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Age-related Changes in Laboratory Test Results in Home Health Services: A Retrospective Study

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Abstract

Objective: Home healthcare services play a crucial role in reducing health expenditure, providing tailored care, and improving the quality of healthcare, particularly for managing chronic diseases.

Methods: This retrospective cross-sectional study analyzed the blood test and laboratory results of 1,461 patients who were evaluated by the home health services unit in Ankara between May 1, 2020, and July 31, 2020. The patients' ages, genders, and laboratory data were collected, and statistical analyses were performed using SPSS software. A p-value of <0.05 was considered statistically significant.

Results: The study included 1,461 patients, of whom 64.06% were female and 35.94% were male. Significant age differences were observed among the patients ($p<0.001$). Home visits were conducted for medical examinations and laboratory tests, and the results showed age-related variations in several parameters, such as albumin, alkaline phosphatase, alanine aminotransferase (ALT), aspartate aminotransferase, creatine-kinase, gamma-glutamyl transferase (GGT), calcium (Ca), free triiodothyronine, free thyroxine, total protein, triglycerides, prothrombin time, activated partial thromboplastin time, urea, uric acid, creatinine, and potassium. Gender differences were also observed, with varying levels of amylase, activated partial thromboplastin time, ALT, total bilirubin, direct bilirubin, GGT, C-reactive protein, albumin, phosphorus, high-density lipoprotein cholesterol, Ca, and unsaturated iron binding capacity.

Conclusion: Considering age-related laboratory test results is crucial in home healthcare settings.

Keywords: Elderly healthcare services, home care services, sociodemographic factors, blood chemical analysis

INTRODUCTION

Advancements in science and technology, along with the widespread availability of healthcare services and the evolution of preventive healthcare practices alongside modern medicine, have contributed to an increase in average life expectancy. This trend is evident both globally and in Turkey, where life expectancy at birth has been steadily rising, paralleled by a growing elderly population (1). According to data from the Turkish Statistical Institute in 2020, life expectancy at birth in Turkey was 78.6 years during the period of 2017-2019. Additionally, the proportion of individuals aged 65 and older within Turkey's total population was 9.5% as of 2020. Notably, an estimated 1.5 million elderly individuals reside alone in Turkey, with one in every four households accommodating an elderly person (2).

Aging is an inherent physiological process accompanied by various mental and physical declines. With increasing age, there is a heightened susceptibility to chronic diseases and their associated complications, as well as issues such as joint ailments and cognitive decline. Consequently, there arises an urgent need for on-site evaluations of elderly individuals and the provision

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of medical care within their living environments, a need that will only intensify as the elderly demographic expands. Within the realm of home healthcare services, directly delivering care to individuals within their homes serves several paramount purposes, including reducing healthcare expenditures, ensuring personalized care, fostering familial support structures, expediting recovery, enhancing healthcare quality, and empowering patients and their families with better healthcare knowledge, thereby improving overall quality of life (3).

In Turkey, the inception of home healthcare services dates back to the implementation of the "regulation on the delivery of home care services" in 2005, which mandated the provision of such services by the private sector under the supervision of the Ministry of Health. Subsequently, in 2010, with the issuance of the "directive on implementation procedures and principles of home health services provided by the Ministry of Health", public institutions and organizations began to offer home healthcare services. By 2017, the responsibility for providing home healthcare services had been entirely transferred to hospitals (4).

Home healthcare services encompass a spectrum of medical interventions, including assessments, analyses, treatments, and rehabilitation services delivered within patients' homes as part of diagnosis and planned treatment protocols. These services also include prescribing medications, facilitating medical device usage, and generating reports on their application. Notably, the home healthcare framework mandates that patients be transferred to healthcare facilities when necessary. A significant proportion of home healthcare recipients are elderly individuals, many of whom have a history of chronic illnesses and medication use. It is imperative for the management of chronic conditions that individuals undergo blood tests conducive to medical evaluations within their home environment. The role of laboratory testing in clinical diagnostics has assumed heightened importance, with approximately 70% of disease diagnoses relying on laboratory results (5).

Advancements in science and technology, coupled with the accessibility of healthcare services and the evolution of preventive healthcare practices, have led to an increase in average life expectancy globally and notably in Turkey. With a growing elderly population, there is a significant need for on-site evaluations and medical care within their living environments. Home healthcare services play a vital role in addressing this need, offering personalized care, reducing healthcare costs, and improving the overall quality of life. However, there remains a gap in the provision of essential medical services, such as laboratory testing, in home settings. Therefore, the aim of this study was to assess the feasibility and effectiveness of conducting blood tests for elderly individuals receiving home healthcare services, with the hypothesis that integrating laboratory testing into home healthcare protocols can improve the management of chronic conditions and enhance the overall quality of care for elderly patients.

