The Use of Dietary Supplements in Two Groups of New Zealand Children and Adolescents

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Dedicated to the memory

of my parents,

Betty and Jack Crowley

Abstract

In Western societies, personal responsibility for health has become an important pre-occupation during the latter part of the 20th century, with guidelines issued by governments as part of encouraging a healthy lifestyle. Many sectors of any given society have embraced this issue, but often in different ways. Dietary supplementation, as part of general self-medication, is particularly prevalent among women, but not exclusively so. Supplementation reflects concerns about dietary adequacy and an attempt to manage nutritional status. It may also be that by virtue of the roles which many women occupy, including as shopper and health care dispenser, they may be more exposed to dietary and health information that encourages a degree of dissatisfaction with existing diets and makes supplementation more attractive. The consumption of supplements by children suggests that supplementation reflects a range of group or social influences. Communication between family members and external sources of health information, for example, friends, the family doctor and the media, may also encourage the adoption and maintenance of supplementation patterns.

The purpose of this study was to determine the use of dietary supplements in two different groups of New Zealand children and adolescents. The first group consisted of children between 1 and 14 years of age from rural and urban areas who were targeted for the pilot study for the Children's Nutrition Survey. The pilot study consisted of a pre-testing and validation component. In the pre-testing component, there were 428 children, 137 of whom were Maori, 147 were Pacific peoples and 148 European/Pakeha. In the validation component, there were 183 children, with 60 Maori, 63 Pacific and 60 European/Pakeha. Questionnaires were used to provide demographic data and information on food and dietary supplement use. The pilot study found that 12.8% of the children of 1 to 14 years of age consumed dietary supplements. Supplement use was highest in children in the age range of 1 to 5 years (52.3%) and decreased to 47.6% in children 6 to 14 years. Maori and Pacific children were less likely to consume supplements than European/Pakeha children. The most popular supplements consumed were vitamin C, either alone or in combination with vitamins A and D, or echinacia (49.9%), and multi-vitamins (30.9%). Herbal combinations were

consumed by 16.5% of the children. Most of the children who consumed supplements took them daily.

Further study of the prevalence of dietary supplement use by children in New Zealand will take place in the proposed Children's National Nutrition Survey.

The athletes' study provided the second set of data. One hundred year 9 and 10 children (67 males and 23 females), who were identified as having potential in their respective sports, were recruited from two decile one North Shore secondary schools. Questionnaires were used to provide demographic data, information on the use of dietary supplements, influences on dietary supplement use and the perceived benefits of dietary supplement use. The mean age of the athletes was 13.5 years. Twenty-eight sports were represented. Seventy percent of the athletes took dietary supplements. Supplement use was higher in females (84.8%) than males (62.5%). Energy products, the most popular dietary supplement, were consumed by 43.1% of the athletes. These were followed by vitamins (28.7%) and recovery products (7.1%). Meal replacers, herbal supplements and "other" (12.2%) were the least popular supplements. Vitamin C and multivitamins were the most popular vitamins consumed, while minerals were consumed only by a few athletes. Parents and coaches were found to be the most important sources of information amongst those who took dietary supplements (59.5%) and they were also found to be the most likely to be the person(s) who suggested taking dietary supplements (66.39%). Dietary supplements were perceived to benefit athletes' performances in a variety of ways, from providing more energy, to improving fitness, or to preventing illness.

The findings from the athletes study suggests that sports organisations need to adopt a pro-active stance to ensure that young athletes understand the importance of nutrition for both their sporting performance and their long-term health.

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1 Introduction

Since the late seventies, there has been an increased emphasis on preventative medicine and individual responsibility for health. This emphasis on personal responsibility has been accompanied by an increase in self-medication reflecting the public concerns about dietary adequacy. Approximately 40% of the population in the United States use vitamin and mineral supplements regularly, making them the major form of self-directed health-promoting behaviour practiced by the public (Ervin et al, 1999). Vitamin and mineral supplement use represents a self-conscious attempt on the part of users to manage their nutrition status through some knowledge and an awareness of the nutritional issues (Levy and Schucker, 1987). As Western societies have become concerned with wellness, and more and more scientific studies establish a relationship between good health and good nutrition, the topic of supplementation assumes a new prominence (Shangraw, 1990). The market for supplements has burgeoned. By 1981, vitamin and mineral supplement sales in the United States totalled $1.7 billion (Koplan et al, 1986). In 1988, they reached $2-2.5 billion (Shangraw, 1990) and by 1996, sales of vitamins and minerals and other food concentrates were valued at $4 billion a year (Thomas, 1996).

Interest in the use of dietary or nutritional supplements appears to be growing in the United States in particular. It is not clear whether this interest is fuelled by recommendations from family, friends, the print and television media, advertising, health professionals or scientific literature. Some of the reasons people give for taking supplements include: to improve nutrition, to make up for nutrients missing in the food supply, to decrease susceptibility to or severity of disease, or to increase energy or improve performance (Schultz, 1982; Sobal and Marquart, 1994b). Herbs and other dietary supplements are also taken as alternatives to conventional medical therapies (Brody, 1995; Eliason et al, 1997; Ervin et al, 1999). Another factor that may contribute to increased interest in the use of supplements is scientific evidence linking diets high in some nutrients (vitamins A, C, and E, folate, beta carotene, and calcium) with a lower risk for diseases or other conditions including aging, certain cancers, heart disease, osteoporosis, or neural tube defects (Ervin et al, 1999).

The next sections review the literature on the debates that have emerged in recent decades, both scientific and non-scientific, and the empirical evidence concerning diet and supplementation. Much of the literature concerns the USA, primarily because of the sheer volume that has been generated in that country, but where there is material available for other countries, including New Zealand, that too is referenced and discussed.

2 Literature Review

2.1 *Definitions and Regulations*

2.1.1 Vitamins: Nature, Classification and Functions

Vitamins are micro-nutrients. They are defined as a group of unrelated compounds that are needed in relatively small amounts in the body to perform highly specific metabolic, growth and maintenance functions (Keith, 1989). These compounds are widely recognised as necessary components in bodily processes, but they are also considered ancillary nutrients because they do not directly supply energy, serve as structural units for other compounds, or contribute substantially to body mass (Armstrong and Maresh, 1996).

Vitamins are either classified as either fat-soluble or water-soluble. The fat-soluble vitamins, A, D, E, and K, are primarily stored in the liver but also in fat tissues, mainly subcutaneous, and can be accumulated at levels that are toxic. Water-soluble vitamins, vitamin C and B complex, are not appreciably stored in the body and must be supplied routinely in the diet. These vitamins are normally eliminated in the urine, because their plasma concentration exceeds the capacity for reabsorption by the kidneys (Armstrong and Maresh, 1996). It is no longer accepted that all water soluble vitamins are safe at any level and all fat soluble vitamins are toxic (Bendich, 1992). Vitamins perform numerous biological functions. Examples of these functions include the following: vitamin A is vital for epithelial cell function and maintenance of vision, growth processes and the body's immune response; beta-carotene, the major precursor of vitamin A, plays a role as an anti-oxidant (Clarkson, 1991b); vitamin D possesses hormone-like activity promoting bone calcification and intestinal calcium absorption (Norman and Miller, 1984); vitamin E has important anti-oxidant functions protecting cell membranes from free radical damage (Kagan et al, 1989); vitamin K is involved in the formation of blood clotting proteins and osteocalcin, important for bone health (Suttie, 1984); and water-soluble vitamins serve as enzymes and coenzymes for lipid, carbohydrate, and protein metabolism (Chaney, 1982). Vitamins thus have diverse roles in the body, as do minerals.

2.1.2 Minerals: Nature, Classification and Functions

Minerals are essential components of cell membranes, enzymes, and glandular secretions; they regulate osmotic pressure, acid-base balance, blood volume, and the activities of nerves and muscle. Minerals include the electrolytes sodium, potassium, chloride, calcium and magnesium (Armstrong and Maresh, 1996). The maintenance of relatively narrow limits for the concentrations of electrolytes, both inside and outside the cell, is required for nervous transmission and contractions to occur (Pivarnik, 1989). The sensitivity of the heart muscle to electrolyte imbalances can lead to arrhythmias and possibly death (Armstrong and Maresh, 1996).

There are fifteen essential trace elements in the body; iron, zinc, iodine, copper, manganese, cobalt, selenium, molybdenum, arsenic, chromium, fluoride, lead, nickel, vanadium, and silicon and these metal ions are required in very small amounts such as micrograms or nanograms per gram, for optimal body function (Keen and Hackman, 1984). They have functions that are necessary in metabolism: they are components of body fluids, co-factors in enzymatic reactions, structural components of non-enzymatic macromolecules, or are vital for transport and release of oxygen and deficiencies could affect physical performance (Keen and Hackman, 1984).

2.1.3 Recommended Dietary Allowances

The Recommended Dietary Allowances (RDA) are defined as the levels of intake of essential nutrients that, on the basis of scientific knowledge, are judged to be adequate to meet the nutritional needs of most healthy persons according to the Food and Nutrition Board (FNB, 1989). These may also be referred to as recommended dietary intake (RDI) and estimated average requirement (EAR). The RDA values are intended to ensure that most of the population (95%) would avoid the consequences of deficiency if the RDA in question were ingested daily according to the Council on Scientific Affairs (CSA, 1987). Nutrient intakes below the RDA do not necessarily indicate inadequate intake, but intakes below 75% of the RDA are a cause for concern in terms of an adequate supply of nutrients (Block et al, 1988). The RDAs do not cover the particular needs of nutrients by people with specific clinical problems, nor is the research base as broad as the experts would choose with insufficient studies available to determine minimum and average nutrient requirements for each age and sex groups, or to estimate population variability in need, and to feel comfortable about the judgements made to derive the nutrient allowances (Thomas, 1996). The RDAs are therefore estimates of need, based on the data available (Lachance, 1998a). For some nutrients, there are no RDA because of no, or insufficient data, upon which to base a decision. The nutritional requirements of these nutrients are expressed as estimated daily intake (ESSADDI), estimated by the Food and Nutrition Board (FNB, 1989).

At present, there is an evolving public and scientific debate over whether some nutrients at intakes well above RDAs may provide benefits beyond their essential function, that is the prevention of degenerative disease, as the RDAs do not recognize the prevention of non-deficiency related degenerative disease pathology and the synergy between nutrients and non-nutrients for promoting optimum health (Lachance, 1998a). In 1986, the FNB acknowledged that the RDAs should include the prevention of disease and upper safety limits (Lachance, 1998a). The new figures for vitamins C, E and selenium released in 2000 include both a RDA and an upper limit which represents food and supplements for vitamin C and selenium intake and supplements alone for vitamin E intake (Nutrition Today, 2000). The optimum intake of any nutrient will probably vary substantially among individuals, throughout their life and in relation to specific needs (Thomas, 1996).

Breskin et al (1985) suggest that the RDAs for children has generally been interpolated from information obtained from infants and adults and may be equated with amounts that will maintain a satisfactory rate of growth in specific age and sex categories, a view endorsed by the Canadian Paediatric Society (CPS), (1990). The amounts necessary to maintain maximum body stores are not always considered and whether maximum stores should be equated with optimum stores is unknown (Breskin et al, 1985).

2.1.4 The Regulation of Dietary Supplements

In the United States, supplement regulations are governed by the Dietary Supplement and Health Education Act 1994 (DSHEA). Dietary supplements are defined in DSHEA as products intended to supplement the diet that bears, or contains, one or more of the following ingredients: (a) a vitamin; (b) a mineral; (c) an herb or other botanical; (d) an amino acid; (e) a dietary supplement used by man to supplement the diet by increasing the total dietary intake; or (f) a concentrate, metabolite, constituent, extract, or combination of any ingredient described in clause (a), (b), (c), (d), or (e). The law specifies that a dietary supplement is a product that is labelled a such and is not represented for use as a conventional food, or as the sole item of a meal, or the diet. These products can be ingested as a capsule, powder, gelcap, tablet, liquid, or other form. The DSHEA specifically excludes dietary supplements from regulations as food additives (Neisheim, 1998).

The DSHEA basically applies the same conditions in defining the safety of dietary supplements as those used to define safety in foods: the supplements must be safe under the conditions recommended on the label or, if no conditions of use are suggested on the label, under ordinary conditions of use (Neisheim, 1998). The responsibility for safety is placed on the manufacturer of existing supplements, and the Federal Drug Authority (FDA) must establish unreasonable risk if the product is to be removed from the market for reasons of safety (Neisheim, 1998).

2.1.5 Nutrition and Education Labelling Act, 1990

In the United States, the 1990 Nutrition Education and Labelling Act (NLEA) allows health claims on foods and dietary supplements. Health claims are statements that characterise a relationship between a nutrient or food component and a disease or health-related condition (Neisheim, 1998). There have been five health claims approved for both food and dietary supplement labels since 1990. These claims relate to calcium and osteoporosis, folic acid and neural tube defects, fibre and whole oats and coronary heart disease, fibre from psyllium seed husk and coronary heart disease, and sugar alcohols and dental caries (Report of the Commission on Dietary Supplement Labels, 1997). The legal basis for the labelling claim is that (1) some substantiation exists, (2) the FDA should be notified within 30 days of its presence on the label, and (3) two additional sentences are added to such claims: "The statement has not been evaluated by the FDA. This product is not intended to diagnose, treat, cure, or prevent any disease" (DSHEA, 1994).

Along with "structure function" claims, a retailer may provide literature on supplements which is supposed to be balanced scientifically and should not be misleading. Literature can be found in books and magazines as well as on the web sites of companies that sell supplements via the Internet. Literature limitations are contested by some members of the American supplement industry as threatening their absolute freedom of speech to provide whatever information they think appropriate, while other supplement industry groups demonstrate a growing boldness with their claims, even with mainstream dietary supplements (Thomas, 1996). While there may be some public health benefits from the promotion of supplements by increasing the public awareness of nutrients, diet, and the disease relationships, the risks might well outweigh the benefits: the promotional information fails to give information on food-related alternatives to supplements; the public rarely has the expertise to evaluate the information used in the promotion; consumer expectations of the product effectiveness may also be heightened by the hype and lead to the irrational use of the product (Thomas, 1996).

2.1.6 Quality of Dietary Supplements

In the United States, supplements fall into the grey area between food and drugs, and few federal manufacturing and formulation standards exist (Shangraw, 1990; Radimer et al, 2000). Calcium from many commercial calcium products was found not to be bioavailable, and many of the principles of product quality, accepted as commonplace in the formulation and manufacture of pharmaceuticals, were rarely considered in the manufacture of vitamin and mineral products, such as potency, content, uniformity, disintegration, dissolution and stability (Shangraw, 1990). Some supplement labels now carry a statement that the product meets voluntary disintegration and dissolution standards developed by the US Pharmacopoeia, the scientific organisation that establishes drug standards, although expiry dates are decided on what is generally thought to be reasonable are not supported by stability experiments (Shangraw, 1990; Thomas, 1996).

Patients with prescription drugs are monitored by their doctor or pharmacist and it quickly becomes obvious if a product is not producing the desired physiologic or therapeutic effect, but consumers taking non-prescription drugs monitor themselves in terms of how they feel and this reinforces the need for, and adherence to, standards for vitamin and mineral supplements (Shangraw, 1990).

In processing supplements, ingredients are both concentrated and distilled. This process involves heat, solvents and usually removes most of the compound from the raw material (Thomas, 1996). While there are those who believe that "natural" vitamins are better than synthetic ones because "natural" vitamins contain unidentified factors said to enhance nutrient utilisation, it is not known whether these factors exist, are present in the raw material or survive the extensive processing (Thomas, 1996).

2.1.7 Non-Vitamins and Non-Minerals

The 1994 DSHEA broadened the traditional definition of dietary supplements which had previously only encompassed essential dietary nutrients. The terms used to classify non-vitamins and non-minerals (NVNM) are confusing. For example, herbs are technically defined as "non woody seed producing plants that die at the end of the season" (Radimer, 2000). Strict adherence to this definition would exclude many botanicals derived from trees, such as ginko and hawthorn. The term "herbal" in relation to dietary supplements is often used loosely and encompasses a variety of other botanicals as well (Radimer, 2000).

Data on the prevalence and use of vitamins and minerals are readily available, but it is limited for NVNM. Sales data suggest that total intake of "herbs/botanicals" and "speciality products", for example, fish oils, shark cartilage, amino acids, is increasing with ginseng and garlic amongst the most popular (Radimer et al, 2000). The FDA conducted national telephone surveys in 1994 and 1995 and reported an 8% and 12% respective use of herbal supplements or teas (Roe et al, 1997).

In NHANES III, while respondents were only asked about vitamin and mineral supplements, many reported other types as well. From this data, garlic and lecithin were found to be the most commonly used, and there was a suggestion that NVNM supplement use was associated with age and more healthful lifestyles, although there was also a link with higher alcohol consumption and obesity (Radimer et al, 2000).

2.2 *Who Needs Supplements?*

2.2.1 Nutrition Experts

Expert nutrition groups suggest that healthy children and adults should obtain adequate nutrient intakes from dietary sources and that meeting nutrient needs by choosing a variety of foods in moderation, rather than by supplementation, reduces the potential risk for both nutrient deficiencies and toxicities (see, for example, The Joint Public Information Committee of the American Institute of Nutrition and the American Society for Clinical Nutrition, 1987; CSA, 1987; ADA, 1996). Individual recommendations to take dietary supplements should be based on scientific evidence and come from doctors or dietitians after individual diet and nutrition assessment (The Joint Public Information Committee of the American Institute of Nutrition and the American Society for Clinical Nutrition, 1987; ADA, 1996).

There are instances when dietary supplements are advised, for example, where dietary selection is limited and for therapeutic nutrient supplementation. Nutrient supplementation to help meet the RDAs include: supplemental vitamin B12 for strict vegetarians who eliminate all animal products from the diet; folic acid for women of child-bearing age who consume limited amounts of fruits, leafy vegetables, and legumes; vitamin D for those with limited milk intake and sunlight exposure; calcium for those with lactose intolerance or allergies to dairy products; a multi-vitamin and mineral supplement for those following severely restricted weight-loss diets or the emotionally disturbed (CSA, 1987; Truswell, 1990; ADA, 1996). Therapeutic supplementation is recommended in order to treat nutrient deficiency in a variety of specific clinical situations related to increased nutrient requirements, reduced nutrient consumption, absorption, or utilization, or increased nutrient excretion (CSA, 1987; Truswell, 1990; ADA, 1996). Also, as interaction between and among vitamins and drugs occurs, long term administration of some medications may place people at risk of vitamin deficiencies (CSA, 1987).

Concerns about general nutrient intake, particularly of the more nutritionally vulnerable groups, has stimulated scientific discussion about whether to advocate the use of modest or general doses of general multi-vitamin/mineral supplements to help meet RDAs (Keen et al, 1994). In 1989, the FNB (1989) recommended that it was both practicable and desirable to meet the RDAs by consuming a variety of foods, and it was also the best way to ensure a balance of nutrients and the consumption of appropriate amounts of healthful food components for which there were no established RDA. While there is little scientific evidence of harm from the use of low-dose multi-vitamin/mineral supplements, it is possible that even modest amounts of vitamin and mineral supplements may contribute to excesses or imbalances (FNB, 1989; ADA, 1996) and therefore nutrient supplements should not be used as a substitute for healthful eating (ADA, 1996).

2.2.2 Rational Combinations

The dosage of therapeutic vitamins varies for different situations. Multiple vitamin preparations that claim effectiveness for the prevention or treatment of vitamin deficencies should be formulated on the basis of supplying all those vitamins whose combined deficiencies may be expected in a significant target population (CSA, 1987). The use of fat-soluble vitamins alone is not recommended because the conditions that may lead to the depletion of some of these vitamins would be more rationally treated with all needed vitamins, except biotin and vitamin K as these deficiencies are rare (CSA, 1987). For water-soluble vitamins, a preparation containing all B group vitamins, with or without vitamin C, to prevent or reverse disease is recommended for the following reasons: they are less well stored in the body than fat-soluble ones, they may be depleted more rapidly in the presence of an altered intake or disease, and several B group vitamins occur together in the same foods. (CSA, 1987). The vitamins should be combined in amounts from 50-150% of the RDA to prevent nutritional disease, and in amounts 2 to 10 times the RDA to treat disease (CSA, 1987).

