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Research Article

Anthropometric Measurements and Somatotype Determination in Adult Climbers

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Abstract: The aim of this study was to compare the anthropometric measurement parameters and to determine the body somatotype of mountaineering athletes and Alpine style climbers. The sample of the study consisted of 40 men who were actively mountaineering athletes, climbing Alpine style, with an average age of 27.05±2.89 years. Age, height, body weight, skinfold thickness, circumference and diameter measurements were taken. SPSS 29.0 package programme was used to analyse the data and Independent Samples T-Test was used. As a result of the analysis, it was revealed that the climbers participating in the study had normal body mass index (24.59±2.12), normal body fat percentage (13.10±4.42) and mesomorphic endomorph (4.70-5.39-1.98) characteristics. As a result of the T-Test, it was determined that there was a statistically significant difference in the endomorphic (t=5,31; p<.001), mesomorphic (t=8,57; p<.001) and ectomorphic (t=-8,60; p<.001) characteristics of the climbers. Conclusions: It was determined that Alpine climbers exhibited the characteristics of mesomorphic endomorph body structure, had normal fat percentage and body mass index, while the 4-4-3 Balanced Somatotype evaluation of Alpine climbers changed to 5-5-2 Mesomorphic - Endomorphic feature according to previous studies in terms of somatotype characteristics.

Keywords: Alpine climbing; mountaineering; anthropometry; somatotype; physical fitness.

1. Introduction

One of the most important factors in performance is physical structure (Canuzakov et al., 2018) The physical features that come with the physical structure are one of the most important steps in the utilization of the athlete's capacity (Bisharat, 2009; Krakuer, 2009; Kaya et al., 2025). It is thought that the body structure and type of the athletes are in direct proportion with the branch they are engaged in (Della, 2016). In this context, various studies have shown that age and sex-related morphological differences can significantly affect somatotype development, even from childhood (Dzhanuzakov et al., 2025). In mountaineering sport, climbing is performed in different techniques such as Alpine style climbers, expedition climbers, rock climbers (Grant et al., 1996). The alpine environment, with its intrinsic ecological problems, has captivated humanity for millennia. From antiquity to the Middle Ages, mountains were regarded with reverence, linked to spirituality, and believed to be the abodes of deities (Della, 2016). The inception of mountaineering is credited to the ascent of Mont Ventoux, as recorded by Francesco Petrarca in 1336. His expedition fostered a novel viewpoint on such pursuits, specifically to ascend a mountain just to "strive for heights." However, it required several more centuries before humanity began to ascend renowned peaks in the Alps during the 19th century (Fleming, 2006). Currently, mountaineering, rock climbing, and other alpine sports, including skiing and ski mountaineering set to debut as a new Olympic event at the Milan/Cortina 2026 Winter Olympic Games are exceedingly popular and have evolved into a thriving economy. Numerous alpine habitats have become publically accessible because to advancements in transportation and contemporary mountain-rescue techniques; yet they continue to present different hazards, including high altitude, fall risks, avalanches, and abrupt weather fluctuations. Furthermore, alpine regions are significantly affected by climate change, resulting in heightened challenges and risks (Mourey et al., 2022).

Psychological characteristics, such as thrill seeking, differ across various alpine sports disciplines (Kopp et al., 2016), and mountaineers may exhibit reduced neuroticism and higher conscientiousness compared to the general population (Jackman et al., 2023). Despite the generally low prevalence of mental disorders among mountaineers (Niedermier et al., 2017), particular aspects of mountaineering may elevate the risk for specific mental issues, including rock climbing and eating disorders (Jouber et al., 2020), high altitude exposure and transient psychosis (Hüfner et al., 2023), as well as alpine rescue missions and post-traumatic stress disorder (Salvotti et al., 2024; Mikutta et al., 2022). The subpopulation of mountaineers has also exhibited characteristics of behavioral addiction (Habelt et al., 2023). Acute mountain sickness (AMS) is a physiological response to diminished atmospheric pressure and may serve as a limiting factor for climbers. Burtscher et al. examine potential psychological disorders linked to AMS in this publication (Burtscher et al., 2024). Özkan and Sarol, (2008) stated that 'Alpine climbing, which is one of the climbing styles of mountaineering, refers to climbing directly to the summit using mountaineering techniques and equipment, which includes rock, snow, glacier, sport climbing features, while rock climbing is a form of climbing on steep and massive granite walls using climbing techniques and safety equipment in a mountain environment' (Özkan & Sarol, 2008). Considering that each climbing style has its own dynamics, it is believed that body types will be clustered in athletes who climb in the same style (Kidd, 2009). Due to the nature of the sport, it is thought that the athlete will change the style according to his/her own body somatotype, although the first experience is to start climbing on the climbing style desired by the individual. Because, unless the characteristics of the physical structure are not suitable for the style of the sport, it will not reach the desired performance level and will require more effort (Kural, 2013; Mermier et al., 2000; Ross & Marfell, 1991).

