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ORIGINAL PAPER

NUTRITIONAL STATUS, MORPHOLOGICAL AND BIOCHEMICAL BLOOD PARAMETERS IN HIV-POSITIVE ADULTS FROM NORTHERN POLAND[1]

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Abstract

Since the onset of the HIV/AIDS epidemic, nutrition has been considered an important factor in the course of infection. The study enrolled 150 HIV-positive adults (21-58 years) and 150 control group adults from Gdansk and Bialystok, within the same age, sex and education. Dietary intake was assessed together with hematological and biochemical parameters. HIV-positive adults had a 5-33% lower intake of 15 nutrients. The most significantly different from the control ($P < 0.05$) were vitamins B and folic acid, vitamin A, vitamin C, iron, zinc, and copper. When considering the percentage of the Estimated Average Requirement (% of the EAR), the most severe nutritional deficiencies were found for folic acid, vitamin D and calcium (<52% of EAR). When taking into account the level of total intake (diet plus supplements) a severe deficiency remained only for calcium and vitamin D, with 47-58% of the EAR. In contrast, a higher intake of 15 nutrients has been reported in HIV-positive adults as compared to the control group, with the most significant increase of the daily intake for vitamins B (B_1, B_3, B_{12},

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folic acid), vitamin A, vitamin C, vitamin D, vitamin E, sodium, iron, and copper (22-120%). The differences observed in the increased intake between the groups correlated with higher daily diet supplementation by HIV-positive participants ($P < 0.041$). Interestingly, the supply of vitamin D, vitamin B_6 and vitamin E was increased in 41 immunocompromised participants (27.3%) with white blood cell (WBC) counts below $4.3 \cdot 10^3$ μL^{-1}, by: 23.5%, 10.1% and 6.6%, respectively ($P < 0.05$). In contrast, the supply of folic acid (20.8%), iron (14.2%), vitamin B_{12} (12.4%), copper (8.1%) and vitamin C (7.1%) was significantly decreased ($P < 0.05$). Higher $CD4^+T$ cells count ≥ 400 cells μL^{-1} was observed in women compared to men ($P < 0.05$). The total cholesterol level was significantly decreased in WBC counts below $4.3 \cdot 10^3$ μL^{-1} (167.6 ± 33.98 *vs.* 193.2 ± 48.59 mg dL^{-1}, $P < 0.020$) as compared to high WBC counts. Targeted nutritional intervention may improve the nutritional intake and biochemical status of HIV-positive adults.

Keywords: HIV, $CD4^+T$ cells, food frequency questionnaire, vitamins, minerals.

INTRODUCTION

At the end of 2016, 36.7 million people (17.8 million women and 16.7 million men) were estimated to be living with HIV and nearly 1.8 million people had become newly infected with HIV, while 1.0 million had died during the same year. 53% of infected people living with HIV were receiving antiretroviral treatment in 2016, according to WHO HIV/AIDS report.

Highly active antiretroviral therapy (HAART) is effective in prolonging survival in HIV-infected people by suppressing viral replication and restoring the immune function. However, while HAART restoration of the immune system is primarily achieved, antiretroviral therapy does not eliminate weight loss and wasting, which continue to be the strong independent predictors of mortality.

Even in populations not infected with HIV, nutritional intake is an often--overlooked factor in the disease progression, although the relation between nutrition and the immune function is well established (Chandra 1999, Gay, Meydani 2001, Bogden, Olaske 2007, Majewski et al. 2016, 2017*a*).

This can raise the possibility that normalization of the status of micronutrients may increase the quality of life and prolong the survival period (Baum et al. 1995, Faintuch et al. 2006, Majewski et al. 2017*b*).

Micronutrient supplementation is beneficial among the HIV infected population (Fawzi et al. 2004*b*, Mehta, Fawzi 2010). However, the surplus of micronutrients may also become harmful, as high intakes of vitamin A, selenium, zinc and iron are associated with progression of AIDS (Sappey et al. 1995, Fawzi et al. 2002, 2004*a*, McClelland et al. 2004, Bogden, Oleske 2007). High daily vitamin C and calcium intakes change the pharmacokinetics of certain HIV medications (Jensen-Fangel et al. 2003, Slain et al. 2005).

These studies raise concern about the risk of increased toxicity or viral resistance in instances where curative drug pharmacokinetics is enhanced and supplementation with high micronutrients implemented.

Abnormally low concentrations of plasma minerals: selenium, zinc, iron, calcium and magnesium, are likely to occur in the majority of HIV seropositive adults and children. The same has been reported for vitamins A, E, C, B_6,

B_{12}, carotenes and total choline. Conversely, copper, folate and carnitine have been shown to be increased (Baum et al. 1995, Constans et al. 1995, Periquet et al. 1995, Bogden, Oleske 2007, Doddigarlaa et al. 2013). Decrease in vitamin B_6 might be due to the increased activity of enzyme Kynurenine aminotransferase (Majewski et al. 2016), which produces in brain toxic kynurenic acid and thus is responsible for psychotic symptoms in HIV-1 infected patients (Atlas et al. 2006, Majewski et al. 2018). B_2 deficiency is able to inhibit Kynurenine 3-monooxygenase, thus promoting kynurenic acid formation (Majewski et al. 2016).