2.2.3 Supplementary Intake in Excess of the RDA

The National Research Council (NRC) recommends that individuals avoid taking supplements in excess of the RDA (NRC, 1989). In the 1987 National Health Interview

Survey, with the exception of vitamin C, most Americans, even those at the 90th or 95th percentiles of daily nutrient intake from supplements, received nutrient intakes which did not greatly exceed their RDAs (Subar and Block, 1990). However, a segment of the vitamin and mineral supplement user population consumed certain vitamins far in excess of the RDA: for 10% of adult male and female users, the average daily intake of six vitamins, vitamins E, C, thiamin, riboflavin, vitamin B6, and vitamin B12 was greater than 15 times the RDA; for 5% of these men and women the average daily intake of thiamin, riboflavin, vitamin B6, and vitamin B12, was in excess of 30 times the RDA; and 5% percent of women consumed vitamin E at levels in excess of 35 times the RDA (Moss et al, 1989). At these levels, the risk of toxicity is greatly increased. Concern at the toxic intake levels of vitamin A among some women, based on NHANES III data, has also been expressed (Brech, 1999).

2.2.4 Bioavailability

A nutrient is bioavailable when it disintegrates and is dissolved in time for absorption in the body (CSA, 1987; Park et al, 1991). The bioavailability of nutrients contained in products depends on many factors, the type of mineral compound used, the physical form of the product (eg tablet versus gelatin capsule), the substance used to coat the pill, and the thickness of the coating; the amount of pressure used to form the tablet; and other nutrients present that may interfere with the supplement nutrient (CSA, 1987; Park et al, 1991). It is recommended that all products marketed as single ingredients, or as combination products, should be in a form in which all active ingredients are biologically available, which has not always been the case (CSA, 1987). For example calcium, from calcium carbonate tablets, was not bioavailable; ferrous sulphate tablets have been recovered in patients stools and disintegration tests involving simulated gastric and intestinal juice demonstrated that some multi-vitamins took up to five hours to disintegrate (Shangraw, 1990).

2.2.5 Safety and Efficacy

Safety and efficacy are crucial but separate issues for vitamin and mineral supplementation. Efficacy is the ability of a supplement to provide a health benefit related to either prevention or deficiency, or a reduction in risk of chronic disease, whereas safety is a reasonable certainty that there will be no adverse effects from excess intake of a nutrient (Hathcock, 1993). Consumers probably consider both by assuming safety and judging efficacy in their individual decisions (Hathcock, 1993). While both issues are treated separately under federal labelling and safety regulations, they can also be treated in a manner that does not clearly separate them. For example, the safe and adequate daily intakes (ESADDI) of selected vitamins and minerals is used as an alternative to RDAs when the data are inadequate for setting a RDA (Hathcock, 1996). Another example is the term "safe and adequate" which has been misinterpreted as "safety limit" by the Codus Alimentarius Commission (Committee on Nutrition for Special Dietary Uses, Codex Alimentarius Commission, 1995). A more accurate definition of "safe and adequate" and the ESADDI would be "the recommended intake, an amount that is also safe" (Hathcock, 1996:p427). The RDAs are intended to be intakes that safely provide the known benefits for most healthy people (Hathcock, 1993). The margin of safety between the usual intake and the intake that would produce adverse effects varies greatly among different nutrients (The Joint Public Information Committee of the American Institute of Nutrition and American Society of Clinical Nutrition, 1987). High intakes of some nutrients have well documented adverse health effects that are variously described as toxicities, adverse reactions or poisonings (Hathcock, 1993).

2.2.6 Merging of Supplements and Medicines

The line dividing vitamins and minerals from drugs is, in many cases, gradually becoming less clear. Calcium supplements are used in the treatment of osteoporosis and are reported to be effective in treating some types of cancer and hypertension; iron is used in the treatment of iron deficiency anaemia; niacin has proved to be effective in lowering cholesterol levels (Shangraw, 1990). However, supplements that supply nutrients beyond what can reasonably be obtained from food should be viewed with caution and high potency products should not be used without thought and expert help (Thomas, 1996).

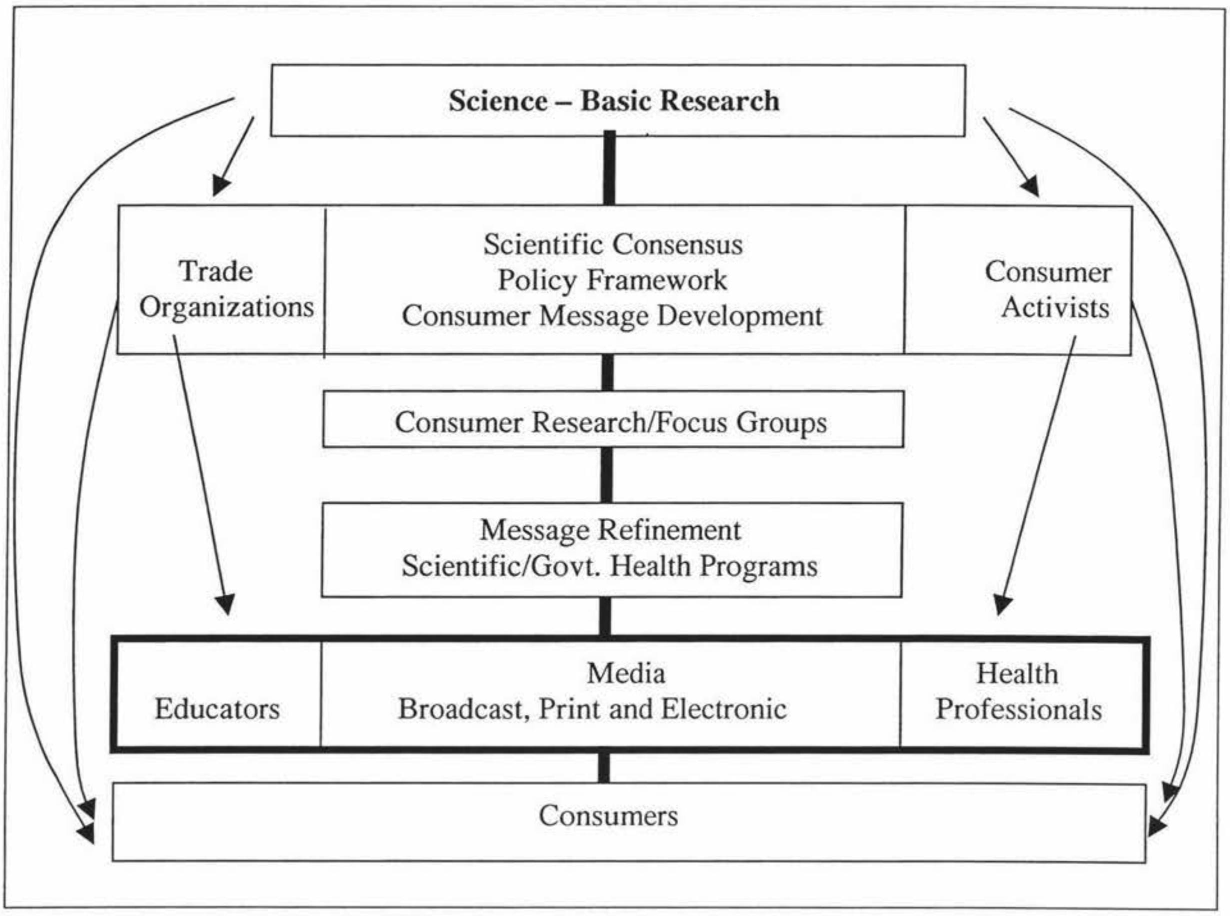
2.3 *Why Do People Take Supplements?*

2.3.1 Key Players

The proliferation of computer programmes and on-line services enhances the ability of consumers to self-manage their health and nutrition regimes but it also raises concerns about accuracy and the sources of information reaching consumers (McMahon, 1995; 1996). Those groups that seek to influence consumer attitudes and behaviours must realise and take responsibility for the impact of their actions and the way in which they communicate via the media (McMahon, 1996).

Examples of such groups include: the media, consumer product and the food service industry, regulatory and legislative bodies, scientific and academic communities, food nutrition education groups, professional organizations and consumer advocacy groups (McMahon, 1995). There is interaction among and between these groups as seen in Figure 1. Consumers information comes from all these sources. The practice adopted by scientists, universities and professional societies of publishing the results of research by press release via the general media as a means of gaining publicity for their findings has a major flaw, as it typically fails to contextualise and explain complex findings in a way that is useful for consumers (McMahon, 1996).

Figure 1 **Groups That Influence Consumer Attitudes to Health**



(McMahon, 1996)

The majority of consumers in the 1995 American Dietetic Association (ADA) Nutrition Trends Survey agreed that new research findings should only be released after there has been general acceptance amongst nutrition and health professionals of their validity and that these findings needed to be put in a context that avoided confusion and misinformation (McMahon, 1996). In spite of what is often a confused atmosphere of advertising and news reports of individual studies that show the benefits of supplements for numerous health issues, some consumers are still willing to make their own decisions about supplement use (Nesheim, 1998). For example, media attention on the possible protective role of vitamins A, C, and beta-carotene against chronic diseases may be responsible for the increased intakes of these vitamins (Slesinski et al, 1995).

There is concern that the use of dietary supplements offers a false sense of security to some people who use them as a substitute for a good diet. It is natural for humans to want an easier way to achieve health without being vigilant, especially when short of time and feeling stressed. At such times, people may not exercise and food choices may be based on convenience and ease of preparation. When people avoid making lifestyle changes, taking supplements can become a deliberate, or unconscious, excuse for not trying to improve diet and lifestyles (Thomas, 1996).

2.3.2 Demographic Factors and Lifestyles

Changes in the demographics of consumers and their lifestyles have had a significant impact on how consumers accept nutrition and health information. The baby-boom generation, people born between 1946 and 1964, have driven many of the trends in the consumer marketplace throughout their lives (McMahon, 1998). They are very interested in living longer, and staying healthier for longer, than any other previous generation (Russell, 1997). Their interest in health and longevity has set the stage for the increased use of vitamin and mineral supplements, organic foods and for the introduction of functional foods and neutraceuticals (Messenger, 1997).

2.3.3 The Marketing of Supplements

The active marketing of vitamin and mineral supplements has contributed to their sales growth. In the past 20 years, there have been significant changes in the distribution of vitamin and mineral supplements in the United States. While they are still purchased from drugstores and health food stores, supermarket sales have increased through the growth of nutrition centres which provide, in addition to fresh foods, a broader line of vitamin and mineral supplements than previously available (Bender et al, 1992). This adds authority to their use. Dietary supplements are also available from mail order catalogues and small home-based industries. All of these sales outlets attest to their widespread use and their growth into a multi-million dollar industry (Eliason et al, 1997). Further, in the last 20 years, the emphasis of public health-related information on macro-nutrient disease relationships, while still important, has been added to in the 1990s by a growing body of scientific literature supporting the importance of micro-nutrients to chronic disease relationships (Blumberg, 1995).

Arguments in support of taking regular vitamin supplements are often couched in terms of achieving "optimal nutrition". While not easily defined, an optimum diet may be considered to be one in which not only is disease prevented, but every system in the body is working with maximum efficiency (Basu and Dickerson, 1996). People who follow a healthy lifestyle often take supplements because of the media-promoted message that vitamin pills are part of a healthy life-style (Herbert, 1993). Both the medical profession and the public are often bombarded with "scare tactics" as well as genuine advertising (Spillman, 1996).

2.4 Who Takes Supplements?

2.4.1 National Studies in the United States

Early studies in the United States on dietary supplements have focused primarily on the adult population, or groups within that population, and they tend to be limited in their comprehensiveness or representativeness. For example, there is limited data on the use of dietary supplements in children at a national level. Despite recommendations from the medical community that dietary supplements in adults or children are unnecessary, except for high risk groups, and that there is a lack of sufficient evidence which indicates beneficial effects, these studies generally indicate a high prevalence of use among adults and children (The Joint Public Information Committee of the American Institute of Nutrition and American Society for Clinical Nutrition, 1987; CSA, 1987; CPS, 1990).

The National Health and Nutrition Examination Surveys (NHANES) are national, representative surveys of the United States population and constitute the most comprehensive research available. NHANES I was conducted between 1971 and 1975, NHANES II, between 1976 and 1980 and NHANES III, between 1988 and 1994. Supplement use was examined in these surveys according to a wide range of demographic data and behavioural characteristics. There were some overwhelming conclusions to the findings. For example, NHANES I found that significantly fewer Black people than White consumed vitamins regularly (Block at al, 1988). Significant differences were also seen for age, sex, geographic region, education, poverty, type of alcoholic beverage consumed, and Quetelet index (Block et al, 1988). In the second survey, NHANES II, a higher nutrient intake and the use of vitamin supplements were particularly associated with older age, higher income, higher educational levels and being White. Of interest was the finding that people with higher nutrient intakes were still more likely to take vitamin supplements (Koplan et al, 1986). In NHANES III, approximately 40% of the American population took some form of supplements, and females were more likely to take supplements (44%) than males (35%). As with the previous survey, there was a trend for the increasing use of supplements with age, although children under five were an exception (see below), and supplement use was associated with high levels of education, income and self-reported health status (Ervin et al, 1999). The higher incidence of supplement intake in the west of the United States among both men and women was also confirmed (Ervin et al, 1999).

The other major national surveys are the National Health Interview Surveys (NHIS). These annual household surveys consist of a core set of questions, relatively unchanged each year, and one or more sets of supplementary questions (Kovar, 1985). Both the 1986 and 1987 NHIS included questions on the use of vitamin and mineral supplements, and confirmed the demographic characteristics identified in the NHANES I, II and III studies (Koplan et al, 1986; Block et al, 1988; Moss et a, 1989; Subar and Block, 1990; Ervin et al, 1999). In 1986, the rate of regular consumption was 36% in the two weeks prior to the interview (Moss et al, 1989) and in 1987, 51% of adults had consumed supplements in the previous year (Subar and Block, 1990).

One national telephone survey reported that supplement use was more prevalent amongst women than men and above average consumption of supplements occurred in the western United States (Stewart et al, 1985). Another national telephone survey divided adult supplement users into four groups; Light, Moderate, Heavy, and Very Heavy, on the basis of the type and amount of nutrient intake from supplements (Levy and Schucker, 1987). Young supplement users (16 and 25 years) tended to be in the Light user group. Older adults (41 and 64 years) and residents of the western United States tended to be in the Heavy and Very

Heavy user groups. Light and Moderate users tended to take a broad-spectrum supplement as insurance against possible nutrient deficiencies. Heavy and Very Heavy users typically took two or more specialised products as part of a personalised supplement regimen, and were associated with more frequent visits to health food stores, greater nutrition activity and less physical involvement (Levy and Schucker, 1987).

2.4.2 Other National Studies

In a representative sample of the Dutch population, it was reported that more than 17% consumed supplements (Dorant et al, 1993). Age, sex, social class, alternative food habits, smoking and adherence to a special diet were related to the use of supplements but not region of residence, in contrast to the United States research findings (Dorant et al, 1993; Ervin et al, 1999). Adherence to special diets was also found in the United States and Australia (Horwath and Worsley, 1989; Kim et al, 1993). In Australia, women were more likely to be supplement users as in the United States (Worsley and Crawford, 1984a; Block et al, 1988). Supplement use increased with age in the Netherlands as it did in the United States, but no such association was found in Australia (Willet et al, 1981; Worsley and Crawford, 1984b; Koplan et al, 1986; Block et al, 1988; Subar and Block, 1990; Dorant et al, 1993; Ervin et al, 1999).

About half the New Zealand population (51%) used vitamin and or mineral supplements during the year preceding the 1997 National Nutrition Survey (Russell et al, 1999). Women were more likely to take supplements than men and to take them regularly rather than occasionally. Regular use remained relatively constant across all age groups while occasional use declined with age. Provincial and metropolitan females reported similar supplement use while metropolitan males reported higher use than provincial males (Russell et al, 1999).

2.4.3 Non-Representative Studies

Non-representative studies are studies that usually only involve small numbers of subjects and the results relate to a particular region or area of the country rather than the entire nation. In the United States, non-representative studies that have investigated demographic data such as education, income and occupation have also found strong socio-economic influences on supplement intake (Bootman and Wertheimer, 1980; Willet et al, 1981). One study found that the consumption rate among younger supplement users was significantly higher than in older supplement users (Schultz et al, 1982) while another study found that supplement use was not significantly related to educational achievement (Sowers and Wallace, 1986). These non-representative studies support the findings of national surveys, that there was a greater prevalence of the use of supplements in the west of the United States where adults, especially women, had more concerns about their health (Willet et al, 1981; Schultz, 1982). Women's concerns about their health and supplement use were confirmed in an ADA survey (1997) where it was reported that a significant increase in consumers, especially women, believed it was necessary to take nutritional supplements in order to ensure proper health (McMahon 1998).

An Australian survey reported that 37% of men and 53% of women took some form of supplement and overall supplement use appeared to be unrelated to occupation and educational status (Worsley and Crawford, 1984a). This finding contrasts with another Australian study where it was found that significant differences in the intake of vitamins and minerals existed among different adult social status groups, in both foods and supplements in adults, and that women and high social status men were the main users of vitamin and mineral supplements (Smith and Baghurst, 1993).

Table 1 **Studies of Vitamin and Mineral Supplement Use in the United States in Adults**

Year	Percentage Use	Percentage Daily Use	Study	Authors
1971-1974	32.9	22.8	NHANES I	Block et al, 1988
1976-1980	Approx 35	21.4	NHANES II	Koplan et al, 1986
1980	39.9	-	FDA	Stewart et al, 1985
1986	36	-	NHIS	Moss et al, 1989
1987	51.15	23.1	NHIS	Subar and Block, 1990
1987	22.5	-	NHEFS	Kim et al, 1993
1988-1994	Approx 40	-	NHANES III	Ervin et al, 1999
1992	46.2	24	NHIS	Slesinski et al, 1995

2.4.4 Prevalence of Supplement Use

In the United States, the proportion of the population consuming supplements on a daily basis and the demographic pattern of usage has not changed significantly in the past two decades. In NHANES I, II, and III, differences exist in the manner in which supplement use was defined but the prevalence was similar throughout. In NHANES I and II, respondents chose between regular use (defined as daily consumption) irregular use (defined as at least once per week) or not taken. In NHANES III, consumption of any type of supplements in the month before the interview was recorded. In NHANES I, 32.9% of adults 18 to 74 years were regular, or irregular users, of whom 22.8% used supplements regularly (Block et al, 1988). In NHANES II, almost 35% of adults 18 to 74 years were regular or irregular users, of whom 21.4% consumed supplements regularly (Koplan et al, 1986). In NHANES III, 42% of adults 20 to 74 years used any type of supplement (Ervin et al, 1999).

Other national surveys also report a fairly stable prevalence of use in the last two decades. For example, almost 40% of adults consumed vitamin and mineral supplements on a daily basis 14 days prior to interviews in a Food and Drug Administration (FDA) Survey (Stewart et al, 1985). In the 1986 NHIS, it was reported that 36.4% of adults and 43% of children used vitamin and mineral products (Moss et al, 1989). In the 1987 NHIS, a supplement use rate of 38.7% was reported amongst adults when the reference period of Stewart et al (1985) was approximated (Subar and Block, 1990). A 4% decline in supplement use amongst adults was seen between the 1980 FDA survey (42%), and the 1986 NHIS (38%) (Bender et al, 1992). A similar decline in supplement use amongst adults between the 1987 (51%) and 1992 (46%) NHIS was also reported (Slesinski et al, 1995). Direct comparisons across all of these surveys cannot be made, but the results suggest that the prevalence of supplement use among adults remained fairly stable over the past 20 years (Ervin et al, 1999).

The magnitude of supplement use decreased in the 1980s but the prevalence of light users taking broad-spectrum products, usually people under 45 years, increased and supplement use, became more likely and more intense among individuals with one or more health problems and those who perceived their health as good (Bender et al, 1992).

The prevalence of dietary supplement use in the Netherlands at 17% was lower than that reported in the United States, or Australia (Worsley and Crawford, 1984; Koplan et al, 1986; Block et al, 1988; Dorant et al, 1993). However, the mean number of different types of supplements used in the Netherlands for both sexes was 1.5, close to the 1.7 mean in the United States in 1992 (Bender et al, 1992; Dorant et al, 1993).

