An analysis of the baseline dietary intake of HIV-positive/AIDS patients

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Abstract
This study analysed the baseline dietary intake of people living with HIV/AIDS in the African community of Bloemfontein. A validated food frequency questionnaire was used to assess the dietary intake of both macronutrients and micronutrients in 35 HIV-positive/AIDS patients. The patients demonstrated energy and dietary intake of major macronutrients higher than the estimated energy intake (EER) and recommended daily allowance (RDA) respectively and this tended to be higher ($P<0.05$) in males than in females. The result also showed that the mineral and trace element dietary intake exceeded the RDA/AI (adequate intake), except for iodine (82.9%) and selenium (40%). The majority of the patients reported adequate intake of most vitamins; however a relatively high percentage of the patients indicated an inadequate intake for folate (34.3%) and vitamin D (25.7%). It is envisaged that the high dietary intake of major macronutrients and micronutrients will help in maintaining the nutritional status and in reducing wasting in the patients. However, the relatively high percentage of the patients with an inadequate intake of iodine, selenium, folate and vitamin D is of great concern and calls for urgent attention, hence further in-depth research is recommended.

Key words: malnutrition, HIV/AIDS patients, baseline dietary analysis, macronutrients, micronutrients and nutritional status.

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Introduction

Good nutrition is the cornerstone for maintaining an optimum immune response.[1] Normal antibody production, phagocytic cell and T-lymphocyte functions depend on the adequate intake of energy, protein, fat, minerals and vitamins.[2, 3] It is a fact that malnutrition alters the immune function with a subsequent increase in susceptibility to infections[4], faster disease progression[3, 5, 6], reduced functional status, quality of life, and increased morbidity and mortality.[3, 7]

Nutritional deficiencies are well-documented complications of HIV infection.[8, 9, 6] HIV-positive/AIDS patients develop severe protein and energy malnutrition; although the severity of protein and energy malnutrition depends on the stage of HIV infection/AIDS.[10] Several vitamins and minerals have been found to be deficient as well.[11] The pathogenesis of nutritional impairment in HIV-positive patients is multifaceted and includes decreased food intake, decreased nutrient absorption and decreased efficiency of utilisation, in addition to increased nutritional demand.[12, 13] Literature reports[14, 15] clearly indicate that HIV infection contributes to malnutrition for physiological reasons related to HIV infection itself and because most people living with HIV/AIDS, particularly in developing countries, often have diets that are deficient in energy, proteins, vitamins and other nutrients. Friis and Michaelsen[16] reported that macro-and micronutrient deficiencies could impair host immune functions and promote viral replication and pathogenicity, thus potentially affecting the clinical course of HIV infection. Therefore, nutrition may play a role in the progression of HIV infection to AIDS, as well as mortality from AIDS. Other studies indicate that in the early period of HIV infection, weight gain or maintenance might be achieved through adequate diet and that this has helped to reduce the consequences of wasting in people living with HIV/AIDS.[4, 11]

Chlebowski *et al*.[17] reported reduced dietary intake in AIDS patients compared with asymptomatic HIV-positive subjects. McCorkindale *et al*.[8] demonstrated decreased food intake even in asymptomatic HIV-infected subjects and early AIDS Related Complex (ARC) subjects during a 16-month period, and this was associated with significant weight loss. On the other hand, Dworkin *et al*.[18] and Kotler *et al*.[19] found no differences in dietary intake among patients with AIDS or AIDS-Related Complex (ARC) and asymptomatic HIV-positive controls or uninfected controls. Hellerstein *et al*.[20] found that dietary intake was adequate in most HIV-positive/AIDS persons.

The effects of HIV infection on the nutritional status are likely to be more pronounced among under-privileged populations with a low dietary intake. However, only few data have been reported in developing countries.[2, 21, 10, 22] Baum *et al*.[13] concluded that although the metabolic response to HIV infection may contribute to low nutritional status in HIV-infected individuals, there is no doubt that the intake of nutrients at levels recommended for the general population does not appear to be adequate for HIV-1 infected persons. Thus, the importance of any possible effects of nutritional deficiency on HIV progression is evident.

An association between physiological nutritional deficiencies and disease progression has been demonstrated in developed countries[13], while a possible relationship between dietary intake and disease progression has also been established.[23] However, there are limited data in reference to dietary intakes and disease progression in HIV-infected persons from African countries and further studies in African countries have been advocated.[10, 22]

The aim of this study was to assess the nutritional status by analysing the dietary intake among HIV-positive/AIDS patients living in a low socio-economic community in Bloemfontein, South Africa.

Subjects and Methods

A cross-sectional descriptive study was carried out at Medi Inn Clinic, Bloemfontein and it formed part of a clinical trial that involved a target group (HIV-positive/AIDS patients). Fifty HIV-1 sero-positive/AIDS patients were recruited at screening (baseline visit) from Tsepo home-based care and from the South African Red Cross home-based care in Bloemfontein). Of the 50 patients recruited at screening visit, only 35 completed the study (10 dropped out while 5 died). Validated questionnaires were used to determine the socio-demographic profile and food consumption patterns. An approval from the Ethics Committee of the Faculty of Health Sciences, University of the Free State (ETOVS 32/03) was obtained. The patients signed the consent form after they had been informed about the purpose and procedures of the study. The inclusion criteria included male and female patients between 18 and 65 years of age that were HIV positive, willing to undergo a pre-study medical examination, were not on anti-retroviral therapy, had a $CD4^{+}$T-cell count of 100-350 cells/mm^3, able to comprehend and willing to sign the statement of informed consent.

Administration of questionnaires

Medi Inn clinic and Tsepo home-based care were chosen as centres for the study. The patients at Tsepo home-based care were seen at the home-care centre while patients from the South African Red Cross home-based care, Bloemfontein, were transported to Medi Inn clinic where they were examined.

Socio-demographic details such as age, gender and residential address were obtained from each patient. Information concerning financial and employment status, level of education, marital status, type of house, monthly income, amount spent weekly or monthly on food, available cooking utensils, smoking habit, number of children (live or dead) and number of persons living in the house were obtained and recorded. Where respondents could not speak English, interpreters were used in completing the questionnaires. The socio-demographic questionnaire was completed only at the screening visit. There was no follow-up due to logistic problems (cost and time frame).