Development of the deficiency of vitamin A or vitamin B_{12} is associated with a decline in the $CD4^+$T cell count, while normalization of vitamin A, vitamin B_{12} and zinc is associated with a higher $CD4^+$T cell count (Baum et al. 1995). However, excessive dietary zinc intake is linked to reduced survival (Baum et al. 2003). Also, normalization of the plasma selenium level is related to a lower risk of mortality and an increased $CD4^+$T cell count in the first year of the follow-up (Kupka et al. 2004). Jiamton et al. (2003) reported that supplementation with low doses of multivitamins for one year may reduce mortality in subjects with baseline $CD4^+$ counts <100 cells μL^{-1}.

Only a few studies have assessed the dietary intake of HIV adult outpatients. Semba et al. (1995) and Kupka et al. (2004) observed the effects of vitamin A and selenium on HIV progression. Lebiedzińska et al. (2009*a*) reported a low energy intake in daily diet with a small protein and carbohydrate content but a high fat level. In another study, vitamins C, E, and vitamins from B group were below the dietary reference values (Lebiedzińska et al. 2009*b*).

In order to achieve normal plasma nutrient values, HIV-positive patients appear to require an intake of some vitamins (A, E, B_6, B_{12}) and minerals (zinc). Dietary supplementation may mollify some of these deficiencies, although high doses should be discouraged in daily supplementation.

The aim of this study was to provide a comprehensive assessment of the nutrient intake and the hematological and biochemical status of Polish HIV-positive adults, and to investigate if there are nutritional differences compared with HIV-negative adults.

MATERIAL AND METHODS

Subjects

The study was based on a survey conducted among patients treated in the Department of Infectious Diseases and Hepatology at the Medical University of Bialystok and Department of Infectious Diseases of Gdansk, Poland, remaining under clinical observation of Adult Consulting Points.

First, participants were asked to complete a general questionnaire comprising socio-demographic and anthropometric elements (Tables 1 and 2)

Table 1

Characteristics of male participants

Specification	HIV-positive n = 92 (61.3%)	Control group n = 96 (64%)	P value
Age, years	34.87 ± 6.711	36.32 ± 11.44	0.683[$]
Body composition			
weight (kg)	73.74 ± 10.34	79.44 ± 13.78	**0.038[#]**
height (cm)	178.1 ± 7.054	177.2 ± 8.014	0.488[$]
BMI (kg m^{-2})	22.27 ± 3.164	24.97 ± 2.472	**0.011[#]**
WHR	0.942 ± 0.074	0.950 ± 0.112	0.698[$]
$CD4^+T$ (cells count, μL^{-1})	368.1 ± 139.4 (124-597)		
Categories, n (%)			
non-malnourished	96	100	0.765*
at risk	4	0	
malnourished	0	0	
material situation, n (%)			
not satisfied	47	10.5	**<0.001***
satisfied	53	89.5	
Source of nutrition information, n (%)			
TV, radio, books	23	28	**<0.025[€]**
internet	13	2	
family	17	70	
friends and clinic	29	0	
not-interested	18	0	
Taking micronutrients, n (%)			
no	41	67	**0.025***
yes	59	33	
vitamins	3	8	
minerals	25	25	
vitamins and minerals	61	50	
other	11	17	

Data are presented as % of sample, mean ± SD or median (Q1–Q2).
$P < 0.05$ (*chi-square test, [#] nonparametric Wilcoxon rank sum test,
[$] independent samples t-test, [€]ANOVA with *post-hoc* Tukey test)

including: sex, age, material situation, education and body composition (weight, height to further calculate body mass index BMI and waist-to-hip ratio for WHR measurement). Commonly accepted BMI ranges are (kg m^{-2}) underweight under 18.5, normal weight 18.5 to 25, overweight 25 to 30, obese over 30. The BMI and WHR have been used as an indicator to measure

Table 2

Characteristics of female participants

Specification	HIV-positive n = 58 (38.7%)	Control group n = 54 (36%)	P value
Age, years	33.39 ± 8.361	32.68 ± 9.572	0.813[$]
Body composition			
weight (kg)	63.20 ± 12.12	68.61 ± 12.27	**0.029[#]**
height, (cm)	167.1 ± 7.022	165.5 ± 6.562	0.561[$]
BMI (kg m^{-2})	21.62 ± 3.122	24.70 ± 3.471	**0.035[#]**
WHR	0.792 ± 0.051	0.771 ± 0.125	0.268[$]
$CD4^+T$ (cells count, μL^{-1})	384.0 ± 138.2 (209-435)		
Categories, n (%)			
non-malnourished	96	90	0.590*
at risk	3	10	
malnourished	1	0	
Material situation, n (%)			
not satisfied	57	3	**<0.001***
satisfied	43	97	
Source of nutrition information, n (%)			
TV, radio, books	34	43	**<0.038[€]**
Internet	20	3	
family	20	41	
friends and clinic	21	13	
not-interested	5	0	
Taking micronutrients, n (%)			
no	49	61	**0.041***
yes	51	39	
vitamins	2	5	
minerals	27	37	
vitamins and minerals	71	58	
other	0	0	

Data are presented as % of sample, mean ± SD or median (Q1–Q2), $P < 0.05$ (*chi-square test, [#] nonparametric Wilcoxon rank sum test, [$] independent samples t-test, [€] ANOVA with *post-hoc* Tukey test).

the risk of developing serious health conditions. The WHO states that abdominal obesity is defined as a waist-hip ratio above 0.90 for males and above 0.85 for females.

The second part of the survey was constructed exclusively for this study

and included monitoring of the daily intakes of micronutrients, checked once a day, few times a week, or once a week.

