

Original Article

Age-and Sex-Specific Reference Intervals for Blood Chemistry Analytes in Kuwaitis Aged 15 Years and Older

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ABSTRACT

Objective: There are no published reference intervals for blood chemistry analytes for Kuwaitis and yet this is important for proper management of patients. The purpose of this study was to determine the age and sex-specific reference intervals for routine blood chemistry analytes for Kuwaitis aged 15 years and over.

Methods: Using a stratified sampling method, 2500 Kuwaiti households were selected from the governorates in Kuwait. Subjects aged 15 years and over who volunteered to give blood were selected randomly to represent the age and sex distribution of the Kuwaiti population. They were visited in their homes and blood samples were drawn and analyzed for blood chemistry analytes on the Beckman's Synchron Coulter LX 20 autoanalyser. The reference interval, mean value, median value, and standard deviation for each analyte was reported for males and females and for four age groups (15-24, 25-44, 45-59 and 60-79 years).

Results: Kuwaitis had lower serum creatinine but higher serum cholesterol, triglyceride, LDL-cholesterol and uric acid concentrations than the commercially available reference intervals currently in use at the Ministry of Public Health Hospitals in Kuwait. Age-dependent differences existed for glucose, urea, potassium, calcium, phosphate, albumin, total cholesterol, triglyceride, alanine aminotransferase and LDL-cholesterol. Sex differences existed for blood urea, creatinine, albumin, HDL-cholesterol, uric acid, total bilirubin and aspartate transaminase. We did not find any significant differences in blood chemistry analytes between people from the different governorates in Kuwait.

Conclusion: We produced age and sex-specific reference intervals for blood chemistry analytes in Kuwaitis aged 15 years and older. Since the values obtained are different from the commercial reference intervals, we

KEY WORDS: blood chemistry analytes, reference intervals, adult Kuwaitis

INTRODUCTION

The words "reference values" appeared at the beginning of the 1970s associated with the Scandinavian group^[1,2]. Simultaneously with this work, some clinical chemists, essentially from North America initiated, a series of studies on the subject^[3-7]. The International Federation of Clinical Chemistry (IFCC) and a French-speaking group within Societe Francaise de Biologie Clinique (SFBC) put together a series of publications at the beginning of the introduction of the reference value concept, using the name but introducing essentially a series of theoretical recommendations^[8-20].

In clinical management of patients, physicians frequently rely on blood chemistry analytes for accurate diagnosis, proper treatment and follow-up of patients. The correct interpretation of the results from these analytes presupposes that the clinician and the laboratory medicine physician have good reference information. Although there are many published reference intervals in the

literature^[21-32], they usually do not represent adequately the specific population from which the patient comes for characteristics such as age and sex. In addition, for convenience and economy, reference values produced by reagent manufacturers are determined from analysis of blood samples of a few "normal" employees who may not represent the general population. Thus, reference information is often the weakest data provided by clinical laboratories, even though such data are critically important for the correct and proper interpretation of laboratory results.

There are no published reference intervals for blood chemistry analytes for Kuwaiti nationals. The clinical chemistry laboratories of the Ministry of Public Health hospitals rely on reagent manufacturers' published reference intervals, which, as stated above, may not adequately represent Kuwaiti nationals. The purpose of this article is to report adult reference information for routine blood chemistry analytes for Kuwaitis.

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MATERIALS AND METHODS

Subjects: The IFCC recommendation on the selection of individuals for the production of reference values^[9] was strictly followed. Briefly, the Departments of Medicine, Pathology and Community Medicine embarked upon a study of the epidemiology of rheumatic diseases in Kuwaiti nationals. From the information obtained from the Ministry of Civil Information, 2500 Kuwaiti households were randomly selected from all the governorates in Kuwait. Trained interviewers, who collected information on the demography as well as the epidemiology of rheumatic diseases, visited these households. In addition, the interviewers explained to every Kuwaiti aged 15 years and over in each household the purpose of the study on blood chemistry analytes. If they agreed to participate, they were asked to sign consent forms, and appointments were scheduled for phlebotomists to visit them at their homes to draw blood. The Faculty of Medicine, Ethical Committee on Human Research, approved the study on the prevalence of rheumatic diseases. The importance of a fasting blood specimen was emphasized to each subject. According to the IFCC'S recommendation^[9], individuals taking medication, those presenting risk factors such as excessive body weight, smoking, and those with a

particular physiological state (e.g. pregnancy, strenuous exercise), and those with known diseases (e.g. diabetes, jaundice, renal failure) were excluded from giving blood. The remaining respondents formed the subjects of this study.

Blood Collection: A blood sample was drawn using a 21-gauge, stainless steel vacutainer needle from the antecubital vein of each respondent's arm while they were in a sitting position. For logistic reasons, blood was collected early in the morning in some homes but mainly between 6 and 7 p.m in most homes before the evening meal. Approximately 10 ml of blood was obtained from each fasting respondent into a plain tube. Samples thus collected by each phlebotomist from each district were immediately transferred in a cool box to the clinical chemistry laboratory of the Department of Pathology, Faculty of Medicine, Kuwait University where they were centrifuged, and serum separated. The serum samples were then taken to the clinical chemistry laboratory of Mubarak Al-Kabeer Hospital, Jabriya where the chemistry assays were performed.

Chemical Assays: The assays were performed routinely on the Beckman's Synchron Coulter LX 20 autoanalyser using the established techniques summarized in Table 1^[33].

