossing techniques. A basic belief of the investigator was that the older students could be motivated to learn how to master the flossing technique in less time than do younger pupils. It was hypothesized that those with well developed eye-hand coordination skills could learn how to manipulate floss in less time than those with poor eye-hand coordination abilities. Furthermore, it was hypothesized that girls would do better than boys on the eye-hand coordination test and also would learn how to use dental floss more readily than boys.

The Experimental Design

The investigation proposed to determine the relationships between age, sex, eye-hand coordination, the time it took children to learn how to manipulate dental floss into all the interproximal spaces, and the time necessary to learn how to effectively clean the teeth. An effective flosser must have achieved at least a 50

percent reduction from the pretest rating on the Flossing Performance Index and a score of 13 or less on the same index.

The study was designed to compare the maturation and ability levels of four elementary age levels: eight, nine, ten and eleven year olds. It was also designed to show the relationship between the four age levels so that predictions could be made concerning the readiness of children to learn a dental flossing technique.

Using letters and subscripts designated by Gage (20) for the formulation of a design, the following notations described the type of design used in this investigation. Although Gage's subscripts are used, it should be made clear that this is not one of his designs, and the X represents the flossing instruction program rather than the independent variable.

<u>Age</u>	<u>Sex</u>					
8	M	0 ₁	X	0 ₂	0 ₃	0 ₄
8	F	0 ₁	X	0 ₂	0 ₃	0 ₄
9	M	0	X	0 ₂	0 ₃	0 ₄
9	F	0 ₁	X	0 ₂	0 ₃	0 ₄
10	M	0 ₁	X	0 ₂	0 ₃	0 ₄
10	F	0 ₁	X	0 ₂	0 ₃	0 ₄
11	M	0 ₁	X	0 ₂	0 ₃	0 ₄
11	F	0 ₁	X	0 ₂	0 ₃	0 ₄

where:

0₁ represents the question and observation pretest given to the eight, nine, ten and eleven year old children.

O_2 represents the degree of flossing skill as measured by time and the Direct Observation Evaluation.

O_3 represents the degree of flossing skill as measured by the Flossing Performance Index.

O_4 represents the student's time on the Moore Eye-Hand Coordination Test.

X represents the flossing instruction program given to the eight, nine, ten and eleven year old children.

Eye-hand coordination, age and sex are the independent variables.

Selected Instruments

Pretest Questions

The following questions were asked just previous to the administration of the eye-hand coordination test in order to determine whether a student could participate in this study. If the individual had used floss before, then he was eliminated from the study population. The questions were:

1. Do you know what dental floss is?
2. Have you ever seen this material before? (Dental floss is shown to the student.)
3. Do you know how to use the floss?
4. Show me how you would manipulate the floss in between the teeth.

Direct Observation Evaluation

This test involves the rating of a student according to his ability to scrape the mesial and distal portions of each tooth within a predetermined amount of time. Each of the interproximal (between the teeth) spaces and the distal sides of the last back molars were assigned a value of one. Necessary times were set up for the completion of flossing and these times depended upon the number of interproximal spaces each student had. The following numbers of interproximal spaces were assigned the following corresponding necessary completion times:

30 and 31	9 minutes
28 and 29	8 minutes 30 seconds
26 and 27	8 minutes
24 and 25	7 minutes 30 seconds
22 and 23	7 minutes
20 and 21	6 minutes 30 seconds
18 and 19	6 minutes

Thus, according to the number of interproximal spaces, established by the hygienist during the pretest, a student would have a certain amount of time to complete the Direct Observation Evaluation. For example, if he had 26 interproximal spaces, he would be allowed only eight minutes to complete the test. If he finished before the eight minutes were up, he then could go back over any teeth he wished to in order to make sure that he had flossed effectively. If all the interproximal spaces were penetrated by the floss in the corresponding

required amount of time, the student had passed the Direct Observation Evaluation.

Flossing Performance Index

The purpose of this study was to measure flossing ability and thus only the mesial and distal portions of specified teeth were measured. The time necessary for the oral hygiene examination was kept to a minimum. The oral hygiene examination proceeded in a set routine, i.e., calling off the teeth in their numbered order, and always giving the distal score first. The examiner practiced classifying according to this oral hygiene index before entering the study. Also, it was found that accuracy increased with fewer pauses and more rapid classification.

The Flossing Performance Index was administered in a similar fashion to the Patient Hygiene Performance Index as described in Ramirez' study (44). However, instead of using erythrosin dye, a fluorescein sodium stain was used to disclose the plaque. A student was administered two drops of a fluorescein sodium solution and asked to use his tongue to make sure all the teeth became coated with the material. Then each student was asked to take one mouthful of water, swish it around the teeth, and deposit it back in the paper cup. An instrument known as the Plak-Lite has to be used to disclose the stained plaque. The Plak-Lite, manufactured by the International Pharmaceutical Corporation, transmits a 5000 angstrom

light source which activates the disclosing solution so that the plaque fluoresces brilliantly.

The portions of the teeth surveyed included only a one and one-half millimeter wide area on each distal and mesial side of each tooth. To rate the amount of plaque which had built up in these areas, six predetermined teeth were checked in a particular order and scores were recorded on special forms. The surfaces included:

- #3 - mesial and distal surfaces, viewed from the buccal,
upper right first molar.
- #8 - mesial and distal surfaces, viewed from the buccal,
upper right central incisor.
- #14 - mesial and distal surfaces, viewed from the buccal,
upper left first molar.
- #19 - mesial and distal surfaces, viewed from the lingual,
lower left first molar.
- #24 - mesial and distal surfaces, viewed from the buccal,
lower left central incisor.
- #30 - mesial and distal surfaces, viewed from the lingual,
lower right first molar.

If a designated tooth is not a fully erupted permanent tooth, has a full crown restoration, has surfaces reduced in height by caries or trauma, or is missing, a substitution was made in the order listed:

- For tooth #3 - tooth a - Upper right second deciduous molar
tooth b - Upper right first deciduous molar
- For tooth #8 - tooth e - Upper right deciduous central incisor
tooth 9 - Upper left central incisor
tooth f - Upper left deciduous central incisor
tooth d - Upper right deciduous lateral incisor
tooth g - Upper left deciduous lateral incisor
tooth 7 - Upper right cuspid
- For tooth #14- tooth j - Upper left second deciduous molar
tooth i - Upper left first deciduous molar
- For tooth #24- tooth o - Lower left deciduous central incisor
tooth #25- Lower right central incisor
tooth p - Lower right deciduous central incisor
tooth n - Lower left deciduous lateral incisor
tooth q - Lower right deciduous lateral incisor
- For tooth #30- tooth t - Lower right second deciduous molar
tooth s - Lower right first deciduous molar

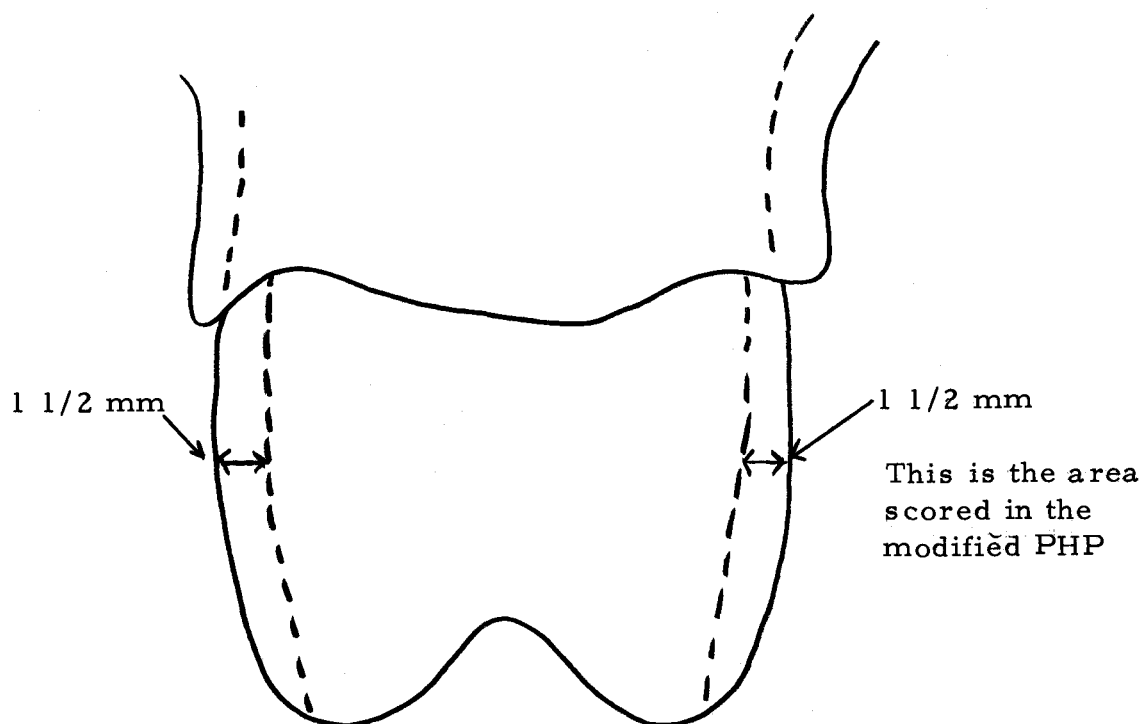
All distal and mesial surfaces of the teeth examined were scored by a trained hygienist as follows (49):

