# AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF VITAMIN B-12 ON THE GROWTH AND PHYSICAL PERFORMANCE OF UNDERNOURISHED BOYS

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This is to certify that the

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John Edward Walker

A THESIS

Submitted to the School of Education of Michigan
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Department of Health, Physical Education,
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J.E.W.

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AN ABSTRACT OF A THESIS

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Statement of the Problem:

This experiment was designed to determine the effects, if any, of a daily fifty microgram oral supplement of Vitamin B-12 on the growth and physical performance of undernourished boys.

Need for the Study:

The need for this study stems from the realization that the fullest development of an individual can not be obtained when he is not "up to par" physically or nutritionally. It is felt that by improving the nourishment of a selected group of undernourished boys that their growth and physical performance would likewise improve. A comprehensive review of the literature revealed few studies in this area of nutrition.

Methods and Procedure:

Twenty-five undernourished boys between the ages of twelve and seventeen were selected as subjects in this experiment. Of these twenty-five boys, twelve formed the experimental group and received the Vitamin B-12 capsule, while the remaining thirteen boys made up the control group and received the placebo (blank) capsule. The Wetzel Grid was employed to select subjects and to determine their degree of growth failure. Once the subjects were selected, they were randomly divided into the two experimental groups according to their respective degrees of growth failure. Exact height and weight measurements, plus a battery of physical performance tests were administered to each subject at the beginning and end of the three month experimental period. The Student "t", or small sample technique, was used in analyzing and comparing the results of the two groups.

Conclusions:

1. No significant differences were found in the initial measurements of growth and physical performance in the two groups.

2. In comparing the improvements of the two groups, there were no significant improvements in any of the categories of growth and physical performance in favor of either group at the termination of the three month experimental period.

3. When the Vitamin B-12 and placebo groups were combined, an appreciable improvement in height was noted during the experiment.

4. The other "t" values for growth and physical performance with the two groups combined, although not statistically significant, indicate general improvement in growth and physical performance during the period of the experiment.

Henry J. Montoye
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# CHAPTER I

## INTRODUCTION

Physical education is now recognized as an integral part of the educational program. Its aims are inextricably related to the general aims of education in that they are concerned with the total development of each individual mentally, physically, socially, and emotionally. The possibilities of the physical education program are aptly expressed by Voltmer when he states, "Physical education, when well taught, can contribute more to the goals of general education than any other school subject."[1]

One of the most important aims of physical education is to give to each individual a workable knowledge of many sports skills. Thus, by the time a person leaves high school, he will have a repertoire of sport skills from which to choose to make his leisure hours as an adult worthwhile and enjoyable. Due to the increased amount of leisure time brought about by great technological advances, this phase of physical education has taken on new significance. In support of this, one can justly predict that the amount of leisure time will continue to increase with the advent of

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[1]Edward F. Voltmer and Arthur A. Esslinger, _The Organization and Administration of Physical Education_ (Second edition; New York: Appleton-Century-Crofts, Incorporated, 1949) p. 14.

the atomic age.

A person usually thinks of the fundamentals of education as consisting of reading, writing, the ability to use numbers, and the elements of oral expression. These are the intellectual tools supplied by an education, but what about the physical tools? LaPorte, in the following paragraph, aptly expresses the status of our physical tools when he says:

> The physical tools to a large extent have been overlooked or disregarded. As a result, there can be found at all school levels a vast army of children below par physically, unable to protect themselves, unable to express themselves freely and efficiently, and woefully weak in adapting themselves readily to their physical environment.[2]

Voltmer and Esslinger fully realize this need for the physical tools and describe them as "fundamental processes" or defined, "those physical skills common to America in general and to one's own locality in particular."[3] The importance of the child acquiring these fundamental processes is further crystallized in that:

> The child needs them now for happy living, but also because future physical endeavors and many life occupations are based on them. . . . Children live on a different level from that of adults. In play situations

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[2]W.R. LaPorte, "Physical Education Contributes to the Seven Cardinal Principles of Education," _Journal of Health and Physical Education_, 4:10, March, 1933.

[3]Voltmer and Esslinger, _op. cit._, p. 22.

> the good performer is the hero and the poor performer is pushed into the background. Much of the child's life is play life and a large share of it deals with physical skills, where only a small part of adult life is play and a good performance is not stressed so much. . . . The child does not have those numerous other phases of endeavor to which he can turn for success if he fails miserably in his physical skills. He must master the fundamental processes or suffer the consequences of loss of standing among his fellows in one of the major fields of youthful endeavor. That is one of life's most severe punishments, and it can be avoided by improving physical abilities.[4]

Although the preceding paragraph gives several reasons why the child's physical abilities should be developed, it does not mention the psychological repercussions upon the child when poor ability in performance is exhibited. When lack of ability is displayed, feelings of inferiority and insecurity are often manifested. Physical education then becomes an annoying experience and methods are devised to obtain release from physical education classes. Some common excuses might be the feigning of illness or the expression of a desire to indulge in some other activity of more interest, which in reality, is merely a less annoying activity. When such situations are permitted to exist, the very boys who need physical education the most are excused or delegated nonskill pastimes of negigible value.

Health, which tops the list of the Seven Cardinal Principles of Education, rightfully merits such a position.

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[4]Voltmer and Esslinger, op. cit., p. 22.

Such is expressed by the Commission on the Reorganization of Secondary Education when its members so wisely said, "To discharge the duties of life and to benefit from leisure, one must have good health. The health of the individual is essential also to the vitality of the race and the defense of the nation."[5] Although this first applied more specifically to health education, it is also very applicable to physical education. LaPorte aptly applies this statement to physical education in his statement that, "While all departments and subjects in the school should contribute positively to this objective, physical education must accept it as a major responsibility."[6] His definition of health is expressed as:

> The state of being in which the individual (or group) within the limits of its native capacity is able to function most effectively and satisfyingly for self and others--physically, mentally, and socially.[7]

Health is indeed a goal of first importance in education, as is further illustrated by the Educational Policies Commission when they formulated the Purposes of Ed-

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[5]Commission on the Reorganization of Secondary Education, United States Bureau of Education Bulletin, "Cardinal Principles of Secondary Education", No. 35, (Washington: United States Printing Office, 1928) p. 4.

[6]LaPorte, loc. cit.

[7]Ibid. p. 11.

ucation in American Democracy. A part of this statement reads, "Health is a factor which conditions our success in all our undertakings, personal and social."[8]

## Need for the Study

The preceding paragraphs suggest the need for this study. Can we truly accomplish these worthy objectives and goals of physical education, and visualize at the same time the fullest development of each individual when some of them are obviously not "up to par" physically or nutritionally? The author cannot conceive the fullest physical and mental growth of each individual when malnutrition is evidenced, as in many physical education classes. Futhermore, many activities require strength, endurance, and quickness, which are not generally a part of the malnourished person's physical makeup. Nutritionists are in agreement with the above contention and recognize that "where real deficiencies exist, there is little question that physical performance is hindered."[9] In light of this, it is the investigator's contention that all too often physical educators fail to

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[8]Educational Policies Commission; Purposes of Education in American Democracy, (Washington D.C.: National Education Association, 1938), p. 60.

[9]Ancel Keys, "Physical Performance in Relationship to Diet," Federation Proceedings, 2:164, June, 1943.

ascertain the underlying cause for poor physical performance. Instead, they frequently associate one's physical ineptness to lack of native ability, or to the fact that he just happens to be thinner or smaller than his healthier associates. Unfortunately, this cursory observation is all too often the last step involved. Thus, the physical educator continues to teach a skill in the same routine manner, regardless of whether or not the individual is capable physically to acquire the skill readily, or at all.

It is felt that the responsibility in part, rests with the physical education program, for it is this phase of the educational system which is primarily concerned with the development of one's physical tools. When certain individuals leave high school without a basic knowledge of sports skills, they are handicapped in their own adult pursuits of recreation and wise use of leisure time. Probably these same individuals would have developed an interest and some skill in sports if they had experienced some success in the lower grades. Could the fact that some of them possibly exhibited growth failure have something to do with their lack of success? This experiment will be directed towards answering this question.

The importance of health as one of the paramount goals of education has been mentioned in the introductory paragraphs. It is also well recognized that the problem of malnutrition represents one of the crucial health problems of our country and nations abroad. This further suggests the need for this study, since it is concerned with improving one's health through better nutrition, specifically the addition of Vitamin B-12 supplements to the diet of young, malnourished boys.

That health is inextricably related to proper nutrition is quite generally accepted. Deihl, one of the foremost authorities on health expresses his views on its importance in the following words.

> Health and well being are dependent upon proper diet and wise choice of foods. Fatigue and lowered resistance to infection may be due to lack of certain essential nutrition requirements. Adequate nutrition is the first prerequisite to vigorous health.[10]

It is also generally recognized that poor nutrition is related to mental, emotional and physical stress.[11,12] Without proper nutrition, the delicate organic system of balances and counterbalances will go askew. In addition, it is well recognized that undernourishment and malnutrition

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[10] Harold S. Deihl, Textbook of Healthful Living, (Fourth edition; New York: McGraw-Hill Book Company, Inc., 1950), p. 80.

[11] Tom D. Spies, Rehabilitation Through Better Nutrition, (Philadelphia: W.B. Saunders Company, 1947) pp.1-2.

[12] H.H. Mitchell, "Nutrition and Stress", Borden's Review of Nutritional Research, 13:97-107, November, 1952.

influence human emotions and behavior.[13] In light of this, the nutrition of all people takes on added importance, for there is not a question that correction of nutritional disturbances is beneficial to behavior and to the physical performance of human beings.[14]

Probably the most important reason for this study lies in the fact that the boys themselves, who are undernourished, are deeply sensitive to their physiques as well as their inability to perform. Bridgeman and Steitz[15] speak of this adolescent period as one in which there is a keen interest in the physical well-being of the body and that boys' interests evolve around strength. Also, adolescents always want to know whether or not they are "normal" and how to correct abnormalities. This is further substantiated by the personal comments of two adolescents in the present experiment when they remarked, "I sure do hope these pills will help me grow," and "I've been this big for the last four years,

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[13] "Vitamin Supplementation and Physical Performance," Nutrition Reviews, 13:102-4, April, 1955.

[14] Ibid.

[15] Donald F. Bridgeman and Edward F. Steitz, "The Needs and Problems of Adolescents in the Area of Physical Development," The High School Journal, 35:39, October, 1951.

and I sure do wish I could put on some weight."[16] It is with such statements as these in mind and with the realization that proper diet is related to one's health and physical performance that this study has been conducted.

## Statement of the Problem

The problem is to determine the effects of Vitamin B-12 supplements to the diet on growth and physical performance of boys exhibiting growth failure. More specifically, the aspects of physical performance to be studied will consist of measurements of strength, endurance, power and cardiovascular fitness.

## Limitations of the Study

In any experimental study there is always the human element to consider. Even though the testing was carried out diligently and carefully in as scientific a manner as possible, "Human fallibility can never be completely eliminated from any human effort."[17] The number of subjects and

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[16]Comments made by two subjects in the experiment.

[17]Steering Committee of the Research Section and the Research Council of the Research Section of the American Association for Health, Physical Education, and Recreation, Research Methods Applied to Health, Physical Education and Recreation, (Revised edition; Washington: American Association for Health, Physical Education and Recreation, 1952) p. 302.

the length of the experimental period represent other possible limitations. However, it was felt that accurate work done with a few subjects over a short period of time would result in some tentative conclusions.

Previous growth records were not obtainable for the subjects. Hence, they were selected as subjects only on the basis of their present growth status as determined by their respective height and weight measurements, with age also being another consideration in the selection of stunted boys. There were no available data on their living and eating habits before they came to the institution. It was difficult, therefore, to judge whether their present growth failure was related to an inadequate consumption of the essential food elements or due to a special need for more of one particular kind of vitamin. Due to the small number of under nourished boys, borderline cases of undernourishment were used as subjects.

A limitation of this study becomes apparent, for a good nutrition program, such as the one in operation at this institution, would correct the former types of malnutrition possibly without additional supplements of Vitamin B-12. It would be virtually impossible to find conditions wherein both the manner of living and nutrition were both known and controlled. Nevertheless, it is felt that the favorable conditions present justify this experiment.

## Definition of Terms Used

Growth Failure. The term growth failure will be used interchangeably with malnutrition and undernourishment throughout this thesis. Specifically, it applies to those boys whose growth status plots on the Wetzel Grid growth index chart[18] in physique channels $B_2$, $B_3$, or $B_4$. It also includes four small boys, who showed retarded growth by their respective developmental plottings on or near the 98 per cent auxodrome.

Placebo. A placebo is a blank capsule, which looks exactly like a real Vitamin B-12 capsule. The placebo or control group represents the subjects who received the blank capsule.

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[18] C.F. Wetzel Grid in Chapter III, Methodology.

# CHAPTER II

## REVIEW OF THE LITERATURE

The effect of food on one's physical performance is not a new interest. Napoleon, realizing that his men were ill on the front lines as a result of food spoilage, stimulated action to improve the preservation of food, which ultimately resulted in the evolution of the canning industry. Although the canning of food and the use of food to promote physical fitness are not new, the use of vitamin supplements as aids in promoting physical performance is a relatively recent idea. World War II gave impetus to this interest, especially in the armed services and industrial fields where a high premium was placed on the physical performance of the soldier and industrial worker.