Dietary Intake

This was assessed by the use of a food frequency questionnaire. At baseline, a validated food frequency questionnaire (adapted from the Transition and Health During Urbanisation of South Africans (THUSA) study 2002 (Potchefstroom University) was used to determine the habitual types and quantities of food and drink consumed by respondents over the six months prior to data collection, and to determine the habitual intakes of total energy, macronutrients and micronutrients. Both traditional and western foods were included in the food frequency questionnaire. A food frequency questionnaire was chosen to determine the dietary intake because it is believed to be a suitable method for use in describing the intake of groups rather than for individuals[24], and is commonly used in epidemiological studies to determine the relationships between diet and disease.[25, 26] It also provides an overall picture of food intake[27], which was found to be relatively cheaper and more representative of the usual food intake than a few days of diet records. The food frequency questionnaire (ffq) was administered only at the screening visit. There was no follow-up due to logistic problems (cost and time frame).

Food models were used to assist with the accuracy of the size of food portions described by the respondents. Each respondent was asked to demonstrate the quantity of a given food that he/she consumed on a daily, weekly or monthly basis via an interview. The food frequency questionnaires were completed by the research scientist and four members of the research team.

The portion sizes were estimated using household measures and converted to grams using the conversion figures in the Medical Research Council (MRC) of South African Food Quantities Manual.[28]. The quantities of food consumed on a daily basis were entered accordingly. The quantities of foodstuffs not selected by the respondents per day, were calculated as food in grams consumed per week divided by 7 days, or food in grams consumed per month divided by 30 days. The recorded food items were coded by means of food composition tables of the MRC. Complex dishes not appearing in the food composition tables were broken down into individual ingredients and weights and coded as such. The dietary data were analysed by means of a computer software programme applying MRC food composition tables. The energy intake was compared with the estimated energy requirement. Macro- and micronutrient intakes were compared with the recommended daily allowances (RDA) or Adequate Intake (AI).[29] A value of <67% of the RDA/AI was considered to be inadequate.[29]

Statistical analysis

An independent Biostatistician at the Faculty of Health Sciences, University of the Free State, South Africa did the statistical analyses of results. The analysis of variables was done using SAS.

Results

A total of 50 HIV-positive/AIDS volunteers were enrolled in this study at the screening visit. Ten patients dropped out, and 5 died during the period of the trial. Eight (8) of the 35 patients who completed the food frequency questionnaires were male (22.9%) while 27 (77.1%) were female. The difference in the number of male and female patients was taken into consideration in the statistical analysis of the data.

The nutrient intakes with their mean, standard deviation, median, RDA/AI and the percentage of patients with a dietary intake of less than 67% of the RDA/AI are presented in table 1. The male (n=8) and female (n=27) HIV-positive/AIDS patients examined in this study demonstrated energy and dietary intakes of major macronutrients higher than the estimated energy requirements (EER) and RDA values respectively. Observation of the results showed that the dietary intake tends to be higher in males (P<0.05) than in females except for animal and plant protein that were higher in females. As whole group, the majority of the patients reported an adequate dietary intake.

An examination of the mineral and trace element intakes as shown in table 2, revealed that the mean intake exceeded the RDA/AI, except for iodine. In the male patients (n=8), 12.5% took in less than 67% of the RDA for selenium while 75% of the male patients took in less than 67% for iodine. On the other hand, 48.2% of the female patients (n=27) had an inadequate intake of selenium and 82.9% of the female patients (n=27) had an inadequate intake of iodine. The micronutrient intakes were also higher in the male patients than in the female patients with the exception of copper and total iron. This inadequate intake of selenium and iodine is also reflected in the whole group of patients studied.

Table 3 shows that the majority of the male and female patients and the whole group demonstrated mean dietary intake higher than the recommended daily allowance (RDA)/adequate intake (AI). In addition, table 3 indicates the percentage of patients who took in less than 67% of the RDA/AI for these groups of patients. The mean dietary intake of vitamins A, C, K, folate and B_{12} was higher in the female patients than in the male patients. The male group reported a higher intake of other vitamins except riboflavin and thiamine. A relatively high percentage of the study population reported an inadequate intake of folate and vitamin D.

Discussion

Adequate nutrition, which is best achieved through consumption of a balanced healthy diet is vital for the health and survival of all HIV-infected persons. Energy requirements are likely to increase by 10% to maintain body weight and physical activity in asymptomatic HIV-infected adults.[30] During symptomatic HIV infection, and subsequently during AIDS, energy requirements increased by approximately 20% to 30% to maintain adult body weight.[30]

As observed in this study, the mean energy intake is higher than the EER for both male and female patients (table 1). This agrees with previous findings as reported by Hogg *et al*.[31] that HIV-infected patients had a higher energy intake than their HIV-negative counterparts. The present results also confirm the World Health Organization[30] report that energy requirements increase significantly during the symptomatic stage of HIV-infection. It is important to note that energy intake is related to the stage of the infection, rapid weight loss, anorexia, opportunistic infections, malabsorption and altered metabolism.[23] In another study performed by Kim *et al*.[32], it was suggested that energy and dietary intake is a complex socio-behavioural phenomenon that reflects the confluence of attitudinal, economic and lifestyle factors. In the population studied, these factors may have contributed in one way or the other to the higher energy intake. Although necessary precautions were taken in collating dietary data from patients (a food frequency questionnaire was used to determine the habitual types, quantities and frequency of food and drink consumption by recording consumption on a daily, weekly and monthly basis over a period of six months prior to the study), it is possible however that difficulties regarding recalling food intake correctly and over reporting were experienced and possibly contributed to the dietary energy intake recorded.

It is also possible that the higher energy intake may be directly or indirectly related to the staple food consumed by the population. Whether this increase in energy intake is sustained every day or is only representative of their intake during "best" days or days during recording of food intake cannot be confirmed by the food frequency questionnaire in this study with a single dietary analysis at baseline. If it is agreed with the WHO[30] that energy requirements increase significantly as the HIV disease progresses, then it might be viewed as a good trend for patients with high energy intake as reported in this study. The higher energy intake could assist to a certain degree in reducing wasting and improve the well-being of the patients. According to Macallan[6], reduced energy intake promotes wasting.