Dietary recall

The third part of the study included a 24-hour dietary recall by trained dieticians and was analyzed with *'Diet 4.0'* computer program prepared by the National Food and Nutrition Institute in Warsaw for energy intake and nutrient analysis. During the recall, the participants needed to report the types and quantities of all foods and beverages consumed during a normal day at home. After 2-3 days, another 24-hour interview was carried out for comparison of the variability in nutrient intake among the subjects. The results were compared with the control group (Table 3) and with the Estimated Average Requirement (Table 4).

Biochemical and hematological parameters

Fasting blood samples were collected from the arm vein and further tested for the morphological (SYSMAX XT4000i apparatus) and biochemical status (COBAS INTEGRA 400plus apparatus). Levels of blood parameters were considered as deficient if below reference values.

The blood total cholesterol profile was used to determine the correlation with the cholesterol content in daily diet. The same was done for blood hemoglobin *vs.* daily iron intake, plasma glucose *vs.* sugar intake, HDL cholesterol *vs.* dietary fat content and blood triglycerides *vs*. fat content in daily diet.

In addition, relations between the WBC and nutrient intake, as well as the WBC and blood hematological/biochemical parameters were analyzed.

In order to investigate potential nutritional errors in the HIV-positive population, the present study compared daily food intake and hematological/biochemical status of HIV-positive adults together with the control group, as well as with the current Estimated Average Requirements. If no EAR was stated, the Adequate Intake (AI) was used.

Data analyses

Data are expressed as a mean ± standard deviation (SD) and as a percentage of the surveyed participants. Homogeneity of variance was tested for all data using the Levene's test and data distribution was checked with the Shapiro-Wilks test at α 0.01. For parametric variables, Student's *t*-test was used to compare two experimental groups and one-way ANOVA with the Tukey *post-hoc* test. For nonparametric calculations, the Wilcoxon and *U*-Mann-Whitney tests were used. The chi-square test was applied in an analysis of eating disorders and nutrients intake. The threshold level of significance was set at $P < 0.05$ using SPSS (version 24.00) software.

Table 3

Energy and nutrient intake including daily dietary intake and total daily nutrient intake (with supplements) of the HIV-positive and HIV-negative participants

Specification	Supplement users†	Daily dietary intake			Total daily intake with nutrients		
		HIV-positive (n = 150)	control group (n = 150)	*P value	HIV-positive (n = 150)	control group (n = 150)	*P value
1	2	3	4	5	6	7	8
Energy (MJ)		10.2 ± 5.5	9.51 ± 4.3	0.981	10.2 ± 5.5	9.51 ± 4.3	0.981
Energy (kcal)		2436 ± 1296	2271 ± 1040	0.692	2436 ± 1296	2271 ± 1040	0.692
Carbohydrate (g)		315 ± 194	324 ± 168	0.468	315 ± 194	324 ± 168	0.468
Carbohydrate (En%)		52.16 ± 10	57.1 ± 10	0.758	52.16 ± 10	57.1 ± 10	0.758
Protein		80 ± 42	92 ± 38	0.049	80 ± 42	92 ± 38	0.049
Protein (En%)		13.13 ± 3.8	16.2 ± 3.3	0.165	13.13 ± 3.8	16.2 ± 3.3	0.165
Fat (g)		116 ± 56	95 ± 51	0.031	116 ± 56	95 ± 51	0.031
Fat (En%)		42.8 ± 8.4	37.6 ± 9.3	0.044	42.8 ± 8.4	37.6 ± 9.3	0.044
Vitamin B_1 (mg)	10%	0.798 ± 0.443 (79.80%)	0.978 ± 0.491 (97.85%)	0.005*	1.300 ± 0.802 (130.0%)	1.046 ± 0.58 (104.6%)	<0.001*
Vitamin B_2 (mg)	15%	1.130 ± 0.476 (113.0%)	1.311 ± 0.495 (131.1%)	0.025*	1.505 ± 0.704 (150.5%)	1.546 ± 0.648 (154.6%)	0.696
Vitamin B_3 (mg)	10%	8.958 ± 4.491 (77.90%)	13.44 ± 8.251 (116.8%)	0.046*	17.82 ± 9.927 (154.9%)	15.65 ± 10.67 (136.0%)	<0.001*
Vitamin B_6 (mg)	23.8%	1.149 ± 0.517 (104.5%)	1.264 ± 0.361 (114.9%)	0.076	1.655 ± 0.828 (150.4%)	1.788 ± 0.567 (162.5%)	0.839
Vitamin B_{12} (μg)	23.8%	1.615 ± 0.594 (80.75%)	1.957 ± 1.143 (97.85%)	0.019*	3.435 ± 1.404 (171.7%)	3.185 ± 2.067 (159.2%)	0.048*
Folic acid equivalents (μg)	20%	164.2 ± 98.52 (51.30%)	185.4 ± 87.06 (57.95%)	0.018*	240.1 ± 160.1 (75.01%)	222.8 ± 116.2 (69.61%)	0.025*
Vitamin A (μg)	23%	740.7 ± 402.9 (131.1%)	842.7 ± 350.4 (149.1%)	<0.001*	1004 ± 606.8 (177.7%)	910.6 ± 420.7 (161.2%)	<0.001*
Vitamin C (mg)	26%	48.73 ± 16.65 (72.20%)	73.10 ± 44.11 (108.3%)	<0.001*	91.34 ± 34.67 (135.3%)	81.4 ± 54.58 (120.6%)	0.014*