In this study, it was aimed to investigate whether there is a significant similarity between the body measurements and body somatotype of the athletes climbing the same style. The characteristics of some anthropometric measurements of individuals climbing alpine style in mountaineering sport and whether there is a significant similarity between these measurement results and determination of body somatotype constitute the problem of this research. The independent variable of this problem is voluntary participants climbing Alpine style in mountaineering sport and the results of anthropometric measurements and body somatotype of these participants. Mountaineering, as can be understood from its name, is performed in nature and in an environment that can be considered high altitude. This study encounters limitations in the environment where mountaineering sport is performed. Harsh and harsh natural conditions (snow, glacier, cold weather, strong wind, etc.) limit the study.

2. Materials and Methods

2.1. Research Group

The study consisted of mountaineer athletes whose age, height, body weight, body mass index, body fat percentage and somatotype characteristics were studied in terms of means and standard deviations. Forty male Alpine style mountaineering climbers with age 27,05±2,89 years, height 177,40±4,89 cm, body weight 77,50±8,53 kg, body mass index 2,59±2,12, body fat percentage 13,10±4,42, somatotype characteristics Endomorphic 4,70±1,41, Mesomorphic 5,39±0,89, Ectomorphic 1,98±0,78 participated in the study voluntarily.

2.2. Research Design

Age, height, body weight, skinfold thickness (triceps, subscapular, supraspinal, abdominal thing, chest), circumference (biceps, calf) and diameter (femur, humerus) measurements were taken. Mesitaş brand, wall type, sliding callipers were used for height measurements, Newfeel brand electronic scale with digital display for body weight, Saehan brand sliding callipers for skinfold thickness, Saehan brand anthropometric tape measure for circumference measurements, Jacson and Pollock formula for body density, Siri formula for body fat percentage and Heath-Carter Somatotype method for somatotype values.

2.3. Data Collection

In order to collect the data, firstly, the previously published sources about the data and methods to be collected were reviewed. The relevant literature on the subject was examined and archive scanning was carried out. It was decided how the measurements and methods to be taken would be. After obtaining the approval of the ethics committee, the sample group to be subject to the study was formed by taking and calculating the measurements. In accordance with the approval of the ethics committee, Informed Consent Form for Research Purpose Study was obtained from the volunteer athletes participating in the study and the measurement results obtained were recorded in the Participant Personal Information Form. All volunteer athletes participating in the study were brought together in a closed classroom environment, their measurements were taken in turn, and due care was taken by paying attention to their personal privacy.

2.3.1. Height Measurement

Height measurements of all participants were taken with a wall-type sliding caliper height gauge (Mesitaş, Turkey) with a precision of 0.01 m. The measurements were taken without socks on the feet of the participants or with socks with a thickness that would not affect the measurement. It was ensured that the floor on which the participants stood was flat. It was ensured that both feet of the participant were in a position to carry the body weight equally on the ground. It was ensured that the heels were together, touching the height scale, the scapula, hip protrusion and occipital region of the head were close to the height scale. The patient was asked to hold the height measurement while the head was in the Frankfort plane and in a deep inspiration state and to hold the heels of the feet without leaving the floor. Subsequently, the movable part of the height gauge was positioned to contact the top of the head and the hair was compressed until it was 1 mm.

