

LIPID PROFILE OF YOUTH SPORT CLIMBERS: A PRELIMINARY INVESTIGATION

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Abstract

Introduction. Lipid profile is one of the main determinants of cardiovascular health status. Moderate and vigorous physical activity can positively influence lipid profile, and one such activity is sport climbing. The main aim of this study was to determine the lipid profile and to investigate the influence of training experience on the lipid profile of youth climbers. **Material and Methods.** This research included 12 youth climbers aged 15.33 ± 1.30 years (6 males, 6 females), who were tested on anthropometric indices and lipid profile (total cholesterol, high-density lipoproteins, low-density lipoproteins, triglycerides) using the point-of-care testing. Variables of lipid profile were correlated with years of climbing experience by Spearman's rank correlation coefficients, while the differences between females and males were checked by the Mann-Whitney U test. **Results.** Youth climbers had acceptable levels of all measured lipid parameters. Training experience was significantly positively correlated with body mass index ($R = 0.76$, $p < 0.01$) and significantly negatively correlated with cholesterol ($R = -0.80$, $p < 0.01$). **Conclusions.** Results support that climbing as a vigorous and enjoyable physical activity might be advertised as a proxy for reaching recommended amounts of physical activity among adolescents, which is associated with improved lipid profile. However, this is only a preliminary investigation advocating that determinants of health status related to climbing practice should be further investigated.

Key words: cardiovascular health, cholesterol, recreation, physical activity, young athletes, wellbeing

Introduction

Cardiovascular health status (CVHS) is defined as an important determinant of health [1]. Also, CVHS developed in childhood and adolescence was shown to be the main predictor for cardiometabolic outcomes in adult life [2, 3]. One of the most important definers of CVHS is lipid profile [1]. Lipid profile stands for lipid levels in the blood, and it consists of high-density lipoprotein cholesterol (HDL-C) cholesterol, low-density lipoprotein cholesterol (LDL-C), cholesterol (CHOL), and triglycerides [4]. Regarding the association of indices of lipid profile with health, increased levels of LDL-C and triglycerides are shown to be indicators that impose a risk of cardiovascular disease, while higher HDL-C is associated with a healthy cardiovascular system [5]. Physical activity plays a significant role in improving CVHS, and, precisely, lipid profile [6, 7]. Indeed, physical activity and exercise can improve lipid profiles by elevating the ability of muscles to use lipids instead of glycogen, leading to lower plasma lipid levels [6]. Furthermore, higher levels of energy expenditure have a higher influence on lipid profiles in both genders [8]. Moreover, the main role in changes of the lipid profile is related to food intake [9, 10]. It can be noted that physical activity in general has positive effects on CVHS and lipid profile.

Despite the well-known positive effects of physical activity and exercise, there is a worryingly high prevalence of 80% of adolescents not reaching the recommended levels of physical activity, globally [11]. This trend in inactivity imposes a threat to overall health [12]. There is evidence that the main point of dropping the levels of physical activity occurs at around 14 years of age probably as a consequence of dropping out from

sports [13]. Therefore, the emphasis should be placed on offering enjoyable, fun, and challenging sports and recreative types of activities that would make adolescents continue partaking in sports and any other forms of physical activity (e.g., recreational activities). One of the sports and recreational activities which is becoming more and more popular among youth is climbing (i.e., rock climbing). Sport climbing has been increasing in popularity since its introduction to the Olympic Games in Tokyo 2021, which means that there is a growth in the number of indoor climbing walls and the number of sports climbing clubs [15].

There is a lot of evidence on the positive effects of climbing on health. Precisely, climbing can improve fitness status, including muscular strength, endurance, and flexibility [16, 17]. Moreover, climbing is shown to be improving cardiometabolic health in adult climbers [17]. Furthermore, improved functional fitness along with decreased anxiety has been reported as a consequence of climbing activity in healthy adults [18]. A recent systematic review included studies that investigated the effects of therapeutic climbing in various patients and conditions and found that therapeutic climbing can improve physical, social, mental, and general wellbeing [19]. Also, what is most important to mention for this study, climbing can be comparable to moderate and vigorous physical activity because exercise intensity in recreational adult climbers ranged from 70-72% of maximal aerobic capacity [20]. Thus, climbing could be seen as an activity that improves CVHS, including the lipid profile.