cont. Table 3

1	2	3	4	5	6	7	8
Vitamin D (μg)	10%	4.111 ± 1.843 (41.15%)	4.512 ± 1.941 (45.12%)	0.057	5.760 ± 2.869 (57.60%)	4.512 ± 2.157 (45.12%)	<0.001*
Vitamin E (mg)	23%	6.071 ± 2.876 (67.45%)	6.412 ± 2.853 (71.25%)	0.056	12.98 ± 6.832 (144.2%)	7.225 ± 3.572 (80.28%)	<0.001*
Sodium (mg)		3765 ± 1697 (251.1%)	2710 ± 1164 (180.7%)	0.455	3765 ± 1885 (251.0%)	2710 ± 1293 (180.7%)	<0.001*
Potassium (mg)		3022 ± 1233 (64.30%)	2623 ± 976.2 (55.80%)	0.039*	3022 ± 1369 (64.30%)	2622 ± 1084 (55.81%)	0.228
Calcium (mg)	20%	342 ± 199.5 (42.75%)	372.4 ± 186.9 (46.55%)	0.245	378.2 ± 245.1 (47.27%)	393.8 ± 219.7 (49.23%)	0.550
Phosphorus (mg)		1268 ± 538.7 (218.7%)	1114 ± 399.3 (192.1%)	0.121	1268 ± 598.5 (218.7%)	1114 ± 443.7 (192.1%)	0.214
Magnesium (mg)	23%	210.3 ± 96.41 (68.40%)	213.2 ± 74.71 (69.35%)	0.765	284.1 ± 144.7 (92.40%)	277.7 ± 108.1 (90.33%)	0.354
Iron (mg)	26%	4.389 ± 2.236 (62.70%)	6.517 ± 3.625 (93.10%)	0.008*	13.57 ± 7.683 (193.8%)	7.242 ± 4.476 (103.4%)	<0.001*
Zinc (mg)	22%	7.002 ± 2.601 (86.45%)	7.849 ± 2.965 (96.90%)	0.048*	10.00 ± 4.128 (123.5%)	9.835 ± 4.128 (121.4%)	0.689
Copper (mg)	10%	0.632 ± 0.376 (90.25%)	0.831 ± 0.351 (118.7%)	<0.001*	1.380 ± 0.913 (197.1%)	1.072 ± 0.503 (153.1%)	0.024*

Data are presented as mean ± SD and/or (%) of norm realization;
* Comparison of HIV-positive *vs.* HIV-negative participants, $P < 0.05$ (independent samples *t*-test),
† Number of subjects consuming micronutrients *via* a dietary supplement.

Table 4

The content and percentage of the norm of energy and total daily nutrient intake (including supplementation) in men and women

Nutrient	Nutritional reference values*			HIV-positive†		Control group†	
		men	women	men $n = 92$	women $n = 58$	men $n = 96$	women $n = 54$
1	2	3	4	5	6	7	8
Energy (MJ**)	EER	11.2	8.8	11.87 ± 4.82	9.374 ± 4.05	11.37 ± 4.79	8.787 ± 3.492
Vitamin B_1 (mg)	EAR	1.1	0.9	1.57 ± 0.968 (142.7%)	1.03 ± 0.635 (114.4%)	1.282 ± 0.715 (116.5%)	0.81 ± 0.452 (89.56%)
Vitamin B_2 (mg)	EAR	1.1	0.9	1.80 ± 0.842 (163.6%)	1.21 ± 0.566 (134.4%)	1.851 ± 0.776 (168.3%)	1.24 ± 0.520 (137.8%)
Vitamin B_3 (mg)	EAR	12	11	20.35 ± 11.34 (169.6%)	15.29 ± 8.517 (138.9%)	18.03 ± 12.29 (150.3%)	13.26 ± 9.045 (120.5%)
Vitamin B_6 (mg)	EAR	1.1	1.1	1.77 ± 0.885 (160.9%)	1.54 ± 0.770 (139.7%)	1.906 ± 0.605 (173.3%)	1.67 ± 0.530 (151.8%)
Vitamin B_{12} (μg)	EAR	2.0	2.0	3.65 ± 1.492 (182.5%)	3.22 ± 1.316 (160.9%)	3.3 ± 2.142 (165%)	2.87 ± 1.863 (143.5%)
Folic acid equivalents (μg)	EAR	320	320	296 ± 197.3 (92.5%)	224 ± 149.3 (70%)	248.8 ± 129.8 (77.75%)	176.8 ± 92.24 (55.25%)
Vitamin A (μg)	EAR	630	500	1201 ± 725.9 (190.6%)	807.8 ± 488.3 (161.6%)	1095 ± 505.9 (173.9%)	725.9 ± 335.4 (145.2%)
Vitamin C (mg)	EAR	75	60	107.0 ± 40.61 (142.7%)	75.67 ± 28.72 (126.1%)	139.9 ± 93.80 (186.5%)	103.0 ± 69.06 (171.7%)
Vitamin D (μg)	EAR	10	10	6.18 ± 3.078 (61.8%)	5.11 ± 2.545 (51.10%)	5.75 ± 2.749 (57.50%)	4.98 ± 2.380 (49.80%)
Vitamin E (mg)	AI	10	8	15.22 ± 8.013 (152.2%)	10.74 ± 5.653 (134.2%)	8.83 ± 4.366 (88.3%)	5.62 ± 2.779 (70.25%)
Sodium (mg)	AI	1500	1500	3900 ± 1953 (260%)	3630 ± 1817 (242%)	2845 ± 1357 (189.7%)	2575 ± 1229 (171.7%)
Potassium (mg)	AI	4700	4700	3445 ± 1561 (73.3%)	2599 ± 1178 (55.30%)	3045 ± 1259 (64.79%)	2199 ± 909.2 (46.79%)
Calcium (mg)	EAR	800	800	430.4 ± 278.9 (53.79%)	325.9 ± 211.1 (40.74%)	446 ± 248.8 (55.75%)	341.6 ± 190.5 (42.70%)

