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Dependence of Biochemical Blood Markers and Sports Skills Level in Puberty Period

Yayin Döneminde Biyokimyasal Kan Belirticileri Ve Spor Beceri Düzeyinin Bağimliliği

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ABSTRACT
The main propose of the present research was to study of age-related metabolism characteristics in case tendency to age-onset reducing of the systematic physical exercises and quicker sports success achievement. Was provided the metabolic state markers analysis of adolescent athletes via traditional laboratory tests is required. In an experiment we have took male (701) and female (363) youth people including 576 athletes and 125 members control for male and 320 athletes and 43 in a control for female. The authors have made a non-personalized database including age, gender, body mass index, sports qualifications, and 24 biochemical markers of blood serum was created. We havefound in athletes aged 12-15 body mass index, aspartate aminotransferase activity, glucose/low-density lipoprotein ratio elevation and total iron-binding activity serum decrease in athletes of both sexes; increase in urea and triglycerides, alpha-amylase activity and decrease in calcium, albumin/globulin ratio in male athletes; decreased activity of alkaline phosphatase in female athletes. In 16-18 year age group some changes also were observed: opposing changes in the content of low-density lipoproteins, the activity of aspartate aminotransferase and glucose/low-density lipoprotein ratio in athletes of both sexes; increase in urea, creatinine and atherogenic index values in male athletes; a decrease in the alanine aminotransferase, alkaline phosphatase, creatine phosphokinase activity and the coefficient of creatine phosphokinase/aspartate aminotransferase ratio in males athletes; total bilirubin, glucose/indicators decrease in female athletes. Identified changes in biochemical markers seemed to detect metabolic disorders in the body of athletes during puberty.
Keywords*:*puberty, biomarkers, sports, metabolism, gender differences.

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INTRODUCTION

The youth athletic department of the International Olympic Committee provides an ethical approach maintenance during laboratory and field testing, and effectively translate them to optimize the youth sports participation and performance (1). HELENA's study was conducted in 10 cities of 9 European countries. The 528 adolescents aged 12.5–17.5 years were studied for cardiometabolic risk factors, such as homeostasis model assessment index, systolic blood pressure, triglycerides, total cholesterol by high-density lipoprotein cholesterol ratio, sum of 4 skinfolds and cardiorespiratory fitness. The survey showed that physical activity is the most significant way to protect adolescents from cardiometabolic pathology (2).

Puberty is the process of adolescent's body transformation with maturing and procreation capability. The average weight gain of adolescent males is 35 kg (medium annual gain 6–12.5 kg), and for female adolescents — 25 kg (medium gain 5.5–10.5 kg). The average body length accretion for adolescent males is 36 cm (7–12 cm) and slows down to 14 years, while adolescent females reach peak height velocity earlier — by 12 years of age with average height growth 24.5 cm (6–10.5 cm per year). However, male adolescents reach a plateau of muscle growth and strength about 2 years earlier compared to females. By the age of 12, most children are physically and cognitively being able to solve complex problems arising at various sports and competitions (3, 4). The total energy intake should be considered during adolescent's protein requirements assessment. Therefore, the intensive physical activity with high energy intake may cause excessive protein and amino acids usage with further growth and development slowing (5, 6).

It is well known, children have better fatigue resistance during high-intensity exercise than adults. However, puberty induces the physiological changes leading to increased neuromuscular system fatigue during intensive physical exercise by two mechanisms. Firstly, via the slow-twitch muscle fibers decreasing (type I) and the fast-twitch muscle fibers increasing (type II). Secondly, adolescents have a lower oxidative metabolism activity comparing to prepubertal children, therefore, their ATP recovery is slower (7). Girls puberty begins at 10–12 and lasts until 15–16 years; for boys – begins at 12–14 till 17–18 years (8). Early-onset of puberty depends on the neuroendocrine system condition and leads to adverse health consequences (9, 10).