Table 1:

Assay methods literature reference and day to day coefficient of variations for Serum Analytes on the Beckman Synchron Coulter LX 20

| Serum Analyte | Assay Method | Reference | Reference Range Day to Day Coefficient of Variation (%) |
|----------------------------|-------------------------|-----------|---------------------------------------------------------------|
| Glucose | Enzymatic | 33 | 3 |
| Blood Urea | Enzymatic | " | 8.9 |
| Creatinine | Jaffe | " | 4.5 |
| Sodium | ISE | " | 3.0 |
| Potassium | ISE | " | 3.0 |
| Carbon dioxide | PH rate change | " | 2.8 |
| Calcium | ISE | " | 1.3 |
| Phosphate | Ammonium Molybdate | " | 1.0 |
| Total Protein | Biuret method | " | 2.0 |
| Albumin | Bromocresol Purple | " | 2.3 |
| Total Cholesterol | Enzymatic | " | 4.5 |
| Triglyceride | Enzymatic | " | 2.6 |
| Uric Acid | Enzymatic | " | 1.9 |
| Total Bilirubin | Diazo method | " | 1.9 |
| Alkaline Phosphatase | Enzymatic | " | 4.61 |
| Aspartate Aminotransferase | Enzymatic | " | 5.3 |
| Alanine Aminotransferase | Enzymatic | " | 4.61 |
| Lactate Dehydrogenase | Enzymatic | " | 5.3 |
| HDL-Cholesterol | Selective Precipitation | " | 2.2 |
| LDL - Cholesterol | Calculated | - | - |
| Corrected Calcium | Calculated | - | - |
| Osmolality | Calculated | - | - |

Statistical Methods: According to the IFCC's recommendations^[13] on the statistical treatment of data for reference values, we first tested for the homogeneity of the population by testing for Gaussian distribution of each analyte. Some of the analytes (e.g. glucose) that did not show normal Gaussian distribution were then log transformed. We calculated the intervals containing 95% values of each analyte, first by parametric method (mean \pm 2SD) and then by non-parametric method. The Mann-Whitney U test (non-parametric) was used to find the significant difference by sex, age, and age group for each analyte investigated. We tabulated both the reference values obtained by parametric and non-parametric calculations.

RESULTS

A total of 540 apparently healthy Kuwaitis aged 15 years and over and from all the governorates in Kuwait gave blood for this study. There were 300 males and 240 females with a mean age of 47.5 years.

The mean, standard deviation, and the median values for the blood chemistry analytes in the population are shown in Table 2. Although blood specimens were drawn from 540 subjects, Table 2 shows that the numbers for certain analytes were less because subjects with abnormal values (all values outside the mean \pm 3SD) for these analytes were excluded from the statistical analysis of the results.

Table 3 shows that extremely significant sex differences ($p < 0.0001$) exist for blood creatinine, albumin, uric acid, total bilirubin and alanine aminotransferase with males having higher values. Males also had significantly higher values for urea ($p = 0.001$), calcium ($p = 0.02$), and triglyceride ($p = 0.01$) than females. On the other hand, females have significantly higher HDL-cholesterol values ($p < 0.0001$) than males.

Table 4 shows the effect of age on the blood analytes of Kuwaiti subjects. Significant age differences exist for blood glucose ($p = 0.001$), blood urea ($p = 0.001$), potassium ($p = 0.001$), calcium ($p = 0.01$), phosphate ($p = 0.01$), cholesterol ($p = 0.001$), triglyceride ($p = 0.001$), alanine transaminase ($p = 0.0001$), corrected calcium ($p = 0.001$), osmolality ($p < 0.001$) and LDL-cholesterol ($p < 0.001$), which increase especially in the 60-79 year age group and serum albumin ($p < 0.0001$), which decreases with age especially in the 60-79 year age group.

Table 5 shows the mean value and standard deviation of each analyte by governorate. Except for serum triglycerides and alkaline phosphatase,

which were slightly higher in people from Jahra than in people from the Capital, there were no significant differences in the values of serum analytes between people from the different governorates.

Table 6 shows the reference intervals (mean \pm 2 SD) and (quantiles), mean and median values for blood chemistry analytes in the Kuwaiti nationals aged 15 years and over, while Table 7 gives the sex- and age-specific reference intervals for the same population.

DISCUSSION

Our study reports age and sex specific reference intervals for routine blood chemistry analytes in apparently healthy Kuwaitis aged 15 years and over which have not been reported previously. There were no significant differences between the parametric and non-parametric reference intervals, but since the IFCC recommended the use of non-parametric method^[13] for reference intervals, we suggest the use of these intervals in Kuwait. Our values are slightly different in the Kuwaiti population from the manufacturer's reference intervals that are currently in use in the Ministry of Public Health Hospitals in Kuwait. For example, the reference range of blood creatinine in the Kuwaiti population (50-114 $\mu\text{mol/L}$) is lower than the manufacturer's reference range of 60-120 $\mu\text{mol/L}$. This may enable nephrologists to revise their parameters for renal functions in Kuwaitis. Kuwaitis have higher blood total cholesterol, triglyceride and LDL-cholesterol values than the commercial reference intervals. However, the upper range of serum cholesterol of 5.42 mmol/L should not be considered as 'normal' or 'healthy' since serum cholesterol concentrations greater than 5.2 mmol/L have been associated with significant atherosclerosis. Kuwaitis also have relatively higher serum uric acid concentration (141-423 $\mu\text{mol/L}$) than the manufacturer's reference range (150-400 $\mu\text{mol/L}$). The significance of this is not fully known but it may be associated with the high prevalence of gall bladder and kidney stone diseases among Kuwaitis^[34-40].

Our finding that serum cholesterol increases with age is in agreement with other reports in the literature^[25-27]. Also consistent with other reports in the literature^[26,27], we found that adult Kuwaiti women have higher serum HDL-cholesterol concentration than men in the same age group. Although serum LDL-cholesterol increases with

age in both sexes, we did not find any gender difference in serum LDL- cholesterol concentration unlike West and Ash^[29].