cont. Table 4

1	2	3	4	5	6	7	8
Phosphorus (mg)	EAR	580	580	1331 ± 628.2 (229.5%)	1205 ± 568.7 (207.8%)	1177 ± 468.7 (202.9%)	1051 ± 418.6 (181.2%)
Magnesium (mg)	EAR	350	265	351.6 ± 179.1 (100.5%)	216.7 ± 110.3 (81.77%)	344.4 ± 134.1 (98.40%)	211.1 ± 82.19 (79.66%)
Iron (mg)	EAR	6	8	10.85 ± 6.143 (180.8%)	16.29 ± 9.223 (203.6%)	6.33 ± 3.913 (105.5%)	8.15 ± 5.038 (101.9%)
Zinc (mg)	EAR	9.4	6.8	12.42 ± 5.127 (132.1%)	7.59 ± 3.133 (111.6%)	12.22 ± 5.130 (130%)	7.45 ± 3.127 (109.6%)
Copper (mg)	EAR	0.7	0.7	1.47 ± 0.972 (210.1%)	1.29 ± 0.853 (184.3%)	1.164 ± 0.546 (166.3%)	0.98 ± 0.460 (140.0%)

Data are presented as mean ± SD and/or (%) of norm realization (Jarosz 2012);
AI, adequate intake; EAR, estimated average requirement; RI, recommended intake;
* In case an EAR range is given, the lower bound value is stated;
† HIV study and control group include total daily nutrient intake (diet plus supplementation);
** EER based on a physical activity level (PAL) of 1.6: light active lifestyle, 70 kg for men and 60 kg for women and 31-50 years of age.

RESULTS AND DISCUSSION

The study enrolled 150 HIV-positive participants (92 men and 58 women), age ranging from 21 to 58 years, with the mean age of 34.3 ± 9.33 years (34.87 ± 6.71 years in men and 33.39 ± 8.36 years in women). Participants aged between 30-39 years made up 32% of the infected population tested, and the largest increase was recorded in this age group. 66 men (72%) and 38 women (65%) were ≤ 45 years of age. The control group was chosen for being the same age, sex and educational level. First, the duration of the illness in each patient was determined. The majority of participants had been diagnosed over the last year, with a few cases diagnosed more than 27 years ago. The highest number of participants were diagnosed between 7 to 10 years of a HIV infection event.

Among the population studied, 3.3% were at risk of malnutrition and 1.3% was actually malnourished, with no significant difference in the control group ($P = 0.125$). Patients with AIDS had a decreased protein intake by 13%, a 7% weight loss and la ower BMI ($P < 0.035$). The waist-to-hip ratio did not differ significantly from the control group.

HIV-positive adults might be at risk of certain micronutrient deficiency due to lower food consumption, increased malabsorption and increased losses of micronutrients due to an elevated incidence of gastrointestinal tract infections, with frequent diarrhoea, as previously reported in other study (Bogden, Oleske 2007).

Transmission of HIV is more common among drug addicts, participants were asked about injecting of drugs or any illicit substances in the past history. The results are shown in Figure 1. HIV-positive users of illicit drugs are at risk of developing micronutrient deficiencies, at least partially because of their low salary income and poor dietary intake with malnutrition (Baum et al. 2003).

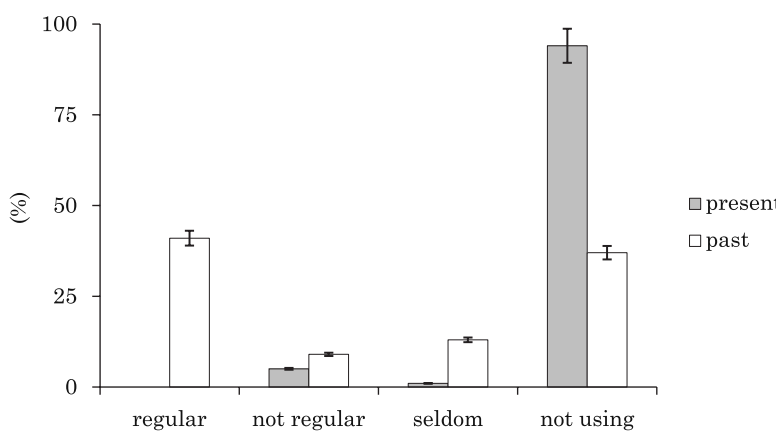

Fig. 1. Use of intravenous substances among HIV-positive participants (%)

Our survey confirmed that HIV-positive adults are less satisfied with their income and care obtained. In the HIV-positive group, 53% men and 43% women were only satisfied with the actual living situation, compared to 89.5% men and 97% women from the control group ($P < 0.001$). The low economic status, poor living conditions, depression, lack of interest in nutrition and inadequate sources of information as to the proper nutrition, have all resulted in the negative feedback from the evaluation of menus (Tables 1 and 2). Providing HIV patients with social and psychological support could minimize the negative effects of the disease on the quality of life of patients, as was previously also reported by Okuno et al. (2015).

Depression, which is common in the HIV-infected population, might be due to inadequate zinc intake and severe zinc deficiency, as previously stated (Poudel-Tandukar et al. 2016).