METHODS

Design and Patient Selection

This retrospective, cross-sectional, and observational investigation was designed. This encompasses an analysis of blood tests and laboratory findings for patients assessed by the home health services unit in Yıldırım Beyazıt University Yenimahalle Training and Research Hospital from May 1, 2020, to July 31, 2020. The study received approval from the Non-interventional Clinical Research Ethics Committee of Niğde Ömer Halisdemir University (decision number: 2022/01, date: 13.01.2022).

Data on patient age, gender, and laboratory outcomes were extracted from the laboratory information system. In total, 36,923 test results from 1,461 patients were retrospectively analyzed. This analysis included averaging the laboratory findings for patients who underwent multiple evaluations and those obtained within the specified timeframe. Patients were categorized according to age and gender. A comprehensive evaluation of the laboratory results, including glycated hemoglobin (HbA1c)%, albumin, alkaline phosphatase (ALP), alanine aminotransferase (ALT), amylase, activated partial thromboplastin time (aPTT), aspartate aminotransferase (AST), vitamin B12, creatine kinase (CK), C-reactive protein (CRP), direct bilirubin, D-dimer, iron, ferritin, fibrinogen, folate, phosphorus, free triiodothyronine (FT3), free thyroxine (FT4), gamma-glutamyl transferase (GGT), glucose, high-density lipoprotein cholesterol (HDL-C), calcium (Ca), chlorine, creatinine, lactate dehydrogenase, magnesium, potassium, prothrombin time (PT), sodium, total bilirubin, total cholesterol, total protein, triglycerides, thyroid stimulating hormone (TSH), unsaturated iron binding capacity (UIBC), urea, uric acid and complete urine analysis was performed based on these groups. This was a retrospective study; thus, informed consent was not obtained.

Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) for Windows (version 20.0, released in 2011; IBM Corp., Armonk, NY, USA). The distribution of interval data was assessed using either the Kolmogorov-Smirnov test or the Shapiro-Wilk test. Data with a parametric distribution are

presented as mean ± standard deviation, and non-parametric distribution as median [interquartile range (IQR)]. The comparison between independent groups for parameters with a parametric distribution was conducted using Student's t-test, and the Mann-Whitney U test was used for parameters with a non-parametric distribution. When the comparison involved more than two groups, analysis of variance (ANOVA) and the Kruskal-Wallis test were used. The chi-square test was used for the analysis of ordinal data. A p-value of <0.05 was deemed statistically significant.

RESULTS

In this investigation, 936 (64.06%) of the examined patients were females, while 525 (35.94%) were males, all of whom were 18 years or older. 83.1% of the patients included in our study were 65 years or older. Across the entire patient cohort, the median age was 77 years (IQR =16), with females exhibiting a median age of 78 years (IQR =16) and males 75 years (IQR =17), indicating a statistically significant age gap (p<0.001). Patients were grouped according to their ages as 18-64, 65-74, 75-84 and over 85, and further investigations were performed according to these groups.

Home visits were arranged for all participants to undergo medical assessments and necessary laboratory examinations. Throughout the study period, biochemistry panels were ordered for 1,093 patients, and complete blood counts were conducted for 1,092 individuals. Hormone and biomarker tests were administered to 579 patients, coagulation profiles were obtained in 478, and glycosylated hemoglobin levels were monitored in 381 patients. Complete urinalysis was also performed in 63 patients.

Age group analysis revealed a statistical decline in albumin, ALP, ALT, AST, CK, GGT, Ca, FT3, FT4, total protein, triglycerides, PT, and aPTT values with increasing age (p<0.005, p=0.015, p<0.005, p=0.029, p=0.012, p<0.005, p<0.005, p<0.005, p=0.007, p=0.00, p=0.00, p=0.01, p=0.00). Conversely, significant increases were observed in urea, uric acid, creatinine, and potassium levels with age (p<0.005, p=0.001, p<0.005, p=0.01). Notably, significant differences were observed among various age groups for glucose, HbA1c, chlorine, and TSH levels, although these changes did not consistently trend upwards or downwards (Table 1). No significant variations were observed for the other evaluated tests.