In conclusion, we report the reference intervals for blood chemistry analytes in Kuwaitis aged 15

years and over (Table 6). Table 7 summarizes these reference intervals, grouping age and sex where no differences exist and separating them where there are differences.

Table 2:
Mean, Standard Deviation (S.D) and Median for blood analytes in the adult Kuwaiti nationals

| Blood Analyte | N | Unit | Mean | S.D | Median |
|----------------------------|-----|--------|------|-------|--------|
| Glucose | 329 | mmol/L | 4.89 | 0.58 | 4.80 |
| Blood Urea | 458 | mmol/L | 4.68 | 0.99 | 4.70 |
| Creatinine | 424 | umol/L | 81 | 15.06 | 78 |
| Sodium | 513 | mmol/L | 140 | 2.58 | 140 |
| Potassium | 510 | mmol/L | 4.13 | 0.35 | 4.10 |
| Carbon dioxide | 428 | mmol/L | 24 | 1.83 | 24 |
| Calcium | 510 | mmol/L | 2.43 | 0.08 | 2.44 |
| Phosphate | 459 | mmol/L | 1.13 | 0.14 | 1.13 |
| Total Protein | 505 | g/L | 72 | 3.97 | 72 |
| Albumin | 481 | g/L | 40 | 2.92 | 40 |
| Cholesterol | 327 | mmol/L | 4.33 | 0.54 | 4.40 |
| Triglyceride | 313 | mmol/L | 1.20 | 0.44 | 1.21 |
| HDL-Cholesterol | 415 | mmol/L | 1.31 | 0.30 | 1.24 |
| Uric Acid | 477 | μmol/L | 283 | 60.58 | 281 |
| Total Bilirubin | 504 | μmol/L | 9 | 3.13 | 8 |
| Alkaline Phosphatase | 378 | IU/L | 65 | 12.73 | 65 |
| Alanine Aminotransferase | 503 | IU/L | 22 | 10.86 | 18 |
| Aspartate Aminotransferase | 519 | IU/L | 22 | 5.64 | 21 |
| Lactate Dehydrogenase | 516 | mmol/L | 161 | 45.01 | 146 |
| Osmolality | 528 | mOsm/L | 282 | 7.12 | 281 |
| Corrected Calcium | 532 | mmol/L | 2.45 | 0.09 | 2.44 |
| LDL-Cholesterol | 528 | mmol/L | 2.79 | 0.84 | 2.72 |

N = Number of analytes

S.D. = Standard Deviation

The differences between the estimated and corrected calcium numbers and between cholesterol and calculated LDL numbers are due to differences in the deleted abnormal values.

Table 3:

Sex differences in blood analytes (p-values) in the adult Kuwaiti nationals

| Blood Analytes | Unit | Female | | Male | | p-value |
|----------------------------|--------|--------|------|------|------|---------|
| | | Mean | S.D | Mean | S.D | |
| Glucose | mmol/L | 4.91 | 0.58 | 4.83 | 0.59 | 0.45 |
| Blood Urea | mmol/L | 4.51 | 1.09 | 5.03 | 0.85 | 0.001 |
| Creatinine | umol/L | 74 | 12 | 89 | 13 | < 0.001 |
| Sodium | mmol/L | 140 | 3 | 141 | 3 | 0.42 |
| Potassium | mmol/L | 4.20 | 0.37 | 4.15 | 0.33 | 0.34 |
| Carbon dioxide | mmol/L | 24 | 2 | 24 | 2 | 0.34 |
| Calcium | mmol/L | 2.43 | 0.08 | 2.46 | 0.07 | 0.02 |
| Phosphate | mmol/L | 1.14 | 0.14 | 1.13 | 0.14 | 0.51 |
| Total Protein | g/L | 72 | 4 | 71 | 4 | 0.51 |
| Albumin | g/L | 40 | 3 | 42 | 3 | < 0.001 |
| Cholesterol | mmol/L | 4.33 | 0.47 | 4.32 | 0.53 | 0.92 |
| Triglyceride | mmol/L | 1.10 | 0.43 | 1.29 | 0.46 | 0.03 |
| HDL-Cholesterol | mmol/L | 1.37 | 0.42 | 0.96 | 0.26 | < 0.001 |
| Uric Acid | umol/L | 269 | 58 | 322 | 52 | < 0.001 |
| Total Bilirubin | umol/L | 8 | 3 | 11 | 3 | < 0.001 |
| Alkaline Phosphatase | IU/L | 64 | 16 | 64 | 16 | 0.98 |
| Alanine Aminotransferase | IU/L | 19 | 10 | 32 | 36 | 0.001 |
| Aspartate Aminotransferase | IU/L | 21 | 5 | 23 | 5 | 0.04 |
| Lactate Dehydrogenase | mmol/L | 145 | 28 | 136 | 18 | 0.59 |
| Osmolality | mOsm/L | 281 | 6 | 282 | 5 | 0.07 |
| Corrected Calcium | mmol/L | 2.44 | 0.08 | 2.43 | 0.07 | 0.28 |
| LDL-Cholesterol | mmol/L | 2.83 | 0.70 | 2.70 | 0.77 | 0.24 |

S.D. = Standard Deviation

Table 4:

Age differences in blood analytes (p-values) in the adult Kuwaiti nationals

| Blood Analyte | Unit | Age Group (Years) | Mean | S.D | p value |
|----------------|--------|-------------------|----------|-------|---------------|
| Glucose | mmol/L | 15-24 | 4.70 (a) | 0.59 | (a&b) 0.22 |
| | | 25-44 | 4.84 (b) | 0.50 | (b&c) 0.04 |
| | | 45-59 | 5.13 (c) | 0.58 | (c&d) 0.24 |
| | | 60-79 | 5.41 (d) | 0.57 | (a&d) 0.001 |
| Blood Urea | mmol/L | 15-24 | 4.48 (a) | 1.06 | (a&b) 0.43 |
| | | 25-44 | 4.63 (b) | 0.90 | (b&c) 0.15 |
| | | 45-59 | 4.95 (c) | 1.07 | (c&d) 0.16 |
| | | 60-79 | 5.49 (d) | 1.07 | (a&d) 0.01 |
| Creatinine | µmol/L | 15-24 | 78 (a) | 14.47 | (a&b) 0.46 |
| | | 25-44 | 80 (b) | 15.62 | (b&c) 0.63 |
| | | 45-59 | 82 (c) | 15.24 | (c&d) 0.85 |
| | | 60-79 | 83 (d) | 11.73 | (a&d) 0.20 |
| Sodium | mmol/L | 15-24 | 140 (a) | 2.14 | (a&b) 0.50 |
| | | 25-44 | 140 (b) | 2.64 | (b&c) 0.55 |
| | | 45-59 | 140 (c) | 2.87 | (c&d) 0.72 |
| | | 60-79 | 139 (d) | 2.47 | (a&d) 0.11 |
| Potassium | mmol/L | 15-24 | 4.09 (a) | 0.29 | (a&b) 0.50 |
| | | 25-44 | 4.13 (b) | 0.33 | (b&c) 0.06 |
| | | 45-59 | 4.26 (c) | 0.33 | (c&d) 0.40 |
| | | 60-79 | 4.34 (d) | 0.43 | (a&d) 0.001 |
| Carbon dioxide | mmol/L | 15-24 | 24 (a) | 1.55 | (a&b) 0.86 |
| | | 25-44 | 24 (b) | 1.69 | (b&c) 0.23 |
| | | 45-59 | 24 (c) | 1.70 | (c&d) 0.14 |
| | | 60-79 | 23 (d) | 1.57 | (a&d) 0.68 |
| Calcium | mmol/L | 15-24 | 2.46 (a) | 0.08 | (a&b) 0.11 |
| | | 25-44 | 2.44 (b) | 0.07 | (b&c) 0.46 |
| | | 45-59 | 2.43 (c) | 0.08 | (c&d) 0.60 |
| | | 60-79 | 2.42 (d) | 0.07 | (a&d) 0.02 |
| Phosphate | mmol/L | 15-24 | 1.16 (a) | 0.15 | (a&b) 0.90 |
| | | 25-44 | 1.16 (b) | 0.14 | (b&c) 0.91 |
| | | 45-59 | 1.16 (c) | 0.14 | (c&d) 0.08 |
| | | 60-79 | 1.09 (d) | 0.13 | (a&d) 0.05 |
| Total Protien | g/L | 15-24 | 72 (a) | 3.91 | (a&b) 0.58 |
| | | 25-44 | 72 (b) | 3.42 | (b&c) 0.52 |
| | | 45-59 | 71 (c) | 4.70 | (c&d) 0.72 |
| | | 60-79 | 71 (d) | 3.67 | (d&a) 0.18 |
| Albumin | g/L | 15-24 | 42 (a) | 2.62 | (a&b) 0.01 |
| | | 25-44 | 41 (b) | 3.07 | (b&c) 0.17 |
| | | 45-59 | 40 (c) | 2.70 | (c&d) 0.22 |
| | | 60-79 | 39 (d) | 3.00 | (a&d) < 0.001 |

Cont'd

Table 4 (cont'd):

Age differences in blood analytes (p-values) in the adult Kuwaiti nationals

| Blood Analyte | Unit | Age Group (Years) | Mean | S.D | p value |
|----------------------------|--------|-------------------|----------|-------|---------------|
| Cholesterol | mmol/L | 15-24 | 4.10 (a) | 0.52 | (a&b) 0.001 |
| | | 25-44 | 4.41 (b) | 0.39 | (b&c) 0.73 |
| | | 45-59 | 4.46 (c) | 0.41 | (c&d) 0.44 |
| | | 60-79 | 4.62 (d) | 0.63 | (a&d) 0.01 |
| Triglyceride | mmol/L | 15-24 | 0.94 (a) | 0.41 | (a&b) 0.001 |
| | | 25-44 | 1.29 (b) | 0.40 | (b&c) 0.93 |
| | | 45-59 | 1.30 (c) | 0.39 | (c&d) 0.91 |
| | | 60-79 | 1.32 (d) | 0.49 | (a&d) 0.01 |
| HDL Cholesterol | mmol/L | 15-24 | 1.25 (a) | 0.42 | (a&b) 0.91 |
| | | 25-44 | 1.24 (b) | 0.35 | (b&c) 0.52 |
| | | 45-59 | 1.18 (c) | 0.49 | (c&d) 0.65 |
| | | 60-79 | 1.13 (d) | 0.43 | (a&d) 0.26 |
| Uric Acid | mmol/L | 15-24 | 280 (a) | 61.91 | (a&b) 0.71 |
| | | 25-44 | 285 (b) | 63.09 | (b&c) 0.26 |
| | | 45-59 | 299 (c) | 56.45 | (c&d) 0.66 |
| | | 60-79 | 306 (d) | 63.12 | (a&d) 0.11 |
| Total Bilirubin | µmol/L | 15-24 | 10.4 (a) | 7.6 | (a&b) 0.62 |
| | | 25-44 | 9.8 (b) | 4.6 | (b&c) 0.09 |
| | | 45-59 | 8.4 (c) | 2.5 | (c&d) 0.42 |
| | | 60-79 | 7.7 (d) | 4.2 | (a&d) 0.12 |
| Alkaline Phosphatase | IU/L | 15-24 | 66 (a) | 15 | (a&b) 0.31 |
| | | 25-44 | 62 (b) | 17 | (b&c) 0.60 |
| | | 45-59 | 65 (c) | 17 | (c&d) 0.60 |
| | | 60-79 | 67 (d) | 17 | (a&d) 0.79 |
| Alanine Aminotransferase | IU/L | 15-24 | 31 (a) | 15 | (a&b) 0.14 |
| | | 25-44 | 23 (b) | 39 | (b&c) 0.78 |
| | | 45-59 | 21 (c) | 10 | (c&d) 0.57 |
| | | 60-79 | 19 (d) | 10 | (a&d) 0.001 |
| Aspartate Aminotransferase | IU/L | 15-24 | 23 (a) | 5 | (a&b) 0.50 |
| | | 25-44 | 23 (b) | 5 | (b&c) 0.29 |
| | | 45-59 | 21 (c) | 5 | (c&d) 0.70 |
| | | 60-79 | 21 (d) | 6 | (a&d) 0.06 |
| Lactate Dehydrogenase | IU/L | 15-24 | 126 (a) | 16 | (a&b) 0.04 |
| | | 25-44 | 165 (b) | 12 | (b&c) 0.11 |
| | | 45-59 | 141 (c) | 3 | (c&d) 0.11 |
| | | 60-79 | 140 (d) | 3 | (a&d) 0.11 |
| Osmolality | mOsm/L | 15-24 | 280 (a) | 5 | (a&b) 0.63 |
| | | 25-44 | 281 (b) | 5 | (b&c) 0.06 |
| | | 45-59 | 282 (c) | 4 | (c&d) 0.01 |
| | | 60-79 | 286 (d) | 6 | (a&d) < 0.001 |