A $CD4^+$T cells count above 400 cells μL^{-1} was observed in 28% men and 60% women, 200-400 μL^{-1} in 56% men and 40% women and below 200 μL^{-1} in 16% men and none in women – see Tables 1 and 2. A $CD4^+$T cells count <200 cells μL^{-1} is always associated with an increased risk of a new AIDS event or death (Semba et al. 1995).

Moreover, the loss in $CD4^+$T cells was significant in male participants compare to women, 368.1 ± 139.4 *vs.* 384.0 ± 138.2 μL^{-1}, $P = 0.044$, with the median of 124-597 and 209-435 μL^{-1}, respectively (Tables 1 and 2). This is in accordance with an earlier report (Maldonado-Martínez et al. 2013).

The daily food portions analyzed supply amounts of energy within the norms for the Polish population, both men and women (Table 3). However, according to the WHO, an increase of the energy requirement is needed in HIV-positive participants in Stage I asymptomatic and Stage II symptomatic, up to 110% and 110-130% of the norm, respectively. In our study, increased needs for energy were sufficient to cover the energy requirement of 105.98% in men and 106.52% in women (Table 4).

The results indicate that the energy intake came mainly and in high amounts from fat (42.8 ± 8.4%), which considerably exceeded the recommendations for the Polish population (20-35%). Despite this, the majority of the respondents had correct BMI values.

Although the mean carbohydrate intake (52.16%) was within the requirement of 50-70% (En%), 15% of the HIV-positive adults and 8% of the HIV-negative group were below that range. Similarly to energy obtained from carbohydrates, energy from proteins (13.13 ± 8%; En%) was also found to be sufficient to cover daily requirements (10-15%).

The dietary daily intake of the HIV-positive and negative groups is shown in Table 3. When considering dietary intake only (excluding supplementation), significantly lower intakes in the HIV-population were noticed for 10 nutrients: vitamin B_3 (33.3%), vitamin C (33.3%), iron (32.6%), copper (24%), vitamin B_1 (18.4%), vitamin B_{12} (17.5%), vitamin B_2 (13.8%), vitamin A (12.1%), folic acid (11.4%) and zinc (10.8%), as compared to the intakes by

HIV-negative adults. In addition, daily intakes of vitamin B_6 (9.1%), vitamin D (8.9%), calcium (8.2%), vitamin E (5.3%) and magnesium (1.4%) were lower in the HIV-positive adults, although the differences were not significant ($P > 0.059$). This was opposite to dietary sodium, potassium and phosphorus, whose intake was higher in the HIV-positive participants.

Regarding a daily diet plus supplementation, higher intakes of 15 nutrients were determined in the HIV-positive group. The most significant increase was found for iron (120%), vitamin E (85%), vitamin B_3 (47%), vitamin C (45%), vitamin B_1 (43%), vitamin D (37%), vitamin B_{12} (25%), vitamin A (22%), and folic acid (19%) as compared to the control. Also, the increased intake of sodium and copper was found to be significant ($P < 0.024$).

The daily intakes of vitamin B_6 (7.4%), calcium (4%) and vitamin B_2 (2.6%) were within the lower range ($P > 0.550$).

When the groups were compared as to % of the EAR, most of the mean nutrients intakes (without supplementation) among the examined HIV--positive population were below the reference values, with the highest deficiencies of vitamin D, calcium, folic acid, potassium and iron. When considering a diet plus supplementation, deficiency still remained for vitamin D, calcium, folic acid and potassium, but not for iron. Similar results were obtained in the control group.

The HIV-positive participants, without consulting a specialist, supplemented their diets with either single, dual, or multiple micronutrients. Most often, self-supplementation (53% respondents) included high daily dose of multivitamins (more than 61% HIV-positive participants), vitamin E, vitamin B complexes and magnesium, calcium, iron as well as fish oil, see Table 3 for details. The differences in the increased intake between the groups correlated with higher supplementation of a daily diet by the HIV-positive participants ($P < 0.041$). This is in accordance with some earlier research (Visser et al. 2017), and may in part explain the higher daily intakes of nutrients in the HIV-positive group.

The 24-hour dietary recall revealed a better supply of nutrients in the HIV-positive men. The differences in the increased intake were correlated with higher supplementation of a daily diet by HIV-positive male participants (Table 4).

However, men had a deficient intake of some nutrients with low daily % of the EAR for folic acid (92.5%), potassium (73.3%), vitamin D (61.8%) and calcium (53.8%).

When taking into account HIV-positive women, lower intakes of magnesium (81.8%), folates (70%), potassium (55.3%), vitamin D (51.1%) and calcium (40.7%) were determined. More deficiencies persisted among the adults from the control group, both men and women. Supplementation, therefore, seems to reduce the discrepancies between the analyzed groups.

In the study group, 124 participants (82.7%) were treated with antiretroviral therapy-HAART. However, it was not the duration of the illness, but

the conditions of the immune system which had an effect on the medicinal treatment. We recorded one case of a 47-year-old participant who did not require pharmacotherapy during the last 27 years of infection. In addition, there was no correlation between gastrointestinal disorders and adverse drug reaction to HAART therapy (Table 5). However, those who reported gastrointestinal dysfunction, most often complained about the lack of appetite (89%), diarrhoea (50%), constipation (29%) and chronic oral candida (19%).