For decades, individual metabolite analysis (including routine biochemical tests), as biomarkers of health status and diseases, was conducted. The biochemical characteristics changes during puberty are observed Among them: increases of creatinine serum levels, total cholesterol, high-density lipoprotein cholesterol, triglycerides, uric acid, urea, bilirubin, as well as a decreasing of alkaline phosphatase activity, lactate dehydrogenase, aspartate aminotransferase and calcium levels (11). Recently, seven laboratory panels for biomarker research in sports have been accepted (12). Panel 1 "Nutrition and metabolism" is interesting due to low-cost and wide availability. This panel provides the macronutrient metabolism assessment (glucose, triglycerides, free fatty acids, cholesterol, lipids, total protein, albumin, globulins, blood urea nitrogen, amino acids) and micronutrient metabolism (vitamins B, D, E, magnesium, iron, zinc, chromium). Hence, this work aims to provide a comparative study of the adolescent athlete's health state based on their metabolism biochemical markers.

MATERIALS AND METHODS

Participants

Adolescents were divided into 3 groups — early (12–15 years), middle (16–18 years), and late (19–20 years). Each group was distinguished 2 subgroups. The first one was the control group (CG) — people who started sports, but did not receive qualifications; the second group ones included adolescents, who had received sports qualifications due to the systematic sports activities. In the present study — 363 of females (including 320 athletes and 43 members of the CG), and 701 males (576 athletes and 125 members of the CG) have participated. Blood serum biochemical markers (24 markers) of the participants, were carried considering the age, gender, body mass index and athletic qualifications. The data were collected during the period 2011–2019 in the Vitebsk Sports Medicine Dispensary (Republic of Belarus). The following international classification of sports qualifications was used in the article: Third-Class Junior Sportsman, Second-Class Junior Sportsman, First-Class Junior Sportsman, Third-Class Sportsman, Second-Class Sportsman, First-Class Sportsman, Candidate for Master of Sport, and Master of Sport.

Biochemical analysis

Biochemical analyses of blood serum were carried out in a certified laboratory "Vitebsk Regional Diagnostic Center".[13] The levels of 24 serum markers were measured at sample collection, such as glucose (GLC), urea, total cholesterol (TC), high-density lipoprotein cholesterol (HDL), triglyceride (TG), low-density lipoprotein (LDL), calcium, potassium, serum uric acid, creatinine, total bilirubin, direct bilirubin, iron, total iron-binding capacity (TIBC), total protein, albumin, globulin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), creatine phosphokinase (CPK), alpha-amylase, gamma-glutamyltransferase (GGT), atherogenic index values (AI) (TC — HDL/HDL) and albumin/globulin (A/G), AST/ALT, CPK/AST, GLC/TC, GLC/HDL, CPK/ALP, GLC/LDL ratio.

StatisticalAnalysis

Obtained data was analyzed with a nonparametric analysis (Statistica 10.0, StatSoftinc.). Kruskal-Wallis test was used for multiple group comparisons. Mann–Whitney U test was used for comparing the difference among various groups. Differences were considered significant at $p < \backslash.0.05$, Bonferroni correction was used for post hoc pairwise comparisons. Data are presented as medians between 25% and 75% percentile.

Ethics

The study was approved by the ethics committee of Vitebsk State University and was written by the standards set out by the Declaration of Helsinki. Written informed consent was obtained from parents/guardians of each participant followed by verbal consent from participants themselves. All the patients and parents/guardians did agree to participate in the experiment and do not deny the results of the experiment to be provided in the research paper.