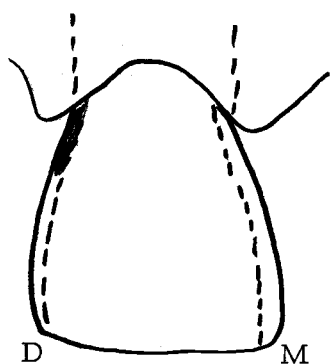
- 0 - no visible plaque present
- 1 - specks of plaque present
- 2 - at least one-half the area is covered with plaque
- 3 - the entire area is covered with plaque

Thus, the maximum score for each tooth is six since there are two surfaces rated per tooth. Also, the maximum rating for all six teeth tested would then be 36. In order for a student to be released from the study and to be labeled an effective flosser by this test,

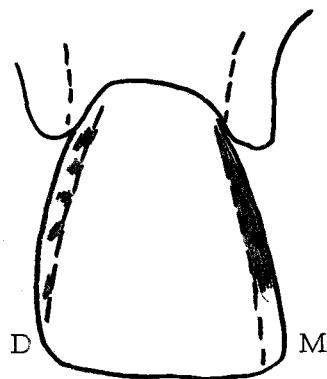
he or she had to achieve at least a 50 percent reduction from the pre-test rating on the Flossing Performance Index, and a score of 13 or less on the same index. The following diagrams illustrate how the Flossing Performance Index was scored:

- 0 - no visible plaque
- 1 - specks of plaque visible
- 2 - at least one-half the area is covered with plaque
- 3 - the entire area is covered with plaque

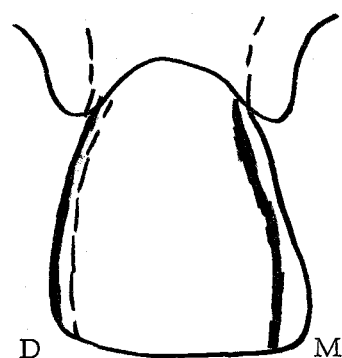




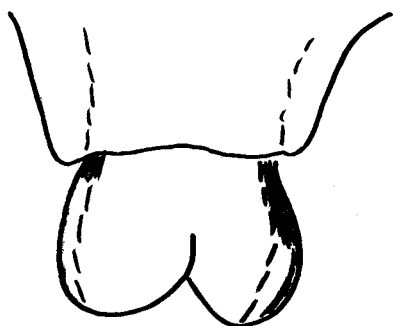
Distal 1
Mesial 0



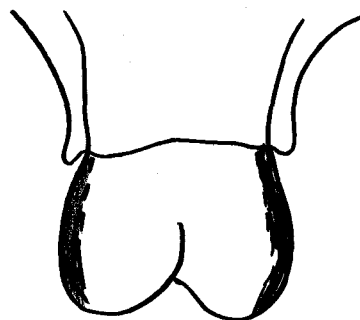
Distal 1
Mesial 2



Distal 2
Mesial 2
(failed to wrap floss
around - just got
edge)



Distal 1
Mesial 2



Distal 3
Mesial 3

Dotted line marks 1 1/2 mm. mark

Moore Eye-Hand Coordination Test (MEHCT)

The Moore Eye-Hand Coordination Test, developed and manufactured by Joseph E. Moore and Associates, was used to determine a student's ability to coordinate the eye, finger and thumb in a task developed to measure the speed and accuracy of placing marbles in predetermined positions (38).

The test consists of a flat, rectangular, fiberboard box which consists of four marble retaining compartments and four long rectangular compartments. The four marble retaining compartments each hold eight marbles to be used during the test. The long rectangular compartments each have eight equally spaced holes in which the marbles are placed as the student performs the test. The score for the MEHCT is the time it takes an individual to place all the marbles into the 32 holes. Each individual performs the test three times and the final score is the sum of the times on the three separate trials.

Selection of the Sample

Personal communication between the investigator and dentists throughout the United States indicates that most people believe that students in second grade and other lower age groups do not have the eye-hand coordination to learn how to use dental floss effectively. Many dentists even suggest that most fifth graders do not have the manual dexterity to learn how to floss effectively. However, a task

force of dentists in San Antonio, Texas, found their flossing and brushing program to be effective at all age levels, K-6. They did suggest that some form of flossing aid might be appropriate for K-2 grades because of limited motor development. They state (46, p. 3):

In one test group, 97 percent of the students showed improvement in gum tissue health and the percentage of 'poor' mouth hygiene students changed from 81 percent to 16 percent after ten weeks of the program. In the two years, more than 1100 children participated in the dental disease prevention program.

Although primarily designed for the elementary levels, the program can be used at all grade levels. In grades K-2, modified use of dental floss may be indicated due to the limited manual dexterity.

Because of the San Antonio study, the second grade was chosen as a starting point for the flossing program since dentists have found difficulty teaching the flossing technique at this age level. Also, since the instruction of the technique will not cover more than two weeks time, it is doubtful whether many students younger than age seven could learn how to floss in this short period.

It was decided that the fifth grade would be the best age level to terminate the investigation. The University of Oregon Dental School's Hygiene Department is administering a flossing program now to the fifth grade classes in some of the Portland schools, and have found the program to be successful. The study in San Antonio, Texas shows that fifth as well as Kindergarten through fourth grade children can learn how to floss. Thus, the investigation will be

limited to the second through the fifth elementary grades for predicting the optimum starting time to begin teaching the flossing technique.

Lebanon, Oregon was established as the site for the investigation since the schools could meet the above criteria, and thus supply the study with sufficient students at the second through fifth grade levels.

Lebanon was also chosen as the site of the flossing study due to its accessibility, varied socioeconomic situation, lack of fluoride in the water, and drastic need for preventive dental care. Two elementary schools, Santiam and Queen Anne, were selected for the study. These two schools were chosen because the health coordinator for the Lebanon Public Schools felt that they most nearly approximated a cross section of the Lebanon population. Both schools are within a mile of downtown Lebanon, and both schools have students from the suburban residential area as well as the country. The population of Lebanon is about 7,540 although the rural area surrounding Lebanon contributes another 7,000 to the district population. The town of Lebanon is made up of businesses, schools, and paper and lumber industries.

Santiam and Queen Anne's Schools were also chosen because they each had sufficient numbers of students at the eight, nine, ten and eleven year old age levels. The second and fourth grade

classes were arbitrarily assigned to Santiam School and the third and fifth grade classes were likewise assigned to Queen Anne's School. When these assignments were made, information concerning school student representation and teachers at the respective levels, was unknown.

All second and all fourth grade students in Santiam School were selected to participate in the study. One third and one fifth grade class were randomly selected from the possible two third and two fifth grade classes at Queen Anne's School. All of the ten year olds and all of the nine year old males were chosen from the extra third grade class. All of the eleven year olds from the extra fifth grade class also participated in the study.

