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Long-term regular exercise effect on retinal and choroidal structure: insights from real-life data

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ABSTRACT

Aims: Exercise increases ocular perfusion pressure. The retina and choroid can autoregulate blood flow to a certain extent in response to this increase. Most of the studies have focused on short-term ophthalmologic effects of exercise and showed conflicting results. This study aimed to evaluate the long-term effects of regular exercise on retinal and choroidal structures, as well as the potential contribution of exercise-related systemic changes.

Methods: Participants who had engaged in regular exercise for at least two years were included in the study group, while those who had not exercised were assigned to the control group. Clinical assessments included blood pressure, heart rate, body-mass index, HbA1c, complete blood count, lipid profile, thyroid-stimulating hormone, fT3, fT4, and C-reactive protein. Retinal and choroidal thicknesses in the right eye were measured using optical coherence tomography.

Results: The trained group consisted of 36 participants and the untrained group included 35 participants. The mean duration of regular exercise was 4.29±2.5 years. Choroidal thickness was greater at all measured points in the trained group compared with controls, with significant differences at nasal ($p<0.05$) and subfoveal ($p<0.01$) measurements. Red blood cell count, hemoglobin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, and eosinophil counts were also significantly higher in the trained group.

Conclusion: This study is, to our knowledge, the first to investigate the effects of long-term, consistent physical activity by non-professionals in real-life settings on retinal and choroidal structures. Choroidal autoregulation normally maintains stable blood flow even when ocular perfusion pressure rises during exercise. However, the observed long-term choroidal thickening suggests that prolonged physical activity may exceed this regulatory capacity.

Keywords: Cardiovascular risk factors, choroid, exercise, hematological parameters, real-life conditions, retina

INTRODUCTION

During physical activity, ocular blood flow increases in parallel with rises in blood pressure (BP) and heart rate (HR).[1] It has been shown in many studies that autoregulatory mechanisms prevent the increase of ocular blood flow during exercise.[2] Retinal vessels have no innervation and retinal blood flow is regulated with oxygen, carbon dioxide and local metabolic factors.[1] The typical retinal response to exercise is vasoconstriction.[1,3]

The choroid is a highly vascularized layer of the eye.[4] Its vascular bed receives both sympathetic and parasympathetic innervation, with sympathetic input and ocular perfusion pressure (OPP) serving as the main regulatory factors.[4] Moreover, abnormalities in blood count, glucose metabolism, BP, and lipid profile can influence choroidal structure.[5] Therefore, the choroid is likely to be affected by cardiovascular risk factors.[5] Variations in hemogram parameters may also alter choroidal blood flow (CBF) and thickness.[6]

Regular exercise exerts systemic effects on the arterial vasculature.[7,8] It reduces total peripheral resistance and cardiac afterload; however, these are not the only mechanisms through which exercise lowers BP.[7] Regular training also decreases sympathetic activity, prevents arterial stiffness, and contributes to BP reduction by mitigating inflammation.[7] In addition, exercise improves traditional cardiovascular risk factors, including insulin resistance, hypertension, dyslipidemia, and obesity.[8,9]

There are only a few studies evaluating the long-term effects of exercise on the retina and choroid. The aim of this study is to evaluate the impact of regular exercise on the retinochoroidal structure of healthy people under real-life conditions. In

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addition, the study was designed to assess systemic parameters that may influence the retina and choroid in conjunction with exercise.

METHODS

This is a cross-sectional study that enrolled voluntary participants of the same ethnicity aged 18 to 50 years. This study was approved by the University of Health Sciences Hamidiye Clinical Researches Ethics Committee (Date: 23.11.2023, Decision No: 2023.23.11-63) and conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants. Best corrected visual acuity, intraocular pressure (IOP), biomicroscopic anterior segment, and pupil-dilated posterior segment examinations were performed.