Gender-based examination indicated that levels of amylase, aPTT, ALT, total bilirubin, direct bilirubin, GGT, CRP, and creatinine were notably higher in male patients (p=0.005, p=0.012, p<0.001, p=0.012, p<0.001, p<0.001, p<0.001, p<0.001). Conversely, albumin, HDL-C, Ca, and UIBC levels were significantly elevated in female patients (p=0.027, p<0.001, p<0.001, p=0.001) (Tables 2-4). No significant differences were observed between genders in the other tests.

Table 1. Non-parametrically distributed laboratory results according to age groups

	18-64 years			65-74 years			75-84 years			>85 years			
	n	Median	IQR	n	Median	IQR	n	Median	IQR	n	Median	IQR	p
Albumin	158	38.0	7.2	209	36.0	8.0	370	35.0	7.00	303	34.0	7.0	<0.005
ALP	103	95.0	54.0	130	90.0	48.5	232	84.0	42.50	191	82.0	47.0	0.015
ALT	165	16.0	13.3	224	13.0	10.7	389	11.0	8.00	319	10.5	6.0	<0.005
AST	185	20.0	9.5	223	19.0	8.0	389	19.0	8.00	318	18.0	7.0	0.029
CK	133	54.0	44.0	160	52.5	52.8	271	44.0	43.00	221	43.0	35.0	0.012
GGT	183	31.0	32.0	218	27.0	27.3	381	20.0	22.00	313	18.0	14.5	<0.005
Glucose	182	89.5	50.3	218	102.5	58.4	385	95.0	50.50	317	92.0	43.5	<0.005
HbA1c	55	6.3	2.3	83	7.3	2.3	150	6.8	1.83	93	6.3	1.4	<0.005
Ca	186	9.1	0.7	222	9.1	0.7	385	9.0	0.70	312	8.9	0.7	<0.005
Cl	157	103.0	5.8	187	102.0	6.0	327	103.0	5.00	256	104.0	5.0	<0.005
Crea	182	0.7	0.4	222	0.8	0.5	390	0.9	0.44	319	1.0	0.5	<0.005
Urea	184	33.3	17.1	223	40.8	25.5	388	45.0	20.78	318	52.2	35.3	<0.005
Uric acid	147	5.3	2.5	168	5.9	2.9	304	5.9	2.30	258	6.0	2.8	0.001
TSH	102	1.4	1.4	111	2.1	1.8	205	1.6	1.54	182	1.4	1.6	0.013
FT3	100	3.9	1.1	108	3.5	1.0	203	3.5	1.04	178	3.4	1.0	<0.005
FT4	98	14.8	4.7	110	14.0	3.9	203	14.0	3.30	178	13.6	3.5	0.007

IQR: Interquartile range, ALP: Alkaline phosphatase, ALT: Alanine transaminase, AST: Aspartate transferase, CK: Creatine kinase, GGT: Gamma-glutamyl transferase, HbA1c: Glycated hemoglobin, Ca: Calcium, Cl: Chlorine, Crea: Creatinin, TSH: Thyroid stimulating hormone, FT3: Free triiodothyronine, FT4: Free thyroxine

Table 2. Parametrically distributed laboratory results according to age groups

	18-64 year			65-74 year			75-84 year			>85 year			
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	p
Potassium	165	4.06	0.57	220	4.22	0.56	385	4.22	0.55	316	4.23	0.57	0.01
PT	119	29.49	8.43	160	28.97	8.62	134	28.57	11.48	65	24.77	9.37	0.01
T. prot	126	65.71	6.77	158	64.71	6.62	284	64.28	5.92	235	63.12	6.32	0.00
Trig	135	147.08	129.43	170	149.19	123.24	305	127.79	85.32	255	117.38	58.75	0.00
aPTT	117	37.47	6.31	158	37.11	6.64	134	36.27	7.56	65	33.46	6.55	0.00

PT: Prothrombin time, T. prot: Total protein, Trig: Triglycerides, aPTT: Activated partial thromboplastin clotting time, SD: Standard deviation

Table 3. Parametrically distributed laboratory results according to gender

	Female			Male			
	n	Mean	SD	n	Mean	SD	p
Amylase	569	69.98	39.08	304	77.77	39.68	0.005
aPTT	301	35.85	6.83	173	37.51	6.96	0.012
T. bil	608	0.65	0.45	327	0.76	0.62	0.002
T. chol	563	191.3	52.8	302	166.8	44.6	<0.001

aPTT: Activated partial thromboplastin clotting time, T. bil: Total bilirubin, T. chol: Total cholesterol, SD: Standard deviation