The students in the study were administered the Moore Eye-Hand Coordination Test and their scores were compared with standardized scores for this test by using a Chi-Square Goodness of Fit Test. It was determined that the eight year olds from the study population satisfactorily fit the standardized population, and that it was questionable whether the nine and ten year olds from both the standardized population and the study population were the same. Also, the Chi Square Test indicated that the eleven year old study group absolutely did not fit the standardized population. Since the standardized and sample population scores could not be considered as coming from the same group, the Moore Eye-Hand Coordination

scores of the sample populations in the flossing investigation are recorded in the Appendix A, B, C and D, to help further identify the elementary students involved in the study.

Instruction Procedures

Two independent Lebanon schools were involved in the flossing project and thus each school had to be given separate oral hygiene instruction. A general oral hygiene program involving a lecture-slide presentation, demonstrations, and pupil centered investigations was administered. The purpose of the program was to explain to the students why they were going to learn how to use dental floss, and hopefully motivate them to want to use it. Motivation, however, was not a problem nor a variable in the flossing study. During flossing instruction, which did not take place during the general oral hygiene program, the students were constantly supervised and encouraged to floss. Also students were requested not to floss or brush their teeth at home during the study, except during weekends or holidays. A letter was sent home to the parents requesting their cooperation in letting their children go without brushing for two weeks. Thus, because students were not flossing independently of supervision and instruction, motivation was considered not to be an important variable.

The general oral hygiene program was administered to both the second and fourth grade classes on Monday, January 17 and to both the third and fifth grade classes on Wednesday, February 23. Each program was identical to the other and lasted for two hours. An outline of the presentation was made and posted along the walls of the classrooms, so that the order of the program remained the same. Also, a cassette recording was made of the first presentation to help the instructor present an identical program.

Fifteen students enrolled in the Dental Assistant Program at Linn Benton Community College were used as aids to help with the instruction. All of the students had been through intensive training on the use of dental floss at the College. The investigator of this study directed all of the oral hygiene instruction, while the student dental assistants followed his instructions.

Group Flossing Instruction Program

The flossing instruction program began on the afternoons of January 17 at Santiam School and February 23 at Queen Anne's School. The first afternoon instruction sessions lasted for 50 minutes and were administered to each grade level separately. Because of the size of the third grade class an extra instructor helped with the flossing program and the class was given ten more minutes of instruction. There were 28 second graders in the first session, 32

fourth graders in the second session, 41 third graders in the third session and 32 fifth graders in the last session. If the time of instruction were computed on an individual basis, each student received approximately 25 minutes of personal instruction.

Four children aged seven and two aged twelve years were involved in the instruction sessions, but were not included in the statistical analysis. Also, eight students were eliminated from the study due to incessant absences, because they had moved from the school district, or because they had previously been acquainted with the flossing technique. Thus, the final sample population totalled 117 elementary students.

The students were each given some dental floss (POH-Oral Health Products, Inc., Tulsa, Oklahoma), a 6" table mirror, and a typodont (manufactured by Block Drug Company) or a model of the human denture. The typodont or denture model was constructed by making a template of the pattern of teeth in a lower denture. A $\frac{3}{8}$ inch drill was used to make the pattern in a piece of thin veneer. Then $\frac{3}{4}$ inch thick wood was cut into approximately five inch squares. The template was placed over the wood and $\frac{1}{2}$ inch holes were drilled into the prepared squares. One and $\frac{1}{2}$ inch long pieces of three-quarter inch dowel, to represent teeth, were then hammered into the holes in the prepared square to form a denture model.

Slides taken from the photographs on flossing procedure on pages 17, 18 and 19 in the pamphlet "Clean Teeth Brighten Your Smile" were used to show some proper ways to hold and manipulate the floss (57). Students were asked to follow the instructor or the student dental assistants while they explained and demonstrated how to wrap the floss on the middle finger of each hand. The students were then instructed according to the procedures outlined in Chapter II as described by O'Leary and Nabers (41). Once the students learned how to wrap the floss around their middle fingers and were able to manipulate the floss with their index fingers they were asked to try flossing around the denture model. While practicing the flossing procedures during the first session and throughout the following two weeks the children were constantly reminded to: 1) keep the index fingers as straight as possible, 2) keep the last three fingers of each hand completely folded into the palm, and 3) keep the floss as taught as possible against the index fingers.

Once the students had finished practicing with the denture models the student dental assistants were asked to allow the children to view their teeth with the Plak-Lites. Then the students were administered two drops of the sodium fluorescein dye, given a cup of water to rinse with, and again asked to observe their teeth by looking in the table mirror. Finally the children were allowed to use the Plak-Lites to observe the plaque formation on their teeth. The pupils were asked

to determine where most of the plaque was accumulating and whether the interproximal spaces seem to have quite a bit of plaque present. The students were then given a fresh piece of dental floss and asked to see how well they could clean between the teeth. The student dental assistants worked from one individual to another helping them manipulate the floss between the teeth. They also instructed the children by showing them how they, as dental assistants, would floss their own teeth, and also the teeth of the child. This terminated the first group flossing instruction session and also terminated the first day of the program.

The following ten days involved both individualized and group flossing instruction. Six or seven students at a time were sent down to our dental lab rooms, situated near each school's main office, for their individualized instruction. The necessary lab facilities consisted of chairs, sinks, outlets, paper towels, shelves, mirrors, floss, Plak-Lites, timers, and paper cups. Students were arbitrarily assigned to particular positions where student dental assistants were stationed. The student dental assistants were asked not to instruct any pupil more than one day during the study.

The children were immediately given a piece of dental floss and asked to begin practicing manipulating the floss on the typodont or denture model. The instructors recorded the child's name, and from the pretest records, determined the number of interproximal

spaces and time allowed to finish the flossing test, and recorded this information on the data sheet. The instructors then spent a total of three minutes helping the children with their own personal problems associated with the use of dental floss. When each student had been instructed three minutes, the director of the program explained the flossing test and what they had to do to pass it. The director then gave the signal for everyone to get their dental floss ready and for the student dental assistants to set the timers.

While the children were involved in the flossing test, the student dental assistants, the hygienist and the director were looking over the children's shoulders into a mirror. They instructed the children on how they might maneuver the floss more effectively and how they might manipulate it around the teeth so that the floss cleaned as much of the tooth surface as possible. The instructors were limited to verbalizing their communication, and were not permitted to help the child physically manipulate the floss. While the children were involved in flossing, the instructors made notations on a data sheet which identified the problems children had while attempting the technique.

When the child completed flossing all of the interproximal areas the time elapsed was recorded, and if the individual had more time, according to the set timer, he was allowed to go back and refloss any area that he thought he had missed. When a student's time was up he was requested to stop and to throw away his used floss. The

time used and the number of interproximal spaces flossed were recorded in the appropriate spaces on the data sheet. The students were then required to expose the plaque remaining on their teeth by applying sodium fluorescein dye and using a Plak-Lite to see the areas that they had failed to clean.

Each student was given a fresh piece of dental floss and asked to again floss around the typodont or denture model while the instructors observed, noted and commented on particular problems. While this three minute additional flossing instruction took place, the students were examined individually by the hygienist for their Flossing Performance Index. Once they had completed the three minute instruction session and had been examined for flossing effectiveness they were sent back to their classrooms.

Group Instruction During Testing Days

After all students in the flossing program had been examined on each of the testing days, the six instructors, including the hygienist and program director, administered a 15 minute group lesson on dental flossing. The same material given in the 50 minute flossing lesson was reviewed in these late afternoon group sessions. Again, each class of students was taught independently from each of the other classes. Additional information and advanced training on flossing procedures was presented each day the program went on. Students were taught that it was possible to wrap the floss on any of the last three

fingers and were asked to try these techniques. It was explained how they could obtain a fresh piece of floss between their index fingers. They were shown how to unwrap the floss on one of their fingers in order to expose fresh floss and then how to wrap up the old used floss on the other finger. Again they were given time to try these procedures.

The 15 minute group lessons were administered to all students involved in the program regardless of whether or not they had passed the flossing tests. However, when there were only five or six students left at any particular grade level, they then were brought back to the lab to be instructed as a group. When the students were brought into the lab, they were given the same amount of attention they had received in the larger groups.

Summary

Each student had 50 minutes of group flossing instruction on the first day of the program. At this time 16 or 17 instructors helped teach each grade level separately, and thus there was approximately one instructor for every two children. During all group instruction sessions there was an extreme effort made to give every child an equal amount of instruction. During the remaining ten days each student received approximately 13 minutes per day of direct personal instruction until he or she passed both the Direct

Observation Evaluation and the Flossing Performance Index tests.

