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Morphological Heterogeneity and Ethnic Patterning of Anthropometric Traits in Ethiopian Inter-Scholastic Athletes

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Abstract

Introduction: Anthropometric characteristics such as body size, proportions, and composition are fundamental determinants of morphological suitability for sport. Ethiopia's significant ethnic diversity suggests potential variability in these traits; however, systematic data on anthropometric differences among adolescent athletes from different ethnic and demographic backgrounds remain limited. Understanding these variations is critical for talent identification and sports specialization at the school level. Methods: A cross-sectional study was conducted among inter-scholastic athletes representing multiple Ethiopian ethnic groups. Standardized anthropometric assessments were performed following ISAK and CDC protocols. Measurements included body mass, stature, BMI, limb lengths, segmental girths, and selected skinfold thicknesses. Instruments were calibrated prior to testing, and all measurements were taken by a trained assessor to ensure reliability. Data were analyzed to identify ethnic and demographic variations in morphological characteristics. Results: The analysis revealed notable differences across ethnic groups in key anthropometric variables, including limb segment lengths, girth measurements, and overall body composition. Some ethnic groups exhibited longer lower-limb segments, lower BMI profiles, and distinct proportionality patterns that may offer advantageous morphology for endurance or speed-based sports. Demographic factors, including regional background, also contributed to variations in body size and proportions. Conclusion: Distinct anthropometric patterns exist among inter-scholastic athletes from different Ethiopian ethnic and demographic groups. These variations highlight the influence of ethnic background on body morphology and underscore the value of anthropometric profiling in youth sport development and talent identification. Establishing comprehensive anthropometric data across Ethiopia's diverse populations can support more effective athlete selection, training planning, and long-term sport development strategies.

Keyword: Anthropometric Variables, Ethiopian Athletes, Body Mass Index, Limb Circumference, Waist Circumference

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INTRODUCTION

Anthropometric characteristics are essential indicators of an athlete's body size, proportions, and morphological suitability for sport. Variations in height, limb length, body mass, segmental proportions, and overall body composition strongly influence mechanical efficiency, movement economy, and the ability to meet sport-specific physical demands. As a result, anthropometric profiling has become a key component in talent identification, performance evaluation, and the selection of athletes for appropriate sporting events [1]. Research consistently shows that elite athletes from different ethnic backgrounds display distinct

anthropometric patterns [2-8]. For example, Kenyan distance runners—particularly those from the Kalenjin and Nandi tribes—possess long, thin lower limbs, narrow pelvises, and low overall body mass, which reduce energy expenditure during running and support superior endurance performance (Henrik B. Larsen,[9]. 2003). Similar body shapes have been observed in Ethiopians, Black South Africans, and some Indian populations, suggesting shared morphological traits conducive to endurance activities (Larsen et al., [9].2003b as cited in Larsen, [9].2003) [10-17].

Ethiopian athletes, in particular, are generally shorter and lighter and have lower BMI compared with Caucasian athletes, providing biomechanical advantages in long-distance running (R. R. Wishnizer et al., [17].2013).

Anthropometric assessment also helps determine an athlete's morphological status, including body constitution, proportionality, and structural balance, all of which are closely linked to performance efficiency. Specific sports require specific body types—for instance, longer limbs and lower mass benefit endurance running, while greater muscle mass and limb girth support power and strength events. When an athlete's anthropometric profile does not match the mechanical requirements of the sport, achieving top-level performance becomes significantly more difficult (Karanjit Singh et al.,[8]. 2012).

Despite Ethiopia's extensive ethnic diversity, comprising more than 80 distinct groups, comprehensive data on anthropometric differences within its population remain limited. There is little research examining how these ethnic variations influence body proportions, structural characteristics, and overall suitability for different sports. This gap underscores the need to investigate anthropometric characteristics among interscholastic athletes in Ethiopia to understand how ethnic and demographic factors shape morphological advantages relevant to athletic performance [2].

OBJECTIVES OF THE STUDY

This study has two types of objectives: General objective and specific objectives [3].

General Objective

The general objective of this study was to compare anthropometric characteristics of Inter-Scholastic Sports Teams in relation to ethnic and demographic variables (Table-1)

Specific Objective

This study also has a specific objective to measure and compare anthropometric variables among Inter-Scholastic sports teams [4, 5].