Both male and female patients reported a mean total protein intake of 155.9 and 159.8 g higher than the RDA of 63 g and 50 g respectively, while 3.7% of the female patients took in less than 67% of the RDA (table 1). Walsh *et al*.[33], also reported a mean total protein intake in HIV-positive patients that was higher than the RDA. According to Dannhauser *et al*.[22] and Kim *et al*.[32] studies carried out on HIV-infected patients in the Free State province of South Africa and in Boston (USA) respectively, reported that majority of the patients had a total protein intake that met at least 67% of the RDA. The high intake of total protein as observed in this study is suggested to be associated with urbanisation. It is believed that, in some cases, urbanisation is accompanied by an increased intake of animal protein depending on the economic status of the individual. It has been observed that diets become diverse with urbanisation and that more people add meat, fish, diary products, eggs and cheese to their meals.[34] The availability of cheaper cuts of red meat, offal, sausage, chicken and chicken offal could have contributed to the high intake of total protein in the studied population. The mean plant protein intake (64.8 g) in the female subjects was insignificantly higher than that of their male counterparts [64.0 g] (table 1). The mean plant protein intake reported for male and female subjects was lower than the animal protein intake for both sexes (being 86.2 g in male and 91.5 g in the female subjects, table 1). This is in line with the work of Maclntyre[35] who found that the ratio of plant to animal protein intake has changed significantly in the diets of urbanised Africans, with rural Africans consuming more plant proteins than their urban counterparts. We envisaged that the high total protein intake reported in this study may compensate for the increased urinary nitrogen loss, increased protein utility, decreased skeletal protein synthesis and increased skeletal muscle breakdown that is reported in HIV-infected individuals. The differences in plant and animal protein intake between male and female subjects, as seen in this study, is not clear, but may partly be related to economic and social factors.

The mean total carbohydrate intake of both male and female subjects exceeded the RDA and may have contributed significantly to the energy intake, required to meet the metabolic needs of HIV-positive/AIDS patients. The mean intake of dietary fibre in the male patients was slightly lower than the AI intake, but was not significantly lower than the AI while the median dietary fibre intake of female subjects exceeded the AI (table 1). The dietary fibre is known to reduce colonic cancer and the consumption of minimally processed foods such as whole-wheat bread and whole-wheat rice should be encouraged in respect of HIV-positive/AIDS patients. On the whole, the total carbohydrate intake may compensate for increased peripheral glucose utilization and increased gluconeogenesis common in advanced HIV disease.[11]

The total fat intake of 175.3 g/day for male patients and 140 g/day for female patients (table 1) exceeded the RDA of <96 g and <73 g per day for male and female subjects respectively. In both male and female patients the dietary intakes were significantly (P<0.05) higher than the RDA, with the male patients showing a higher intake. The high intake of fat may be ascribed to preference for cheaper fatty red meat, eggs, brick margarine, meat drippings and potato crisps. There is no evidence to suggest that total fat needs are increased beyond normal requirements as a consequence of HIV infection. To ensure macronutrient intakes at RDA, HIV-positive/AIDS patients are encouraged to consume healthy diets; nevertheless the dietary intake of macronutrients at RDA may not be sufficient to correct nutritional deficiencies in HIV-infected populations. Because weight and lean body mass changes are major indicators of the health status of people living with HIV/AIDS, an optimal intake of kilojoules and protein is vital and, according to Woznicki & D'Alessandro[36], the intake of calorie-yielding nutrients (carbohydrates, protein and fat) at levels that exceed the RDA is advisable.

The role of micronutrients in immune and infectious disease is well established.[30] Observational studies have shown that low blood levels and decreased dietary intakes of some micronutrients are associated with faster HIV disease progression, altered immune function and mortality. However, these studies' methodological limitations preclude definitive conclusions about the relationship between micronutrient dietary intakes and HIV infection. In this study, the majority of patients demonstrated an adequate or high intake of micronutrients that was 67% or higher than the RDA. The study also revealed the percentage of some micronutrients with an intake of less than 67% of the RDA, such as selenium and iodine (table 2) and vitamins, such as A, E, D and folate (table 3) in the male patients. The female patients showed a wider range of inadequate intake (<67% of the RDA) of calcium, copper, total iron, chromium, zinc, magnesium, selenium and iodine (table 2) and of vitamins (A, E, C, D, folate, niacin, riboflavin, thiamine and B_6, table 3).

Evidence from cross-sectional epidemiological studies have shown that some minerals/trace elements may be key factors in maintaining health despite human immunodeficiency virus infection and in reducing mortality. For instance, selenium appears important in reducing the virulence of HIV and slowing the disease progression, while a positive association has been noted between the dietary intake of zinc and the CD4+T-cell count of HIV-infected persons.[37, 12] Values higher than the RDA were identified for calcium, copper, iron, chromium, zinc and magnesium, but not iodine, in male and female patients in this study population. In male patients 75% had inadequate intake of iodine. The reason for the high percentage of inadequate intake of selenium and iodine, as seen in the population is not quite understood since table salt in South Africa is iodated. Each of the mineral/trace elements examined in this study may contribute to the general well-being of HIV-infected persons.

Calcium has been shown to reduce diarrhoea in HIV-positive/AIDS patients.[38] About 50% of HIV-positive/AIDS patients using protease inhibitors have been found to significantly lose calcium from their bones.[39] In the present study, the mean calcium intake was higher than the RDA. Therefore, the results obtained from this study tend to suggest that patients with a high dietary intake (>RDA), might be able to replace lost calcium, especially those who may be fortunate to undergo antiretroviral therapy and perhaps reduce the burden of diarrhoea. There is a plan by the South African government to start providing antiretroviral drugs for HIV-infected persons. Currently, the provision of antiretroviral drugs has started in most provinces. it is likely that an adequate dietary intake of calcium could play a compensatory role in correcting drug-induced calcium lost from the body.

Copper is a mineral essential in small amount for proper health and required for red and white blood cell maturation, iron transport, cholesterol metabolism, glucose metabolism, immune function and protection against oxidative stress.[40] A recent study showed that a diet deficient in copper affects the immune system[40] while adequate dietary intake was associated with a significant decrease in the risks of AIDS.[41, 42] In the current study, majority of the patients showed adequate intake of copper with only 5.7% of intake less than 67% of RDA. It is believed that adequate copper intake would enhance immune function and improves the nutritional status of the patients living with HIV/AIDS. It is therefore suggested that HIV-positive/AIDS patients should include legumes, liver, kidney and cow's milk as they are rich source of copper.