In both the United States and the Netherlands, the prevalence of supplement use among heavy smokers was considerably less than that among non-smokers, or light smokers (Block et al, 1988; Subar and Block, 1990; Dorant et al, 1992). In NHANES II, former smokers were the heaviest supplement users, followed by non-smokers (Koplan et al, 1986). In the 1987 NHIS, supplement use was more common, in non-smokers, especially former smokers, and those who did not drink alcohol heavily (Subar and Block, 1990).

2.5 What Do People Take?

2.5.1 National and Non-Representative Studies in the United States

In both national and non-representative studies in the United States, the most commonly consumed specific supplements in adults were multi-vitamins, vitamin C, vitamin A and calcium (Schultz, 1982; Sowers and Wallace, 1986; Block et al, 1988; Moss et al, 1989; Merkel et al, 1990). The use of specific preparations such as vitamins A, B group and C increased with age (Willet et al, 1981; Levy and Schucker, 1987; Moss et al, 1989; Ervin et al, 1999). Multi-vitamins alone, or in combination with iron, were consumed by similar proportions of men and women (Stewart et al, 1985; Moss et al, 1989). Vitamin C was consumed either alone, or in combination with other nutrients (Stewart et al, 1985; Moss et al, 1989; Park et al, 1991; Ervin et al, 1999). Calcium and iron were the most commonly included minerals in products (Moss et al, 1987; Park et al, 1991).

While most adults consumed only one supplement, the number of adults who took more than one supplement varied between the studies (Stewart et al, 1985; Moss et al, 1989; Ervin et al, 1999). Almost 11% of adults had consumed five or more products in a national telephone survey (Stewart et al, 1985) and 5% of adults consumed at least five products in the 1987

NHIS (Moss et al, 1989). In the 1987 NHIS, the median intake from supplements was 100-200% of the RDA for men women and children (Moss et al, 1989). Specialised vitamins such as vitamin A, C, and E were generally consumed in quantities many times the RDA in a survey among registered nurses (Willet et al, 1981). However, in the 1987 NHIS, it was noted that few if any supplements were consumed in amounts considered to be toxic (Subar and Block, 1990).

2.5.2 Comparisons Between Countries

As in the United States, multi-vitamins and vitamin C were commonly consumed in both the Netherlands and Australia (Worsley and Crawford, 1984a; Dorant et al, 1993; Ervin et al, 1999). Multi-vitamins and/or multi-mineral combinations were commonly consumed in New Zealand with vitamin C consumed by a relatively small proportion of the population (Russell et al, 1999). While vitamins A and D were consumed by adults in the United States, they did not rank among the most commonly consumed vitamins, as they did in the Netherlands (Dorant et al, 1993; Moss et al, 1989; Subar and Block, 1990). In the Netherlands, other supplements, especially garlic and brewer's yeast, were widely consumed amongst older adults (Dorant et al, 1993). In some studies in the United States, the use of other supplements, such as kelp and brewer's yeast, are prominent (Block et al, 1988; Schultz et al, 1982). In NHANES I, only 2.3% of the total population reported use of supplements not categorised as vitamins or minerals (Block et al, 1988). However, the use of NVNM in the United States has slowly grown to 12% in NHANES III (Radimer et al, 2000). In contrast, Australia's first national survey in 1979 found that bran was the most frequently used dietary supplement (Worsley and Crawford, 1984a). In New Zealand, 29% of the population reported the use of other dietary supplements: the three most common categories of preparations taken were garlic, oils, such as evening primrose and botanicals (Russell et al, 1999).

2.5.3 Impact of Dietary Supplements

Several studies have investigated the impact of dietary supplements on nutritional status. Looker et al (1988) examined NHANES II data to compare dietary intake and biochemical indices of several nutrients and food groups in adult regular supplement users and non-supplement users. Supplement users consumed more dietary vitamin C, and ate fruit and vegetables more frequently, than did non-supplement users. Also, iron status was reported not to be associated with supplement use (Looker et al, 1988).

NHANES II data was analysed for both adults and children to evaluate the effect of the regular use of nutritional supplements on serum vitamin C levels (Dickinson et al, 1994). Regular supplement use had a strong impact on serum vitamin C levels, independent of other dietary and demographic characteristics of supplement use that may have favoured improved nutritional status (Dickinson et al, 1994).

The relationship between the reported use of vitamin and mineral supplements and mortality in a national cohort of adults was analysed from the NHANES I Epidemiologic Follow-up Study (NHEFS) and no evidence was found that the risk of cancer was decreased, or all-cause mortality, or longevity differed among those who used vitamin and mineral supplements (Kim et al, 1993). As noted in other studies, supplement users were more likely to consume more nutrients from their food alone than non-supplement users (Looker et al, 1988; Merkel et al, 1990; Kim et al, 1993) which affirms the idea that the vitamins people choose to take are often not the ones lacking in their diet (Worsley and Crawford, 1984b; Merkel et al, 1990). It would appear that those adults who use supplements are unlikely to benefit from their use (Looker et al, 1988), nor increase their longevity (Kim et al, 1993).

2.6 Children's Studies

2.6.1 United States Children's Studies

In the United States, supplement use in children at a national level has only been reported to a limited extent, but the data indicates a high prevalence of use. For example, in the 1981

NHIS Child Health Supplement it was reported that approximately half of the children, from birth to six years, had been given a vitamin or mineral supplement in the previous two weeks (Kovar, 1982). A similar level of intake was found in the 1986 NHIS; 43% of 2 to 6 year olds were given vitamin or mineral supplements within two weeks of the survey (Moss et al, 1989). Fifty-five percent of all three year olds were given a vitamin or mineral supplement in the 30 days prior to the 1991 Longitudinal Follow-up Study (Yu et al, 1997). Non-representative studies also support the high incidence of supplement use in pre-school and school-aged children (Cook and Payne, 1979; Breskin et al, 1985; Krummerys et al, 1995).

The use of supplements decreases with age. For example, in the 1981 NHIS Child Health Supplement, approximately 50% of children in the age range birth to six years, and 36% of children under 18 years had consumed a vitamin and mineral supplements in the two week period prior to the survey (Kovar, 1982). In NHANES II, it was reported that 39% of two year olds and about 11% of teenagers regularly received a vitamin or mineral supplement (Bowering and Clancy, 1986). The decline in supplement use in boys plateaued at around 10% at 13 years of age while among girls it increased (Bowering and Clancy, 1986). The high use of supplements in young children and a decreasing use in older children were confirmed in NHANES III; young children 1 to 5 years of age were found to be major users of supplements with 42-51% of toddlers and pre-school aged boys and girls, and between 24-35% of school-aged children and adolescents respectively took supplements in the month prior to the interview (Ervin et al, 1999).

2.6.2 Other Children's Studies

The high incidence of supplement consumption amongst pre-school children was also seen in a small Canadian study where 63% percent of the mothers gave their children vitamin or mineral supplements (Campbell, 1993). In a larger Canadian study, it was reported that 36% of 8 to 15 year olds consumed supplements (Whiting et al, 1995). These rates of use were comparable to similarly aged children in the United States (Bowering and Clancy, 1986). No differences in dietary adequacy, based on nutrients from food alone between supplement users and non-users were also reported (Whiting et al, 1995). Both Canadian studies report that multi-vitamins were the most commonly consumed vitamins as was found in the

American studies (Bowering and Clancy, 1986: Campbell, 1993; Whiting et al, 1993; Ervin et al, 1999).

There are very few British children's dietary supplement studies. An Edinburgh study found that 25% of pre-schoolers took vitamin or mineral supplements (Payne and Belton, 1992). The widespread use of dietary supplements did not appear necessary when the energy intakes of 132, 7 to 8 year old Edinburgh school children were found to be in excess of the reference nutrient intake (RNI) (Ruxton et al, 1993). Supplement use amongst primary school children living in England and Scotland was approximately 16% in the month preceding the National Study of Health and Growth (Bristow et al, 1997). This result, and that of the Edinburgh study, indicate a lower incidence of use compared with the United States (Payne and Belton, 1992; Bristow et al, 1997; Ervin et al, 1999). The type of supplement taken, the frequency of intake, and a lack of significant gender differences in childhood were all similar to the pattern of intake in the United States (Bristow et al, 1997; Ervin et al, 1999). A significant finding was that cultural background influenced supplement use, with children of Afro-Carribean, Asian or other origins more likely to take a supplement, compared to White English and Scottish groups (Bristow et al, 1997).

Young people in the Netherlands consumed mainly fluoride, vitamin A and D preparations which differed from the reported findings in the United States (Dorant et al, 1993; Ervin et al, 1999). However, as in the United States, increased age was associated with a shift to other supplements with Dutch adolescents (Dorant et al, 1993; Ervin et al, 1999).

Several studies report certain similarities in terms of the key predictors of children's supplement use. For example, children with the least need for supplements, as defined by socio-economic variables, were more likely to take them (Cook and Payne, 1979; Yu et al, 1997; Bristow et al, 1997). Young children whose parents received higher education, were more likely to receive supplements (Kovar, 1982; Bowering and Clancy, 1986; Dorant et al, 1993; Bristow et al, 1997) and if the head of the household was White (Bowering and Clancy, 1986). In a study of vitamin and mineral supplement use among pre-school children in the United States, the following characteristics were identified for mothers who typically gave supplements to their children: older, married, insured, had access to private health care, and took supplements during pregnancy (Yu et al, 1997). Supplement use by mothers and pre-school children was highly correlated (Bowering and Clancy, 1986) as mothers were an important role model for children whose supplement practices potentially influenced other family members (Merkel et al, 1990; Thomsen et al, 1987). Supplement use in children was associated with particular characteristics: first birth order, eating problems or poor appetites (Yu et al, 1997). The number of children in the home, and the total number of cigarettes smoked in the home, were also significantly associated with supplement use (Bristow et al, 1997).

2.6.3 What is Taken?

In the United States, multi-vitamins, with or without iron and vitamin C, were the most commonly consumed supplement by children, as with adults (Cook and Payne, 1979; Bowering and Clancy, 1986; Moss et al, 1989; Ervin et al, 1999). Greater numbers of children consumed multi-vitamins without iron added, than with iron added (Bowering and Clancy, 1986; Ervin et al, 1999). Vitamin C was the second most popular supplement and also the most common single nutrient consumed (Bowering and Clancy, 1986; Yu et al, 1997). Other single nutrients consumed included calcium, fluoride and iron (Moss et al, 1989). Older children were less likely to take multi-vitamins, and more likely to take single or B group vitamins (Bowering and Clancy, 1986; Moss et al, 1989; Ervin et al, 1999). Most children consumed only one supplement on a daily basis (Bowering and Clancy, 1986; Moss et al, 1989; Krummeys et al, 1995; Ervin et al, 1999) but one study noted that a significant proportion of pre-school children consumed two or more supplements (Yu et al, 1997).

2.6.4 Impact of Dietary Supplements in Children

Few studies have compared biochemical indexes of nutritional status between children who do, and do not, take supplements. Improvements were not observed in biochemical indexes of several water-soluble vitamins between those who did, and did not, take supplements and the mean intakes of nutrients only differed significantly between the two groups when the supplements were considered (Breskin et al, 1985). Two studies using NHANES II data and different analytical techniques did not find improvements in iron status (Bowering and Clancy, 1986; Looker et al, 1987). One study used multiple iron indicators, including serum ferritin, in its iron analysis and incorporated sample weights and design effects to avoid incorrect point estimates, variances, and test statistics to analyze the complex NHANES II design (Looker et al, 1987) which the other study failed to use (Bowering and Clancy, 1986).

As with adults, children who consumed supplements tended to consume more vitamin C and fruit and vegetables than non-supplement users (Bowering and Clancy, 1986). The percentage of children who met the RDA for vitamins A and C, thiamin, riboflavin, and niacin was greater amongst supplement users than non-users (Cook and Payne, 1979). Regular supplement users obtained substantial intakes of some nutrients from vitamin and mineral preparations, and supplements probably contributed to an already adequate dietary intake for some (Bowering and Clancy, 1986).

In 1988, Benton and Roberts (1988) published a paper purporting to show that eight months of the daily administration of a vitamin/mineral supplement in 30, 12 to 13 year old Welsh school children produced a statistically significant increase in non-verbal intelligence compared with a matched group receiving a placebo. There were numerous responses to this paper (Bates et al, 1988; Bender, 1988; Emery et al, 1988; Hutton and Ashby, 1988; MacFarlane, 1988; McNair, 1988; Yudkin, 1988) and the key criticisms were that the reported dietary data, based on 3-day diaries, were unlikely to give a true picture of the dietary status of the children; that the supplement was not tailored to the subjects' apparent needs; and that the association between supplementation and non-verbal intelligence was due not so much to the increase of scores in the treated group but to an "adverse" placebo effect, ie the failure of the placebo group to increase their scores when in practice the average score would be expected to increase on the repeated administration of the tests (Bates et al, 1988; Bender, 1988; Hutton and Ashby, 1988; MacFarlane, 1988; McNair, 1988; Yudkin, 1988). From the work published to date, there is little to suggest that the diets of most western children who are seen to be growing adequately are so deficient in micro-nutrients as to impair their mental functioning (Nelson, 1992). However, there may be a proportion of children whose diets are poor, and whose poorer performance on intelligence tests could theoretically be due to marginal nutrient deficiencies, independent of the effects of social class, parental education, or other confounding factors, but the evidence for such an association is weak (Nelson, 1992).

2.7 Why Supplements are Taken?

2.7.1 Key Findings

Few studies have examined the reasons for supplement use. In NHANES I, Block et al (1988) identified the health habits and beliefs, and the key socio-demographic variables, that influence an individual's supplement intake (Block et al, 1988). The following factors influenced supplement intake:

1) Individuals who, believed that diet affects disease, were significantly more likely to be regular supplement users, than those who did not.

2) Non-drinkers and lighter drinkers were somewhat more likely to use supplements than were heavier drinkers.

3) Never and former smokers were more likely to be supplement users than were current smokers.

4) Individuals in the highest quartile of body mass index were less likely to use supplements than were those in the other three quartiles (Block et al, 1988: p302).

Similar results were found from alcohol intake, smoking, and body mass index in NHANES II (Koplan et al, 1986). Supplement practices were related to people's physical and emotional states of health, as well as their dietary habits, food, and nutritional beliefs (Worsley and Crawford, 1984b). Supplement use was also associated with control over health and sense of well being (Kim et al, 1993) and positively correlated with good health (Bender et al, 1992). Control over one's health included the attempt to prevent minor illnesses, perceived dietary deficiencies through an unbalanced diet, or negative perceptions of the food supply, and perceived health benefits to prevent degenerative diseases (Fleischer and Read, 1982;

Schultz, 1982; Worsley and Crawford, 1984b; Levy and Schucker, 1987; Merkel et al, 1990; Bender et al, 1992; Kim et al, 1993).

Supplements were also consumed because of medical advice, menstrual and hormonal problems, maternal influence, adherence to vegetarian food patterns, and peer recommendation (Fleischer and Read, 1982; Schultz et al, 1982; Bowering and Clancy, 1986; Sobal and Marquart, 1994a; Yu et al, 1997; Ervin et al, 1999). Statements such as: to provide energy, to promote weight loss or weight gain, or to help with sport were also given as reasons for supplement use (Fleisher and Read, 1982; Schultz, 1982; Sobal and Marquart 1994a).

People who regularly supplement their diet appeared health oriented and used diet, among other means, to ameliorate their health (Worsley and Crawford, 1984b; McMahon, 1998). These people perceived their health in a worse light than other people and were more accepting of general and specific claims about the benefits associated with vitamins and minerals (Worsley and Crawford, 1984b). Only a small number of sampled supplement users indicated that the supplements they consumed were of little or no value (Read et al, 1989).

In the United Kingdom, the pattern of supplement consumption in children was more related to beliefs and cultural background than health needs (Bristow et al, 1997). In contrast in Canada children's supplement use was related to possible dietary deficiencies (Campbell, 1993) and in the United States to behavioural traits (Yu et al, 1997). Children with the least need for supplements were the most likely to receive them (Bowering and Clancy, 1986; Bristow et al, 1997).

2.8 The Limitations of Supplement Use

2.8.1 Supplements: Health, Well-Being and Resistance to Disease

The major chronic diseases in Western societies have multiple causes. The advent of antibiotics and vaccines led many people to think that the cure of these diseases awaited specific "magic bullets" and some proponents of supplements feel that supplements are the nutritional "magic bullets" for heart disease, and other maladies (Thomas, 1996). While Americans are a nation hungry for simple nutritional solutions to complex health problems (Brody, 1995), others warn against thinking in a penicillin mode (Golub, 1994). This can be easily done in nutrition because the first identified nutrient-related diseases were caused by deficiencies, but there are no simple cause and effect relationships for cardiovascular disease, cancer, stroke, diabetes or osteoporosis (Thomas, 1996). Vitamin E is an example of a nutrient that may, or may not, influence the risk of developing heart disease; for some people, it may be potentially important, but for others, it is at best one factor, probably not a major one (Thomas, 1996: p47). Genetic inheritance is a primary contributor to chronic disease risk as "genes have a powerful influence over body size and disease risk, and though diet helps temper unwanted tendencies, who you are is often more important than what you eat... Because of genetics, diets help some people a lot, some people a little, and a very few people not at all" (Hisler, 1995: p49). The other factors that are influential include the risk of chronic disease are exercise, smoking, alcohol consumption, stress levels, rest and relaxation, and eating a diet that meets the and dietary guidelines (Thomas, 1996). Genetic inheritance, and these lifestyle factors, influence our health and disease, not the use of supplements (Thomas, 1996).

2.8.2 Food: More Than the Sum of its Nutrients

Food constituents and compounds that are not classical nutrients can apparently influence health and disease (Thomas, 1996; ADA, 1996). Phytochemicals, which include flavonoids, monoterpenes, phenolics, indoles, allyic sulphides and isothiocyanates are examples. Their roles in improving health, treating disease, or extending life are, as yet, only ideas for research which reinforces the preference of most public health and nutrition scientists for people to obtain their nutritional requirements from food (Thomas, 1996).

2.8.3 Intervention Supplement Studies

Epidemiology studies show that fruit and vegetable consumption reduces the risk of lung cancer in smokers from foods containing beta-carotene and many other carotenoids and phytochemicals. A summary of these studies can be found in van Poppel and Goldbohm (van Poppel and Goldbohn, 1995). However, epidemiology studies can only identify whether the variables under study are related in some way to an outcome. The following studies are recent clinical trials of single nutrients where subjects were randomly assigned to a treatment or a control group to help to identify a cause-and-effect relationship.

The Alpha-Tocopherol Beta-Carotene (ATBC) Study sought to determine whether daily supplements with alpha-tocopherol, beta-carotene, or both, would reduce the incidence of lung cancer and other cancers. A total of 29,133 male smokers 50 to 69 years of age were randomly assigned to one of four daily regimens; 50mg alpha-tocopherol, 20mg beta-carotene, both alpha-tocopherol and beta-carotene, or placebo. No reduction in the incidence of lung cancer was seen after 5 to 8 years of supplementation of alpha-tocopherol or beta-carotene but the possibility was raised that these supplements may actually have harmful as well as beneficial effects (The Alpha-Tocopherol Beta-Carotene Study Prevention Group, 1994).

In the Beta-Carotene Retinol Efficacy Trial (CARET), 18,314 smokers, former smokers and workers exposed to asbestos took either daily supplements of combined 30mg of beta-carotene, 25,000 IU vitamin A, or a placebo to compare the incidence of lung cancer. After an average of four years supplementation, the study was halted because no clear benefits were seen, and those who received the supplements had a higher rate of death from lung cancer and heart disease (Omenn et al, 1996).

In the Nurses Health Study (NHS), a prospective cohort of 87,000 female nurses were studied from 1980 to 1988 for cardiovascular disease. A 34% reduction in the risk of cardiovascular disease was found after adjustment for age and smoking amongst women who consumed high supplementary intakes of vitamin E, which were greater than 100IU/day (Stampher et al, 1993). The Health Professionals Follow-up Study, another cohort prospective study, followed approximately 40,000 men aged 40 to 75 years who were free of cardiovascular disease, diabetes, or cholesterol for four years. The contribution of vitamin E from foods and from supplements was examined separately. After a four year follow-up, a significant reduction in the risk of coronary disease was limited to those with an intake of vitamin E that was greater than 100IU/day from supplements. In both this study and the NHS, short-term use was not associated with any obvious benefit (Stampher and Rimm, 1995). In the Physicians Health Study (PHS), 22,071 physicians of whom 11% were current smokers and 39% were former smokers took either 50mg beta-carotene or a placebo on alternate days. Twelve years of supplementation with beta-carotene produced neither benefit nor harm for cancer or heart disease among these healthy men (Hennekens et al, 1996:p1).