2.3.2. Body weight

It was measured with an electronic scale (Seca, Vogel and Halke, Hamburg) with a precision of 0.1 kg. The participants were taken without socks on their feet or with socks whose thickness did not affect the measurement. It was ensured that the floor on which the participants stood was flat. It was ensured that both feet of the participant were in a position to carry the body weight equally on the ground. It was ensured that the participants were wearing minimal clothing (shorts, t-shirt) that would not affect the weight (Sarı & Tutar, 2025).

2.3.3. Skinfold measurement

Measurements were made in the triceps, subscapular, suprailiac, abdominal, biceps, chest, thing, calf regions with a skinfold caliper (Saehan, South Korea) that applies 10 g pressure per 1 mm2 at each opening with an error of ±2 mm. Measurements were taken by standing on the right side of the participant (Rudarlı, 2024).

2.3.4. Anthropometric Measurements

Biceps and calf circumferences were measured with an anthropometric tape measure (Saehan, South Korea) (Carter, 2002). Measurements were made by standing on the right side of the participant. Biceps, calf, humerus and femur measurements were taken from the participants.

2.3.5. Somatotype Measurements

The somatotype values of the participants were determined by Heath-Carter Somatotype Method (Ross & Marfell-Jones, 1991). The somatotype structure was determined with the formulae used in the somatotype evaluation of the participants.

Endomorf formula=-0.7182+0.1451X-0.00068X"2"+0.0000014X"3"

Mezomorf formula= 0.858(E)+0.601(K)+0.188(A)+0.161(C)-0.131(H)+4.5

Ektomorf formula= RPI:height/kg3 (RPI = Reciprocal ponderal index)

2.4. Data Analysis

In the analysis of the data obtained, the comparison of the physical fitness and somatotype characteristics of the climbers according to the Alpine climbing type was made by Independent Samples T-Test. SPSS 29.0.1.0 (SPSS, SPSS Inc, Chicago, IL, USA) package programme for MacBook Pro was used for data analysis and significance level was taken as 0.05. For the G-Power test, G*Power version 3.1.9.6 package programme for MacBook Pro was used to analyse the data and the significance level was taken as 0.05 for 0.95 Power (1-β err prob).

2.5. Ethics Committee Permission

Participants were given permission to participate voluntarily with the informed consent form. In addition, this study was approved ethically by the Ethics Committee of Istanbul Nişantaşı University (Date: 07.03.2024, Number: 2024/03), based on the application titled "Determination of Anthropometric Measurements and Somatotype in Adult Mountaineers". Before data collection, participants were thoroughly informed about the study through a detailed presentation and subsequently provided written consent. The research was carried out in accordance with the ethical guidelines of the Declaration of Helsinki.