During the last ten days each student received 15 minutes per day of group flossing instruction from six instructors. Again, each grade level was separately taught the dental flossing techniques. The instructor - pupil ratio for the 15 minute group sessions was approximately one to six.

CHAPTER IV

ANALYSIS OF RESULTS

Findings of the Study

This study proposed to investigate the relationship between age, sex, eye-hand coordination (X_1), the time required for students to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1), and the ability of the student to effectively clean the interproximal surfaces of his teeth with dental floss (Y_2). The first three hypotheses in this investigation, analyzing the above relationships, were tested with the F-test, an analysis of variance.

Hypothesis four was formulated to determine how variables of age, sex and eye-hand coordination could be used as predictors of flossing manipulation time (Y_1) and the time it takes individuals to become effective flossers (Y_2). A linear regression analysis was run to get a rough estimate of the variables' predicting qualities.

Null hypothesis five was an attempt to determine whether there were significant differences between males and females in the various age groups tested on the scores of eye-hand coordination (X_1), flossing-manipulation (Y_1) and flossing effectiveness (Y_2). Finally, null hypothesis six was tested to determine whether there were significant differences amongst the age groups in their scores on eye-hand

coordination (X_1), flossing manipulation (Y_1) and flossing effectiveness (Y_2). T-tests were used to determine significant differences in both null hypotheses five and six.

To provide a more complete background of the sample population and the statistics gathered concerning such population analyzed in this study, tables will be included in Appendixes A, B, C and D. Appendixes A, B, C, and D describe data for eight, nine, ten and eleven year olds respectively. Data included are eye-hand coordination scores, sex, age, number of days it took students to learn how to manipulate dental floss between the teeth and number of days it took students to learn how to effectively floss their teeth. Standard deviations and means for the above data are also included. Appendixes A, B, C and D indicate that all of the eight, nine, ten and eleven year olds in this study learned to effectively clean their teeth with dental floss within ten, seven, six and five days, respectively.

Tests of Hypotheses

Hypothesis I

Hypothesis I: There is a significant relationship between age and eye-hand coordination (X_1), the time it takes an individual to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1), and the time it takes an individual to learn how to effectively clean the interproximal surfaces of the teeth with dental floss (Y_2).

Table 1 presents the F statistics for the variable of age in respect to the time for a student to complete X_1 , Y_1 , and Y_2 .

Table 1 indicates that all of the F scores relating to age, are significant at the .01 level. F scores, of 28.50, age in relation to X_1 , 13.14, age in relation to Y_1 , and 18.56, age in relation to Y_2 , are reported. Thus, it can be concluded that there is a significant relationship between age and X_1 , Y_1 and Y_2 . Hypothesis I is, therefore, not rejected.

TABLE 1. Analysis of Variance Tables for the Regression of Eye-Hand Coordination (X_1), Flossing Manipulation Skill (Y_1), and Flossing Effectiveness (Y_2) on the variable of Age.

Source of Variance	SS	DF	MS	F
X_1 on Age	9685.33	3	3228.44	28.50**
Residual	13213.16	113	117.02	
Total	22898.49	116	197.40	
Y_1 on Age	89.85	3	29.95	13.14**
Residual	257.40	113	2.28	
Total	347.25	116	2.99	
Y_2 on Age	137.06	3	45.69	18.56**
Residual	278.40	113	2.46	
Total	415.45	116	3.58	

**Significant at the .01 level.

SS-Sums of Squares

DF-Degrees of Freedom

MS-Mean Squares

F-Test of Variance

Hypothesis II

Hypothesis II: There is a significant relationship between sex and eye-hand coordination (X_1), the time it takes a student to learn how to manipulate dental floss between all of the interproximal surfaces

(Y_1), and the time it takes an individual to learn how to effectively clean the interproximal surfaces of the teeth with dental floss (Y_2).

Table 2 presents the F-statistics for the variable of sex in respect to the ability of student to complete X_1 , Y_1 , and Y_2 . F scores of .37, sex in relation to X_1 , 3.66, sex in relation to Y_1 , and 1.34, sex in relation to Y_2 , are reported. The preceeding F scores were not significant at the .05 level of significance. Thus, it can be concluded that there is not a significant relationship between sex and X_1 , Y_1 , and Y_2 . Hypothesis II is therefore rejected.

TABLE 2. Analysis of Variance Tables for the Regression of Eye-Hand Coordination (X_1), Flossing Manipulation Skill (Y_2) Flossing Effectiveness (Y_2) on the Variable of Sex.

Source of Variance	SS	DF	MS	F
X_1 on Sex	75.27	1	75.27	.37
Residual	22823.22	115	198.46	
Total	22898.49	116	197.40	
Y_1 on Sex	10.71	1	10.71	3.66
Residual	336.54	115	2.93	
Total	347.25	116	2.99	
Y_2 on Sex	4.79	1	4.79	1.34
Residual	410.66	115	3.57	
Total	115.45	116	3.58	

SS - Sums of Squares

DF- Degrees of Freedom

MS- Mean Squares

F- Test of Variance

Hypothesis III

Hypothesis III: There is a significant relationship between eye-hand coordination and the time it takes a student to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1), and the time it takes an individual to learn how to effectively clean the interproximal surfaces of the teeth with dental floss (Y_2).

Table 3 also presents the F statistics for the variance of eye-hand coordination in respect to the ability of a student to complete Y_1 and Y_2 . F scores of 19.79, eye-hand coordination in relation to Y_1 , and 32.36, eye-hand coordination in relation to Y_2 , are reported. The preceeding F scores were all significant at the .01 level of significance. Thus, it can be concluded that there is a significant relationship between eye-hand coordination and Y_1 and Y_2 . Hypothesis III is, therefore, not rejected.

TABLE 3. Analysis of Variance Tables for the Regression of Flossing Manipulation Skill (Y_1) and Flossing Effectiveness (Y_2) on the Variable of Eye-Hand Coordination.

Source of Variance	SS	DF	MS	F
Y_1 on Eye-Hand Coordination	51.07	1	51.07	19.79**
Residual	296.18	115	2.58	
Total	347.25	116	2.99	
Y_2 on Eye-Hand Coordination	91.27	1	91.77	32.36**
Residual	324.19	115	2.81	
Total	415.45	116	3.58	

** Significant at the .01 level.

SS-Sums of Squares

DF-Degrees of Freedom

MS-Mean Squares

F-Test of Variance

Table 4 presents the regression of eye-hand coordination (X_1), flossing manipulation skill (Y_1), and flossing effectiveness (Y_2) on age within the male and female groups in the total study population. The F statistics included help determine whether or not there are some significant differences between the eight, nine, ten, and eleven year old age levels within the male or female groups. F scores of 14.95, males in relation to Y_1 , 3.96, females in relation to Y_1 , 12.65, males in relation to Y_2 , 8.26, females in relation to Y_2 , 16.41, males in relation to X_1 , and 15.35, females in relation to X_1 , were all significant at the .05 level. Thus, it can be concluded that there is a significant difference somewhere for the males and also for the females at the eight, nine, ten and eleven year old age levels in relation to X_1 , Y_1 , and Y_2 .

Hypothesis IV

Hypothesis IV: Age, sex, and eye-hand coordination scores, separately or in combination, are good predictors of flossing manipulation skill (Y_1) and flossing effectiveness (Y_2).

Hypothesis IV was tested by running a linear regression analysis of the data. This statistical analysis uses the variables of eye-hand coordination, sex and age, individually or as a group, to determine an equation for approximating Y_1 and Y_2 . The R squared statistic is a rough estimate of how well this equation does predict the time it takes an individual to learn how to manipulate dental floss between

TABLE 4. Regressions for X_1 , Y_1 , and Y_2 on Age within Male and Female Groups.