RESULTS

JuniorSportsmanqualification

The levels of glucose, direct bilirubin, uric acid, total protein, globulin, TC, HDL, LDL, AI; ALT, AST, GGT activities, potassium, iron contents and AST/ALT, GLC/HDL, GLC/LDL ratios are almost identical. Only one indicator has changed in both groups – TIBC. Some gender differences were found between athletes. The level of serum triglycerides and alpha-amylase activity was increased for males, while the body mass index for females. The levels of serum bilirubin, calcium, CPK activity, the ratios A/G, CPK/AST, GLC/TC, CPK/ALP were decreased for male athletes compared to the CG. Simultaneously, for female athletes, only three biochemical indicators were decreased – levels of urea, creatinine and ALP activity (Table 1).
{Table 1 is here}

Sportsman, Candidate for Master of Sport, and Master of Sport qualifications

Obtained data demonstrate the raising of the level of serum urea and decreasing of TIBC values for male athletes 12-15 years old compared to the CG. Those participants, who received Sportsman qualifications six indicators were increased (BMI, the content of globulins, TG, α-amylase activity, AST/ALT, GLC/LDL ratios) and four indicators were decreased (the levels of albumin, calcium, A/G, CPK/AST ratios). The value of BMI, urea concentration and GLC/LDL ratio were increased with simultaneously decreasing TIBC value were observed for adolescent athletes, who received the Candidate for Master of Sport qualification. The level of serum bilirubin and GLC/TC ratio were decreased for those adolescents who had a Master of Sport qualification. Increasing physical activity leads to changes in biochemical indicators of blood serum. The levels of BMI, GLC, total protein, albumin, globulin, HDL, TG, calcium, TIBC, AST/ALT and GLC/TC ratios did not change for males from the middle-aged group. The activity of ALT, AST, ALP, CPK and CPK/AST ratio was decreased for all athletes (regardless of the level of sports qualifications) compared to the CG. The CPK activity and CPK/AST ratio were decreased for males of the late aged group compared to the CG (Table 2).

{Table 2 is here}

The dependence of GLC, albumin, AI, TG, LDL, TIBS levels with simultaneously increasing ALT, AST activity and GLC/LDL ratio compared to the CG have been observed for females was revealed. Additionally, biochemical indicators were changed for the participants, who had Master of Sport qualification: decreased of the urea and HDL level and ALP activity, while the CPK/ALP ratio was increased (Table 3).

{Table 3 is here}

The activity of AST, GLC/TC, and GLC/LDL ratios was increased for all female athletes (regardless of the level of sports qualifications) compared to the CG. The activity of ALP was increased with simultaneously decreasing TC and LDL levels for Sportsmen. The values of TC and LDL were decreased for Candidates for Master of Sport, whereas the value of TG — for Masters of Sport. The level of serum bilirubin was increased for female Candidates for Master of Sport and Masters of Sport. Obtained data demonstrate that systematical physical activities induce changes in the lipid transport (possibly because of the TC distraction to the synthesis of sex hormones) and overload of the musculoskeletal system. Females of the late aged group with Candidates for Master of Sport qualification had increased serum bilirubin level with a low concentration of TG, while Masters of Sport had slightly increased of bilirubin level.

DISCUSSION

Analysis of biochemical indicators of adolescent’s blood with Junior Sportsman qualifications shows that systematic sports activities do not affect the transport capacity of cholesterol, the endogenous antioxidant system, the liver and muscle membranes, and the body’s energy supply. A TIBS value was significantly reduced for both male and female adolescents due to the systematical physical activities that may cause increased iron transport requirements. Also, sports are associated with some changes in duodenal-pancreatic function for males and with increases in BMI for females. Moreover, changes in the biochemical indicators of blood serum are n 2.3 times more for males compared to females. Obtained results reveal faster dynamics of age-related biochemical indicators changes (serum calcium concentration, ALP and AST activities) for Junior Sportsmen compared to the CG. Increasing of the AST and ALP levels leads to a lowering of the ratios of CPK/AST and CPK/ALP for Junior Sportsmen. This observation confirms the longer age-related dynamics of the activity of these enzymes during the male puberty indicated elsewhere (13-15).