According to the abovementioned, it could be hypothesized that climbing is a form of physical activity and exercise which can influence the lipid profile of participants. However, to our knowledge, there is no direct evidence that this assumption is

true. Hence, the aim of this study was to determine the lipid profile and to investigate the influence of training experience on the lipid profile of youth climbers.

Material and Methods

Participants

This is a cross-sectional type of the study. The sample of participants included 12 (6 females, 6 males) recreational and low-level competitive youth climbers aged 15.33 ± 1.30 years, all members of one sport climbing club. Their mean training experience was 7.50 ± 2.75 years, and the mean training volume was 5.2 ± 1.5 hours a week. The climbing level was not included since youth climbers do not regularly climb outdoors, and this scale could not be observed as a value of the performance level of climbers included in this study. During the investigation, the climbers did not have any illnesses or injuries. Athletes were informed about the research procedures, risks, and aims. Participants (or parents/legal guardians) were requested to sign a written consent form, before the start of the study. The study followed the declaration of Helsinki, and the Ethical Board of the University of Split, Faculty of Kinesiology, approved the study.

Variables

This research included anthropometric indices and lipid profiles. All the measurements were made in the morning (9:00 AM to 10:00 AM). The participants were instructed to come to testing on an empty stomach to remove any influence on lipid profile.

The anthropometric indices included: body height (BH), body mass (BM), body mass index, body fat percentage (BF%), and ape index (ratio between arm span and BH (APE)) [21]. Arm span and BH were measured using a measuring tape. BM and BF% were assessed by the bioimpedance scale (Tanita BC 418 scale; serial number: 15010067, 2015).

Procedures

Lipid profiles consisted of total cholesterol (CHOL), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), and CHOL/HDL-C ratio. We used point-of-care testing (POCT) to evaluate this study's lipid profile, with blood sampling from the fingertip. POCT is a minimally invasive diagnostic method with the potential to provide accurate and rapid results [22]. POCT is based on reactive strips with a membrane which removes the red blood cells, and plasma lipids are evaluated by a dry chemical reaction. The Mission Cholesterol Test Device (ACON Laboratories, Inc., San Diego, CA, USA) was used in this study. The used device directly measured the concentrations of CHOL, HDL-C and TG, while it indirectly calculated the LDL-C and CHOL/HDL-C ratio. The detailed testing procedure has been described in a recent study conducted on adolescents [23].

According to the National Cholesterol Education Program (NCEP) Expert Panel on Cholesterol Levels in Children and Adolescents, cut-off values for plasma lipid levels displayed in Table 1 were used [24].

Statistical analysis

Statistical analysis included descriptive measurements of all variables. Kolmogorov-Smirnov test determined the normality of distributions. Due to the small sample size, the non-parametric Mann-Whitney U test was used to compare the results of males and females in all study variables. Spearman's rank correlation

coefficients were used to assess the correlations between age, training experience, anthropometric indices, and lipid profile.

All analyses were done in the statistical package Statistica ver. 13.5 (Tibco Inc., Palo Alto, Ca, USA), with applying a p-level of 0.05.

Results

Descriptive statistics of all included variables with differences between males and females are shown in Table 2. Males and females differed in some anthropometric indices (body height, body fat percentage), while they did not differ in any of the parameters of the lipid profile. Results show that youth climbers have acceptable values of all parameters of the lipid profile, including CHOL, TG, HDL-C, Non-HDL-C, and LDL-C.

Spearman Rank Order Correlations between age, training experience, anthropometric indices, and lipid profile for the total sample are presented in Table 3. Age was positively correlated with arm span and Ape index. Moreover, training experience was positively correlated with body mass index (Spearman's $R = 0.76$, $p < 0.01$) and negatively correlated with cholesterol ($R = -0.80$, $p < 0.01$).

Discussion

This study aimed to determine the lipid profile and investigate the influence of training experience on the lipid profile of youth climbers. According to the aims, there are few main findings of this study. First, youth climbers have acceptable lipid profiles. Second, training experience was associated with cholesterol levels in youth climbers. These results will be discussed in the following text.

The results show that climbers in our study possess good lipid profiles according to the cut-off values for plasma lipid and lipoprotein levels of the National Cholesterol Education Program (NCEP) Expert Panel in similar age groups [24]. Similar to the results of our study, college female athletes aged 19.70 ± 1.20 years had total cholesterol of 165.70 ± 34.0 mg/dL, HDL-C 62.8 ± 15.03 mg/dL, and a total cholesterol/HDL ratio of 2.8 ± 0.6 , which was within a healthy recommendation range for that age, along with per sport level [25]. The study suggested that participating in organized sports may help in meeting physical activity recommendations, lead to healthy lipid profiles, and prevent cardiovascular disease in adolescent athletes regardless of competition level [25].

