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THE NUTRITIONAL STATUS AND PHYSICAL WORK PERFORMANCE OF CHILDREN OF MIGRANT AGRICULTURAL WORKERS IN SOUTHERN BRAZIL

by

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B.Sc., University of British Columbia, 1978

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE STUDIES

Division of Human Nutrition

School of Home Economics

We accept this thesis as conforming

to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

April 1981

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Date April 24, 1981

DE-6 (2/79)

ABSTRACT

A study was conducted to investigate and compare the nutritional status and physical work performance of children of Brazilian migrant agricultural workers with Brazilian children from well-to-do backgrounds. The relationship between nutritional status and physical work performance was also investigated.

Dietary analysis was conducted using the 24-hour diet recall method. Evidence was found that intakes of energy, calcium, thiamin, riboflavin, niacin, and vitamin C may have been inadequate among migrant worker children. Their diet was generally monotonous and consisted mainly of rice, beans, and coffee with sugar. Diets of well-to-do children were considerably more varied with good representation from all major food groups.

Anthropometric assessment indicated that migrant worker children had values for weight and triceps skinfold thickness that were low compared to American standards. Values for height, arm circumference, and arm muscle circumference were average compared to American standards. Well-to-do children exceeded American standards for all anthropometric parameters measured.

Biochemical investigations of protein and iron status were also conducted. Serum total protein and albumin levels were normal in most subjects in both groups. However, many migrant worker children had low values for hematocrit, serum iron, and transferrin saturation. Most well-to-do children had normal values for these parameters. Hemoglobin levels were adequate in most subjects.

Physical work performance was found to be impaired in migrant worker children. Exercise heart rates and post-exercise blood lactic acid levels in response to a standardized bicycle-ergometer work test were significantly higher in migrant worker compared to well-to-do children. In addition, a significant correlation was found between anthropometric indicators of nutritional status and parameters of physical work performance.

Finally, socio-economic and ecological assessment indicated that the living conditions of migrant worker children were impoverished and unsanitary. This probably aggravated health problems such as infections that were found to occur among these children. Well-to-do children did not share these conditions.

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ACKNOWLEDGEMENTS

To my research director, Dr. I.D. Desai, I would like to extend my sincere thanks for facilitating this project and for assisting me throughout it. I also wish to express my appreciation to my other research advisors, Dr. Melvin Lee and Dr. Blanca Muratorio, for their guidance and encouragement in the preparation of this thesis. In addition, I wish to thank Lewis James and Virginia Green for their most valuable help in developing computer programs to analyse the data for this project.

I would like to offer a special thanks to the many Brazilian people without whom this project would not have been possible: Dr. J.E. Dutra de Oliveira, Director of the Faculty of Medicine, University of São Paulo, Ribeirão Preto; E. Duarte and M.L. Robazzi from the School of Nursing, University of São Paulo, Ribeirão Preto; Dr. L.S. Cevallos Romero and Dr. F.L. Vichi from the Cardiology Unit, Hospital das Clinicas, University of São Paulo, Ribeirão Preto; C. Boseret, Director, Vita Pax Colegio; V.L. Faria Fernandes, Director, Centro Educational SESI No. 346; and M. Iozzi, Director, Organizacão Vida Nova.

A special thanks is also offered to M. Desai and to the staff at both the Hospital das Clinicas and the Department of Clinical Medicine at the University of São Paulo in Ribeirão Preto for their cheerful assistance in conducting this research.

To the Brazilian children who participated in this study and from whom I learned so much: obrigada, from the heart!

Finally, I wish to acknowledge the friends, both Canadian and Brazilian, and the family members who gave me great support in doing this thesis. In particular, I extend a special thanks to David Jiles, my parents, and George Hermanson. Their warmth, patience, and informed feedback enabled me to see this work to completion.

CHAPTER I

INTRODUCTION

> "The oppressed, who have been shaped by the death-affirming climate of oppression, must find through their struggle the way to life-affirming humanization, which does not lie simply in having more to eat (although it does involve having more to eat and cannot fail to include this aspect). The oppressed have been destroyed precisely because their situation has reduced them to things. In order to regain their humanity they must cease to be things and fight as men."
>
> (Paulo Freire, 1970)

Brazil has been heralded by many to be an example of a development miracle among third world nations. A country traditionally bound to an agricultural-export economy, Brazil in the early 1970's managed to increase its agricultural and industrial output by an astounding 10% annually, a growth rate exceeded by few developed countries. Yet closer scrutiny of this development miracle has yielded increasing evidence that national economic growth has occurred at the expense of the vast majority of Brazilian people. The agricultural and industrial labourers on whom prodocution depended have realized very little of the burgeoning Brazilian wealth. For most workers and peasants, poverty, malnutrition, illiteracy, inadequate medical care, inadequate housing, and lack of participation in political processes have continued to be a way of life, as in the past. These are the oppressed about whom Freire (1970) speaks. These are also the subjects of this study.

Brazil today is the world's seventh largest country in terms of population, and fifth in terms of size. Its economy is still largely based on the export of agricultural products such as coffee, soybeans, and sugar, however massive expansion of the industrial sector has occurred recently in the south of Brazil, especially in the state of São Paulo. The north of Brazil is very poor in comparison to the south: climate is dry and inhospitable to agriculture, except on the coast, and industries other than subsistence fishing and farming have not been developed.

Extreme poverty, crop failures, and chronic unemployment are major motivating factors for Brazilians from the north to migrate south, attracted to the hope of jobs in the cities or on the fertile coffee or sugar plantations. Unfortunately, urban centers in the south have rarely been equipped to handle the influx of migrants. Most migrants must live in hastily constructed _favelas_ or shanty-towns on the edges of cities and towns, and most lack access to even the most basic facilities for medical care or education.

The existence of malnutrition in Brazil has been documented by many researchers. It occurs among the peasant farming and fishing families of the north and among those who migrate south and dwell in urban _favelas_. Specific problems that have been identified include inadequate vitamin A, protein, energy, thiamin, riboflavin, vitamin C, iron, and calcium nutriture, although malnutrition with respect to these nutrients has often been identified as sub-acute or early-stage (Interdepartmental Committee on Nutrition for National Defense - ICNND, 1965; Patrick and Simões, 1971; Roncada, 1972; Alves, 1977; Jansen _et al_., 1977; Martins _et al_., 1976; and Desai _et al_., 1980). Vitamin A and sub-acute protein-energy malnutrition have been identified as problems particularly affecting Brazilian children (Waterlow and Vergara, 1956; ICCND, 1965; Guitti, 1974; Sigulem _et al_., 1976; Simmons, 1976; Roncada _et al_., 1978; and Olson, 1979).

Insufficient attention has been paid in the past to ameliorating these nutritional problems of the Brazilian poor, perhaps because much of their malnutrition is not acute or late in stage. Malnutrition in its early stages is often undramatic and unobtrusive even though it can cause daily erosion of health in epidemic proportions among people in developing countries such as Brazil (Berg, 1973). One possible side effect of malnutrition in its earlier stages which has not been clearly characterized, especially among children, may be the impairment of physical work performance (Spurr et al., 1978).

The association between nutritional status and physical work performance is of interest for several reasons. First, the loss of health and well-being, including loss of physical fitness, which may be experienced by the individual who is undernourished is of unequivocal importance and needs to be well-documented so that preventive measures can be effectively conceived. Second, undernourished individuals may experience economic losses if income is directly dependent on work output, as is the case for many agricultural labourers in countries such as Brazil (Food and Agriculture Organization-FAO, 1962).

Third, there may be economic ramifications for developing countries such as Brazil, which depend heavily on manual labour for production, if the physical work performance of many individuals is adversely affected by malnutrition. It has been suggested that inadequate diets can result in net losses for national economies by causing decreased work output, shorter working life span, and increased costs for medical care (FAO, 1962 and Berg, 1973). Indeed, Correa and Cummins (1970) estimated that increased caloric consumption alone could account for 5% of the growth in national product in nine Latin American countries studied between

1950 and 1962. Economic arguments such as these may sway government planners to recognize and address malnutrition where humanistic arguments have failed (Berg, 1973).

Few studies in the past have focussed on the possible association between undernutrition and impairment of physical work performance in Brazilian populations. Also, while researchers of other populations have examined and found a relationship between nutritional status and physical work performance in adults, few studies have examined this relationship in children. Conflicting results have been obtained from studies that have been done in children (Areskog et al., 1969; Spurr et al., 1978; Satyanarayana et al., 1979; Ferro-Luzzi et al., 1979; and Desài et al., 1981).

The relationship between nutritional status and physical work performance in children is of interest in countries like Brazil because children leave school at an early age to begin various kinds of manual labour. Any impairment of their physical work performance that could result from undernutrition will adversely affect both their sense of well-being and their ability to earn a living, as is the case with adults. Undernutrition may have an even greater impact on children than adults because of additional nutritional requirements for growth.

Hence, the present study was designed to obtain information on the nutritional status and physical work performance of children of Brazilian migrant agricultural workers residing in urban favelas. Children from higher socio-economic groups were selected to serve as a control group. The primary objectives of this study were twofold: to determine whether nutritional status and physical work performance of children of migrant workers differed significantly from nutritional status and physical work performance of children from higher socio-economic groups;

and to ascertain whether physical work performance was related to nutritional status in these 2 groups of children.

This study was conducted during 1979 in the city of Ribeirão Preto, which is located in the interior of the state of São Paulo in southern Brazil, and which has a population of approximately 300,000 people. Many migrant workers are attracted to Ribeirão Preto because jobs are available on nearby sugar cane and coffee plantations. Subjects for this study were either children of migrant workers residing in favelas on the periphery of Ribeirão Preto, or children of well-to-do Brazilian professionals or businesspeople residing in affluent areas of Ribeirão Preto.

Nutritional status was evaluated using the following criteria: socio-economic considerations; dietary assessment, using the 24-hour recall method; anthropometric assessment, including the measurement of weight, height, mid-upper-arm circumference, and triceps skinfold thickness; and biochemical assessment, including the determination of serum protein and albumin, and percentage of transferrin saturation. Physical work performance was assessed by measuring changes in heart rate and blood lactic acid levels in response to a bicycle-ergometer work test. A total of 94 subjects between the ages of 11 and 14 were studied.

In keeping with the thoughts of Paulo Freire (1970) expressed at the beginning of this introduction, it was not expected that this study would address the problems of Brazilian migrant workers in their entirety. Rather, it was merely hoped that the results of this study, by documenting some of the ramifications of malnutrition in migrant workers' children could serve as a basis for informed action to ameliorate nutritional and other problems among Brazilian migrant workers and their families.

CHAPTER II

REVIEW OF THE LITERATURE

1. Socio-economic Factors in Malnutrition

Human malnutrition is widely acknowledged to be a socio-economic and ecological problem the etiology of which is complex and multi-factorial. Probably no other factor has greater impact on nutritional status than income (Mellor, 1973), and numerous studies have documented highly significant differences in food consumption across the income spectrum (Call and Levinson, 1973). Another factor that affects nutritional status is food availability, which is influenced in turn by climate, soil, irrigation, transport, storage, and population growth (Berg, 1973). Lack of knowledge about nutritional needs is another factor which can often cause malnutrition even in the midst of wealth (Devadas, 1970).

It has been well-documented that bacterial, viral, or parasitic infections can exert synergistic effects on the development of malnutrition (Jelliffe, 1966). Infections are themselves exacerbated by lack of medical and educational services, and by poor sanitary conditions (Sai, 1976). Finally, cultural habits are powerful social factors that influence what people eat. Foods may have religious significance, may express social status, may be distributed unequally within families, or may be rejected due to unfamiliarity (Devadas, 1970).

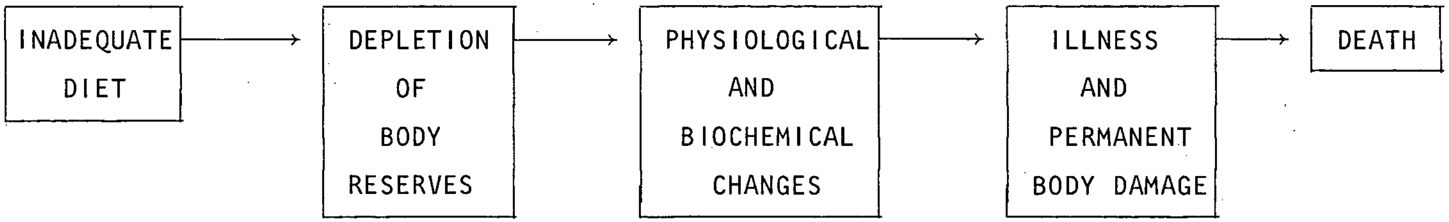
In summary then, factors which can influence nutritional status include the following: income level; food availability; knowledge of nutritional needs; presence of infections; level of medical and educational services; and cultural habits. Because many factors influence malnutrition, any attempt to assess nutritional status or to ameliorate malnutrition in the community must take a multi-faceted approach (Sai, 1976). Anyone attempting to understand or ameliorate malnutrition must also be willing to grapple with the underlying causes of poverty, food scarcity, and lack of medical and educational services which contribute to malnutrition in much of the world (McLaren, 1978).

Malnutrition has been said to be the consequence of a malfunctioning society (Cravioto and Licardie, 1973). Yet the acknowledgement may be long overdue that certain sectors in society gain from exploiting the world's poor. It has been well documented recently that the interests and activities of multinational food and agribusiness corporations, major governments, and third world elites play a role in perpetuating poverty and food scarcity in the world (Frank, 1969; George, 1976; and Lappé and Collins, 1977). These exploitative interests and activities constitute the underlying causes of poverty and food scarcity which McLaren (1978) has suggested should be examined more rigorously.

2. Assessment of Nutritional Status

The development of malnutrition proceeds through several stages commencing with inadequate diet. This is followed by depletion of body stores, physiological and biochemical changes, illness, and finally death. As Béhar (1976) pointed out, different methods of assessment must be used to evaluate different stages of malnutrition. This is illustrated in Figure II-1. An important note is that in the interests of prevention, it is always preferable to assess malnutrition in its earliest stages.

The earliest stage of malnutrition, an inadequate diet, can be detected using ecological, socio-economic, dietary, and food balance sur-



- ecological studies
- socio-economic studies
- dietary surveys
- food balance sheets

- biochemical studies

- biochemical studies
- anthropometry

- clinical examination
- morbidity data

- morbidity data
- mortality data

FIGURE II-1

Stages of malnutrition[a]

a Modified from Béhar, 1976.

veys. The second stage of malnutrition, depletion of body nutrient stores, can be detected using biochemical tests of body tissues. The ensuing physiological and biochemical changes that follow depletion of body nutrient stores can be assessed using biochemical and clinical studies. Advanced malnutrition which manifests itself in illness and permanent body damage can be assessed using clinical examinations alone. Malnutrition which has resulted in death can be studied by examining morbidity and mortality data.

Because there are inherent limitations in methodologies for assessment of malnutrition at all stages, most comprehensive nutrition surveys examine as many indices of nutritional status as possible (Jelliffe, 1966). This review will cover aspects of dietary, anthropometric, and biochemical assessment of nutritional status.

Dietary assessment is the only tool that allows the researcher to estimate what subjects are actually eating. This knowledge is essential in the interpretation of results from biochemical and anthropmetric components of a nutrition survey (ICNND, 1963). Dietary assessment is usually conducted in three phases: collection of food intake data; analysis of nutritive value of food; and interpretation of data (Jelliffe, 1966).

There are three basic methods that exist for the collection of food intake data: diet records, diet histories, and diet recalls (Pekkarinen, 1970). Diet records are accounts of food consumption kept by institutions, families, or individuals for periods ordinarily ranging from 1 day to 4 weeks (Pekkarinen, 1970). Subjects keeping diet records often weigh all foods to be consumed. Problems that have been noted with diet records include inaccuracy due to faulty memory or untruthfulness of subjects; and unconscious changes in the usual dietary habits of individuals being surveyed (Chalmers et al., 1952).

The diet history is a tool which gives an estimate of an individual's average food intake pattern over a longer time period. This usually involves conducting a detailed one-hour interview which includes questions designed to estimate both the usual amounts and the frequencies of food intake over periods of a year or more (Burke, 1947). The major drawback to this method is that it can be very time-consuming.

The diet recall is the method most frequently used in nutrition surveys. It usually involves interviewing individuals or families as to their food consumption during the preceeding 24-hour or 7-day period (Pekkarinen, 1970). The diet recall method is quick and inexpensive, and can be used in non-modernized societies where poverty and illiteracy are widespread (Flores, 1962). Also, the 24-hour recall is preferable to the diet history when studying children (Rasanen, 1979). However, the diet recall method lacks accuracy for the following reasons: it is dependent on the subject's memory and willingness to tell the truth; it makes no estimate of usual intake (Beaton et al., 1979); it overestimates intake when consumption is low and underestimates it when consumption is high (Linusson et al., 1974 and Madden et al., 1976) and it cannot be used with any accuracy to assess intake of individuals, only of populations (Garn et al., 1978 and Stapleton and Abernathy, 1980).

Once dietary information is collected, analysis of nutrient value of food intake may be conducted. Actual food samples may be collected and chemically analysed for nutrient composition (ICNND, 1963), or foods may be compared to food composition tables and nutrient content calculated.

The final stage in dietary assessment involves interpreting dietary data obtained. Many authors simply compare actual nutrient intake to recommended intakes. However, as Beaton (1975) pointed out, it is not possible to judge from this whether an observed intake is deficient because recommended intakes are calculated to meet the requirements of most of the population, and individual requirements vary greatly. Beaton (1975) suggested that dietary data, instead, should be interpreted in terms of the probability that nutritional inadequacy exists. For instance, if most subjects in a population have dietary intakes below the recommended intake, then the probability is high that inadequate intakes do exist (Beaton, 1975).