Regular physical activity for obtaining Sportsman, Candidate for Master of Sport, and Master of Sport qualifications accelerates the age dynamics of some biochemical indicators and forms

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the optimal adaptation of the muscular system. An additional increase of uric acid and iron levels has been obtained for males Sportsmen, Candidates for Master of Sport, and Masters of Sport, which indicates the trend in the endogenous antioxidants functioning during the labialization of iron reserves. The raising of urea and LDL levels with simultaneously decreasing of GLC/HDL and GLC/LDL ratios were observed for males of the late aged group with Master of Sport qualification. Such results could be explained by optimizing liver functions, including urea formation, and lipid transport. The positive effect of physical activity was observed for males with Master of Sport qualification, in particular, improving the liver functional state, muscles, lipid transport, and the endogenous antioxidant system. The lowering of the serum TG, LDL, TIBC and BMI levels with simultaneously increasing of GLC/LDL ratio was observed for early aged group females with Sportsman qualification. Therefore, physical activity affects the lipid transport in the bloodstream in conditions of relative transferrin deficiency and an increase in direct route cholesterol transport (probably, because of steroid hormones food).

The levels of urea, globulin, TG, calcium, α-amylase activity, TIBS, and A/G ratio were changed for the participants, who had a Master of Sport qualification. The level of serum bilirubin and GLC/TC ratio were additionally decreased for the male Masters of Sport. The levels of urea, HDL and ALP activity were lowered with simultaneously increasing the CPK/ALP ratio for females Masters of Sport.

Intensive physical activity during female puberty accelerates negative effects on some biochemical processes, such as a tendency to hypoglycemia and hypoalbuminemia, increasing hepatocytes and myocyte’s plasma membrane permeability, iron, and lipid pathways alterations, the impaired formation of liver's ability to the synthesis of urea (13, 16). The close relationship between sports doctors and trainers is necessary to monitoring the state of metabolism and correcting physical activity for athletes in this age period.

Using the routine biochemical markers to control metabolism in the puberty of athletes should also be estimated. Metabolomics studies have shown, that only 11 out of 328 blood metabolites were associated with physical activity (including branched-chain amino acids - valine, leucine and isoleucine, and glutamate, 2-hydroxybutyrate, glucose, and mannose) (17). Aromatic amino acids (phenylalanine and tyrosine) were added to the list of metabolites associated with physical activity (18). Additionally, metabolic profiling of serum samples of elite athletes has shown that out of 743 metabolites, glutamic acid and its derivatives were significantly reduced, while the levels of steroid hormone precursors, diacylglycerols and eicosanoids were changed (19).However, during the cycling task 68 out of 80 analyzed metabolites have been significantly changed. In particular, metabolite concentration during and followed by cycling was increased by 36% and 14% respectively; six clusters of correlated metabolites demonstrated unique metabolite trajectories (20). Dependence of the transcriptome and proteome reorganization (that determines the phenotypic features of energy supply and muscle functioning) on intensity, type, and duration of physical activity was established via transcriptomics and proteomics methods (21). However, analysis of the biochemical indicators of blood serum also could be used to control puberty and to detect metabolic disorders in athletes during this period. To maximize adaptive response, coaches and scientists need to control the stress applied to the athlete at the individual level and affordable lab equipment, especially in developing countries, is required (22).

PRACTICAL APPLICATIONS

Our findings can be used in sportsmen preparing period to the best understanding of the physiological processes during the active sport time in such an important time of human life as puberty.

CONCLUSION

The blood serum biochemical indicators of the athletes with four different qualifications have been studied. Any significant changes were not observed within investigated groups, in particular Junior Sportsmen, Sportsmen, Candidates for Master of Sport and Masters of Sport. However, some general tendencies are observed within 3 qualifications. In the early-age group (12–15 years) several differences were observed, such as raising BMI, AST activity and GLC/LDL ratio and decreasing of TIBS level as for male as well as female athletes; increasing of the levels of urea, TG, alpha-amylase with lowering the level of calcium and A/G ratio for males; decreasing the ALP activity for females. In the middle-age group (16–18 years) some additional differences were observed. Firstly, the opposite directional changes in biochemical indicators for male and female athletes (LDL levels, AST activity, GLC/LDL ratio). Secondly, increasing the levels of urea and creatinine, AI values with decreasing activities of ALT, ALP, CPK and CPK/AST ratio for male sportsmen. Finally, raising the total bilirubin level and GLC/TC ratio and lowering TC level for female athletes.