Participants who had engaged in regular exercise for ≥2 years and accumulated >1500 metabolic equivalent of task (MET) per week were included. Physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ). One MET denotes resting energy expenditure (≈3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$ ≈1 $kcal \cdot kg^{-1} \cdot h^{-1}$). Moderate-intensity activities (e.g., recreational cycling, dancing at a moderate pace) were assigned a value of 4 METs, and vigorous-intensity activities (e.g., aerobics, basketball, high-intensity fitness training) 8 METs. The weekly total MET value was calculated as the sum across all reported activities: exercise constant (4 or 8)×exercise duration (minutes)×exercise frequency (days per week).

Biochemical and hematological parameters were measured using standardized kits and automated analyzers. After an overnight fast of at least eight hours, peripheral blood samples were obtained from all participants. The analyses included HbA1c, complete blood count (CBC), lipid profile, thyroid-stimulating hormone (TSH), fT3, fT4, and C-reactive protein (CRP). The lipid profile comprised total cholesterol, HDL-cholesterol, LDL-cholesterol, and triglycerides. CBC analysis was performed with the Mindray BC-6800Plus hematology analyzer using SF Cube technology. The lipid profile was assessed with the Roche Lipid Panel on the cobas c 501 analyzer using an enzymatic colorimetric method. HbA1c was measured with the Cobas b 101 system, which employs an immunoassay method. Thyroid function tests were measured using the Elecsys TSH assay on the cobas e 601 analyzer based on the electrochemiluminescence immunoassay technique.

HR, BP, height, and weight were measured for all participants, and body-mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. The standard protocol for office BP monitoring included a 5-minute rest period before measurement, abstinence from smoking, alcohol, or caffeine for at least 30 minutes, and avoidance of talking during and between measurements. BP measurements were obtained using automated oscillometric sphygmomanometers. Systolic blood pressure (SBP), diastolic blood pressure (DBP), and HR were recorded from the upper arm using the Omron M6 Comfort HEM-7360-E device.

The exclusion criteria included refractive errors greater than 3 diopters of myopia, hyperopia, and astigmatism, glaucoma, ocular surgery, retinal diseases, diabetes, respiratory, thyroid, and cardiovascular diseases, hypertension, vascular diseases, nephropathy, uveitis, cigarette smoking, alcohol intake, underweight BMI (<18.5 kg/m²); and overweight BMI (>25 kg/m²).

The right eyes of the patients were evaluated. Optical coherence tomography (OCT) measured total retinal thickness and retinal layer thicknesses, including the nerve fiber layer (NFL), inner plexiform layer (IPL), ganglion cell layer (GCL), inner nuclear layer (INL), outer plexiform layer (OPL), outer nuclear layer (ONL), and retinal pigment epithelium (RPE) layer, using the early treatment diabetic retinopathy study (ETDRS) grid at 1, 3 mm. Enhanced depth imaging (EDI)-OCT was used to measure subfoveal choroidal thickness (SFCT) and at 1000 μm nasal and temporal to the foveola.

Statistical Analysis

IBM SPSS 26.0 package program was used in the statistical analysis of the study. For comparisons of parameters, the independent samples t-test was used when the data were normally distributed, and the Mann–Whitney U test was used when the data were not normally distributed. Before all comparisons, the Shapiro Wilk test was used to determine whether the data were normally distributed according to groups. ANCOVA analysis was performed to account for the imbalance in gender distribution. All statistical analyzes were evaluated at the 95% confidence interval and significance at the p<0.05 level.

RESULTS

The trained group included 36 participants, while the untrained group included 35 participants. Thirteen participants (36.1%) of the trained group were women, while 23 (63.9%) were men. In the untrained group, 31 participants (88.6%) were women, and 4 (11.4%) were men. The average age of those who exercised was 28.42±9.10 years, while it was 29.06±6.60 years for those who did not exercise. There was no significant difference in the mean IOP (15.80±2.17 mmHg in the trained group; 15.29±1.92 mmHg in the untrained group) (p>0.05). A significant difference was observed in the spherical equivalent between the two groups (-0.12±0.55 in the trained group; -0.58±1.16 in the untrained group) (p<0.05).