Anthropometric assessment allows the researcher to detect long term effects of malnutrition on growth, size and body composition because most nutritional deficiencies cause growth deceleration (Jelliffe, 1966). Anthropometric indicators are not nutrient-specific however, and many non-nutritional factors can influence growth and size, including genetics, sex, disease, and social status (Tanner, 1973). Complex methodology is available for nutritional anthropometry, especially the assessment of growth and development of children, and the estimation of body fat in relation to height and weight (Jelliffe, 1966). This review will concern itself mainly with nutrition survey anthropometry as it relates to the assessment of children.

According to Jelliffe (1966), the following principal measurements can be taken in nutrition surveys of children: weight; height; head circumference; chest circumference; upper-arm circumference; and triceps and/

or subscapular skinfold thickness. The four measurements most commonly taken are weight, height, upper-arm circumference, and triceps skinfold thickness. Jelliffe (1966) outlined standard recommended procedures for obtaining these four measurements.

The relative merits of the anthropometric measurements commonly used in nutrition surveys have been assessed by several authors. Rao and Singh (1970) found that the ratio weight/height^2 was a better age-independent index for predicting protein-energy malnutrition in children than other anthropometric indices. Similarly, Dugdale (1971) found that weight/height$^{1.6}$ was correlated better with overall nutritional status of children than were other antropometric indices. Keys and co-workers (1972) examined various indicators of body shape and body density (which gives a measure of "fatness") and found that weight/height^2 and triceps skinfold thickness were both well-correlated to body density. Upper-arm circumference, finally, has been found to be a good indicator of decreasing body mass in protein-energy malnutrition, especially if compared to height (Loewenstein and Phillips, 1973).

The appropriate evaluation of anthropometric measurements depends on choice of standards used for comparative purposes, but community standards are difficult to define (Jelliffe, 1966). In many countries, local standards for growth and development have not been prepared, so survey results are compared to North American standards, even though the applicability of North American growth standards to developing countries is highly questionable (Garn, 1965). Jelliffe (1966) recommended that where possible, anthropometric results should be compared to both local and international standards. Once a standard has been selected, severity of malnutrition in an individual subject may be graded according to what percentage of the standard the individual subject achieves (Gomez et al., 1956).

Biochemical tests provide perhaps the most objective means by which to assess nutritional status because they permit detection of nutritional deficiency at sub-clinical stages. More accurate assessments of body stores would be furnished by analyses of liver, muscle, and bone tissue; however, in human surveys biochemical assessment usually must be restricted to blood, urine, and hair analyses (Jelliffe, 1966). Numerous well-documented methods are available to assess vitamin and mineral nutriture, however, this review shall concern itself primarily with the biochemical assessment of protein and iron status.

No biochemical measurement exists at present that is highly satisfactory in evaluating protein nutriture. While severe forms of protein malnutrition can be better diagnosed by clinical than biochemical means, milder forms of protein deficiency remain difficult to diagnose (Sauberlich et al., 1974). Biochemical parameters commonly used in protein status assessment include: serum levels of protein and albumin; serum amino acid ratios; urinary creatinine excretion; urinary hydroxyproline excretion; and urinary urea-creatinine ratios.

The procedures have been reviewed by Sauberlich and co-authors (1974) as follows. Serum total protein appears to have little value alone as a sensitive indicator of protein nutriture, however serum albumin levels have been shown to decrease in protein-deficient children not exhibiting clinical signs of malnutrition. Children with protein malnutrition also tend to have reduced serum concentrations of the essential amino acids. As well, they tend to excrete less creatinine as a function of lower body mass, and tend to excrete elevated amounts of hydroxyproline, which is a by-product of collagen metabolism. Fasting urinary urea/creatinine ratios are often reduced in protein malnutrition, although this ratio is more reflective of recent dietary intake than long-term protein nutrition. Serum total protein and albumin are parameters most commonly assessed because of methodological simplicity (Jelliffe, 1966, and ICNND, 1963).

The biochemical assessment of iron status has been recently reviewed by Cook and Finch (1979). These authors have noted that although hemoglobin and hematocrit have been the parameters most commonly measured to assess iron-deficiency, these methods are insensitive, lack specificity, and indicate iron-deficiency only in late stages. A preferred method, available in recent years, is the determination of the percentage of transferrin saturation, which is derived from the ratio of serum iron to iron-binding capacity, and which is an early indicator of iron deficiency. An even more sensitive indicator of iron status than transferrin saturation is thought to be serum ferritin, levels of which correlate highly with body stores of iron. Serum ferritin affords a measure of iron-deficiency at its earliest stage. Unfortunately, the methodology for its determination is as yet too complicated for extensive use in field surveys.

Cook and Finch (1979) have recommended combining several methods in assessing iron deficiency at different stages, including serum ferritin, transferrin saturation, and hemoglobin. However, Jelliffe (1966) has pointed out that frequently hemoglobin and hematocrit determinations are the only estimations practicable in large nutrition surveys.

3. Assessment of Physical Work Performance

Physical fitness for work has been defined as the capacity, in terms of both endurance and strength, to enjoy moderate muscular activity without discomfort (Jones *et al*., 1975). Concommitantly, it has long been known that continuance of a given activity eventually leads to impairment in performance of fatigue (Simonson, 1971). A vast literature exists on the physiology of work and exercise, however, this review will summarize only the salient physiological changes that accompany fatigue and how they may be monitored to assess physical work performance.

The following highly simplified account of responses to exercise in the human body is distilled from the works of several authors (Simonson, 1971; Morehouse and Miller, 1976; and Astrand and Rodahl, 1977). Activity causes an increase in the requirement of the contracting muscles for both oxygen and energy-yielding substances such as glycogen. This increased oxygen requirement can be met partially by increasing the cardiac output. Both heart rate and stroke volume may increase so that more blood is pumped to the working muscle. Fatigue develops in prolonged activity when oxygen sufficiency cannot be maintained the these mechanisms and when energy-yielding substances become depleted.

When sufficient oxygen is available to the working muscle, pyruvic acid formed in glycolysis is normally metabolized to acetate and then through the Kreb's cycle to form adenosine triphosphate (ATP). Under anaerobic conditions, however, pyruvic acid is reduced to lactic acid instead. Lactic acid accumulates in the muscle under anaerobic conditions and diffuses into the blood. The combined accumulation of both lactic acid and pyruvic acid can eventually result in metabolic acidosis. Concommitant to this whole process, muscle glycogen stores, the sole energy source for the anaerobically working muscle, become depleted and fatigue becomes pronounced.

Given these basic physiological responses to prolonged muscular activity, there are several indices by which the body's response to work may be assessed: increased respiratory rate; increased heart rate; accumulation of lactic acid and pyruvic acid in the muscle and blood; metabolic acidosis; and depleted muscle glycogen stores. In addition to these indices, maximal oxygen uptake can be measured. Maximal oxygen uptake refers to the level of oxygen uptake during exercise beyond which further increase in exercise intensity is not accompanied by any increase in oxygen uptake.

The subject who has a high physical capacity will exhibit the following characteristics in response to exercise: low respiratory rate; low heart rate; low blood and muscle levels of lactic acid and pyruvic acid; a low degree of metabolic acidosis; high muscle glycogen levels; and high maximal oxygen uptake. This is in comparison with the subject who has a low physical capacity. Most assessments of physical performance employ more than one index of fatigue and the choice of indices to be used often depends on technical and logistic considerations. As well, it is preferable that physical performance be measured in response to well-standardized exercise tests such as the treadmill or bicycle-ergometer, where power output can be accurately regulated (Jones et al., 1975).

Maximal oxygen intake is widely regarded to be the best indicator of maximal physical capacity or physical fitness when exercise is prolonged (Morehouse and Miller, 1976). However, it has also been well-established that increases in heart rate and ventilation rate parallel increases in oxygen consumption in exercise of increasing intensity, and that maximum oxygen uptake can in fact be predicted from heart rate (Morehouse and Miller, 1976). When blood samples can be taken, elevated lactic acid levels of venous blood are regarded to be a meaningful indicator that anaerobic metabolism is taking place (Morehouse and Miller, 1976), and blood pH is a good indicator of metabolic acidosis (Jones et al., 1975). Tests of muscle glycogen stores, while excellent indicators of fatigue, are technically more unwieldy than the other tests mentioned because they involve taking needle biopsies (Simonson, 1971).

There are other tests reported in the literature that assess physical work performance in a less direct or physiological fashion than those just discussed. Endurance time to exhaustion at a given work load, strength at a specific task like hand-grip, actual output produced at a factory or agricultural job, and simple observations about level of work efficiency are all techniques that have been used to assess physical work performance. These kinds of tests are more conspicuously influenced by extraneous factors such as motivation than tests that measure physiological changes in response to exercise (Simonson, 1971). This makes results of these tests difficult to interpret, but at the same time, these tests may approximate reality more closely than other kinds of tests.

Results of tests of physical work performance must always be interpreted in view of the fact that many factors influence performance. Durnin (1976) reviewed sex differences in energy requirements for work and concluded that females have lower energy expenditure and lower maximal physical work capacity than males, independent of body size or basal metabolic rate. Several authors (Dehn and Bruce, 1972 and Nylind et al.,

1978) have noted that physical fitness declines with age, and environmental factors such as temperature, humidity, and altitude have been shown to influence physical performance (Sen Gupta _et al_., 1977; Lane _et al_., 1978; and Buskirk and Mendez, 1967). Habituation is another factor which strongly influences physical performance: regularly active people demonstrate much greater physical capacity than their sedentary counterparts (Dehn and Bruce, 1972 and Watson and O'Donovan, 1977). Socio-economic factors also cannot be discounted: Wyndham and co-workers (1964) found that motivation, skill, and wages were all more influential on job performance than maximal physical work capacity; and Wyndham and Cook (1964) found that productivity on the job was directly related to quality of supervision. Thus, socio-economic factors can obscure the effects of physical capacity on work performance.

In summary, while maximal oxygen uptake is the best measure of physical capcity of fitness, physiological responses to sub-maximal exercise also provide a means to assess work performance. Indicators that may be used to assess sub-maximal work performance include: heart rate, respiratory rate, blood lactic acid levels, blood pH, and muscle glycogen stores. Factors such as sex, age, environmental conditions, habituation, and socio-economic situation should also be considered when assessing physical work performance.

4. Association Between Nutritional Status and Physical Work Performance

It has been well documented that under actual and experimental conditions of food shortages of extended duration, the effects of nutritional deficiencies manifest themselves in physiological, psychological, and psychomotor changes that can undermine physical work performance. A vast literature exists on the effects of acute starvation or semi-starvation in this regard (Shils, 1980), however, it is the purpose of this review to examine only the literature that deals with the effects of sub-optimal nutritional status on the physical work performance of humans. Sub-optimal nutritional status, more specifically, refers to the erosion of health caused by chronic but non-acute nutritional deficiencies that may be experienced for a lifetime (Berg, 1973).

The relationship between nutritional status and physical work performance has been extensively studied in humans only within the last 20 years, as increasing attention has been paid to the situation of chronic undernourishment in developing countries. The FAO (1962) reviewed the consequences of an inadequate diet for working people and found them to be fourfold: lethargy; low resistance to disease; high absenteeism; and high accident rates. These factors are postulated to result in decreased work output. Conversely, when inadequately nourished workers have received supplemental rations, as studies cited by the FAO (1962) indicate, work output has improved. Numerous studies since this review have examined the relation between undernourishment and physical work performance more directly but the literature is not without controversy.

Individual variability is a confounding factor when studying nutritional status and physical work performance because wide ranges of variation exist in human metabolic and work efficiency (Edmundson, 1979), and it has long been accepted that nutrient requirements vary widely between individuals, independent of sex, activity, or basal metabolic rate (Rose and Williams, 1961 and Widdowson, 1962). This latter observation has led some authors (Durnin et al., 1973) to comment that human energy requirements in relation to expenditure are indeed poorly understood.

Several studies have investigated energy expenditure and requirements in manual labourers and have found work performance to be unaffected by seemingly inadequate energy intakes (Ramanamurthy and Dakshayani, 1962; Ramanamurthy and Belavady, 1966; Belavady, 1966; and Ashworth, 1968). These investigators assessed caloric intake, and then either measured actual hourly work output or assessed work efficiency by simple observation. Actual physiological responses to exercise were not tested in these studies.

Areskog and co-workers (1969) examined several parameters of nutritional status and tested physical work performance by measuring heart rate in response to increasing bicycle-ergometric workload in poorly nourished Ethiopian boys. Bicycle-ergometer tests showed that undernourished children had poorer maximal work capacity for age but greater maximal work capacity for size than did Swedish controls. These authors concluded that there was no demonstrable correlation between physical work performance and nutritional status. Results of studies such as these have prompted the suggestion that there may be adaption to inadequate diets such that physical fitness is not impaired by undernourishment (Durnin et al., 1973).

In a study of work output of coal-miners, test subjects were given 500 supplemental kcal daily while control subjects consumed their usual sub-optimal diets (Satyanarayana et al., 1972). After 6 months, supplementation had no effect on work output or attendance on the job, but supplemented subjects gained a significant amount of weight and reported improved stamina. Another study (Heywood et al., 1974) examined various factors influencing productivity of Jamaican sugar cane cutters, including weight, height, skinfold thickness, arm circumference, hemoglobin, hematocrit, and food intake. Weight and weight/height, assumed to reflect nutritional status, were found to have the strongest correlation with productivity.

In a study of peasant farmers in East Java, Edmundson (1977) found no correlation between daily energy intake and output. Work output, or energy expenditure, was determined for 10 basic activities, then total daily energy expenditure of each subject was calculated from activity records. No correction was made for basal metabolic rate, nor for adequacy of the diet with regards to nutrients other than energy.

Chronically undernourished Colombian rural dwellers were given a complete assessment of nutritional status including estimation of body composition, and as well, maximum oxygen consumption and endurance time at a treadmill work test were evaluated (Barac-Nieto et al., 1978). It was found that maximum aerobic power was correlated to muscle cell mass, anthropometric variables, and hemoglobin levels, however endurance did not appear to be affected by nutritional state. Another study in Brazil (Angeleli, 1978) examined heart rate of agricultural workers in response to submaximal bicycle-ergometric work before and after dietary supplementation. After several weeks, exercise heart rates were significantly reduced in workers receiving supplements as compared to controls.

Satyanarayana and co-workers (1977) measured work output of factory workers in India, as well as anthropometric indices, hemoglobin, serum albumin, and socio-economic variables. Subjects did not appear to be suffering from any overt nutritional deficiencies, but anthropometric data varied widely. High work output was significantly correlated with high body weight. A later study by the same investigators (Satyanarayana et al., 1979) examined the effects of nutritional deprivation in early childhood on body size and heart rate response to bicycle-ergometric work of boys in India. Maximal physical work capacity was strongly correlated to current weight and height, and to levels of habitual physical activity.

Desai's group (1981) also found that low body size was related to low work performance in Brazilian children. However, this result was not in agreement with a study of Italian children (Ferro-Luzzi et al., 1979), which found that children who were marginally malnourished had lower heart rates in response to exercise, despite growth retardation, than their well-nourished counterparts.

While the data for children seems to be more controversial (Spurr et al., 1978), it is becoming generally accepted that malnutrition affects physical work performance in adults (Spurr et al., 1979). Spurr and co-workers (1979) presented results of their studies on heart rate in response to sub-maximal treadmill work in malnourished Columbian adults during a period of dietary replenishment. Increased severity of malnutrition including underweight for height was associated with increased heart rate response to work to such a degree that these authors suggested that sub-maximal work tests may be useful as a functional assessment of nutritional status.

While the studies just discussed have examined physical work performance in relation to a wide range of parameters of nutritional status, there is another body of literature which has concerned itself primarily with the effects of iron-deficiency on physical work performance. Davies and co-authors (1973) assessed responses to bicycle-ergometric exercise in African industrial workers with moderate (hemoglobin 8-10 g/100 ml) and severe (Hemoglobin less than 8 g/100 ml) anemia. Both moderately and severely anemic subjects exhibited increased exercise heart rates compared to non-anemic (hemoglobin greater than 13 g/100 ml) controls. Severely anemic subjects also exhibited significantly lower maximum aerobic power than controls.

Gardner and co-workers (1975) studied iron-deficiency anemia and its effect on physical performance in Venezuelan adults. Heart rate, blood lactic acid, and maximal oxygen consumption responses to a standard step test were determined, as well as muscular strength, iron status, and anthropometric measurements. One group of anemic subjects then received iron injections and treatment for hookworm infestation. Eighty-three days after initiation of treatment, exercise heart rates and blood lactic acid levels were lower and maximal oxygen consumption higher in the treated group than in the untreated. Muscle strength appeared to be unaffected by iron status.

Gardener's group conducted a later study on iron-deficiency anemia in tea estate workers in Ceylon (Gardner et al., 1977). Heart rate was monitored as subjects performed treadmill tests and blood lactic acid levels were determined before and after exercise. Both exercise heart rate at all work loads and post-exercise blood lactic acid levels were significantly higher in subjects with hemoglobin levels below 7 g/100 ml than in non-anemic controls. When anemic workers then received iron supplements for one month, an increase in hemoglobin and a significant increase in amount of tea picked was observed for iron-treated subjects as compared with placebo-treated subjects (Edgerton et al., 1979). Levels of everyday activity also appeared to increase significantly after iron treatment.

The same researchers, in another study (Ohira et al., 1979) found that hemoglobin and maximal work endurance began to increase in anemic

Ceylonese workers as soon as four days after commencement of iron treatment. Another recent study of anemia and work productivity was carried out in Indonesia by Basta and co-workers (1979). In male workers on a West Java rubber plantation, hemoglobin levels were correlated to step test performance, to actual work output, and to morbidity from diarrhea and infections. Iron treatment resulted in significant improvements in these parameters in comparison with placebo-treated controls. Dietary assessment showed that caloric intake was not correlated to either step test performance or work output.