3. Results

Graphic 1. Descriptive statistics of participants

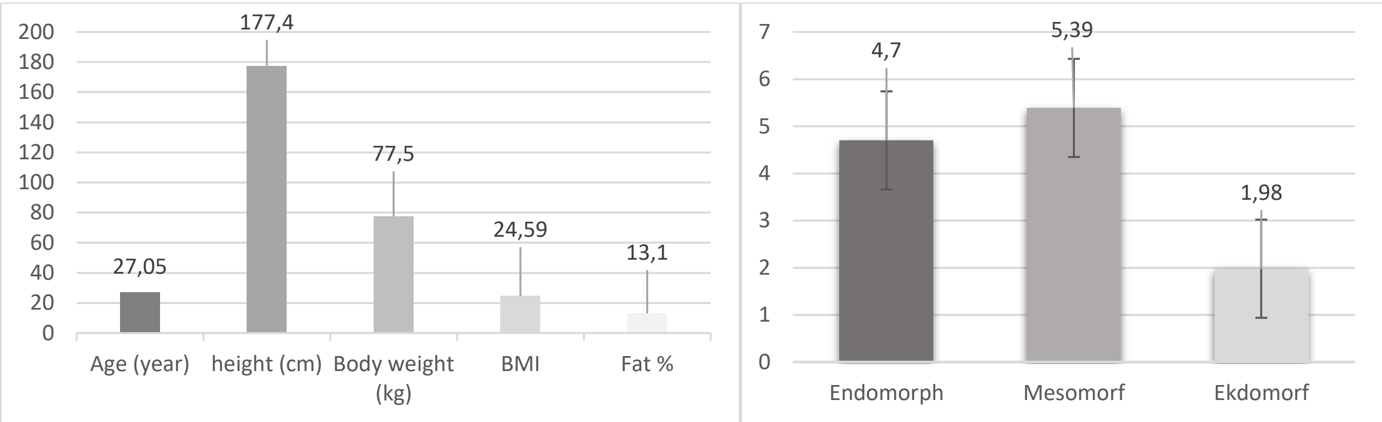


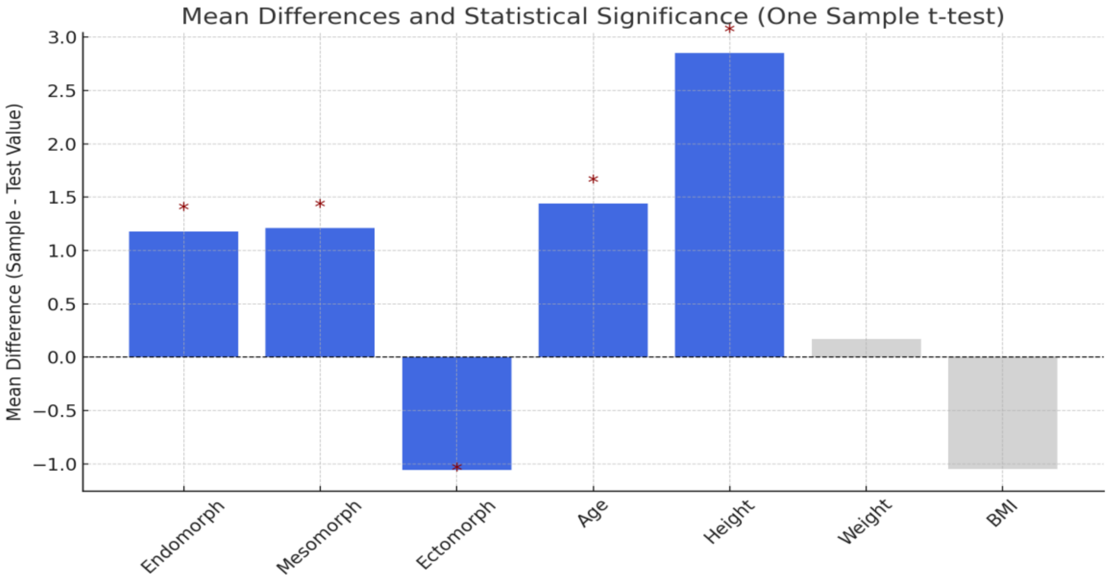
Table 2. One-sample t-test results and effect sizes (Cohen's d)

Variable	t	df	One-sided p	Two-sided p	Test Value	Sample Mean – Test Value	Cohen's d
Endomorph	5,31	39,00	<.001	<.001	3,52	1,18	0,84
Mesomorph	8,57	39,00	<.001	<.001	4,18	1,21	1,36
Ectomorph	8,60	39,00	<.001	<.001	3,04	–1.06	–1.36
Age	1,86	39,00	0,04	0,07	175,96	1,44	0,50
Height	2,11	39,00	0,02	0,04	74,65	2,85	0,58
Weight	0,50	39,00	0,31	0,62	24,42	0,17	0,02
BMI	–1.55	39,00	0,07	0,13	13,82	–1.05	–0.37

**%; percentage, kg: kilogram, cm; centimeter*

One-sample t-test analyses conducted on the participants' somatotype values revealed significant differences compared to the test values for the endomorph (t(39)=5.31; p<.001), mesomorph (t(39)=8.57; p<.001), and ectomorph (t(39)=8.60; p<.001) components. Particularly, the high level of mesomorphy and low level of ectomorphy indicate a dominant muscular and strong body structure within the sample. The endomorph level being above the test value also suggests a relatively higher body fat ratio. Significant or borderline significant differences were also observed in height (t(39)=2.11; p=.04) and age (t(39)=1.86; p=.07) variables compared to the test values. On average, participants were approximately 2.85 cm taller than expected. However, no significant differences were found in body weight (t(39)=0.50; p=.62) or body mass index (BMI) (t(39)=–1.55; p=.13). These findings suggest that the sample group possesses a muscular and athletic physique in terms of somatotype, although their overall body weight and BMI do not significantly deviate from reference values. According to Cohen's d values, very large effect sizes were detected in the mesomorph (d=1.36) and ectomorph (d=–1.36) components. A large effect size was also observed for the endomorph component (d=0.84). Medium effect sizes were found in height and age variables (d=0.58 and d=0.50, respectively), while the effects in body weight and BMI were very small (d=0.02 and d=–0.37). These results indicate that the body composition characteristics of the group include not only statistically significant but also practically meaningful differences.