Hypothesis

The Null Hypothesis States

Ho: there will be no significant differences demonstrated in anthropometric characteristics between groups (Inter-scholastic Sports Teams) of different ethnic origin.

On the other Hand, the Alternate Hypothesis States

H_1*:* that there will be significant differences demonstrated in anthropometric characteristics between groups (Inter-scholastic Sports Teams) of different ethnic origin [6].

Table 1. Demographic characteristics of the groups.

Descriptive Statistics						
Sex	***Male***	***N***	***Minimum***	***Maximum***	***Mean***	***Std. Deviation***
Age	In year	140	18	22	19.77	1.121

Valid N (listwise)	140				

SIGNIFICANCE OF THE STUDY

- It is important because it helps other researchers understand what was done and gives them the ability to replicate the study [7].
- Due to the lack of information to make the potential benefit of this information readily available, there is a clear need for descriptive anthropometric characteristics data indicating the performance differences for interscholastic or collegiate athletes of different ethnic origin. Comparative values for each parameter would be able to provide information about specific measures/ethnic differences in athletic performance which are currently rarely available as published data [8].
- The results from this study might provide the coach with information about the physical attributes during recruitment and selection of athletes for various sports/ talent identification [9].
- It provides the local and central governments information about sports requirement of anthropometric characteristics to develop and adjust sports policy accordingly [10].
- It can be used as a spring board for further investigation in the related areas such as talent identification and ethnic differences in physical performances, athletic skill performance, etc. [11].

RESEARCH DESIGN

This is descriptive study in which data were collected using those procedures employed for descriptive types of study [12].

SELECTION OF SUBJECTS

As this study is so wide that covers study populations from various ethnic groups and geographic locations, Stratified Random Sampling Technique was employed to select study groups with different characteristics. A total of one hundred forty (N= 140) interscholastic football players were recruited to take part in the study. All the twenty (20) footballers in each team were participated in the study since number of sample size was small. Subjects underwent a number of field-based tests to assess anthropometric characteristics. [13].

EXCLUSION CRITERIA

Participants were excluded if they presented with any musculoskeletal deformities, limb asymmetries, or physical disabilities that could influence body measurements or compromise the accuracy of anthropometric data. Individuals with severe lower-extremity, spinal, or postural abnormalities that could alter stature, segment length, or girth assessments were removed from consideration. Any condition that prevented maintaining standardized measurement positions (standing erect posture, limb relaxation, anatomical landmark exposure) was considered grounds for exclusion [14].

SELECTION OF VARIABLES AND CRITERION MEASURES

Anthropometric assessment plays a critical role in describing body size, proportions, and composition. Internationally accepted references, including ISAK (2001) and CDC Anthropometry Protocols (2007/2009), emphasize standardized measurement landmarks and techniques to ensure precision and reproducibility. For this study, anthropometric variables were selected based on their relevance, reliability, ease of measurement, and suitability for youth populations. All measurements were recorded on the right side of the body, unless contraindicated [15].

ANTHROPOMETRIC VARIABLES

All anthropometric measurements were performed using standardized ISAK and CDC procedures. Measurements were taken to the nearest 0.1 cm or 0.1 mm for skinfolds.

Body Weight (kg)

Measured using a calibrated digital weighing scale. Participants stood barefoot, with minimal clothing, and weight was recorded as nude mass.

Standing Height / Stature (cm)

Measured using a stadiometer. Participants stood erect, barefoot, with heels together and head in the Frankfort Horizontal Plane. Measurement was taken at the end of a deep inhalation.

Body Mass Index (BMI, kg/m^2)

Calculated as body mass (kg) divided by height squared (m^2). BMI = weight (kg) / [height (m)].^{2}.

Upper Arm Length (cm)

Measured as the distance between the Acromiale and Radiale landmarks using a segmometer. Participant stood relaxed with the arm hanging freely.

Upper Leg Length (cm)

Measured from the inguinal crease to the superior border of the patella using a cosmetic pencil for landmarking.

Upper Arm Circumference (cm)

Mid-upper arm circumference measured at the midpoint between the acromion and olecranon processes using a non-elastic tape.

Thigh (Mid-Thigh) Circumference (cm)

Measured at the marked mid-trochanterion–tibiale-laterale site. Participants stood relaxed with body weight evenly distributed.