Iron is essential for the formation and functioning of red blood cells, and vitamin C is known to promote the absorption of iron. In both male and female patients the median total iron intake was higher than the RDA, nonetheless 25.9% of the female (table 2) population took in less than 67% of the RDA. Iron has been observed as a micronutrient that is commonly deficient in HIV infection. However, an oversupply of iron is also regarded as harmful in HIV infection. When oversupplied, iron can stimulate free radical production and further damage the immune system.[43] In one study, iron levels were higher in people with HIV infection.[43] Iron blood level was not determined in this study so as to verify its correlation with dietary intake. Considering the danger of an oversupply of iron, it would be appropriate to measure and monitor blood levels of iron so as to be able to regulate its intake in HIV-positive/AIDS patients. As mentioned earlier, 25.9% of the female population had an inadequate intake of iron as opposed to none in the males. The reason for this discrepancy is not clear, but it may be related to the fact that iron is lacking in women's food due to a lack of knowledge, or because of extra demands during the menstrual cycle (women need extra iron until they pass the menopause stage). Anaemia has been associated with increased rates of mortality in American[44], European[45] and Malawian[46] studies of HIV-infected persons. This may have serious implications for patients in this study with an inadequate intake of iron.

Chromium is mainly involved in the metabolism of glucose but recent research in animal models showed that chromium can enhance the ability of the white blood cells to respond to infection.[47] Results of the present study indicated a high intake in both males and females except for 11.11% of the female (table 2) population with an inadequate intake. Information on the role of chromium in HIV information is virtually unavailable but it is assumed that in its normal biological function, it would help in the proper carbohydrate metabolism in HIV-infected persons, as a carbohydrate abnormal metabolism has been reported in HIV-infected persons.[11] As observed in this study, the mean intake for chromium was higher than the RDA. It is believed that the patients examined in this study will benefit from such high intake.

Another important element that was considered in the analysis is zinc. Zinc is a mineral that is necessary for protein and energy metabolism, as well as in DNA and RNA synthesis. It also appears to be essential for T-cell differentiation and maturation as well as lymphocyte activation.[48, 15]. Dietary intakes of zinc in both male and female patients were higher than the RDA. An intake of less than 67% of the RDA was recorded in 7.4% of the females (table 2). There is some evidence to indicate that inadequate dietary intake may contribute to the prevalence of altered nutritional status in HIV-infected individuals, underscoring the importance of maintaining adequate nutritional support for HIV-positive/AIDS patients. Kupka & Fawzi[15] found a positive association between dietary intake of zinc and immune status. By deduction, an adequate dietary intake of zinc (other micronutrients inclusive), as seen in the study population, could contribute to maintaining the nutritional and immune status of HIV-positive/AIDS patients. If this applies to other anti-oxidants such as selenium, vitamin A, C and E, this could help in maintaining the oxidative status and in turn in reducing the oxidative stress which is common in HIV-positive/AIDS patients. Oxidative stress in HIV disease may be related to a failure in such anti-oxidant defence mechanisms, as well as to the chronic and progressive inflammatory reaction associated with the development of HIV infection.[49] It is possible that such a failure in antioxidant defence mechanisms is partly the result of an inadequate intake of these antioxidants (zinc inclusive) in the diets of HIV-positive/AIDS patients either because of the unavailability of the fruits/sources containing the antioxidant or because of economic or social factors.

Magnesium, one of the minerals analysed in the present study is needed for energy production and protein synthesis and is found in whole grains, legumes, leafy green vegetables and nuts. An adequate intake can assist in preventing muscle spasms and tremor and it seems likely that an adequate or high intake in HIV-positive/AIDS would therefore be useful to these patients. It is known from literature that nutrient requirements for HIV-positive/AIDS patients are higher than those of HIV-negative individuals due to the catabolic activity of HIV infection/disease, and in most cases scientists have suggested dietary intakes higher than the RDA for HIV-positive/AIDS persons.[50, 51, 11] The mean magnesium intake reported for this study population was significantly higher than the RDA. This adequate intake can therefore help in preventing complications associated with inadequacy in HIV-positive/AIDS patients.

Selenium, although needed in trace amounts, is important in respective HIV infection because of its role in the metabolism of the essential anti-oxidant glutathione. Selenium also function synergistically with vitamin E in blocking the rate of lipid peroxidation.[43] In this study, selenium intakes of male patients were higher than the RDA, although 12.5% who had an intake of less than 67% of the RDA. In the female patients, selenium dietary intakes were less than the RDA while 48.2% had intakes of less than 67% of the RDA. Selenium deficient HIV-infected persons have been found to be nearly twenty times more likely to die from HIV-related causes than those with an adequate intake.[48] The mean selenium intake of women in a study in Bloemfontein was reported to be slightly lower than the RDA and about half of the total population took in less than 67% of the RDA.[52] An inadequate selenium intake may be a general problem in the African community in Bloemfontein area, probably resulting from an inadequate intake/deficient in their diets, thus further investigation into the reason or reasons for this inadequate intake of selenium among this community is necessary.

The mean intake of the water-soluble vitamins (niacin, riboflavin, B_6, B_{12}, C and folate) was higher than the RDA required for both male and female patients. Other studies have documented an adequate or higher intake of these vitamins.[33, 53] Higher intakes of micronutrients such as riboflavin, thiamine and niacin have been associated with higher CD4+T-cell counts at baseline.[12] The current study did not examine the correlation between dietary intake for riboflavin, thiamine, niacine and CD4+T-cell count. Tang *et al*.[42, 54] observed a slower progression of disease and reduced risk of mortality with an increased intake of riboflavin, thiamine and vitamin C.

Vitamin C has been found to affect immune function in several ways.[55] It can stimulate the production of interferons; the proteins that protect cells against viral attack. It has also been shown that vitamin C can stimulate the synthesis of humoral thymus factor and antibodies IgG and IgM classes.[55, 56]. It has been shown that vitamin C was effective in the inactivation of a wide range of pathogenic bacteria including *Staphylococcus aureus*,[55, 48]. The dietary intake of vitamin C was adequate in the patients examined in the current study. There is accumulating epidemiological evidence that increased intakes of vitamin C may help to reduce the risk of diseases associated with increased oxidative stress.[55, 57] It is therefore envisaged that the adequate vitamin C intake reported among the patients in this study is beneficial to the patients.