Table 4. Non-parametrically distributed laboratory results according to gender

	Female			Male			
	n	Median	IQR	n	Median	IQR	p
Age	936	78	16	525	75	17	<0.001
Albumin	681	36	7	359	35	8	0.027
ALT	716	11	8	381	13	10	<0.001
CRP	659	5.7	13.45	349	9.8	25.45	<0.001
D. bil	597	0.11	0.07	324	0.13	0.09	<0.001
Potassium	471	3.4	0.7	252	3.3	0.79	0.001
GGT	705	20	21	370	24	25	<0.001
HDL	560	45	16	299	37	13.5	<0.001
Calcium	708	9.1	0.7	377	9	0.7	<0.001
Creatinin	717	0.79	0.46	376	0.96	0.52	<0.001
Magnesium	680	2	0.4	362	2	0.3	<0.001
UIBC	579	2.37	0.99	299	2.16	0.9	0.001

IQR: Interquartile range, ALT: Alanine transaminase, CRP: C-reactive protein, D. bil: Direct bilirubin, GGT: Gamma-glutamyl transferase, HDL: High-density lipoprotein, UIBC: Unsaturated iron binding capacity

DISCUSSION

The principal target population for home healthcare services is the elderly population (6,7). Accordingly, 83.1% of the patients included in our study were 65 years of age or older. In addition, we found the average age of female patients to be significantly higher than that of male patients, which is in line with the age-related findings of many similar studies conducted in the field of home healthcare services (6-8).

Albumin is the most abundant protein in the blood, accounting for approximately half of the total protein (9). In light of known age-related declines, it is expected that both the total protein content of the blood and the albumin level will decrease with age, unless diseases present cause increases in other proteins, such as globulins. Indeed, in many prior studies that have sought to evaluate the relationship between albumin and age, the albumin level has been found to decrease with age, although a number of other studies have observed the albumin

level to be within normal limits in healthy elderly people (10,11). In the present study, the albumin and total protein levels both decreased with age; however, the albumin level was significantly higher in female patients than in male patients. A number of studies have found the albumin level to be higher in male patients, although this difference was reversed during the postmenopausal period, with the albumin level being found to be higher in female patients. Due to their age, the majority of female patients included in our study could be expected to be in the postmenopausal period, which may explain their higher albumin levels than male patients.

It is important to note that changes in patients' albumin levels are reflected in their Ca levels (12). In this study, a significant difference was observed between the age groups in terms of Ca levels, which decreased with age. Moreover, female patients exhibited significantly higher Ca levels than male patients. If the serum albumin level of a patient is less than 4 g/dL due to the binding of Ca to albumin, the patient's total Ca level should be corrected using the following equation: corrected Ca = serum total Ca (mg/dL) + 0.8 × [4.0 - serum albumin (g/dL)] (13). In the present study, the albumin levels of 812 patients were found to be less than 4 g/dL. However, when we re-evaluated all of the Ca results following correction using the previously mentioned equation, we found that there was no statistically significant difference between the age groups (p=0.08). Given this change in results, physicians should calculate and use the corrected Ca level during follow-up given that the Ca level may initially be interpreted as low due to hypoalbuminemia among elderly patients receiving home healthcare. In other words, we believe that family physicians, who are likely to frequently encounter members of the elderly population, should be particularly careful in relation to the follow-up of patients' Ca levels because of the increasing frequency of hypoalbuminemia (10).

Previous studies have shown that both ALT and AST levels decrease with age (12). Although the exact mechanism underlying this decrease remains unknown, it is believed that a change in glucose-insulin metabolism may occur with age. The age-related decrease in fasting blood glucose levels observed in previous studies supports this hypothesis (14). In our study, although the patients' ALT and AST levels decreased with age, no significant difference was noted in terms of their glucose levels. The reason for this may be that the patients' blood samples were not always taken after eight hours of fasting. In addition, in the context of home healthcare services, the time between sample collection and cell separation via centrifugation is not standardized. This is relevant because it has previously been established that glucose levels in non-centrifuged samples decrease by 5-7% per hour due to glycolysis (15). Thus, we consider the HbA1c test to be more reliable than glucose or fasting glucose tests in relation to follow-up of patients with diabetic home care or those with suspected diabetes. However, although the ALT level was found to be significantly higher in male patients in our study, no gender difference was observed regarding the AST or glucose levels. Some previous studies have suggested that male patients are associated with higher AST and ALT levels (12,16).