When the results of CARET were combined with those of the ATBC Cancer Prevention Study and the PHS, it became clear that there could be little confidence in the efficacy, or safety, of supplemental beta-carotene or vitamin A in efforts to reduce the burdens of cancer and heart disease in certain populations (Omenn et al, 1996). The results of these studies counter the claim that taking supplements protects the health of those who do not eat, or take care as much as they should and, also that science cannot be rushed (Thomas, 1996).

In contrast, the Nutrition Intervention Trials in Linxian, China, involved the measurement of cancer and mortality incidence among 29,584 adults who received daily vitamin and mineral supplementation during a five year period. The subjects were randomly assigned to four intervention groups: retinol and zinc; riboflavin and zinc; vitamin C and molybdenum; and beta-carotene, vitamin E and selenium. A significantly lower total mortality risk occurred among those receiving supplementation with beta-carotene, vitamin E, and selenium (Blot et al, 1993). However, Linxian is an area known historically to have limited food availability and variety and the subjects were a very different population from those examined in other studies (Omenn et al, 1996).

2.8.4 Dietary Supplements: A Potential Source of Toxicity

Nutrients, like all other substances, can produce adverse effects if intakes are sufficiently high (Hathcock, 1993) and these vary widely from nutrient to nutrient and may vary with the age of the individual (The American Institute of Nutrition and American Society of Clinical Nutrition, 1987). "Mega-vitamin therapy" described as the consumption of vitamins in amounts of more than 10 times the recommended intake (Woolliscroft, 1983) is rejected by others (Basu Dickerson, 1996) as a misnomer because no clear definition or dose limit exists.

Vitamins taken in such high doses act more like drugs than nutrients (Basu and Dickerson, 1996). Mega-mineral therapy describes those instances in which minerals were taken in amounts above recognised biologic requirements (CPS, 1990). Mega-vitamin and mega-mineral regimens are advocated as "natural therapies" by various lay healers, although there has been little scientific evaluation of these therapies (CPS, 1990). Those who take dietary supplements unsupervised can therefore face the possibility of toxicity. High-dose tablets, described as "high potency" to convey an aura of acceptability, illustrate this possibility. In children, the major concern is the oversupply of vitamin A and vitamin D, and to a lesser extent, iron and calcium which reflects the interplay between availability and toxicity (CPS, 1990). Iron supplements intended for other household members are the most common cause of paediatric poisoning deaths in the United States (The United States Preventative Services Task Force, 1993).

2.8.4.1 Fat-Soluble Vitamins

Fat-soluble vitamins tend to cause toxic reactions at lower multiples of the RDA than do water soluble vitamins because they are stored in the body, rather than excreted if taken in excess for a long period of time (Basu and Dickerson, 1996). Evidence of the adverse effects of vitamin A is usually associated with intakes greater than 7500ug retinol equivalents (RE) or 25,000 international units (IU) (Hathcock, 1997). Vitamin A analogues, used in the treatment of acne, are also known for their teratogenic effects (Hall, 1984). The effects of alcohol or high intakes of retinol have been offered as an explanation for the adverse outcomes with beta-carotene in the ATBC and the CARET trial (Albanes, 1996). Sub-group analysis of the ATBC and CARET data indicated that the hazardous-promoting effects of B-carotene were seen primarily in subjects who consumed alcohol and smoked more (Albanes et al, 1996; Omenn et al, 1996). Lachance (1998b) suggests that because epidemiological results are strongly supportive of the role of anti-oxidants in the defence of oxidative insults, any results from intervention trials of the long-term oxidative insults of smoking which questionably incriminate beta-carotene to be a hazardous chemical must be viewed with caution (Lachance, 1998b:p35). He argues that both the ATBC and CARET studies failed to consider the interplay of anti-oxidant nutrients or include toxic amounts of compounds that promoted a co-morbidity outcome leading to both lung cancer and liver pathology that resulted from heavy smoking and (a) alcohol consumption (ATBC) or (b) toxicity of vitamin A (CARET) (Lachance, 1998:p35). In adults, vitamin D intakes of 10,000IU for several months resulted in marked disturbances in calcium metabolism (Woolliscroft, 1983). Intakes of 2000-3000IU/day of vitamin D caused "idiopathic hypercalcemia" in children (Forfar at al, 1956).

2.8.4.2 Water-Soluble Vitamins

Thiamin, riboflavin, vitamin B12 and biotin do not seem to cause toxic reactions in humans when taken in large doses orally (CSA, 1987). Nicotinic acid, taken to lower serum lipids, can produce liver toxicity when gram quantities are taken (Rader et al, 1992). Large doses of vitamin B6, used in the treatment of premenstrual syndrome, can cause sensory neuropathy (Schaumburg et al, 1983), although women vary considerably in their sensitivity to the vitamin (Dalton, 1985).

Vitamin C and beta-carotene are both anti-oxidants. At physiologic levels, ascorbate acts primarily as an anti-oxidant. As pharmacologic levels are reached, its pro-oxidant effects predominate (Repka and Hebbel, 1991). In the presence of iron, excess vitamin C is a very potent pro-oxidant that converts iron stores to catalytic iron, a very oxidant substance (Herbert, 1992). Ascorbic acid enhances iron absorption from the digestive tract. In those who are genetically susceptible to iron overload, this can lead to haematochromatosis (Basu and Dickerson, 1996). It has been suggested that with high levels of stored iron, serrum ferritin is a risk factor for coronary heart disease (Salonen et al, 1993). However, this work has not been substantiated. Vitamin C in doses greater than 500mg can be harmful to people with a predisposition to form oxalate stones (Levine et al, 1996). There has been speculation that high doses of ascorbic acid could result in adaptation to the high intake, resulting in greater than normal metabolism of the vitamin and lead to "conditioned scurvy" when the high intake is discontinued, but these claims have not been substantiated (Hathcock, 1997). Although no toxic affects of folate have been clearly established, consuming excessive amounts of this vitamin can mask a vitamin B12 deficiency and could delay the diagnosis of pernicious anaemia, with irreversible neurological damage (Basu and Dickerson, 1996).

While the safe intake level of many trace elements has not been defined, an excess clearly may lead to toxic effects (O'Dell, 1984; CPS, 1990). As trace elements may share a common transport and enzyme system, there is concern that the ingestion of excessive quantities of one trace element may reduce the absorption of others (CPS, 1990). For example, while large amounts of zinc caused toxicity, lower intakes of zinc (still in excess of the RDA) interfered with the utilization of copper and iron, and adversely affected high density lipoproteincholesterol concentrations (Fosmire, 1990). Zinc therapy has also induced copper deficiency (Prasad et al, 1978).

2.8.5 Adverse Nutrient Interactions

Nutrients derived from food, and not supplements, are less likely to contribute to adverse interactions with medical care (ADA, 1996). Little information is available to demonstrate that long-term, and possibly lifetime intakes, of large doses of supplements are completely safe as studies on the consequences of large nutrient intake in humans rarely have a large sample size and rarely go beyond several months (Thomas, 1996). Many problems associated with doses of single nutrients reflect interactions that result in a relative deficiency for another nutrient. For example, vitamin E acts synergistically with anti-coagulant drugs (Bendich, 1992). High amounts of calcium inhibit the absorption of iron (Cook et al, 1991). Very large doses of beta-carotene decreased the concentration of lycopene, another important carotinoid in the low-density lipoproteins, by 12-25 % (Graziano et al, 1995). Tryptophan supplements have been associated with eosinphilia-ayalgia syndrome, a connective tissue disease (Roufs, 1992; ADA, 1996).

2.9 Vitamins, Minerals and Exercise Performance

2.9.1 Impact of Vitamins and Minerals on Exercise Performance

What are the effects of sport and exercise on vitamin and mineral status? Does physical training result in vitamin and mineral deficiencies? Are the vitamin and mineral requirements of athletes increased? Moderate physical activity does not adversely affect vitamin and mineral nutritional status when recommended amounts of vitamins and mineral elements are consumed in the diet (Clarkson, 1991b; Keith, 1989; Lukaski, 1995). A heavy exercise programme may increase requirements for some nutrients, including B group vitamins and iron, but athletes involved in such programmes would benefit from nutritional counselling (Burke and Read, 1993). When athletes typically consume a well balanced diet, they exceed their RDA/RDI levels (Faber and Spinner-Benade, 1991; Sobal and Marquart, 1994b; Brill and Keane, 1994). Many studies have found that most adult athletes consume high calorie diets with adequate amounts of vitamins and minerals and have little need for supplementation (Nieman et al, 1989; Keith, 1989; Lane, 1989; Clarkson, 1991b; Lukaski, 1995). The situation is different for those athletes who are on weight loss diets, have poor dietary habits with restricted variety in their diet, have limited access to food, or have eating disorders (Moffat, 1984; Clarkson, 1991a; Burke and Read, 1993). Poor dietary habits associated with the maintenance of low body weights are more likely to be found in sports that may promote unrealistically low body fat levels, and where fad diets and eating disorders are more common, in the case of dancers, gymnasts and wrestlers (Clarkson, 1991a, Burke and Read, 1993). These athletes may be unwilling to increase their energy intake to satisfy RDA levels. Supervised supplementation of vitamins and minerals may be required in cases of on-going sub-optimal dietary intake or to meet short-term goals (Burke and Read, 1993; Armstrong and Maresh, 1996).

2.9.2 Supplements: Nutritional Aids to Exercise Performance and Health

During the past two decades, Americans have been encouraged to increase their levels of physical activity as a means of preventing chronic disease and enhancing their quality of life (Lukaski, 1995). Sport can be a leisure activity for participants and provide exercise (American College of Sports Medicine, 1990). In New Zealand, the importance of physical activity to health has also been expounded by experts and maintaining health was given as the main reason for participation in physical activity by 72% of those surveyed in the Life in New Zealand Survey (Russell et al, 1991). In the past, there has been confusion between the relationship of nutrition, exercise and sport, which has arisen from misinformation, misconceptions and unrealistic expectations and can usually be traced to lack of fundamental knowledge and recent research findings (Dreizen, 1989). Nutrients such as carbohydrates and water have been used by athletes to maintain and enhance endurance performance (Burke and Read, 1993) but misconceptions still exist about the relationship between vitamin and mineral supplements and exercise performance (Clarkson, 1991b; Kies, 1995).

2.9.3 Vitamin and Mineral Status of Athletes

Food intake can be monitored to assess vitamin and mineral intake. Dietary records, although unreliable in some circumstances, can increase the knowledge base for both athletes and non-athletes in population groups (Short, 1989). Dietary adequacy can be addressed by a comparison of the dietary record with the RDAs but these vary from country to country as they are established independently. For example, the RDA for adult men for vitamin C in the United Kingdom is 40mg (Ministry of Health, 1998) and in the United States, it is 90mg (Nutrition Today, 2000). Studies used to set the RDAs did not include athletes nor was the exercise status of the individual reported (Clarkson, 1991a) which questions the accuracy of using the RDA to evaluate the nutritional needs of the athletes (Sirota, 1994).

The status of the body content of certain vitamins and minerals can be more accurately assessed by clinical signs, tissue or blood samples analysis than with dietary records. Tissue analysis accurately documents specific deficiencies, but involves invasive and costly techniques. Vitamin levels can be measured directly from blood serum or plasma, or indirectly by an assessment of erythrocyte enzyme function (Clarkson, 1991b). These techniques are also associated with problems. For example, two different methods used to measure thiamin status in the blood yielded different results (Guillard et al, 1989). Test accuracy can be questionable. For example, tests for biochemical deficiency are considered to be equivocal for the assessment of magnesium, copper, and zinc status (Lukaski, 1995). A problem associated with interpreting results is whether blood levels accurately reflect what is in the tissues as these can be affected by several factors, including acute exercise (Clarkson, 1991b). There may be mobilisation of vitamins and minerals from tissues into the blood, during or after exercise, and exercise may affect their levels in the blood by loss in sweat, or altered excretion in the urine. Also, there is variation in the time taken for these changes to return to resting levels (Clarkson, 1991b).

2.9.4 The Relationship of Vitamin and Mineral Status to Performance

While numerous studies have been carried out to assess the effectiveness of vitamin and mineral as ergogenic aids, many are fraught with methodological problems. Problems may be related to: study design, number of subjects, age range, nutritional assessment of subjects, individual variation in response, degree of compliance, length of supplementation period, level of activity, status of athletes, methods of measurement, control, and statistical analysis (Weight, 1988; Clarkson, 1991b).

Research has shown that vitamin deficiencies may result in decreased physical performance, and that vitamin supplementation improves physical performance in people with pre-existing deficiencies (Armstrong and Maresh, 1996). For example, van der Beek et al (1984) induced biochemical deficiencies of vitamins B1, B2, B6, and C in healthy men to demonstrate impaired maximal oxygen uptake and anaerobic threshold.

Many studies demonstrate that the quantity of vitamins needed by athletes is usually available in the diet and that supplementation has little or no effect on athletic performance (Barnett and Conlee, 1984; Weight, 1988; Haymes, 1991; Singh et al, 1992; Telford et al, 1992b). Vitamin supplementation in athletes who were already consuming the RDA of vitamins through diet alone increased the blood levels of some nutrients but was found to have no effect on athletic performance (Telford et al, 1992a). High potency multi-vitamin/multi-mineral tablets have been found to have no effect on maximal oxygen uptake, endurance capacity, or isotonic strength in well-nourished men who maintained their physical activity (Singh et al, 1992).

It has been suggested that athletes participating in strenuous training may have difficulty in maintaining adequate tissue levels of vitamins, even if consuming the RDA (Van Dam, 1978; Colgan, 1986). Despite evidence to the contrary, multi-vitamin supplementation continues to be widely practised by athletes in an effort to cope with the rigors of strenuous training and/or to gain a performance advantage (Deuster et al, 1986; Worme et al, 1990; Burke and Read, 1993; Sobal and Marquart, 1994; Brill and Keen, 1994). The perceived need for vitamin supplementation, and the presumed associated benefits, is based more on anecdotal reports than on firm scientific evidence. There are concerns that the use of high potency multi-vitamin formulations may be harmful and cause imbalances (Haymes, 1991) and that food selection by athletes is often dictated on the basis of tradition, emotion or superstition (Sobal and Marquart, 1994; Burke and Read, 1993; Worme et al, 1990).

For most athletes, it is unlikely that a deficiency of a single vitamin would occur due to diet alone, or that exercise increases the loss of a single vitamin from the body at a rate greater than can be replaced by a well balanced dietary intake (Armstrong and Maresh, 1996). Biologic actions of most vitamins involved with energy metabolism work in concert with other vitamins which suggests that studies which examine single vitamin supplements are violating the principle of nutrient interaction (Telford et al, 1992b).

2.9.5 Vitamins as Anti-Oxidants

Free radicals have been implicated in a number of disease states and in the natural process of aging. They originate in both bodily processes and from environmental exposures (Kanter, 1994). In both physical exercise and recovery, oxygen-generated free radicals appear to be generated (Jenkins, 1993). They have the capacity to damage virtually every component of the cell, although the most susceptible parts appear to be those which contain considerable amounts of unsaturated fat and iron (Jenkins, 1993). Other free radicals may be generated during mechanical compression and trauma (Symons, 1988).

Free radicals are held in check by anti-oxidants, and when there is a balance of anti-oxidants and free radicals, they do not pose a problem. The primary nutritional anti-oxidants are the fat-soluble vitamins E, beta-carotene and water-soluble vitamin C. Vitamin E appears to be the most important anti-oxidant related to exercise (Armstrong and Maresh, 1996). Takanami et al (2000) recommend the use of 100-200mg/day of vitamin E supplements for endurance athletes. Although the majority of well-controlled studies have reported no significant effect on physical performance from vitamin E supplements, they may play an important role in preventing the free radical damage associated with endurance exercise via mobilisation from tissue stores and redistribution to prevent exercise induced lipid peroxidation (Takanami et al, 2000).

2.9.6 Sports Drinks and Electrolytes

The threat of dehydration during exercise is potentially more serious than the loss of any electrolyte (Armstrong and Maresh, 1996). Sports drinks are effective in enhancing sports performances as they help avoid the exercise-induced changes to body homeostasis. The homeostatic disturbances detrimental to performance include, decreased plasma volume (Gisolfi et al, 1990) and increased osmolarity and core temperature, electrolyte disturbances and decreased availability of muscle fuels (Buskirk and Puhl, 1989). In prolonged exercise, electrolyte disturbances such as hyponatremia may also become a threat (Noakes et al, 1992). In general, sports drinks contain carbohydrate in the concentration range 5-10% together with small levels of electrolytes, usually sodium and potassium (Burke and Read, 1993). When exercise is greater than one hour, carbohydrate intake enhances performance (Maughan, 1991).

2.9.7 Trace Elements

Few trace element studies have documented any beneficial effect of supplements on performance. However, those that do are equivocal and further research is required (Armstrong and Maresh, 1996). As the dietary intakes of chromium in United States citizens are low, chromium deficiency may be possible (Clarkson, 1991a; Newhouse and Clement, 1995). Iodine and zinc supplements may be necessary during prolonged sweating (Keen, 1993). Phosphate supplements may enhance performance (Clarkson, 1991a) as may magnesium (Clarkson, 1991a; Brilla, 1995). These results reaffirm that physically active people require counselling to consume foods with high nutrient densities rather than relying on nutrient supplements (Lukaski, 2000).

2.9.8 Effects of Exercise on Iron Status

The literature shows that iron deficiency decreases performance (Weight, 1993; Burke and Read, 1993; Newhouse and Clement, 1995). The prevalence of iron deficiency is reported to be higher in segments of the population that chronically exercises compared to segments that do not exercise (Weaver and Rajaram, 1992; Telford et al, 1993). None of the published studies are sufficiently powerful, or are sufficiently well designed, to allow an accurate estimate of the prevalence of iron-deficiency anaemia in exercising populations (Beard and Tobin, 1995:p34). The possible causes of iron deficiency during athletic training are attributed to decreased absorption, increased excretion, increased haemolysis of red cells and poor diet (Brune et al, 1986; Weaver and Rajaram, 1992; Eichner et al, 1992; Telford et al, 1993). Few studies are convincing given the methodological problems of the timing of blood samples, no control groups, no dietary assessment or control, and poor methods for the determination of dependent variables (Beard and Tobin, 1995:p40).

Weight et al (1992b) suggested that the incidence of anaemia in athletes was equivalent to that of non-athletes. They further suggest that "sports anaemia" occurred independently of a negative iron balance with the apparent reduction in haemoglobin concentration due to the plasma volume expansion resulting from training and was therefore a dilutional problem (Weight et al, 1993). The established clinical criteria for iron deficiency (serum ferritin of less than 12ug/litre, less than 18% saturation of transferrin, and haemoglobin levels below 140g/litre in males and 120g/litre in females) may not be appropriate for athletes due to the dilutional effect of the expanded blood volume (Weight et al, 1992a). When a more stringent criteria for defining iron deficiency in athletes was applied (at least two of the designated indices were abnormal), the condition was less common among athletes of both sexes than the literature suggested (Weight et al, 1992a).

Iron supplements apparently benefit iron-deficient athletes only if anaemia is involved (Bucci, 1989) and iron supplements do not significantly affect work capacity until haemoglobin levels drop (Newhouse and Clement, 1995). Athletes should avoid poor iron status since exercise can decrease iron levels over a prolonged period (Beard and Tobin, 1995), although a moderate exercise-induced decline in iron status can be prevented by appropriate dietary iron or supplementary iron intakes (Lyle et al, 1992).