Even though the early efforts to improve physical performance rest on tenuous ground,[1] interest should not wane, for, with the discovery of each new vitamin, new fields of research are opened in its application to nutrition and physical performance. Also the fact that there is ample clinical experience and convincing experimental evidence available which show that a deficiency of vitamins, particularly

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[1] "Vitamin Supplementation and Physical Performance", Nutrition Reviews, 13:103, April, 1955.

those of the B-complex, results in a marked deterioration in the ability to do work,[2] further suggests a need for continued research in this area of nutrition.

Vitamin B-12

In recent years great advancements have contributed much to our knowledge of the nutritional needs of the body. Of particular importance in this respect was the discovery and identification of Vitamin B-12 in 1948.[3] This discovery was ultimately stimulated by the work of Minot and Murphy, who, in 1926, observed that the blood count nearly doubled in all of forty-five patients treated for pernicious anemia with a diet rich in liver.[4] At first it was thought that the folic acid in the liver was the solution, but it proved to be ineffective in relieving many of the symptoms of the disease.[5] Many studies were carried on to find this potent substance in liver extract, but it was not until 1948 that

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[2]"Vitamin Supplements and Performance Capacity", Nutrition Reviews, 8:317, October, 1950.

[3]Lester E. Smith, "The Discovery and Identifications of Vitamin B-12," British Journal of Nutrition, 6:295-299, January, 1952.

[4]George R. Minot and William P. Murphy, "Treatment of Pernicious Anemia by a Special Diet", Journal of the American Medical Association, 87:476, August, 1926.

[5]Lenna F. Cooper, et al., Nutrition in Health and Disease, (Philadelphia: J.B. Lippincott Company, 1953), p. 103.

Vitamin B -12 was isolated in the form of a red crystalline substance. From the start it was abundantly clear to researchers that this substance was definitely a member of the B-complex group of vitamins and resulted in labeling it "Vitamin B-12."[6]

Chemical and Physical Properties. The chemical structure of Vitamin B-12 has only been partially determined.[7] There is agreement, however, that this complex molecule consists of a nitrogenous compound containing one atom each of phosphorous and cobalt, plus minute quantities of carbon, hydrogen, and oxygen.[8,9,10] Vitamin B-12 occurs in deep red crystals containing a variable amount of water of crystallization. It is moderately soluble in water (1.2 per cent) and in alcohol, but not in most other organic solvents. It is also very stable, even in a dry state of one hundred degrees

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[6]Smith, op. cit., p. 295.

[7]Smith, loc. cit.

[8]Cooper et al., loc. cit.

[9]Smith, op. cit., p. 297.

[10]Edward L. Rickes, et al., "Crystalline Vitamin B-12," Science, pp. 107-396, April, 1948.

Centigrade.[11] From the foregoing statement, one might conclude that Vitamin B-12 is capable of standing for long periods of time without decomposition concentrates.

Source and Requirements. Natural Vitamin B-12 is not found in vegetable tissues because plants lack the ability to synthesize this vitamin.[12] The orginal source of Vitamin B-12 in nature appears in fungi, and perhaps certain other micro-organisms.[13,14] It is well known that Vitamin B-12 is widely distributed in foods of animal origin; the two richest sources being liver and kidney, with small quantities contained in meats, egg yolk, cheese and casein.[15,16]

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[11] Smith, *loc. cit.*

[12] *Ibid.*, p. 298.

[13] *Ibid.*

[14] James S. McLester and William J. Darby, *Nutrition and Diet in Health and Disease*, (Philadelphia: W.B. Saunders, 1952), pp. 78-80.

[15] Smith, *op. cit.*, p. 299.

[16] "Vitamin B-12 Distribution in Nature," *Nutrition Reviews*, 13:113-4, April, 1955.

A common commercial source is the fermentation of liquor of Streptomyces griseus.[17,18] Since the source material, whether it be liver or fermentation liquor, contains about one part per million of Vitamin B-12. The factors involved in purification entail a long sequence of steps including at least one chromatographic separation. The methods of purification will not be elaborated on further except to mention that at the present time there are several assay methods for Vitamin B-12.[19]

The efficiency of absorption of Vitamin B-12 in normal individuals has not yet been clearly defined, but it is apparent that the normal human being requires a dietary supply of this factor; the level of which is of microgram proportions.[20,21] A deficiency of this vitamin in healthy men and women is rare, but their bodies do not seem immune to absorbing additional quantities of it when given intramuscularly.[22,23]

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[17] McLester and Darby, op. cit., p. 79.

[18] Smith, op. cit., p. 296. [19] Ibid., p. 298.

[20] Ibid.

[21] McLester and Darby, op. cit., p. 80.

[22] Calvin Lang, et. al., "Retention of Crystalline Vitamin B-12 by Healthy Male Individuals following Intramuscular Injection," Journal of Nutrition, 46:221, February, 1952

[23] Bacon F. Chow, "The Role of Vitamin B-12 in Metabolism," Southern Medical Journal, 45:604-11, July, 1952.

Importance of Vitamin B-12 in Metabolism. Vitamin B-12 carries out many very important functions of the body. The fact that Vitamin B-12 contains nitrogenous compounds, that are alone found in proteins which are necessary for the building of new tissues and repairing of worn out tissues, enhances the carrying out of these important bodily functions. These are carried out in the procwss of digestion when the proteins are broken down into different amino acids, which are the building blocks of body tissue. Even though amino acids are a constant necessity, they are not stored by the body.[24] It is, therefore, very important that the diet supply be furnished with adequate amounts of protein and Vitamin B-12.

Another pertinent function of Vitamin B-12 is the decisive role it plays in the bio-synthesis of methionine, a very essential amino acid.[25,26] The use of Vitamin B-12 as a therapeutic measure with wounds has manifested good

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[24] Harold S. Diehl, Textbook of Healthful Living, (New York: McGraw-Hill Book Company, Inc., 1950), pp. 90-91.

[25] L.W. Charkey, et. al., "Vitamin B-12 in Amino Acid Metabolism", Proceedings of the Society of Experimental Biological Medicine, 73:21-4, January, 1950.

[26] Jacob Dubnoff, "Vitamin B-12 in Methionine Formation", Federation Proceedings, 10:178, 1951.

results by decreasing the wound healing time.[27] Also, an absence of Vitamin B-12 in animals on a high glycine diet resulted in an earlier death.[28] This indicates that Vitamin B-12 is necessary in the metabolism of glycine, another important amino acid.

Absorption and Retention of Vitamin B-12. Most vitamins are readily absorbed from the intestine in man. However, Vitamin B-12 absorption is a much more difficult process requiring a special component or gastric juice in order to fulfill the body's requirements.[29] When absorption difficulties are present in patients, they become of great concern to the physician. Consequently, many studies have been made to determine the absorption and retention of Vitamin B-12 in people with and without pernicious anemia.

Wolf and associates made an interesting study of the intestinal absorption of Vitamin B-12 in man. The subjects were twenty, healthy young men. They were given varying amounts of Vitamin B-12 orally. It was concluded that the

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[27]Charles W. Findlay Jr., "Effect of Vitamin B-12 on Wound Healing," Proceedings of the Society of Experimental Biological Medicine, 82:492-3, March, 1953.

[28]O.H. Menge and G.F. Combs, "Action of Vitamin B-12 in Counteracting Glycine Toxicity in the Chick", Proceedings of the Society of Experimental Biological Medicine, 75:142, October, 1950.

[29]W.B. Castle, "Development of Knowledge Concerning the Gastric Intrinsic Factor and Its Relationship with Pernicious Anemia," New England Journal of Medicine, 249:603,12, October, 1953.

absorption and retention of Vitamin B-12 was directly related to the frequency and amount of daily doses. That is, with increased doses of 150 micrograms of Vitamin B-12 taken daily during four to eight days, absorption in the blood was increased in six patients, who were not affected by smaller single doses.[30] These findings were confirmed by similar experiments carried on for basically the same purpose.[31,32]

Absorption and retention studies of Vitamin B-12 in humans of different age levels have also concluded that significantly greater amounts of Vitamin B-12 are secreted in the urine of young receiving all levels of dosage as compared to older men receiving like amounts.[33,34]

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[30] R. Wolff et al., "Intestinal Absorption of Vitamin B-12 in Man," Nutrition Abstracts and Reviews, 23:415, April, 1953.

[31] Lang, et. al., Journal of Nutrition, op. cit., p. 221.

[32] Lockard Conley, et. al., "Observations on the Absorption, Utilization and Excretion of Vitamin B-12", Journal of Laboratory and Clinical Medicine, 38:84-94, July, 1951.

[33] Donald M. Watkin, et. al., "Agewise Differences in the Urinary Excretion of Vitamin B-12 Following Intramuscular Administration", Journal of Nutrition, 50:341-9, July, 1953.

[34] Calvin A. Lang and Bacon F. Chow, "Retention of Vitamin B-12 After Administration to Subjects of Different Ages", Federation Proceedings, 11:88, March, 1953.

Some observations of the metabolism of nineteen Jamaican children receiving Vitamin B-12 over a period of nine months showed a significantly higher plasma concentration in the B-12 group as compared to the control group. Also, when comparing children of a normal growth pattern in the experimental group with children of retarded growth in the same group, no marked differences were observed between them in their urinary excretion of Vitamin B-12 or in the rate of its removal from the plasma.[35] Thus, it might be said that growth patterns do not determine absorption and retention of Vitamin B-12.

Vitamin B-12 in Pernicious Anemia and Other Diseases. The discovery of Vitamin B-12 is inextricably related to the early efforts of physicians to find a remedy to cure or combat pernicious anemia.[36] Such a cure was indeed necessary, for, prior to 1927, this condition was "uniformly fatal as inoperable cancer, and with each new attack, the red blood count of patients with pernicious anemia would go lower;

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[35] S.T. Patrick, "Some Observation on the Metabolism of Vitamin B-12 by Jamaican Children", Journal of Nutrition,

[36] Minot and Murphy, loc. cit.

culminating in death within two to five years."[37] With the discovery and isolation of Vitamin B-12 in 1948,[38] physicians now had at their disposal a substance which they could effec--tively use in the treatment of pernicious anemia, and no longer would they have to rely solely on a liver-rich diet. The potency of Vitamin B-12 in effectively combating pernicious anemia is estimated to have a biological activity of 11,000 times that of standard liver extract.[39,40]

The next problem was to find out why certain people would get pernicious anemia and others wouldn't. Castle and associates were pioneers in determining the reason for this. They postulated that the development of pernicious anemia is dependent upon an inadequate gastric digestion of proteins, thus permitting a virtual deficiency of Vitamin B-12 in the face of a diet adequate for the normal man. Furthermore, they concluded that, in contrast to the condition

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[37] Anton J. Carlson and Victor Johnson, The Machinery of the Body, (Chicago: University of Chicago Press, 1953) pp. 102-4.

[38] Smith, op. cit., p. 195.

[39] Cooper, et. al., loc. cit.

[40] S.S. Kahn and R.J. Stave, "Nutrition in Medicine", Annual Review of Medicine, 1:127-52, 1950.

within the stomach of the pernicious anemia patient, there is found within the normal stomach some substance capable of promptly and markedly relieving the anemia of these patients during digestion of beef muscle.[41] Since Castle was instrumental in determining the why of pernicious anemia, he attached the term "intrinsic factor" to that condition which does not allow the patient with pernicious anemia to absorb the normal amounts of Vitamin B-12 found in the usual diet.[42] Confirmation has been given to Castle's conclusions in a later study made by Callender and Lagtha.[43]

In recent years several studies showing the positive effects of Vitamin B-12 supplements in the treatment of pernicious anemia have been carried on.[44,45,46] Ungley found,

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[41] William B. Castle, et. al., "Observation of Etiologic Relationships of Achylia Gastrica to Pernicious Anemia," American Journal of the Medical Sciences, 178:763, November, 1929.

[42] Ibid.

[43] Sheila T. Callender and L.J. Lagtha, "Nature of Castle's Hemapoietic Factor," Blood, 6:1239, December, 1951.

[44] Randolph West, "Activity of Vitamin B-12 in Addisonian Pernicious Anemia", Science, 107:398, April, 1948.

[45] M.C. Israels and S. Shubert, "The Treatment of Pernicious Anemia by Insufflation of Vitamin B-12", Lancet, 266:341-43, February, 1954.

[46] C.C. Ungley, "Vitamin B-12 in Pernicious Anemia: Parenteral Administration", British Medical Journal, 2:1370, December, 1949.

in the treatment of fifty-three patients with pernicious anemia intramuscularly, that small doses of 1.25 micrograms had little effect, but doses of 2.5 micrograms produced a definite small response. Larger doses produced still greater increases in the red blood cells in fifteen days.[47] In another study using normal individuals and patients with pernicious anemia in relapse, oral administration of one thousand micrograms of Vitamin B-12 showed no significant alteration in the serum concentration. When the dosage was increased to five thousand micrograms, the serum concentration in both groups was increased.[48] From the foregoing studies, one could conclude that smaller amounts of Vitamin B-12 are needed in the treatment of pernicious anemia when given intramuscularly as compared to oral administration: The difference being that when Vitamin B-12 is administered intramuscularly, it passes directly into the blood, whereas when it is given orally it must be absorbed into the blood stream.

The insufflation of Vitamin B-12 has also been used effectively as a means of treating patients with pernicious anemia.[49] The method involved the blowing of one-hundred

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[47] Ibid.

[48] W.R. Pitney and M.F. Beard, "Serum and Urine Concentrations of Vitamin B-12 Following Oral Administration of the Vitamin", The American Journal of Clinical Nutrition, 2: 94-5, March,April, 1954.