There was no significant difference in BMI, HR, SBP, and DBP between the two groups (**Table 1**). All retinal layers, except for the RPE, showed no statistically significant differences (p>0.05) in thickness at the ETDRS grid 1-and 3-mm measurements between the trained and untrained groups (**Table 2, 3**). In the RPE layer, a significant difference was observed at the superior 3-mm area (p=0.032) (**Table 3**). Choroidal thickness (CT) was found to be increased in the trained group compared to the untrained group in all measurements, but only the nasal and subfoveal values were statistically significant (p=0.013 and p=0.004) (**Table 4**). After statistically adjusting for the difference in gender ratio, the significance of CT remained unchanged.

Red blood cell count (RBC) (p=0.008), hemoglobin (HGB) (p=0.0001), hematocrit (HCT) (p=0.0001), mean corpuscular volume (MCV) (p=0.021), mean corpuscular hemoglobin (MCH) (p=0.043) and eosinophil counts (p=0.010) were

Table 1. Blood pressure, heart rate, body mass index and metabolic equivalent of task comparison between groups

	Trained group n=36			Untrained group n=35			
	Median	Min-max	Mean±SD	Median	Min-max	Mean±SD	p
Systolic BP (mmHg)	114	80-130	111.44±9.65	110	90-134	109.37±11.8	0.13[a]
Diastolic BP (mmHg)	70	52-90	70.11±8.25	70	59-87	70.11±6.34	0.926[a]
Heart rate (bpm)	74.5	50-103	75.67±12.03	74	61-110	75.89±10.03	0.934[b]
BMI (kg/m^2)	24.72	19.35-33.22	24.3±2.87	22.49	14.84-45.37	23.88±4.9	0.25[a]
MET	2772	1542-9030	3727.22±2120.6	990	330-1498	991.14±335.1	0.0001[a]**

[a]: Mann Whitney U test, [b]: Independent samples t-test, p<0.05 *, p<0.01**, SD: Standard deviation, Min: Minimum, Max: Maximum, Systolic BP: Systolic blood pressure, Diastolic BP: Diastolic blood pressure, BMI: Body-mass index, MET: Metabolic equivalent of task

Table 2. Thickness of all retinal layers in central 1-mm of ETDRS grid

	Trained group n=36			Untrained group n=35			
	Median	Min-max	Mean±SD	Median	Min-max	Mean±SD	p
RT	262.5	219-346	264.67±23.8	264	225-317	265.26±18.1	0.645[a]
RNFL	12	6-20	12.31±2.6	12	8-23	12.34±2.6	0.74[a]
GCL	15.5	8-52	16.94±8.5	14	5-36	15.66±6	0.624[a]
IPL	21	12-42	21.25±5.9	20	14-30	20.14±3.6	0.607[a]
INL	17	10-38	18.08±5	17	9-33	17.8±5.1	0.782[a]
OPL	23	12-32	23.03±4.7	25	16-54	25.91±7	0.057[a]
ONL	87.5	66-106	86.44±9.3	89	43-112	86.83±13.1	0.887[b]
RPE	17	13-22	17.31±2	17	13-21	17.2±2.3	0.837[b]

[a]: Mann Whitney U test, [b]: Independent samples t-test, p<0.05 *, p<0.01**, SD: Standard deviation, Min: Minimum, Max: Maximum, ETDRS: Early Treatment Diabetic Retinopathy Study, RT: Retinal thickness, RNFL: Retinal nerve fiber layer thickness, GCL: Ganglion cell layer, IPL: Inner plexiform layer, OPL: Outer plexiform layer, ONL: Outer nuclear layer, RPE: Retinal pigment epithelial layer. Thicknesses are expressed in micrometers. p<0.05 shows statistical significance.

statistically significantly higher in the trained group (**Figure 1**). Statistical subgroup analysis was performed considering the difference in gender ratio. In women, only white blood cell values showed a significant difference, whereas in men, HGB, HCT, and HDL levels were significantly higher in the trained group (p>0.05), while triglyceride levels were significantly higher in the untrained group (p<0.05) (**Figure 2a, b**).