2.9.9 Why Athletes Use Supplements

Athletes have been targeted as a significant consumer group for vitamin and mineral supplements. Sports magazines are often filled with advertisements for vitamins and minerals purported to enhance performance, delay fatigue, and speed up recovery (Armstrong and Maresh, 1996). There have been few formal studies conducted solely on the use of nutritional supplements by athletes and most information about supplement practices was provided, in surveys of dietary intake of athletic populations. A summary of those findings compared to those in national surveys of the general public indicated that the average prevalence of use by athletes was not much greater than that of the general public (Burke and Read, 1993:). National surveys report that population sub-groups differ in their use of supplements, as do the supplement practices between different groups of athletes (Burke and Read, 1993). For example, bodybuilders and weightlifters report up to 100% supplement use (Lamar-Hildebrand, 1989; Kleiner et al, 1989; Burke and Read, 1988; Brill and Kean, 1994). In Australia, athletes used supplements more in individual sports (75%) such as swimming, powerlifting and cycling than amongst team sports (32%) such as baseball, soccer, hockey, ice hockey and netball (Australian Sports Federation, 1983).

Athletes are concerned with the goals of maximising performance as well as being fearful that their competitors may gain a decisive edge. They are highly susceptible to faddish claims and it is not surprising that they use supplements (Van der Beek, 1985). Many studies of athletes' supplement practices do not address important issues including the types of supplements used; the amounts taken; and the rationale for their use especially as it is here that practices of athletes may been seen to differ from those of the general population (Burke and Read, 1993:p46). Concern has been expressed about some athletes using a large number of supplements concurrently, in doses that would provide very high nutrient intakes in comparison with normal dietary intakes (Australian Sports Federation, 1983; Burke and Read, 1993). The effectiveness and safety of vitamin and mineral supplements should be documented to prevent their inappropriate use and the development of nutritional quackery (Williams, 1989).

Supplement use increased with age in United States marathon runners, but no significant associations between supplement use and gender, ethnicity, marital status, education, dietary intake or training level was found (Nieman et al, 1989). In contrast, supplement use was found to decrease with age in the Australian Sports Medicine Survey and the attitudes within the particular sport, especially that of the coach, strongly influenced supplementation practices (Australian Sports Federation, 1983). Coaches reinforce supplement behaviour by recommending supplements, regardless of the extent of their nutritional knowledge (Clarkson, 1991b). Others note that some athletes become psychologically dependent upon high dose vitamin and mineral supplements (Parr et al, 1984; Grandjean, 1983).

The reasons for supplement use fall into three areas: to compensate for less than adequate diets or lifestyles; to meet unusual nutrient demands induced by heavy exercise; and to produce an ergogenic effect (Nieman et al, 1989). Ergogenic aids are defined as substances or devices that are reputed to improve athletic performance above the levels which are normally expected (Bucci, 1989). Different attitudes and beliefs are thought to underlie the supplementation practices of various athletic groups (Burke and Read, 1993).

Nutritional supplements, commonly used by athletes are taken without regard for specific deficiencies, so that even after supplementation, athletes remain deficient in certain nutrients (Clarkson, 1991a). This could occur because most studies report that athletes do not have an adequate knowledge of proper dietary practices and have not received qualified dietary advice (Short, 1989). More than two-thirds of American college and high school athletes were not familiar with dietary goals or guidelines other than the basic food groups (Parr et al, 1984). A significant finding of this study was that athletes who were familiar with the dietary guidelines, used them regularly (Parr et al, 1984) which endorsed the idea that if athletes become acquainted with proper nutritional practices, they may make better use of them (Clarkson, 1991a) and correct the specific vitamin and/or deficiencies that have been shown to exist in some athletic groups with a well balanced diet (Clarkson, 1991b).

2.10 Adolescents

2.10.1 Adolescent Athletes and Nutrition

Adolescents, as a group, were at risk from nutritional problems, both from a physiological and a psycho-social standpoint, as their dramatic increase in physical growth and development created a high demand for nutrients and energy (Story and Resnick, 1986). The psycho-social changes that were part of an adolescent's search for independence and identity, a concern for appearance, and an active lifestyle could have a strong impact on nutrient intake and food choices (Story and Resnick, 1986). Physical, behavioural and social characteristics were found to have a marked impact on food intake in terms of both food categories chosen and gender (Woodward, 1986). Studies show that there can be discrepancies between teenagers health knowledge and their behaviour (Radius, 1980; Story and Resnick, 1986; Woodward et al, 1991). Knowledge of nutrition may be an insufficient basis for convincing people that sound eating habits were important (Yetley and Roderuck, 1980).

2.10.2 Adolescents and Supplements

Few studies that have investigated the use of supplements in adolescents or adolescent athletes. Three studies reported supplement use in high school athletes in the United States of 19%, 46% and 38% respectively (Douglas and Douglas, 1984; Parr et al, 1984; Sobal and Marquart, 1994a). In one study, supplement use did not differ by gender (Sobal and Marquart, 1994a) and, in another, males were more likely to take vitamin, mineral and protein supplements than females (Parr et al, 1984). The later study also reported that multi-vitamins and vitamin C usually taken daily were the most commonly consumed supplements (Parr et al, 1984), a finding similar to general population studies (Ervin et al, 1999). Adolescent beliefs about the use of supplements were based on a blend of scientific fact and fallacies (Parr et al, 1984; Thomsen et al, 1987; Henderson and Woodward, 1991). Basic nutrition and appropriate eating patterns were important concerns of athletes (Parr et al, 1984). This supports the suggestion that sport participation may be a catalyst for nutrition knowledge (Douglas and Douglas, 1984). Parents were perceived as the best source of nutrition knowledge (Douglas and Douglas, 1984; Parr et al, 1984; Thomsen et al, 1987; Krowchuk et al, 1989; Henderson and Woodward, 1991).

In both adolescents, and adolescent athletes studies, supplement use appeared to be motivated more by family and health-oriented reasons (Thomsen et al, 1987; Henderson and Woodward, 1991; Sobal and Marquart, 1994a) but sports performance and sporting aspirations were also reasons for consuming supplements (Sobal and Marquarst, 1994a). In two studies, athletes believed that supplement consumption improved performance (Krowchuk et al, 1989; Sobal and Marquart, 1994a).

2.11 Summary

The use of dietary supplements is now an established practice by people of all ages, and all sectors, of Western society although supplement users are predominantly from higher socio-economic backgrounds. The significant factors that have contributed to the use of supplements include: the perceived need as promoted by marketing campaigns; personal interest in, and the responsibility for, ones own health; and scientific evidence linking diets high in some nutrients with a lower risk of chronic diseases. The most popular supplements are multi-vitamins and vitamin C. In recent years, there has been an increase in the use of NVNM and this is associated with an interest in more healthful lifestyles. Given the growing use of dietary supplements, more needs to be known about the contribution that supplements make to nutrition but also what influences the preference for certain supplements among national, social and cultural groups.

3 Aims of the Study

The overall aim of this thesis was to investigate the use of dietary supplements in two groups of children.

Aim: Study 1 To investigate the use of dietary supplements in children participating in the pilot study for the Children's National Nutrition Survey aged 1 to 14 years.

Objectives: To describe the types of supplements taken by age, ethnicity and gender.

To compare the nutrient intakes of supplement users with age matched controls.

Aim: Study 2 To investigate the use of dietary supplements in potentially elite athletes from two large co-educational decile 10 North Shore secondary schools.

Objective: To survey, using a questionnaire, the types of dietary supplements taken by these athletes.

4 Methods One: Pilot for the Children's Nutrition Survey

4.1 Introduction

Current interest in supplement use in adults highlights the need to investigate use in the paediatric population in New Zealand. Available data from the pilot of the Children's Nutrition Survey was used to investigate supplement use in children aged 1 to 14 years.

4.2 Pilot for the Children's Nutrition Survey

The Ministry of Health commissioned a national survey to assess the nutritional status of children aged 1 to 14 years of age in New Zealand. The results of the survey are intended to help formulate health and education policies for children. The policies include specific concerns with:

- recommendations with respect to food eating habits for children in general.
- specific recommendations pertaining to Maori and Pacific children in general.
- the identification of sections of the childhood population whose diet may be inadequate.

In addition, the trends in the nutritional status of children could be monitored if a similar study is repeated in the future. To provide the quantitative component for this survey, a pilot study was used to trial certain approaches and techniques.

The pilot study was approached in two stages:

Stage 1: Development and pre-testing

Stage 2: Validation

A Children's National Nutrition Survey has never been conducted in New Zealand before. This project provided the opportunity to investigate the use of dietary supplements in children, a matter that has never been investigated previously at a national level.

The pilot for the Children's National Nutrition Survey was carried out by Massey University, Auckland University of Technology and Auckland University. The data was collected by trained investigators.

4.3 Goals of the Pilot Study

The pilot study was developed as follows:

Goal 1: The development of a 24-hour recall methodology, which described and quantified the food, beverage and dietary supplement intake of children aged 1 to 14 years.

In addition to the standard multiple pass 24-hour recall method, the Ministry of Health requested that a 24-hour record assisted recall be developed. Both methods required validation, which became the second goal.

Goal 2: To develop validated 24-hour recall methods that would accurately assess group dietary intake in children 1 to 14 years and, as a result, identify the most accurate recall method for the different age groups.

The most accurate method for each group would be identified from the results. Lists of the foods consumed by children to increase the existing crop and food data-base of food composition were developed from the following resources:

- food records obtained from A.C. Nelson national supermarket sales of food categories relevant to this age group.
- consultation with various food manufacturers.

- consultation with Maori and Pacific groups.

- visits to various supermarkets and food outlets.

A direct data-capture programme for the 24-hour recall record was developed which enabled the recording of whatever the child consumed, regardless of age or ethnicity, and reflected the unique needs of the Children's National Nutrition Survey.

The questions associated with the 24-hour recall, the recall process and the 24-hour dietary recall record were tested using focus groups. Focus groups involved Maori, Pacific and European/Pakeha children aged 5 to 14 years. Members of the Kaitiaki Group and Pacific Island Food and Nutrition Action Group (PIFNAG) expert advisory groups also reviewed the questionnaires.

Goal 3: The development and pre-testing of a questionnaire to obtain information on dietary supplement use and general dietary intake patterns.

The questions from the National Nutrition Survey on dietary supplements and dietary intake patterns in adults were adapted (as necessary) for use with children. The dietary supplement questions were kept open to encourage answers. See appendix 3.

A child supplement list was developed from the supplement use questionnaire along with the questions associated with the food records obtained from the children in the food frequency development. In addition, a wide search of children's supplement products which were available in health food shops, supermarkets and other outlets was conducted and some idea of their usage obtained from the retailer.

The questions were assessed using the focus groups to ensure the appropriate use of language and to ensure cultural specificity. They were then reviewed by members of the Kaitiaki Group and PIFNAG.

Goal 4: The development of a single food frequency questionnaire (FFQ) that covered the total energy intake of Maori, Pacific and European/Pakeha children 1 to 14 years.

The FFQ needed to:

- include foods, beverages and dietary supplements commonly consumed by Maori, Pacific, and European/Pakeha children.

- estimate consumption of seasonal foods.

- be reproducible for all ethnic groups.

4.4 Sample

The study sample comprised of 137 Maori children, 143 Pacific children from all the main Pacific Island groups and 148 European/Pakeha children. Written consent was obtained from parents/caregivers of all the children who participated in this study.

4.5 Validation

To validate the 24-hour recall, and the 24-hour record assisted recall, a 4-day weighed diet record was used in children 1 to 4 years and doubly labelled water was used for children 5 to 14 years. The use of the 4-day weighed diet record in the young children was justified by the very close agreement between 4-day weighed records and doubly labelled water for children aged 1.5 to 4.5 years in the pilot of a British study (Davies et al, 1994). The doubly labelled water (DLW) method is now the ideal reference method for validating dietary question methods (Bandini et al, 1997).

Goal 5: The development of a 4-day weighed diet record to obtain a detailed description of the food and beverages consumed (including preparation, cooking method, brand name and recipe if appropriate) by weighing and recording all food and beverages eaten by the child.

The format of the 4-day diary was developed from various diaries used in other studies of children in New Zealand. The interviews took place in the home and the interviewers were of the same ethnicity as the subjects. Parents/caregivers were given electronic balances and detailed tuition on recording for the 4-day weighed diet record.

When the weighed diet intake method is used for determining the validity of other methods, it is necessary to ensure that the number of days collected is representative of the normal dietary intake to account for the variation in the frequency of the consumption of nutrients found in high concentration in few foods. Quality control procedures were put in place at each stage of the dietary assessment to limit random and systematic bias.

Energy and nutrient intake data were analysed and the standard ratio calculated for a selected number of nutrients to predict the effect of the number of diary days on the precision of each nutrient of interest. For validation of the 24-hour recall methods, the mean and standard deviation for the intakes derived from each 24-hour recall method and the weighed method were calculated. A paired t-test was used to establish whether the two means were statistically different if the data was normally distributed. The median and selected percentile points (tertiles) were used to quantify average intakes and their variability.

Ethical permission was obtained to use DLW. The subjects were dosed with the water and urine samples were collected for analysis of the isotopes for the time period studied.

4.6 Sample

The study sample comprised 183 children: 91 children (30 Maori, 31 Pacific, 30 European/Pakeha) boys and girls equally, aged 1 to 4 years to validate energy and macro-nutrient intakes from the 24-hour recall and record assisted recall methods against the 4-day weighed diet record method and 92 children (30 Maori, 32 Pacific, 30 European/Pakeha) boys and girls equally, aged 5 to 14 years, to validate energy intake from the 24-hour recall and record assisted recall methods against energy expenditure from the DLW method. Written consent was obtained from parents/caregivers of all the children participating in the study.

4.7 Pre-Testing

The pilot study was pre-tested to determine its feasibility and acceptability in both urban and rural settings and for targeted Maori/Pacific communities using 70 children from metropolitan South Auckland and 70 children from Shannon and Feilding.

The goals for the pre-testing interview phase were:

To develop the processes necessary for the successful community acceptance for

the project.

- To pilot the methodology proposed for the national survey. This included: 24-hour record, with questions on the use of dietary supplements 24-hour record assisted recall.
- The feasibility and acceptability of the collection and long-term storage of blood.

4.8 Statistical Analysis

The data was used from the pre-testing and validation studies to investigate supplement use in children aged 1 to 14 years. Due to the limited numbers in each age group, it was difficult to do any detailed statistical comparisons for nutrient intake between supplement users and non-supplement users.

5 Results: Pilot Study for the Children's National Nutrition Survey

Aim: Study 1 To investigate the use of dietary supplements in children participating in the pilot for the Children's National Nutrition Survey.

5.1 Introduction

The questionnaire in the pilot for the Children's National Nutrition Survey included questions on the use of dietary supplements. Of the total six hundred and eleven children who participated in the pre-testing and validation studies, forty two (12.8%) took supplements.

5.2 Who Took Supplements?

Forty two (12.8%) of the children in the pre-testing and validation studies took supplements. The characteristics of these children are presented in Table 2, while the distribution of supplement intake by age is shown in Table 3.

Table 2 **Characteristics of The Children Who Took Supplements**

Age (Years)	Ethnicity	Children (n)		Weight (Kg)		Height (metres)	
		Male	Female	Median	Range	Median	Range
1	1E	-	1	11.3	-	0.92	-
2	5E 1P	3	3	16.6	15.6-18.8	0.967	0.895-1.015
3	4E 2M	2	4	18	15.8-20.3	1.014	0.961-1.076
4	3E 3M	3	3	19.0	17.0-21.2	1.134	1.010-1.142
5	1E 2M	2	1	22.6	19.3-25.5	1.138	1.100-1.200
6	1E 2M 1P	3	1	26.9	20.8-34.8	1.213	1.165-1.260
7	1E 1M	2	0	33.3	30.3-36.3	1.392-	1.350-1.434
8	2E 1P	0	3	33.5	26.1-34.6	1.338	1.330-1.432
9	2E 1P	0	3	33.6	26.7-33.8	1.422	1.285-1.425
11	4E	1	3	34.6	29.5-42.4	1.479	1.452-1.582
13	1E 1M	2	1	54.1	28.6-62.8	1.630	1.394-1.753
14	1E	0	1	48.5	-	1.545	-

Notes: E=European/Pakeha, P=Pacific, M=Maori

Table 3 **Distribution of Supplement Intake**

Age (years)	Children (n)	Percentage of Each Age Group Taking Supplements %
1	28	3.5
2	33	18.1
3	29	20.6
4	30	20.0
5	25	20.0
6	33	11.4
7	30	6.6
8	28	10.7
9	29	10.3
10	31	0.0
11	40	10.0
12	27	0.0
13	25	12.0
14	40	2.5

5.3 Supplements by Age

Supplements were taken by children throughout the age range (1-14 years) of the study sample but no children 10 or 12 years took supplements. In two age bands 1 and 14 years, only one child took supplements. Of the children who took supplements, they were taken by the greatest number in the age bands 3 to 5 years (60.6%) and the least in the 7 year age band (6.6%).

5.4 Supplements by Gender

Eighteen males (42.8%) and 24 females (57.1%) took supplements. Twenty-two of the children (10 males and 12 females) were in the 1 to 5 year age band and 20 children (10 males and 10 females) were in 6 to 14 age band.

5.5 Supplements by Ethnicity

Twenty-seven (64.2%) of the children who took supplements were European/Pakeha (10 male and 17 female). Fourteen were 1 to 5 years (6 males and 8 females) and 13 were 6 to 14 years (4 males and 9 female). Twelve (28.5%) of the children who took supplements were Maori (9 male and 3 female). Seven were 1 to 5 years (4 male and 3 female) and five males were 6 to 14 years. Three (7.1%) of the children who took supplements were Pacific Islanders (1 male and 2 female). One female was 1 to 5 years of age, and one each male and female were 6 to 14 years of age.

5.6 What was Consumed?

Thirty-two (76.1%) children took vitamin and mineral supplements, 10 (23.8%) took a combination vitamin and herbal supplement and seven (16.6%) took herbal supplements. Three (11.1%) European/Pakeha children took herbal supplements, 11 (40.7%) took a combination vitamin and herbal supplement and 27 (81%) took a vitamin or a vitamin and mineral supplement. Six Maori children (50%) took herbal supplements, two (16.6%) took a combination vitamin and herbal supplement and seven (58.3%) took vitamin or a vitamin and mineral supplement. All Pacific children who took supplements (100%) took vitamin or a vitamin and mineral supplement. The most commonly consumed supplements in descending order were multi-vitamins, echinacia and vitamin C and vitamin C, followed by herbal combinations, Berocca, single nutrients, echinacia drops and Kawariki. Thirty-three of the children (78.5%) took one supplement, eight children (19%) took two supplements and one child (2.3%) took three supplements. The range of supplements consumed by the children is presented in Table 4.

Table 4 **Range of Supplements Taken by Children**

Supplement Taken	Children (n)	Percentage (%)
Multi-vitamins	13	30.9
Echinacia + Vitamin C	10	23.8
Vitamin C	8.	19
Garlic Combinations	6	14.2
Cod Liver Oil	4	9.5
Berocca	3	7.1
Haliborange	3	7.1
Calcium	1	2.3
Kawariki	1	2.3
Echinacia (drops)	1	2.3

5.7 Frequency of Intake

The majority of children (71.4%) took supplements daily. Five children (11.9%) took supplements twice daily, or two tablets per day. One child (2.3%) took a supplement once per week, two children (4.7%) took supplements three times per week, one child (2.3%) took a supplement four times per week and one child (2.3%) took a supplement occasionally.

5.8 Matched Controls

Twenty-six children from the pre-testing and validation studies were used as matched controls for the children who took supplements. The children were matched for ethnicity, gender, age and income. Not all the children who took supplements could be matched with controls from within the study because of incomplete data on income or insufficient numbers of a particular ethnic group in a specific age category.

The Australian Dietary Intakes 1990 (Truswell et al, 1990) were used to examine the nutrient intake of both the children who took supplements and their matched controls. The Food for Health Report of the Nutrition Taskforce recommended that these be adopted by New Zealand until an extensive revision of the New Zealand RDI's was conducted (Department of

Health, 1991). Both the food, and the food plus supplement intakes, were examined separately for the children who took supplements. The median and range of intakes for these nutrients for both groups were then compared to the RDI for the different age groupings.

During the analysis of the nutrients, it became apparent that children who consumed supplements did not achieve the RDI for vitamins A, B3, and E. For this reason, the intakes of these nutrients were compared between the two groups. Vitamin C was the most common nutrient consumed by children with the intake of this nutrient in excess of the RDI for most children.