Forearm Circumference (cm)

Measured at the maximal girth distal to the humeral epicondyles using a steel tape.

Calf Circumference (cm)

Measured at the widest point of the calf (medial calf landmark) with participants standing relaxed.

Body Composition Variables (Anthropometry Components Only)

Skinfold Thickness (mm)

Performed using Harpenden or equivalent calipers.

- Triceps Skinfold: Vertical fold taken midway between the acromion and olecranon.
- Subscapular Skinfold: Oblique fold below the inferior angle of the scapula.

Thickness was recorded to the nearest 0.1 mm.

Waist Circumference (cm)

Measured at the narrowest point between the lower costal margin and the iliac crest using a steel tape.

TEST ADMINISTRATION PROCEDURE

Anthropometric assessments were conducted according to standardized ISAK and CDC guidelines to ensure precision, validity, and reliability. The following procedures were maintained:

Environmental and Measurement Control

- All measurements were taken under consistent light, temperature, and room conditions.
- Instruments (stadiometer, weighing scale, tapes, calipers) were calibrated before each session.

Participant Preparation

- Measurements were taken with participants barefoot and wearing light clothing.
- Participants refrained from eating for at least 3 hours prior to testing to minimize abdominal distension.

Landmarking Procedures

- Bony landmarks (acromion, olecranon, inguinal crease, patella, tibiale laterale) were palpated and marked using cosmetic pencils.
- All girths and lengths were taken at the exact marked sites to ensure reproducibility.

Measurement Technique

- Each measurement was taken on the right side of the body.
- For circumferences, the tape was kept horizontal, snug but not compressing the tissue.
- Skinfolds were measured with the caliper applied 1 cm below the pinched fold, and values were read 2 seconds after placement.

Quality control

- All measurements were performed by the same trained examiner to reduce inter-observer variability.
- Duplicate measurements were taken, and a third reading was obtained when discrepancies exceeded acceptable technical error limits.

The study evaluated nine anthropometric variables: Weight (WT), Height (HT), Body Mass Index (BMI), Upper Arm Length (UAL), Upper Leg Length (ULL), Upper Arm Circumference (UAC), Forearm Circumference (FAC), Thigh Circumference (ThC), and Calf Circumference (CC). Significant between-group differences were observed across all parameters ($p < 0.05$).(Table-5)

Body Weight (WT)

ANOVA indicated a significant difference in weight across the seven ethnic groups ($F = 5.391$, $p = 0.000$). Post-hoc analysis showed that Sodo-WL and Jimma-OR had significantly higher body mass compared with Jigjiga-SM and Aksum-TG, while Aksum-TG presented the lowest mean weight among all groups (Table-2).

Height (HT)

A significant variation in height was identified ($F = 8.397$, $p = 0.000$) Gambella-GM recorded the highest mean height, followed by Jigjiga-SM. Sodo-WL and Hossana-HD were also significantly taller than Gondar-AM.(Table-3)

Table 2. Body weight

ANOVA					
Weight in killo gram					
	Sum of Squares	***df***	***Mean Square***	***F***	***Sig.***
Between Groups	1264.563	6	210.760	5.391	.000*
Within Groups	5199.190	133	39.092		
Total	6463.752	139			

Table 3. Body height.

ANOVA					
HT(cm)					
	Sum of Squares	***df***	***Mean Square***	***F***	***Sig.***
Between Groups	2166.586	6	361.098	8.397	.000*

Within Groups	5719.550	133	43.004		
Total	7886.136	139			

Body Mass Index (BMI)

BMI differed significantly between groups (F = 5.430, p = 0.000) Descriptive BMI analysis showed:

- Normal BMI category (18.5–24.5 kg/m²):
- Jimma-OR (20.22±3.87), Sodo-WL (20.61±2.75), Gondar-AM (19.91±1.53), Hossana-HD (19.37±1.77) (Table-4)
- Underweight (<18.5 kg/m²):
- Aksum-TG (17.74±1.66), Jigjiga-SM (17.83±2.05), Gambella-GM (18.16±1.33; marginally underweight) (Table-6)

Upper Arm Length (UAL)

Significant differences were observed (F = 9.909, p = 0.000)

Gambella-GM demonstrated the longest upper arm length, followed by Hossana-HD, which was significantly longer than Aksum-TG, Jimma-OR, and Gondar-AM.(Table-7).