Table 1. Plasma lipid and lipoprotein level cut-off values

Category	Acceptable mg/dL	Borderline mg/dL	High mg/dL
CHOL	<170	170 to 199	≥ 200
LDL-C	<110	110 to 129	≥ 130
Non-HDL-C	<120	120 to 144	≥ 145
TG	<90 (1 mmol/L)	90 to 129	≥ 130
Category	Acceptable mg/dL	Borderline mg/dL	Low mg/dL
HDL-C	>45	40 to 45	<40

CHOL – Cholesterol, TG – Triglycerides, HDL-C – High-Density Lipoprotein Cholesterol, non-HDL-C – Non-High-Density Lipoprotein Cholesterol, LDL-C – Low-Density Lipoproteins.

Table 2. Descriptive statistics of all included variables and differences between males and females

	Total sample		Females		Males		Mann-Whitney	
	Mean	SD	Mean	SD	Mean	SD	Z	p-value
Age (years)	15.33	1.30	15.17	0.98	15.50	1.64	-0.24	0.81
Training experience (years)	7.50	2.75	6.83	2.79	8.17	2.79	-0.80	0.42
Body mass (kg)	54.98	7.50	50.68	4.20	59.27	7.86	-1.68	0.09
Body height (cm)	170.68	8.45	165.38	6.79	175.98	6.59	-2.16	0.03
Body mass index (index)	18.73	1.22	18.32	1.01	19.13	1.36	-0.72	0.47
Body fat (%)	15.53	4.28	18.55	3.74	12.52	2.09	2.32	0.02
Arm span (cm)	174.23	10.75	167.68	7.79	180.78	9.52	-1.84	0.07
APE index	3.55	3.74	2.30	3.69	4.80	3.66	-0.80	0.42
Cholesterol (mg/dL)	152.67	37.17	159.00	36.65	146.33	39.99	0.72	0.47
HDL-C (mg/dL)	62.92	13.06	69.50	13.98	56.33	8.71	1.68	0.09
Triglycerides (mg/dL)	54.50	9.31	55.33	9.40	53.67	10.03	0.24	0.81
CHOL/HDL-C ratio	2.31	0.95	2.30	0.20	2.32	1.40	0.00	1.00
LDL-C (mg/dL)	48.58	45.26	57.17	47.60	40.00	45.44	0.56	0.58

HDL-C – High-Density Lipoprotein Cholesterol, LDL-C – Low-Density Lipoprotein Cholesterol, SD – standard deviation.

Table 3. Correlations between age, training experience, anthropometric indices, and lipid profile for the total sample.

Variable	Spearman Rank Order Correlations	
	Age	Training experience
Body mass	0.51	0.42
Body height	0.50	0.27*
Body mass index	0.17	0.76**
% body fat	-0.55	-0.35
Arm span	0.68*	0.36
APE index	0.59*	0.53
CHOL	-0.02	-0.80**
HDL-C	-0.56	-0.48
Triglycerides	-0.41	-0.08
CHOL/HDL-C ratio	0.21	-0.47
LDL-C	-0.48	-0.20

* – denotes $p < 0.05$; ** – denotes $p < 0.01$, HDL-C – High-Density Lipoprotein Cholesterol, LDL-C – Low-Density Lipoprotein Cholesterol, CHOL – Cholesterol.

Indeed, there is extensive evidence that sports and other forms of physical activity have a positive influence on lipid status. Precisely, a study that evaluated the blood lipid levels of athletes compared to sedentary college students aged 20.24 ± 1.08 years recorded that sedentary participants had higher LDL-C, TG, and CHOL, while athletes had higher HDL-C [26]. Supportively, a study on college students aged 22.8 ± 2.00 years noted a decrease in triglyceride levels after 8-week resistance training [27]. Collectively, a review study reported that regular exercise can lower triglycerides by 5-38 mg/dl and raise HDL-C levels by 2-8 mg/dl, which is attributed to increased energy expenditure [28]. To attain health benefits, children and adolescents should participate in at least 60 minutes of moderate-to-vigorous physical activity daily, which is defined as more than four metabolic equivalents of task (METs) and a heart rate of 140-160 beats per minute [29].