The median and range of selected macro-nutrients chosen, which were predominant in supplements for children 1 to 3 years, are presented in Table 5. For the purposes of presentation, children who consumed supplements were referred to as subjects.

Table 5 **Median and Range of Selected Micro-Nutrient Intakes for Children, 1-3 Years**

	Vitamin A ug		Vitamin B3 mg		Vitamin C mg		Vitamin E mg	
RDI	300		10		30		5.0	
(Numbers of Subjects)	Median	Range	Median	Range	Median	Range	Median	Range
Subjects Food Only (13)	349	148-927	7.7	2.17-14.29	77	20-155	5.0	1.2-8.8
Subjects Food & Supplement	349	214-1722	8.5	2.1-32.7	127	40-688	5.9	3.1-13.2
Controls (12)	606	464-916	7.9	6.7-11.3	49	37-238	5.2	2.5-6.3

For children 1 to 3 years, the median intake for vitamins A and C were above the RDI for the three groups and the median intake for vitamins B3 and E were below the RDI for the three groups. The range of intake for vitamin C was above the RDI for both Food and Supplements and Controls intake. The median Food Only vitamin C intake (77mg) was greater than the Controls vitamin C intake (49mg). The median Food Only vitamin A intake (349ug) was less than the Controls vitamin A intake (606ug). The intake of vitamins B3 (7.7 & 7.9mg) and E (5.0 & 5.2mg) were similar to each other for both the children who took supplements and the Controls.

The median and range of selected macro-nutrients chosen which were predominant in supplements for children 4 to 7 years are presented in Table 6.

Table 6 **Median and Range of Selected Micro-Nutrient Intakes for Children, 4-7 Years**

	Vitamin A ug		Vitamin B3 ug		Vitamin C ug		Vitamin E mg	
RDI	350		12		30		6.0	
(Numbers of Subjects)	Median	Range	Median	Range	Median	Range	Median	Range
Subjects Food Only (15)	506	185-1722	12.9	4.6-38	113	20-245	8.5	2.6-13.3
Subjects Food & Supplement	776	285-750212	16	9.7-30.4	169	37-2312	10.9	3.7-21.1
Controls (15)	376	193-2483	12	5.8-20.1	102	22.8-247	5.7	3.2-13.3

For children 4 to 7 years of age, the median intakes for vitamins A, B3, C and E for the three groups were above the RDI. For example, the RDI for vitamin C is 30 mg, the median for the Food Only group was 113mg, the Food and Supplements group was 169mg and the Controls group was 102 mg. The range of intakes for vitamin C was also above the RDI for the Food and Supplements intake. The Food Only intakes were greater than the Controls intake in all four nutrients.

The median and range of selected micro-nutrients chosen which were predominant in supplements for boys 8 to 11 years are presented in Table 7.

Table 7 **Median and Range of Selected Micro-Nutrient Intakes for Boys, 8-11 Years**

	Vitamin A ug		Vitamin B3 mg		Vitamin C mg		Vitamin E mg	
RDI	500		15		30		8.0	
(Numbers of Subjects)	Median	Range	Median	Range	Median	Range	Median	Range
Subjects Food Only (3)	853	703-1004	17.9	16.2-19.7	104	81-127	9.7	7.4-12
Subjects Food & Supple-ment	1762	703-2822	29.5	16.2-42.8	154	81-227	14.7	7.4-22
Controls (3)	460	351-570	12.8	9.2-16.5	40	30-50	4.25	2.7-5.8

For boys 8 to 11 years of age, the median intakes for Food Only and Food and Supplements were above the RDI for all four nutrients. The median intake for vitamins A, B3 and E for the Controls were less than the RDI and the median vitamin C intake was above the RDI. For example, the RDI for vitamin C is 30mg, the median Food Only intake was 104 mg, the median Food and Supplements intake was 154mg and the median Controls intake was 40mg. The median for Food Only and Food and Supplements intakes were greater than the Control intake in all four nutrients.

The median and range of selected micro-nutrients chosen which were predominant in supplements for girls 8 to 11 years are presented in Table 8.

Table 8 **Median and Range of Selected Micro-Nutrient Intakes for Girls, 8-11 Years**

	Vitamin A ug		Vitamin B3 mg		Vitamin C mg		Vitamin E mg	
RDI	500		15		30		8.0	
(Numbers of Subjects)	Median	Range	Median	Range	Median	Range	Median	Range
Subjects Diet Only (7)	638	412-865	23.4	10-36.9	84	37-131	6.4	2.8-10
Subjects Diet & Supple-ment	638	412-865	48.4	10-86.9	537	37-1037	6.4	2.8-10
Controls (4)	602	409-796	21.3	18.4-24.2	177	111-243	12.6	9.6-15.6

For girls 8 to 11 years, the median intakes for vitamins A, B3 and C were above the RDI for all three groups, as was the Controls intake of vitamin E. The median intakes for vitamin E for Food Only and Food and Supplements children were below the RDI. The range of vitamin C intakes was above the RDI in all three groups. For example, the RDI for vitamin C is 30mg, the Food Only range was 37-131mg, the Food and Supplements range was 37-1037mg and the Controls range was 111-243mg. The median Food Only intakes were greater than the Controls for vitamins A, B3 and C but less than the median Control intake for vitamin E.

The median and range of selected micro-nutrients chosen which were predominant in supplements for boys 12 to 15 years are presented in Table 9.

Table 9 **Median and Range of Selected Micro-Nutrient Intakes for Boys, 12-15 Years**

	Vitamin A ug		Vitamin B3 ug		Vitamin C ug		Vitamin E ug	
RDI	725		20		30		10.5	
(Numbers of Subjects)	Median	Range	Median	Range	Median	Range	Median	Range
Subjects Food Only (2)	401	207-1659	15.1	8.9-21.3	95	47-317	6.6	1.4-9.5
Subjects Food & Supple-ment	375,204	207-750401	13.5	8.9-35.9	367	55-816	6.6	1.4-9.5
Controls (2)	1615	448-2782	11.4	10.5-29.6	102	46.4-160	6.8	5.4-11.8

For boys 12 to 15 years, the median intake for vitamin A for Food Only was below the RDI and the median intakes for Food and Supplements and Controls were above the RDI. For example the RDI for vitamin A is 725ug, for Food Only it was 401ug, for Food and Supplements it was 375,204ug and Controls it was 1615ug. The median intake for vitamin C was above the RDI for all three groups, and the median intakes for vitamins B3 and E were below the RDI for all three groups. The median intake for Food Only was greater than the median Controls intake for vitamin B3 and less than the Control median intake for vitamins A, C and E.

The median and range of selected micro-nutrients chosen which were predominant in supplements for girls 12 to 15 years are presented in Table 10.

Table 10 **Range of Selected Micro-Nutrients Intake for Girls, 12-15 Years**

	Vitamin A ug		Vitamin B3 mg		Vitamin C mg		Vitamin E mg	
RDI	725		15		30		9.0	
(Numbers of Subjects)	Median	Range	Median	Range	Median	Range	Median	Range
Subject Food Only (2)	2922	1513-3331	17.85	9.2-26.5	143	88-198	8.2	3.9-12.5
Subject Food & Supple-ment	3765155	1513-751518	22.7	9.2-36.2	318	163-473	13.2	3.9-22.5
No Controls (0)	-	-	-	-	-	-	-	-

For girls 12 to 15 years, the median and the range of intakes for vitamin A and C were above the RDI for both Food Only and Food and Supplements. The median intake for vitamins B3 and E for the Food Only were just below the RDI and the median intake for Food and Supplements was above the RDI. There were no controls for girls 12 to 15 years.

5.9 Vitamin C Intakes

Vitamin C intake was ranked for both those who took supplements and their matched controls.

The vitamin C quartiles for the Food Only and Controls for children 1 to 5 years are presented in Table 11.

Table 11 **Vitamin C Quartiles for Food Only and Control Children, 1-5 Years**

Vitamin C Intake	Subject	%	Controls	%
25th quartile intake 49mg	6	17.1	2	5.7
50th quartile intake 102mg	4	11.4	5	14.2
75th quartile intake 127	8	22.8	1	2.8

Vitamin C intakes for the subjects and their controls were spread throughout the quartiles.

The vitamin C quartiles for Food Plus Supplements and Controls in children 6 to 14 years are presented in Table 12.

Table 12 **Vitamin C Quartiles for Food Plus Supplement and Control Children, 6-14 Years**

Vitamin C Intake	Subjects	%	Controls	%
25th quartile intake 69mg	2	6.0	6	18.1
50th quartile intake 160mg	4	12.1	5	15.1
75th quartile intake 345mg	6	18.1	2	6.0

When the Food Plus Supplements vitamin C intakes were ranked with those of the Controls, there was an increase in the number of Controls in the 25th and 50th quartiles and a decrease in the number in the 75th quartile.

A comparison of the results from Table 11 and Table 12 suggests that the children who took supplements had a greater intake of vitamin C than their matched controls.

5.10 Socio-Economic Status

No income was reported for seven children who took supplements and this was thought to be because some interviewees were sensitive to questions on occupation and benefit status and were reluctant to answer the income questions. Five children lived in households where the total income was between $20-$30,000 annually, six with $30-$40,000, six with $40-$50,000 and 18 with $50,000 plus annually.

5.11 Recommended Dietary Intake

The mean intake of nutrients from the daily energy intakes were examined for both the children who took supplements and their controls. The median energy intake and the percentage of children who achieved the RDI with and without supplements for fat-soluble vitamins are presented in Table 13.

Table 13 **Children's Energy Intake and the Role of Supplements in Achieving the RDI for Fat-Soluble Vitamins**

	Energy Intake		Vitamin A		Vitamin E	
	Median (KJ)	Range (KJ)	Food Only %	Food & Supplement %	Food Only %	Food & Supplement %
Children 1-3 years	5,550	3,551-7,667	61.5	84.6	84.6	92.3
Children 4-7 years	8,028	4,274-13,812	66.6	80	80	86.6
Boys 8-11 years	9,460	8,924-11,264	100	100	66.6	66.6
Girls 8-11 years	8,767	6,675-12,674	42.8	57	37.5	37.5
Boys 12-15 years	10,718	5,080-16,356	50	50	50	50
Girls 12-15 years	7,967	5,582-10,348	100	100	50	100

The RDI was achieved for vitamin A by Food Only for all boys 8 to 11 years and girls 12 to 15 years. The RDI was not achieved by Food Only for any other age groups for vitamins A and E. All girls 12 to 15 years achieved the RDI for vitamin E with food plus supplements and the percentage of subjects who achieved the RDI with food plus supplements for all other groups either remained the same or increased slightly.

The percentage of subjects who achieved the RDI for B group vitamins with and without supplements are presented in Tables 14a and 14b.

Table 14a **Subjects Who Achieved the RDI for Vitamins B1, B2 and B3 With and Without Supplements**

	Vitamin B1		Vitamin B2		Vitamin B3	
	Food Only %	Food & Supplement %	Food Only %	Food & Supplement %	Food Only %	Food & Supplement %
Children 1-3 years	100	100	100	100	15.3	46.1
Children 4-7 years	93.3	100	100	100	60	80
Boys 8-11 years	100	100	66.6	100	100	100
Girls 8-11 years	100	100	85.7	100	28.5	42.8
Boys 12-15 years	50	50	50	50	50	50
Girls 12-15 years	50	100	50	100	0	100

Table 14b **Subjects Who Achieved the RDI for Vitamins B6, Folate and B12 With and Without Supplements**

	Vitamin B6		Folate		Vitamin B12	
	Food Only	Food & Supp	Food Only	Food & Supp	Food Only	Food & Supp
Children 1-3 years	100	100	100	100	92.3	100
Children 4-7 years	100	100	100	100	93.3	93.3
Boys 8-11 years	100	100	100	100	100	100
Girls 8-11 years	57.1	71.1	85.7	85.7	85.7	100
Boys 12-15 years	50	50	50	50	100	100
Girls 12-15 years	50	100	50	50	100	100

All children 1 to 3 years achieved the RDI for vitamins B1, B2, B6, folate and B12 by food alone and less than 50% of the children achieved the RDI for vitamin B3 with food and supplements. All children 4 to 7 years consumed the RDI by food alone for vitamins B2, B6 and folate. All children consumed the RDI in vitamin B1 with food plus supplements while the percentage who reached RDI for vitamins B3 and B12 with food plus supplements increased or remained unchanged. All boys 8 to 11 years realised the RDI in the B group vitamins by food alone except for vitamin B2, which was realised with food plus supplements. All girls 8 to 11 years achieved the RDI for vitamin B1 by food alone and vitamins B2 and B12 by food plus supplements. The percentage of girls in this group who attained the RDI for vitamin B6 increased, remained unchanged for folate and remained at less than 50% for vitamin B3. The RDI for all the B group vitamins was not attained by food alone nor with food plus supplements for boys 12 to 15 years. All girls 12 to 15 years reached the RDI with food alone for vitamin B12 and with food plus supplements for vitamins B1, B2, B3 and B6 but the percentage who reached the RDI for folate remained unchanged with the inclusion of supplements.

The percentage of subjects who achieved the RDI for vitamin C and selected minerals with and without supplements are presented in Tables 15a and 15b.

Table 15a **Subjects Who Achieved the RDI for Vitamin C With and Without Supplements**

	Vitamin C	
	Food Only	Food & Supp
Children 1-3 years	84.6	100
Children 4-7 years	80	86.6
Boys 8-11 years	100	100
Girls 8-11 years	100	100
Boys 12-15 years	100	100
Girls 12-15 years	100	100

Table 15b **Subjects Who Achieved the RDI for Selected Minerals With and Without Supplements**

	Calcium		Phosphorus		Iron		Zinc		Selenium	
	Food Only %	Food & Supp %	Food Only %	Food & Supp %	Food Only %	Food & Supp %	Food Only %	Food & Supp %	Food Only %	Food & Supp %
Children 1-3 years	30.7	30.7	100	100	69.2	76.9	84.6	84.6	61.8	61.8
Children 4-7 years	60	60	86.6	86.6	100	100	73.3	73.3	80	80
Boys 8-11 years	33.3	33.3	100	100	100	100	66.6	100	0	0
Girls 8-11 years	42.8	57.1	100	100	100	100	42.8	42.8	14.2	14.2
Boys 12-15 years	50	50	50	50	50	50	50	50	50	50
Girls 12-15 years	0	0	50	50	50	100	0	50	0	0

The RDI for vitamin C for all children 1 to 3 years was only achieved by food plus supplements. Phosphorus was the sole mineral achieved by Food Only for children in this age group. The percentage of children who realised the RDI for calcium, zinc and selenium remained unchanged, while that of iron increased slightly when food plus supplements were included in the total nutrient intake. All children 4 to 7 years attained the RDI for iron by food alone, but it was not attained for any other mineral or vitamin C either by food alone or with food plus supplements. All boys 8 to 11 years consumed the RDI for vitamin C, phosphorus and iron by food alone and zinc with food plus supplements, but there was no change in the percentage who consumed the RDI for calcium with food plus supplements. No boys attained the RDI for selenium with food plus supplements. All girls 8 to 11 years reached the RDI for vitamin C, phosphorus and iron by food alone. The percentage of these girls who reached the RDI by food plus supplements for calcium increased slightly while zinc and selenium both remained less than 50%. Both boys 12 to 15 years achieved the RDI for vitamin C by food alone but one boy failed to achieve the RDI for any mineral with food plus supplements. Both girls 12 to 15 years realised the RDI for vitamin C by food alone, one girl realised the RDI by food alone for phosphorus and one girl for iron by food plus supplements. One girl achieved the RDI for zinc with food plus supplements and neither girl reached the RDI for calcium and selenium by food plus supplements.

5.12 Controls

The energy intake and percentage of Controls who achieved the RDI for vitamins A, C and E are presented in Table 16.

Table 16 **Control Energy Intake and Percentage Who Achieved the RDI for Vitamins A, C and E**

(Numbers of Subjects)	Energy Intake		Vitamin A %	Vitamin C %	Vitamin E %
	Median	Range			
Children 1-3 years (6)	5,003	3,546-6,141	100	100	66.6
Children 4-7 years (12)	5,458-8,946	5,458-8,946	58.3	91.6	50
Boys 8-11 years (2)	5,866	5,495-6,237	50	100	0
Girls 8-11 years (4)	6,815	4,662-12,968	75	100	25
Boys 12-15 years (2)	1,2057	9,400-14,714	50	100	50

All children 1 to 3 years consumed the RDI for vitamins A and C but not for vitamin E. The RDI for vitamins A and E were not achieved by all the children 4 to 7 years but the RDI for vitamin C was achieved by almost all of them. Both boys 8 to 11 years realised the RDI for vitamin C, one for vitamin A and neither boy for vitamin E. All girls 8 to 11 years attained the RDI for vitamin C, three for vitamin A and one for vitamin E. Both boys 12 to 15 years reached the RDI for vitamin C and one each for vitamins A and E.

The percentage of controls who achieved the RDI in the B group vitamins are presented in Table 17.

Table 17 **The Percentage Who Achieved the RDI for Control B Group Vitamins**

(Numbers of Subjects)	Vitamin B1 %	Vitamin B2 %	Vitamin B3 %	Vitamin B6 %	Folate %	Vitamin B12 %
Children 1-3 years (6)	100	100	16.6	100	100	100
Children 4-7 years (12)	91.6	100	50	41.6	100	83.3
Boys 8-11 years (2)	0	0	50	50	0	50
Girls 8-11 years (4)	0	0	50	50	50	25
Boys 12-15 years (2)	100	0	50	100	50	100

All children 1 to 3 years attained the RDI for vitamins B1, B2, B6, folate and B12 but not for vitamin B3. All children 4 to 7 years realised the RDI for vitamins B2 and folate but not for vitamins B1, B3, B6 and B12. The RDI for vitamins B3 and B6 was consumed by less than 50% of the children in this age group. One boy 8 to 11 years consumed the RDI for vitamins B3, B6 and B12 while neither boy consumed the RDI for vitamin B1, B2 and folate. The RDI was not attained by any girls 8 to 11 years for vitamins B1 and B2. It was attained by two girls in this age band for vitamin B6 and folate and one for vitamin B12. Both boys 12 to 15 years reached the RDI for vitamins B1, B6 and B12, and one for folate but neither boy reached the RDI for vitamin B2.

The percentage of Controls who achieved RDI for selected mineral intakes are presented in Table 18.

Table 18 **The Percentage Who Achieved RDI for Controls for Selected Minerals**

(Numbers of Subjects)	Calcium %	Phosphorus %	Iron %	Zinc %	Selenium %
Children 1-3 years (6)	50	100	50	83.3	16.6
Children 4-7 years (12)	41.6	91.6	91.6	83.3	58.3
Boys 8-11 years (2)	0	50	0	0	0
Girls 8-11 years (4)	0	100	75	25	0
Boys 12-15 years (2)	0	50	100	100	0

All children 1 to 3 years and all girls 8 to 11 years consumed the RDI for phosphorus and both boys 12 to 15 years consumed the RDI for iron and zinc. The RDI for other minerals was not achieved by all children in the other age groups, but almost all children 4 to 7 years achieved the RDI for iron. The RDI for calcium and selenium was not realised by any boys and girls 8 to 11 years and boys 12 to 15 years, nor was it realised by either boy 8 to 11 years for iron and zinc.

A comparison of the children who took supplements and their control groups suggest that the children who took supplements had better diets than their controls.

6 Discussion: Pilot for the Children's Nutrition Survey

6.1 Introduction

In New Zealand, it is recognised that there is a lack of information describing the nutritional status of children and adolescents between the ages 1 to 14 years. The proposed Children's Nutrition Survey will provide this information. The pilot study for this national survey included questions on the use of dietary supplements.

6.2 Results

The pilot study was designed to have equal numbers of European/Pakeha, Maori and Pacific children. It was not a national study and this prevents direct comparisons with overseas studies but some similarities in trends can be observed. The level of supplement intake for children in the pilot study was 12.8%. Bristow et al (1997) found that supplement use among children 4 to 12 years was 16% in England and Scotland, which was higher than the present study but it also covered older children (Bristow et al, 1997). The level of supplement use in a sample of eight year old Australians, 8.5% was similar to the level of 7.1% found in the eight year olds in the present study (Margarey et al, 1987). In the NHANES studies, the levels of supplement intake for children and adolescents were separated into pre-school children and school-aged children. The present study includes school-age children up to, but not beyond, 14 years of age and precludes any similarities.