Participants engaged in regular exercise for a mean period of 4.29±2.5 years. Exercise duration per week was calculated according to intensity. The mean weekly duration of moderate-intensity exercise (4 METs) averaged 389.31±383.70 minutes, while high-intensity exercise (8 METs) was 271.81±218.10 minutes. The mean length of a single exercise session was 73.71±55.10 minutes for moderate-intensity exercise and 76.29±53.20 minutes for high-intensity exercise.

The weekly duration of high-intensity exercise showed a positive correlation with RBC, HGB, HCT, and MCH. Furthermore, the length of individual high-intensity exercise sessions was positively correlated with HGB, HCT, MCV, and MCH. The total MET value demonstrated a positive correlation with SFCT, whereas no correlation was observed between CT and RPE thickness.

DISCUSSION

This study is the first to evaluate the effect of regular exercise during 4 years on the thickness of the choroid and retina layers, BP, hematological and lipid profiles.

Increases in HR and SBP correlates with OPP during exercise.[10] Choroidal, retinal, and optic nerve head blood flow tends to remain stable with increases in OPP of up to 40–60%. In an isometric exercise study, a 60% rise in OPP did not elevate CBF, suggesting regulatory mechanisms of CBF.[11] Lovasik et al.[12] examined the relationship between OPP and CBF during a 20-minute cycling protocol and at rest. OPP increased by 43% at exercise onset, subsequently decreasing to approximately 10% above resting levels at the end of the test.[12] In contrast, CBF demonstrated a linear increase and remained within 10% of baseline values.[12] These findings suggest that CBF is primarily regulated by arteriolar sympathetic vasoconstriction during exercise.[12]

An OCT-angiography study reported a decrease in vessel density at the superficial capillary plexus, which correlated with increased SBP during exercise.[3] Similarly, Szalai et al.[1] observed retinal thinning one minute after intense exercise, followed by retinal thickening at 5 and 15 minutes post-exercise. They attributed this result to autoregulatory vasoconstriction during exercise and vasodilation post-exercise.[1] In the present study, significant RPE thinning was only observed in the 3 mm superior subfield of the ETDRS grid. The RPE thinning observed in this study may be secondary to the enlargement of choroidal vessels and compression by a thickened choriocapillaris, resembling pachychoroid morphology.[13] However, this finding could also represent an incidental observation. To date, only one study has evaluated the long-term effects of exercise on the retina, specifically measuring retinal vessel diameter in marathon runners, and found no significant changes.[14]

Different results have been reported in studies investigating the effect of exercise on the choroid. Alwassia et al.[15] did