In addition to the effects of iron-deficiency on physical work performance, other specific nutrient deficiencies may influence work performance. Vitamin A deficiency in poultry has been found to influence muscle carbohydrate metabolism (Sundeen, 1980), in that severe deficiency has been shown to cause restriction in glycogen deposition. This may affect work performance since muscle ability to perform prolonged exercise is influenced markedly by muscle glycogen stores (Astrand, 1967 and Bergstrom _et al_., 1967). Long term protein and energy malnutrition, through impeding myelination, was found to cause significant reduction in nerve conduction velocity in children, which may affect muscle coordination and ability to perform work tasks (Kumar _et al_., 1977).

Finally, extraneous dietary factors can influence exercise performance in various ways. Carbohydrate-rich diets can prolong exercise time to exhaustion if administered before or during exercise testing (Martin _et al_., 1978), since carbohydrate is regarded to be the preferred energy source for the working muscle following periods of caloric restriction (Consolazio and Johnson, 1972; and Bergstrom _et al_., 1967). Caffeine intake can also have an affect on exercise performance. By stimulating free fatty acid mobilization, an energy source for the aerobically working muscle, caffeine exerts a sparing effect on muscle glycogen, resulting in prolonged endurance at heavy exercise (Costill *et al.*, 1978).

5. Nutrition in Brazil

a) Brazilian Socio-economic Situation

Brazil was first settled in 1532 by the Portuguese, who organized a colonial society in the northeast of the country to protect their interest in Brazil's abundant natural resources. This early Brazilian society was founded on plantation agriculture, patriarchal family life, and the labour of Negro and Indian slaves (Freyre, 1956). In 1822 Brazil gained independence from Portugal and in 1889 an independent Republic was declared (Worcester, 1973).

Brazilian political history has been stormy since 1889. Authoritarian and military dictatorships have only occasionally been interspersed with elected populist governments (Rosenbaum and Tyler, 1972). The most recent change of government, in 1964, resulted from the forcible overthrow of an elected party by a military coup (Frank, 1969).

Brazil's economic past was dominated by the exploitation and export of its cash crops and minerals, often to the exclusion of production of adequate local food supplies (Frank, 1969 and Worcester, 1973). Major products that were exported at various times since 1600 have included: sugar, gold, rubber, cacao, and coffee (Margolis, 1973). Brazil maintained a primarily colonial agricultural export economy until the 1950's, at which time dramatic industrial development began, especially in the automotive and steel industries (Rosenbaum and Tyler, 1972).

Brazil is a large country which occupies 47% of the geographic area of South America (Government of Brazil, 1976). This is illustrated in Figure II-2. Brazil has a diverse climate ranging from the dry backlands and tropical forests of the north to the fertile, temperate regions of the South. Its population is 90% Catholic and the national language is Portuguese (Government of Brazil, 1976).

The population of Brazil is currently estimated to be 119,656,000 people (Inter-American Development Bank - IADB, 1979). The population growth rate is 2.8% annually (United Nations - UN, 1979a). The average life expectancy at birth is 57.6 years for males and 61.0 years for females (UN, 1979a), while the infant mortality rate is 9-10% (IADB, 1979).

The Brazilian economy today, as in the past, is still based primarily on agriculture. Brazil's leading exports are coffee beans, soya beans, and unrefined sugar (UN, 1980). Other principal products for export include kidney beans, rice, beef, cocoa, tea, tobacco, and cotton (Government of Brazil, 1976). In most parts of the country, the proportion of the population that is rural exceeds 50% (Shrimpton, 1975).

Although the small annual growth rate of the industrial sector soared over 10% in the early 1970's, this rate of increase has started to decline (UN, 1980). Brazil's balance of trade is now negative with imports exceeding exports. Inflation is a major problem; so much so that in 1979 consumer prices rose by over 50% (IADB, 1979). According to Shrimpton (1975), incomes in Brazil are unevenly distributed such that 10% of the population receives 48% of the wealth. The wages of the Brazilian working class have not kept pace with the severe inflation that has plagued the country since 1950 (Arruda, 1975), and the present estimated per capita income is thought to be approximately US $1,384 per year (UN, 1979a).

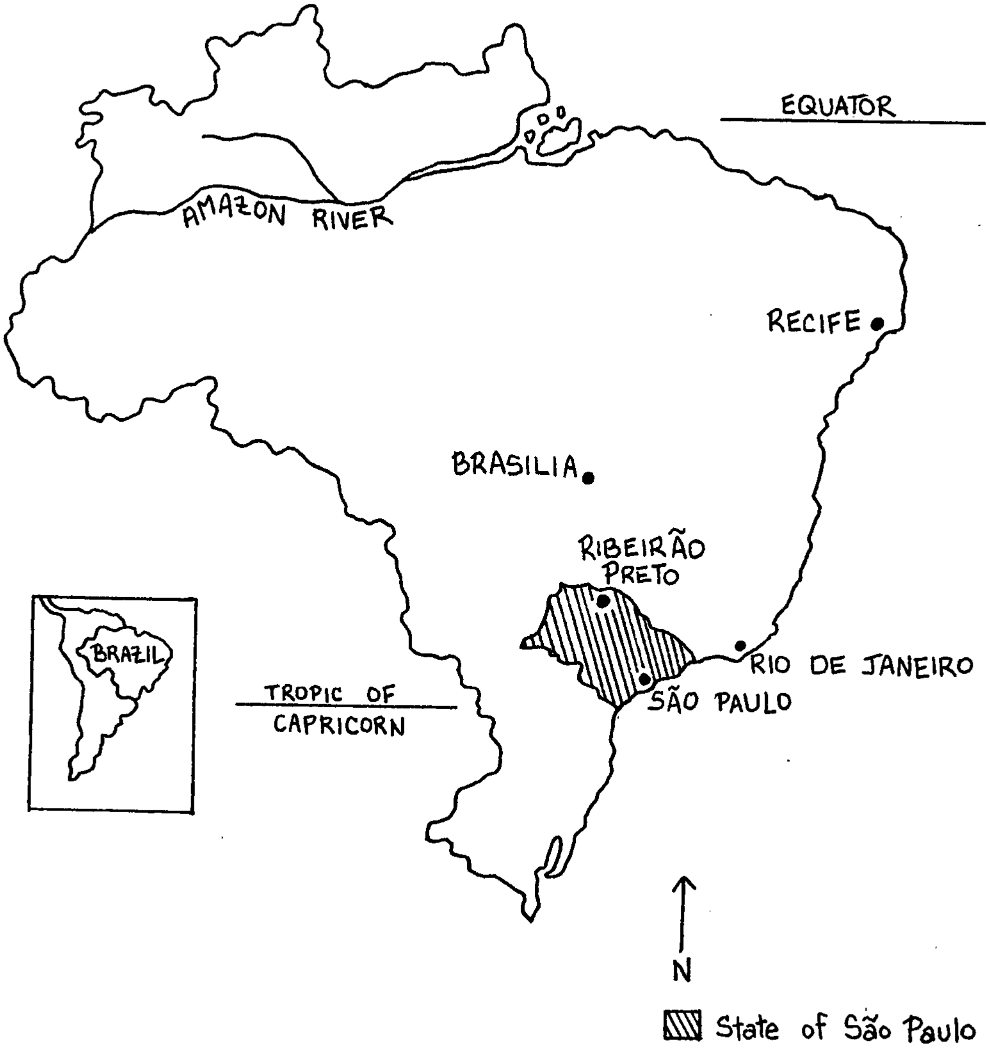


FIGURE II-2
Map of Brazil.[a]

a From Government of Brazil, 1976.

There exists an official minimum salary, but employers are not forced to pay this wage to non-unionized workers. In addition, the majority of Brazilian people have no social security or unemployment insurance (Government of Brazil, 1976). Unemployment has been estimated to vary between 15 and 30% of the male adult work force (Shrimpton, 1975). As previously mentioned, high unemployment is the driving force of migration. Workers leave their homes and families in the north hoping to secure employment in wealthier southern states of Brazil (Margolis, 1973).

The universal right to education is recognized by the Brazilian government (1976), yet of all Brazilian children entering primary school, only a fraction ever reach university (Freire, 1970). Most poor children rarely reach even the second grade (Government of Brazil, 1976), and illiteracy is a national problem of considerable proportion (Freire, 1970 and 1973).

The Brazilian government (1976) asserts that health care is paid for by the state in childbirth, infancy, and childhood, but Shrimpton's analysis (1975) of the medical system revealed that 48% of townships in Brazil had no doctor, 85% of all hospitals beds were private, and 60% of the Brazilian population had no health insurance. The leading causes of death in Brazil are enteritis and diarrheal disease (UN, 1979), both of which are diseases associated with malnutrition (Berg, 1973). Schistosomiasis, malaria, Chagas' disease, and tuberculosis are continuing endemic public health problems in Brazil (Government of Brazil, 1976).

Brazil still exhibits many of the characteristics of an underdeveloped country: high infant mortality; low life expectancy; high population growth rate; large rural population; distribution of income heavily skewed in favour of a small percentage of the population; widespread illiteracy; and a high incidence of diseases related to malnutrition and poor hygiene. Because so much of Brazil is still so underdeveloped, it has been suggested that Brazil's so-called development miracle, namely the rapid increase in industrial growth since the 1950's, has actually benefitted only a small minority of Brazilian people (Frank, 1969; Forman, 1975; Davis, 1977; and Souza, 1975).

b) Nutritional Status of Brazilian People

i) National Studies

Numerous studies have investigated the nutritional status of Brazilian people. This review will summarize results of pertinent studies conducted within the last 20 years.

There have been two comprehensive surveys that examined dietary, anthropometric, biochemical, and clinical aspects of the nutritional status of Brazilian families. The ICNND conducted a survey in 1963 of over 5,500 individuals in northeastern Brazil (ICNND, 1965). The outstanding findings of this survey were that energy and protein intakes were low among most of the sample population; that heights and weights of children were well below American standards; and that few clinical signs of malnutrition were observed. This survey also found that 60% of the population had either low or deficient levels of serum vitamin A, which indicates probable depletion of body vitamin A stores. Examinations of serum total protein, urinary thiamin, and urinary riboflavin indicated that approximately 25% of the population appeared to be deficient in these nutrients.

A more recent survey of 500 São Paulo families (Campino *et al.*, 1975) found that of the poorest 20% of people studied, 50% had clinical signs malnutrition, 25% were below American standards for height and weight, and most had protein and energy intakes significantly lower than wealthier subjects studied.

Dietary assessment of the Brazilian population has been the subject of many studies. As cited by Shrimpton (1975), in 1961-1963, family food consumption surveys were conducted by the Vargas Foundation in Brazil. Covering 9,000 families, 48 cities, and rural areas in 7 states, these surveys provided the following estimates of food consumption: 75% of people in the northeast consumed energy-deficient diets; the rural population in the south appeared to be well nourished, while nearly half the urban population in the south consumed energy deficient diets; and in all areas, most people consumed adequate amounts of protein.

Chaves (1964) noted that basal diets in the northeast of Brazil consisted of dry salted beef, flour, beans, and sugar. Siqueira (1970) noted that although food production in Brazil increased dramatically between 1948 and 1961, Brazil still compared unfavourabley with other Latin American countries in terms of individuals' food purchasing power. Indeed, Patrick and Simões (1971) found that poor people in central Brazil spent 80% of their income on food but most people failed to meet recommended dietary allowances for any of the nutrients considered.

Jansen and co-workers (1977) found that total availability of calories and protein was greatly dependent on income, and that low-income urban Brazilians simply could not purchase an adequate quantity of food to meet their needs. In another study (Alves, 1977) of 2,380 São Paulo families, 15% of families consumed inadequate amounts of protein and energy, and the mean income of families who did consume an adequate diet was twice that of families who did not.

Martins and co-authors (1977) reported that mean intakes of vitamin A, thiamin, riboflavin, vitamin C, and calcium were well below recommended levels in 337 São Paulo families of low-income. In other São Paulo studies, Szarfarc (1979) found that intakes of high quality protein foods such as meat, milk, and eggs had declined by over 20% between 1969 and 1975 in low-income families; and Roncada (1972) found that most people consumed less than 40% of the recommended amounts of vitamin A in the diet.

Biochemical and clinical indices of nutritional status of the general Brazilian population have been examined by several authors. Roncada (1972) examined biochemical and clinical as well as dietary indices of vitamin A status in São Paulo families. In this study, it was reported that 10-30% of subjects had low serum vitamin A values and that several clinical signs of hypovitaminosis A were found.

Another biochemical study (Szarfarc, 1972) found that 40% of people in São Paulo village families had low hemoglobin values. As well, in another study, 40% of individuals from low-income São Paulo families were found to excrete sub-normal levels of riboflavin in their urine (Wilson _et al_., 1977).

Apart from studies of the general population, the nutritional status of Brazilian infants and children has been of particular concern to many investigators. An early work by Waterlow and Vergara (1956) outlined the results of a protein malnutrition survey made of children in five towns in Brazil. It was found that many infants were weaned early into diets that were inadequate in most nutrients including protein and that in most cases, unsanitary conditions caused many children to contact diarrhea and infections during the first year of life. These factors greatly aggravated existing malnutrition and many of these children either died or developed clinical signs of kwashiorkor (Waterlow and Vergara, 1956).

Puffer and Serano (1973) included Brazil in their study of infant mortality in Pan-American countries. Recife, in northeast Brazil, was found to have the fourth highest infant mortality rate among 25 cities studied. Most infants who died in Recife were reported to die of infectious diseases. Puffer and Serano (1973) also estimated that nutritional deficiency was an underlying cause of 46% of deaths in children under 5 years in Recife.

Breast feeding patterns in Brazil were reviewed by Sousa and colleagues in 1975. Breast feeding appeared to be declining generally, especially among low-income women. Over 70% of women employed bottle-feeding by the time their infant was 2 months old. Ignorance about the benefits of breast feeding, and the influence of infant formula advertising were cited as two major reasons for the rise in bottle-feeding (Sousa et al., 1975). More recent studies have shown that while many women breat feed their children for six to twelve months after birth, weaning foods like sugar water, cassava flour, and rice flour are introduced as early as two weeks after birth (Desai et al., 1980, and Swann, 1979).

Dietary studies have been conducted among several groups of older children in Brazil. Rosenberg (1977) found that breakfast consisted of bread and coffee with a little sugar and milk for the majority of São Paulo school children, although no comment was made as to the nutritional efficacy of this breakfast. Santos' group (1979) studied the nutritional value of a rice (Oriza sativa) and bean (Phaseolus vulgaris) diet, traditional Brazilian fare, for pre-school children. They found this diet could be a satisfactory protein source if accompanied by adequate energy intake.

Many researchers have looked at anthropometric indices of nutritional status in Brazilian children. Marcondes and co-workers (1971) published a cross-sectional anthropometric study of over 9,000 low-income São Paulo children between ages 3 months and 12 years. The results of this study are often used in Brazil as a local standard for height and weight (Shrimpton, 1975), even though values obtained for height and weight were low in comparison with both American standards and values for Brazilian children from higher socio-economic groups.

Guitti (1974) also examined low-income school-age children in Brazil, comparing them to American standards. Low body weight and small head circumference for age were found in 63% of subjects. Another study of children under 5 years (Sigulem et al., 1976) showed that children from high-income Brazilian families tended to meet or exceed American standards for height and weight; whereas, low-income children fell below American standards. Several later studies (Guitti et al., 1977; Turini et al.,, 1978; Hegg, 1978; Yunes et al., 1978; and Desai et al., 1981) have expressed similar results for children who are school age and younger.

Clinical studies of Brazilian children confirm the existence of nutrition problems among low-income groups. Maldonada (1968) reported widespread dental caries and some cases of enlarged thyroid among poorly nourished school children in central Brazil. Simmons (1976) found a high incidence of clinical signs of hypovitaminosis A, including blindness among pre-school children in northeast Brazil.

Biochemical assessment of Brazilian children has shown that low-income subjects have significantly poorer riobflavin status, as indicated by urinary riboflavin/creatinine ratios than well-to-do children (Martins et al., 1976). In another biochemical study of iron-deficiency anemia in São Paulo, low hemoglobin levels, while not prevalent in the population as a whole, did occur with significantly greater frequency in children of low socio-economic status (Sigulem, 1978).

Roncada's group (1978) examined serum vitamin A and carotene in children of national migrants in São Paulo. They found that over 50% of children had low or deficient values of both serum vitamin A and carotene. This confirmed the results of previous studies (Gomes et al., 1970 and Varela et al., 1972) showing that children from lower Brazilian socio-economic groups tend to have marginal vitamin A nutriture.

Olson, in his study of liver vitamin A reserves (1979), found that 30% of children in central Brazil between 3 weeks and 2 years old who had died of various causes had extremely low liver vitamin A reserves. Furthermore, vitamin A reserves in 50% of children who died under 4 years of age were classified as inadequate in this study, indicating probable widespread cause for concern about vitamin A nutriture of Brazilian children in this area (Olson, 1979).

ii) Studies in Ribeirão Preto, São Paulo

Relatively few nutrition studies have been previously conducted in the Ribeirão Preto area of São Paulo state in Brazil. Puffer and Serano (1973) included Ribeirão Preto as a project area in their study of infant mortality. Ribeirão Preto was found to be superior to other areas in Latin America in that it had lower infant mortality rates and a lower incidence of infant deaths having malnutrition as an associated cause.

The nutritional status of 586 Ribeirão Preto children aged 2 to 10 years was investigated by Dutra de Oliveira and co-workers in 1964. All subjects in this study were found to have values for height, weight, and arm circumference well below American standard values. Energy intakes in this study were found to be low, and iron status, as indicated by hemoglobin levels, was found to be generally adequate.