[49] Israels and Shubert, op.cit., p. 342.

micrograms of Vitamin B-12 into the nasal passage of anemic patients. It was first blown into the nose from one to three times daily, and later, twice weekly for maintenance. It was well tolerated locally, and the five patients used as subjects were successfully treated.[50] In light of these good results another method for the successful treatment of pernicious anemia has found its place in the medical field.

Vitamin B-12 has also found good use in the treatment of many other diseases. Specifically, some of these include diabetes mellitus,[51] spinal cord involvements[52,53] and recently poliomyelitis.[54] In the latter disease, early treatment with Vitamin B-12 as Rubiviton Bayer given to thirty-four patients prevented the onset of paralysis in twentv-six

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[50] Ibid.

[51] Salvatore M. Sancetta, Perry R. Ayres, and Ray W. Scott, "The Use of Vitamin B-12 in the Management of Neurologic Manifestations of Diabetes Mellitus, with Notes on the Administration of Massive Doses," Annuals of Internal Medicine, 35:1028-48, November, 1951

[52] F. Romeo, "Central Nervous Syndrome in Pernicious Anemia and Vitamin B-12", Nutrition Abstracts and Reviews, 21:735, January, 1952.

[53] Byron E. Hall, et al., "Vitamin B-12 and Coordination Exercises for Combined Degeneration of the Spinal Cord in Pernicious Anemia," Journal of the American Medical Association, 141:257-60, September, 1949.

[54] W. Daur, "Vitamin B-12 in the Treatment of Poliomylelitis," Nutrition Abstracts and Reviews, 25:239, January, 1955.

of the treated patients.[55] The author questions very much whether or not this can be contributed solely to the good effects of Vitamin B-12.

## Vitamin B-12 and Growth

Vitamin B-12 and Growth in Animals. It is well known that Vitamin B-12 is associated with growth in many species of animals.[56,57,58,59,60,61,62] The study of this

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[55] Daur, loc. cit.

[56] Arthur J. Hartman, Leslie P. Dryden, and Charles A. Cary, "A Role of Vitamin B-12 in the Normal Mammal," Archives of Biochemistry, 23:165, August, 1949.

[57] W.F. Cuthbertson and Doreen M. Thornton, "The Effect of Parenteral Nutrition on the Growth Response of the Rat To Vitamin B-12," British Journal of Nutrition, 5;xii, May, 1951.

[58] W.C. Sherman, et. al., "The Use of Depleted Rats For Investigation of Vitamin B-12 and Unidentified Factors," Journal of Nutrition, 55:255-63, February, 1955.

[59] J.E. Burnside et. al., "The Influence of Crystalline Aureomycin and Vitamin B-12 on the Protein Utilization of Growing and Fattening Swine", Journal of Animal Science, 13:184-200, 1954.

[60] A. Ferriot, J. Quentin and J. Robert, "Vitamin B-12 and Antibiotics in the Nutrition of Animals", Nutrition Abstracts and Reviews, 24:500, January, 1955.

[61] A. Trautman and Hill, "Vitamin B-12, Animal Protein Factors in Experiments on Pigs", Nutrition Abstracts and Reviews, 22:399, October, 1952.

[62] Charles A. Lassiter et. al., "Crystalline Vitamin B-12 Requirement of the Young Dairy Calf", Journal of Dairy Science, 36:592, 1953.

series made by Hartman and associates dealing with rats led to conclusions showing that Vitamin B-12 plays a fundamental role in affecting the capacity of normal mammals for utilizing protein.[63] Also, the growth of rats given a "deficient diet" improved greatly with supplements of Vitamin B-12.[64]

Burnside and his collaborators studied the effects of Vitamin B-12 when taken alone had little effect on growth, but when taken in combination, it improved utilization in all groups of pigs.[65] Positive effects of Vitamin B-12 on the growth of swine were noted by others, who concluded that the increased growth resulted not in additional fat, but in high quality pork and ham.[66,67]

A favorable effect of Vitamin B-12 on calves has also been observed.[68,69] Draper and his associates showed that calves kept on a diet lacking Vitamin B-12 ceased to

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[63]Hartman, et. al., op. cit., p. 167.

[64]Hartman, et. al., op. cit., pp. 166-67.

[65]Burnside, et. al., op. cit., p. 200.

[66]Ferriot, Quentin and Robert, loc. cit.

[67]Trautman and Hill, loc. cit.

[68]Harold H. Draper, J.T. Sime, and B.C. Johnson, "A Study of Vitamin B-12 Defieiency in the Calf", Journal of Animal Science, 11:332-40, June, 1953.

[69]Lassiter, et. al., loc. cit.

grow, demonstrated poor appetite, and exhibited poor co-ordination of movement.[70] With the addition of Vitamin B-12 orally, growth was renewed in some cases, whereas further addition of casein to the diet demonstrated all calves growing normally. This suggests that casein might supply something in addition to Vitamin B-12 essential for the normal development of the calf. The amount needed for maximum growth was set at forty micrograms.[71]

*Effects of Vitamin B-12 on Growth in Humans*. Over-nourishment and undernourishment have long been problems of first concern to both physicians and nutritionists. The effects of Vitamin B-12 on human growth have been studied quite extensively , especially in relation to malnourishment and growth failure. Some of the first studies have been those concerned with the effects of Vitamin B-12 on the growth of premature infants. Generally, the results of these studies have been rather discouraging in that they indicated that

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[70]Draper, Sime and Johnson, *loc. cit.*

[71]Lassiter, *loc. cit.*

Vitamin B-12 does not enhance the growth of premature infants.[72,73,74,75,76] In only one study did Vitamin B-12 seem to help the growth of premature children, and in that case only the larger ones seemed to benefit at all.[77] Due to the negative outcomes of these studies, it is the contention of one writer that routine administration of Vitamin B-12 to premature infants is not justified.[78]

In the diet of infants not premature, some interesting effects of Vitamin B-12 supplementation have been

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[72] F.J. Menchaca and D.S. Decorts, "Vitamin B-12 in Treatment of Premature Infants", Nutrition Abstracts and Reviews, 22:531, October, 1951.

[73] Daniel F. Dowing, "Failure of Vitamin B-12 to Promote Growth in Premature Infants," Science, 112:181, August, 1950.

[74] Robert F. Chinnock and Harvey W. Rosenberg, "Results of Administration of Vitamin B-12 to Newborn Infants", Journal of Pediatrics, 40:182-5, February, 1952.

[75] Henry Rascoff, Alla Dunewitz and Robert Norton, "The Weight Progress of Premature Infants Given Supplementary Feedings of Vitamin B-12, A Comparative Study", Journal of Pediatrics, 39:61-4, July, 1951.

[76] Laurence Finberg and Bacon F. Chow, "Lack of Effect of Supplementary Vitamin B-12 Administered to Premature Infants", American Journal of Diseases of Children, 84:165-7, August, 1952.

[77] Menchaca and Decorts, loc. cit.

[78] Finberg and Chow, loc. cit.

noted.[79,80,81,82] Salmi, in his study of the nutritional disturbances in infants, found "dramatical" improvement clinically in five hypotropic infants. Under Vitamin B-12 treatment the blood levels of protein, amino acids, iron and cholesterol reached normal levels.[83] In a group of malnourished infants, DeMezei observed beneficial effects of Vitamin B-12 supplements on eight patients.[84] Confirmation was given to this in a later study by Wilde when he observed an increase in the growth rate of seven Aleut infants treated with Vitamin B-12.[85]

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[79] L. Salmi, "The Effect of Vitamin B-12 in Chronic Nutritional Disturbances in Infants", Clinical Pediatrics, 32:617, November, 1953.

[80] M.B. DeMezei, "The Effect of Vitamin B-12 in Malnourished Infants," Archives of Argentina Pediatrics, 37:31, 1952.

[81] Edwin Wilde, "The Growth of Aleut Infants," Canadian Medical Association Journal, 68:70-1, January, 1951.

[82] Bacon F. Chow, "Sequelae to the Administration of Vitamin B-12 in Humans," Journal of Nutrition, 43:323-43, February, 1951.

[83] Salmi, loc. cit.

[84] DeMezei, loc. cit.

[85] Wilde, op. cit., p. 71.

Chow carried on an interesting experiment on the effects of Vitamin B-12 supplements upon sick children residing in a special home for the chronically ill.[86] Alternate admissions to this home received the Vitamin B-12 supplement or remained untreated. At the end of three months the weight gained by the treated was significantly the greater; however, there was a higher incidence of rheumatic and congential heart disease in the treated group.[87] This could be attributed to the fact that there was a greater number of such cases in the supplemented group at the start than in the unsupplemented group. If however, Vitamin B-12 actually enhanced these diseases, further studies should take a cognizance of these defects and not permit the affected subjects to partake in the experiments.

Vitamin B-12 supplementation has been found to be extremely useful in its application in promoting the growth

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[86] Chow, <u>Journal of Nutrition</u>, <u>op. cit.</u> pp. 341-2.

[87] <u>Ibid</u>.

of undernourished school children.[88,89,90,91,92,93] The initial experiment carried on in this field was by Wetzel and associates.[94] The experiment was carried in one of the large school systems in Cleveland, Ohio, where growth failure among some of the school children was plainly evident. The number of subjects in this first study was eleven, with three

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[88]Norman C. Wetzel, et. al., "Growth Failure with School Children as Associated with Vitamin B-12 Deficency--Response to Oral Therapy", Science, 110:651-3, December, 1949.

[89]G.C. O'Neil and A.J. Lombardo, "Vitamin B-12 in the Treatment of Malnutrition and Celiac Disease in Infants and Children", Journal of the Omaha Mid-West Clinical Society, 12:57, April, 1951.

[90]N.C. Scrimshaw and M.A. Guzman, "Effects of Dietary Supplements of Vitamin B-12 and Aureomycin on the Growth of Children of School Age," Nutrition Abstracts and Reviews, 24:429, April, 1954.

[91]Edwin Wilde, "The Treatment of Growth Failure in Aleut School Children", Journal of Pediatrics, 40:565-9, May, 1952.

[92]John W. Larcomb, Claude S. Perry and Robert A. Peterman, "Dietary Supplementation of Vitamin B-12 in Pre-Puberty School-Age Children: Growth Studies," Journal of Pediatrics.

[93]Norman C. Wetzel, et. al,, "Growth Failure in School Children. Further Studies of Vitamin B-12 Supplementation", American Journal of Clinical Nutrition, 1:17-31, September, October, 1952.

[94]Wetzel, et. al., Science, loc. cit.

being selected because of slow progress in growth, and the other eight selected at random from a group of seventy-six children being treated for varying degrees of malnourishment. Clinical examinations prior to the administration of Vitamin B-12 supplements revealed no characteristic abnormalities in the hair, skin, mouth or nervous system. With the addition of ten micrograms of Vitamin B-12 daily, beneficial results were noted in five of the treated children. This was shown by a rapid and dramatic improvement in growth and physical vigor, along with increased alertness, better behavior and increased appetite. Probably the most accurate of these observations was the increased appetite, which was evidenced by increased demands for "second helpings", as contrasted to comparatively indolent food habits prior to the supplementation.[95]

Statistically the effect of Vitamin B-12 on the weight of the five benefited school children was significant at the $p=0.01$ level of confidence at the end of the first three weeks and at the end of four weeks it was statistically significant at the $p=0.001$ level of confidence.[96] Confirmation

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[95]Wetzel, *et*. *al*., *Science*, *op*. *cit*. p. 653.

[96]*Ibid*.

has been given to Wetzel results in a similiar study by Wilde.[97] He observed the effects of Vitamin B-12 supplements on nine undernourished Aleut school children. After plotting each subject's previous growth progress, he noted, in seven of the nine schoolchildren an increased growth of 65.2 per cent over their previous growth rate.[98]

Vitamin B-12 growth experiments on undernourished school children have not been limited to one sector of the world. Scrimshaw and Guzman observed the effects of Vitamin B-12 supplements on the growth of undernourished school children residing in the urban and rural areas of El Salvador. Eighty children served as subjects. When comparing the treated children with the children in the same area having no supplement, an increase in height and weight was noted in the treated group. When the Vitamin B-12 supplements were withdrawn, the growth rates of the treated children were lowered.[99]

No positive effects of Vitamin B-12 supplements on the growth of school children have been reported in one

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[97] Wilde, Journal of Pediatrics, loc. cit. p. 568.

[98] Ibid.

[99] Scrimshaw and Guzman, loc. cit.

case.[100] The study was carried on in the famous "open air schools" of England, which are health centers for under-nourished school children. The subjects consisted of 418 British school children. Each subject received ten micro-grams of Vitamin B-12 on five days of the week for ten weeks. There was no greater gain in weight or height in the children receiving the Vitamin B-12 supplement than those receiving no supplement.[101] The study was continued because it was later learned that the Vitamin B-12 supplements of ten micro-grams were weakened to a potency of five micrograms by a sugar concentrate.[102]

In the second study the subjects were classified into those who were initially up to expected weight and those grossly underweight. In comparing the weight gained between the treated and the untreated in the grossly underweight group it was concluded that there was no difference, nor was there a difference in their heights or in their morbidity rates.[103] Although the work of Benjamin and Pirrie appears

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[100]B.Benjamin and G.D. Pirrie, "Vitamin B-12 by the Mouth", The Medical Officer, 87:137-40, April, 1952.