Graphic 2. Mean Differences and Statistical Significence (One Sample t-test)



The graph displays the mean differences between the sample means and the test values for various variables, along with the statistical significance of these differences. Significant differences were observed for the variables Endomorph, Mesomorph, Ectomorph, Age, and Height. Specifically, the sample means for Endomorph, Mesomorph, Age, and Height were significantly higher than the test values (positive differences with $p < 0.05$). Conversely, the sample mean for Ectomorph was significantly lower than the test value (negative difference with $p < 0.05$). No significant differences were found for Weight and Body Mass Index (BMI), which are represented in gray. These findings indicate that certain physical and demographic characteristics differ significantly from the test values, highlighting meaningful variations in the sample.

4. Discussion

The aim of this study was to determine the anthropometric measurements and body somatopy of alpine style climbers among adults who are engaged in mountaineering branch. As a result of the results obtained from the sample group, it was found that the endomorph ratio was 4.70, the mesomorph ratio was 5.39, and the ectomorph ratio was 1.98. In addition, it was found that the body fat percentage was 13.10 and the body mass index was 24.59. When the literature was reviewed, it was seen that there were not many studies on these data. 16 years ago, an independent T-Test correlation was calculated with the study of Özkan and Sarol (2008). According to the test result, it was determined that there was a statistically significant difference in the endomorphic (t=5,31; p<.001), mesomorphic (t=8,57; p<.001) and ectomorphic (t=-8,60; p<.001) characteristics of the climbers and Table 2. When the findings of this study were subjected to G-Power T Test with the study conducted by Özkan and Sarol (2008), it was concluded that this study should be carried out with more people in the calculations made for Endomorphic, Mesomorphic and Ectomorphic body somatype. The instruments used for measurement were calibrated according to the measurements to be taken in a normobaric city environment. Therefore, the measurements were made in the city and room environment. It should be investigated how the same measurements will give results in hypobaric high-altitude environment. There is no data on similar studies carried out in hypobaric high-altitude environment.