Angeleli (1978) examined general aspects of nutritional status of male agricultural migrant workers, popularly known as boia-frias (or "cold meal eaters") residing in the Ribeirão Preto area. It was found that adult male energy intakes averaged 2,200 kcal per day and that most individuals followed a similar meal pattern: no breakfast; rice and beans for lunch; and rice and beans for supper occasionally supplemented with eggs, beef, tomatoes, or sausage. 78% of subjects showed evidence of parasitic infestation, and 42% of subjects exhibited anthropometric indices of first grade malnutrition according to the Gomez (1956) classification, using American standards for comparison.

Biochemical tests were also conducted in Angeleli's (1978) study. Over 90% of subjects had normal values for plasma vitamin A and carotene; 87% had normal values for hemoglobin; and 57% had normal values for hematocrit. Protein and albumin in the serum were normal in most subjects.

A recent comprehensive nutrition survey of 100 boia-fria migrant worker families was conducted in Ribeirão Preto by Desai and co-workers (1980). A socio-economic questionnaire used in this study yielded the following information: male family members usually worked as day labourers cutting sugar cane or picking coffee on large land holdings near the city; women and children often worked as well to supplement the family income; most families reported earning substantially less than the legal minimum wage; and 40-60% of adult boia-frias had no education whatsoever. There was no sewage system in most homes and parasitic infestation was found in

60% of children examined.

The typical diet of boia-frias, as revealed from food frequency questionnaires, is outlined in Table II-1. Quantitative analysis of the adult boia-fria diet, based on 24-hour recall interviews, showed that the average daily intake of most nutrients was below the World Health Organization/Food and Agriculture Organization (WHO/FAO) recommended dietary allowances. Very low nutrient intakes were reported for calcium, retinol, thiamin, niacin, riboflavin, and ascorbic acid, and for iron among women only. For all anthropometric parameters measured, mean boia-fria values were well below American standards, except for weight in female adults.

In terms of biochemical analyses, 25% of the adult population examined showed low serum vitamin A values, 30% showed low or deficient serum carotene values, and 25% showed low values for hemoglobin and hematocrit. These results differ somewhat from Angeleli's (1978). This could be due to the fact that Angeleli (1978) studied only male subjects; whereas, Desai and co-workers (1980) studied both males and females, and found that males had higher mean values than females for plasma vitamin A and carotene, and for hemoglobin and hematocrit. In a separate report, Desai and co-workers (1980a) indicated that vitamin E status of boia-frias appeared to be satisfactory.

TABLE II-1

Typical diet of *boia-fria* migrant workers.[a]

Meals	Foods and beverages consumed		
	Daily	Weekly	Sometimes
Breakfast	Coffee & sugar, white bread	Hot milk & sugar[b]	
Lunch	White rum, rice & beans	Beer Egg-fried Salad-raw: -tomato -onion	Beef or chicken-fried Salad-raw: - lettuce - wild chicory Vegetables-boiled: - potato - cassava
Dinner	White rum, rice & beans	Beer Macaroni-soup White bread	Sausage-fried
Snacks	Coffee & sugar	Tea & sugar Soft drinks[b]	Limewater & sugar Fruits: banana, orange
Fats	Soybean oil, pork lard		
Condiments	Salt, onion, garlic	Red pepper	Tomato sauce

a Modified from Desai *et al*., 1980.

b Consumed mainly by children.

CHAPTER III

METHODS AND MATERIALS

1. Population and Sample

A study was designed to obtain information on the nutritional status and physical work performance of children of migrant agricultural workers, commonly identified as boia-frias, living in southern Brazil. For the purposes of comparison, information was also obtained on the nutritional status and physical work performance of children from higher socio-economic groups who had access to adequate diets and health care. In the study, these latter children were identified as "well-to-do" and served as controls. The objectives of the study were to compare boia-fria children with their well-to-do counterparts in terms of nutritional status and physical work performance, and to determine whether parameters of physical work performance were related to parameters of nutritional status. The study was conducted during the months of May through August, 1979.

The subjects of the study were boys aged 11-14 years living in Ribeirão Preto in the state of São Paulo, Brazil, whose parents were either migrant agricultural workers, or well-to-do professionals and businesspeople. Several factors were considered in selecting subjects for the study. First, only male children were studied due to time constraints.

Second, the age range of 11-14 years was chosen because this is a critical growth period when nutritional needs are high. Also, many boia-fria children leave school by age 15 to become agricultural labourers, while well-to-do children remain in school. It was thought that children in a younger age range who were all still in school would be more likely than older children to be similar in terms of their daily activities. Third, the city of Ribeirão Preto was chosen to be the location for the study because many migrant workers lived there and because excellent research facilities were available at the University of São Paulo Hospital.

Finally, subjects for the study had to be selected from one of two groups living in Ribeirão Preto: either children of migrant workers, or children of well-to-do professional and business people. It was decided to choose two schools in the city that were populated mainly by one or other of the two groups to be studied, and to select subjects from these schools. Schools were selected on the basis of previous studies (Desai _et al_., 1980) and with the help of local people. _Boia-fria_ children were selected from a public school in Vila Recreio, a _favela_ or slum area on the periphery of Ribeirão Preto where most migrant workers lived. Vila Recreio was characterized as being one of the poorest areas of the city in terms of income levels, housing, and education levels. Well-to-do children were selected from a private school in Jardim Recreio, a residential area of Ribeirão Preto which was populated almost exclusively by professionals and businesspeople. Jardim Recreio was considered to be one of the most affluent areas of the city in terms of income, housing, and education. A total of 94 subjects were tested, 59 _boia-fria_ and 35 well-to-do.

2. _Experimental Procedure_

All tests except biochemical bloodwork were conducted at the University of São Paulo Hospital in Ribeirão Preto. Biochemical bloodwork was done in laboratories of the Department of Clinical Medicine in the Faculty of Medicine at the University of São Paulo in Ribeirão Preto.

On the morning of testing, subjects were taken to the hospital at 8 a.m. They were first given a physical examination and an electrocardiogram by a physician to detect any medical conditions that might prevent participation in the study. Subjects were then interviewed to obtain information about their diet. Following the interview, experimental equipment and procedures were explained to the subject and a first blood sample was taken. The subject then performed a work test on a bicycle-ergometer and a second blood sample was taken.

After the work test, subjects rested and were given refreshments. Anthropometric measurements were taken after the rest period. Subjects then returned to their schools and blood specimens were transported to the laboratory for analysis. The entire procedure took each subject approximately 3 hours.

3. Assessment of Nutritional Status

a) Socio-economic Factors

Socio-economic factors that may have bearing on nutritional status were assessed by conversing with local people and by making visits to houses, markets, and shops to obtain qualitative information about local culture and home life. Information about general physical health of *boia-fria* as compared to well-to-do children was obtained from an examination conducted by a physician on each subject prior to experimental testing. It was expected that this information might provide helpful background in interpreting results of more direct tests of nutritional status.

b) Dietary Analysis

Information on dietary intake was obtained using the 24-hour recall method. Each subject in the study was interviewed in Portuguese by a

Brazilian nurse who had been previously trained to do 24-hour diet recalls. Foods eaten were recorded by the interviewer and quantities were expressed in terms of local measures. Any supplements consumed were noted. Figure III-1 illustrates the questionnaire used in the interview. All foods recorded for each subject were then coded for food number, food group number, and quantity. This information was transcribed onto computer cards for analysis. The modified food composition table for Brazilian foods developed by Swann (1979) was used for nutrient analysis, with the addition of 35 new foods.

Information on the composition of the 35 foods not included in Swann's table was obtained from Leung and Flores (1961) and Watt and Merrill (1963), and nutrient composition was expressed per 100g of food. If a food was listed in both sources, the more locally applicable source was used. If a food could not be found in either source, the composition of the food most closely approximating it was used. α-tocopherol values for foods were obtained from composition tables developed by Bauernfeind and Desai (1977). For mixed dishes, Brazilian recipes were obtained from local cookbooks and from local women. These recipes were averaged where appropriate and ingredients and quantities of foods used in mixed dishes were approximated. The mixed dish was then coded in terms of individual ingredient foods.

Computer programmes developed by statisticians at the University of British Columbia were used for nutrient analysis. Nutrient intake and percentage contribution of food groups to nutrient intake were determined for each subject. Nutrient intakes were compared to WHO/FAO recommended daily intakes (Passmore et al., 1974).

QUANTIDADES DE COMIDAS E BEBIDAS CONSUMIDAS NO DIA ANTERIOR

(ÚLTIMAS 24 HORAS)

NOME DA FAMÍLIA .... DATA: ....

NOME DA CRIANÇA .... IDADE:...........

VILA RECREIO ☐ VITA ET PAX ☐ SEXO: ....

HORÁRIO	ALIMENTOS	QUANTIDADE	OBSERVAÇÕES
Café da Manhã			
Entre Café e Almoco			
ALMOÇO			
Entre Almoço e Jantar			
JANTAR			
Noite			

FIGURE III-1

Questionnaire used in 24-hour diet recall interviews.

c) Anthropometric Determinations

All anthropometric measurements were taken according to standard recommended procedures (Jelliffe, 1966). The following parameters were measured: weight, standing height, mid-upper-arm circumference, and triceps skinfold thickness. In addition, mid-upper-arm muscle circumference was calculated.

To measure weight, a platform beam balance was used. Subjects were weighed to the nearest 1/10 kg before meals, without shoes, and wearing a minimum of light clothing. No correction was made for clothing. Standing height was measured using a platform beam balance equipped with a vertical measuring rod. Subjects were measured to the nearest mm without shoes.

Mid-upper-arm circumference was measured using a plasticized fibre tape. Measurements were taken to the nearest mm on the fully relaxed left arm. Triceps skinfold thickness was measured using Lange skinfold calipers which exerted a uniform pressure of 10 g/mm^2. Measurements were taken to the nearest 1/10 mm on the fully relaxed left arm. Mid-upper-arm muscle circumference was calculated for each subject using the following formula (Jelliffe, 1966):

$$x_1 = x_2 = \pi(x_3)$$

where: x_1 = mid-upper-arm-muscle circumference (cm)
x_2 = mid-upper-arm circumference (cm)
x_3 = triceps skinfold thickness (cm)

All anthropometric measurements were compared to both international standards (Nelson _et al_., 1979 and Frisancho, 1974) and Brazilian standards (Marcondes _et al_., 1971) where possible.

d) Biochemical Tests

Subjects were asked to give blood before and after exercise tests. Before exercise, approximately 10 ml of venous blood were drawn using sterilized disposable needles and rubber-stoppered glass vacutainer tubes Of the 10 ml, approximately 4 ml were drawn into a tube containing the anti-coagulant ethylene-diamine tetraacetic acid (EDTA), for test requiring whole blood, and approximately 6 ml were drawn into a tube containing no anti-coagulant, for tests requiring serum. After exercise, another 4 ml of blood were drawn into a tube containing EDTA. Blood samples were refrigerated and analysed within 24-48 hours for the following: total hemoglobin, hematocrit, serum iron, total serum iron-binding capacity, serum total protein, and serum albumin. The percentage of transferrin saturation in serum was also calculated.

Total hemoglobin was determined using the cyanomethemoglobin colorimetric method (Crosby and Houchin, 1957; Drabkin, 1949; and Eilers, 1967). For each sample, 20 µl of whole blood were added to 5.0 ml of Drabkin's solution (100 parts sodium bicarbonate, 20 parts potassium ferricyanide, and 5 parts potassium cyanide in 1,000 ml of water with 0.5 ml of Brij-35 solution, 30 g/100 ml, added). After being mixed well and standing for 15 minutes, sample absorbances were read at 540 nm on a Beckman DU spectrophotometer. Standards were prepared according to the specifications of Eilers (1967) and total hemoglobin in each sample was determined from a calibration curve.

Hematocrit was determined using the ICNND standard method (1963). For each sample, a small amount of whole blood was introduced into a micro-capillary tube, which was then sealed at one end with Critoseal putty, and centrifuged at 3,000 rpm for 5 minutes. When the cells were packed, the percentage of volume that was red blood cells was determined using a standard micro-capillary hematocrit reader.

Serum iron and total serum iron-binding capacity were determined using ferrozine colorimetric methods (Carter, 1971 and Persijn et al., 1971). To determine serum iron, 0.5 ml of serum was added to 2.5 ml of buffer solution (hydroxylamine hydrochloride 1.5% w/v in acetate buffer, pH 4.5), and initial absorbance was read at 560 nm on a Beckman DU spectrophotometer. Then 0.05 ml of ferrozine (0.85% w/v in hydroxylamine hydrochloride solution) was added and the solution was incubated at 37° for 10 minutes. Final absorbance was then read at 560 nm. A standard was prepared and the following formula was used to calculate serum total iron:

$$\text{Serum total iron } (\mu g/100m) =$$

$$\frac{\text{Final } A_{test} - \text{Initial } A_{test}}{\text{Final } A_{standard} - \text{Initial } A_{standard}} \times \text{Concentration}_{standard} (\mu g/100 \text{ ml})$$

Where: A_{test} = absorbance at 560 nm of test.

$A_{standard}$ = absorbance of 560 nm of standard.

To determine total serum iron-binding capacity, 0.5 ml of serum was added to 0.5 ml of iron standard solution which contained 500 μg/100 ml of iron, and initial absorbance was read at 560 nm. Then 0.05 ml of ferrozine was added and the solution was incubated at 37° for 10 minutes. Final absorbance was read at 560 nm. A standard was prepared and the following formulae were used to calculate total iron-binding capacity:

1. Serum unsaturated iron-binding capacity =

$$\text{Concentration}_{\text{standard}}(\mu g/100\ ml) - \left[\frac{\text{Final } A_{\text{test}} - \text{Initial } A_{\text{test}}}{\text{Final } A_{\text{standard}} - \text{Initial } A_{\text{standard}}}\right] \times \text{Concentration}_{\text{standard}}(\mu g/100\ ml)$$

where: A_{test} = absorbance at 560 nm of test

A_{standard} = absorbance at 560 nm of standard

2. Serum total iron-binding capacity (µg/100 ml) =

Serum total iron (µg/100 ml) + Serum unsaturated iron-binding capacity (µg/100 ml)

Percentage of transferrin saturated was calculated using the following formula:

$$\%\ \text{transferrin saturation} = \frac{\text{Serum total iron } (\mu g/100\ ml)}{\text{Serum total iron-binding capacity } (\mu g/100\ ml)} \times 100$$

Serum total protein was determined using the biuret colorimetric method (Gornall et al., 1949). For each sample, 0.1 ml of serum was added to 5.0 ml of biuret reagent (0.15% w/v copper sulfate in 3.0% w/v sodium hydroxide). The solution was mixed well, allowed to stand at room temperature for 15 minutes, then absorbance was read at 540 nm on a Beckman DU spectrophotometer. A standard was prepared and serum total protein was calculated using the following formula:

Serum total protein (g/100 ml) =

$$\frac{\text{Absorbance}_{(540)} \text{ of test}}{\text{Absorbance}_{(540)} \text{ of standard}} \times \text{Concentration}_{\text{standard}}(g/100\ ml)$$

Serum albumin was determined using the bromcresol green colorimetric method (Doumas and Biggs, 1972 and Rodkey, 1965). 20 µl of serum were added to 5.0 ml of bromcresol green solution (0.01% w/v in buffer, pH 4.0), and the sample was mixed well. After standing for 10 minutes at room temperature, the absorbance of the sample was read at 630 nm on a Beckman DU spectrophotometer. A standard was prepared and serum albumin was calculated using the following formula:

Serum albumin (g/100 ml) =

$$\frac{\text{Absorbance}_{(630)}\ \text{test}}{\text{Absorbance}_{(630)}\ \text{standard}} \times \text{Concentration}_{\text{standard}}(\text{g/100 ml})$$

For all biochemical determinations, subjects' values were compared to normal values (Sauberlich _et al_., 1974).

4. Assessment of Physical Work Performance

Two tests were used to assess physical work performance: change in heart rate in response to work, and change in blood lactic acid in response to work.

To assess the change in heart rate in response to work, the following procedure was used. First, each subject was connected to a continuous heart rate monitor using electrodes which were taped to his chest. The subject then was seated on a bicycle-ergometer (Brazilian-made Funbec model) and following a 3 minute rest period, commenced pedalling. Subjects pedalled for 3 minutes with a load of 25 watts, 3 minutes with a load of 50 watts, and 3 minutes with a load of 75 watts. This was followed by another 3 minute rest period. Pedalling was thus continuous for 9 minutes with pace held constant at 50 rpm.

Heart rate was recorded at the end of each minute of testing, including rest periods. Change in heart rate was calculated by subtracting minimum recorded heart rate from maximum recorded heart rate. If at any time during testing a subject's heart rate exceeded 180 beats per minute, testing was stopped. A cardiologist was present throughout the entire test period.

As an idex of fatigue, lactic acid in response to work load was measured in whole blood collected before and after exercise in a manner previously described. Immediately after collection, 2.0 ml of whole blood were transferred into 4.0 ml of cold perchloric acid (8% w/v) to precipitate blood proteins and stabilize lactic acid (Long, 1944; Marbach and Weil, 1967; and Segal _et al_., 1956). This solution was mixed vigorously and centrifuged. The resulting clear supernatant was then used to determine lactic acid by the lactate dehydrogenase enzymatic method (Long, 1944; Marbach and Weil, 1967; and Segal _et al_., 1956). For each sample, 0.2 ml of supernatant was added to 2.8 ml of a solution containing: 10 mg of nicotinamide adenine dinucleotide (NAD); 2.0 ml of glycine buffer, pH 9.2; 4.0 ml of water; and 0.1 ml of lactate dehydrogenase suspension, 1,000 units/ml in ammonium sulfate. The solution was mixed and incubated at 37° for 30 minutes. Then absorbance was read at 340 nm on a Zeiss spectrophotometer.

Lactic acid in the sample was calculated using the following formula:

Blood lactic acid (mg/100 ml) =

$$A_{340} \times \frac{\left[\frac{3.0}{6.22 \times 0.0667 \times 1}\right] \times 90.0}{10} = A_{340} \times 65.1$$

Where: A_{340} = maximum absorbance of sample at 340 nm

3.0 = reaction value (ml)

6.22 = millimolar extinction coefficient of NADH at 340 nm

0.0667 = volume of blood sample in cuvet (ml)

1 = lightpath (cm)

90.0 = molecular weight of lactic acid (g/mole)

10 = conversion factor 1000 ml ÷ ml.