Source of Variance	SS	DF	MS	F
X_1 - Males	4563.38	3	1521.13	16.41**
Error	5284.38	57	92.71	
Total	9847.77	60		
X_1 - Females	6093.27	3	2031.09	15.35**
Error	6882.19	52	132.35	
Total	12975.45	55		
Y_1 - Males	99.94	3	33.31	14.95**
Error	127.04	57	2.23	
Total	226.98	60		
Y_1 - Females	20.38	3	6.79	3.96*
Error	89.17	52	1.71	
Total	109.55			
Y_2 - Males	97.43	3	32.48	12.65**
Error	146.37	57	2.57	
Total	243.80	60		
Y_2 - Females	53.86	3	17.95	8.26**
Error	113.00	52	2.17	
Total	166.86	58		

* Significant at the .05 level.
 ** Significant at the .01 level.
 SS-Sums of Squares
 DF-Degrees of Freedom

MS - Mean Squares
 F - Test of Variance

all of the interproximal surfaces (Y_1), and the time it takes an individual to learn how to effectively clean his teeth with dental floss (Y_2). The proportion of total variation in (Y_1) or (Y_2) caused by each variable included in the model is measured by R squared. R squared values corresponding to the individual variables as well as possible combinations of variables are reported in Table 5.

TABLE 5. Summary of R Squared Values of a Linear Regression Analysis of Variables Age, Sex and Eye-Hand Coordination and their Ability to Predict Y_1 and Y_2 .

Test	Variables Entered	R squared
Y_1	Age	.259
	Eye-Hand Coordination	.147
	Sex	.031
	Age + Eye-Hand Coordination	.317
	All Variables	.320
Y_2	Age	.330
	Eye-Hand Coordination	.220
	Sex	.012
	Age + Eye-Hand Coordination	.363
	All Variables	.378

R squared values of .320 for Y_1 and .378 for Y_2 in Table 5 indicates that the best possible predictor of Y_1 and Y_2 would be the combination of the three variables sex, age, and eye-hand coordination. Age by itself contributed most to the equation's predicting qualities as

demonstrated by R squared values of .259 for Y_1 and .330 for Y_2 . Sex alone, on the other hand, contributed the least as indicated by R squared values of .031 for Y_1 and .012 for Y_2 . R squared values of .147 for Y_1 and .220 for Y_2 also suggest that eye-hand coordination makes a major contribution to the equation's predicting qualities. Finally, R squared values of .317 for Y_1 and .363 for Y_2 indicate that age and eye-hand coordination will predict Y_1 and Y_2 with almost as much accuracy as will all three variables used together. However, as reported in Table 7, all R squared values are below .500, suggesting that all of the variables, separately or in combination, will not predict Y_1 or Y_2 with any degree of confidence. Thus, we must reject the hypothesis that the variables of age, sex and eye-hand coordination are good predictors of the time it takes an individual to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1) and the time it takes an individual to learn how to effectively clean his teeth with dental floss (Y_2).

Hypothesis V

Hypothesis V: There is no significant difference between males and females at the eight, nine, ten and eleven year old age levels in regards to the factors X_1 , Y_1 and Y_2 .

Although there was not a significant correlation between sex and X_1 , Y_1 and Y_2 , as revealed by Table 2, there were some sex differences that the author considered important to note. Thus, a

comparison of males and females was made concerning their differences in regards to X_1 , Y_1 and Y_2 . Table 6 summarizes the t-test scores for the comparison of sex in the four age groups in relation to the time it takes an individual to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1).

TABLE 6. Summary of t-test Scores for the Comparison of Means of Males and Females at the Four Age Levels in Regards to Y_1 .

Source	8 years	9 years	10 years	11 years
	Mean Values in Days			
Males	5.58	2.63	2.36	2.21
Females	3.25	2.37	2.15	1.54
t	3.25**	.49	.46	1.70

** Significant at the .01 level.

The t-scores, .49, .46, and 1.70, show that there are no significant differences between the sexes in reference to Y_1 at the nine, ten and eleven year old age levels, respectively. However, there was a significant difference, as indicated by a t score of 3.25, at the .01 level, between the eight year old males and females.

Table 7 summarizes the t-scores for the comparison of sex in the four age groups in relation to the time it takes an individual to learn how to effectively clean his teeth with dental floss (Y_2). The t-test results in Table 7, 1.72, .69, and .72, indicate that there are no significant differences between the sexes in regards to Y_2 at the eight, nine and ten year old levels, respectively.

TABLE 7. Summary of T-test Scores for the Comparison of Means of Males and Females at the Four Age Levels in Regards to Y_2 .

Source	8 years	9 years	10 years	11 years
Mean Values in Days				
Males	6.75	3.81	4.00	3.26
Females	5.31	3.44	3.61	2.63
t	1.72	.69	.72	2.05*

* Significant at the .05 level.

However, a 2.05 t-test score points out that there was a significant difference, at the .05 level, for the eleven year old age group. It is also noted that there was very little difference between the ten year olds and nine year old age levels in respect to their ability to effectively learn how to floss their teeth. The ten year olds completed the flossing tests in an average of 3.8 days while all of the nine year olds passed the tests within an average of 3.62 days.

Table 8 summarizes the t-scores for the comparison of sex in the four age groups in relation to eye-hand coordination ability (X_1). The t-tests results, .12, 2.45, and -0.13, comparing the

TABLE 8. Summary of T-tests for Comparison of Means for Sex in the Four Age Groups in Regards to X_1 .

Sources	8 years	9 years	10 years	11 years
Mean Values in Days				
Males	130.99	122.59	116.44	107.32
Females	130.40	113.11	116.96	100.50
t	.12	2.45	-0.13	2.56*

* Significant at the .05 level.

sexes for their ability on the Moore Eye-Hand Coordination Test (X_1), showed no significant differences at age levels eight, nine and ten years, respectively, but a score of 2.56 did indicate that there was a significant difference, at the .05 level, at age eleven. The results from Tables 7 and 8 also seem to indicate that there is a strong correlation between Y_2 and X_1 for the eleven year old males and females.

The results of the comparison of males and females for sex at the four age levels in regards to X_1 , Y_1 and Y_2 indicate that sex was an important variable at the eight year old age level for Y_1 , and at the eleven year old age level for X_1 and Y_2 . However, when determining the significance of sex as a variable in all of the four age groups together, it is found to be insignificant at the .01 or .05 levels. Thus, hypothesis V is rejected for eight year olds on Y_1 , and for eleven year olds on X_1 and Y_2 .

Hypothesis VI

Hypothesis VI: There is no significant differences between any of the four age groups, eight, nine, ten and eleven year olds, in reference to X_1 , Y_1 , and Y_2 .

The F-test scores in Tables 1 and 3 suggest that there is a good correlation between age and eye-hand coordination and Y_1 and Y_2 . Therefore, a comparison of the mean X_1 , Y_1 and Y_2 scores amongst the four age groups should reveal some significant findings. Table 9 is a summary of a comparison of the mean scores using

t-tests, amongst age groups on eye-hand coordination (X_1), the time it takes an individual to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1), and the time it takes an individual to learn how to effectively clean his teeth with dental floss (Y_2). The mean scores were compared within the eight and nine, nine and ten, ten and eleven, nine and eleven, and eight and ten year old age groups.

TABLE 9. Summary of T-tests for the Comparison of Means Amongst Age Groups on X_1 , Y_1 and Y_2 .

Source (X_1)	Mean Values Seconds	t
8 years	130.69	4.05**
9 years	117.85	
9 years	117.85	.40
10 years	116.65	
10 years	116.65	4.92**
11 years	103.91	
Source (Y_1)	Mean Values Days	t
8 years	4.41	3.72**
9 years	2.50	
9 years	2.50	.71
10 years	2.26	

TABLE 9. (Continued).

Source (Y_1)	Mean Values Days	t
10 years	2.26	1.01
11 years	1.88	
9 years	2.50	1.67
11 years	1.88	
8 years	4.41	4.23**
10 years	2.26	
Source (Y_2)	Mean Values Days	t
8 years	6.03	4.68**
9 years	3.62	
9 years	3.62	-.50
10 years	3.81	
10 years	3.81	2.63**
11 years	2.95	
9 years	3.62	1.88*
11 years	2.95	

* Significant at the .05 level.