[101]*Ibid*. p. 138

[102]Benjamin and Pirrie, *loc. cit.*

[103]*Ibid*.

to be in conflict with the work of others in this area of nutrition, Wetzel claims that their findings are not incompatible with his.[104] Wetzel's reasons are not entirely clear, however it is felt in reviewing the two studies that the findings of Benjamin and Pirrie were based on the group as a whole,[105] whereas Wetzel based his good results only on the cases who had definitely benefited.[106] Therefore, the benefits of Vitamin B-12 supplementation would tend not to be so noticeable in the former study.

The effect of Vitamin B-12 on the growth of normal children[107,108] and adults[109] has shown no effect on weight gained. In light of this, Chow has established criteria for future growth studies. They state that a response depends on (1) a previous history of some kind of physiological stress resulting in retardation of growth from the subjects'

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[104]Wetzel *et al.*, *The Journal of Clinical Nutrition*, *op. cit.*, p. 31..

[105]Benjamin and Pirrie, *op. cit.*, p. 138.

[106]Wetzel *et al.*, *Science*, *op. cit.*, p. 653.

[107]Benjamin and Pirrie, *op. cit.*, p. 137.

[108]Henry J. Montoye *et al.*, "Effects of Vitamin B-12 Supplementation on Physical Fitness and Growth of Young Boys," *Journal of Applied Physiology*, 7:589-92, May, 1955.

[109]Gilbert M. Bayne and William P. Boger, "Vitamin B-12 Supplementation in the Diet of Healthy Adults," *The Journal of Clinical Nutrition*, 1:424-29, September-October, 1953.

expected pattern, (2) ad libitum feeding, and (3) distribution of calories in the dietary.[110] The conditions of the present experiment meet these requirements in that undernourished boys and those showing retarded growth were used as subjects, they were given ample opportunity to eat all they wanted, and an adequate diet was administered through the nutrition department of the state institution where the experiment was carried out.

Vitamin B-12 and Physical Performance

The armed services and industry are the two fields where the effects of vitamin supplements have been studied most extensively. As previously stated, the demands of World War II directly stimulated an interest in this approach of improving the physical performance of both the soldier and industrial worker. Concerning industry, a review in 1950 noted the work of Borsook and associates who studied the effects of vitamin supplements on over one-thousand workers at the Lockheed Aircraft Corporation at Burbank, California.[111]

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[110] Chow, Southern Medical Journal, op. cit., p. 610.

[111] "Vitamin Supplementation and Performance Capacity", Nutrition Reviews, 8:313-14, October, 1950, citing Melbank Memorial Fund Quarterly, 20:329, (1942); 21:115 (1943); 23:113 (1945); 24:99,251 (1946);

The subjects were divided at random into two groups; one receiving supplements given five days per week for nine to twelve months, while the other group was given a placebo. The need for appropriate controls is evidenced by the response to the direct question as to whether the subjects were receiving any benefits from the pills. Over seventy per cent of the men representing both groups reported benefits such as fewer colds, better appetite, general improvement in their feelings of well-being, and less eye discomfort.[112] Thus, the benefits of vitamin supplementation would appear null, since both groups claimed benefits.

The principal claim for the beneficial effects of the vitamin supplements was based on indirect indices of industrial morale and work performance.

During the first six months there were no significant differences in the absenteeism rates. However, in the second six months, the total absenteeism rate of the vitamin subjects was 3.90 days per 100 working days as compared to 4.79 days for the placebo subjects. The non-military termination of employment was somewhat higher in the placebo group than in the vitamin group, (13.4 and 8.4 per 100

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[112] *Ibid.*, p. 314.

employees respectively), but it did not reach the five per cent level of significance.

In addition to absenteeism rates and non-military terminations, the results of the Merit Review ratings were utilized in evaluating the effects of vitamin supplements. Each man was rated by his immediate supervisor on six characteristics; the rating scale for each characteristic being 1 to 8. The average overall Merit Review score at the end of the study was 6.22 for the placebo and 6.38 for the vitamin group. Although the difference was very small, it was considered to be highly significant statistically.[113] The results of this study give no index of an increase in output as a result of the vitamins. Therefore, the effects of vitamin supplements on the physical performance of the industrial worker are still to be determined, even though some evidence tends to show possible beneficial effects. Since the amount of research directly relating to this problem is very limited, the need for carefully controlled research in this area of vitamins and industrial performance is great.

The fact that the efficiency of any military unit depends on the maximal performance of each soldier had led

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[113]Ibid. p. 315.

to studies concerned with vitamins and performance.[114,115] One of the first studies was carried out by Keys and Henschel in 1942. The twenty-six soldiers used as subjects were given large daily supplements of thiamine chloride, nicotinic acid, calcium pantothenate, riboflavin, pyridoxine and ascorbic acid. These were given in daily doses over a period of four to six weeks alternating with equal periods of placebo administration. The men were repeatedly subjected to standardized severe physical exercise on a motor driven treadmill, and circulatory, metabolic and blood chemical responses to the imposed stress were measured. The specific characteristics studied were: pulse rate, heart size, stroke output of heart, oxygen consumption, respiratory quotient, urinary nitrogen and ketone body excretion, and concentration in the blood of lactate acid, sugar, hemoglobin and ketone bodies. "In neither brief but extremely severe exercise nor in prolonged hard physical work had vitamin supplementation a significant effect on the ability to carry on exhausting

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[114] Ancil Keys and Austin F. Henschel, "Vitamin Supplementation of U.S. Army Rations in Relation to Fatigue and the Ability to do Muscular Work", Journal of Nutrition, 23:259-67, March, 1942.

[115] Robert Ryer, et. al., "The Effect of Vitamin Supplementation on Soldiers Residing in a Cold Climate, Part I of Physical Performance and Response to Cold Exposure", American Journal of Clinical Nutrition, 2:97-131, March-April, 1954.

work or on recovery from exertion".[116] It was concluded that no useful purpose would be served by enriching the diet of the present United States Army garrison with the vitamins studied.[117]

Even with these discouraging results, within recent years Ryer and associates have carried on a study specifically designed to determine whether the functional capacity of a soldier exposed to a cold environment might be improved by supplements of ascorbic acid and of B-complex vitamins.[118] The subjects in this study consisted of eighty-six volunteer army personnel. The experiment was carried out for a period of ten weeks with the subjects randomly divided into two groups, the supplemented and the placebo. The forty-two men who served as subjects in the placebo group each received a brown capsule containing six mg. of ascorbic acid four times daily. The supplemented group consisted of forty-four men, who each received an orange colored capsule four times daily. Each capsule provided the following ingredients: thiamine (10 mg.), riboflavin (10 mg.), niacinamide (100 mg.),

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[116] Keys and Henschel, *op. cit.*, p. 267.

[117] *Ibid.*

[118] Ryer, *et. al.*, *loc. cit.*, p. 97.

calcium pantothenate (80 mg.), pyridoxene (40 mg.), folacin acid (2.5 mg.), ascorbic acid (300 mg.), and Vitamin B-12 (4 mcg.).

Measurements of physical performance were made at weekly intervals during periods of calorie adequacy of 3,500 calories the first six weeks and a calorie deficit of 2,250 calories daily during the last three weeks. Motivation was offered through recognizing individual excellence and by having competition between platoons. Lighter clothing was worn, and the barracks fires were blanketed to promote stressing conditions. The conclusions showed that there were no statistical differences between the two experimental groups in the scores attained on the Harvard Step Test, the army physical fitness test, the performance with the hand dynamometer, a standardized forced march, or a contest march. Also a battery of six psychological tests failed to reveal any differences between the two study groups.[119]

Due to the negative results of studies related to the effect of vitamin supplements on physical performance, the following summarizing statement was made.

> Until convincing evidence is presented to the contrary, it seems reasonable to assume that maximal physical performance can be expected of industrial workers or of soldiers if they are provided adequate diets

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[119] Ryer, et.al., Ibid., pp. 130-131.

> consisting of natural foodstuffs and the specific nutrients inherently contained therein, providing account is taken of the total energy requirement of the individual under prevailing circumstances of physical exertion and of environment.[120]

Although such a statement might hold true with most known vitamins, it is felt that increased study should be carried on using different approaches to the problem and also utilizing some of the more recently discovered vitamins.

To the experimentor's knowledge there have been only three studies directly related to the effects of Vitamin B-12 on physical performance; one being concerned with back, leg and grip strength,[121] and the other two with its effect on endurance.[122,123] The former study was a continuation of a previous study by Wetzel, but included, in addition to an index of growth, a measurement of physical performance. Physical performance was measured by a comparison of leg, grip, and back strengths taken at weekly intervals for

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[120] Vitamin Supplementation and Physical Performance," _Nutrition Reviews_, 13:104, April, 1955.

[121] Wetzel, _et_. _al_., _American Journal of Clinical Nutrition_, _loc_. _cit_.

[122] Montoye, _et_. _al_., _Journal of Applied Physiology_, _loc_. _cit_.

[123] Montoye, _et_. _al_., "The Effects of Vitamin B-12 on Work Capacity," _Arbeitsphysiologie_, 16:20-4, October, 1954.

durations of six and sixteen weeks. The 236 subjects were divided into four groups. One represented a control group of normal children. Two groups represented those with growth failure, who were given the Vitamin B-12 supplements. (One group was supplemented for six weeks and the other for sixteen). The final group represented the unsupplemented subjects exhibiting growth failure. Although there was an increase in general sense of well-being in the supplemented groups, there was no definite correlation between the growth response to Vitamin B-12 and the physical performance as measured by back, leg or grip strength.[124]

Since this is the only known study related directly to the effects of Vitamin B-12 supplementation on physical performance, and since it covers only a limited number of tests measuring physical performance, another study is warranted. Also it is felt that the main purpose of Wetzel's study was to further substantiate the results of his first study,[125] that is, the stimulating effect of Vitamin B-12 on growth. To further support this contention, the author,

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[124] Wetzel, et. al., American Journal of Clinical Nutrition, op. cit., p. 28.

[125] Wetzel, et. al., Science, op. cit., pp. 651-3.

in reviewing the report on Wetzel's study, found that little was mentioned concerning the procedure of testing the subjects used. In light of this, the conclusions of the study raise a question in the author's mind, and indicate a need for this study.

Montoye and his co-workers made an initial study of the effects of Vitamin B-12 supplementation on the endurance of young boys.[126] The subjects were fifty-one boys between the ages of twelve and seventeen, who resided in a state correctional institution. They were divided into three groups as follows: (1) the Vitamin B-12 group of sixteen boys, (2) the placebo group of sixteen boys, and (3) the control group of nineteen boys. Every day for seven weeks, each boy in the Vitamin B-12 group received one capsule containing fifty micrograms of B-12. The placebo group received an identical blank capsule, while the control group received no supplementation. The Harvard Step Test was administered at the beginning and end of the experiment. Also, the Vitamin B-12 and placebo groups ran the half-mile three times per week. Although there was a shift in the channels on the Wetzel Grid made by both groups, (B-12 and placebo), toward more

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[126]Montoye *et al.*, *Journal of Applied Physiology*, *loc. cit.*

linear body builds, there was no significant difference in the changes made by placebo subjects as compared to those supplemented by Vitamin B-12 in either the Harvard Step Test scores, half mile running time, or in weight and height. However, in the few thin subjects, ($B_1$ channel, Wetzel Grid), weight loss was less in the B-12 subjects than in those receiving placebos.[127]

An interesting study of the effect of Vitamin B-12 on the work capacity of three normal young men has been completed.[128] The subjects were tested daily except Sundays at nearly the same time early each morning. On reporting to the laboratory, each subject's grip strength was taken five times, and each rode a frictional bicycle ergometer at ten miles an hour for one minute. Four pounds of resistance was used, and the pulse recovery was counted from one to one and a half minutes after the completion of the exercise. After a rest of about fifteen minutes, each subject then rode "all out" at the same speed and resistance until he could no longer maintain the required speed. The performance effort of each subject was recorded in seconds.

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[127] Ibid., p. 592.

[128] Montoye, et. al., Arbeitsphysiologie, op. cit. pp. 21-3.

Vitamin B-12 administration did not start until after four weeks of training. Then during the following four weeks Vitamin B-12 was administered alternately every other week with placebo capsules. A graphic plotting of the scores showed no effect of the Vitamin B-12 supplements on the work capacity of the three subjects as measured by grip strength, pulse rate recovery following a standard exercise, or maximum work on a bicycle ergometer.[129]

In retrospect, the results showing the positive effects of Vitamin B-12 supplements,[130,131,132] or other vitamins [133,134,135] on one's physical performance have been rather discouraging. The probable reasons for this lack of effect of additional vitamin supplements on one's physical performance are: (1) that the subjects used in these experiments have been normal, healthy individuals and that (2) these same healthy individuals were receiving adequate amounts

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[129] Ibid.

[130] Wetzel, et. al., American Journal of Clinical Nutrition, op. cit., pp. 17-31.

[131] Montoye, et. al., Arbeitsphysiologie, loc. cit.

[132] Montoye, et. al., Journal of Applied Physiology, loc. cit.

[133] Ryer, et. al., loc. cit.

[134] Keys and Henschel, op. cit., pp. 259-57.

[135] "Vitamin Supplementation and Performance Capacity," Nutrition Reviews, 8:312-7, October, 1950.

of the experimental vitamins in their regular daily diet so that additional amounts were not necessary for the promotion of optimum performance. In light of this, and since there has been only one limited experiment[136] concerning the effects of Vitamin B-12 on the physical performance of undernourished individuals it is felt by the investigator that future studies along this line should include experiments related to the effects of vitamin supplementation on the physical performance of undernourished individuals, which is the purpose of this study.