Change in blood lactic acid was calculated by subtracting latic acid before exercise from lactic acid after exercise. Percentage difference between lactic acid before and after exercise was also calculated.

5. Statistical Analysis

All statistical analyses were conducted using computer facilities and programmes at the University of British Columbia. For all data, boia-fria and well-to-do children were first compared as two separate groups. Student's t-test and the chi-square test were used to determine the significance of differences between the two groups.

Then, to determine the association between nutritional status and physical work performance, correlation analysis was used. Pearson's correlation coefficients were determined for selected pairs of variables, treating boia-fria and well-to-do subjects as one group. Correlation coefficients were also determined for the same variables treating the two groups separately. However, since these values were not found to be different than those for the two groups treated as one, they are not reported in the study.

CHAPTER IV

RESULTS

1. Assessment of Nutritional Status

a) Socio-economic Factors

Local visits yielded the following information about living conditions in Vila Recreio and in Jardim Recreio.

Vila Recreio was located approximately 10 km, or 45 minutes by bus, from the center of Ribeirão Preto. Living conditions in Vila Recreio were generally very poor. Most families lived in two-or three-room houses that they constructed themselves with dirt floors, wooden walls and tile or tin roofs. Figure IV-1 is illustrative of typical migrant worker housing. These homes often had no electrical lighting or ventilation, and much of the time cooking was done outdoors on open fires. Many homes did not have running water, so families shared water taps located in public lots.

There was no sewage system in most Vila Recreio homes, so sewage and other waste water flowed into the streets. Figure IV-2 illustrates a typical street scene in Vila Recreio where children played barefoot in the effluent, a practice probably aggravating chronic problems with parasitic infection that have been documented among _boia-frias_ (Desai _et al_., 1980). Soil in the area was dry and red (_terra roxa_) and red dust often coated children and their clothing. Very few families planted vegetable gardens or fruit trees, but some kept domestic animals such as dogs or cats.

Most _boia-fria_ families did not possess their own cars or horses for transportation and depended on bicycles or the municipal bus to travel to

FIGURE IV-1
Typical house in Vila Recreio.

FIGURE IV-2
Typical street in Vila Recreio.

the city center. Bus travel was both time-consuming and costly so that as a result, most families bought food locally at corner stores such as the one illustrated in Figure IV-3. These stores had limited stock selection with prices approximately 15% higher than in the larger stores in the city center (Swann, 1979). Figure IV-4 shows the type of goods available in a Vila Recreio corner store: liquor, cigarettes, white unenriched bread, and sausages, as well as white rice and dried kidney beans. Fresh produce was seldom sold.

Jardim Recreio was also located approximately 10 km from the center of Ribeirão Preto but living conditions in this suburb were superior to those in Vila Recreio. Most families in Jardim Recreio lived in attractive three- or four-bedroom homes built of wood and stucco or brick construction with tile floors and roofs. Figures IV-5 and IV-6 illustrate typical homes found in Jardim Recreio. All homes here had electricity, running water, and flush toilets. Most families had gas stoves and refrigerators, as well as applicances such as washing machines, televisions, and radios. In many of these homes, boia-frias were hired to perform domestic duties and to do gardening chores.

The streets in Jardim Recreio were all paved and most homes had fenced gardens where fruit, vegetables and flowers were grown. Most families owned cars and did their shopping in downtown Ribeirão Preto. The selection of foods available in the city markets was wide-ranging: fresh produce, meats, various baked goods, and imported confections. People from Jardim Recreio also frequented the many restaurants located in Ribeirão Preto.

It was established from conversations with local people that the average migrant worker earned approximately US$1,000 annually. The average

FIGURE IV-3
Typical corner store in Vila Recreio.

FIGURE IV-4
Goods available in typical store in Vila Recreio.
(Photo courtesy of Dr. I.D. Desai)

FIGURE IV-5
Typical house in Jardim Recreio.

FIGURE IV-6
Typical house in Jardim Recreio.

working person's income in Jardim Recreio was estimated to be approximately US$10,000 annually. Thus, there was a tenfold difference in average incomes in the two areas. As previously mentioned, most people in Vila Recreio earned their living picking coffee or cutting sugar-cane on nearby farms. On the other hand, most people in Jardim Recreio were doctors, lawyers, professors, or business executives.

Information about the health status of boia-fria and well-to-do children, obtained from physical examinations, is summarized in Table IV-1. From this table it can be seen that proportionally fewer boia-fria than well-do-do subjects were apparently healthy, as indicated by a normal electrocardiogram (ECG) and by the absence of bronchial infection. More boia-fria than well-to-do subjects had cardiac irregularities, and more boia-fria than well-to-do subjects exhibited symptoms of infection such as fever, cough, or sore throat.

b) Dietary Analysis

The mean daily nutrient intake of boia-fria and well-to-do subjects is shown in Table IV-2. For all nutrients except α-tocopherol, the intake of boia-fria subjects was lower than that of well-to-do subjects. For the following nutrients, differences in mean intake between boia-fria and well-to-do subjects were statistically significant: energy, protein, total fat, calcium, iron, vitamin A, thiamin, riboflavin, and vitamin C. Standard deviation was very high for mean intakes of calcium, vitamin A, niacin, and vitamin C.

Table IV-3 shows the mean daily nutrient intake of boia-fria and well-to-do subjects in comparison with WHO/FAO recommended intakes (Passmore et al., 1974). The mean intake of boia-fria subjects was less

TABLE IV-1

Comparison of indicators of health status in subjects from *boia-fria* and well-to-do families.

Health status indicator	Number of subjects[a]	
	Boia-fria (n = 58)	Well-to-do (n = 34)
Apparently healthy: as indicated by a brief physical examination and an ECG.	35 (60.3)[b]	30 (88.2)
Cardiac irregularities: as indicated by an abnormal ECG.	6 (10.3)	1 (2.9)
Bronchial infection: as indicated by presence of fever, cough, sore throat, or chest congestion	17 (29.3)[b]	3 (8.8)

a Figures in parentheses denote % of total in group.

b Values for *boia-fria* and well-to-do subjects are significantly different ($p < .001$) using chi-square test.

TABLE IV-2

Comparison of daily nutrient intake of subjects from *boia-fria* and well-to-do families.

Nutrient	Daily intake (mean ± SD) Boia-fria (n = 42)	Daily intake (mean ± SD) Well-to-do (n = 32)
Energy (kcal)	1475.6 ± 485.9[b]	1863.2 ± 604.0
(kcal/kg)	43.4 ± 18.2	37.7 ± 15.6
Protein (g)	51.0 ± 27.0[a]	79.4 ± 32.8
(g/kg)	1.49 ± 0.79	1.61 ± 0.65
Total fat (g)	60.9 ± 21.9[b]	81.6 ± 42.1
Carbonhydrate (g)	182.7 ± 66.5	206.7 ± 67.6
Calcium (mg)	391.1 ± 264.4[a]	681.8 ± 359.0
Iron (mg)	7.9 ± 3.1[d]	10.0 ± 4.3
Vitamin A (RE)	451.9 ± 253.1[a]	1121.6 ± 570.9
Thiamin (mg)	0.59 ± 0.24[d]	0.76 ± 0.40
Riboflavin (mg)	0.78 ± 0.38[a]	1.27 ± 0.46
Niacin (mg)	8.55 ± 7.14	12.04 ± 11.89
Vitamin C (mg)	28.7 ± 42.6[a]	95.0 ± 85.8
α-Tocopherol equivalents (mg)[d]	4.65 ± 1.85	4.34 ± 1.99

a - c Values for *boia-fria* and well-to-do subjects are significantly different using Student's one-tailed t-test:

a $p < .001$
b $p < .01$
c $p < .05$

d α-Tocopherol equivalent value obtained by multiplying mg α-tocopherol x 1.2 to correct for non-αtocopherols (Desai *et al.*, 1980a).

TABLE IV-3

Daily nutrient intake of subjects from *boia-fria* and well-to-do families in comparison with WHO/FAO recommended daily intakes.

Nutrient	WHO/FAO Recommended daily intake[a]	Mean daily intake expressed as % of WHO/FAO recommended	
		Boia-fria	Well-to-do
Energy	2600 kcal	56.8[c]	71.7
	71 kcal/kg	61.1[c]	53.1[c]
Protein	37 - 43 g[b]	118.6	214.6
	1.0-1.2 g/kg[b]	129.6	159.4
Calcium	600 - 700 mg	60.2[c]	104.9
Iron	5 - 7 mg[b]	112.9	200.0
Vitamin A	575 RE	78.6	195.1
Thiamin	1.0 mg	59.0[c]	76.0
Riboflavin	1.6 mg	48.8[c]	79.4
Niacin	17.2 mg	49.7[c]	70.0
Vitamin C	20 mg	143.5	475.0

a Passmore *et al.*, 1974.

b Lower value applies to diet rich in animal source foods (well-to-do). Higher value applies to mixed cereal-legume diet with small amounts of animal source foods (*boia-fria*).

c Values are less than 2/3 WHO/FAO recommended values.

than 2/3 of that recommended for the following nutrients: energy, calcium, thiamin, riboflavin, and niacin. In contrast, the mean intake of well-to-do subjects was greater than 2/3 of the recommended intake for all nutrients except energy intake per unit of body weight. The mean intakes of protein, iron, and vitamin C were over 100% of the recommended intake for both boia-fria and well-to-do subjects.

Table IV-4 shows the actual number of subjects in each group who had daily nutrient intakes that were below 2/3 of the levels recommended by the WHO/FAO. As this table illustrates, between 60 and 80% of boia-fria subjects had daily intakes below 2/3 of those recommended for the following nutrients: energy, calcium, thiamin, riboflavin, niacin, and vitamin C. In general, fewer well-to-do subjects than boia-fria subjects had nutrient intakes that were below 2/3 of the recommended levels. These differences between boia-fria and well-to-do subjects were statistically significant for the following nutrients: energy, calcium, thiamin, riboflavin, niacin, and vitamin C.

The percentage contribution of various food groups to nutrient intake is illustrated in Table IV-5. In boia-fria diets, most energy was supplied by cereals (40.0%) and legumes (24.4%). Comparatively, most energy was supplied by animal protein sources (25.2%), cereals (18.9%), and sweets (15.4%) in well-to-do diets. Protein in the boia-fria diet was derived from animal sources (34.0%), legumes (25.2%), and cereals (23.8%); whereas, in the well-to-do diet, protein was derived mainly from animal sources (57.8%). In both groups, dairy products supplied approximately one half of the calcium in the diet. In the boia-fria diet, 48.8% of iron came from legumes and 18.2% from the animal protein sources; whereas, in the well-to-

TABLE IV-4

Number of subjects with daily nutrient intake less 2/3 of recommended daily intake.

Nutrient	Number of subjects[a] Boia-fria	Well-to-do
Energy	30 (71.4)[b]	15 (46.9)
Protein	7 (16.7)	0 -
Calcium	29 (69.0)[b]	8 (25.0)
Iron	8 (19.0)	2 (6.3)
Vitamin A	10 (23.8)	1 (3.1)
Thiamin	30 (71.4)[b]	14 (43.8)
Riboflavin	31 (73.8)[b]	9 (28.1)
Niacin	34 (81.0)[c]	20 (62.5)
Vitamin C	26 (61.9)[b]	8 (25.0)

a Figures in parentheses denote % of total in group.

b - c Values for boia-fria and well-to-do subjects are significantly different using chi-square test:

b $p < .001$
c $p < .05$

TABLE IV-5

Contribution of food groups to nutrient intake[a]

Nutrient		Food groups								
		Dairy Products	Animal protein sources	Legumes	Vegetables	Fruit	Cereal, grain products	Fats, oils	Sugars, sweets	Miscellaneous foods
Energy	b	6.2	12.6	24.4	2.2	1.9	40.0	5.0	7.5	0.2
	c	13.2	25.2	12.0	3.4	5.8	18.9	5.2	15.4	0.8
Protein	b	12.9	34.0	25.2	2.0	1.0	23.8	0.8	0.0	0.1
	c	16.9	57.8	10.5	1.9	1.2	9.9	0.5	0.5	0.7
Total fat	b	7.8	15.3	36.3	1.3	1.0	25.9	12.4	0.0	0.0
	c	19.1	32.2	16.5	2.8	0.9	11.9	13.9	2.6	0.0
Carbohydrate	b	4.9	0.4	17.1	3.1	3.3	55.3	0.1	15.3	0.5
	c	9.7	1.0	9.1	4.8	12.5	29.0	0.3	32.1	1.4
Calcium	b	46.6	12.6	16.4	1.6	3.7	16.1	0.6	1.0	1.4
	c	57.5	17.6	5.9	2.3	5.5	7.5	0.5	3.0	0.2
Iron	b	5.9	18.2	48.8	4.3	4.0	14.7	0.7	1.3	2.0
	c	8.5	35.8	22.0	5.7	12.8	10.0	0.7	3.9	0.6
Vitamin A	b	20.4	17.5	24.2	14.4	8.3	1.2	13.7	0.5	0.0
	c	32.2	15.1	5.3	18.2	14.1	3.8	6.5	4.8	0.0
Thiamin	b	9.6	12.7	47.2	5.8	5.7	16.4	0.8	0.4	1.4
	c	12.5	28.4	20.1	8.0	13.6	11.4	0.7	4.7	0.6
Riboflavin	b	32.8	30.3	18.6	2.9	2.7	9.0	1.1	0.5	2.0
	c	32.9	42.3	6.3	3.8	4.7	4.8	0.5	4.5	0.2
Niacin	b	2.5	30.1	18.0	7.1	2.8	30.2	0.9	0.0	8.3
	c	3.3	53.7	8.4	8.9	7.2	14.0	0.9	0.7	2.9
Vitamin C	b	24.6	0.0	0.0	33.5	28.5	0.0	0.3	4.8	1.2
	c	9.2	0.0	0.0	27.2	49.9	2.2	0.6	10.0	0.7
α-Tocopherol equivalents	b	0.3	8.7	41.1	2.7	2.3	32.4	12.5	0.0	0.0
	c	7.2	19.5	23.5	5.6	3.8	17.7	21.0	1.6	0.0

a Values are percentage food group contributes to nutrient intake.
b Boia-fria diet.
c Well-to-do diet.

do diet, 22.0% of iron came from legumes and 35.8% from animal protein sources.

Vitamin A in boia-fria diets was derived from legumes (24.2%), dairy products (20.4%), and animal protein sources (17.5%). In well-to-do diets, vitamin A came from dairy products (32.2%), vegetables (18.2%), and animal protein sources (15.1%). Thiamin was supplied primarily by legumes (47.2%) and cereals (16.4%) in boia-fria diets, but by animals protein sources (28.4%), legumes (20.1%), and fruit (13.6%) in well-to-do diets.

Both groups obtained most riboflavin from dairy products and from animal protein sources. Boia-fria subjects obtained niacin from cereals (30.2%) and animal protein sources (30.1%); whereas, well-to-do subjects obtained niacin mainly from animal protein sources (53.7%). Vitamin C was obtained from vegetables (33.5%), fruit (28.5%), and dairy products (24.6%) in boia-fria diets, but mainly from fruit (49.9%) and vegetables (27.2%) in well-to-do diets. Finally, tocopherols came from legumes (41.4%) and cereals (32.4%) in boia-fria diets, but from legumes (23.5%), fats and oils (21.0%), and animal protein sources (19.5%) in well-to-do diets.

Tables IV-6 and IV-7 show randomly selected but representative daily menus for boia-fria and well-to-do subjects. The boia-fria diet was generally quite monotonous. Breakfast usually consisted of white bread with coffee or milk, while lunch and supper usually consisted of rice and beans supplemented occasionally with meat, eggs, or vegetables. Not many foods were eaten between meals, but those reported included bread, ice cream, and soft drinks. In contrast, diets of well-to-do children showed greater variety. For breakfast, they usually had white bread with milk and coffee. Lunch usually consisted of rice and beans plus meat, frequently beef but sometimes chicken or seafood, green vegetables, and fruit

TABLE IV-6

Sample daily menus taken from diet recalls collected from boia-fria subjects[a].

Breakfast	1 slice white bread with margarine, 1 cup hot milk with sugar.	2 slices white bread with with margarine, 1 cup coffe with milk and sugar.
Lunch	1 cup white rice, 3/4 cup kidney beans, 2 fried chicken wings.	3/4 cup white rice, 3/4 cup kidney beans.
Afternoon snack		2 slices white bread with margarine.
Supper	1 cup white rice, 3/4 cup kidney beans, 1 tangerine,	1 cup white rice, 3/4 cup kidney beans, 1/2 cup fried potatoes.

a Quantities are approximate.

TABLE IV-7

Sample daily menus taken from diet recalls from well-to-do subjects[a].

Breakfast	2 white rolls with butter, 3/4 cup coffee with milk and sugar.	3 slices white bread with butter, 1 cup coffee with milk and sugar.
Morning snack	4 plain cookies.	
Lunch	1 cup white rice, 3/4 cup kidney beans, 4 oz beef steak, lettuce salad with tomatoes and oil dressing, 1 tangerine, 1 cup orange juice with sugar.	1 cup white rice, 3/4 cup kidney beans, 6 oz beef steak, lettuce salad with tomatoes and oil dressing, 1 cup fried potatoes, 2 cups orange juice.
Afternoon snack	1 apple, 1 tangerine.	2 slices white bread with butter.
Supper	1 cup white rice, 3/4 cup kidney beans, 1/2 cup fried cassava, lettuce salad with tomatoes and oil dressing.	1 ham and cheese sandwich on white bread with butter, 1 cup coffee with milk and sugar, 2 cups cola pop.
Evening snack	1 1/2 cups orange pop.	1 cup hot milk with sugar.

a Quantities are approximate.

or juice. Supper was either similar to lunch or was a lighter meal of sandwiches and coffee. Many well-to-do subjects reported eating foods between meals such as cake, cookies, fruit, soft drinks, bread, milk, or candies. Most subjects, both well-to-do and boia-fria, reported eating three meals a day although breakfast was seldom very large.

c) Anthropometric Determination

A comparison of physical growth and development of subjects from boia-fria and well-to-do families is shown in Table IV-8. For all parameters measured, boia-fria subjects had significantly lower values than well-to-do subjects. In addition, boia-fria subjects had significantly lower values than well-to-do subjects for several calculated parameters including mid-upper-arm muscle circumference, weight for height ratios, and weight and height for age.