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TABLES

Table 1. Biochemical indicators in adolescents 12-15-year-old who received Junior Sportsman qualification

Indicators	Males		Females	
	Controlgroup (76)	**JuniorSportsmanqualification(44)**	**Controlgroup (34)**	**JuniorSportsmanqualification (103)**
BMI, kg/m^2	19.7 (18.5–20.9)	19.4 (18.0–19.8)	18.2 (17.1–20.2)	19.1* (18.0–20.8)
Urea, mmol/L	4.10 (3.60–4.79)	4.00 (3.70–4.36)	4.68 (3.49–5.21)	3.82* (3.23–4.44)
Creatinine, μmol/L	83.0 (83.0–90.0)	80.0 (76.0–90.0)	80.0 (70.0–100)	70.0* (70.0–80.0)
Bilirubin, μmol/L	13.4 (11.3–16.6)	12.0* (9.30–15.4)	14.5 (10.8–16.6)	12.6 (10.6–18.1)
TG, mmol/L	0.60 (0.46–0.87)	0.85* (0.78–0.99)	0.81 (0.69–1.26)	0.90 (0.74–1.20)
ALP, IU/L	204 (140–484)	481 (209–638)	202 (150–396)	139* (97.9–304)
CPK,IU/L	263 (182–376)	173* (120–224)	141.00 (124–179)	138.00 (109–177)
α-amylase,IU/L	58.0 (43.0–78.0)	100* (47.5–113)	58.0 (46.5–77.5)	51.5 (37.7–84.7)
Calcium, mmol/L	2.50 (2.30–2.56)	2.20* (2.05–2.35)	2.33 (2.21–2.40)	2.35 (2.25–2.40)
TIBC,μmol/L	62.5 (54.7–67.0)	49.5* (46.7–54.0)	60.0 (51.25–64.75)	44.50*(40.00–51.25)
A/G	1.67 (1.40–1.91)	1.39* (1.21–1.63)	1.46 (1.28–1.65)	1.39 (1.24–1.56)
CPK/AST	10.0 (7.42–14.8)	6.00* (4.51–7.23)	5.81 (5.25–7.07)	6.13 (4.93–8.11)
GLC/TC	1.16 (1.04–1.39)	1.08* (0.96–1.32)	1.12 (0.96–1.29)	1.06 (0.94–1.29)
CPK/ALP	1.07 (0.46–2.21)	0.39* (0.25–1.01)	0.80 (0.40–1.18)	0.88 (0.51–1.29)

* - P<0.05 in comparison with the “Control group”

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Table 2. Dependence of biochemical parameters of blood serum of male athletes on sports ranks