Adequate intake of vitamin B_6 and B_{12} were reported in majority of the patients. The inclusion of animal sources in the diet probably contributed to this adequate intake. The adequate intakes of vitamin B_6 and B_{12} reported in the studied group may contribute to slower progression of HIV infection and reduced mortality. B_6 is particularly important for immune function and deficiency can lead to decreased white blood cell response and shrinkage of the critical immune system organ, the thymus.[47, 40] B_{12} is also central to immune processes because it governs cell division and growth. Deficiency of B_{12} negatively affects red cell maturation.[47]

Folate (folic acid) is known to play an important role in the prevention of megaloblastic anaemia. The relatively high percentage of folate (37.5% and 33.3% in male and female (table 3) patients respectively) having a dietary intake of less than 67% of the RDA is therefore a matter of concern in this group of patients. Although, the greater percentage of patients examined in this study had a dietary intake of the water-soluble vitamins higher than the RDA, it should be noted that even a mild state of deficiency of these vitamins could result in an altered immune function, especially in patients who are not on antiretroviral drugs. As HIV infection progresses, coupled with opportunistic infections and metabolic demand, HIV-infected individuals may be unable to meet their required nutritional needs due to decreased oral intake, decreased nutrient absorption, increased nutrient requirements and changes in metabolism and nutrient transport, which could steadily result in greater inadequacies of these vitamins.[22] The percentage of nutrients with an intake of less than 67% of the RDA reported in some of the patients for the above-mentioned vitamins may be related to their high intake of maize, a poor source of these nutrients, in addition to other biological factors. Dannhauser *et al*.[22] alluded to the fact that regular consumption of maize-meal could be the cause of an inadequate intake of these vitamins.

In this study, a significantly higher percentage of the patients had a dietary intake higher than the RDA for B_6 and B_{12}. Although the risk of progression of HIV infection to AIDS was not tested in the current, nonetheless, by inference, the higher intake reported in the patients for this study could be considered beneficial to the patients in terms of the risk of HIV progression to AIDS.

Researchers have provided both animal and human evidence that an adequate vitamins A and E intake and their corresponding blood levels are important for modulating normal immune function.[58] The dietary intake of other fat-soluble vitamins is reported and discussed in this study. The dietary intake of vitamin A in this study was higher than the RDA for a greater percentage of the patients, with only 12.5% of male and 14.81% of female having an intake of less than 67% of RDA (table 3). Karter *et al*.[59] reported that 12%-19% of HIV-positive patients at various stages of HIV infection showed vitamin A deficiency/inadequacy and that this inadequacy may be more prevalent in women than in men. The reported 12.5% (male) and 14.81% (female) of vitamin A intake of less than 67% of the RDA in this study is similar to the trend reported by Karter *et al*.[59] On the other hand, Walsh *et al*.[33] reported a high intake of vitamin A (higher than the RDA) in HIV-positive patients that is similar to the results of this study. Previous study has shown that there is a relationship between the dietary intake of vitamin A, its blood levels and immune function.[60] The high dietary intake of vitamin A observed in the patients may be related to metabolic demand during the acute phase of HIV infection, or an increased dietary intake, while the low intake could probably be associated with a more rapid progression to AIDS[61]; the presence of local pathological conditions such oral thrush, and a reduced dietary intake, among other factors.[62, 9, 6]

An inadequate vitamin E intake (table 3), found in this study population, occurred in females (14.81%), in males (12.5%) and in the whole group of patients (14.3%). Meanwhile the majority of the patients documented an intake of vitamin E that was higher than the RDA. In this population, the same factors tend to influence a high or low dietary intake for most of the vitamins, vitamin E inclusive. In a study[63] of 100 asymptomatic HIV-seropositive persons, 26% had an intake of vitamin E that was less than the RDA and 27% had an overt or marginally deficient intake. In another study[43], 50% of 18 AIDS patients, 58% of 12 ARC patients and 38% of 13 HIV-positive persons had an intake of vitamin E less than the RDA. The 14.8% reported in the present study is lower than that reported by Cairns.[43] Factors such as increased dietary intake, differences in methodologies and design, stages of HIV infection and study population could possibly explain the difference in the percentages (high or low) of vitamin E.

There is limited and conflicting evidence on the influence of vitamin D on immunity and HIV infection. Some research suggests that high intake/levels of vitamin D may have a suppressive effect and that it may stimulate HIV replication.[43] This evidence is based on test tube studies.[43] On the other hand, the active form of vitamin D has been shown to stimulate macrophages and white blood cells. A study[63] compared 54 HIV-infected people with non-HIV-infected controls. Fifty-four percent of the HIV-positive group were deficient in vitamin D in contrast to the control group, who were not vitamin D deficient. Inadequate intake in this study was reported for vitamin D (table 3) in 12.5% of male patients and 29.63% of female patients (intake less than 67% of AI). This value was significantly lower in this study than that of Haug[63], however, the 29.63% inadequate vitamin D intake found in the female group is similar to that reported by Hattingh[52]. Significantly, a higher percentage of the patients had a vitamin D intake higher than the required AI.

The mean intakes of vitamin K were high, with both male and female patients exceeding the AI. Inadequate intake was found in 25% of male and 11.11% of female patients (table 3). Scientific reports on the intake of vitamin K in HIV-positive/AIDS is very limited. An adequate intake of vitamin K may be vital for HIV-positive patients with bleeding disorder. Previous studies carried out on HIV-positive/AIDS patients in the Free State province of South Africa did not analyse the vitamin K intake. However, it was shown to be adequate or higher than the AI in the HIV-negative population in the Free State province.[60, 22, 52]

Conclusion

The results of this study provide survey data on the dietary/nutritional intakes of HIV-positive/AIDS patients; particularly those living in Bloemfontein, and perhaps reflect the dietary intakes of HIV-positive/AIDS patients in the African community. Generally, the dietary intakes were higher than the RDA/AI. The study therefore establishes that the estimated energy requirements, macronutrient and micronutrient intakes of most clinically stable AIDS and HIV-sero-positive patients meet the RDA standards. This high intake may be related to employment status, the provision of food security from families, friends and monthly allowances from the government. The high intake could help in correcting nutritional impairment and retard wasting to a certain extent and, in turn, in maintaining the nutritional level of the nutrients in the blood. On the other hand, the high percentage of patients with an inadequate intake of iodine and selenium is of great concern and calls for further investigation.

The cross-sectional nature of the study, the small number of patients studied, the absence of a control group and the lack of references adapted for HIV-positive/AIDS patients, make it difficult to extrapolate the results. Furthermore, in the present study, there is a lack of information on some important predictors of patients' nutritional status, for instance, blood levels of the corresponding nutrients analysed in the study were not determined and therefore prevent one from making casual references or definite conclusions. However, it is suggested that many serum micronutrients are affected by infection and inflammation (hence their blood levels may not reflect a true picture of the nutritional status of HIV-infected/AIDS patients); therefore, the determination of dietary intake thus plays an important role in the assessment of nutritional status of HIV-positive/AIDS patients. Both macronutrients and micronutrients play an important role in maintaining nutritional status, and probably delay disease progression. Irrespective of the availability of anti-retroviral therapy, an adequate, well balanced diet, providing required foods and consequently adequate nutrients to meet the increased requirements of HIV infection/AIDS, is an important measure in maintaining nutritional health in people living with HIV/AIDS.