Anthropometric measurements were compared to American standards (Nelson et al., 1979, and Frisancho, 1974) and to Brazilian standards (Marcondes et al., 1971) where possible. Weight of boia-fria and well-to-do subjects in comparison with standards is shown in Figure IV-7. Boia-fria subjects' mean weight was 82.7% of the Amercian standard, but 100.4% of the Brazilian standard. Well-to-do subjects' mean weight exceeded the American and Brazilian standards by 20.2% and 50.6% respectively. Figure IV-8 shows height of boia-fria and well-to-do subjects in comparison with standards. Boia-fria subjects mean height was 93.6% of the American standard, but 101.4% of the Brazilian standard. Well-to-do subjects' mean height was 102.0% of the American standard and 110.5% of the Brazilian standard.

Figure IV-9 shows triceps skinfold thickness, arm circumference, and

TABLE IV-8

Comparison of physical growth and development of subjects from boia-fria and well-to-do families.

Parameter	Mean ± SD Boia-fria (n = 59)	Mean ± SD Well-to-do (n = 35)
Age (years)	12.1 ± 1.0	12.4 ± 0.9
Weight (kg)	34.0 ± 5.3[a]	49.4 ± 10.8
Height (cm)	141.7 ± 7.7[a]	154.5 ± 8.7
Arm circumference (cm)	20.0 ± 2.6[a]	23.9 ± 3.1
Triceps skinfold thickness (mm)	6.3 ± 1.7[a]	11.1 ± 4.0
Arm muscle circumference (cm)	17.9 ± 2.6[a]	20.5 ± 2.6
Weight/height^2 (kg/cm^2)	$1.7(10^{-3})$ ± .000[a]	$2.1(10^{-3})$ ± .000
Weight/height (kg/cm)	.24 ± .03[a]	.32 ± .06
Height/age (cm/years)	11.8 ± 0.8[a]	12.5 ± 0.7
Weight/age (kg/years)	2.8 ± 0.4[a]	4.0 ± 0.9

a Values for boia-fria and well-to-do subjects are significantly different ($p < .001$) using Student's one-tailed t-test.

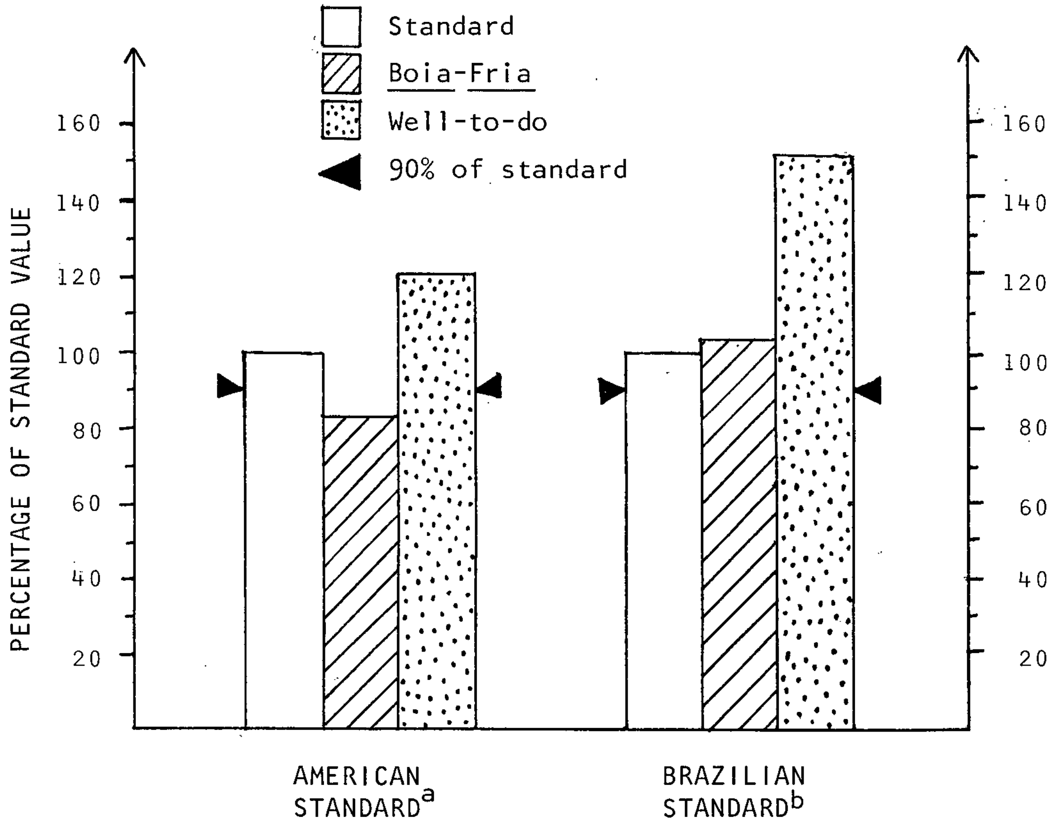


FIGURE IV-7

Weight of subjects from boia-fria and well-to-do families in comparison with standards.

a Nelson *et al.*, 1979 (100.0% = 41.1 kg).

b Marcondes *et al.*, 1971 (100.0% = 32.8 kg.).

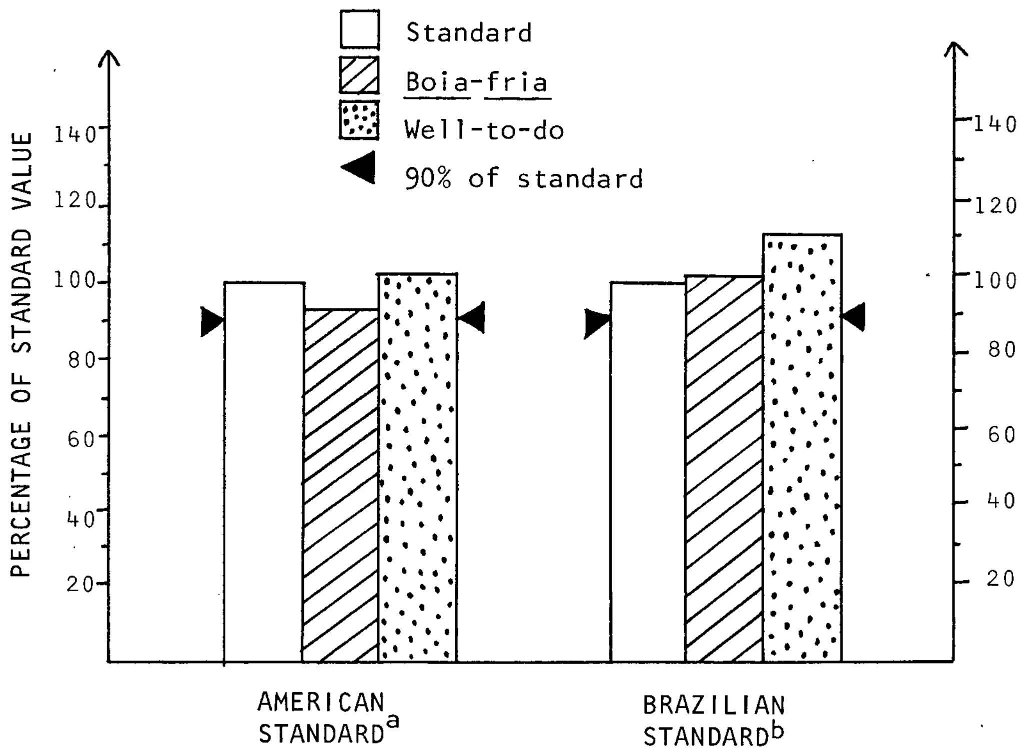


FIGURE IV-8

Height of subjects from *boia-fria* and well-to-do families in comparison with standards.

a Nelson *et al.*, 1979 (100.0% = 151.4 cm).

b Marcondes *et al.*, 1971 (100.0% = 139.8cm).

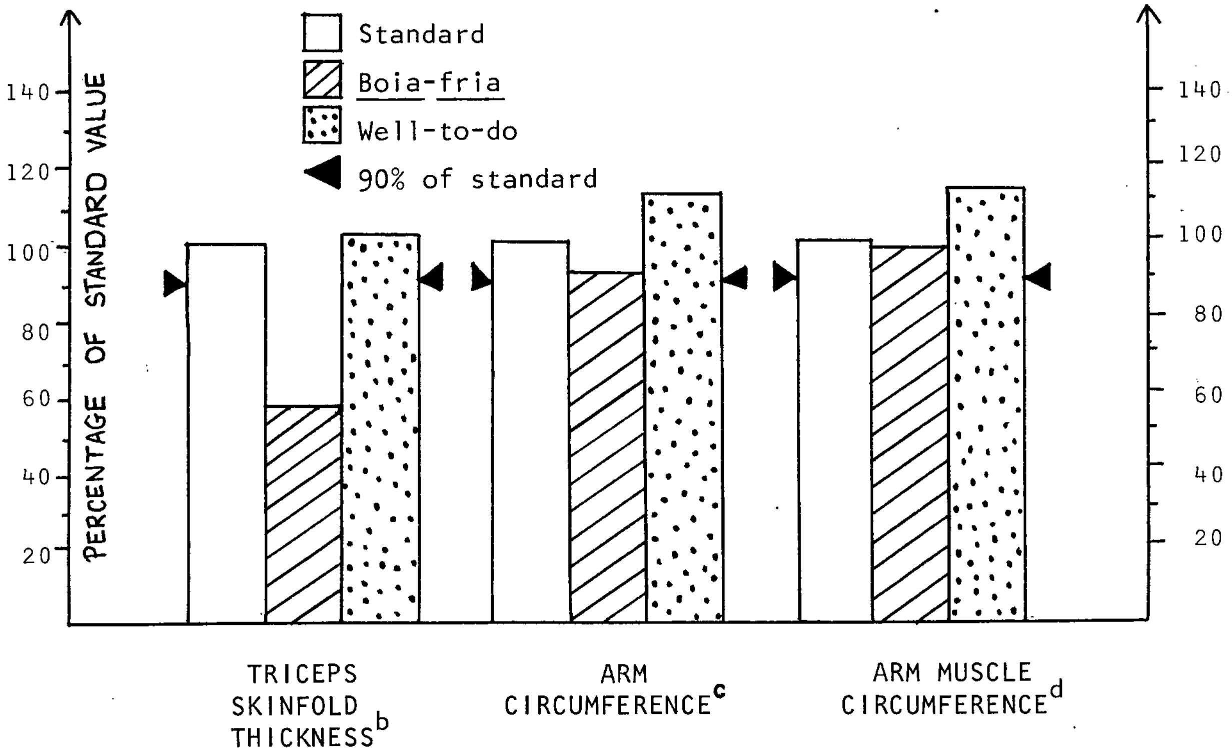


FIGURE IV-9

Skinfold thickness, arm circumference, and arm muscle circumference of subjects from *boia-fria* and well-to-do families in comparison with standard values.[a]

a Frisancho, 1974.

b 100.0% = 11.0 mm.

c 100.0% = 21.6 cm.

d 100.0% = 18.1 cm.

arm muscle circumference in comparison with American standards. Boia-fria subjects' mean measured values were as follows: 57.3% of standard for triceps skinfold thickness; 92.6% of standard for arm circumference; and 98.9% of standard for arm muscle circumference. Well-to-do subjects' mean measured values, by comparison, were as follows: 100.9% of standard for triceps skinfold thickness; 110.6% of standard for arm circumference; and 113.3% of standard for arm muscle circumference.

d) Biochemical Tests

Results of biochemical blood tests are shown in Table IV-9. There were significant differences between boia-fria and well-to-do subjects in values obtained for hematocrit, hemoglobin, and serum total protein. The values obtained for other biochemical parameters measured were not significantly different for boia-fria and well-to-do subjects. The standard deviation was very high in values obtained for serum iron. Table IV-10 shows boia-fria and well-to-do subjects' mean values for biochemical parameters in comparison with normal values (Sauberlich et al., 1974). All measured mean values exceeded 100.0% of the normal values in all subjects, with the exception of hematocrit in boia-fria subjects, which was 96.8% of the normal value.

Table IV-11 expresses the actual number of subjects in each group having biochemical parameters below normal. Among boia-fria subjects, 57.9% had hematocrit values below normal, 40.0% had serum iron values below normal, and 47.1% had transferrin saturation below normal. Comparatively, among well-to-do subjects, 32.3%, 30.0%, and 27.6% had values below normal for hematocrit, serum iron, and transferrin saturation, respectively. Differences between boia-fria and well-to-do subjects were

TABLE IV-9

Comparison of blood biochemistry in subjects from *boia-fria* and well-to-do families.

Parameter	Mean ± SD[a]	
	Boia-fria	Well-to-do
Hematocrit (%)	39.3 ± 5.0(38)[b]	42.0 ± 2.9(31)
Hemoglobin (g/100 ml)	15.3 ± 1.2(38)[b]	16.4 ± 1.8(31)
Serum iron (μg/100 ml)	80.5 ± 56.4(35)	82.8 ± 33.7(30)
TIBC (μg/100 ml)	313.1 ± 78.4(34)	314.4 ± 56.5(29)
Transferrin saturation (%)	25.1 ± 13.0(34)	26.4 ± 10.7(29)
Serum total protein (g/100 ml)	7.57 ± 0.65(33)[b]	7.12 ± 0.53(30)
Serum albumin (g/100 ml)	4.64 ± 0.46(34)	4.42 ± 0.67(30)

a Figures in parentheses denote number of subjects.

b Values for *boia-fria* and well-to-do subjects are significantly different ($p < .01$) using Student's two-tailed t-test.

TABLE IV-10

Blood biochemistry in subjects from *boia-fria* and well-to-do families in comparison with normal values.

Parameter	Normal Value[a]	Mean expressed as % normal value	
		Boia-Fria	Well-to-do
Hematocrit	⩾ 40.6%	96.8 (38)[b]	103.4 (31)
Hemoglobin	⩾ 13.9 g/100 ml	110.1 (38)	118.0 (31)
Serum iron	⩾ 60.0 μg/100 ml	134.2 (35)	138.0 (30)
Transferrin saturation	⩾ 20%	125.5 (34)	132.0 (29)
Serum total protein	⩾ 6.0 g/100 ml	126.2 (33)	118.7 (30)
Serum albumin	⩾ 3.5 g/100 ml	132.6 (34)	126.3 (30)

a Sauberlich *et al*., 1974.

b Figures in parentheses denote number of subjects.

TABLE IV-11

Number of subjects having biochemical parameters below normal value

Parameter	Number of subjects[a]	
	Boia-fria	Well-to-do
Hematocrit	22 (57.9)[b]	10 (32.3)
Hemoglobin	5 (13.2)	3 (9.7)
Serum iron	14 (40.0)	9 (30.0)
Transferrin saturation	16 (47.1)[b]	8 (27.6)
Serum total protein	0 -	1 (3.3)
Serum albumin	0 -	2 (6.7)

a Figures in parentheses denote % of total in group.

b Values for *boia-fria* and well-to-do subjects are significantly different ($p < .01$) using chi-square test.

statistically significant for hematocrit and transferrin saturation.

2. Assessment of Physical Work Performance

Figure IV-10 illustrates the change in heart rate with time and in response to increasing sub-maximal work load in both boia-fria and well-do-do subjects. Excluding the initial 3 minutes and the final 1 minute, heart rate was significantly higher in boia-fria than in well-to-do subjects at every minute of testing. The mean values for maximum, minimum, and change in heart rate are shown in Table IV-12 for both groups. The maximum heart rate and the change in heart rate are both significantly higher in boia-fria than in well-to-do subjects.

Changes in blood lactic acid in response to exercise are shown in Table IV-13. Blood lactic acid levels after exercise were significantly greater in boia-fria than in well-to-do subjects. However, although boia-fria subjects showed greater actual and percentage increases in lactic acid with exercise than well-to-do subjects, these differences between the two groups were not significant. The standard deviation was very high in values obtained for blood lactic acid.

3. Association Between Nutritional Status and Physical Work Performance

Pearson correlation coefficients were obtained for the following combinations of variables: maximum heart rate with all other variables; change in heart rate with all other variables; actual increase in lactic acid with all other variables; and percentage increase in lactic acid with all other variables. Table IV-14 shows those pairs of variables for which Pearson correlation was significant at the 99% level or better. Variable pairs for which no significant correlation was obtained are not reported.