Cont'd

Table 4 (cont'd):

Age differences in blood analytes (p values) in the adult Kuwaiti nationals

| Blood Analyte | Unit | Age Group (Years) | Mean | S.D | p value |
|-------------------|--------|-------------------|----------|------|---------------|
| Corrected Calcium | mmol/L | 15-24 | 2.43 (a) | 0.07 | (a&b) 0.23 |
| | | 25-44 | 2.41 (b) | 0.07 | (b&c) 0.09 |
| | | 45-59 | 2.44 (c) | 0.08 | (c&d) 0.001 |
| | | 60-79 | 2.49 (d) | 0.08 | (a&d) 0.001 |
| LDL Cholesterol | mmol/L | 15-24 | 2.36 (a) | 0.53 | (a&b) 0.001 |
| | | 25-44 | 2.77 (b) | 0.65 | (b&c) 0.30 |
| | | 45-59 | 3.09 (c) | 0.77 | (c&d) 0.75 |
| | | 60-79 | 3.16 (d) | 0.82 | (a&d) < 0.001 |

Table 5:

Mean values for blood chemistry analytes in subjects from different governorates of Kuwait

| Blood Analyte | Mean | | | | | P-Value | | | |
|----------------------------------|-------------|-------------|------------|-----------|---------------|---------|------|-------|------|
| | Capital (1) | Hawalli (2) | Ahmadi (3) | Jahra (4) | Farwaniya (5) | 1&2 | 1&3 | 1&4 | 1&5 |
| Glucose (mmol/L) | 4.87 | 4.86 | 5.07 | 4.84 | 4.73 | 0.96 | 0.25 | 0.90 | 0.44 |
| Blood Urea(mmol/L) | 4.71 | 4.62 | 4.87 | 5.05 | 4.64 | 0.71 | 0.54 | 0.35 | 0.78 |
| Creatinine (umol/L) | 77 | 79 | 84 | 99 | 79 | 0.64 | 0.10 | 0.001 | 0.59 |
| Sodium (mmol/L) | 140 | 141 | 140 | 141 | 140 | 0.09 | 0.18 | 0.08 | 0.22 |
| Potassium (mmol/L) | 4.23 | 4.20 | 4.14 | 3.95 | 4.17 | 0.69 | 0.27 | 0.06 | 0.48 |
| Carbon dioxide (mmol/L) | 25 | 24 | 24 | 25 | 24 | 0.01 | 0.05 | 0.43 | 0.01 |
| Calcium (mmol/L) | 2.46 | 2.44 | 2.43 | 2.46 | 2.43 | 0.24 | 0.18 | 0.94 | 0.26 |
| Phosphate (mmol/L) | 1.14 | 1.12 | 1.13 | 1.10 | 1.16 | 0.54 | 0.89 | 0.56 | 0.55 |
| Total Protein (g/L) | 72 | 71 | 72 | 73 | 71 | 0.21 | 0.78 | 0.92 | 0.15 |
| Albumin (g/L) | 42 | 41 | 41 | 41 | 41 | 0.11 | 0.40 | 0.30 | 0.09 |
| Cholesterol (mmol/L) | 4.25 | 4.40 | 4.29 | 3.99 | 4.39 | 0.26 | 0.77 | 0.38 | 0.37 |
| Triglyceride (mmol/L) | 0.96 | 1.19 | 1.19 | 1.52 | 1.22 | 0.07 | 0.11 | 0.02 | 0.05 |
| HDL-Cholesterol (mmol/L) | 1.20 | 1.28 | 1.01 | 1.02 | 1.28 | 0.43 | 0.05 | 0.24 | 0.52 |
| Uric Acid (µmol/L) | 301 | 284 | 280 | 314 | 292 | 0.25 | 0.20 | 0.61 | 0.57 |
| Total Bilurubin (µmol/L) | 11 | 9 | 8 | 11 | 10 | 0.06 | 0.05 | 0.74 | 0.58 |
| Alkaline Phosphatase(IU/L) | 65 | 66 | 63 | 78 | 58 | 0.74 | 0.56 | 0.03 | 0.19 |
| Alanine Aminotransferase(IU/L) | 27 | 26 | 23 | 26 | 21 | 0.92 | 0.23 | 0.90 | 0.13 |
| Aspartate Aminotransferase(IU/L) | 24 | 21 | 22 | 22 | 22 | 0.09 | 0.44 | 0.44 | 0.41 |
| Osmolality(mOsm/L) | 281 | 282 | 281 | 282 | 282 | 0.59 | 0.85 | 0.38 | 0.56 |
| Corrected Calcium (mmol/L) | 2.44 | 2.44 | 2.42 | 2.43 | 2.44 | 0.88 | 0.36 | 0.64 | 0.90 |
| LDL-Cholesterol (mmol/L) | 2.70 | 2.86 | 2.74 | 2.71 | 2.75 | 0.29 | 0.81 | 0.95 | 0.78 |