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[136]Wetzel, _et_. _al_., _American Journal of Clinical Nutrition_, _loc_. _cit_.

# CHAPTER III

# METHODOLOGY

One of the first and most pertinent considerations in a study involving growth failure of young boys is the determination of those individuals who fall in such a group. The author was indeed fortunate in this respect, for age, height, and weight records were kept on file in the athletic director's office of the Boys Vocational School, where the experiment was to be carried out. By checking these records, prospective subjects were easily determined by replotting their respective heights and weights on the Wetzel Grid and also by checking for growth failure in stunted boys by merely plotting their growth in accordance with their age and developmental level. In the latter respect, the investigator was again fortunate, for in the existing institutional organization, all small boys were grouped in the same cottage, thus facilitating the process of determining those boys who were extremely small for their age.

## Experimental Design

Boys, between the ages of twelve and seventeen, residing in a State Correctional Institution were the twenty-seven subjects used in this experiment. Two of these cases were later dropped; one because of an emergency, which permitted him to leave before a final testing could take place and the other because of insufficient time in the experiment. Two of the twenty-five remaining subjects were cardiac cases. They took part in all the tests except the Harvard Step Test and the half-mile run.

Once the subjects were selected on the basis of growth failure, they were divided into five groups according to the degree of their growth failure as indicated by their respective plottings on the Wetzel Grid. The five groups were: (1) $B_2$ borderline, (2) $B_2$, (3) $B_2$-$B_3$, (4) $B_4$, and (5) four stunted subjects. The latter four cases were determined by their growth plottings on or near the 98 per cent auxodrome, The subjects in each group were then randomly divided into the experimental and control groups. The two twins in the study were placed in opposite groups. Late arrivals who classified as subjects were admitted alternately into the B-12 or placebo groups.

The first testing took place in the field house of the institution on the two successive days after the subjects had been determined. The order of the test administration on the first day was height, weight, Harvard Step Test (modified), chins, dips and the vertical jump. On the second day the order of testing was grip strength, push and pull strength, back and leg strength and lastly the half-mile run. On one occasion, the half-mile run was scheduled on a third successive day. The subjects wore their street shoes and with no trousers for all tests except the half-mile run, when gym shorts and tennis shoes were worn.

Records were kept of the weather and the conditions of the track with a conscious effort made to test under similar conditions. Since the first testing of the half-mile run was carried out in early April, the track was a bit soggy in places. The final testing to be used for statistical comparisons was carried out in exactly the same manner. Dr. Henry J. Montoye, a specialist in tests and measurement, administered some of the more difficult tests, as he did in the initial testing. At no time did he or the other helpers know which boys were in the experimental or control groups. Also, during the times when the author tested the subjects, he did not know which boys belonged in which group. A bias was further curtailed by encouraging all subjects to give a maximum performance.

At the completion of each subject's first testing, a fifty microgram capsule (Vitamin B-12 or placebo) was administered daily to each subject, according to the group in which he belonged. The distribution of capsules took place at the field house between eight and nine o'clock in the morning on Monday through Friday. The subjects were watched to see that they swallowed the capsules. On week-ends, the capsules were sent to each subject's respective cottage where the cottage parents, who were informed of the purpose and importance of the daily supplementations, supervised the distribution of the capsules. Explicit instructions concerning the administration of the capsules were written on each envelope containing the week-end supply. A simple check to determine whether the capsules were distributed was noted by inspecting the returned cottage envelopes.

During one phase of the study several days were missed because of an unforeseen difficulty in securing a new supply of capsules. This was compensated for by double doses on the following four days. The regimentation that characterized the daily program of the institution provided an excellent climate for this study. As a part of the regimentation, all boys were required to attend physical education classes daily. Regular meals and regular hours of sleep further provided an ideal climate for this experiment.

## Explanation of Wetzel Grid[1]

The main purpose of the Grid is well described in the words of Wetzel, its orginator, who states;

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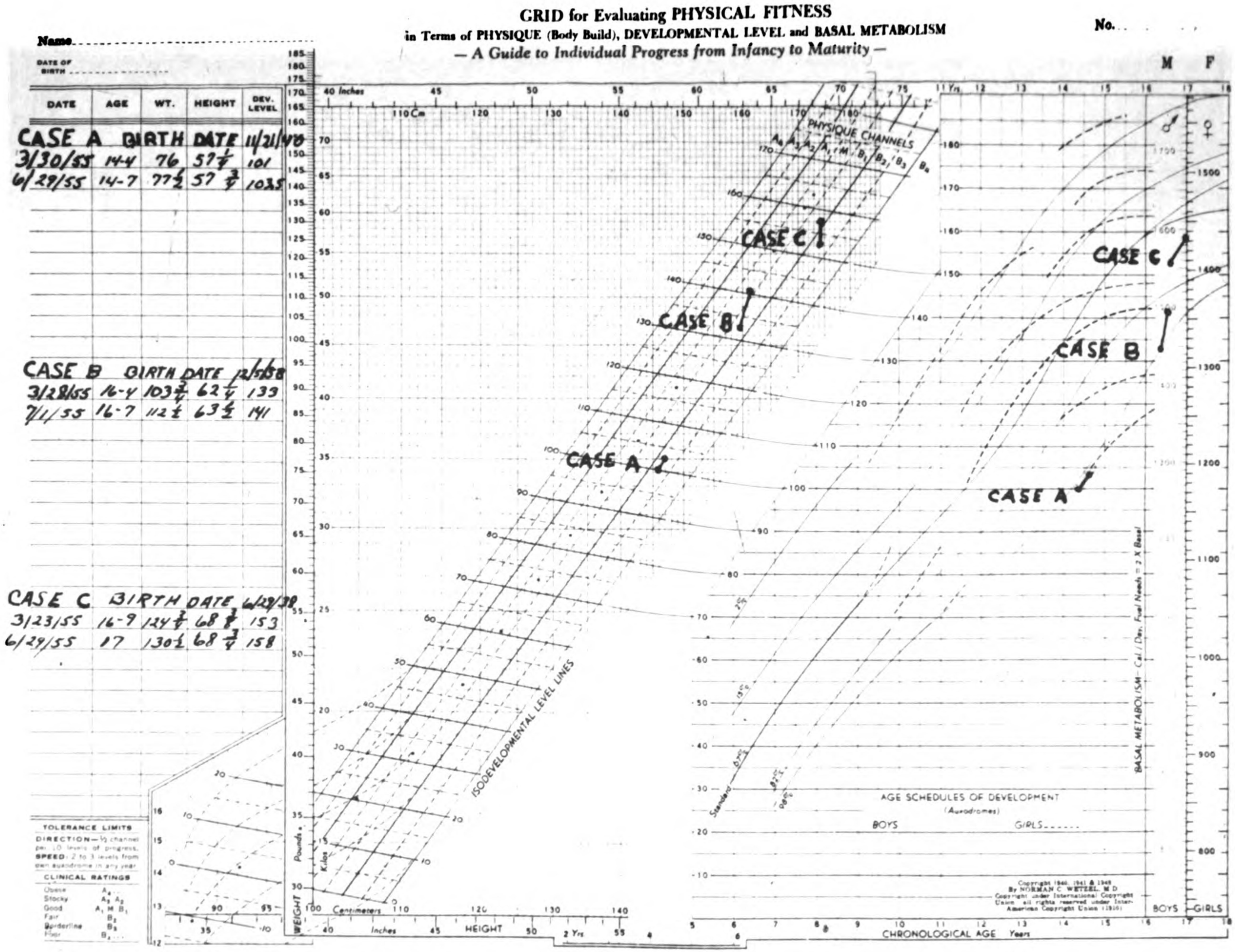
[1]See Figure I on the following page.



GRID for Evaluating PHYSICAL FITNESS
in Terms of PHYSIQUE (Body Build), DEVELOPMENTAL LEVEL and BASAL METABOLISM
— A Guide to Individual Progress from Infancy to Maturity —
Name
No.
DATE OF BIRTH
DATE
AGE
WT.
HEIGHT
DEV. LEVEL
CASE A BIRTH DATE 11/21/40
3/30/55 14-4 76 57 1/4 101
6/29/55 14-7 77 1/2 57 3/4 103.5
CASE B BIRTH DATE 12/5/38
3/28/55 16-4 103 3/4 62 1/4 139
7/1/55 16-7 112 1/4 63 1/2 141
CASE C BIRTH DATE 6/29/38
3/23/55 16-9 124 3/4 68 3/4 153
6/29/55 17 130 1/2 68 3/4 158
TOLERANCE LIMITS
DIRECTION—½ channel per 10 levels of progress.
SPEED: 2 to 3 levels from own auxodrome in any year.
CLINICAL RATINGS
PHYSIQUE CHANNELS
CASE C
CASE B
CASE A
ISODEVELOPMENTAL LEVEL LINES
WEIGHT
Pounds
Kilos
HEIGHT
Centimeters
Inches
AGE SCHEDULES OF DEVELOPMENT
(Auxodromes)
BOYS
GIRLS
BASAL METABOLISM—Cal / Day; Fuel Needs = 2 X Basal
CHRONOLOGICAL AGE Years
BOYS
GIRLS
M
F


FIGURE 1

> The whole purpose of the Grid is to reveal the operating physical conditions of a child regarded as a functioning unit. It does so whether this be failure or not, by pictorializing growth in tangible terms, and even more, by supplying a simple method of measureing growth quality. As a result, one may quickly decide when growth is good enough to be called 'acceptable' and bad enough to be called 'unacceptable'.[2]

In the actual administration of the Grid one only needs to know the weight, height and age of the subject. The most widely used phase of the Grid consists of plotting each subject's weight and height on the vertical and horizontal axis of the Grid respectively, and at the point of intersection[3] one's growth status can be ascertained according to established standards. Wetzel has divided these standards into physique channels numbering them $A_4$, $A_3$, $A_1$, M, $B_1$, $B_2$, $B_3$, and $B_4$, with A and B denoting above and below middle M respectively. The various channels distinguish children of different body type or physique, with the stocky to the left of center, $A_4$, $A_3$, $A_2$; the medium build children in the three center channels, $A_1$, M, and $B_1$; and those of increasing slenderness in channels $B_2$, $B_3$, and $B_4$.[4] Wetzel further recommends that those children who plot in the last three

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[2]Norman Carl Wetzel, The Treatment of Growth Failure in Children, An Application of the Grid Technique, (Cleveland: N.E.A. Services, 1948), p.v.

[3]Figure 1, Case A, B, and C.

[4]Wetzel, op. cit. p. 12.

mentioned channels, should be considered as subjects who need improvement nutritionally.[5] An example of this would be Case A and C[6] who orginally plot in channel $B_2$. All such cases, who, after exact weight and height measurements, plotted in any of these three channels ($B_2$, $B_3$, and $B_4$) were used as subjects in this experiment. Cases to the other extreme ($A_4$ and $A_3$) although nutritional problems in that they represent individuals who tend to be overweight, were not considered in this study since it is primarily concerned with the growth progress and physical performance of undernourished boys.

Another valuable fact of the Grid lies in its ability to detect individuals who represent another type of growth failure, namely those individuals who are very small when compared to others of the same age. Individuals who fall in this group can be determined by following and interpolating (if necessary) the developmental lines which cross the physique channel plotting. By following one's closest developmental line, which runs horizontally to the right of the Grid, and intersecting it with one's vertical line which represents the subject's chronological age, advancement or

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[5] Ibid.

[6] Figure 1, Case A. and C.

retardation in growth can be determined by noting where the point of intersection lies on the "auxodromes". These "auxodromes" indicate various schedules which children follow in their growth progress. For example, Case B at the right of the Grid, Figure 1, page 52 , orginally plots on the 98 per cent auxodrome. This indicates that the subject is retarded in growth about two and one half years when compared to the growth of another individual of different age who plots on the standard 67 per cent auxodrome at the same developmental level. It should be noticed that the physical channel plotting of Case B is normal, but growth failure can be detected by considering his age as another factor.

Basically, the function of the channel graph is to determine direction of growth, and that of the "auxodrome" graph is to determine speed of development. In relationship to speed of development, all boys who plotted on or near the 98 per cent auxodrome were considered as indicating abnormal growth and were used as subjects in this experiment.

## Calibration of the Scales

In a growth study such as this, a high premium is placed on accurate weight and height measurements. Therefore, all subjects through out the experiment were weighed and measured for height wearing only shorts. Consistency in measuring the exact height of each individual was not a problem for the height instrument was stable and of high quality with the inches clearly marked out in quarters on a white wall. To insure an accuracy and consistency in the weight measurements of all subjects included in this experiment, a calibration of the scales was carried out prior to each weighing.

The process of calibration required that one-hundred and fifty pounds of weight lifting equipment be brought from the field house of the correctional institution, where the weighing would take place, to Michigan State University where the weights were weighed in kilograms on the nutrition scales available there. These scales are used constantly by the nutrition department, with checking and calibration carried on periodically. Since the scales were recently calibrated, actual weight measurements were made of each of the weights. The weights consisted of two barbells marked fifty pounds, two barbells marked twelve and one-half pounds, two barbells marked ten pounds and one barbell which was marked five pounds.[7] The total marked weight of the barbells was one-hundred and fifty pounds. It was felt that all boys used in this experiment would fall somewhere in the range of from fifty to one-hundred and fifty pounds.

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[7]See Table I, column one.