Application

Assessment of HIV-positive/AIDS patients is important at all stages of the disease in order to identify those with inadequate dietary intake who will require counselling. The inferences drawn from this study will in no small measure assist the government and health professionals in designing nutritional support for HIV-infected persons. Results from the study may also provide useful information for health professionals who are involved in studies on the nutritional implications of antiretroviral drugs that the government is currently providing for her citizens.

Recommendations

To avoid malnutrition in people with HIV/AIDS, nutritional counselling is imperative and is therefore suggested in order to assist people with HIV/AIDS to maintain their body weight and quality of life. The nutritional counselling should:

- Provide information on adequate and well balanced diets, including recipes for preparing meals
- Stress the importance of optimising and maintaining nutritional status
- Stress early treatment of opportunistic infections as infections increase the need for nutrients, impair nutrient absorption and reduced dietary intake
- Discuss alternative therapies
- Provide guidelines for home-based assessment of body weight.

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References

1. Woods MN, Spiegelman D, Knox TA *et al*. Nutrient intake and body weight in a large cohort that includes women and minorities. J Am Diet Assoc 2002; **102**: 203-211.
2. Semba RD. Vitamin A, immunity and infections. Clin Infect Dis 1994; **19**: 489-499.
3. Scrimshaw NS & SanGiovanni JP. Synergism of nutrition, infection and immunity: An overview. Am J Clin Nutr 1997; **66**: 464S-477S.
4. Semba RD & Tang AM. Micronutrients and the pathogenesis of human immunodeficiency virus infection. Br J Nutr 1999; **81**: 181-189.
5. Baum MK & Shor-Posner G. Micronutrient status in relationship to mortality in HIV-1 disease. Nutrition Reviews 1998; **56**: S135-S139.
6. Macallan DC. Wasting in HIV Infection and AIDS. J Nutrition 1999; **129** (1): 238S-242S.
7. Kotler DP. Management of nutritional alterations and issues concerning quality of life. J Acquir Defic Syndr & Hum Retrovirol 1997; **16** (S1): S30-S35.
8. McCorkindale C, Dybevik K, Coulston AM, Sucher KP. Nutritional status of HIV-infected patients during the early disease stages. J Am Diet Assoc 1990; **90**: 1236-1241.
9. Cuff PA. Acquired immunodeficiency syndrome and malnutrition: role of gastrointestinal pathology. Nutr Clin Practice 1990; **5**: 43-53.
10. Castetbon K, Kadio A, Bondurand A *et al*. Nutritional status and dietary intakes in human immunodeficiency virus (HIV)-infected outpatients in Abidjan, Cote d'Ivoire, 1995. European J Clin Nutr 1997; **51**: 81-86.
11. Piwoz EG & Preble EA. HIV/AIDS and nutrition: a review of the literature and recommendations for nutritional care and support in sub-Saharan Africa. A Technical Report 2000: 1-8.

Table 1: Baseline energy, major macronutrients and cholesterol intake of HIV-positive/AIDS patients.

Nutrients	Mean	SD	Median	RDA/AI	% of patients <67% of RDA/AI
Energy (KJ)/day					
Male n=8	20217.4	6992.8	19316.7	12180	0
Female n=27	18402.8	9102.2	17266.5	9240	11.1
Whole Group n=35	18817.6	8603.5	17889.6	10710	8.6
Plant protein (g)/day					
Male	64.8	29.0	56.8	N/A	0
Female	64.0	35.7	62.1	N/A	0
Whole Group	62.3	33.9	62.1	N/A	0
Animal protein (g)/day					
Male	86.2	24.7	92.9	N/A	0
Female	91.5	79.9	75.3	N/A	0
Whole Group	90.3	70.8	84.6	N/A	0
Total protein (g)/day					
Male	155.9	48.0	131.3	63	0
Female	159.8	98.6	131.3	50	3.7
Whole Group	158.9	89.0	131.7	56.5	2.9
Total CHO (g)/day					
Male	605.8	208.5	554.4	358-430	0
Female	573.8	315.6	548.2	272-324	3.7
Whole Group	581.2	292.1	548.2	298-346	2.9
Total dietary fibre (g)/day					
Male	40.5	14.1	37.2	38*	12.5
Female	43.8	26.4	43.6	25*	14.8
Whole Group	43.1	24.0	46.6	31.5*	14.3
Total fat (g)/day					
Male	175.3	75.7	149.4	<96	0
Female	140.0	65.8	132.9	<73	0
Whole Group	148.1	68.7	144.7	<84.5	0
Cholesterol (mg)/day.					
Male	595.2	222.0	592.0	<300	0
Female	536.5	522.4	382.1	<300	0
Whole Group	549.9	468.5	437.5	<300	0

N/A: not applicable

Table 2: Baseline mineral and trace element intake of HIV-positive/AIDS patients

Nutrients	Mean	SD	Median	RDA/AI	% of patients <67% of RDA/AI
Calcium (mg)/day					
Male n=8	1637.0	816.7	1381.1	1200*	0
Female n=27	1257.1	618.8	1281.9	1000*	18.5
Whole Group n=35	1343.9	675.5	1295.7	1100*	14.3
Copper (mg)/day					
Male	3.1	1.8	2.2	0.9	0
Female	3.4	3.9	2.5	0.9	7.4
Whole Group	3.4	3.5	2.5	0.9	5.7
Total iron (mg)/day					
Male	25.0	13.8	19.0	8	0
Female	25.6	19.3	22.2	18	25.9
Whole Group	25.4	18.0	21.4	13	20
Chromium (mg)/day					
Male	70.9	30.3	57.9	25*	0
Female	61.0	58.0	42.8	25*	11.1
Whole Group	63.2	52.7	52.7	25*	8.6
Zinc (mg)/day					
Male	20.4	7.3	20.3	11	0
Female	18.1	10.4	16.3	8	7.4
Whole Group	18.6	9.7	18.0	9.5	5.7
Magnesium (mg)/day					
Male	706.4	268.7	646.6	420	0
Female	696.8	353.7	674.4	320	7.4
Whole Group	699.0	332.4	674.4	370	5.7
Selenium (μg)/day					
Male	77.0	37.0	71.5	55	12.5
Female	71.1	78.8	38.6	55	48.2
Whole Group	72.4	71.0	45.4	55	40
Iodine (μg)/day					
Male	74.0	27.8	78.3	150	75.0
Female	52.9	41.4	38.8	150	82.9
Whole Group	57.7	39.4	46.7	150	82.9

*Adequate Intake

Table 3: Baseline vitamin intake of HIV-positive/AIDS patients.