Climbing is categorized as a moderate-to-vigorous physical activity [30]. Indeed, a study on novice youth climbers aged 11.5 ± 2.3 years reported that climbing met recommendations for moderate exercise intensity and duration, which is associated with improved health-related fitness [31]. It has to be noted that the changes in the lipid profile as a result of an exercise or training program differ according to the type of exercise, its intensity, frequency, duration of each session, and the time spent in the exercise or sports program (i.e., training experience) [32]. That being said, there is a certain background for the assumption that years of climbing experience would be associated with lipid profile. Indeed, our study recorded a negative correlation between training years and total cholesterol levels, which means that climbers with more climbing experience had lower total CHOL levels leading to better lipid status and probably better CVHS. This result might imply that being involved in climbing for more years leads to a better lipid profile. One might be wondering whether the age differences of the included climbers could have influenced these results. However, a study on a similar sample of youth climbers divided them into two age categories: younger (13-15 years of age), and older (16-19 years of age), and found that they have similar training experience (8.33 ± 1.66 and 8.67 ± 2.22 years, respectively) and similar sport-specific fitness status [33]. Similar was the case in our study, with younger climbers aged 13-15 years and older climbers aged 16-18 years having similar training experience (7.00 ± 2.61 and 8.00 ± 3.03 years, respectively). This is most likely due to new generations of athletes getting into sports climbing younger than ever and children starting to practice climbing even at the age of four years [34].

We have to emphasize that this is only a preliminary and cross-sectional analysis at this point, which means that we are unable to determine the causality of the observed issue. Also, we investigated climbers aged 13-18 years, which might have influenced the noted associations, as they are still in the growth and developmental life phase and maybe some other factors could have influenced results (i.e., differences in the biological age and maturation level, nutritional intake, etc.). However, even though we are not able to draw any precise conclusions regard-

ing the health-related impact of climbing, we might suggest that future studies investigate this issue in more detail, prospectively, and both in young and adult populations of climbers.

Limitations and strengths

One of the main limitations of this study is the small sample size, which means that results should be interpreted with caution, and further checked in larger sample sizes. Moreover, one of the limitations is the fact that we did not have a control group of non-active adolescents and that is why we cannot draw any precise conclusions about the influence of climbing on the measured variables. What is more, we did not evaluate a possible influence of relative energy deficiency in sports (RED-S) on the measured lipid parameters. As RED-S is an increasing problem in climbing, further studies should place special attention on this issue while investigating any health-related parameters associated with sport climbing. Also, we did not evaluate the dietary intake of studied athletes.

However, we must emphasize that this is a preliminary study that tried to stress the importance of studying determinants of health in youth climbers. Precisely, we are aware that youth are less and less physically active each year and that some enjoyable forms of activity and physical exercise should be offered to the wider populations (e.g., introduce climbing in schools and physical education curriculum). That being said, one of the strengths of this study is the direct evaluation of blood parameters such as lipid profile, body composition, and anthropometric indices which determine health status. This way, we were able to emphasize the importance of evaluating mentioned parameters and provide youth climbers' insight into their health status. Moreover, we used the point-of-care method for testing lipid blood parameters, which is an easy and fast sampling and analysing method. This means that many climbers can be investigated and provided with immediate results about their health status. This way, coaches, parents, and athletes themselves can take immediate actions for improving their health and consequently sports performance.

Conclusions

Collectively, the main findings of this study are that youth climbers have good lipid profiles, and that training experience was associated with cholesterol levels in youth climbers. These results confirm that sports and other forms of physical activities of moderate-to-vigorous intensity have a positive influence on the lipid profile. However, this is only a preliminary investigation advocating that determinants of health status related to climbing practice should be further investigated, with emphasis on prospective studies both in youth and adult populations and in recreational and competitive climbers. Also, we recommend that future studies include monitoring the signs of RED-S and nutritional intake, as they might significantly influence measured blood parameters.