Maximum heart rate was significantly correlated with weight, height,

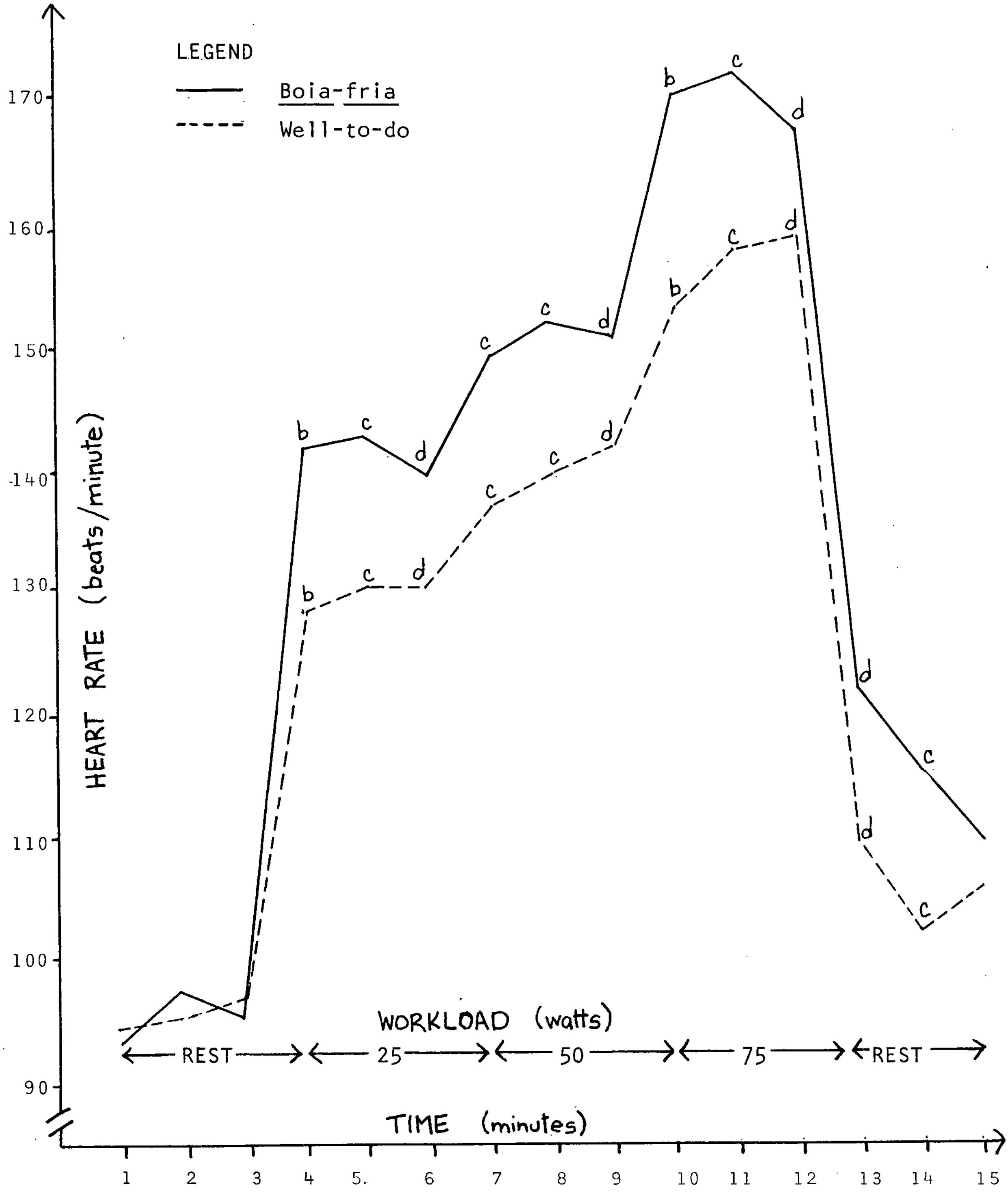


FIGURE IV-10

Change in heart rate with time in boia-fria and well-to-do subjects.[a]

a Values are sample mean

b-d Values for boia-fria and well-to-do subjects are significantly different using Student's one-tailed t-test:

- b $p < .001$
- c $p < .01$
- d $p < .05$

TABLE IV-12

Comparison of change in heart rate in subjects from boia-fria and well-to-do families.

Parameter	Mean ± SD	
	Boia-fria (n = 31)	Well-do-do (n = 30)
Maximum heart rate (beats/min)	177.4 ± 15.9[a]	161.4 ± 17.1
Minimum heart rate (beats/min)	87.7 ± 13.0	84.5 ± 10.8
Change in heart rate (beats/min)	89.6 ± 16.6[b]	76.9 ± 14.9

a-b Values for boia-fria and well-to-do subjects are significantly different using Student's one-tailed t-test:

a $p < .001$
b $p < .01$

TABLE IV-13

Comparison of blood lactic acid levels before and after exercise in subjects from *boia-fria* and well-to-do families.

Parameter	Mean ± SD[a] Boia-Fria	Mean ± SD[a] Well-to-do
Lactic acid before exercise (mg/100 ml)	11.74 ± 5.19(32)	10.35 ± 4.37(30)
Lactic acid after exercise (mg/100 ml)	18.87 ± 6.19(30)[b]	14.91 ± 6.10(28)
Increase in lactic acid (mg/100 ml)	6.98 ± 5.54(30)	4.98 ± 4.51(28)
Increase in lactic acid (%)	71.3 ± 66.7 (30)	52.5 ± 48.8 (28)

a Figures in parentheses denote number of subjects.

b Values for *boia-fria* and well-to-do subjects are significantly different ($p < .01$) using Student's one-tailed t-test.

arm circumference, arm muscle circumference, and, to a lesser extent, with dietary vitamin A, blood lactic acid after exercise, dietary vitamin C, and dietary riboflavin. Change in heart rate was significantly correlated with weight, height, arm circumference, arm muscle circumference, and, to a lesser extent, with serum albumin and dietary vitamin A. Coefficients of determination were relatively low (.09 to .42) for all variables correlated.

TABLE IV-14

Correlations between selected pairs of variables.[a]

Associated variables	Pearson correlation coefficient (r)	Coefficient of determination (r^2)
Maximum heart rate with:		
weight	-.617[b]	.38
height	-.645[b]	.42
arm circumference	-.563[b]	.32
arm muscle circumference	-.577[b]	.33
dietary vitamin A	-.425[b]	.18
post-exercise blood lactic acid	+.338[c]	.11
dietary vitamin C	-.309[c]	.10
dietary riboflavin	-.307[c]	.09
Change in heart rate with:		
weight	-.564[b]	.32
height	-.590[b]	.35
arm circumference	-.523[b]	.27
arm muscle circumference	-.553[b]	.31
serum albumin	-.365[c]	.13
dietary vitamin A	-.302[c]	.09

a Boia-fria and well-to-do subjects treated as one group.

b Statistically significant ($p < .001$).

c Statistically significant ($p < .01$).

CHAPTER V

DISCUSSION

1. Socio-economic Considerations

Visits to local homes and markets yielded information that largely confirmed the findings of other recently published authors (Desai *et al*., 1980) who reported generally poor living conditions among Brazilian migrant workers. Living conditions of *boia-fria* families were found to be poor in this study as well. Housing was crowded and dirty, and indoor running water, electricity, and sewage facilities were frequently non-existant.

In contrast, well-to-do families lived in homes that were spacious, clean, and fully equipped with modern amenities. As well, income levels of *boia-fria* families were estimated in this study to be roughly ten times lower than those of well-to-do families. This is despite the fact that it has been documented that *boia-fria* families frequently paid higher food prices than well-to-do families (Swann, 1979).

Many previous studies in Brazil have reported that low incomes are a major factor which severely limits people's ability to feed themselves adequately (Jansen *et al*., 1977; Alves, 1977; Guitti *et al*., 1977; Sigulem *et al*., 1978; and Szarfarc, 1979). It is likely that the low incomes of *boia-fria* families in the present study were also limiting their ability to purchase an adequate diet.

Stores in the *favela* areas offered little selection of fresh produce, animal protein sources, or dairy products. The time and expense of travelling to the city center where a greater variety of good were available would probably preclude boia-frias from purchasing these items even if they were affordable. Hence, most people relied on cheap staples like white rice, beans, white bread, coffee, and sugar to make up their diet.

The general health of subjects in the present study was only assessed in a limited way. Still, statistically significant differences were found between boia-fria and well-to-do subjects. A great many more boia-fria than well-to-do subjects presented evidence of cardiac anomalies and bronchial infections. Although it was not tested for in this study, previous studies (Angeleli, 1978 and Desai et al., 1980) have shown that many boia-fria adults and children also suffered from parasitic infestation.

The existance of health problems such as bronchial infections and parasitic infestation was not surprising given the crowded and unsanitary conditions these people lived in. The high incidence of bronchial infection coupled with high rates of parasitic infestation are factors which also probably greatly aggravate any nutritional deficiencies existing among boia-fria children. The significance of the higher incidence of cardiac anomalies observed in boia-fria subjects as compared to well-to-do subjects is not clear and probably warrants further study.

To summarize, brief socio-economic and ecological assessment yielded evidence that impoverished living conditions, low incomes, and the presence of infections were factors that boia-fria children had to contend with in their daily lives. These factors probably synergistically influenced and aggravated any nutritional problems existing among these children. In contrast, these factors appeared to be absent from the lives of most well-to-do subjects. It is unlikely that nutritional problems of boia-fria children could be ameliorated without simultaneously ameliorating these socio-economic problems.

2. Assessment of Nutritional Status

a) Dietary Analysis

The diet recall method which was used in this study for dietary assessment has specific limitations and inherent errors, namely: subjects may not remember food intake accurately; there is no estimation of usual intake; intake may be overestimated when low or underestimated when high; and this method cannot be used to assess intake of individuals, only of populations (Beaton et al., 1979; Linusson et al., 1974; Madden et al., 1976; Garn et al., 1978; and Stapleton and Abernathy, 1980). Keeping these limitations in mind, the dietary findings of this study shall be discussed.

The mean daily intake of boia-frias was less than well-to-do subjects for all nutrients examined with the exception of α-tocopherol. These differences were significant for the following nutrients: energy, protein, calcium, iron, vitamin A, thiamin, riboflavin, and vitamin C.

When mean daily intakes of both groups were compared to WHO/FAO recommended intakes (Passmore et al., 1974), it was found that boia-frias consumed less than 2/3 of the recommended intake for energy, calcium, thiamin, riboflavin, and niacin. On the other hand, well-to-do subjects consumed over 2/3 of the recommended intake for all nutrients considered.

While it is not possible from simple comparison with the recommended daily intake to discern whether defincient intakes truly exist, it is possible to assert that there is some probability of deficient intakes if many subjects consume substantially less than the recommended intake (Beaton, 1975). For the purpose of this study, the figure 2/3 of the recommended intake was chosen to be a rough indicator of low intake.

Further inspection of the data showed that for the following nutrients, 60-80% of boia-fria subjects had intakes below 2/3 of the recommended intake: energy, calcium, thiamin, riboflavin, niacin, and vitamin C. Comparatively, the only nutrient for which over 60% of well-to-do subjects consumed below 2/3 of the recommended intake was niacin.

From the dietary data obtained in this study then, it appears that the probability is greater that boia-frias consumed low nutrient intakes than that well-to-do subjects did. It also appears that if boia-fria subjects were at risk of having low intakes of any nutrients, they would include these: energy, calcium, thiamin, riboflavin, niacin, and vitamin C. Any conclusions more definitive than this are not justifiable given the limited nature of the dietary recall method.

Energy intakes and overall quantities of food consumed have frequently been reported to be low among Brazilian populations (ICNND, 1965 and Shrimpton, 1975), especially those from the lowest socio-economic classes (Patrick and Simões, 1971 and Jansen et al., 1977). The low mean energy intake, including energy intake per unit of body weight, of boia-fria subjects reported in this study suggests that overall quantities of food consumed may have been low. As well, most energy in the boia-fria diet was derived from rice, beans, and bread, a finding which is consistent with previous studies (Angeleli, 1978 and Desai et al., 1980) which found boia-fria diets to be quite monotonous.

Well-to-do subjects appeared to be at little risk of consuming low energy intakes. In the well-to-do diet, most energy came from animal protein sources such as beef, chicken, or eggs. Significant percentages of energy in the diet were also contributed by rice, bread, sugar and sweets, and dairy products. This would seem to indicate that there was much greater variety in the well-to-do than the boia-fria diet.

Mean intakes of protein in both boia-fria and well-to-do subjects appeared to be adequate. Previous studies on protein intakes of Brazilian people have yielded differing results. Several studies conducted in various regions of Brazil including São Paulo (ICNND, 1965; Campino et al., 1975; and Patrick and Simões, 1971) found evidence of deficient intakes among both children and adults. But results of other studies, again conducted in various regions of the country including São Paulo (Vargas Foundation as cited by Shrimpton, 1975; Martins et al., 1977; and Desai et al., 1980) found protein intakes to be generally adequate.

A study conducted in the Ribeirão Preto area by Santos' group (1979) found that the traditional Brazilian rice and bean diet can supply adequate protein for children if consumed in sufficient quantities. It appears that this holds true for children in the present study.

Calcium is a nutrient which has not been frequently studied in Brazilian populations. Food intake studies have indicated that consumption of dairy products is low among many Brazilians, including school-age children (Chaves, 1964; Angeleli, 1978; Rosenberg, 1977; and Desai et al., 1980). These studies have reported that school-age children from low-income families frequently consumed as much as one glass of milk a day, but it is doubtful that this quantity was sufficient to meet the calcium requirements of a growing child unless other calcium sources were also consumed.

In the present study, inspection of boia-frias' diet recalls showed consumption of dairy products was very limited, often no more than a few ounces of milk taken in coffee once or twice a day. In keeping with the findings of previous Brazilian studies cited above, it is probable that calcium intakes of boia-fria subjects in this study were at risk of being deficient. In contrast, most well-to-do subjects consumed dairy products frequently and had daily intakes close to the recommended intake.

Iron in Brazilian diets has not often been reported to be inadequate, the main exception to this being the very low iron intakes that were reported for adult boia-fria women in a recent Ribeirão Preto study (Desai et al., 1980). Mean intakes of iron for all subjects in the present study appeared to be adequate. However, 75% of iron in the boia-fria diet came from plant or non-heme sources and may not have been readily available to the body.

Vitamin A intakes in this study did not appear to follow the trend noted in previous studies of São Paulo families which reported very low dietary intakes (Martins et al., 1977; Roncada, 1972; and Desai et al., 1980). However, it can be difficult to interpret results of diet-recall studies for nutrients like vitamin A where daily intakes vary greatly. As Stapleton and Abernathy (1980) pointed out, results of such studies are seldom accurate for nutrients like vitamin A unless numerous diet recall interviews are conducted with each subject. Hence, an accurate quantitative interpretation of vitamin A intakes reported in this study is probably not possible.

The dietary assessment of Brazilian people with respect to thiamin, riboflavin, and niacin intakes has received less attention in the past than has assessment of protein, energy, or vitamin A intakes, although several studies have reported low vitamin B intakes among low-income São Paulo subjects (Martins et al., 1977; Wilson et al., 1977; and Desai et al., 1980).

This study appears to confirm these previous findings for several reasons. First, 70-80% of boia-fria subjects consumed less than 2/3 of the recommended daily intake for thiamin, niacin, and riboflavin, suggesting that the probability exists that there were low intakes of these nutrients. Second, all boia-fria subjects reported eating white refined rice and bread in substantial amounts in their diets. Flour and cereals are not enriched in Brazil after refining (Desai et al., 1980), and substantial amounts of B vitamins may be lost during the commercial milling of rice and wheat flour. Finally, B vitamins may also be lost through prolonged cooking of beans and rice. Considering these facts, boia-frias were probably at risk of having low B vitamin intakes.

Well-to-do subjects presented a better picture: most had high intakes of thiamin and riboflavin, although niacin intakes were lower. Major sources of these three B vitamins in the well-to-do diet were meat, eggs, and dairy products. Thus, well-to-do subjects were much less affected than boia-frias by B vitamin losses which occurred through commercial refining of rice and wheat flour.

Dietary intakes of vitamin C have not been widely studied among Brazilian people, although mean intakes as low as 50% of recommended intake have been reported among poorer socio-economic groups (Patrick and Simões, 1971; Martins et al., 1977; and Desai et al., 1980). The boia-fria mean intake of vitamin C was nearly 150% of the recommended intake, but this figure obscures the fact that while a few individuals consumed very large amounts of vitamin C, over 60% of subjects consumed intakes of less than 2/3 of the recommended intake. Considering, too, that boia-frias consumed very limited amounts of fresh fruit and vegetables, which are superior dietary sources of vitamin C, it is likely that low vitamin C intakes occurred.

The mean vitamin C intake of well-to-do subjects was nearly 500% of the recommended intake! Considering as well that 75% of well-to-do subjects consumed over 2/3 of the recommended intake, and that most of these children reported frequent consumption of fresh fruits and vegetables, it is unlikely that their vitamin C intakes were inadequate.

In summary, the boia-fria diet was very monotonous. Most meals consisted mainly of bread, rice, and beans. Consumption of dairy products, fruit, vegetables, and animal protein sources appeared to be very limited. Comparatively, the higher socio-economic status of well-to-do subjects was reflected in the greater variety and the preponderance of more expensive foods such as meat, seafood, and confections in their diet. Judging from the diet recalls, boia-fria subjects also consumed a lower quantity, as well as quality, of food. If boia-fria subjects were at risk of consuming low intakes of any nutrients, those nutrients would probably include: energy, calcium, thiamin, riboflavin, niacin, and vitamin C.

b) Anthropometric Determinations

All anthropometric parameters measured in this study were found to be significantly lower in boia-fria than in well-to-do subjects. Large differences between boia-fria and well-to-do subjects were also observed when anthropometric parameters were compared to American and Brazilian standards.

In comparison to American standards (Nelson et al., 1979), weights of most boia-fria subjects fell below 90% of the standard, indicating first degree malnutrition according to the Gomez (1956) classification. However, mean weight of well-to-do subjects exceeded the American standard by 20%, possibly indicating overweight, although the comment should be made here that most well-to-do subjects appeared large for age but not obese. Mean heights of both boia-fria and well-to-do subjects fell within 10% of the American standard, indicating normal height according to the Gomez (1956) classification.

Boia-fria subjects' mean weight was very similar to the Brazilian standard; whereas, well-to-do subjects' mean weight exceeded the Brazilian standard by 50%! Mean heights of boia-fria and well-to-do subjects fell within 10% of the Brazilian standard.