Table 3. Thickness of all retinal layers in inner 3-mm ring of ETDRS grid

	Trained group n=36			Untrained group n=35			
	Median	Min-max	Mean±SD	Median	Min-max	Mean±SD	p
RT							
3-S	339	307-366	339.33±15.1	343	313-360	340.91±12.9	0.625[a]
3-I	339	302-373	338.42±16.5	339	306-367	340.4±15.5	0.604[b]
3-N	337.5	251-364	337.67±19.7	340	293-368	339.37±15.7	0.809[a]
3-T	327	300-358	326.25±14.6	328	12-350	316.66±55.2	0.927[a]
RNFL							
3-S	23	17-29	22.61±2.7	23	18-29	23.17±2.7	0.384[b]
3-I	25.5	14-30	25.36±3.5	27	18-38	26.63±3.7	0.301 [a]
3-N	20	16-27	20.64±2.3	20	15-27	20.74±2.5	0.802 [a]
3-T	16	15-19	16.44±1	17	14-20	16.86±1.3	0.121[a]
GCL							
3-S	53	41-63	52.75±5	52	44-65	53.11±4.8	0.755[b]
3-I	53.5	28-66	53±6.4	53	45-61	53.74±3.8	0.632[a]
3-N	53	43-68	53.11±5.3	52	37-61	51.54±4.9	0.203[b]
3-T	49	38-59	48.47±5.3	48	27-56	47.2±5.7	0.381[a]
IPL							
3-S	41	33-48	41.14±3.3	42	36-48	41.66±3.1	0.503[b]
3-I	41	31-50	41.25±3.7	42	34-48	42.09±3.2	0.315[b]
3-N	42	36-50	41.89±3.5	43	32-48	41.86±3.6	0.970[b]
3-T	41	32-50	41.08±3.8	41	27-46	40.69±3.8	0.954[a]
INL							
3-S	41	33-55	40.92±5	41	35-46	40.17±3.4	0.463[b]
3-I	40	33-47	40.64±3.8	40	34-46	40.57±3.2	0.935[b]
3-N	41.5	34-46	40.89±3.4	41	31-47	40.03±3.5	0.274[a]
3-T	37	30-44	37.42±3.6	38	26-45	37.49±3.9	0.939[b]
OPL							
3-S	30.5	25-57	33.64±9.1	29	23-55	31.89±7.5	0.413[a]
3-I	28	24-53	30.83±6.3	32	24-51	33.03±6.5	0.050[a]
3-N	31	26-40	31.42±4	31	24-63	32.57±8.3	0.817[a]
3-T	29	25-39	30.08±3.3	29	24-44	29.6±4.6	0.364[a]
ONL							
3-S	68.5	45-84	67.67±10	72	46-86	69.89±11.1	0.191[a]
3-I	70.5	36-85	68.06±10.5	64	46-79	64.09±9.6	0.072[a]
3-N	72	56-85	70.72±8	70	38-88	69.94±12	0.778[a]
3-T	71,5	52-85	71.33±6.9	73	50-86	71.86±8.3	0.496[a]
RPE							
3-S	15	13-19	14.89±1.2	15	13-18	15.37±1.3	0.032[a]*
3-I	14.5	12-19	14.53±1.4	14	12-17	14.2±1.3	0.437[a]
3-N	15	12-18	14.97±1.2	15	12-18	15.34±1.5	0.182[a]
3-T	15	13-17	14.58±1.1	14	11-17	14.26±1.4	0.381[a]

[a]: Mann Whitney U test, [b]: Independent samples t-test, p<0.05 *, p<0.01**, SD: Standard deviation, Min: Minimum, Max: Maximum, ETDRS: Early Treatment Diabetic Retinopathy Study, 3S: 3 mm superior subfield, 3I: 3 mm inferior subfield, 3N: 3 mm nasal subfield, 3T: 3 mm temporal subfield, RT: Retinal thickness, RNFL: Retinal nerve fiber layer thickness, GCL: Ganglion cell layer, IPL: Inner plexiform layer, OPL: Outer plexiform layer, ONL: Outer nuclear layer, RPE: Retinal pigment epithelial layer. Thicknesses are expressed in micrometers. p<0.05 shows statistical significance.

not find any change in CT at the 3rd minute of stress testing in patients with a mean age of 60 years. Kinoshita et al.[16] analyzed the choroid more thoroughly after mild dynamic exercise. They observed no change in central CT, mean luminal and stromal areas, or the mean luminal/choroidal area ratio within 10 minutes after exercise.[16] In contrast, the study by Sayın et al.[17] found thickening of the choroid 5 minutes after medium-intensity training, which returned to normal values 15 minutes post-exercise. In the present study, temporal, subfoveal, and nasal CT was found to be increased in the trained group compared to the untrained group, but only the nasal and subfoveal measurements were statistically

Table 4. Choroidal thickness in nasal, subfoveal and temporal measurements

	Trained group n=36			Untrained group n=35			
	Median	**Min-max**	**Mean±SD**	**Median**	**Min-max**	**Mean±SD**	**p**
Nasal CT	379	226-584	380.22±90	342	197-458	333.31±63.5	0.013[a]*
Subfoveal CT	396.5	267-619	405.08±84.6	355	168-483	348.8±74.6	0.004[a]**
Temporal CT	384.5	249-554	383.36±88.3	344	243-464	349.51±55.1	0.057[a]

[a] Independent samples t-test, p<0.05 *, p<0.01**, SD: Standard deviation, Min: Minimum, Max: Maximum, CT: Choroidal thickness. Thicknesses are expressed in micrometers.