Watts et al. conducted a study on young mountain climbers. The mean (SD) experience level of participants was 3.2 (1.9) years and subjects competed in 10 (5) organised competitions over a 12-month period. Despite age similarity, significant differences (p<0.01) were found between climbers and control subjects in height, mass, percentile scores for height and mass, ratio of arm span to height (‘monkey index’), biilocrystalline/biacromial ratio, sum of seven and nine skinfolds, estimated body fat percentage and hand grip/mass ratio. Despite significantly lower skinfold totals and estimated body fat percentage, no differences were found between climbers and controls for absolute BMI or BMI expressed as a percentile score. According to the results obtained, it can be concluded that young climbers have similar anthropometric characteristics to adults. Grant et al. (2001) investigated the anthropometric characteristics, strength and flexibility skills of non-climbers, recreational climbers and professional climbers. The study consisted of 3 groups. Group 1 consisted of 10 elite climbers aged 31.3 ± 5.0 years (mean ± s) who had reached the 'hard very severe' standard; Group 2 consisted of 10 recreational climbers aged 24.1 ± 4.0 years who had reached the 'severe' standard; and Group 3 consisted of 10 physically active individuals aged 28.5 ± 5.0 years who had not previously rock climbed. Tests included finger strength (grip strength, finger strength measured on climbing-specific apparatus), flexibility, bent arm hang and pull-ups. Regression procedures (analysis of covariance) were used to examine the effect of body mass, leg length, height and age. For finger strength, elite climbers recorded significantly higher values ($P<0.05$) than recreational climbers and non-climbers (four fingers, right hand: elite 321 ± 18 N, recreational 251 ± 14 N, non-climbers 256 ± 15 N; four fingers, left hand: elite 307 ± 14 N, recreational 248 ± 12 N, non-climbers 243 ± 11 N). For grip strength of the right hand, elite climbers recorded significantly higher values than recreational climbers only (elite 338 ± 12 N, recreational 289 ± 10 N, non-climbers 307 ± 11 N). The results suggest that elite climbers have greater finger strength than recreational climbers and non-climbers. Fanchini et al. compared maximal muscle strength and fast force capacity of the finger flexors between national-international level rock climbers and lead climbers. Ten rock climbers (mean ± SD, age 27 ± 8 years) and 10 lead climbers (age 27 ± 6 years) volunteered for the study. Ten non-climbers (age 25 ± 4 years) were also tested. 'Isometric maximal voluntary contraction (MVC) force and rate of force development (RFD) produced in 'curled' and 'open curled' hand positions were assessed in an instrumented grip. Climbers were found to be stronger than non-climbers. Furthermore, MVC force and RFD were significantly higher in rock climbers compared to lead climbers in both curved and open curved positions ($p<0.05$). The largest difference between rock and lead climbers (34-38%) was observed for the RFD variable. RFD may reflect the special requirements of rock climbing and seems to be more suitable for investigating muscle function in rock climbers than pure maximal power. Grant et al. (2001) conducted a study on hip and shoulder girdle strength and flexibility in elite and recreational climbers in 2007. The results of the study show that elite climbers have greater shoulder girdle endurance, finger strength and hip flexibility compared to recreational climbers and non-climbers. It is said that those aiming to lead climbs at 'el' standard or higher should consider training programmes to increase their finger strength, shoulder girdle strength and endurance and hip flexibility. Ozimek et al. (2017) conducted a study on strength and somatotype in elite and advanced climbers. Twenty climbers (age: 28.5±6.1 years) were analysed and divided into two groups according to their climbing level according to the International Rock-Climbing Research Association (IRCRA). Elite climbers represented the 8b-8c Rotpunkt (RP) climbing level (n=6) and advanced climbers represented the 7c+8a RP level (n=14). Height, weight, lean body mass, upper limb length, arm span and forearm, arm, thigh and calf circumference were measured. Participants also underwent a special test for finger strength, an arm strength test and a muscular endurance test (hanging from 2.5 and 4 cm ledges). In addition, pull-ups were performed to measure muscle resistance to fatigue. Elite climbers recorded significantly higher values for finger strength (129.08 vs. 111.54 kg; $t(18) = 2.35$, $p = 0.03$) and arm endurance (33.17 vs. 25.75 pull ups; $t(18) = 2.54$, $p = 0.02$) than advanced climbers. Furthermore, calf circumference was significantly lower in elite climbers than in advanced climbers (34.75 vs. 36.93 cm; $t(18) = 3.50$, $p = 0.003$). According to these results, it is stated that elite climbers have better physical capacity. Investigation of Kalaycı's (2023) studies there was a significant relationship between right hand grip strength, left hand grip strength, left hand fingertip grip strength, right hand palmar grip strength, left hand palmar grip strength, back strength and competition scores in male and female participants ($p<0.05$). The relationship between medicine ball throwing and righthand fingertip grip strength was significant only in women. In anaerobic power measurement, there was no significant relationship in men and women ($p>0.05$). Addition significant relationships were found between upper extremity strength values and competition results, but not in anaerobic power measurement.