A previous study found that the ALP level increases with age until menopause in female patients and then decreases during the postmenopausal period (17). In light of these findings, the ALP levels of the female patients included in this study may have been decreased because the majority of them were 65 years of age or older. We found no significant differences between the genders in our study.

Our study also evaluated the patients' CK levels, which has previously been observed to be directly proportional to age and body mass index (18). We found that CK levels decreased with age in both female and male patients.

In this study, the patients' triglyceride level was noted to decrease with age. A number of earlier studies have investigated the relationship between triglyceride levels and age and found that triglyceride levels increase with age (19,20). However, the patients included in our study were all home healthcare patients with nutritional status that differed from that of healthy individuals. It has been established that the lipid profile of a patient is directly related to that patient's nutritional status (21). Thus, we believe that the age-related decrease in triglyceride levels observed in the patients included in this study may be related to their nutritional status.

We did not identify any relationship between the patients' HbA1c levels and their age or gender. In the literature, a number of studies have sought to evaluate the relationship between HbA1c and age and have found that HbA1c levels either increase with age or are unrelated to age (22,23).

Although the patients' TSH levels were not found to be associated with age in our study, both their FT3 and FT4 levels were observed to have decreased. Some prior studies have reported that patients' TSH levels increase with age, whereas others have found that it is not related to age (24,25). In accordance with our findings, previous studies have shown that FT3 and FT4 levels decrease with age (26).

CONCLUSION

The majority of patients receiving home healthcare services are elderly. However, age-related reference ranges are not typically used for most clinical laboratory tests. As the data presented in our study and supported by findings previously reported in the literature show that some test results increase or decrease with age, physicians should consider age in relation to follow-up of relevant parameters. For example, in the case of an increase observed in a parameter that is expected to be low due to age, additional care should be taken, and the patient should be closely followed, even if the result is within the reference range.

Family physicians frequently work with members of the geriatric patient population. Moreover, in addition to physical examination, biochemical tests are recognized as an important aspect of patient evaluation. In this context, we suggest that it is important to be aware of the changes that occur in certain parameters with age among the elderly population and to keep them in mind during patient follow-up.

Ethics

Ethics Committee Approval: The study received approval from the Non-interventional Clinical Research Ethics Committee of Niğde Ömer Halisdemir University (decision number: 2022/01, date: 13.01.2022)

Informed Consent: This was a retrospective study; thus, informed consent was not obtained.

Authorship Contributions

Surgical and Medical Practices: H.D.B., Concept: H.D.B., Design: H.D.B., F.E., Data Collection or Processing: H.D.B., F.E., H.B.Y., Analysis or Interpretation: H.D.B., F.E., H.B.Y., A.R.D., Literature Search: H.D.B., F.E., H.B.Y., A.R.D., Writing: H.D.B., F.E., H.B.Y., A.R.D.