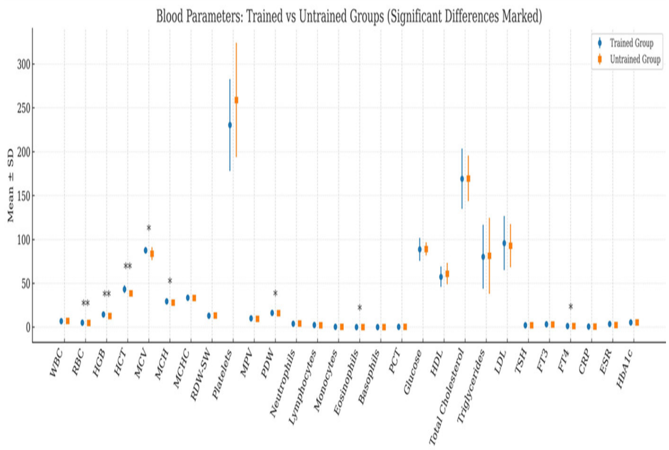

Figure 1. Comparison of hematological and biochemical parameters between trained and untrained groups. Overall analysis including both sexes.
Data are presented as mean±SD. Blue circles represent the trained group, and red squares represent the untrained group. Asterisks denote statistically significant differences (*p<0.05, **p<0.01; Independent samples t-test, Mann–Whitney U test). WBC: White blood cell, RBC: Red blood cell, HGB: Hemoglobin, HCT: Hematocrit, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, RDW-SW: Red blood cell distribution width-standard deviation, MPV: Mean platelet volume, PDW: Platelet distribution width, PCT: Procalcitonin, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TSH: Thyroid-stimulating hormone, CRP: C-reactive protein, ESR: Erythrocyte sedimentation rate

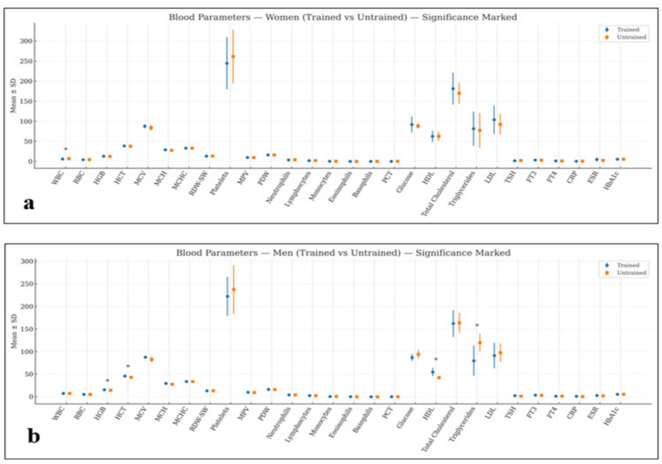

Figure 2. Hematological and biochemical parameters in trained versus untrained groups, stratified by sex: **a)** women **b)** men
Data are presented as mean±SD. Blue circles represent the trained group, and red squares represent the untrained group. Asterisks denote statistically significant differences (*p<0.05, **p<0.01; Mann–Whitney U test). WBC: White blood cell, RBC: Red blood cell, HGB: Hemoglobin, HCT: Hematocrit, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, RDW-SW: Red blood cell distribution width-standard deviation, MPV: Mean platelet volume, PDW: Platelet distribution width, PCT: Procalcitonin, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TSH: Thyroid-stimulating hormone, CRP: C-reactive protein, ESR: Erythrocyte sedimentation rate

significant (p<0.05 and p<0.01). There is only one long-term study (the CHAMPS study) in the literature that aimed to find a correlation between physical activity and CT in children.[18] They reported no association between CT and physical activity.[18]