** Significant at the .01 level.

T-test scores in Table 9, 4.05, 3.72, and 4.68, indicate that the eight year old students are significantly slower than all other age groups in eye-hand coordination (X_1), the time it takes an individual to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1), and the time it takes an individual to learn how to effectively clean his teeth with dental floss (Y_2), respectively. There are differences in X_1 , Y_1 and Y_2 amongst the other age groups but they are not nearly so profound as between the eight year olds and all the other age levels. Whereas the ten and eleven year olds had significantly different eye-hand coordination scores (X_1), and flossing effectiveness scores (Y_2), they were not significantly different in the time it takes them to learn how to manipulate dental floss (Y_1). T-test statistics of 4.92 for X_1 and 2.63 for Y_2 point out the significant differences between ten and eleven year olds. The comparison of means with t-test scores of .40 for X_1 , .71 for Y_1 and -.50 for Y_2 , also suggests that there was virtually no differences between the nine and ten year old age groups. Null hypothesis VI, therefore, was not rejected for the nine and ten year old groups in reference to X_1 , Y_1 and Y_2 . It also was not rejected for the ten and eleven, and nine and eleven year old groups in reference only to Y_1 . Most importantly, null hypothesis VI was rejected for all other age group combinations for X_1 , Y_1 , and Y_2 .

Summary of Results

Although it was found that there were significant correlations between the variables, age and eye-hand coordination, and the time children take to learn the techniques associated with flossing manipulation (Y_1) and effective cleaning (Y_2), the results of the linear regression analysis suggests that the variables would make poor predictors of Y_1 and Y_2 . Sex was not significantly related to Y_1 or Y_2 when all age groups were combined to determine its effects on the ability of an individual to learn the flossing techniques. However, there were some significant differences between the males and females at the eight and eleven year old age levels. It was also found that the best prediction of the readiness of individuals to learn the flossing techniques could be achieved by combining the effects of all three variables, age, sex and eye-hand coordination.

Finally, the analysis of the data suggested that there was a great difference between the eight year old youngsters and all of the other age groups in their abilities to learn how to floss and operate a simple eye-hand coordination test. The eight year olds took an average of 6.03 days to complete both flossing tests whereas all other groups completed the test in 3.81 days or less. It was also discovered that there was no significant difference between the nine and ten year old children in regards to their ability to learn the flossing techniques and complete a manual dexterity task.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Research examined in this study indicates that youngsters as well as adults have progressive dental health disease. Most of the dental problems at the elementary age level are attributed to dental caries but many have primary gingivitis which leads to periodontal disease. Both caries and periodontal disease are attributed to plaque, an accumulation of food debris, salivary products and bacteria. Dental floss has been found to be one of the safest and most efficient interproximal cleansing devices, and thus a beneficial aid in removing plaque from the tooth surfaces.

Research suggests that the frequency with which dental cleansing should occur depends upon the oral environment of the individual. One investigator believes that the time interval may vary as much as seven days between individuals. Most authorities, however, recommend that cleaning take place at least once every 24 hours.

Eye-hand coordination abilities in children have been investigated to determine the relationship between training and achievement. Results indicate that individuals will differ in training capabilities and achievement depending upon their maturation level. Experience and physical factors seem to be good indicators of maturation while

age alone gives a broad estimate of maturation. Physical maturation seems much more important in relation to eye-hand coordination than is intelligence, socioeconomic status or sex.

Motor abilities, specifically eye-hand coordination, are necessary for learning complex motor tasks. It is also suggested that motor abilities can be predictive of the performance of various stages of learning these tasks. However, perceptual-motor abilities include several areas of visual perception (eye-hand coordination, figure-ground perception, perception of form constancy, position and spatial relationships) which develop independently from one another. Therefore, specific tests may be necessary to predict specific performance.

The investigation's sample population consisted of 117 students from two elementary schools in Lebanon, Oregon. There were 12 male and 16 female-eight year olds, 16 male and 16 female-nine year olds, 14 male and 13 female-ten year olds, and 19 male and 17 female-eleven year olds.

The Flossing Performance Index was used to determine when a student had learned how to effectively clean the interproximal surfaces of his teeth. This test consisted of measuring the plaque built up on one and one-half millimeter wide sections of 12 predetermined surfaces of six teeth. Plaque buildup was rated from zero, no buildup, to three, plaque covering the entire surface. In order to have

passed the Flossing Performance Index Test each student had to achieve at least a 50 percent reduction from the pretest rating, and a score of 13 or less on the same index.

The Direct Observation Evaluation Test was used to determine when the student had learned how to manipulate the floss into all of the interproximal spaces. Instructors and aids simply observed the students' flossing techniques and determined whether or not they penetrated each interproximal space. Both the Flossing Performance Index Test and the Direct Observation Evaluation Test had to be satisfactorily completed before the student was released from the study.

Only one manual dexterity test, the Moore Eye-Hand Coordination Test, was used to determine finger-thumb dexterity. This was the only specific motor ability test available which was simple to operate, not time consuming, valid and reliable, and had standardized norms.

The following hypotheses were tested:

1. There is a significant relationship between age and the following three factors: 1) eye-hand coordination (X_1), 2) the time it takes an individual to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1), and 3) the time it takes an individual to learn how to effectively clean the interproximal surfaces

of the teeth with dental floss (Y_2).

2. There is a significant relationship between sex and the three factors (X_1), (Y_1), and (Y_2).
3. There is a significant relationship between eye-hand coordination and factors, (Y_1) and (Y_2).
4. Age, sex and eye-hand coordination scores, separately or in combination, are good predictors of Y_1 and Y_2 .

The following null hypotheses were also treated statistically:

5. There is no significant differences between males and females at the eight, nine, ten and eleven year old age levels in regard to factors X_1 , Y_1 and Y_2 .
6. There is no significant differences between any of the four age groups, eight, nine, ten and eleven year olds, in reference to X_1 , Y_1 and Y_2 listed in question one.

Results of the F-tests applied to the first three hypotheses indicated that there was a significant correlation, at the .01 level, between age and eye-hand coordination (X_1), the ability to learn how to manipulate dental floss between all of the teeth (Y_1), and the ability to learn how to effectively clean the interproximal surfaces of the teeth (Y_2). There was also significant correlation, at the .01 level, between eye-hand coordination and Y_1 and Y_2 .

It was concluded that there was a significant correlation between age and X_1 , Y_1 and Y_2 , and also between the eye-hand coordination variable and Y_1 and Y_2 . However, it was discovered that there was not a significant correlation between the variable of sex and X_1 , Y_1 and Y_2 . Thus, hypotheses I and III were not rejected while Hypothesis II was rejected.

An analysis of variance was also used to determine whether or not to use the t-tests to test for significant differences in Hypotheses V and VI. In all cases the results revealed that there were significant differences somewhere at the eight, nine, ten and eleven year old age levels in the male (female) group in relation to eye-hand coordination (X_1), the ability to manipulate dental floss between all the teeth (Y_1), and the ability to learn how to effectively clean the interproximal surfaces of the teeth (Y_2). Therefore, t-tests were used to determine exactly where the sexes were significantly different in respect to X_1 , Y_1 and Y_2 .

The t-tests revealed very few significant differences between the sexes in reference to X_1 , Y_1 and Y_2 . There was a significant difference, at the .01 level, however, between the male and female eight year olds for the time it takes an individual to learn how to manipulate dental floss between all the interproximal surfaces (Y_1). At the eleven year old age level there was a significant difference, at the .05 level, in sexes for the time it takes an individual to learn

how to clean the interproximal surfaces effectively with dental floss (Y_2). There was a significant difference, at the .05 level, between male and female 11 year olds on the results of the Moore Eye-Hand Coordination Test (X_1). Thus, null hypothesis V was not rejected for the nine, ten and eleven year olds in reference to Y_1 . Null Hypothesis V was not rejected for the eight, nine and ten year olds in reference to X_1 and Y_2 . Finally null hypothesis V was rejected for eight year olds on Y_1 , and eleven year olds for X_1 and Y_2 .

The t-test was also used to determine if there were significant differences between the age groups for the ability to learn how to manipulate dental floss between all of the interproximal surfaces, (Y_1), the ability to learn how to clean the interproximal surfaces effectively with dental floss (Y_2), and eye-hand coordination (X_1). Both sexes were considered together since very few significant differences existed between the sexes. The greatest significant differences existed between the eight and nine year old age groups, while there were not any significant differences between the nine and ten year olds in reference to X_1 , Y_1 and Y_2 . Therefore null hypothesis VI was not rejected for the nine and ten year olds on all tests, X_1 , Y_1 , and Y_2 . It was also not rejected for the groups of ten and eleven, and nine and eleven year olds in reference only to eye-hand coordination X_1 . Finally, null hypothesis VI was rejected for all other age group combinations relating to X_1 , Y_1 and Y_2 .