As each barbell was weighed and recorded in kilograms, grooves were scratched on each weight to distinguish one from the other. The kilogram recordings were then converted in pounds as shown in Table I on the following page. The importance of distinguishing one barbell from another is clearly evidenced by a discrepancy of nearly five pounds between the two marked fifty pound barbells.[8]

Once knowing the actual weight of each barbell, or a combination of barbells, it was a simple task prior to each weighing to calibrate the scales. Using the fifty-one pound barbell as one division, and also other combinations of actual weight barbells for other divisions, the error for each division was easily determined by taking the difference between the actual weight at these divisions and the registered weight of the barbells at these divisions. It was then added or subtracted as a correcting measure according to whether the registered weight of the barbells was greater or less than the actual weight at the respective division. In this experiment the registered weight was always greater than the actual weight at these divisions, therefore, the error of correction was always subtracted in the weighing of the subjects. Since the correction error was not the same at all

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[8]See Table I, column three.

TABLE I

ACTUAL WEIGHT OF BARBELLS AS MEASURED BY THE CALIBRATED NUTRITION SCALES OF MICHIGAN STATE UNIVERSITY

| Weight Number | Classified (pounds) | Actual Weight to nearest quarter pound |
|---|---|---|
| I | 50 | 51 |
| II | 50 | 46 |
| III | 12.5 | 12.5 |
| IV | 12.5 | 13 |
| V | 10 | 9.75 |
| VI | 10 | 9.75 |
| VII | 5 | 4.5 |

divisions of actual weight, the correctional difference closest to the registered weight of the subject was used for correctional purposes in the determination of his actual weight. Table II on the following page shows the daily weight corrections as have been discussed.

## Explanation of the Tests

The tests used in this experiment were selected on the basis that they would give the experimenter an overall view of some of the various factors that are known to be related to one's physical performance. The tests selected for this purpose were the Harvard Step Test, chins, dips, vertical jump, and the half-mile run. Others included tests of grip strength, push and pull strength, and back and leg strength. In order that the reader may understand the purpose and technique involved in each test, a brief discussion of the aforementioned tests will be presented in the following paragraphs.

The Harvard Step Test:[9] The first test administered to all the subjects, except two who were cardiac cases, was a modified Harvard Step Test. The test was modified in that

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[9]Lucien Brouha, "The Step Test: A Simple Method of Measuring Physical Fitness for Muscular Work in Young Men," Research Quarterly, 43:31-35, March, 1943.

TABLE II

DAILY WEIGHT CORRECTIONS AS DETERMINED BY THE DIFFERENCES BETWEEN THE ACTUAL WEIGHT AND RECORDED WEIGHT OF BARBELLS

| Date | Recorded weight of barbells in pounds at their actual weight divisions | | | |
|---|---|---|---|---|
| | 51 | 76.5 | 97 | 122.5 |
| 3/23/55 | 51.5 | 78.5 | 98 | 123.5 |
| 3/28/55 | 51.5 | 77.25 | 97.5 | 123 |
| 4/7/55 | 52.5 | 78.25 | 99 | 124.25 |
| 5/3/55 | 51.5 | 77.25 | 98 | 123 |
| 5/4/55 | 51.5 | 77.25 | 98 | 123 |
| 5/16/55 | 51.5 | 77.25 | 98 | 123 |
| 6/1/55 | 55.25 | 81.25 | 101.5 | 127.75 |
| 6/2/55 | 51.5 | 77.5 | 97.5 | 123 |
| 6/6/55 | 51.5 | 78.25 | 98 | 123.25 |
| 6/11/55 | 51.25 | 77.5 | 97.75 | 123 |
| 6/14/55 | 52 | 77.5 | 98 | 123.5 |
| 6/17/55 | 51.5 | 77.25 | 97.5 | 123 |
| 6/29/55 | 54 | 80 | 101 | 126.5 |
| 7/1/55 | 51.5 | 77.5 | 98 | 123.5 |
| 7/13/55 | 55 | 80.75 | 101 | 126.25 |
| 8/3/55 | 51.75 | 78 | 98.25 | 123.75 |

only one pulse count was taken after the five minute stepping period. Also a step sixteen inches high was used instead of the prescribed twenty inch step. The test consisted of stepping up onto a sixteen inch platform at a rate of thirty times per minute.[10] Prior to the administration of the test, explicit instructions were given concerning the technique involved. The subjects were then allowed to practice the rhythm (up, 2, 3, 4) which was counted out by the administrator at a cadence of thirty times per minute. During the actual administration of the test the cadence was also counted. The pulse reading was then taken from one to one and one-half minutes immediately following the end of the stepping.

This test measures "the general capacity of the body, and, in particular, the cardiovascular system, to adapt itself to hard work and to recover from what it has done."[11] In using this test, an index of each subject's general fitness as well as his cardiovascular fitness is available.

The physical education program provides one of the most useful fields for its application because through its administration the fit can be separated from the unfit and

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[10] Ibid. p. 33

[11] Ibid. p. 31

a program of physical training can be geared to each group, according to its respective capacities and needs. Thus an individual will not be placed in a group of greater skill where he has little opportunity for success, and conversely, the individual with greater skill will not be retarded in his performance because of his association with a group of lesser skill.[12]

Chin and Dip Tests:[13] The chief purposes of the chin and dip tests were to measure arm and shoulder strength, particularly, the biceps and triceps muscle group. The technique used by all subjects was an overhand grip on an eight foot horizontal bar. One complete chin was recorded for each time the subject, after grasping the bar, pulled his body upward until his chin was even with or above the bar. In this way, the process was repeated as many times as the subject could perform. A "kip" motion was not allowed nor were other chins that weren't performed in the prescribed fashion.[14]

The performances of each subject on the dip test were

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[12] J. Roswell Gallagher and Lucien Brouha, "A Simple Method of Testing the Physical Fitness of Boys," Research Quarterly, 43:23-30, March, 1943.

[13] Charles Harold McCloy and Norma Dorothy Young, Tests and Measurements in Health and Physical Education, (Third edition; New York: Appleton Century-Crofts Inc., 1954), pp. 150-1.

[14] For more complete details refer to McCloy and Young, p. 151.

recorded similarly, that is, only when complete and correct A complete dip was made on the parallel bars when the subject lowered his body to the point where an angle of ninety degrees or less was formed by the elbows in the dipping process, and then from this point pushing the body upward until the arms were completely extended.[15,16] In all tests each subject was encouraged to do his best. The competition between subjects generally enhanced optimum performance throughout the testing.

Vertical Jump: The primary purpose in the administration of this test was to obtain some index of each subject's muscular power.[17] Its derivation is based on the principle,as McCloy aptly states, that "Whenever a person projects his body or external object through space, power, which is the product of force (strength) and velocity, is involved."[18] The method of administration as used in this experiment was the "wet finger" variation of the Chalk

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[15]McCloy and Young, op. cit., p. 150.

[16]For more complete details refer to McCloy and Young, p. 150.

[17]Paul A. Hunsicker and Henry J. Montoye, Applied Tests and Measurements in Physical Education, (New York: Prentice-Hall Inc., 1953), pp. 75-77.

[18]McCloy and Young, op. cit., p. 66.

Jump.[19,20]

Grip Strength: A simple grip dynamometer which was recently calibrated was employed to measure grip strength.[21,22] Using carbonated magnesium, to prevent the hands from slipping, each subject gripped the hand dynamometer first with the right hand and then with the left hand, completing the cycle twice. The best grip strength effort of each hand was added together and later compared with the sum of the best right and left grip efforts in the final testing.

Push and Pull Strength: The purpose of this test was to determine to some degree each subject's pulling and pushing strength, or more specifically, the strength of the pectorali major (push) and lastissmus dorsi (pull) muscle groups. Using the push and pull attachment,[23] the hand

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[19]Hunsicker and Montoye, loc. cit.

[20]For graphic description and explanation, see Hunsicker and Montoye, pages 75-77.

[21]Hunsicker and Montoye, op. cit., pp. 53-55.

[22]For graphic description and administration of the test refer to Hunsicker and Montoye, pages, 53-55.

[23]A photograph of attachment appears in McCloy and Young, page 151.

dynamometer is placed between its jaws. The technique involves the placing of the palms of the hands facing each other at the height of the chest, and, with forearms almost horizontal, the subject is instructed to grasp the handles of the push-and-pull attachment, and push on the handles as vigorously as possible.[24] The position of the hands for the pulling strength are the same as those for the pushing strength, but the subject is instructed to pull as vigorously as possible.[25]

Back and Leg Strength: The back and leg dynamometer was employed to measure each subject's strength in these respective areas of the body. Carbonated magnesium was again rubbed on each subject's hands prior to the administration of the back dynamometrical strength test. The test was administered as described by Hunsicker and Montoye.[26] Using the same dynamometer the leg strength test was administered according to the method described by the previously cited authors.[27]

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[24] Ibid.

[25] Ibid.

[26] Hunsicker and Montoye, op. cit., pp. 55-57.

[27] Ibid. pp. 56-57.

Half-Mile Run: A study of physical performance should include some test of endurance. The half-mile run was selected for this purpose. It was thought that the test would not be so severe that the subjects would not finish because of lack of training, nor was it so easy that the endurance of each subject would not be taxed. The method used in the first running, which included the bulk of the subjects, was the dividing of the subjects into two groups with each subject in each group having a partner in the opposite group. Thus by running one group at a time, and with the instructor calling the time in seconds as the runners crossed the finish mark, the times were recorded for the subjects by each one's partner who was not running. These times were reported immediately at the end of the first running, and the second group was run through the same procedure.

In the subsequent testings only one, two and three subjects were run at a time. Therefore, the competitive conditions which make for better performance were not always present. However, it was felt that since alternate admissions into the experiment went into either the Vitamin B-12 or placebo groups, such discrepancies which might arise would have little effect on the final analysis of the data. The one subject who dropped out before completing the run was not used in the statistical analysis.

Organization and Analysis

An individual data sheet was kept on each subject in the experiment. At the completion of the second testing of each subject, his growth and physical performance measurements were tabulated on a tabulation sheet.[28] All the subjects were in the experiment for a period of two to three months, except one, who was in for a seven week period. Because of the differences in the amount of time of each subject in the experiment, the mean change in growth and physical performance was computed on a weekly basis.

Since there were only twelve subjects in the experimental group and thirteen subjects in the control group, the Student "t" or small sample technique was used in comparing the weekly mean changes in growth and physical performance of each group. Also the Student "t" was used to compute whether there were significant differences in the mean initial scores of the two groups. The significance of "t" was determined by entering the "t" table with twenty-three degrees of freedom. In computing the "t" for the half-mile run and Harvard Step Test, twenty and twenty-one degrees of freedom were used respectively.

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[28]See appendix, Table VIII and Table IX.

In order to test whether the two groups under comparison came from the same population with respect to variance of scores, the F test was applied. When the F test was significant at the 0.05 level, the Vitamin B-12 and placebo groups were not combined in computing the "t" for general improvement. When the F test was not significant in the comparisons of the weekly mean changes of the Vitamin B-12 with the placebo, the two groups were combined, to determine the significance of general improvement in growth and physical performance.

## CHAPTER IV

## RESULTS

An analysis of the data showed there were no significant differences in the mean initial measurements of growth and physical performance between the Vitamin B-12 and placebo groups as indicated in Table III. In further observing Table III, one will notice that the initial height and weight measurements of the placebo group are a little greater than those of the Vitamin B-12 subjects. This probably, in part, accounts for the better showing that the placebo group made in its initial physical performance measurements of strength.

In a comparison of the weekly mean changes in growth between the two groups, no significantly greater improvements in one group over the other are evidenced by the "t" values in Table IV. It is interesting to note that the Vitamin B-12 group had a higher weekly mean increase in height than the placebo group (.07 to .05 inches), while the placebo group had a higher mean weight gain per week than the Vitamin B-12 group(.253 to .190 pounds). The "t" values for developmental level, percentile, and channel shift are small when comparing the two groups. This again indicates the lack of effect of Vitamin B-12. This is a logical outcome because the differences in height and weight changes are insignificant. The

TABLE III

COMPARISON OF VITAMIN B-12 AND PLACEBO GROUPS IN MEAN INITIAL MEASUREMENTS OF GROWTH AND PHYSICAL PERFORMANCE

| Growth and Performance Category | VITAMIN B-12 Initial Mean Measurement | N | PLACEBO Initial Mean Measurement | N | Student "t" | $P_t$ |
|---|---|---|---|---|---|---|
| Height (inches) | 64.57 | 12 | 65.98 | 13 | .713 | >.1 |
| Weight (pounds) | 107.73 | 12 | 114.58 | 13 | .192 | >.1 |
| Developmental Level) | 136.12 | 12 | 142.85 | 13 | .890 | >.1 |
| Percentile | 77.50 | 12 | 79.83 | 13 | .419 | >.1 |
| Harvard Step Test (pulse recovery rate) | 58.00 | 10 | 58.38 | 13 | .140 | >.1 |
| Chins | 3.42 | 12 | 4.46 | 13 | .958 | >.1 |
| Dips | 2.88 | 12 | 1.96 | 13 | -.986 | >.1 |
| Vertical Jump (centimeters) | 34.92 | 12 | 34.00 | 13 | -.306 | >.1 |
| Sum of Best Right and Left Grip Strength (pounds) | 153.25 | 12 | 175.77 | 13 | 1.301 | >.1 |
| Push Strength (pounds) | 78.83 | 12 | 77.38 | 13 | -.234 | >.1 |
| Pull Strength (pounds) | 56.75 | 12 | 63.54 | 13 | .931 | >.1 |
| Back Strength (pounds) | 220.42 | 12 | 244.85 | 13 | 1.051 | >.1 |
| Leg Strength (pounds) | 449.33 | 12 | 480.00 | 13 | .598 | >.1 |
| Half-Mile-Run (seconds) | 196.56 | 9 | 187.54 | 13 | .918 | >.1 |

## TABLE IV

### COMPARISON OF VITAMIN B-12 AND PLACEBO GROUPS IN WEEKLY MEAN CHANGES IN GROWTH DURING EXPERIMENTAL PERIOD

| GROWTH CATEGORY | VITAMIN B-12 | | PLACEBO | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean Change Per Week | Number | Mean Change Per Week | Number | "t"* | $P_t$ | F | $P_f$ |
| Height (inches) | .070 | 12 | .050 | 13 | -1.474 | >.1 | 1.10 | >.1 |
| Weight (pounds) | .190 | 12 | .253 | 13 | .456 | >.1 | 4.49 | <.05->.01 |
| Developmental Level | .199 | 12 | .235 | 13 | .303 | >.1 | 2.57 | >.1 |
| Percentile | -.2058 | 12 | -.2061 | 13 | .001 | >.1 | 1.05 | >.1 |
| Channel Shift (toward stockier build) | .0046 | 12 | .0101 | 13 | .335 | >.1 | 4.00 | <.05->.01 |

*Weekly mean change of Vitamin B-12 group always subtracted from weekly mean change of Placebo group in computing the "t" values.