Table 6:

Reference intervals (+/- 2 Standard Deviation, Mean and Median for blood chemistry analytes in the adult Kuwaiti nationals

| Blood Analyte | Unit | Reference Intervals +/-2 SD | | Mean | Median | Reference intervals (2.5 - 97.5 percentiles) | |
|----------------------------|--------|--------------------------------|------|------|--------|-------------------------------------------------|------|
| | | Low | High | | | | |
| Glucose | mmol/L | 3.7 | 6.1 | 4.9 | 4.8 | 3.9 | 6 |
| Blood Urea | mmol/L | 2.7 | 6.7 | 4.7 | 4.7 | 2.9 | 6.50 |
| Creatinine | µmol/L | 50 | 111 | 81 | 78 | 60 | 114 |
| Sodium | mmol/L | 135 | 145 | 140 | 140 | 135 | 146 |
| Potassium | mmol/L | 3.4 | 4.8 | 4.1 | 4.1 | 3.58 | 4.92 |
| Carbon dioxide | mmol/L | 21 | 28 | 24 | 24 | 22 | 29 |
| Calcium | mmol/L | 2.27 | 2.6 | 2.43 | 2.44 | 2.24 | 2.59 |
| Phosphate | mmol/L | 0.84 | 1.42 | 1.13 | 1.13 | 0.85 | 1.38 |
| Total Protein | g/L | 64 | 79 | 72 | 72 | 64 | 79 |
| Albumin | g/L | 34 | 46 | 40 | 40 | 35 | 46 |
| Cholesterol | mmol/L | 3.24 | 5.42 | 4.33 | 4.39 | 3.12 | 5.14 |
| Triglyceride | mmol/L | 0.31 | 2.08 | 1.2 | 1.21 | 0.44 | 1.96 |
| Uric Acid | µmol/L | 141 | 423 | 282 | 280 | 177 | 391 |
| Total Bilirubin | µmol/L | 0 | 18 | 9 | 8 | 4 | 17 |
| Alkaline Phosphatase | IU/L | 35 | 94 | 64 | 65 | 40 | 87 |
| Aspartate Aminotransferase | IU/L | 10 | 34 | 22 | 21 | 14 | 38 |
| Alanine Aminotransferase | IU/L | 0 | 63 | 24 | 18 | 10 | 49 |
| Lactate Dehydrogenase | IU/L | 70 | 250 | 160 | 140 | 113 | 276 |
| HDL Cholesterol | mmol/L | 0.44 | 1.99 | 1.22 | 1.17 | 0.92 | 2.09 |
| Corrected Calcium | mmol/L | 2.26 | 2.63 | 2.45 | 2.43 | 2.28 | 2.69 |
| Osmolality | mOsm/L | 268 | 296 | 281 | 281 | 271.29 | 297 |
| LDL-Cholesterol | mmol/L | 1.12 | 4.44 | 2.78 | 2.71 | 1.19 | 4.58 |

Table 7:

Age-and sex-specific reference intervals for blood chemistry analytes in the adult Kuwaiti nationals

| Blood Analyte | Unit | Age Group (Years) | Sex | Mean | Reference Interval | |
|----------------|--------|-------------------|-----|------|--------------------|------|
| | | | | | Low | High |
| Glucose | mmol/L | 15-24 | M+F | 4.7 | 3.5 | 5.9 |
| | | | M+F | 4.8 | 3.8 | 5.8 |
| | | 25-44 | M+F | 5.1 | 4.0 | 6.3 |
| | | | M+F | 5.4 | 4.3 | 6.5 |
| Blood Urea | mmol/L | 15-24 | M | 4.2 | 2.5 | 6.0 |
| | | | F | 4.1 | 2.1 | 6.0 |
| | | 25-44 | M | 5.0 | 3.6 | 6.5 |
| | | | F | 5.1 | 3.2 | 6.9 |
| | | 45-59 | M | 5.2 | 3.3 | 7.0 |
| | | | F | 4.9 | 2.6 | 7.1 |
| | | 60-79 | M | 5.9 | 4.5 | 7.3 |
| | | | F | 4.8 | 2.1 | 7.5 |
| Creatinine | μmol/L | 15-24 | M | 89 | 69 | 108 |
| | | | F | 69 | 51 | 86 |
| | | 25-44 | M | 85 | 57 | 113 |
| | | | F | 72 | 52 | 91 |
| | | 45-59 | M | 87 | 60 | 113 |
| | | | F | 77 | 45 | 109 |
| | | 60-79 | M | 91 | 63 | 119 |
| | | | F | 80 | 59 | 110 |
| Sodium | mmol/L | 15-24 | M+F | 141 | 136 | 145 |
| | | 25-44 | M+F | 140 | 135 | 146 |
| | | 45-59 | M+F | 140 | 134 | 146 |
| | | 60-79 | M+F | 140 | 135 | 145 |
| Potassium | mmol/L | 15-24 | M+F | 4.1 | 3.5 | 4.7 |
| | | 25-44 | M+F | 4.1 | 3.5 | 4.8 |
| | | 45-59 | M+F | 4.3 | 3.6 | 4.9 |
| | | 60-79 | M+F | 4.3 | 3.5 | 5.2 |
| Carbon dioxide | mmol/L | 15-24 | M+F | 24 | 21 | 28 |
| | | 25-44 | M+F | 24 | 21 | 28 |
| | | 45-59 | M+F | 24 | 21 | 28 |
| | | 60-79 | M+F | 25 | 21 | 28 |
| Calcium | mmol/L | 15-24 | M | 2.5 | 2.4 | 2.6 |
| | | | F | 2.4 | 2.3 | 2.6 |
| | | 25-44 | M | 2.5 | 2.3 | 2.6 |
| | | | F | 2.4 | 2.3 | 2.6 |
| | | 45-59 | M | 2.4 | 2.3 | 2.6 |
| | | | F | 2.4 | 2.3 | 2.6 |
| | | 60-79 | M | 2.4 | 2.3 | 2.6 |
| | | | F | 2.4 | 2.3 | 2.6 |