Vitamins	Mean	SD	Median	RDA/AI	% of patients < 67% RDA/AI
Niacin (mg)/day					
Male n=8	38.5	20.6	29.3	19	0
Female n=27	36.1	25.8	29.9	14	7.4
Whole Group n=35	36.7	24.4	29.9	11.5	5.7
Riboflavin (mg)/day					
Male	3.7	1.9	3.1	1.3	0
Female	3.1	3.3	2.5	1.1	7.4
Whole group	3.2	3.0	2.7	1.2	5.7
Thiamine (mg)/day					
Male	3.3	1.9	2.6	1.2	0
Female	3.4	2.3	2.7	1.1	7.4
Whole Group	3.3	2.2	2.7	1.2	5.7
Vitamin A (μg RE)/day					
Male	1485.9	1010.7	1171.6	900	12.5
Female	2179.3	2879.7	1221.9	700	14.8
Whole Group	2020.8	2576.6	1221.9	800	14.3
Vitamin E (mg ? TE)/day					
Male	24.03	9.92	21.3	15	0
Female	23.85	15.89	17.0	15	14.8
Whole group	23.89	14.61	20.4	15	11.4
Vitamin C (mg)/day					
Male	199.0	213.2	137.6	90	12.5
Female	223.7	225.6	139.4	75	18.5
Whole group	218.1	220.0	139.4	82.5	17.1
Vitamin D (μg)/day					
Male	10.3	6.00	9.4	15*	12.5
Female	6.2	4.5	5.0	5*	29.6
Whole Group	7.2	5.1	5.8	10*	25.7
Vitamin K (μg)/day					
Male	199.5	161.2	141.8	80*	25.0
Female	287.0	405.1	134.9	60*	11.1
Whole Group	267.0	363.7	134.9	105*	14.3
Vitamin B_6 (μg)/day					
Male	3.4	1.5	3.0	2.4	0
Female	3.0	1.7	2.6	1.3	7.4
Whole group	3.1	1.6	2.6	1.4	5.7
Vitamin B_{12} (μg)/day					
Male	16.8	15.2	10.2	1.7	0
Female	23.6	47.8	10.7	2.4	0
Whole group	22.1	42.4	10.4	2.5	0
Folate (μg)/day					
Male	406.7	280.8	287.4	400	37.5
Female	399.4	300.3	332.7	400	33.3
Whole group	401.1	291.9	332.1	400	34.3

*Adequate Intake

12. Abrams B, Duncan D & Hertz-Picciotto. A prospective study of dietary intake and Acquired Immune Deficiency Syndrome in HIV-1 sero-positive Homosexual Men. J Acquir Immune Defic Syndr 1993; **6**: 949-958.
13. Baum MK, Shor-Posner G, Lu Y. Micronutrient and HIV-1 disease progression. AIDS 1995; **9** (9): 1051-1056.
14. Fawzi WW & Hunter DJ. Vitamins in HIV disease progression and vertical transmission. Epidemiology 1998; **9** (4): 457-466.
15. Kupka R & Fawzi W. Zinc nutrition and HIV infection. Nutrition Reviews 2002; **60** (3): 6979.
16. Friis H & Michaelsen KF. Micronutrients in HIV infection: a review. European J Clin Nutr1998; **52**: 157-163.
17. Chleboski RT, Grosvenor MB, Kruger S *et al*. Dietary intake of HIV infection: relative caloric deficiency in patients with AIDS. In: proceedings of the fifth International Conference on AIDS. Montreal, Canada (Abst 467), 1989.
18. Dworkin BM, Axelrod F, Pierre N *et al*. An analysis of nutrient in patients with AIDS, AIDS-related complex (ARC) and asymptomatic HIV positive control. Gastroenterology 1989; **96**: 133.
19. Kotler DP, Tierney AR, Brenner S. Preservation of short-term energy balance in clinically stable patients with AIDS. Am J Clin Nutr 1990; **51**: 7-13.
20. Hellerstein MK, Kahn J, Mudie, Viteri F. Current approach to the treatment of human immunodeficiency virus-associated weight loss: pathophysiologic considerations and emerging management strategies. Semin Oncol 1990; **17**: 17-33.
21. Phuapradit W, Chaturachinda K, Taneepanichskul *et al*. Serum vitamin A and beta-carotene levels in pregnant women infected with human immunodeficiency virus-1. Obstet. Gynecol 1996; **87**: 564-567.
22. Dannhauser A, Van Staden AM, Van der Ryst E *et al*. Nutritional status of HIV-1 sero-positive patients in the Free State Province of South Africa: Anthropometric and dietary profile. European J Clin Nutr 1999; **53**: 165-173.
23. Dworkin BM, Wormser GP, Axelrod F *et al*. Dietary intake in patients with acquired immunodeficiency syndrome (AIDS), patients with AIDS-related complex and serologically positive human immunodeficiency virus patients: correlations with nutritional status. J Pop Epi Nutr 1990; **14**: 605-609.
24. Dwyer JT. Dietary assessment. In: Modern nutrition in health and disease. ME Shills, JA Olson, M Shike & AC Ross (eds) 9th Edition. Philadelphia, Lea & Febiger 1998: 942.
25. Willett WC. The cellular immune system and its role in host defence, New York, NY: Churchill Livingstone Inc, 1990: 101-138.
26. Paton NIJ, Macallan DC, Jebb SA *et al*. A comparison of methods for measuring changes in fat-free mass in patients with AIDS. Proc Nutr Soc 1996, **56**: 153.
27. Hammond KA. Dietary and Clinical Assessment In: Mahan LK & Escott-Stump S (eds). Kraus's Food Nutrition & Diet Therapy. 11th Edition Philadelphia: WB Saunders Co., 2004: 372.
28. Langenhoven ML, Kruger M, Gouws E *et al*. Medical Research Council (MRC) Food Composition Tables 4th Edition. Parow, South Africa: National programme Nutritional Intervention Medical Research Council, 1998.
29. USA Food & Nutrition Board. Institute of Medicine DRI: dietary reference intakes for vitamin A, K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium and zinc. Washington, DC: National Academy Press, 2001: 3-78.