F test values in Table IV, page 70, indicate that the variances in weight and channel shift of the two groups are not homogeneous. Therefore, these growth indices for the Vitamin B-12 and placebo groups will not be combined, but analyzed separately for general improvement.[1]

The "t" values for the weekly mean change in physical performance between the Vitamin B-12 and placebo groups during the experimental period are presented in Table V. A look at the "t" values shows that no category of physical performance is statistically in favor of either group. This again might be expected, in that growth was evidenced in both groups and not statistically significant in either the Vitamin B-12 or Placebo group.[2] It should be mentioned that the "t" value of -1.613 for the Harvard Step Test is nearly significant at the .10 level in favor of the Vitamin B-12 group.[3] A further analysis of the "t" values shows that in three of the five measurements of strength, the Vitamin B-12 group was slightly favored, while the placebo group was favored in the other two. Such an observation further gives

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[1]An analysis of the general improvement will be discussed later.

[2]Refer to Table IV, page 70.

[3]For twenty-one degrees of freedom, a "t" value of 1.721 is significant at the .10 per cent level.

TABLE V

COMPARISON OF VITAMIN B-12 AND PLACEBO GROUPS IN WEEKLY MEAN CHANGES IN PHYSICAL PERFORMANCE DURING EXPERIMENTAL PERIOD

| PHYSICAL PERFORMANCE CATEGORY | VITAMIN B-12 Mean Change Per Week | N | PLACEBO Mean Change Per Week | N | "t" | $P_t$ | F | $P_f$ |
|---|---|---|---|---|---|---|---|---|
| Harvard Step Test (pulse recovery rate) | -.459* | 10 | -.095 | 13 | 1.613 | >.1 | 2.65 | >.1 |
| Chins | .190 | 12 | .127 | 13 | -1.247 | >.1 | 1.04 | >.1 |
| Dips | .042 | 12 | .067 | 13 | .409 | >.1 | 3.32 | <05->.01 |
| Vertical Jump (centimeters) | .229 | 12 | .440 | 13 | 1.610 | >.1 | 1.40 | >.1 |
| Grip Strength Sum of Best Right and Left (pounds) | 1.262 | 12 | .795 | 13 | -.498 | >.1 | 1.95 | >.1 |
| Back Strength (pounds) | .508 | 12 | .105 | 13 | -.295 | >.1 | 1.19 | >.1 |
| Leg Strength (pounds) | 10.073 | 12 | 3.98 | 13 | -1.156 | >.1 | 2.18 | >.1 |
| Push Strength (pounds) | .582 | 12 | .680 | 13 | .405 | >.1 | 1.46 | >.1 |
| Pull Strength (pounds) | .425 | 12 | .630 | 13 | .566 | >.1 | 1.13 | >.1 |
| Half-Mile Run (seconds) | -.201 | 9 | .067 | 13 | .288 | >.1 | 2.09 | >.1 |

*Weekly mean change of Vitamin B-12 group always subtracted from weekly mean change of Placebo group in computing the "t" values.

evidence to the lack of effect of Vitamin B-12 in promoting strength as a measure of physical performance in this study.

Since the results comparing the weekly mean improvements of each group were not too encouraging in favor of either group, the two groups were combined (when the F test showed homogeneity between groups),as an index of general improvement. A look at the "t" values in Table VI, page 74, shows that only in the gain in height did the two groups combined show a considerable increase; being significant between .10 and the .05 level of confidence. Even though the other "t" values weren't significant, they all are positive and therefore show increased growth and improvement in physical performance, during the experiment period.

Growth and physical performance improvement were computed separately for the Vitamin B-12 and placebo groups when the F score was statistically significant as a result of comparing the standard deviations of the two groups. Table VII, page 75, shows the "t" values of these separate computations. It can again be noted that there was improvement in growth and performance in both groups as indicated by the positive "t" values. However, none of these improvements are statistically significant.

TABLE VI

SIGNIFICANCE OF WEEKLY MEAN CHANGES IN GROWTH AND PHYSICAL PERFORMANCE DURING THE EXPERIMENTAL PERIOD WITH VITAMIN B-12 AND PLACEBO GROUPS COMBINED

| Growth and Performance Category | Mean Change Per Week* | N | "t" | $P_t$ |
|---|---|---|---|---|
| Height (inches) | .060 | 25 | 1.812 | <.1>.05 |
| Developmental Level | .218 | 25 | .440 | >.1 |
| Percentile | -.206 | 25 | -.555 | >.1 |
| Harvard Step Test (pulse recovery rate) | -.253 | 23 | -.462 | >.1 |
| Chins | .165 | 25 | 1.340 | >.1 |
| Vertical Jump (centimeters) | .348 | 25 | 1.080 | >.1 |
| Push Strength (pounds) | .633 | 25 | 1.095 | >.1 |
| Pull Strength (pounds) | .532 | 25 | .680 | >.1 |
| Sum of Best Right and Left Grip Strength (pounds) | 1.019 | 25 | .410 | >.1 |
| Back Strength (pounds) | .299 | 25 | .091 | >.1 |
| Leg Strength (pounds) | 6.906 | 25 | .530 | >.1 |
| Half-Mile-Run (seconds) | -.043 | 22 | -.021 | >.1 |

*A minus mean change per week in percentile, Harvard Step Test, and the half-mile-run indicate improvement and account for the corresponding minus "t" values.

TABLE VII

SIGNIFICANCE OF WEEKLY MEAN CHANGES IN GROWTH AND PHYSICAL PERFORMANCE DURING THE EXPERIMENTAL PERIOD WITH THE VITAMIN B-12 AND PLACEBO GROUPS NOT COMBINED*

| Growth and Performance Category | Mean Change Per Week | N | "t" | $P_t$ |
|---|---|---|---|---|
| Weight (pounds) | | | | |
| Vitamin B-12 | .190 | 12 | .955 | >.1 |
| Placebo | .253 | 13 | .605 | >.1 |
| Channel Shift[x] | | | | |
| Vitamin B-12 | .005 | 10 | .023 | >.1 |
| Placebo | .010 | 11 | .244 | >.1 |
| Dips | | | | |
| Vitamin B-12 | .042 | 12 | .436 | >.1 |
| Placebo | .067 | 13 | .338 | >.1 |

*Due to a significant F value when comparing the Vitamin B-12 and Placebo groups as in Table IV, the above growth and performance measurements were not combined in determining the significance in improvement during the experimental period.

[x]Stunted subjects were not included for significance in improvement in channel shift.

## Discussion of the Results

The hypothesis upon which this experiment was formulated was based on the theory that by increasing the growth of undernourished boys, a concommittant improvement in physical performance would result. Vitamin B-12 is a growth promoting vitamin as well as a vitamin capable of raising the red cell count of individuals nutritionally deficient, as in pernicious anemia. Since the undernourished boys in this experiment represent another kind of malnutrition, it seems possible that the red cell count of the Vitamin B-12 supplement group could have been increased by the supplements. In light of this assumption a possible explanation can be projected for the considerably better performance of the Vitamin B-12 group as compared to the placebo group in pulse recovery rate. The reason for this is that red cells are vehicles for carrying oxygen to the tissues of the body, which in return utilize the oxygen for the contraction of muscles. Hence, an increase in the red blood cells per heart beat would decrease the number of beats necessary to resupply the oxygen lost during exercise.

In the discussion of the limitations of the study, it was mentioned that neither previous growth records or previous living or food habits were available concerning the subjects. Therefore, they were selected solely on the basis of their present growth status. It was felt that the climate in which this experiment was to be carried out was ideal, in that the supervision of the capsule feeding was carried out daily, and also the environmental conditions for all subjects were basically the same. The environmental conditions, which were stabilized as a result of the regimentation of this institution for wayward boys, were regular sleeping hours, regular and adequate feeding, and regular physical education.

It seems that this regimentation, although desirable in a study such as this, could have worked at a disadvantage. For instance, most of the boys who served as subjects probably came from homes of a low economic status, where the daily meals were irregular and deficient in essential vitamins. Since the boys who are brought to this institution often come from broken homes where parental guidance is slight, it seems logical to assume that their conditions of growth failure could be contributed, not only to poor meals, but to poor and irregular hours of sleep. The very regimentation of the institution would solve both of these problems related to malnutrition without any diet supplementation being introduced. In view of these considerations, the lack of effect of Vitamin B-12 in promoting growth is probably due to the fact that the subjects in both groups were receiving enough Vitamin B-12 in their daily feedings at the institution so that additional amounts had little or no effect on the group receiving such amounts.

This is further evidenced by the minus "t" value in Table VI, page 74, for percentile, and a plus "t" value in Table VII, page 75, for channel shift. The percentile shift is towards the standard auxodrome (67 per cent), while the channel shift favors the stockier type boy. Since the channel and percentile indices of growth are a fairly straight line under normal conditions, a movement away from the usual straight line, as in the experiment, indicates favorable growth.

This can be shown graphically in the explanation of the Wetzel Grid,[4] where the growth progressions of three subjects used in this experiment are plotted. Two of these subjects, Case A and Case C, received the fifty microgram capsule of Vitamin B-12 daily, while Case B received the Placebo. It can be shown by their plottings at the beginning and end of the three month experimental period that the growth of both B and C was enhanced favorably during the period, which Case A did not appear to have benefitted. These three cases give a genéral picture of the lack of effect of Vitamin B-12, on the experimental group. Channel shift toward stockier build and percentile shift toward the standard 67 per cent

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[4]See Figure I, page 52.

auxodrome is also evidenced in cases B and C.

Loss of weight by two subjects in each group was also evidenced. The reason for this is not known in three cases, but in one case the subject was sick a good part of the experimental period. Similar conditions might have been true with the other subjects without the experimenter's knowledge. The loss of weight in the two subjects of both groups probably explains why the growth categories of weight, developmental level, percentile, and channel shift were not significant when the two groups were combined as the Table VI, page 74 or uncombined as in Table VII, page 75. The same observation is probably related to the lack of significant "t's" in the improvement in physical performance during the experiment.[5]

It should also be noted that even though the other measurements of growth and physical performance were not statistically significant, the positive "t" values indicate that the boys were growing and increasing in physical performance during the thirteen week experimental period. The explanation of why more growth and physical performance measurements were not significant statistically probably is related to the small number of cases and the shortness of the experimental period.

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[5]See Table VI, page 74, and Table VII, page 75.

# CHAPTER V

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### Summary

Twenty-seven undernourished boys between the ages of twelve and seventeen were selected as subjects in this experiment. Their degree of undernourishment was determined by their respective plottings on the Wetzel Grid. The five different degrees of growth failure were (1) $B_2$ borderline, (2) $B_2$, (3) $B_2$-$B_3$, (4) $B_3$, and (5) four boys who showed stunted growth. The subjects in each of these groups were then randomly divided into two groups, the experimental or Vitamin B-12 group and the control or placebo group. After two subjects dropped out, there were twelve boys in the experimental group and thirteen boys in the control group. The subjects were then given a fifty microgram capsule of Vitamin B-12 or a placebo daily for a period of two to three months, except for one subject who was only in the experiment for seven weeks. Prior to the beginning of the feedings and at the end of the experimental period, growth and physical performance measurements were administered in the following order on two successive days, On the first day, height, weight, pulse recovery rate, chins, dips, and the vertical jump measurements were determined. On the second day, the order of testing was right and left grip strength, push and pull strength, back and leg strength, and the half-mile-run. The measurements were then tabulated for further use in computing and comparing the results.

Conclusions

The following conclusions can be drawn on the basis of a statistical analysis of the data:

1. There was no significant difference in the mean initial measurements in growth and physical performance between the Vitamin B-12 and placebo groups.

2. There were no significant differences in the mean weekly growth changes as determined by height, weight, developmental level, percentile, or channel shift between the Vitamin B-12 group and the placebo group during the experimental period.