Table 5

HAART therapy *vs.* eating disorders

Specification	HAART therapy (% of sample)	
Gastrointestinal disorders (% of sample)	Yes	No
Yes	35.5	7.9
No	47.4	9.2

Non-significant difference between HAART therapy users and gastrointestinal tract disorders, $P > 0.68$ (chi-square test).

Mean hematological and biochemical parameters for the HIV-positive participants are shown in Table 6. Significantly reduced ($P < 0.05$) values of

Table 6

Hematological and biochemical parameters in HIV-positive participants

Specification	Parameters	Reference values	Men $n = 92$	Women $n = 58$
Hematological parameters	leukocytes (10^9 L^{-1})	4.3-10.0	5.34±0.219	5.40±0.293
	erythrocytes (10^{12} L^{-1})	4.7-6.1 men 4.2-5.4 women	4.300±0.089	3.977±0.085
	hemoglobin (g dL^{-1})	14-18	14.35±0.206	12.79±0.302
Biochemical parameters	creatinine (mg dL^{-1})	0.7-1.0	0.732±0.017	0.593±0.021
	plasma glucose (mg dL^{-1})	70-115	90.57±2.231	89.88±2.033
	total cholesterol (mg dL^{-1})	< 200	182.7±7.227	190.5±9.439
	HDL cholesterol (mg dL^{-1})	35-70 men 40-80 women	58.0±3.397	65.48±2.767
	triglycerides (mg dL^{-1})	50-180	160.2±10.75	114.6±15.07
	aspartate transaminase (U L^{-1})	5-40	46.82±16.205	41.17±12.61
	alanine transaminase (U L^{-1})	5-40	49.42±14.09	37.56±13.16

Data are presented as mean ± SD.

Table 7

Implementation of the nutritional standards *vs.* the count of peripheral blood leukocytes (WBC counts) in HIV-positive participants

Element		WBC counts $< 4.3 \cdot 10^3$ μL^{-1}	WBC counts $\geq 4.3 \cdot 10^3$ μL^{-1}
Vitamin B_1 (mg)	EAR	1.327 ± 0.344 (132.7%)	1.326 ± 0.453 (132.6%)
Vitamin B_2 (mg)	EAR	1.467 ± 0.255 (146.7%)	1.478 ± 0.396 (147.8%)
Vitamin B_3 (mg)	EAR	19.54 ± 4.994 (169.9%)	18.45 ± 5.295 (160.4%)
Vitamin B_6 (mg)	EAR	1.808 ± 0.348 (164.4%)	1.643 ± 0.457 (149.4%)
Vitamin B_{12} (μg)	EAR	3.084 ± 0.984 (154.2%)	3.521 ± 1.669 (176.0%)
Folic acid equivalents (μg)	EAR	227.2 ± 44.0 (71.0%)	286.8 ± 134.4 (89.62%)
Vitamin A (mg)	EAR	940 ± 312.8 (166.4%)	961.6 ± 458.8 (170.2%)
Vitamin C (mg)	EAR	90.34 ± 51.81 (133.8%)	97.18 ± 67.23 (143.9%)
Vitamin D (μg)	EAR	4.54 ± 1.790 (45.41%)	3.675 ± 1.420 (36.75%)
Vitamin E (mg)	AI	13.84 ± 3.838 (153.8%)	12.98 ± 7.116 (144.2%)
Sodium	AI	3831 ± 788.2 (255.4%)	3723 ± 1023 (248.2%)
Potassium	AI	3205 ± 592.1 (68.24%)	3017 ± 754.2 (64.2%)
Calcium (mg)	EAR	356.1 ± 83.80 (44.51%)	366.6 ± 126.7 (45.82%)
Phosphorus	EAR	1273 ± 209.6 (219.5%)	1287 ± 332.7 (221.9%)
Magnesium (mg)	EAR	291.8 ± 42.95 (94.89%)	284 ± 85.91 (92.36%)
Iron	EAR	12.77 ± 2.884 (182.4%)	14.88 ± 4.381 (212.6%)
Zinc (mg)	EAR	9.984 ± 1.776 (123.3%)	10.10 ± 2.233 (124.67%)
Copper	EAR	1.329 ± 0.251 (189.8%)	1.446 ± 0.554 (206.6%)

Data are presented as mean ± SD and (%) of norms' realization;
Comparison of WBC counts $< 4.3 \cdot 10^3$ μL^{-1} *vs.* WBC counts $\geq 4.3 \cdot 10^3$ μL^{-1} ($P > 0.05$, independent samples *t*-test)

Table 8

Hematological and biochemical parameters *vs.* the number of peripheral blood leukocytes (WBC counts) in HIV-positive participants

Element	WBC counts $< 4.3 \cdot 10^3\ \mu L^{-1}$	WBC counts $\geq 4.3 \cdot 10^3\ \mu L^{-1}$	**P* value
Erythrocytes ($10^{12}\ L^{-1}$)	4.041 ± 0.13	4.225 ± 0.076	0.190
Hemoglobin (g dL^{-1})	13.30 ± 4.682	13.87 ± 0.206	0.238
Creatinine (mg dL^{-1})	0.676 ± 0.031	0.677 ± 0.018	0.986
Plasma glucose (mg dL^{-1})	88.42 ± 2.776	91.29 ± 13.43	0.362
Total cholesterol (mg dL^{-1})	167.5 ± 8.176	193.1 ± 6.808	0.020
HDL cholesterol (mg dL^{-1})	124.7 ± 15.78	150.0 ± 10.96	0.167
Triglycerides (mg dL^{-1})	67.42 ± 4.966	58.17 ± 2.709	0.094
AST (U L^{-1})	51.37 ± 9.781	54.49 ± 9.499	0.814
ALT (U L^{-1})	67.68 ± 20.59	72.12 ± 19.49	0.871

Data are presented as mean ± SD;
* Comparison WBC counts $< 4.3 \cdot 10^3\ \mu L^{-1}$ *vs.* WBC counts $\geq 4.3 \cdot 10^3\ \mu L^{-1}$ ($P < 0.05$, independent samples *t*-test).

typical blood components: leukocytes, erythrocytes hemoglobin, creatinine and significant increase of total cholesterol, triglycerides, aspartate transaminase and alanine transaminase can be seen.

