Dietary deficiency causes abnormalities in circulating lymphocyte counts. For the present paper, we evaluated correlations between total and subpopulation lymphocyte counts (TLC, SLCs) and parameters of nutrition in peritoneal dialysis (PD) patients. Studies were carried out in 55 patients treated with PD for 22.2 ± 11.4 months. Parameters of nutritional status included total body mass, lean body mass (LBM), body mass index (BMI), and laboratory indices [total protein, albumin, iron, ferritin, and total iron binding capacity (TIBC)]. The SLCs were evaluated using flow cytometry.

Positive correlations were seen between TLC and dietary intake of niacin; TLC and CD8 and CD16+56 counts and energy delivered from protein; CD4 count and beta-carotene and monounsaturated fatty acids 17:1 intake; and CD19 count and potassium, copper, vitamin A, and beta-carotene intake. Anorexia negatively influenced CD19 count. Serum albumin showed correlations with CD4 and CD19 counts, and LBM with CD19 count. A higher CD19 count was connected with a higher red blood cell count, hemoglobin, and hematocrit. Correlations were observed between TIBC and TLC and CD3 and CD8 counts, and between serum Fe and TLC and CD3 and CD4 counts. Patients with a higher CD19 count showed a better clinical–laboratory score, especially less weakness. Patients with a higher CD4 count had less expressed insomnia.

Quantities of ingested vitamins and minerals influence lymphocyte counts in the peripheral blood of PD patients. Evaluation of TLC and SLCs is helpful in monitoring the effectiveness of nutrition in these patients.

Key words
Lymphocytes, dietary intake, nutritional status

Introduction
Malnutrition is common among peritoneal dialysis (PD) patients. Numerous factors lead to depletion of body tissue and nutrients. Among them, reduced nutrient intake (reflecting disturbed appetite) was recently proved in PD patients using an electronic appetite rating system (1).

Dietary deficiency of protein, vitamins, and minerals may cause quantitative and functional abnormalities in lymphocytes circulating in the blood. Therefore, in the present study, we evaluated correlations between total lymphocyte count (TLC) and subpopulation lymphocyte counts (SLCs) and parameters of dietary intake and nutritional status in PD patients.

Patients and methods
The study was carried out in 55 stable uremic patients of mean age 50.9 ± 12.4 years. Their PD duration was 22.2 ± 11.4 months.

Dietary intake was evaluated by computer analysis of diet histories using the software program Food, version 3.0 [Institute of Nutrition and Food Products, Warsaw, Poland (license 86)]. Examined parameters of nutritional status included anthropometric measures [total body mass (TBM), lean body mass (LBM), body mass index (BMI)] and laboratory markers [serum concentration of total protein, albumin, iron, and ferritin; total iron
binding capacity (TIBC); and peripheral blood morphology).

Clinical–laboratory scores, described by Keshaviah (2), include parameters that influence nutritional status (for example, dysgeusia, anorexia, nausea, vomiting) or that are indicators of nutrition (for example, serum albumin concentration, LBM, hematocrit). A higher score indicates "no problem"; a lower score indicates frequent or occasional problems (2). These scores were also used for correlation analyses with TLC and SLCs.

The SLCs were evaluated using flow cytometry. The analyses included CD3 cells (T lymphocytes), CD4 cells (helper lymphocytes), CD8 cells (cytotoxic-suppressor lymphocytes), CD19 cells (B lymphocytes), and CD16+56 cells (natural killer cells).

Correlation analyses were performed using the Spearman coefficient. A \( p \) value below 0.05 was considered statistically significant.

**Results**

Table I presents correlations between TLC and SLCs and dietary intake of various nutrients. The TLC correlated positively with intake of niacin; the CD4 cell count, with intake of beta-carotene and monounsaturated fatty acids; the CD8 cell count, with intake of lactose; the CD19 cell count, with intake of potassium, copper, vitamin A, and beta-carotene. We found negative correlations between dietary intake of saccharose and CD3, CD4, and CD8 cell counts. Lymphocyte counts and ingestion of protein showed no significant correlations, but TLC and CD8 and CD16+56 cell counts were positively related to energy delivered from protein expressed as percentage of total ingested energy (Figure 1). Patients without detectable anorexia had a higher number of B lymphocytes (\( r = +0.277, p = 0.040 \)).

Figures 2–5 show the correlations between TLC and SLCs and nutritional parameters (anthropometric indices and laboratory markers). Higher levels of serum iron concentration and TIBC were both connected with lower TLC and a lower CD3 count (Figure 2). The CD4 and CD8 cell counts were also negatively related to serum iron parameters. Circulating CD8 cells correlated positively with serum albumin concentration (Figure 3). The CD19 cell count correlated with positively red blood cells (Figure 4), hemoglobin concentration (Figure 4), and hematocrit. A positive correlation was also found between the CD19 cell count and serum albumin concentration, and a negative one between the CD19 cell count and LBM (Figure 4). We observed no correlations between TLC or SLCs and TBM, BMI, or serum concentration of total protein and ferritin.

Patients who did not report insomnia had higher CD4 cell counts than did those reporting insomnia in varying degrees. Patients with a higher CD19 cell count also showed higher total clinical–laboratory scores and less pronounced weakness (Figure 5).

**Discussion**

In dialyzed patients, deterioration of lymphocyte proliferation and a reduction in circulating lymphocytes is concomitantly shown with development of protein–energy malnutrition (3–5). A positive nitrogen balance is a good indicator of well-maintained nutritional status. In our previous studies (6), nitrogen balance was positively related to dietary intake of fatty acids, potassium, and energy, and thus, to nutrients also shown in the present study to influence lymphocyte count.