Differences in exercise study outcomes may be attributed to variations in exercise duration, intensity, and the occurrence of hypocapnia. CBF increases by more than 10% when OPP rises by over 60%, depending on exercise intensity and duration.[11,12] Intense exercise could lead to hyperventilation and hypocapnia.[19] A study showed that retinal and CBF increased during submaximal exercise at 6 minutes but decreased with exhaustion due to hypocapnia.[20] In the present study, the observed increase in CT suggests that CBF rose to a level sufficient to induce thickening of the choroid under the given exercise duration and intensity.

The spherical equivalent was significantly more myopic in the untrained group (-0.12±0.55 in the trained group; -0.58±1.16 in the untrained group) (p<0.05). An increase of one diopter in myopia has been shown to decrease SFCT by 13 µm.[21] SFCT was 405.08±84.6 µm in the trained group and 348.8±74.6 µm in the untrained group. Even after recalculating, considering a -0.50-diopter difference, SFCT in the trained group would still be statistically significantly thicker.

In the present study, RBC, HGB, HCT, MCV, MCH, and eosinophil values were observed to be significantly higher in the trained group. However, no correlation was identified between these hematological parameters and CT. Studies on hematological parameters show varying results depending on exercise intensity and whether the exercise is anaerobic or aerobic. A study on a group that regularly engaged in aerobic exercise over the past 12 weeks showed increased HGB, HCT, and platelet levels.[22] Another study compared the effects of aerobic and strengthening exercises after 16 weeks of training and reported significant decreases in RBC, HGB, HCT, and MCV values in the strengthening exercise group.[23] Consistent with these findings, Alam et al.[24] also observed similar hematologic changes in athletes following intense exercise. Bizjak et al.[25] evaluated the effects of a 6-week moderate training protocol on RBCs and found an increase in both young and old RBCs. They attributed the RBC results in their study to the increase in catecholamines, cortisol, growth hormones, and insulin-like factors with exercise, which stimulate erythropoiesis.[25]

Limitations

One of the limitations of the study is the difference in the female/male ratio between the groups. Some studies have found that the choroid is thicker in males than in females, while others have found no difference.[26,27] Another limitation is the absence of an assessment of patients' dietary habits and micronutrient intake, factors that may significantly influence hematological and biochemical parameters.

The elevated eosinophil count observed in this study may reflect non-allergic activation.[28,29] Several studies showed that eosinophils could be activated by exercise in healthy individuals, with both long-term endurance and short-term maximal exercise elevating eosinophil cationic protein levels.[28,29]

In this study, no significant differences were observed in BMI, HR, SBP, DBP, lipid profile, HbA1c, or thyroid function between the trained and untrained groups. A study investigating six months of moderate- and high-intensity exercise reported significant changes in total cholesterol, LDL, and HDL levels in the high-intensity group.[30] Consistent with these findings, our subgroup analysis in men had higher levels of HDL. These findings suggest that both the duration and type of training are key determinants of exercise-related effects on lipid profiles and BP, consistent with the other parameters evaluated in the present study.[30,31] The training regimen of the study group does not appear to have been sufficient to alter lipid profiles and BP in the present study.

CONCLUSION

As a result, to the best of our knowledge, this is the first study to evaluate choroidal and retinal parameters, along with hematologic and lipid profiles, in a predominantly moderately active population engaged in long-term exercise under real-life conditions. CT, RBC, HGB, HCT, MCV, MCH, and eosinophil values were statistically significantly increased in the trained group under real-life conditions. The characteristics of exercise—such as duration, intensity, endurance, and whether it is aerobic or anaerobic—may be the main factors determining the systemic and organ effects of exercise.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was approved by the University of Health Sciences Hamidiye Clinical Researches Ethics Committee (Date: 23.11.2023, Decision No: 2023.23.11-63).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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