Cont'd

Table 7 (cont'd):

Age-and sex-specific reference intervals for blood chemistry analytes in the adult Kuwaiti nationals

| Blood Analyte | Unit | Age Group (Years) | Sex | Mean | Reference Interval | |
|-----------------|--------|-------------------|-----|------|--------------------|------|
| | | | | | Low | High |
| Phosphate | mmol/L | 15-24 | M+F | 1.2 | 0.9 | 1.5 |
| | | 25-44 | M+F | 1.2 | 0.9 | 1.4 |
| | | 45-59 | M+F | 1.2 | 0.9 | 1.4 |
| | | 60-79 | M+F | 1.1 | 0.9 | 1.4 |
| Total Protein | g/L | 15-24 | M+F | 71 | 64 | 80 |
| | | 25-44 | M+F | 71 | 64 | 80 |
| | | 45-59 | M+F | 71 | 64 | 80 |
| | | 60-79 | M+F | 70 | 62 | 78 |
| Albumin | g/L | 15-24 | M | 43 | 39 | 47 |
| | | | F | 42 | 36 | 48 |
| | | 25-44 | M | 43 | 37 | 48 |
| | | | F | 40 | 35 | 45 |
| | | 45-59 | M | 41 | 34 | 47 |
| | | | F | 40 | 35 | 45 |
| | | 60-79 | M | 40 | 33 | 47 |
| | | | F | 38 | 33 | 43 |
| Cholesterol | mmol/L | 15-24 | M+F | 4.10 | 3.06 | 5.14 |
| | | 25-44 | M+F | 4.42 | 3.64 | 5.20 |
| | | 45-59 | M+F | 4.46 | 3.64 | 5.28 |
| | | 60-79 | M+F | 4.62 | 3.64 | 5.89 |
| Triglyceride | mmol/L | 15-24 | M | 1.0 | 0.2 | 1.9 |
| | | | F | 0.9 | 0.1 | 1.7 |
| | | 25-44 | M | 1.5 | 0.7 | 2.2 |
| | | | F | 1.1 | 0.4 | 1.9 |
| | | 45-59 | M | 1.1 | 0.6 | 2.5 |
| | | | F | 1.4 | 0.5 | 2.1 |
| | | 60-79 | M | 1.5 | 0.2 | 2.7 |
| | | | F | 1.2 | 0.4 | 2.3 |
| HDL Cholesterol | mmol/L | 15-24 | M | 1.0 | 0.5 | 1.6 |
| | | | F | 1.4 | 0.5 | 2.3 |
| | | 25-44 | M | 0.9 | 0.5 | 1.4 |
| | | | F | 1.3 | 0.5 | 2.3 |
| | | 45-59 | M | 1.0 | 0.5 | 1.4 |
| | | | F | 1.4 | 0.5 | 2.4 |
| | | 60-79 | M | 0.9 | 0.5 | 1.4 |
| | | | F | 1.4 | 0.5 | 2.2 |
| Uric Acid | | 15-24 | M | 319 | 200 | 423 |
| | | | F | 252 | 140 | 356 |
| | | 25-44 | M | 321 | 200 | 425 |
| | | | F | 253 | 140 | 365 |
| | | 45-59 | M | 317 | 200 | 434 |

Cont'd

Table 7 (cont'd):

Age-and sex-specific reference intervals for blood chemistry analytes in the adult Kuwaiti nationals