The age group of 12-15 years				
Indicators	**Controlgroup (76)**	**Sportsman (134)**	**Candidate for Master of Sport (34)**	**MasterofSport (11)**
BMI, kg/m^2	19.7 (18.5–20.9)	20.5* (19.0–21.7)	21.8* (19.3–24.0)	20.7 (19.8–23.6)
Urea, mmol/L	4.10 (3.60–4.79)	4.60* (3.70–5.20)	5.25* (4.30–6.19)	5.05* (4.28–5.75)
Bilirubin, μmol/L	13.4 (11.3–16.6)	13.4 (10.8–17.8)	14.8 (10.8–23.7)	11.3* (10.6–13.8)
Albumin, g/L	44.0 (41.0- 45.0)	41.0* (38.0–44.0)	43.0 (41.0–45.0)	40.0 (40.0–43.0)
Globulin, g/L	26.0 (24.0–31.0)	30.0* (28.0–33.0)	29.0 (26.2–31.7)	32.0* (29.0–36.5)
TG, mmol/L	0.60 (0.46–0.87)	0.74* (0.53–1.00)	0.73 (0.50–1.00)	0.81* (0.71–1.24)
α-amylase, IU/L	58.0 (43.0–78.0)	89.5* (51.7–130)	54.0 (41.0–64.0)	141* (102–146)
Calcium, mmol/L	2.50 (2.30–2.56)	2.34* (2.24–2.44)	2.39 (2.27–2.52)	2.33* (2.29–2.36)
TIBC, μmol/L	62.5 (54.7–67.0)	54.0* (49.0–57.0)	53.3* (50.2–59.5)	55.0* (46.0–56.0)
A/G	1.67 (1.40–1.91)	1.34* (1.19–1.56)	1.46 (1.30–1.76)	1.29* (1.06–1.56)
AST/ALT	1.34 (1.06–1.89)	1.77* (1.34–2.12)	1.46 (1.31–1.92)	1.38 (1.29–1.89)
CPK/AST	10.0 (7.42–14.8)	8.54* (6.19–12.2)	9.86 (7.26–13.0)	8.52 (6.41–12.3)
GLC/TC	1.16 (1.04–1.39)	1.19 (1.00–1.41)	1.12 (0.98–1.38)	1.02* (0.89–1.21)
GLC/LDL	1.86 (1.60–2.30)	2.23* (1.84–2.85)	2.19*(2.01–2.91)	1.63 (1.38–1.98)
The age group of 16-18 years				
Indicators	**Controlgroup (49)**	**Sportsman (194)**	**Candidate for Master of Sport (123)**	**MasterofSport (36)**
Urea, mmol/L	4.60 (3.90–5.59)	5.00 (4.10–5.89)	5.15* (4.25–6.10)	5.28* (4.50–5.92)
Uricacid, μmol/L	270 (250–310)	310* (270–360)	290 (260–330)	330* (300–363)
TC, mmol/L	3.90 (3.50–4.30)	3.71(3.40–4.30)	4.00 (3.60–4.50)	4.20* (3.65–4.7)
LDL, mmol/L	2.05 (1.45–2.37)	2.09 (1.60–2.40)	2.30* (2.01–2.80)	2.53* (2.17–2.97)
ALT, IU/L	32.0 (20.0–41.0)	23.0* (18.0–31.0)	22.0* (17.2–27.0)	22.0* (16.0–29.0)
AST, IU/L	38.0 (27.0–63.0)	35.0* (28.0–43.7)	31.0* (25.0–37.0)	26.0* (22.5–31.0)
ALP, IU/L	356 (194 – 440)	198* (104 – 331)	191* (117 – 321)	158* (96.9 – 300)
CPK, IU/L	511 (346 – 1740)	344* (224 – 628)	376* (221 – 609)	249* (175 – 352)
Iron,μmol/L	14.1 (11.0–16.6)	18.4* (12.5–22.8)	16.1(12.6–20.4)	17.5 (13.4–19.6)
CPK/AST	15.1 (11.2–29.0)	11.6* (7.81–16.2)	11.7* (8.83–17.4)	8.78* (6.35–11.9)
GLC/HDL	3.58 (3.17–4.78)	3.69 (3.13–4.23)	3.27* (2.82–3.89)	3.52 (3.10–4.80)
CPK/ALP	2.02 (1.21–5.16)	2.05 (1.29–3.70)	1.69 (0.98–3.70)	1.69* (0.64–2.84)
GLC/LDL	2.53 (2.05–2.89)	2.31 (1.92–2.96)	2.00* (1.68–2.43)	1.82* (1.59–2.22)

* - see Table 1.