References

1. El-Ashker S., Pednekar M.S., Narake S.S., Albaker W., Al-Hariri M. (2021). Blood pressure and cardio-metabolic risk profile in young Saudi males in a university setting. *Medicina* 57(8), 755. DOI: 10.3390/medicina57080755
2. Guo L., S. Zhang (2017). Association between ideal cardiovascular health metrics and risk of cardiovascular events or mortality: A meta-analysis of prospective studies. *Clinical Cardiology* 40(12), 1339-1346. DOI: 10.1002/clc.22836
3. Laitinen T.T., Ruohonen S., Juonala M., Magnussen C.G., Mikkilä V. et al. (2017). Ideal cardiovascular health in childhood – Longitudinal associations with cardiac structure and function: The Special Turku Coronary Risk Factor Intervention Project (STRIP) and the Cardiovascular Risk in Young Finns Study (YFS). *International Journal of Cardiology* 230, 304-309. DOI: 10.1016/j.ijcard.2016.12.117
4. Mann S., Beedie C., Jimenez A. (2014). Differential effects of aerobic exercise, resistance training and combined exercise modalities on cholesterol and the lipid profile: review, synthesis and recommendations. *Sports Medicine* 44(2), 211-221. DOI: 10.1007/s40279-013-0110-5
5. Carroll M.D., Fryar C.D., Lacher D.A. (2012). Total and high-density lipoprotein cholesterol in adults; national health and nutrition examination survey, 2009-2010. *NCHS Data Brief* 92, 1-8.
6. Earnest C.P.P., Artero E.G., Sui X., Lee D.C., Church T.S., Blair S.N. (2013). Maximal estimated cardiorespiratory fitness, cardiometabolic risk factors, and metabolic syndrome in the Aerobics Center Longitudinal Study. *Mayo Clinic Proceedings* 88(3), 259-270. DOI: 10.1016/j.mayocp.2012.11.006
7. Baran J., Weres A., Czenczek-Lewandowska E., Wyszynska J., Łuszczki E. et al. (2018). Blood lipid profile and body composition in a pediatric population with different levels of physical activity. *Lipids in Health and Disease* 17(1), 171. DOI: 10.1186/s12944-018-0817-2
8. Scheers T., Philippaerts R., Langendonck L., Duquet W., Duvigneaud N. et al. (2008). Lipid profile in men and women with different levels of sports participation and physical activity. *Public Health Nutrition* 11(11), 1098-1106. DOI: 10.1017/S1368980007001425
9. Farhangi M.A., Dehghan P., Tajmimi S. (2018). Powdered black cumin seeds strongly improves serum lipids, atherogenic index of plasma and modulates anthropometric features in patients with Hashimoto's thyroiditis. *Lipids in Health and Disease* 17(1), 59. DOI: 10.1186/s12944-018-0704-x
10. Javid A.Z., Haybar H., Dehghan P., Haghighizadeh M.H., Mohaghegh S.M. et al. (2018). The effects of Melissa officinalis (lemon balm) in chronic stable angina on serum biomarkers of oxidative stress, inflammation and lipid profile. *Asia Pacific Journal of Clinical Nutrition* 27(4), 785-791. DOI: 10.6133/apjcn.022018.01
11. van Sluijs E.M., Ekelund U., Crochemore-Silva I., Guthold R., Ha A. et al. (2021). Physical activity behaviours in adolescence: current evidence and opportunities for intervention. *Lancet* 398(10298): 429-442. DOI: 10.1016/S0140-6736(21)01259-9
12. Whooten R., Kerem L., Stanley T. (2019). Physical activity in adolescents and children and relationship to metabolic health. *Current Opinion in Endocrinology, Diabetes and Obesity* 26(1), 25. DOI: 10.1097/MED.0000000000000455
13. Løgestad P. A. (2019). Differences between adolescents staying in and dropping out of organized sport: A longitudinal study. *Journal of Physical Education and Sport* 19(2), 444-452. DOI: 10.7752/jpes.2019.s2065
14. Stien N., Frøysaker T.F., Hermans E., Vereide V.A., Andersen V., Saeterbakken A.H. (2021). The effects of prioritizing lead or boulder climbing among intermediate climbers. *Frontiers in Sports and Active Living* 3, 661167. DOI: 10.3389/fspor.2021.661167
15. Lutter C., El-Sheikh Y., Schöffl I., Schöffl V. (2017). Sport climbing: medical considerations for this new Olympic dis-