Variations in anthropometric, physiological, and strength-endurance metrics were noted among sport climbers specia izing in certain subdisciplines, climbers of varying ability levels, and nonclimbers (Saul et., 2011). Nonetheless, discrepancies in the classification of climbers into several categories (e.g., advanced, elite) complicate the ability to derive satisfactory findings from the examined research and reviews. Furthermore, the sports level was frequently assessed using diverse grading systems (e.g., Union Internationale des Associations D'Alpinisme scale, French scale, British technical grading scale, Yosemite Decimal System), which might also be perplexing. This assessment involved the conversion and standardization of ascending difficulty levels to the French scale for lead climbing and the Font scale for bouldering. Body mass values exhibit substantial variation among the examined groups. Specifically, body mass was reduced in the sport climbers relative to the control participants. Furthermore, notable disparities exist between sport climbers attaining 7c 1 RP and those achieving 6a 1 RP (9), as well as between top lead climbers surpassing 8c RP and speed climbers (Levernier et al., 2020), indicating that reduced body mass appears to significantly influence sport climbing performance. Nevertheless, variations in mass, height, and BMI are not considered pertinent indications in this evaluation, as researchers in several studies endeavored to recruit subjects of comparable age and body size. The ape index shown no significant variation among sport climbers of differing ability levels, ranging from 1 to 1.03 (Giles et al., 2021; Levernier et al., 2020; Ozimek et al., 2017). Both male and female sport climbers may have more lean muscle mass compared to control participants. Nonetheless, the difference was demonstrated in single research (Philippe et al., 2012). This phenomena can be elucidated by the study's comparison of elite female and male lead climbers with nonclimbers. The disparity in lean muscle mass was not detected between boulderers ($7B) and non-climbing persons (MacDonald & Calendar, 2011). The subsequent investigations contrasted sport climbers of varying skill levels, which may have led to the absence of substantial differences. Moreover, body fat percentage warrants particular consideration in relation to other body composition metrics. Adipose tissue is a key factor influencing circumferential measurements (Çelik et al., 2015).Advanced sport climbers had reduced lower-body fat levels in comparison to the control group and less advanced athletes. Male lead climbers exhibited the lowest body fat percentages below 10%, specifically at the 8b to 8c RP level (7.97%) (29), >8c RP (7.95%), and 8a to 8b 1 RP (9.8%) (Levernier et al., 2020; Limonta et al., 2018). Additionally, male boulderers at the >8B RP level recorded 7.43%, while male speed climbers had a body fat percentage of 9.42% (Levernier et al., 2020). Climbers with a lower level of proficiency and control participants exhibited body fat percentages above 10%. Therefore, maintaining a body fat percentage below 10% appears essential for elite sport climbers across all three climbing subdisciplines. Sports climbers exhibited markedly greater bone density in the upper limb compared to the control group (Kemmler et al., 2006; MacDonald & Calendar, 2011). In comparison to control participants, elevated bone density has been noted in male boulderers reaching the $7B level (1.1 g·cm²) and male lead climbers attaining the .8a RP level (0.972 g·cm²) (MacDonald & Calendar, 2011). Nevertheless, there is a deficiency of research concerning sport climbers of varying ability levels.

The characteristics of body composition appear much more crucial than the examined anthropometric measures in relation to sport climbing performance. Reduced body fat coupled with increased lean muscle mass may facilitate improved ergonomic mobility and diminish strain while climbing. Therefore, a nutritional assessment, encompassing the analysis of anthropometric and biochemical data, should be regarded for climbing athletes. The mechanical influence of sport climbing on bone mineral density arises from the significant muscular stress exerted throughout the activity. The distribution of load is intricate, facilitating bone adaptation, particularly in the upper limbs (Kemmler et al., 2006). Consequently, this parameter appears to be an adaptive mechanism of the skeletal system in response to sport climbing exercise.

5. Conclusion

Since the study was conducted only with 40 male mountaineer volunteers climbing in Alpine style, it will not represent the whole population. When all these were evaluated and compared with the studies in the literature, it was shown that Alpine style climbing athletes had normal body mass index (24.59±2.12), normal body fat percentage (13.10±4.42) and mesomorphic endomorph (4.70-5.39-1.98) characteristics. Although there is a finding that the body mass index of athletes climbing in Alpine style is within normal limits, it should be known that it is close to the upper limit. In athletes who differ according to their body somatotype, it should be tried to become compatible with additional training programmes, and if they exhibit physical characteristics compatible with the Alpine style body somatotype in different climbing styles, it should be considered to change the climbing style to Alpine style. This study should be carried out with a larger sample group in a high-altitude climbing environment, athletes should be observed during climbing and coach athletes who are constantly climbing should be preferred, the results obtained will better represent the universe of alpine style climbers.

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Declaration of Data Availability: The data is publicly available.

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