In the present study, the level of supplement intake for children 1 to 5 years of age was 52.3%. This finding was similar to that of NHANES III, where between 42-51% of children 1 to 5 years of age used supplements (Ervin et al, 1999). For children 6 to 14 years, the level of supplement use was 47.6%. This differed from the findings of Ervin et al (1999) where between 24 and 35% of school-aged children and adolescents took supplements. The present study only included children up to 14 years, whereas Ervin et al (1999) included adolescents up to 18 years of age (Ervin et al, 1999). The decline in supplement use by children 6 to 14 years in the present study was also less than that noted by Bowering and Clancy (1986).

There was a gender difference in supplement use for children 1 to 5 years, ten males (45.4%) and 12 females (54.5%) who took supplements in this study. For children 6 to 14 years, 10 males and females (50% each) took supplements. This finding differs from that of Bowering and Clancy (1986) where gender differences did not become apparent until adolescence (Bowering and Clancy, 1986).

6.3 Socio-Economic Status

Eighteen of the children (42.8%), in the present study who took supplements lived in households with the highest total income ($50,000 plus) and 88.8% of these children's parents had received further education and qualifications. The majority of the children who took supplements in the present study were European/Pakeha and 77.7% of the children in the highest total income group were European/Pakeha. These socio-economic characteristics – total family income, further education, and being European/Pakeha – have been found to be predictors of supplement use in overseas studies (Dorant et al, 1993, Bristow et al, 1997, Ervin et al, 1999). The income status not reported for seven children was thought to be because of sensitivity to occupation and benefit status. Those people who chose not to answer the questions on occupation and income were likely to be on a benefit of some kind. Other studies support the finding that fewer children in the lower socio-economic groups were given supplements (Block et al, 1990; Ervin et al, 1999).

6.4 What Was Consumed?

Vitamin C alone, or in combination with herbals and other vitamins, were the most common supplements consumed in this study. Vitamin C and multi-vitamins were the most commonly consumed supplements in the United States (Bowering and Clancy, 1986; Ervin et al, 1999) and multi-vitamins were the most commonly consumed supplement in Scotland and England (Bristow et al, 1997). Vitamin C and echinacia was the most common herbal supplement consumed, followed by garlic and garlic combinations. In the United States, garlic and echinacia were found to be among the most commonly reported herbals used and garlic and echinacia were among the top selling herbs in 1995 and 1997 (Radimer, 2000). These findings suggest that the use of herbal supplements alone, or in combination with vitamins and minerals, are part of an accepted supplement programme.

The pattern of supplement use in the pilot study was similar to those found in other studies with most children taking their supplement on a daily basis (71.4%). In the pilot study, 4.7% of the children used supplements three times a week and 2.3% used supplements on a weekly basis.

6.5 Impact of Supplements on Nutrient Intake

A greater percentage of children met the RDI for nutrients among the children who supplemented their food intake than those who did not supplement their food intake in this study. For example, this occurred with vitamins A, B1 and B2, a similar finding to an earlier study (Cook and Payne, 1979). This finding suggests that the children in the present study consumed better diets than those of the matched controls and also supports the suggestion that regular supplement users obtained substantial intakes from some nutrients that probably contributed to an already adequate intake for some (Bowering and Clancy, 1986).

There were children who were at risk of nutritional deficiencies in the pilot study. For example, the vitamin B3 requirements were met by less than half the children who took supplements in the age band 1 to 3 years, less than half the girls in the age band 8 to 11 years and half the boys in the age band 12 to 15 years. Among the children who did not consume supplements, only half in each age band achieved the RDI for vitamin B3 except for the age band 1 to 3 years where only 16.6% achieved the RDI. A similar situation existed with mineral intakes. For example, there was not one age band of children who did, or did not, consume supplements, where all the children reached the RDI for calcium. The age band where the greatest number of children reached the RDI for calcium with supplements was 4 to 7 years (60%), while among the Controls the greatest number of children realised the RDI in the 1 to 3 years age band (50%). There were several age bands in both groups where no children consumed the RDI for selenium.

There is evidence that the consumption of supplements enabled some children to achieve the RDI in the pilot study. There was an increase in the percentage of boys in the age band 8 to 11 years who achieved the RDI for vitamin B2 from 66.6%-100% and an increase in the percentage of girls in the age band 8 to 11 years who achieved the RDI for vitamin B3 from 28.5-42.8%. However, there are also several examples where the percentage of children who realised the RDI remained unchanged among the children who consumed supplements. There was no change in the percentage of boys and girls who achieved the RDI for vitamin E in the age bands 8 to 11 years and 12 to 15 years and no change for all the B group vitamins for boys in the age band 12 to 15 years. These findings support the suggestion that the vitamins people choose to take are often not the ones inadequate in their diet (Truswell et al, 1990). A similar situation existed with mineral intakes among children who consumed supplements. The percentage of children who achieved the RDI for zinc remained unchanged for children in the age band 1 to 3 years, 4 to 7 years, and for girls in the age band 8 to 11 years and boys in the age band 12 to 15 years.

7 Methods Two: Survey of Elite Athletes and Supplement Use

Aim: Study 2 To investigate the use of dietary supplements in potentially elite athletes from two large co-educational decile 10 North Shore secondary schools.

7.1 Subjects

Year 9 and 10 students who were identified as having potential in their respective sports by their school's sports administrators were recruited from two large co-educational decile 10, North Shore secondary schools. The students were from Rangitoto College and Takapuna Grammar School. Each student was approached individually and asked to complete the questionnaire. Overall, 100 students were selected. Of these, 33 were female and 67 were male. The students signed consent forms agreeing to participate in the study. No children declined to participate.

The students from Rangitoto College were selected through the Sports Development Programme. The sporting criteria for selection to this programme involved a number of criteria: having achieved at least North Harbour level in one sport, or considered to have the potential to do so in the near future; be totally committed to training: and to be subject to fitness training throughout the year. Takapuna Grammar did not have a selection criteria for their students, but those who demonstrated ability, enthusiasm, and commitment to training in their chosen sport were selected.

7.2 Questionnaire

All students who agreed to participate in the study were visited by the researcher. Each student completed a written questionnaire to provide demographic data and information on sport played, dietary supplements taken, the frequency of intake of dietary supplements, the duration of intake of dietary supplements, the source of information of dietary supplements, the person(s) who suggested intake of dietary supplements and how dietary supplements assisted in their performance. The students were given the questionnaires and consent forms to take home to complete. They were collected from the students within two days of being issued.

7.3 Statistical Analysis

An attempt was made to submit the results to statistical analysis. However, given the small numbers of participants in each sport, the statistical results were not generally valid. Descriptive data is presented here.

7.4 Ethical Approval

The study was approved by the Human Ethics Committee of Massey University, Albany. The consent form is presented in Appendix 6.

8 Results: Elite Athletes and Supplement Use

8.1 Profile of the Athletes

There were 100 athletes involved in the study, 50 from each school: 67 were male and 33 were female. Fifty-five males (55%) were European/Pakeha, six males (6%) were Maori, five males (5%) were Pacific Islanders and one male (1%) was Chinese. Twenty-six females (26%) were European/Pakeha, three females (3%) were Maori, two females (2%) were Pacific Islanders and two females (2%) were Chinese. The mean age of the athletes was 13.5 years.

The age, sex and ethnicity of the athletes surveyed are presented in Table 10.

Table 19 **Age, Sex and Ethnicity of Athletes**

Athletes	Male	Ethnicity				%	Female	Ethnicity				%
		E	M	P	C			E	M	P	C	
12 years	9	7	1	0	1	13.4	5	4	1	0	0	15.1
13 years	36	33	2	1	0	53.7	22	18	1	1	2	66.6
14 years	18	13	3	2	0	26.8	4	2	1	1	0	12.1
15 years	4	2		2		5.9	2	2				6

Notes: E=European/Pakeha, M=Maori, P=Pacific Islander, C=Chinese

8.2 Sports Played

Twenty-eight sporting codes were represented by the 100 athletes. Many students, 20 male and six females, identified two sports played at this level. One male identified three sports played at this level. The following sports had both male and female participants: athletics, cricket, hockey, soccer, swimming, tennis, and waterpolo.

Some sports had all female participants in the survey: badminton, ballet, cross country, dancesport, kickboxing, netball, and volleyball. Other sports had all male participants: basketball, BMX, cycling, motorcross, diving, golf, judo, rowing, rugby, sailing, skateboarding, skiing, windsurfing.

The sports played by the athletes surveyed are presented in Table 20.

Table 20 **Sports Played by Athletes**

Sporting Code	Male	Female
Athletics	5	1
Badminton		3
Ballet		3
Basketball	4	
BMX	1	
Cricket	8	1
Cross Country		3
Dancesport		4
Diving	1	
Golf	2	
Hockey	6	2
Judo	1	
Karate	3	
Kick Boxing		1
Motorcross	1	
Netball		7
Rowing	3	
Rugby	15	
Sailing	1	
Skateboarding	1	
Skiing	1	
Soccer	19	2
Swimming	4	3
Tennis	9	4
Volleyball		1
Waterpolo	2	4
Windsurfing	1	

8.3 Duration of Sports Played by Athletes

Most athletes had played their respective sports from one to four years. Fifteen athletes had participated for more than eight years in the following sports; ballet, basketball, cricket, karate, rugby, soccer and tennis. Five athletes had participated for less than one year in the following sports; cycling, diving, ice hockey, rowing and hockey. The length of time the athletes had been involved their respective sports is presented in Table 21.

Table 21 **Duration of Sports Played by Athletes**

	Years											
Sporting Code	N/given	<1	1	2	3	4	5	6	7	8	9	10
Athletics			3	1	1	1						
Badminton	1		1	2								
Ballet	1									1		1
Basketball				1		1			1	1		
BMX					1							
Cricket	1		2	1	1				1	1		
Cross Country			1			1	1					
Cycling		1										
Dancesport				2		2						
Diving		1										
Golf				1					1			
Hockey			1			3			1			
Ice Hockey		1										
Inline Hockey					1							
Judo						4						
Karate			1	1						1		
Kick Boxing			1									
Motorcross					1							
Netball				2	2	4						
Rowing	1	1	1									
Rugby		1	4	2	2	1	2				2	1
Sailing												1
Skateboarding				1								
Skiing							1					
Soccer	1		1	3	3	2	1	2		7		1
Swimming				2	3	1			1			
Tennis			2	1	1	1	2	2	2	2		
Volleyball			1									
Waterpolo				3	2	1						
Windsurfing				1								

Notes: N/given = not given, <1 = less than 1

8.4 Dietary Supplements

An extensive range of dietary supplements were taken. These were grouped together under seven headings. Energy products were defined as foods or beverages whose main nutrients were glucose, sucrose, and dextrose. "Others" included premium whey drink, fast burner, spirilina, thermophase and creatine.

Twenty-eight female athletes (84.8%) and 42 male athletes (62.6%) took dietary supplements.

Energy products were the most popular dietary supplement, taken by 43.1% of the athletes. Vitamins were taken by 28.7% of the athletes and recovery products were taken by 7.1% of the athletes. Herbals, meal replacers and "Others" were the least popular dietary supplements and together made up 12.2% of the supplements consumed.

8.5 Multiple Use of Dietary Supplements

Of the 70 athletes who took dietary supplements, 37 (52.8%) took more than one product. Seven males and 14 females (30%) took two products. Seven males and four females (15.7%) took three products. One male and three females (5.7%) took four products. One male (1.4%) took five products.

The range of dietary supplements consumed is presented in Table 22.

Table 22 **Dietary Supplements Taken By Athletes**

Dietary Supplement	Male	Female
Vitamins	23	17
Minerals	1	6
Herbals	3	3
Energy Products	35	25
Recovery Products	8	2
Meal Replacements	3	3
Other	2	3
	45	39

8.6 Vitamin and Mineral Intake

Multi-vitamins and B group vitamins were the most frequently consumed vitamins with males, followed by vitamin C. Only a few males took minerals. Vitamin C was the most frequently consumed vitamin by females, followed by B group vitamins and multi-vitamins. Minerals were also only taken by a few females.

The vitamin and mineral intake of the athletes is presented in Table 23.

Table 23 **Details of Vitamin and Mineral Supplements Taken**

Product	Male	Female
Vitamin A	1	1
B Group Vitamins	10	7
Vitamin C	6	11
Multi-vitamins	12	6
Fish Oil		2
Omega	1	
Calcium		1
Iron	2	3
Zinc	1	2
	33	34

8.7 Frequency of Intake of Dietary Supplements

Athletes may have taken more than one dietary supplement on more than one occasion. Not all athletes indicated how frequently they took their particular supplements. Vitamins were taken most frequently, on a daily basis. A few athletes took vitamins most days, twice per week, once per week, occasionally and rarely. Minerals were taken most on a daily basis, and one athlete took them occasionally. The few herbals taken were either daily, on a weekly basis, or rarely. Energy products were taken most occasionally, twice per week, once per week or rarely with fewer numbers taking them daily or most days. Recovery products were taken daily, most days or occasionally. Meal replacements were taken daily, most days, once per week or occasionally by few athletes. Other products were taken daily, with fewer taken most days, and twice per week.

The frequency of dietary supplement intake, grouped under seven headings, is presented in Table 24.

Table 24 **Frequency of Intake of Dietary Supplements**

Product	Daily	M/Days	2/week	1/week	Occ	Rarely	N/Given
Vitamins	28	8	4	3	5	6	15
Minerals	6				1		
Herbals	3			2		1	6
Energy Products	5	9	10	11	26	13	23
Recovery Products	2	2			1		6
Meal Replacements	3	1		2	1		
Other	6	1	1				

Notes: M/Days = most days, 2/week = twice per week, 1/week = once per week, occ = occasionally, N/Given = not given

8.8 Frequency of Intake of Vitamins and Minerals

Athletes who took vitamin and mineral supplements usually took them daily. Few athletes took them on an irregular basis. The frequency of the intake of vitamins and minerals is presented in Table 25.

Table 25 **Frequency of Intake of Vitamins and Minerals**

Product	Daily	M/Days	2/Week	1/Week	Occ	Rarely	N/Given
Vitamin A	2						
B Group Vitamins	7	1		1	2	3	
Vitamin C	7	3	2	1		3	1
Multi-vitamins	13	4	2	1	3		
Fish Oil	2						
Omega	1						
Calcium	1						
Iron	4				1		
Zinc	2	1					

Notes: M/Days = most days, 2/week = twice per week, 1/week = once per week, occ = occasionally, N/Given = not given

8.9 Duration of Dietary Supplement Intake

Many athletes took several supplements for different periods of time. These athletes could be included more than once. The majority of athletes who consumed vitamins had taken them for more than 24 months. All other time periods had fewer numbers of athletes. The few athletes who took minerals had taken them for 3-6 months, 9-12 months, or more than 24 months. Herbals had either been taken in the last six months or for more than 24 months. Energy products had been taken consistently throughout all time periods, with the greatest number taking them for more than 24 months. The few athletes who took recovery products had taken them for, 3-6 months, 9-12 months, 12-15 months, 18-24 months or more than 24 months. The athletes who took meal replacers had taken them for, 1-3 months, 6-9 months, 9-12 months, 12 –15 months, and 15-18 months. The athletes who took "Others" took them for, 1-3 months, 9-12 months, 12-15 months, and 18-24 months.

The duration of dietary supplement intake is presented in Table 26.

Table 26 **Duration of Dietary Supplement Intake**

Product	1-3 mths	3-6 mths	6-9 mths	9-12 mths	12-15 mths	15-18 mths	18-24 mths	24 plus mths
Vitamins	11	9	1	6	6	2	3	18
Minerals	1	2		2	1			2
Herbals	1	1					1	1
Energy Products	13	6	4	10	7	2	4	17
Recovery Products		2		2	2		2	1
Meal Replacers	1		2	1	1	1		
Others	3			1	3		1	

Notes: "Others" included: spirilina, premium whey drink, creatine and thermophase.

8.10 Duration of Vitamin and Mineral Intake

Not all the athletes answered this question. Multi-vitamins were consumed most consistently by athletes for more than 12 months. There was less consistency in the consumption of all other vitamins and minerals.

The duration of vitamin and mineral intake is presented in Table 27.

Table 27 **Duration of Vitamin and Mineral Intake**

Product	1-3 mths	3-6 mths	6-9 mths	9-12 mths	12-15 mths	15-18 mths	18-24 mths	24plus mths
Vitamin A	1	1						
B Group Vitamins	3	4		2	4			1
Vitamin C	2	2		2			2	8
Multi-vitamins	5	2	1	2	2	2	1	7
Fish Oil	1							
Calcium		1						
Iron	1			1	1			1
Zinc		1	1	1				1

8.11 Source of Information in Taking Supplements

Athletes could indicate more than one choice. Parents, coach and friends together contributed the most important (74.8%) sources of information for taking dietary supplements. Parents and coaches combined contributed almost 60% to the source of information about dietary supplements. Nutritionists (9.4%), sports magazines (3.4%) and "Other" (11.2%) were all minor sources of influence for information about taking dietary supplements. These last three categories contributed almost 25% of the source of information for taking supplement.

The source of information for taking dietary supplements is presented in Table 28.

Table 28 **Source of Information for Taking Supplements**

Dietary Information	%
Parents	35.8
Coach	23.7
Friends	15.3
Other	10.2
Nutritionist	8.9
Sports Magazines	5.7

Other sources of information included: television, doctor, PE teacher, sponsor, chiropractor, manager, homeopath, personal trainer, sporting cousins, pharmacy medical leaflets, and self. One athlete commented that her coach told her secrets about how to stay healthy/thin. This included eating sour fruits after meals to soak up fat.

8.12 Who Suggested Taking Supplements?

Athletes could indicate more than one source for who suggested taking dietary supplements. Parents, coaches and friends together made up 77.5% of those who suggested taking dietary supplements. Parents and coach combined made up 66.3% of those who suggested taking dietary supplements. Nutritionists (9.4%), sports magazines (3.4%) and "Other" (11.2%) were all minor sources of influence for suggesting the consumption of dietary supplements. These last three categories made up almost 25% of those who suggested taking dietary supplements.

The details of who suggested taking dietary supplements is presented in Table 29.

Table 29 **Who Suggested Taking Supplements?**

Taking Supplements	%
Parents	41.3
Coach	25
Other	11.2
Friends	10.3
Nutritionist	9.4
Sports Magazines	3.4

Notes: "Other" included: self, homeopath, chiropractor, manager, television, and gym instructor.

8.13 How Dietary Supplements Help Performance

An extensive range of reasons was given for the perceived benefits of dietary supplements to performance. The complete range of reasons is included in the appendix. Ten groupings of reasons are highlighted here.

Table 30 **How Dietary Supplements Help Performances**

Performance Enhancement	Explanation
Energy	"My energy doesn't burn out"
Fitness	"Improve my fitness"
Tiredness	"Don't get tired quickly"
Strength	"Help me feel stronger"
Health	"Prevents colds"
Immunity	"Boost immune system"
Food Intake	"Energy to perform, without too much food"
Dietary Inadequacy	"Keep vitamin levels up, don't eat red meat"
Hyperactivity	"You run around more"
Well Being	"Feel better"

9 Discussion

9.1 Introduction

In this study, the dietary supplement intake of year 9 and 10 athletes identified as having potential in their respective sports from two New Zealand secondary schools was surveyed. No previous research of this type has been carried out in New Zealand in this area.

9.2 Supplementation Practices of Athletes

Burke and Read (1993) note that few formal studies have been conducted solely on the use of nutritional supplements by athletes and that most information about supplementation practices of athletes was provided, in brief, in surveys of dietary intake of athletic populations. This was also true for the dietary supplement practice reports of high school athletes. In comparing the results of the present study with those of other high school athletic populations, and those of the general population, there were several methodological differences that had to be taken onto account. First, there were differences between surveys and the present study with respect to the definition of dietary supplements. Moffat (1984) limited supplements to vitamin and mineral preparations, whereas the present study included a much broader range of supplements. The definition of "use", and characterisation of "regular", "irregular" and "occasional use" may have also differed. Finally, the method of collecting information could also influence results. For example, a questionnaire versus a written record of dietary intake (Burke and Read, 1993) extract different sorts of information. The present study looked at dietary supplement use in high school athletes over a broad time period, whereas other studies may have identified "snap shot" use of dietary supplement use as part of a wider study of these athletes.