| Blood Analyte | Unit | Age Group (Years) | Sex | Mean | Reference Interval | | | |
|----------------------------|--------|--------------------------|------|-------|--------------------|------|----|-----|
| | | | | | Low | High | | |
| Total Bilurubin | μmol/L | 60-79 | F | 273 | 140 | 387 | | |
| | | | M | 336 | 200 | 445 | | |
| | | 15-24 | F | 301 | 140 | 415 | | |
| | | | M | 14 | 2 | 18 | | |
| | | 25-44 | F | 8 | 2 | 16 | | |
| | | | M | 12 | 2 | 18 | | |
| | | 45-59 | F | 8 | 2 | 16 | | |
| | | | M | 8 | 2 | 18 | | |
| | | 60-79 | F | 8 | 2 | 16 | | |
| | | | M | 8 | 2 | 18 | | |
| Alkaline Phosphatase | IU/L | 15-24 | M+F | 66.0 | 30 | 95 | | |
| | | | M+F | 62.4 | 30 | 95 | | |
| | | 45-59 | M+F | 64.5 | 30 | 100 | | |
| | | | M+F | 67.2 | 30 | 100 | | |
| | | Alanine Aminotransferase | IU/L | 15-24 | M | 25 | 0 | 63 |
| F | 17 | | | | 0 | 46 | | |
| 25-44 | M | | | 44 | 0 | 63 | | |
| | F | | | 17 | 0 | 46 | | |
| 45-59 | M | | | 25 | 0 | 63 | | |
| | F | | | 21 | 0 | 46 | | |
| 60-79 | M | | | 16 | 0 | 63 | | |
| | F | | | 22 | 0 | 46 | | |
| Aspartate Aminotransferase | IU/L | | | 15-24 | M | 22 | 10 | 34 |
| | | | | | F | 21 | 10 | 29 |
| | | 25-44 | M | 26 | 10 | 37 | | |
| | | | F | 20 | 10 | 30 | | |
| | | 45-59 | M | 22 | 10 | 38 | | |
| | | | F | 23 | 10 | 30 | | |
| | | 60-79 | M | 19 | 10 | 35 | | |
| | | | F | 22 | 10 | 26 | | |
| | | Lactate Dehydrogenase | IU/L | 15-24 | M+F | 126 | 90 | 150 |
| | | | | 25-44 | M+F | 165 | 90 | 150 |
| 45-59 | M+F | | | 141 | 90 | 150 | | |
| 60-79 | M+F | | | 140 | 90 | 150 | | |
| Osmolality | mOsm/L | 15-24 | M+F | 280 | 270 | 290 | | |
| | | 25-44 | M+F | 281 | 271 | 290 | | |
| | | 45-59 | M+F | 282 | 274 | 291 | | |
| | | 60-79 | M+F | 286 | 273 | 298 | | |
| Corrected Calcium | mmol/L | 15-24 | M+F | 2.4 | 2.3 | 2.6 | | |
| | | 25-44 | M+F | 2.4 | 2.3 | 2.6 | | |

Cont'd

Table 7 (cont'd):

Age-and sex-specific reference intervals for blood chemistry analytes in the adult Kuwaiti nationals

| Blood Analyte | Unit | Age Group (Years) | Sex | Mean | Reference Interval | |
|-----------------|--------|-------------------|-----|------|--------------------|------|
| | | | | | Low | High |
| LDL Cholesterol | mmol/L | 45-59 | M+F | 2.4 | 2.3 | 2.6 |
| | | 60-79 | M+F | 2.5 | 2.3 | 2.7 |
| | | 15-24 | M+F | 2.4 | 1.3 | 3.4 |
| | | 25-44 | M+F | 2.8 | 1.5 | 4.1 |
| | | 45-59 | M+F | 3.1 | 1.6 | 4.6 |
| | | 60-79 | M+F | 3.2 | 1.5 | 4.8 |

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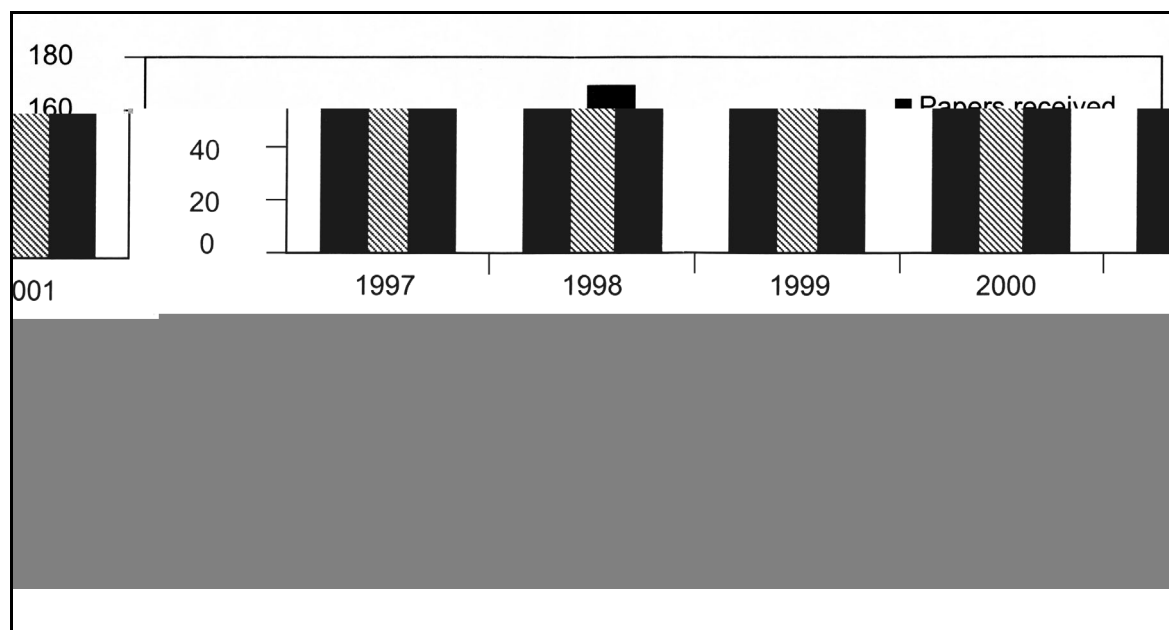
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Erratum: The following figure was missed in the editorial titled 'Report 2001' published in Volume 34, Issue (1), 2002. We regret the inconvenience caused.



**TOTAL NUMBER OF SUBMISSIONS
RECEIVED/PUBLISHED IN THE LAST FIVE YEARS**