30. WHO. Nutrient requirements for people living with HIV/AIDS. Report of a technical consultation. WHO, Geneva 2001: 1-16
31. Hogg RS, Zadra JN, Chan-Yan C. Analysis of nutritional intake in a cohort of homosexual men. J Acquir Immune Defic Syndr Hum Retrovirol 1995; **9**: 162-167.
32. Kim JH, Spiegelman, Rimm Eric *et al*. The correlates of dietary intake among HIV-positive adults. Am J Clin Nutr 2001; **74** (6): 852-861.
33. Walsh C, Bester I & Veldman D. Dietary intake of HIV-positive women (25-44 years) in Mangaung. A preliminary research report 2001: 1-20.
34. Drewnowski A & Popkin BM. The nutrition transition. New trends in the global diet. Nutrition Reviews 1997; **55** (2): 31-43.
35. Maclntyre UE. Dietary intake of Africans in transition in the North-West Province, PhD thesis, Potchefsroom PU for CHE 1998: 21-44.
36. Woznicki D & D'Alessandro G. Nutrition against AIDS. Am Council of Sc & Health 1997; **9** (2): 1-4.
37. Jariwalla RJ. Micronutrient imbalance in HIV infection and AIDS: Relevance to pathogenesis and therapy. J Nutritional & Environmental Medicine 1995; **5** (3):297-204.
38. Harriman GR. Vitamin B-12 malabsorption in patients with acquired immunodeficiency syndrome. Annals of Internal Medicine 1989; **149** (9): 2039-2041.
39. Nolan D, Upton R, James I. Longitudinal analysis of bone mineral density (BMD) in HIV-infected patients treated with HAART. Second International Workshop on Adverse Drug Reactions and Lipodystrophy in HIV, Toronto (Abst 031) 2000.
40. Bowers JM. Nutrition and Immunity. ACRIA Update 2002; **11** (2): 1-4.
41. Bogden JD, Baker H, Frank O. Micronutrient status and human immunodeficiency virus (HIV) infection. New York Acad Sci 1990; **587**: 189-195.
42. Tang AM, Graham NMH, Kirby AJ Dietary micronutrient and risk of progression to acquired immunodeficiency syndrome (AIDS) in human immunodeficiency virus type 1 (HIV-1)-infected homosexual men. Am J Epidemiol 1993; **138**: 1-15.
43. Cairns G. Vitamins, minerals and other supplements: Conference Report 2001: 1-63.
44. Sullivan PS, Hanson DL, Chu SY *et al*. Epidemiology of anaemia in human immunodeficiency virus (HIV)-infected persons: results from the multistate adult and adolescent spectrum of HIV disease surveillance project. Blood 1998; **91** (1): 301-308.
45. Mocroft A, Kirk O, Barton SE, Dietrich M, Proenca R. Anaemia is an independent predictive marker for clinical prognosis in HIV-infected patients from across Europe. EuroSIDA study group. AIDS 1999; **13** (8): 943-950.
46. Semba RD, Shah N, Klein RS *et al*.. Human Immunodeficiency Virus Epidemiology Research) Study Group. Highly active antiretroviral therapy associated with improved anaemia among HIV-infected women. AIDS Patient Care STDS 2001; **15** (9): 473-480.
47. Hoffman R. Nutrients to boost immunity: www.consciouschoice.com 1998 (Accessed on 7 August 2004).
48. Chan G & Collins J. Antioxidants may still have a role in HIV treatment. Treatment Issues 1997; **11** (9): 1-25.
49. Malvy DJM, Richard MJ, Arnaud J. Relationship of plasma malondialdehyde, vitamin E and antioxidant micronutrients to human immunodeficiency virus-1 seropositivity. Clinica Chimica Acta 1994; **224**: 89-94.
50. Sappey C, Leclercq P, Coudray C *et al*. Vitamin, trace element and peroxide status in HIV seropositive patients: asymptomatic patients present a severe ?-carotene deficiency. Clinica Chimica Acta 1994; **230**: 35-42.
51. Fawzi WW, Msamanga GL, Spiegelman D. For the Tanzania Vitamin and HIV Infection Trial Team. Randomized trial of effects of vitamin supplements on pregnancy outcomes and T-cell counts in HIV-1-infected women in Tanzania. Lancet 1998; **351**: 1477-1482.
52. Hattingh Z. The relationship between anthropometry, dietary intake and type 2 diabetes mellitus. M.Tech Thesis, Technikon Free State, Bloemfontein 2001 pp 1-22.
53. Vorster HH, Oosthizen W, Jerling JC *et al*. The nutritional status of South Africans. A review of the literature from 1975-1996. Durban. Health Service Trust 1997; **1**: 1-48.
54. Tang AM, Graham NMH, Saah AJ. Effects of micronutrient intake on survival in human immunodeficiency virus type 1 infection. Am J Epidemiol 1996; **143**: 1244-1256.
55. Watson RR. Nutrition and AIDS. CRC Oress, Boca Raton, London 1994: 120-130.
56. Flodin NW. Pharmacology of micronutrients. Allan Rev Liss Inc 1988 7: 201-244
57. Oguntibeju OO, van Schalkwyk FE, van den Heever WMJ & Veldman FJ. A review of the role of vitamin C in health. Mary Slessor J Med 2003; **3** (2): 75-81.
58. Ross AC. The relationship between immunocompetence and vitamin A. In: Sommer A, West KE, eds. Vitamin A deficiency: health, survival and vision. New York: Oxford University Press 1996: 251-268.
59. Karter DL, Karter AJ, Yarrish R. Vitamin A deficiency in nonvitamin supplemented patients with AIDS: a cross-sectional study. J Acquir Immunodefic Synd Hum Retrovirol 1995; **8**:199-204.
60. Van Staden AM, Barnard HC, Nel M *et al*. Nutritional status of HIV-1 sero-positive patients in the Free State Province of South Africa-laboratory parameters. Cent African J Med 1998; **44** (10): 246-250.
61. Rich KC, Fowler MG, Mofenson LM. Maternal and infant factors predicting disease progression in HIV-1-infected infants. Pediatrics 2000; **105**: E8.
62. Dworkin BM, Wormser GP, Rosenthal WS e*t a*l. Gastrointestinal manifestations of AIDS: a review of 22 cases. Am J Gastroenterol 1985; **80**: 774-778.
63. Haug CJ. Severe deficiency of 1, 25-dihydroxyvitamin D3 in human immunodeficiency virus infection: association with immunological hyperactivity and only minor changes in calcium homeostasis. J Clin Endocrinology & Metabolism 1998; **83** (11): 3832-3838.