It should be noted that the Brazilian standards for height and weight used here were derived from a study of children of low socio-economic status (Marcondes *et al*., 1971). These so-called standards are widely used in Brazil (Shrimpton, 1975), even though Jelliffe (1966) has cautioned that the use of such standards in developing countries is deceiving because they provide a picture of development achieved by children who are probably nutritionally compromised. Jelliffe (1966) suggested that local standards are only meaningful if prepared from growth patterns of children from upper socio-economic strata who have had the opportunity to consume adequate diets.

Thus, the results of the present study indicate that boia-fria subjects are comparable in terms of height and weight to other Brazilian children of low socio-economic status. But this hardly indicates that optimal growth was achieved. Rather, comparisons with both well-to-do subjects and American standards suggest that boia-fria subjects were actually underweight for age and for height. Thus it would appear that acceptable local Brazilian standards for height and weight have yet to be found.

Numerous studies have indicated height and weight in Brazilian children. Early studies conducted in Ribeirão Preto (Dutra de Oliveira *et al.*, 1964) and in northeast Brazil (ICNND, 1965) found both heights and weights of children to be well below American standards. More recent Brazilian studies confirmed this finding for children from low-income families, and found that children from upper socio-economic classes tended to surpass American standards for both height and weight (Campino *et al.*, 1975; Sigulem *et al.*, 1976; Guitti *et al.*, 1977; Turini *et al.*, 1978; and Desai *et al.*, 1981).

Boia-fria subjects in this study were generally short and very thin in comparison with their well-to-do counterparts. However, the fact that they had normal heights compared to American standards suggests that undernutrition in these children was not so severe as to stunt growth. Thus, undernutrition may have been less severe here than for children researched in previous studies. There is support for this in that dietary assessment indicated protein intakes were probably adequate among *boia-fria* children in the present study.

Brazilian standards do not exist for upper-arm circumference, triceps skinfold thickness, or upper-arm-muscle circumference, so in this study American standards (Frisancho, 1974) were used. Mean values for arm circumference and arm-muscle circumference in both *boia-fria* and well-to-do subjects fell within 10% of standard values, indicating adequate development. But *boia-fria* subjects' mean values for triceps skinfold thickness were very low: less than 60% of the standard. Comparatively, well-to-do subjects' mean skinfold thickness approximated 100% of the standard.

In a previous study on triceps skinfold thickness in Brazilian children (Hegg, 1978) values were cited for subjects who were 11 years old, one year younger than the mean age of subjects in the present study. Nevertheless, these previous values were approximately twice those found here for boia-fria subjects. Children in Hegg's (1978) study came from intermediate or high socio-economic groups. A study done in Ribeirão Preto (Desai et al., 1981) yielded results similar to the present study for tricepts skinfold thickness.

The very low boia-fria values obtained for triceps skinfold thickness indicate that these subjects probably had very low fat reserves. The fact that arm circumference and arm-muscle circumference of these subjects did not fall below standards suggests that undernutrition, while severe enough to prevent accumulation of fat stores, was not severe enough to cause muscle wasting.

Well-to-do children had mean values for triceps skinfold thickness that did not greatly exceed standard values. This is in agreement with the observation that well-to-do subject appeared to be big-boned and well-muscled, but not generally obese.

To summarize the anthropometric findings of this study, it appears that boia-fria children were shorter and had lesser fat stores than their well-to-do counterparts. Undernutrition in boia-frias seemed to be manifested mainly in low body weights and low fat stores for height and age, rather than in stunted growth or muscle wasting. This is in comparison with American standards. These results could be interpreted much more meaningfully if appropriate local Brazilian anthropometric standards existed.

c) Biochemical Tests

The biochemical tests conducted in this study assessed the status of two nutrients: iron and protein. While the tests used to assess iron status included some that are generally regarded to be good indicators of body iron stores (Cook and Finch, 1979), the tests used to assess protein status have limitations in sensitivity (Sauberlich _et al_., 1974) and shall be discussed with this in mind.

Boia-fria and well-to-do groups were found to significantly differ from each other in values obtained for hemotocrit, hemoglobin, and serum total protein. _Boia-fria_ values were lower than well-to-do for hematocrit and hemoglobin, but higher for serum total protein. When compared to normal values (Sauberlich _et al_., 1974), mean values for all parameters measured in both _boia-fria_ and well-to-do subjects appeared to be adequate or to marginally exceed normal values. However, there was a very high standard deviation in values obtained for both serum iron and transferrin saturation, which makes mean values difficult to interpret. In fact, 40-60% of _boia-fria_ subjects had hematocrit, serum iron, and transferrin saturation values below normal, suggesting some cause for concern about iron status.

Previous biochemical studies of iron status of Brazilian people have usually examined hemoglobin and hematocrit, which are both late-stage indicators of iron-deficiency. Two previous São Paulo studies found as many as 40% of village populations had low hemoglobin levels (Szarfarc, 1972 and Sigulem _et al_., 1978); while two Ribeirão Preto studies found that hematocrit and hemoglobin levels were generally adequate among low-income children and adults (Dutra de Oliveira _et al_., 1964 and Angeleli, 1978). Most recently, a Ribeirão Preto survey of adult _boia-frias_ found that 25% of subjects had low hemoglobin values. Results of these studies may not agree, but considering that they measured late-stage indicators or iron deficiency, any evidence of low values is cause for concern.

In the present study, a substantial number of boia-fria subjects presented low values for both transferrin saturation, an early indicator of iron-deficiency, and hematocrit, a late indicator. Many boia-fria children have been shown to suffer from parasitic infestation (Desai et al., 1980) which can cause regular blood losses and increased iron requirements. In addition, dietary assessment showed that most boia-frias consumed mainly plant source or non-heme iron which, especially in the absence of vitamin C, may not be readily available in the body. In view of these facts, iron status of boia-fria subjects may well have been marginal and warrants further study.

Most well-to-do subjects presented normal values for all parameters of iron status measured. This relates well with dietary data that showed mean iron intakes to be almost twice the recommended intake, and which showed that most iron in the well-to-do diet was derived from animal sources, where iron is more highly available.

In the present study, serum total protein and albumin levels were generally adequate among all subjects studied. Serum albumin, as has been discussed, is a more meaningful indicator of protein status than serum total protein because albumin levels become depressed much earlier in protein deficiency (Sauberlich et al., 1974). The generally adequate serum albumin levels found here indicate that protein status is probably acceptable in the subjects of this study.

These biochemical findings are in agreement with the dietary assessment conducted in this study which found mean protein intakes were also probably adequate. Few previous studies have measured both serum total protein and albumin in Brazilian populations. The ICNND (1965) reported a high incidence of sub-normal values for serum total protein in northeast Brazil but this is not a good indicator of protein deficiency. More recently, Angeleli (1978) found normal mean values for serum protein and albumin in adult migrant workers in Ribeirão Preto, but no studies were done of children.

In summary then, biochemical assessment yielded evidence that iron status may be marginal among boia-fria but not among well-to-do children in the present study. Protein status was found to be adequate in both groups of children.

3. Assessment of Physical Work Performance

In this study, physical work performance was assessed by measuring change in heart rate and change in blood lactic acid in response to a standardized bicycle-ergometer work test.

Many factors can confound results of work tests such as these, including: age, sex, climate, food intake prior to testing, and habituation to exercise. These factors were controlled in the following way in this study: all subjects were approximately the same age; all subjects were males; and all subjects performed work tests at the same room temperature and altitude.

Food intake prior to exercise was less well-controlled because subjects consumed coffee, milk, sugar, and sometimes bread or juice in their homes before being tested. It was not possible to standardize this pre-exercise food consumption. Habituation to exercise was controlled for in so far as subjects were questioned about their usual levels of physical activity. Boia-fria and well-to-do subjects appeared to be similar in terms of usual levels of physical activity, but it is acknowledged that the evidence used to determine this was essentially qualitative in nature.

Mean heart rate at every minute of exercise testing excluding rest periods was significantly greater in *boia-fria* than in well-to-do subjects. Maximum heart rate and maximum change in heart rate were also significantly higher for *boia-fria* subjects. These higher heart rates are taken to be evidence that work performance was poorer in *boia-fria* subjects than in well-to-do subjects.

This finding is in keeping with the results of several previous studies which found heart rates to be higher in undernourished than in well-nourished subjects when both performed the same work task (Desai *et al*., 1981; Satyanarayana *et al*., 1979; Davies *et al*., 1973; Gardner *et al*., 1975; and Gardner *et al*., 1977). These studies were of both adults and children. Angeleli (1978) also examined exercise heart rates before and after dietary supplementation in undernourished Brazilian adults, and found significant reduction in exercise heart rates after supplementation.

Two previous studies are not in accord with the results described above. Areskog and co-workers (1969) found evidence that malnourished subjects performed better at work tests than their well-nourished counterparts, although this difference was only pronounced when physical capacity was related to body weight. These authors concluded that perhaps dietary requirements are set too high. Ferro-Luzzi and co-workers (1979) also found malnourished subjects performed better at work tests than well-nourished controls, and suggested that there may have been adaptation to inadequate diets such that work performance was not impaired.

The present study would seem to add weight to the evidence that work performance can indeed be impaired in undernourished subjects as compared to well-nourished controls. Adaptation did not appear to be a factor in this study.

Mean blood lactic acid levels after exercise were significantly higher in boia-fria than well-to-do subjects. Maximum values for change in blood lactic acid with exercise were also higher in boia-fria than well-to-do subjects. Blood lactic acid as a parameter of physical work performance has only occasionally been used in research on undernutrition. Gardner's group (1975 and 1977) in two separate studies found blood lactic acid levels in response to exercise were significantly elevated in iron-deficient subjects. Blood lactic acid levels reported in these studies were comparable to those found in the present study.

In the present study, then, boia-fria subjects exhibited poorer work performance as assessed by post-exercise blood lactic acid levels than well-to-do subjects. For both groups of subjects, post-exercise blood lactic acid levels were significantly correlated to maximum heart rate. However, the coefficient of determination for this relationship was only 11%, so it is doubtful that the correlation was of practical significance.

In summary, considering both heart rate and blood lactic acid as indicators of physical work performance, work performance was found to be impaired in boia-fria as compared to well-to-do subjects when both groups were confronted with the same work task.

4. Association Between Nutritional Status and Physical Work Performance

The association between nutritional status and physical work performance was tested by determining correlation coefficients between various indicators of nutritional status and each of the following: maximum heart rate; change in heart rate; post-exercise blood lactic acid; and change in blood lactic acid.

Maximum heart rate was significantly negatively correlated with: weight; height; upper-arm circumference; arm-muscle circumference; dietary vitamin A, dietary vitamin C; and dietary riboflavin. Change in heart rate was significantly negatively correlated with: weight; height; upper-arm circumference; arm-muscle circumference; serum albumin; and dietary vitamin A. Blood lactic acid levels were not found to be correlated with any parameters of nutritional status.

Although correlations may be statistically significant, they have little practical meaning if coefficient of determination is small. This was the case for several variables which were correlated with heart rates, including: dietary vitamin A; dietary vitamin C; dietary riboflavin; and serum albumin.

On the other hand, several anthropometric variables were considerably more strongly correlated to heart rates, including: weight; height; arm circumference; and arm muscle circumference.

The finding that anthropometric variables were correlated to physical work performance is in accordance with several previous studies which found productivity, maximum aerobic power, and exercise heart rates to be strongly correlated to anthropometric variables (Heywood _et al_., 1974; Barac-Nieto _et al_., 1978; and Satyanarayana _et al_., 1977 and 1979).

The nutritional implications of this relationship are that anthropometric variables are widely regarded to be indicators of long-term nutritional status. Indeed, it has recently been suggested (Spurr _et al_., 1979) that because of correlations obtained between anthropometric variables and parameters of work performance, sub-maximal work tests may be useful as functional assessments of nutritional status.

However, the fact that physical work performance has been correlated to anthropometric parameters of nutritional status does not mean that a causal relationship has been demonstrated between undernutrition and physical work performance. Consequently, the results of both this and previous studies must be interpreted cautiously. This and previous studies simply show that anthropometric indicators of nutritional status and parameters of physical work performance appear to vary together.

A further note is that it does not appear from this study that either protein or iron status was correlated with physical work performance. Previous studies had found iron-deficiency anemia to correlate with elevated exercise heart rates (Davies et al., 1973; Gardner et al., 1975; and Gardner et al., 1977). However, in this study, neither dietary nor biochemical assessment yielded evidence that severe protein or iron deficiencies were widespread.

It should be acknowledged that extrapolation of the results of the present study to populations of Brazilian children other than the actual subjects studied can only be made very cautiously. This is because several factors were operant in this study which may have biased the results. Because subjects were volunteers, people may have participated who wanted medical attention or who had different diets than those who did not. Children who were ill and children who had dropped out of school did not participate in this study, which probably added bias. Finally, the fact that sample selection was not random probably added bias. These factors were unavoidable but nevertheless, they require acknowledgement.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study was designed and conducted to evaluate the nutritional status and physical work performance of children of Brazilian migrant workers in comparison with children from well-to-do Brazilian families, and to investigate the relationship between nutritional status and physical work performance in these two groups of children.

Nutritional status was assessed by the following means: socio-economic and ecological observations were made; 24-hour diet recall interviews were used to assess dietary intake; anthropometric measurements, including height, weight, mid-upper-arm circumference, and triceps skin-fold thickness were taken; and hemoglobin, hematocrit, and serum total protein, albumin, iron, and percentage of transferrin saturation were determined as biochemical indicators of protein and iron status.

Physical work performance was assessed by measuring physiological responses, namely heart rate and blood lactic acid changes, to a bicycle-ergometer work test. The two groups of subjects were compared for all parameters of nutritional status and physical work performance. Then, correlation analysis was used to determine whether parameters of physical work performance were associated with parameters of nutritional status. The basic findings of this study were as follows.

Dietary assessment showed that migrant workers' children may have consumed insufficient intakes of the following nutrients: energy, calcium, thiamin, riboflavin, niacin, and vitamin C. The overall quantities of food consumed by these children were low, judging from caloric intakes and from inspection of diet recall results. The basal migrant worker family diet apparently consisted of white rice and kidney beans. It appeared probable that protein and iron, derived mainly from beans and rice, were consumed in adequate amounts by boia-fria subjects.

In contrast, well-to-do children studied apparently ate a varied diet with good representation from all food groups including dairy products and animal protein sources. The well-to-do subjects appeared to be at little risk of low intake for any nutrient with the possible exception of niacin. Generally, the overall quantities of food consumed by these children also appeared to be adequate.

Anthropometric assessment showed that nutritional deficiencies of boia-fria subjects were manifested in low body weights for age and for height, and low body fat reserves as evidenced by extremely low values for triceps skinfold thickness. The well-to-do subjects exceeded American standards for all anthropometric parameters measured.

Biochemical assessment of protein status in both groups of children showed no evidence of overt deficiencies. However, both early- and late-stage indicators of iron deficiency suggested that some boia-fria subjects may have had marginal iron status. The well-to-do children presented normal values for all biochemical indicators of iron status that were assessed.

Physical work performance was found to be impaired in migrant workers' children as compared to well-to-do children in this study. Exercise heart rates and post-exercise blood lactic acid levels were both more elevated in boia-fria than in well-to-do subjects.

Physical work performance as indicated by change in heart rate during exercise was found to be significantly correlated with anthropometric parameters of nutritional status in the subjects studied. This correlation was not demonstrated for other parameters of nutritional status. Neither was a correlation demonstrated between parameters of nutritional status and physical work performance as indicated by blood lactic acid levels during exercise.

The overall significance of the findings of this study appears to be that undernutrition did indeed exist among these migrant workers' children. In contrast, undernutrition was not found in well-to-do children in this study. In addition, functional assessment showed that when confronted with the same work task, boia-frias performed more poorly than well-to-do children.

A brief summary of the living conditions and health status of the two groups was made as an adjunct to this study. Living conditions in the favela or slum area of Ribeirão Preto where most migrant workers lived were generally impoverished, crowded, and devoid of conveniences such as indoor running water, electricity, or sewage facilities.

In contrast, the well-to-do children lived in an area where the picture was much more appealing. Spacious homes, attractive streets and gardens, and full amenities such as electricity and indoor plumbing were the rule. Incomes of well-to-do families were estimated to be substantially higher than those of migrant worker families.

Migrant workers' children also presented a much higher incidence of bronchial infections and cardiac anomalies than did well-to-do children. This was in addition to the parasitic infestation that is known to be endemic among migrant workers in this area. Thus it appears that disease and infection exist synergistically with undernutrition among boia-frias.

To extend socio-economic analysis beyond the simple observations made in this study, it appears that there are factors in the lives of migrant worker families which deeply aggravate any nutritional problems these people may have. Indeed, the existence of these factors probably precludes the solution of nutrition problems in isolation. The litany of these factors is long: impossibly low wages that are ravaged by inflation; jobs that offer little hope of enjoyment or upward mobility; frequent unemployment without provisions for social security; endemic disease without accessible medical care; illiteracy; and squalid living conditions.

Another important factor is the mentality of poverty. These migrant workers see no way to improve the conditions of their lives because they have always been objects, cogs in the wheels of the Brazilian economy. Possiblities for changing their situation lie in the awakening of their sense of their own humanity and their abilities for self-determination such that they themselves can improve the conditions of their lives. This process could be aided by the development of thoughtful programs to alleviate nutrition problems through education and income assistance. As well, programs to improve housing, sanitation, education, and health care would play an important transformational role.

The results of this study are proffered in the hope that they will add weight to the already considerable evidence that nutrition problems exist among migrant worker families in Brazil. It is also hoped that the relationship that was demonstrated here between undernutrition and impaired work performance may fuel economic justifications for improving nutritional conditions among Brazilian agricultural labourers and their children. To conclude on a sombre note, enough is now known about nutritional problems of people such as these migrant worker families. The time for action is overdue.

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