A Linear Regression Analysis was used to test whether eye-hand coordination, sex or age, separately or in combination, could predict the ability of an individual to learn how to manipulate dental floss between all of his teeth (Y_1), and the ability of an individual to effectively clean the interproximal surfaces of his teeth (Y_2). R squared, a rough estimate of the ability of the variables of eye-hand coordination, sex and age to determine an equation that will predict Y_1 and Y_2 , should have at least a value of R squared equal to .500 in order to have a fair prediction. Since the greatest R squared obtained from using all variables together was .378 for Y_2 and .320 Y_1 , this indicates that age, sex and eye-hand coordination are not, separately nor in combination, good predictors of Y_1 and Y_2 . Therefore, hypothesis IV is rejected since the variables are not good predictors of Y_1 and Y_2 .

Finally, an analysis of the X_1 , Y_1 and Y_2 scores and their standard deviations, found in Appendix A, B, C, and D, suggest that as students get older they become more homogenous in respect to their ability to learn fine eye-hand manipulatory skills. For example, the greatest variation in X_1 , Y_1 , and Y_2 scores exist in the eight year old group, while the least variation exists in the eleven year old group.

Discussion

Research on the effectiveness of the dental flossing technique is limited, but substantial enough to provide impetus to the nation wide effort to encourage people to use this oral hygiene device. On the other hand, research concerning the time it takes individuals to learn an effective flossing technique is virtually nonexistent.

This investigation recognized the need to find out how age, sex, and eye-hand coordination related to the ability of elementary students to learn an effective flossing procedure in order to determine the readiness of these individuals to learn this technique.

Dinkmeyer (97) and Hilgard (103) indicate that an awareness of an individual's physical maturity can help determine when to introduce educational tasks. Finally, Hicks and Ralph (100), Roberts (82) and Hilgard (103) suggest that training will help individuals perform specific tasks as long as they are sufficiently mature to handle the task. These studies suggest that age and eye-hand coordination might be important variables in determining when students are ready to learn how to manipulate dental floss between the teeth, and when they are able to learn how to effectively clean their teeth with dental floss.

The results of this study appear to confirm the above research. When individuals of one age group were significantly different from another age group in their eye-hand coordination scores they were

always significantly different in their abilities to learn how to manipulate dental floss, and ability to use the floss effectively. This suggests that not only is eye-hand coordination related to age, but that eye-hand coordination and age are related to the ability of an individual to learn how to manipulate floss between the teeth, and his ability to learn how to effectively floss the teeth. The correlation study using the F-test also substantiated the above findings.

Research has not been able to completely verify the hypothesis that sex is a significant factor in relation to eye-hand coordination ability. Gill, Herdtner and Lough (104) on one hand find no significant differences between the sexes while Moore (108), Stachnik (109) and Sloan (106) do report significant differences. This investigation generally supports Gill, Herdtner and Lough, although at age eleven there was a significant difference between the sexes for eye-hand coordination, at the .05 level of significance. There were also some significant sex differences in the ability of an individual to learn how to manipulate dental floss between the teeth Y_1 and the ability of a person to effectively clean his teeth with dental floss, in two age groups Y_2 . Females and males were significantly different at age eight for Y_1 and at age eleven for Y_2 .

No attempt has been made to determine the exact causes and effects of the above findings. It is certain that although there are differences between the sexes, the t-test at the .05 level of

significance did not reveal all of these differences. Evidently the eight year old males have more difficulty in learning how to manipulate dental floss than do the eight year old girls. It is possible that this is due to hand size differences or the amount of experience that the females had with fine manipulatory tasks as compared to males. Also the investigator noticed that some of the eight year old boys were more hyperactive than most of the eight year old girls. The inability of boys to retain attention on the flossing program is a possible reason for their poor flossing manipulatory scores. However, even though the males learned to manipulate the floss at a slower rate, they were almost able to catch the girls in learning how to clean the teeth effectively. It is possible that at the beginning of the program the eight year old males were concentrating on effectively cleaning the teeth instead of being concerned about flossing between all of the interproximal surfaces. As their skill increased they would probably find that the number of teeth cleaned would also increase.

The results also indicated that the male eleven year olds were significantly slower than eleven year old females on their eye-hand coordination scores and also on the time it took them to learn how to effectively floss their teeth. Since there is a significant relationship between eye-hand coordination and the ability to learn how to effectively floss the teeth, and because there was a significant

difference between the sexes on these two tests, this indicates that the eleven year old males' finger dexterities were not as well developed. The significant difference between males and females at the eleven year old age level, in respect to eye-hand coordination and the time it takes an individual to learn how to effectively clean his teeth, could thus be attributed to the differences in male and female maturation.

Ebel (83) and Kephart (87) suggest that an individual's motor abilities can be predictive of performance on perceptual motor tasks. This investigation found that the three variables of age, sex and eye-hand coordination were not able to predict, with accuracy, when an individual was ready to learn how to manipulate dental floss between the teeth, and when he was ready to learn how to effectively clean his teeth. Individuals exhibited eye-hand coordination and flossing abilities that varied considerably with particular age and sex groups. Therefore, it is likely that more variables are necessary in order to predict, with accuracy, how long it will take elementary students to learn the flossing techniques.

The statistical interpretation of this investigation was encouraging despite the poor predicting qualities of the variables. Age and eye-hand coordination were found to be significantly related to the time it takes an individual to learn how to manipulate dental floss between the teeth, and the time it takes an individual to learn how to

effectively clean his teeth with dental floss. The study suggested that in some cases girls may be more ready or mature to learn the flossing techniques.

The observation of the operation of the investigation also revealed some ancillary and subjective findings. The use of the Plak-Lite, manufactured by the International Pharmaceutical Company, was a convenient device and a definite aid in motivating the student to want to floss their teeth. The Plak-Lite was available at all times and could be used as often as the student wished to check his teeth. The fluorescein dye used to disclose the plaque was easily removed from the mouth by rinsing with water and thus children were not embarrassed by having the stain remain on the tongue, lips and mouth.

The group training sessions, held in the afternoons after the individualized instruction and flossing examinations were completed, seemed quite successful. It is important to note, however, that it was the small teacher-student ratio that enabled it to function so well. Students had to be constantly supervised, reassured, and encouraged in their attempts to experiment with the flossing technique. The investigator also believes that the short duration of the group training session helped bring about optimum results.

A subjective analysis of the investigation also suggests that the proper time to introduce the flossing technique is at an age when

students can learn how to wrap the floss on their fingers and manipulate it between their front teeth. Every student in the study was able to accomplish this feat within the first 25 minute training session. It is believed that if the students can form early habits relating to the use of dental floss each night before retiring, they will develop the technique in time so that all of the teeth may be cleaned.

Conclusions

The following conclusions may be drawn from this study:

1. Eye-hand coordination, sex, and age are related to the time it takes an individual to learn how to manipulate dental floss between all of the interproximal surfaces (Y_1) and the time it takes an individual to learn how to effectively clean his teeth with dental floss (Y_2).
2. Eye-hand coordination and age, of the three variables tested, are the most critical in relation to Y_1 and Y_2 .
3. Eye-hand coordination, as exhibited by the Moore Eye-Hand Coordination Test, sex, and age are not precise predictors of an individual's ability to learn how to use dental floss.
4. All eight year old elementary students in this investigation were able to learn how to effectively clean their teeth with dental floss within ten days.

5. All nine year old elementary students in this investigation were able to learn how to effectively clean their teeth with dental floss within seven days.
6. All ten year old elementary students in this investigation were able to learn how to effectively clean their teeth with dental floss within six days.
7. All eleven year old elementary students in this investigation were able to learn how to effectively clean their teeth with dental floss within five days.

Suggestions for Further Research

Since this investigation is the first of its kind, there is a need to have this same investigation repeated using a different sample population. A much larger sample population should be selected so that each age group has a full complement of eye-hand coordination scores.