Three hematological parameters and 3 biochemical status markers were decreased in the HIV-positive participants. Decreased values were measured in 25% of the participants for leukocytes, in 34% for erythrocytes and 32% for hemoglobin. Creatinine, HDL cholesterol and plasma glucose were decreased in 36%, 18% and 5% of the HIV-positive participants, respectively. In contrast, Opposite, total cholesterol (16%), triglycerides (17%), aspartate transaminase (25%), alanine transaminase (27%), HDL cholesterol (18%) and plasma glucose (5%) were increased in HIV-infected adults. HDL cholesterol was in physiological range only in 64% of respondents.

White blood cell (WBC) counts below $4.3 \cdot 10^3\ \mu L^{-1}$ were measured in 27.5% of HIV-positive participants (11.6% women and 15.9% men). After dividing the subjects into subgroups according to WBC counts, we observed an increased supply of certain nutrients in the immunocompromised group with leukocytes below $4.3 \cdot 10^3\ \mu L^{-1}$ level. A higher degree of the daily intake of vitamins B_3, B_6, D, E and sodium was observed, although the observations were not statistically significant ($P > 0.167$) – Table 7.

Interestingly, the supply of iron, vitamin B_{12}, folic acid, copper and vitamin C was decreased in the participants with WBC counts below $4.3 \cdot 10^3$ μL^{-1}, by: 30.2%, 21.8%, 18.6%, 16.8 and 10.1%, respectively.

In addition, lower levels of all the measured parameters, except triglycerides, were found at WBC counts $< 4.3 \cdot 10^3$ μL^{-1} (Table 8). However, only the difference in total cholesterol level was statistically significant: 167.6 ± 33.98 *vs.* 193.2 ± 48.59 mg dL^{-1}, as compared to high WBC counts $\geq 4.3 \cdot 10^3$ μL^{-1} ($P < 0.020$).

There was a negative correlation between the content of the total fat in the diet and the level of HDL cholesterol in the blood. There was also a positive correlation between the content of total daily fat and the level of triglycerides in the blood. The scatterplot of these observations is shown in Figure 2.

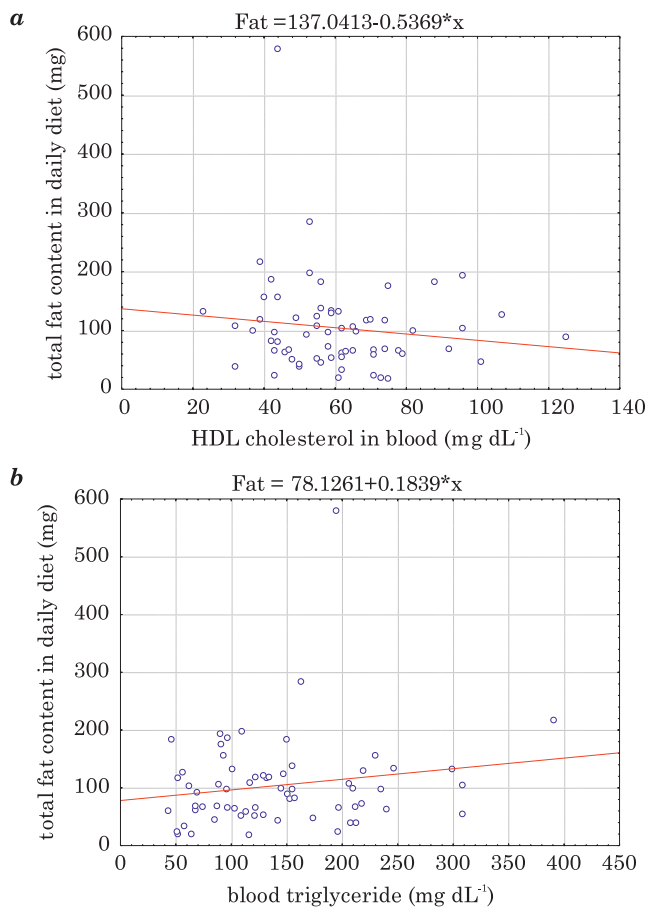

Fig. 2. The level of HDL cholesterol *(a)* and blood triglycerides *(b)* measured in blood *vs.* total fat content in daily diet

CONCLUSIONS

Dietary supplementation reduced the gap between our results and the norms for some of the nutrients, although deficiencies of folic acid, vitamin D, potassium, calcium and magnesium persisted. Supplementation of HIV-infected patients to cover % of the EARs of the above vitamins and minerals is prudent. However, there is clear evidence from the available literature data that excess of vitamin A, selenium, zinc and iron can produce adverse outcomes in the HIV-infected population, thus intake of micronutrients at high doses should be discouraged. A combination of antiretroviral drug therapy, healthy diet and low-dose micronutrient supplementation may be especially effective in the treatment of HIV infected patients.

Conflict of interests

None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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