Serum albumin concentration correlated positively with both nitrogen balance (6) and lymphocyte subpopulations. Nitrogen balance usually improves with an increase in protein dietary intake, but that improvement also depends on ingested calories (7). A low-calorie diet causes a reduction in lymphocyte proliferation (8). In the present study, we observed no correlations between TLC or SLCs and protein intake; however, TLC and natural killer cell and CD8 cell counts were related to energy delivered from protein expressed as a percentage of total ingested energy.

### Table I

Significant correlations between lymphocyte counts and ingested nutrients in patients treated with peritoneal dialysis

<table>
<thead>
<tr>
<th>Lymphocyte type</th>
<th>Nutrient</th>
<th>Correlation coefficient</th>
<th>( p ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLC</td>
<td>Niacin</td>
<td>+0.318</td>
<td>0.018</td>
</tr>
<tr>
<td>CD3</td>
<td>Saccharose</td>
<td>-0.311</td>
<td>0.021</td>
</tr>
<tr>
<td>CD4</td>
<td>Beta-carotene</td>
<td>+0.263</td>
<td>0.049</td>
</tr>
<tr>
<td></td>
<td>Monounsaturated fatty acids</td>
<td>+0.272</td>
<td>0.044</td>
</tr>
<tr>
<td></td>
<td>Saccharose</td>
<td>-0.296</td>
<td>0.028</td>
</tr>
<tr>
<td>CD8</td>
<td>Lactose</td>
<td>+0.299</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>Saccharose</td>
<td>-0.287</td>
<td>0.034</td>
</tr>
<tr>
<td>CD19</td>
<td>Potassium</td>
<td>+0.267</td>
<td>0.049</td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>+0.277</td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td>Vitamin A</td>
<td>+0.278</td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td>Beta-carotene</td>
<td>+0.362</td>
<td>0.007</td>
</tr>
</tbody>
</table>

TLC = total lymphocyte count.
FIGURE 1  Correlations between total lymphocyte count (TLC) and CD8 and CD16+56 cell counts and energy delivered from protein expressed as a percentage of total ingested energy in peritoneal dialysis patients.

FIGURE 2  Correlations between total lymphocyte count (TLC) and CD3 cell count and serum iron concentration and total iron binding capacity (TIBC) in peritoneal dialysis patients.
FIGURE 3 Correlations between CD4 and CD8 cell counts and serum concentrations of iron and albumin and total iron binding capacity (TIBC) in peritoneal dialysis patients.

FIGURE 4 Correlations between CD19 cell count and red blood-cell count (RBC), hemoglobin (Hb) concentration, serum albumin level, and lean body mass (LBM) in peritoneal dialysis patients.
Numerous data indicate relationships between vitamins and lymphocyte proliferation and function. Increased intake of vitamin C stimulates B lymphocytes for synthesis of immunoglobulin G and M antibodies. A decrease in the serum concentration of pyridoxine reduces the circulating lymphocyte count. Low intake of folic acid contributes to reduced synthesis of antibodies. Calcitriol suppresses proliferation of Th1 helper lymphocytes and synthesis of lymphokines (9,10).

Our study did not show correlations between lymphocyte counts and dietary intake of the above-mentioned vitamins. Significant correlations were observed for TLC or SLCs and niacin, beta-carotene, and vitamin A. According to previous studies, carotenoids increase helper lymphocyte counts (11). In patients with chronic bacterial infection, patients with AIDS, and children with acute pneumonia, high supplementation with vitamin A improves CD4 and CD8 cell counts and synthesis of immunoglobulins (12–15). The influence of beta-carotene on the immune system is probably connected to metabolism of vitamin A (16).

Deficiency of exogenous fatty acids deteriorates the structure of lymphocyte cellular membranes, which reduces their proliferation and differentiation. Polyunsaturated fatty acids are involved in the synthesis of immunosuppressive prostaglandins E2 and I2, which reduce proliferation of T lymphocytes and generation of lymphokines (17). In our study, dietary intake of monounsaturated fatty acids was positively related to the CD4 cell (helper lymphocyte) count.

In the study patients, intake of minerals (potassium, copper) positively influenced SLCs, particularly the CD19 cell count. We observed no significant correlations between TLC or SLCs and dietary iron intake. Moreover, in our study, serum iron concentration and TIBC (but not serum ferritin level) were negatively related to TLC and CD3 (T lymphocyte) and CD4 (helper lymphocytes) cell counts. Previous studies have shown that iron overload or repeated blood transfusions may exert a suppressive effect on T lymphocyte function (18,19).

Generally, PD patients with anorexia are suspected to have lower lymphocyte counts. Our study confirmed that suspicion for B lymphocytes. Among all examined nutrients, only saccharose (but not lactose) intake was negatively related to SLCs. That observation needs further investigation.
In our PD patients, we observed positive correlations between the B lymphocyte count and the red blood cell count, hemoglobin concentration, and hematocrit. That effect may be partially explained by administration of recombinant human erythropoietin, which not only promotes red cell formation, but also enhances proliferation of B lymphocytes (20).

The negative correlation shown between CD19 cell count and LBM is not clear. It is noteworthy that higher SLCs in the study patients were connected with better clinical–laboratory scores, which indicate more adequate PD treatment and less pronounced insomnia and weakness.

Conclusions
Supported by previous reports, our data lead us to these conclusions:

- Quantities of ingested nutrients influence circulating lymphocyte counts in PD patients.
- Evaluation of total lymphocyte count and subpopulation lymphocyte counts is helpful in monitoring the effectiveness of nutrition in these patients.

References

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