Research should be conducted to determine other important variables which relate to the readiness of individual's to learn how to floss the teeth. There is a need to find or develop additional eye-hand coordination tests that would relate specifically to the flossing technique. Research involved in the determination of the role of motivation in learning this technique is also extremely important.

Educational methodology is critical to the flossing instruction program. Instructors must know what techniques, strategies, content, procedures and materials are most appropriate for teaching the flossing technique. For example, research is necessary to determine whether or not group instruction techniques are appropriate for flossing education.

Research is needed to determine additional methods which will evaluate the effectiveness of a flossing program. The survey or examination must be developed so that it can be administered in a short period of time, easily operated, and considered a valid and reliable indicator of flossing skill.

Finally, research should be conducted to determine the physical, mental and emotional maturation levels of elementary and pre-school students. More evidence is needed to show how age and sex relate to these maturation levels.

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APPENDICES

APPENDIX A

Summary Table of Actual Data on eight year olds concerning Sex, Eye-Hand Coordination (X_1), the Time it Takes an Individual to learn how to Manipulate Dental Floss Between the Teeth (Y_1) and the Time it Takes an Individual to Learn How to Effectively Clean the Teeth with Dental Floss (Y_2). The Table also includes the means and standard deviations for X_1 , Y_1 and Y_2 .

Student	Age	Sex	X_1 (Seconds)	Y_1 (Days)	Y_2 (Days)	
1	8	M	108.9	5	5	
2	8	M	113.6	6	6	
3	8	M	120.3	4	9	
4	8	M	126.8	2	3	
5	8	M	132.9	6	6	
6	8	M	135.0	7	8	
7	8	M	135.9	10	10	
8	8	M	137.5	5	5	
9	8	M	138.3	6	9	
10	8	M	139.5	3	5	
11	8	M	139.7	8	10	
12	8	M	143.5	5	5	
13	8	F	108.3	3	3	
14	8	F	110.0	3	6	
15	8	F	114.9	6	8	
16	8	F	121.3	2	5	
17	8	F	123.4	1	4	
18	8	F	123.6	2	3	
19	8	F	124.8	2	3	
20	8	F	126.6	6	6	
21	8	F	128.1	4	7	
22	8	F	130.1	3	4	
23	8	F	138.1	1	2	
24	8	F	144.3	3	8	
25	8	F	145.3	2	9	
26	8	F	145.7	4	5	
27	8	F	146.5	4	6	
28	8	F	155.5	6	6	
Sex	X_1 Means	X_1 SD	Y_1 Means	Y_1 SD	Y_2 Means	Y_2 SD
Male	130.99	11.14	5.58	2.15	6.75	2.34
Female	130.40	14.08	3.25	1.65	5.31	2.05

APPENDIX B

Summary Table of Actual Data on Nine Year Olds Concerning Sex, Eye-Hand Coordination (X_1), the Time it Takes an Individual to Learn How to Manipulate Dental Floss Between the Teeth (Y_1) and the Time it Takes an Individual to Learn How to Effectively Clean the Teeth with Dental Floss (Y_2). The Table also includes the means and standard deviations for X_1 , Y_1 and Y_2 .

Student	Age	Sex	X_1 (Seconds)	Y_1 (Days)	Y_2 (Days)	
29	9	M	112.3	3	3	
30	9	M	112.6	1	3	
31	9	M	113.5	7	7	
32	9	M	113.6	1	3	
33	9	M	114.8	3	5	
34	9	M	115.1	2	2	
35	9	M	116.3	2	2	
36	9	M	120.0	3	3	
37	9	M	122.9	1	4	
38	9	M	123.1	1	3	
39	9	M	125.8	2	2	
40	9	M	126.2	4	6	
41	9	M	126.3	5	7	
42	9	M	126.8	2	2	
43	9	M	143.8	3	5	
44	9	M	148.4	2	4	
45	9	F	93.2	1	3	
46	9	F	99.2	4	7	
47	9	F	99.8	3	5	
48	9	F	104.3	1	2	
49	9	F	109.0	1	2	
50	9	F	109.4	1	2	
51	9	F	110.0	3	3	
52	9	F	110.2	3	3	
53	9	F	113.1	1	3	
54	9	F	114.2	2	3	
55	9	F	117.1	2	3	
56	9	F	120.7	3	3	
57	9	F	121.3	3	3	
58	9	F	123.5	2	4	
59	9	F	130.1	5	5	
60	9	F	134.7	3	4	
Sex	X_1 Means	X_1 SD	Y_1 Means	Y_1 SD	Y_2 Means	Y_2 SD
Male	122.59	10.66	2.63	1.63	3.81	1.72
Female	113.11	11.25	2.37	1.20	3.44	1.31

APPENDIX C

Summary Table of Actual Data on ten year olds Concerning Sex, Eye-Hand Coordination (X_1), the Time it Takes an Individual to Learn How to Manipulate Dental Floss Between the Teeth (Y_1) and the Time it Takes an Individual to Learn How to Effectively Clean the Teeth with Dental Floss (Y_2). The table also includes the means and standard deviation for X_1 , Y_1 and Y_2 .

Student	Age	Sex	X ₁ (Seconds)	Y ₁ (Days)	Y ₂ (Days)	
61	10	M	100.7	2	6	
62	10	M	102.8	2	2	
63	10	M	104.9	3	3	
64	10	M	107.6	2	6	
65	10	M	108.6	3	3	
66	10	M	111.9	2	3	
67	10	M	113.1	2	3	
68	10	M	120.5	1	3	
69	10	M	123.0	3	6	
70	10	M	123.2	3	6	
71	10	M	126.5	1	2	
72	10	M	127.5	5	5	
73	10	M	129.8	2	5	
74	10	M	130.0	2	3	
75	10	F	97.3	2	3	
76	10	F	104.3	2	2	
77	10	F	105.9	2	3	
78	10	F	107.9	3	5	
79	10	F	113.8	5	5	
80	10	F	114.3	4	6	
81	10	F	119.5	1	3	
82	10	F	120.5	2	3	
83	10	F	122.9	1	3	
84	10	F	123.0	3	4	
85	10	F	127.2	1	3	
86	10	F	131.7	1	3	
87	10	F	132.2	1	4	
Sex	X ₁ Means	S ₁ SD	Y ₁ Means	Y ₁ SD	Y ₂ Means	Y ₂ SD
Male	116.44	10.50	2.36	1.01	4.00	1.57
Female	116.96	10.85	2.15	1.28	3.62	1.12

APPENDIX D

Summary Data of Actual Data on Eleven Year Olds Concerning Sex, Eye-Hand Coordination (X_1), the Time it Takes an Individual to Learn How to Manipulate Dental Floss Between the Teeth (Y_1), and the Time it takes an Individual to Learn How to Effectively Clean the Teeth with Dental Floss (Y_2). The table also includes the means and standard deviations for X_1 , Y_1 , and Y_2 .

Student	Age	Sex	X_1 (Seconds)	Y_1 (Days)	Y_2 (Days)	
88	11	M	91.9	1	3	
89	11	M	96.7	3	3	
90	11	M	100.4	2	3	
91	11	M	101.6	2	2	
92	11	M	103.7	1	3	
93	11	M	104.7	3	3	
94	11	M	106.3	2	4	
95	11	M	106.3	2	3	
96	11	M	106.4	2	3	
97	11	M	107.2	3	3	
98	11	M	109.1	4	4	
99	11	M	109.2	1	4	
100	11	M	109.8	3	4	
101	11	M	111.6	1	4	
102	11	M	112.6	1	2	
103	11	M	113.5	3	3	
104	11	M	114.6	2	3	
105	11	M	116.7	1	3	
106	11	M	116.8	5	5	
107	11	F	92.1	1	2	
108	11	F	94.8	1	2	
109	11	F	95.0	2	2	
110	11	F	95.5	1	1	
111	11	F	95.9	3	3	
112	11	F	98.3	1	4	
113	11	F	100.5	2	3	
114	11	F	101.2	1	4	
115	11	F	102.7	1	2	
116	11	F	114.4	1	3	
117	11	F	115.2	3	3	
Sex	X_1 Means	X_1 SD	Y_1 Means	Y_1 SD	Y_2 Means	Y_2 SD
Male	107.32	6.59	2.21	1.13	3.26	0.73
Female	100.51	7.74	1.55	0.82	2.64	0.92