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REFERENCES

1. Turkey Statistical Institute, Life Tables; 2017-2019. [Internet] Available from: https://data.tuik.gov.tr/Bulten/Index?p=Hayat-Tablolari-2017-2019-33711. (Accessed: 08.10.2021)
2. Turkey Statistical Institute, Old People With Statistics; 2020. [Internet] Available from: https://data.tuik.gov.tr/Bulten/Index?p=Istatistiklerle-Yaslilar-2020-37227. (Accessed: 08.10.2021)
3. Altuntaş M, Yılmazer TT, Güçlü YA, Öngel K. Home Health Care Service And Recent Applications in Turkey. Anatol J Med. 2010;3:153-8.
4. Doğusan AR. Legislation and Development of Home Health Services in Turkey. Ankara Med J. 2019;3:684-93.
5. Erbil MK. Laboratory Tests and Clinical Use. Ankara: 2007.p.25-6.
6. Çayır Y. Evde Sağlık Hizmetleri Alan Hastaların Özellikleri ve Bakım Verenlerin Beklentileri. Konuralp Medical Journal. 2013;5:9-12.
7. Çevik A, Basat O, Uçak S. Evaluation of Nutritional Status and Its Effect on Biochemical Parameters in Elderly People Admitted to Home Health Care Services. Konuralp Medical Journal. 2014;6:31-7.
8. Moman RN, Gupta N, Varacallo M. Albumin Physiology. StatPearls [Internet]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK459198/. (Accessed: 03.01.2022)
9. Kıskaç N, Hacıoğlu B, Güven M, Rashidi M, Yıldırım G, Hacıoğlu Y. Profile of Home Healthcare Patients and Evaluation of Health Service Provided to Patients-Istanbul Province Example. İstanbul Gelişim Üniversitesi Sağlık Bilimleri Dergisi. 2023;20:409-18.
10. Gom I, Fukushima H, Shiraki M, Miwa Y, Ando T, Takai K, et al. Relationship between serum albumin level and aging in community-dwelling self-supported elderly population. J Nutr Sci Vitaminol (Tokyo). 2007;53:37-42.
11. Cabrerizo S, Cuadras D, Gomez-Busto F, Artaza-Artabe I, Marín-Ciancas F, Malafarina V. Serum albumin and health in older people: Review and meta analysis. Maturitas. 2015;81:17-27.
12. Zhang GM, Xia YJ, Guo XX, Zhu BL, Zhang GM, Ma XB, et al. Reference intervals for total bilirubin, ALT, AST, and creatinine in healthy Chinese elderly. Med Sci Monit. 2014;20:1778-82.
13. Obi Y, Nguyen DV, Streja E, Rivara MB, Rhee CM, Lau WL, et al. Development and Validation of a Novel Laboratory-Specific Correction Equation for Total Serum Calcium and Its Association With Mortality Among Hemodialysis Patients. J Bone Miner Res. 2017;32:549-59.
14. Preuss HG, Kaats GR, Mrvichin N, Bagchi D, Preuss JM. Circulating ALT Levels in Healthy Volunteers Over Life-Span: Assessing Aging Paradox and Nutritional Implications. J Am Coll Nutr. 2019;38:661-9.
15. Turchiano M, Nguyen C, Fierman A, Lifshitz M, Convit A. Impact of blood sample collection and processing methods on glucose levels in community outreach studies. J Environ Public Health. 2013;2013:256151.
16. Bilal M, Tariq A, Khan S, Quratulain, Tariq A, Shahid MF, et al. Influence of gender, BMI, and ethnicity on serum ALT levels of healthy students of a medical school. J Ayub Med Coll Abbottabad. 2011;23:70-2.
17. Mukaiyama K, Kamimura M, Uchiyama S, Ikegami S, Nakamura Y, Kato H, et al. Elevation of serum alkaline phosphatase (ALP) level in postmenopausal women is caused by high bone turnover. Aging Clin Exp Res. 2015;27:413-8.
18. George MD, McGill NK, Baker JF. Creatine kinase in the U.S. population: Impact of demographics, comorbidities, and body composition on the normal range. Medicine (Baltimore). 2016;95:e4344.
19. Spitler KM, Davies BSJ. Aging and plasma triglyceride metabolism. J Lipid Res. 2020;61:1161-7.
20. Cui Y, Ruan X, Jin J, Jin F, Brucker S, Mueck AO. The pattern of lipids and lipoproteins during the menopausal transition in Chinese women. Climacteric. 2016;19:292-8.
21. Yılmaz HÖ. Hyperlipidemia and Nutrition. Turkish Journal of Health Sciences and Research 2019;1:72-82.
22. Polat Ö, Okuturlar Y, Pişkinpaşa H, Akdeniz Y, Sadri S, Bozer DS, et al. Distribution of HbA1c by Age in Diabetic Patients - The Effect of Guidelines on Current Practices. Turk J Diab Obes. 2018;3:107-12.

23. Dubowitz N, Xue W, Long Q, Ownby JG, Olson DE, Barb D, et al. Aging is associated with increased HbA1c levels, independently of glucose levels and insulin resistance, and also with decreased HbA1c diagnostic specificity. Diabet Med. 2014;31:927-35.

24. Gül ÖÖ, Şahin S, Cander S, Gül B, Ünal OK, Akçalı Ü, et al. Investigation of Relationship between Thyroid Functions and Age of the Patients Who Are Admitted to the Endocrinology Out-patient Clinic. Journal of Uludağ University Medial Faculty. 2011;37:67-70.

25. Taylor PN, Lansdown A, Witczak J, Khan R, Rees A, Dayan CM, et al. Age-related variation in thyroid function - a narrative review highlighting important implications for research and clinical practice. Thyroid Res. 2023;16:7.

26. Corsonello A, Montesanto A, Berardelli M, De Rango F, Dato S, Mari V, et al. A cross-section analysis of FT3 age-related changes in a group of old and oldest-old subjects, including centenarians' relatives, shows that a down-regulated thyroid function has a familial component and is related to longevity. Age Ageing. 2010;39:723-7.