- cipline. *British Journal of Sports Medicine* 51(1), 2-3. DOI: 10.1136/bjsports-2016-096871
16. Draper N., Jones G.A., Fryer S., Hodgson C., Blackwell G. (2008). Effect of an on-sight lead on the physiological and psychological responses to rock climbing. *Journal of Sports Science and Medicine* 7(4), 492-498.
17. Aras D., Akalan C. (2015). Sport climbing as a means to improve health-related physical fitness parameters. *The Journal of Sports Medicine and Physical Fitness* 56(11), 1304-1310.
18. Gallotta M.C., Emerenziani G.P., Monteiro M.D., Iasevoli L., Iazzoni S. et al. (2015). Psychophysical benefits of rock-climbing activity. *Perceptual and Motor Skills* 121(3), 675-689. DOI: 10.2466/30.PMS.121c26x9
19. Gassner L., Dabnichki P., Langer A., Pokan R., Zach H. (2022). The therapeutic effects of climbing: A systematic review and meta-analysis. *PM&R* 15(9), 1194-1209. DOI: 10.1002/pmrj.12891
20. Rodio A., Fattorini L., Rosponi A., Quattrini F.M., Marchetti M. (2008). Physiological adaptation in noncompetitive rock climbers: good for aerobic fitness? *The Journal of Strength and Conditioning Research* 22(2), 359-364. DOI: 10.1519/JSC.0b013e3181635cd0
21. MacKenzie R., Monaghan L., Masson R.A., Werner A.K., Caprez T.S. (2020). Physical and physiological determinants of rock climbing. *International Journal of Sports Physiology and Performance* 15(2), 168-179. DOI: 10.1123/ijspp.2018-0901
22. Larsson, A., et al. (2015). The state of point-of-care testing: a European perspective. *Uppsala Journal of Medical Sciences* 120(1), 1-10. DOI: 10.3109/03009734.2015.1006347
23. Kesic M.G., Savicevic A.J., Peric M., Gilic B., Zenic N. (2022). Specificity of the associations between indices of cardiovascular health with health literacy and physical literacy: A cross-sectional study in older adolescents. *Medicina* 58(10), 1316. DOI: 10.3390/medicina58101316
24. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents, National Heart, Lung and Blood Institute (2011). Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: Summary report. *Pediatrics* 128(5), 213-256. DOI: 10.1542/peds.2009-2107C
25. Vento K.A., Delgado F., Lynch H. (2022). Lipid profiles of college female student-athletes participating at different competition levels of organized sport. *Frontiers in Sports and Active Living* 4, 841096. DOI: 10.3389/fspor.2022.841096
26. Koc H. (2011). The comparison of blood lipid levels of athletes and sedentary college students. *Pakistan Journal of Medical Sciences* 27(3), 622-625.
27. Martin S.E. et al. (2002). The influence of resistance training on blood lipid responses to resistance exercise. *Medicine & Science in Sports & Exercise* 34(5), 260.
28. Durstine J.L., Grandjean P.W., Davis P.G., Ferguson M.A., Alderson N.L. (2001). Blood lipid and lipoprotein adaptations to exercise: a quantitative analysis. *Sports Medicine* 31(15), 1033-1062. DOI: 10.2165/00007256-200131150-00002
29. Piercy K.L., Troiano R.P., Ballard R.M., Carlson S.A., Fulton J.E. et al. (2018). The physical activity guidelines for Americans. *Jama* 320(19), 2020-2028. DOI: 10.1001/jama.2018.14854
30. Sheel A. (2004). Physiology of sport rock climbing. *British Journal of Sports Medicine* 38(3), 355-359. DOI: 10.1136/bjsm.2003.008169
31. Siegel S.R., Robinson J.M., Johnston S.A., Lindley M.R., Pfeiffer K.A. (2015). Health-related fitness and energy expenditure in recreational youth rock climbers 8-16 years of age. *International Journal of Exercise Science* 8(2), 174-183.
32. Boraita A. (2004). Plasma lipid profile is improved by participation in sports, but at what intensity? *Revista Española de Cardiología* 57(6), 495-498. [in Spanish]
33. Gilic B., Vrdoljak D. (2023). Sport-specific performances in elite youth sport climbers; gender, age, and maturity specifics. *Biomedical Human Kinetics* 15(1), 49-56. DOI: 10.2478/bhk-2023-0007
34. Kozina Z., et al. (2016). Motor skills formation technique in 6 to 7-year-old children based on their psychological and physical features (rock climbing as an example). *Journal of Physical Education and Sport* 16(3), 866-874. DOI: 10.7752/jpes.2016.03137

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