3. A comparison of the weekly mean change in the physical performance scores between the Vitamin B-12 and placebo groups resulted in no statistically significant changes in any of the measurements of physical performance in favor of one group over the other. However, the "t" value[1] in the Harvard Step Test of 1.613 in favor of the Vitamin B-12 group indicates a trend that Vitamin B-12 might enhance cardiovascular fitness. The basis being that Vitamin B-12 is known to increase the red cell count of anemic patients, and, since the red cells are known to be carriers of oxygen, an increase

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[1]For twenty-one degrees of freedom, a "t" value of 1.721 is significant at the .10 per cent level.

in their number per heart beat might decrease the work of the heart and quicken the pulse recovery rate.

4. Although the "t" values for general improvement in growth and physical performance were not statistically significant, they all indicated improvement in growth and physical performance during the experimental period.

## Recommendations

Even though the results of this experiment are confirmed in the work of Wetzel and associates,[2] in that Vitamin B-12 does not increase grip, back or leg strength, it is not felt that these results should be considered conclusive. In the former study, there was a significant improvement in growth in the Vitamin B-12 group when compared to the placebo group, whereas in this study there was not. Therefore, one would not expect a better performance by the Vitamin B-12 group as evidenced. Since Wetzel and his associates used only three measures of physical performance, their study should be continued using a greater number of physical performance measurements as in this experiment, but in a climate which would show the positive effects of Vitamin B-12 on growth in supplemented groups. The regimented conditions of this experiment obviously did not enhance growth in the Vitamin B-12 group more than in the placebo group, but tended to favor growth in both groups. Therefore, it is further recommended that future studies of growth and performance be made under conditions continuing to be deficient as in the subject's

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[2]Norman Carl Wetzel *et. al.*, "Growth Failure in School Children. Further Studies of Vitamin B-12 Supplementation," *American Journal of Clinical Nutrition*, 1:17-31, September-October, 1952.

pattern of living at the time of growth failure. Also, subjects should not be selected entirely on the basis of their present growth failure, unless severe, but rather on the basis of their growth status over a period of years.

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APPENDIX

TABLE VIII

RAW SCORES

TABULATION SHEET

MICHIGAN STATE COLLEGE
DEPARTMENT OF PHYSICAL EDUCATION, HEALTH AND RECREATION FOR MEN

GRADUATE STUDIES AND RESEARCH

DATE OF TABULATION AUG. 4, 1955

TABULATED BY JOHN EDWARD WALKER

TOPIC EFFECTS OF VITAMIN B-12 ON GROWTH AND PERFORMANCE

| | Weeks in Experiment | Weight | | Height | | Harvard Step Test | | Chins | | Dips | | Vertical Jump | | Grip St. (sum of right and left) | | Push St. | | Pull St. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After |
| PLACEBO | | | | | | | | | | | | | | | | | | | |
| 1 PARKER, ROBERT | 13 | 136 | 141.50 | 71.5 | 71.75 | 66 | 59 | 2 | 5 | 0 | 1 | 36 | 43 | 222 | 235 | 100 | 120 | 69 | 74 |
| 2 PITTMAN, HUBERT | 13 | 103.75 | 102.50 | 62.25 | 63.5 | 66 | 65 | 5 | 6 | 2 | 2 | 42 | 53 | 155 | 195 | 82 | 98 | 58 | 64 |
| 3 BARBER, DELBERT | 13 | 97.75 | 103.50 | 59.25 | 60.75 | 54 | 57 | 8 | 13 | 5 | 3 | 23 | 27 | 135 | 160 | 70 | 77 | 58 | 62 |
| 4 PAQUIN, DON | 10.14 | 82.75 | 87 | 58.5 | 59.5 | 59 | 54 | 3 | 3 | 0 | 1 | 20 | 29 | 112 | 113 | 60 | 70 | 40 | 38 |
| 5 CUNNINGHAM, DON | 13 | 133.75 | 139 | 69.88 | 70.5 | 48 | 54 | 7 | 8 | 0 | 2 | 38 | 40 | 196 | 198 | 98 | 92 | 70 | 86 |
| 6 GRAY, MICHAEL | 11 | 131.50 | 126 | 70 | 70.5 | 61 | 58 | 3 | 4 | 4.5 | 4 | 40 | 44 | 231 | 211 | 101 | 110 | 71 | 72 |
| 7 MORRISON, RICHARD | 9 | 86 | 88.50 | 59 | 59.75 | 55 | 59 | 2 | 5 | 1 | 2 | 29 | 32 | 145 | 141 | 65 | 70 | 58 | 51 |
| 8 CHARTERS, BILL | 13 | 127.75 | 128.5 | 71.5 | 72.25 | 69 | 57 | 8 | 7 | 5 | 2 | 38 | 39 | 221 | 212 | 55 | 72 | 80 | 85 |
| 9 LEEDY, GORDEN | 13 | 115 | 122 | 66.75 | 66.75 | 52 | 55 | 1 | 2 | 0 | 0 | 24 | 26 | 140 | 140 | 78 | 80 | 50 | 70 |
| 10 ONGIE, CLIFFORD | 13 | 119 | 120.5 | 66.5 | 67.25 | 62 | 52 | 3 | 5.5 | 2 | 1.5 | 30 | 38 | 183 | 176 | 85 | 91 | 60 | 86 |
| 11 BROWN, FLOYD | 13 | 124.75 | 137 | 68.25 | 68.75 | 50 | 64 | 7 | 8 | 5 | 6 | 49 | 55 | 165 | 226 | 85 | 97 | 85 | 97 |
| 12 GRIFFIN, EUGENE | 10.29 | 97.50 | 99.75 | 63.63 | 64 | 47 | 61 | 5 | 6 | 1 | 6 | 34 | 34 | 148 | 142 | 66 | 67 | 39 | 63 |
| 13 GREEN, JOHN | 9 | 134. | 128 | 70.75 | 71 | 60 | 51 | 4 | 5 | 0 | 2 | 39 | 47 | 232 | 265 | 61 | 68 | 88 | 84 |
| 14 | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | |
| 18 VITAMIN B-12 | | | | | | | | | | | | | | | | | | | |
| 19 HARRINGTON, DUANE | 13 | 76 | 77.5 | 57.25 | 57.75 | 63 | 61 | 1 | 4 | 6 | 4 | 25 | 36 | 92 | 96 | 64 | 71 | 42 | 45 |
| 20 STEVENS, JEROME | 13 | 97.5 | 95.5 | 60.25 | 61.25 | 54 | 40 | 2 | 5 | 2 | 1 | 34 | 35 | 139 | 125 | 69 | 71 | 48 | 45 |
| 21 HUNTLEY, ROGER | 13 | 124.75 | 103.5 | 68.38 | 68.75 | 65 | 64 | 6 | 7 | 8 | 7 | 40 | 43 | 189 | 258 | 90 | 110 | 73 | 80 |
| 22 WALKER, JESSE | 11.14 | 109.25 | 112 | 66 | 67. | Cardiac | | 4 | 5 | 0 | 1 | 34 | 34 | 186 | 168 | 98 | 95 | 60 | 80 |
| 23 PAQUIN, RON | 13 | 79.25 | 82 | 60 | 61 | 58 | 57 | 0 | 1 | 0 | 1 | 26 | 23 | 91 | 87 | 58 | 62 | 31 | 38 |
| 24 RAEDEL, GEORGE | 6.71 | 103.5 | 103.75 | 60.5 | 61.5 | 50 | 45 | 5 | 8 | 5 | 5 | 36 | 40 | 162 | 163 | 85 | 96 | 64 | 62 |
| 25 KOENIG, GEORGE | 10.14 | 104 | 126.75 | 67.75 | 68.75 | Cardiac | | 5 | 8 | 4 | 3.5 | 28 | 30 | 220 | 221 | 94 | 100 | 58 | 50 |
| 26 TURNER, DAVE | 10.86 | 138.5 | 142 | 70.25 | 70.75 | 56 | 48 | 5 | 6 | 1.5 | 4 | 32 | 39 | 223 | 204 | 100 | 110 | 80 | 80 |
| 27 PASQUEL, WILLIAM | 13 | 108.5 | 113.5 | 66.75 | 67.5 | 62 | 52 | 7 | 11 | 4 | 5 | 46 | 46 | 138 | 181 | 78 | 81 | 69 | 70 |
| 28 SIMMONS, EDWARD | 10.28 | 100.25 | 98.75 | 63.75 | 64.5 | 56 | 51 | 1 | 3 | 1 | 0 | 39 | 39 | 104 | 168 | 58 | 68 | 37 | 58 |
| 29 UNDERWOOD, BILL | 9 | 116.5 | 120.75 | 66.5 | 67.25 | 66 | 63 | 4 | 5 | 1 | 2 | 42 | 47 | 131 | 158 | 72 | 80 | 48 | 60 |
| 30 BASTINELLI, DICK | 8.29 | 114.75 | 115.5 | 67.5 | 67.75 | 50 | 50 | 1 | 2 | 2 | 3 | 37 | 37 | 164 | 164 | 80 | 75 | 71 | 69 |
| 31 | | | | | | | | | | | | | | | | | | | |
| 32 | | | | | | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | | | | | |
| 34 | | | | | | | | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | | | | | | | | |

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MICHIGAN STATE COLLEGE
DEPARTMENT OF PHYSICAL EDUCATION, HEALTH AND RECREATION FOR MEN

GRADUATE STUDIES AND RESEARCH

# TABLE IX
## RAW SCORES
## TABULATION SHEET

TOPIC EFFECTS OF VITAMIN B-12 ON GROWTH AND PHYSICAL PERFORMANCE

DATE OF TABULATION AUG. 4, 1955

TABULATED BY JOHN EDWARD WALKER

| | Back St. | | Leg St | | Half-Mile-Run (seconds) | | Developmental Level | | Percentile | | Channel Shift* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PLACEBO | Before | After | Before | After | Before | After | Before | After | Before | After | After |
| PARKER, ROBERT | 296 | 294 | 580 | 690 | 165 | 181 | 158.5 | 162 | 68 | 58 | .5 |
| PITTMAN, HUBERT | 207 | 260 | 550 | 556 | 193 | 223 | 133 | 141 | 98 | 92 | |
| BARBER, DELBERT | 205 | 212 | 440 | 521 | 195 | 191 | 126 | 132 | 89 | 87 | |
| PAQUIN, DON | 155 | 160 | 430 | 355 | 166 | 182 | 109 | 114 | 69 | 67 | .00 |
| CUNNINGHAM, DON | 320 | 276 | 645 | 623 | 188 | 173 | 161 | 164.5 | 72 | 69 | .2 |
| GRAY, MICHAEL | 328 | 274 | 715 | 625 | 200 | 176 | 160 | 155 | 69 | 74 | -1.00 |
| MORRISON, RICHARD | 203 | 185 | 450 | 310 | 210 | 230 | 112 | 117 | 94 | 92 | .15 |
| CHARTERS, BILL | 290 | 271 | 485 | 678 | 167 | 181 | 157.5 | 159 | 72 | 72 | -.3 |
| LEEDY, GORDEN | 160 | 220 | 210 | 410 | 192 | 203 | 145 | 151 | 85 | 78 | 1.10 |
| ONGIE, CLIFFORD | 268 | 226 | 530 | 510 | 157 | 167 | 148 | 150 | 74 | 74 | -.2 |
| BROWN, FLOYD | 250 | 261 | 380 | 586 | 180 | 178 | 158 | 162.5 | 72 | 61 | .9 |
| GRIFFIN, EUGENE | 225 | 210 | 360 | 521 | 226 | 209 | 128 | 131.5 | 98 | 96 | .25 |
| GREEN, JOHN | 276 | 341 | 465 | 652 | 199 | 167 | 162 | 152.5 | 72 | 76 | -.8 |
| VITAMIN B-12 | | | | | | | | | | | |
| HARRINGTON, DUANE | 128 | 115 | 506 | 264 | 211 | 200 | 101 | 103.5 | 99 | 99 | .2 |
| STEVENS, JEROME | 194 | 189 | 587 | 426 | 204 | 192 | 126.5 | 124 | 85 | 89 | |
| HUNTLEY, ROGER | 270 | 305 | 725 | 891 | 185 | 178 | 153 | 158 | 77 | 72 | .4 |
| WALKER, JESSE | 272 | 253 | 380 | 390 | Cardiac | | 140.5 | 143 | 86 | 84 | -.25 |
| PAQUIN, RON | 170 | 190 | 500 | 455 | 189 | 191 | 106.5 | 111 | 73 | 70 | .00 |
| RAEDLE, GEORGE | 212 | 245 | 471 | 610 | 153 | 179 | 132 | 133 | 91 | 92 | |
| KOENIG, GEORGE | 207 | 240 | 331 | 525 | Cardiac | | 152.5 | 155.5 | 76 | 74 | -.1 |
| TURNER, DAVE | 280 | 311 | 446 | 680 | 162 | 184 | 164 | 167 | 67 | 56 | .2 |
| PASQUEL, WILLIAM | 191 | 227 | 266 | 390 | Failed to finish | | 139.5 | 144 | 74 | 71 | .2 |
| SIMMONS, EDWARD | 198 | 195 | 295 | 563 | 257 | 212 | 130.5 | 129.5 | 69 | 71 | -.4 |
| UNDERWOOD, BILL | 228 | 217 | 440 | 558 | 235 | 206 | 141.5 | 150.5 | 63 | 52 | .2 |
| BASTINELLI, DICK | 295 | 227 | 445 | 738 | 182 | 201 | 145 | 146 | 70 | 69 | .15 |

* The four stunted subjects were not included in the channel shift measurements.

[redacted]

# Date Due

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