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Table 3. Dependence of blood serum biochemical parameters of female athletes on sports ranks

The age group of 12-15 years				
Indicators	**Controlgroup (34)**	**Sportsman (54)**	**Candidate for Master of Sport (30)**	**MasterofSport (12)**
BMI, kg/m^2	18.2 (17.1–20.2)	19.8* (18.4–22.0)	19.8* (18.3–21.6)	22.0* (19.7–24.1)
Glucose, mmol/L	4.90 (4.76–5.10)	4.60* (4.38–4.93)	4.90 (4.53–5.20)	4.51* (4.15–4.80)
Urea, mmol/L	4.68 (3.49–5.21)	4.00 (3.34–4.62)	4.80 (3.80–5.69)	3.50* (2.95–4.27)
Albumin, g/L	43.0 (42.0–45.0)	42.0* (40.0–44.0)	43.0 (40.7–45.0)	41.5* (38.5–43.0)
HDL, mmol/L	1.43 (1.40–1.62)	1.46 (1.30–1.60)	1.36 (1.16–1.59)	1.23* (1.10–1.32)
AI	2.00 (1.83–2.48)	1.82* (1.45–2.19)	1.79 (1.40–2.47)	2.58)1.64–3.27)
TG, mmol/L	0.81 (0.69–1.26)	0.70* (0.60–0.83)	0.77 (0.52–1.23)	0.66 (0.43–1.53)
LDL, mmol/L	2.93 (2.36–3.49)	2.24* (1.80–2.66)	2.24* (1.95–2.49)	2.18 (1.84–3.10)
ALT, IU/L	14.0 (11.0–21.0)	18.0* (15.0–22.7)	15.5 (13.0–18.5)	18.0* (14.0–29.5)
AST, IU/L	25.0 (21.2–27.7)	28.0* (22.5–32.5)	25.0 (22.7–27.0)	32.5* (25.5–39.5)
ALP, IU/L	202 (150–396)	260 (144 – 384)	115* (92.8 – 209)	128* (77.9 – 216)
TIBC, μmol/L	60.0 (51.2–64.7)	53.0* (48.0–56.0)	57.0 (51.5–60.5)	-
CPK/ALP	0.80 (0.40–1.18)	0.74 (0.43–1.60)	1.08 (0.61–1.54)	1.78* (0.94–3.68)
GLC/LDL	1.70 (1.50–1.88)	2.09* (1.70–2.55)	2.27* (2.12–2.48)	1.86 (1.77–2.35)
The age group of 16-18 years				
Indicators	**Controlgroup (9)**	**Sportsman, (38)**	**Candidate for Master of Sport (52)**	**MasterofSport (31)**
Bilirubin, μmol/L	11.8 (10.6–13.0)	12.8 (10.5–21.2)	14.8* (11.6–21.8)	16.9* (10.9–21.1)
TC, mmol/L	5.04 (5.00–5.30)	4.07* (3.80–4.58)	4.10* (3.68–4.60)	4.10 (3.70–4.86)
TG, mmol/L	0.79 (0.65–1.01)	0.75 (0.52–1.00)	0.75 (0.60–1.00)	0.60* (0.50–0.90)
LDL, mmol/L	2.90 (2.65–3.10)	2.40* (2.06–2.60)	2.30* (1.90–2.50)	2.45 (1.87–3.02)
AST, IU/L	22.0 (19.0–23.0)	28.0* (20.5–32.0)	26.0* (21.0–30.2)	26.0* (23.0–33.5)
ALP, IU/L	84.8 (66.5–102)	160* (99.0–219)	104 (79.4–215)	98.7 (81.1–148)
GLC/TC	0.86 (0.81–0.91)	1.10* (0.96–1.29)	1.13* (0.99–1.25)	1.05* (0.91–1.26)
GLC/LDL	1.49 (1.30–1.80)	1.92* (1.67–2.15)	1.97* (1.80–2.43)	1.96* (1.47–2.33)

* - see Table 1 and 2.