9.3 Use of Dietary Supplements

The present study involved a self-selected sample of athletes and found that 70% consumed dietary supplements. Of these athletes, 60% were males and 40% were females. Fewer males than females took dietary supplements as the ratio of males to females was 1:2. A number of studies have investigated the vitamin and mineral supplement intake in high school athletes. They ranged from small (13) to quite large (943) numbers. The range of supplement use was 23-55% (Moffat, 1984; Parr et al, 1984; Douglas and Douglas, 1984; Krowchuk et al, 1989; Sobal and Marquart, 1994a). With such a wide range in numbers, there was little consensus about the prevalence of use of dietary supplements by high school athletes. One study reported 20-25% of adolescents used supplements which suggested that adolescent athletes may be greater consumers of dietary supplements than other groups (Sobal and Muncie, 1988). However, two adolescent dietary supplement studies reported a higher rate of supplement use than the above study. A survey of 245 Tasmanian grade 11 and 12 students found that 33% used vitamin supplements (Henderson and Woodward, 1991). The second study of 568 urban high school males found that 45.5% took dietary supplements (Fleischer and Read, 1982). In the above two studies, dietary supplements included vitamins, minerals and protein supplements but not energy products, herbals, recovery and replacement products which were also included in the present study. When only vitamins and minerals were included in this study, they were used by 47% of the athletes, which was within the range of those studies cited. Approximately 40% of the current US population consumed dietary supplements, which was also within the range of the studies cited (Ervin et al, 1999). This was a much larger figure than the 28% of adult New Zealanders who regularly consumed vitamin and mineral supplements (Russell et al, 1999).

There was also variation in the use of supplements between the different levels of athletes. A review of vitamin and mineral use amongst athletes by Sobal and Marquart (1994b) found that the use of dietary supplements was higher among elite athletes than college athletes and high school athletes. In 21 studies of elite athletes, mean supplement use rate was 59%, for 12 studies of college athletes it was 43%, and for 5 studies of high school athletes it was 47% (Sobal and Marquart, 1994b). Other literature has also found that elite athletes were more likely to use supplements (Nieman et al, 1989).

9.4 Age

The athletes in the present study were younger than those in the studies cited. The rate of use of dietary supplements in relation to an age range of 13 to 18 years was not commented on in other studies (Douglas and Douglas, 1984; Krowchuk et al, 1989; Sobal and Marquart, 1994).

9.5 Gender

In this study, 62.5% of the males and 84.8% of the females took dietary supplements. These results were very high for both genders and appears to be at odds with the suggestion that the average prevalence of dietary supplements use in athletes was not much greater than that of the general public (Burke and Read, 1993). A higher rate of dietary supplement use by females than males was consistent with the general population and adolescent literature (Sobal and Muncie, 1988; Ervin at al, 1999). The female gender role was more closely tied to food and nutrition, and supplement use appeared to be an expression of these health concerns and may also have influenced their use in association with athletes (Sobal and Marquart, 1994a.). The greater use of dietary supplements by females in the present study differs from that of other high school athletes. One American study reported that the prevalence of supplement consumption did not differ significantly by gender or grade in school (Sobal and Marquart, 1994a). There was also a lack of gender difference in a Tasmanian study of adolescents, consistent with other Australian studies (Henderson and Woodward, 1991). In some studies, there was no analysis for gender differences in high school athletes dietary supplement use (Douglas and Douglas, 1984; Parr et al, 1984; Krowchuk et al, 1989).

One study reported that adolescent males who participated in sport took dietary supplements more often than boys not participating in sport and suggested that athletic participation may have been the motivation for their consumption (Fleischer and Read, 1982). Another study suggested that among athletes, with the emphasis on athletic performance and competition traditionally related with the male gender role, supplement use may not follow the gender patterns of the general population (Sobal and Marquart, 1994a). This study provided support for the very high intake of dietary supplements by males in the present study. It was further suggested that athletes who aspired to compete at higher levels of sport may have been more likely to use supplements as ergogenic aids because of their athletic ambitions (Sobal and Marquart, 1994a). The high use of supplements in girls in the present study was supported by one study that found that until 13 years of age the use of dietary supplements in children was similar and then it increased for girls (Bowering and Clancy, 1986).

9.6 Sport

Athletes in the present study participated in a wide variety of sports. Given the sample size and the range of sports played, it was not possible to investigate supplement use by sport. Soccer had the largest group of participants, (21) and three took dietary supplements. Fifteen boys played rugby and four took supplements and 13 athletes played tennis with three taking supplements. All other sports had fewer than 10 participants.

Other literature found that considerable variation in supplement use existed by type of sport, precluding any strong conclusions about supplement use by sport (Grandjean, 1983; Parr et al, 1988; Schultz, 1988). Supplement use appeared to be most prevalent in sports that emphasised muscle size, such as weight lifting and body building (Sobal and Marquart, 1994b). These sports were not represented in the present study.

9.7 Type and Amounts of Supplements Used

There were no studies that gave details of dietary supplement intake of high school athletes in the United States, other than vitamins and minerals. One study reported that 19% of high school athletes took vitamins and minerals regularly, while 36% took them occasionally (Douglas and Douglas, 1984). In another study 38%, of athletes took vitamin and mineral supplements (Sobal and Marquart, 1994a). In the present study, 47% of athletes took vitamin and mineral supplements.

It was discovered in the research reported here that energy products are the most commonly consumed dietary supplement, taken by 43.1% of the athletes. The next most commonly consumed supplements are vitamins (28.7%). Multi-vitamins were the most commonly consumed vitamins, followed by B group vitamins and vitamin C. Minerals were consumed by 8.3 % of the athletes. Iron was the most common mineral consumed, followed by zinc and calcium.

General population studies in the United States have found that in both adults and children, multi-vitamins and vitamin C were the most commonly consumed vitamins (Bowering and Clancy, 1986; Block et al, 1988; Moss et al, 1989). Among New Zealand adults, multi-vitamins and B complex were the most commonly consumed vitamins, and vitamin C was the most commonly consumed single vitamin (Russell et al, 1999). These conclusions support the findings of the present study. However, other studies have found that vitamin C was consumed more than multi-vitamins (Fleischer and Read, 1982; Henderson and Woodward, 1991). In this study vitamin C, was taken by more females than males which is the opposite from the findings of another New Zealand study (Russell et al, 1999). This New Zealand study also found that vitamin C use was greatest in the 15 to 18 years age group, the age of some of the athletes in the present study (Russell et al 1999).

Iron was taken more by females than males in this study. A further study also reported that iron was consumed by more females than males (Sobal and Marquart, 1994a). Iron was the most commonly consumed mineral in both general adult and children's studies (Moss et al, 1989; Park et al, 1991). These results support the findings of the present study.

Those athletes who took dietary supplements in this study, frequently took more than one supplement on a daily basis. One study reported that most adolescents took more than one supplement (Fleischer and Read, 1982). Another study found that most adolescents consumed only a single multi-vitamin tablet (Sobal and Marquart, 1994a). Other studies reported the single use of supplements by both adults and children (Cook and Payne, 1979; Bowering and Clancy, 1986; Moss et al, 1989; Ervin et al, 1999). Sobal and Marquart (1994a) also reported that neither frequency nor duration of intake differed by gender (Sobal and Marquart, 1994a). The daily intake of supplements by athletes in the present study was consistent with the findings of general population studies (Moss et al, 1989). Few of the athletes in the present study consumed their supplements rarely which contrasts with a study where 61% of the athletes took supplements rarely (Sobal and Marquart, 1994).

9.8 The Reasons for Dietary Supplement Use

Athletes were asked to state how they thought dietary supplements helped them in their performance in the present study and a wide range of answers were given. As athletes were not asked to provide a separate explanation for each type of supplement taken, only general comments can be made. The reasons given for helping with performance are in broad agreement with the range of reasons why athletes in general consume dietary supplements: performance enhancement, prevention of illness, compensation for inadequate diet, providing extra energy, and meeting the needs from high levels of activity (see Sobal and Marquart, 1994b). Reasons for helping with performance were also in agreement with those of adolescent dietary supplement intake literature: concern for health, to compensate for dietary inadequacy and to give energy (see Fleischer and Read, 1982; Woodward and Henderson, 1991).

9.9 Source of Dietary Supplement Information

Although adolescence is seen as a time of striving for independence, it has been suggested that adolescents are susceptible to external influences in the use of food supplements and maternal influence, peer supplementation practices, coaches and/or teachers were statistically significant in the use of dietary supplements (Fleischer and Read, 1982). Another study suggested that parents were role models for adolescents supplement consumption (Sobal and Muncie, 1988). In other American studies, parents were also perceived as the best source of nutrition knowledge (Douglas and Douglas, 1984; Thomsen et al, 1987; Elridge and Sheenan, 1994). This was also true for Australian studies (Worsley and Crawford, 1984; Henderson and Woodward, 1991). Family and health-oriented influences were more important in the decision to use supplements than coaches and sports performances (Sobal and Marquart, 1994a). Parents were the major source of information about nutrition in this study, which was consistent with the literature cited. Parents were also the most important source for suggesting taking supplements. Coaches and friends were the second and third sources respectively.

Overall, the results of the present study indicate a very high rate of use of a range of dietary supplements in both male and female secondary school athletes. The limitations of this study include the small sample number, the self-report nature of the questionnaire, and the self-selection of the sports represented in the sample. Also, both secondary schools used in this study were from the same large urban area.

Dietary supplements are often used by athletes and the general population as nutritional support, as well as by athletes to improve physical performance. There are risks associated with nutritional supplements, such as vitamins and minerals, but other ergogenic aids such as steroids, amphetamines, and growth hormone present even greater risks for adolescents involved in athletics. One study cautioned that the "stepping stone" pattern in other types of substance abuse may also occur for ergogenic aids and that athletes who experimented with nutritional supplements in an attempt to enhance performance may advance to more dangerous substances like steroids (Sobal and Marquart, 1994a).

9.10 Comments on the Two Studies

In the pilot for the Children's Nutrition Survey, the level of supplement intake in children 12 to 14 years was 8.0 %, much lower than the 70% found in the athletes' study. In the athletes' study, a wider range of supplements were recorded than in the pilot study. In both studies, the level of intake by girls was higher than that for the boys. Direct comparisons between the levels of supplement intake cannot be made because the children in this study were self-selected whereas those in the athletes' study were specifically targeted. However, the difference between the two groups is marked. A comparison of the nutrient intakes or reasons for the use of supplements by the two groups was also not possible as nutrient intake was not examined in the athletes' study and the reasons for use were not examined in the pilot study. The athletes' study found that athletes consumed their supplements regularly as part of a well-established supplement programme. Supplements were also consumed regularly by children in the pilot study.

9.11 Suggestions for Further Research

Further study in this area could investigate the use of dietary supplements in children 12 to 14 years, including those identified as having potential in their respective sports, to verify the results of this study. Such a study could determine the reasons for use in the two groups, the contribution dietary supplements make to total dietary/nutrient intake and the impact of dietary supplements on health status and sports performance. This would enable recommendations to be made both these groups of children.

10 Conclusion

The New Zealand Food and Nutrition in Guidelines for Healthy Children (Ministry of Health, 1993) note that children are one of the most vulnerable groups in our society with many special dietary needs. Childhood is seen as a time of change between the infant and the adult diets and appropriate nutrition during the childhood years is essential for the maintenance of growth and good health (Ministry of Health, 1993). Most people, including children and adolescents, should be able to obtain adequate nutrients from a wide variety of foods, and vitamin and mineral supplementation are only appropriate in specific circumstances. However, there are people who choose to consume supplements and encourage such behaviour in their children. Older children, in this case teenagers, may also choose to take supplements and to influence their peers for a variety of reasons and in a variety of ways. Supplement use among adults was examined in the 1997 National Nutrition Survey but no previous research has examined the dietary supplement intake of children living in New Zealand. This study identified the levels of supplement intake in children 1 to 14 years who were targeted for the pilot study of the Children's Nutrition Survey, and a small group of years 9 and 10 North Shore secondary school pupils, who were identified as having potential in their respective sports.

The results from both studies revealed interesting findings. However, as neither the pilot study (n=611), nor the athletes' study (n=100), were national representative samples for their specific age groups, it is necessary to validate these results with further research using a random population-based sample.

The pilot for the Children's Nutrition Survey found that 12.8 % of children 1 to 14 years consumed supplements. Of the children who took supplements, the intake was highest in children 1 to 5 years (52.3%) and in children 6 to 14 years reduced (47.6%). Compared to the study of the secondary school athletes, where 70% took a wide variety of supplements, the level of supplement use in the pilot study for the children 12 to 14 years was 8%.

The pilot study has demonstrated that the specific nutritional requirements of the Ministry of Health can be achieved. It found that Maori and Pacific children, although over-represented in this survey, were less likely to consume supplements than European/Pakeha children. The respondents were not asked the reasons for supplement use and this aspect should be an important part of a future national survey to establish why New Zealand children are given dietary supplements. The overseas literature shows that while there are reasons in common among different countries, there are also important differences. The reasons in common include the fact that the children most likely to take supplements are those from White, higher socio-economic backgrounds whose parents had received further education. The differences include the fact that in the United States, supplements were taken by children to improve behaviour, for eating problems and poor appetites. In England and Scotland, cultural background influenced supplement use among Afro-Carribean and Asian children and in the Netherlands, vitamin D was taken because of limited exposure to sunshine during the winter months and fluoride was taken to help prevent dental caries.

The children in the pilot study who consumed supplements were more likely to achieve the RDI for the nutrients specified than those who did not consume supplements. However, there were children among both groups who were at risk of nutritional deficiencies. This was most notable for mineral intakes. The RDI for calcium was not achieved by all children in any one age band, and in several age bands, no children achieved the RDI for calcium. This nutrient is of particular concern because of its importance for bone growth throughout childhood. There were also several age bands where no children achieved the RDI for selenium. The RDI for vitamins B3 and E was not achieved by many of the children. These findings highlight the need for educational programmes to target these children, and their parents, in order to demonstrate how to eat a "well balanced" diet. Whether this is the most effective means of ensuring a balanced diet is still an issue. A lot of influences media messages, body image, peer influences – all contribute to the understanding of what is necessary from food, and what is consumed and how. In spite of these influences, the research evidence is clear. Adequate nutrition for growth and health can be obtained from a wide variety of foods and, as discussed previously, supplements that contain single or a few nutrients are very unlikely to fulfil all requirements.

In recent years, children have been targeted by dietary supplement manufacturers with advertising campaigns that promote their products. Such campaigns only offer the manufacturers viewpoint, and the nature of the advertising is often a product of extensive market research on what images and messages will be most effective in selling a particular product. This is not an objective basis for informed decisions to occur, especially in groups who are susceptible to advertising. These viewpoints have been countered, in part, by the marketing promotions of the large producer boards who have emphasised the essential nutrients that their products contain. For example, the Beef and Lamb Marketing Bureau's "Einstein" advertisements demonstrate a more appropriate message, albeit a self-interested one.

The second group studied were elite athletes at two secondary schools. This study found that at 12 to 14 years many athletes have already participated in a particular sport for several years and that some athletes also had established patterns of dietary supplementation. As indicated earlier, different dietary supplement patterns existed among different groups of athletes but overall the level of supplementation was high. This finding raises some important questions. For example, future research (following on from the present findings) among elite children or adolescent athletes might include examining nutrient intake and their reasons for supplementation, particularly across a of a range of sports to determine if, and how, their chosen sport influences their supplement use. This could be investigated using a scale similar to that of Levy and Schucker (1987) who divided dietary supplement users into groups on the basis of type and the amount of nutrient intake from supplements to assist in identifying the different motivations for the use of dietary supplements.

Athletes have been targeted as a significant consumer group for dietary supplements. Children are encouraged to try and to use products introduced by promotional activities at sponsored sporting activities. These products have "status" appeal among their peers. Children who are athletes experience the same desire to win as do older athletes and are fearful that their competitors may gain a decisive edge. They are also just as vulnerable as older athletes to advertising that stresses the perceived benefits of dietary supplements.

This study supports the findings from the overseas literature that adolescent athletes are encouraged to consume supplements by parents and coaches. This occurs in spite of adolescence being recognised as a period of seeking independence and affirms the need for coaches, and parents, to have a sound understanding of nutrition based on current scientific evidence. The nutrition component of the coaching programmes, especially in relation to the growing elite or academy schemes, currently available in New Zealand needs to be taught by people qualified in sports nutrition to provide credibility in this important area of sports performance. Both parents and the athletes themselves need to be better informed as to the important role good nutrition has in assisting adolescent athletes to achieve their goals. Children have the opportunity to learn sound nutrition practices in the new health curriculum taught in secondary schools and there are now several general advice books available that are specifically written to assist parents, coaches and teachers with sports nutrition for young people (Howe et al, 1999; Gillanders et al, 2000). These books also suggest and acknowledge the role of a qualified sports Dietitian/Nutritionist for specialist advice.

Successful senior athletes are important role models for adolescents and their appearance in both nutrition programmes and advertising campaigns can encourage adolescents to adopt the nutrition regime appropriate for their sport. For example, Bernice Mene, the current New Zealand netball captain has been featured in an advertisement for frozen vegetables to help her "eat well" despite her busy training schedule. Responsible food companies, such as The Sanitarium Health Food Company, have also contributed to community education by providing guidelines in terms of what is needed for nutritional requirements to prepare for sporting events.

There are a number of signs that children who are also athletes need a greater understanding of the role of food and nutrition in their sporting performances. Given that children have specific dietary needs different from those of adults, it is important that if they seek professional help from a Dietitian/Nutritionist, the professional understands the specific nutritional requirements of the sport. For this to occur, research is required to establish the nutritional requirements of the different sports, especially those that have high energy demands, to enable adolescents to maintain growth and good health while achieving sporting goals. Research would also provide credibility for these dietary recommendations and it may influence sporting organisations to adopt a pro-active stance in ensuring that young athletes understand the importance of nutrition for their sporting performance and their long term health.

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Appendix 1 *Literature Review Databases*

Medline	Healthcare Medline	1966-1999
CAB Abstracts		1973-1998
Cinahl		1982-1999

CD Rom Databases

Human Nutrition	Food science and nutrition	1982-1997
Sport Discus	Sport science and management	1975-1996

Appendix 2 *Development of Supplement Questions*

15 Cliff Road
Torbay
North Shore
New Zealand

8 March 1999

Ronette Briefel
National Centre for Health Statistics
6525 Belcrest Road
Room 900
Hyattsville
MD 20782
USA

Dear Madam

I am a post graduate student at Massy University Auckland New Zealand. I am planning to investigate the use of dietary supplements in children for my masters thesis topic. Dr Clare Wall will be my supervisor and she suggested that I write to you, as you were involved in The American Health and Nutrition Survey

The areas I am interested in are:

-How you developed questions for the use of supplements.
-How you validated your results.
-How you used the information obtained.

Thank you for your assistance.

Yours sincerely

Jennifer Crowley

15 Cliff Road
Torbay
North Shore City
New Zealand

8 March 1999

Robert Quigley
C/- Ministry of Health
P O Box 5013
Wellington

Dear Sir

I am a postgraduate student at Massey University Auckland, New Zealand. I am planning to investigate the use of dietary supplements in children for my masters thesis topic. Dr Clare Wall will be my supervisor and she suggested that I write to you as you were involved in the National Nutrition Survey.

The areas I am interested in are:

- how you developed questions for the use of supplements
- how you validated your results
- how you used the information obtained

Thank you for your assistance.

Yours sincerely

Jennifer Crowley

15 Cliff Road
Torbay
North Shore City
New Zealand

8 March 1999

Peter Davies
Associate Professor
School of Human Movement Studies
Faculty of Health
Brisbane
Queensland
Australia

Dear Sir

I am a postgraduate student at Massey University Auckland, New Zealand. I am planning to investigate the use of dietary supplements in children for my masters thesis topic. Clare Wall be my supervisor and she suggested that I write to you as you were involved in the Great Britain National Diet and Nutrition Survey.

The areas I am interested in are:

- how you developed questions for the use of supplements
- how you validated your results
- how you used the information obtained

Thank you for your assistance.

Yours sincerely

Jennifer Crowley