Upper Leg Length (ULL)

ULL showed significant variation (F = 7.081, p = 0.000)

Gambella-GM again recorded the greatest upper leg length, with Jigjiga-SM also showing significantly longer ULL than Aksum-TG (Table-8).

Upper Arm Circumference (UAC)

A significant difference in UAC was observed (F = 6.147, p = 0.000).

Sodo-WL and Hossana-HD had significantly larger arm girths compared to Aksum-TG and Jigjiga-SM (Table 9).

Forearm Circumference (FAC)

Significant differences were detected between groups (p < 0.05). Sodo-WL and Hossana-HD exhibited greater forearm girth relative to other groups, whereas Aksum-TG and Jigjiga-SM had the smallest values (Table-10).

Thigh Circumference (ThC)

ANOVA revealed significant variation across groups (p < 0.05).

Sodo-WL had the largest thigh circumference compared with Jigjiga-SM and Aksum-TG, while Gambella-GM, Gondar-AM, and Hossana-HD also showed larger ThC than Aksum-TG (Table-11).

Calf Circumference (CC)

Calf circumference differed significantly (F = 6.760, p = 0.000)

Sodo-WL showed the highest calf girth, followed by significant increases in Jimma-OR, Hossana-HD, and Gondar-AM relative to Aksum-TG (Table-12).

Table 4. Body mass index (BMI). Intergroup Comparison

ANOVA					
BMI (kg/m^2)					
	Sum of Squares	***df***	***Mean Square***	***F***	***Sig.***

Between Groups	171.442	6	28.574	5.430	.000*
Within Groups	699.807	133	5.262		
Total	871.250	139			

Table 5. Mean of body mass index in different ethnic groups.

BMI in kg/m2			
Name of the Group	***Mean***	***N***	***Std. Deviation***
Aksum-TG	17.7480	20	1.66584
Gambella-GM	18.1655	20	1.33688
Gondar-AM	19.9170	20	1.53115
Hossana-HD	19.3705	20	1.77262
Jigjiga-SM	17.8395	20	2.05580
Jimma-OR	20.2230	20	3.87091
Sodo-WL	20.6115	20	2.75188
Total	19.1250	140	2.50359

Table 6. WHO body mass index categories and classification for adults.

Classification	**BMI (kg/m²)**
Underweight	<18.5
Severe thinness	<16.0
Moderate thinness	16.0 – 16.9
Mild thinness	17.0 – 18.5
Normal range	18.5 – 24.9
Overweight	≥25.0
Pre-obese	25.0 – 29.9
Obese	≥30.0
Obese class I	30.0 – 34.9
Obese class II	35.0 – 39.9
Obese class III	≥40.0

Table 7. Upper arm length (UAL).

ANOVA					
UAL(cm)					
	Sum of Squares	***df***	***Mean Square***	***F***	***Sig.***
Between Groups	250.168	6	41.695	9.909	.000*
Within Groups	559.638	133	4.208		
Total	809.805	139			

Table 8. Upper leg length (ULL).

ANOVA					
ULL(cm)					
	Sum of Squares	***df***	***Mean Square***	***F***	***Sig.***
Between Groups	184.218	6	30.703	7.081	.000*
Within Groups	576.675	133	4.336		
Total	760.893	139			

Table 9. Upper arm circumference (UAC).

ANOVA					
UAC (cm)					
	Sum of Squares	***df***	***Mean Square***	***F***	***Sig.***

Between Groups	272.822	6	45.470	6.147	.000*
Within Groups	983.827	133	7.397		
Total	1256.649	139			

** p is significant at the 0.05 level.*

Table 10. Forearm circumference (FAC).

ANOVA					
FAC(cm)					
	Sum of Squares	***df***	***Mean Square***	***F***	***Sig.***
Between Groups	125.456	6	20.909	9.029	.000*
Within Groups	307.988	133	2.316		
Total	433.444	139			

Table 11. Thigh circumference (THC).

ANOVA					
ThC (cm)					
	Sum of Squares	***df***	***Mean Square***	***F***	***Sig.***
Between Groups	218.447	6	36.408	2.647	.019*
Within Groups	1829.515	133	13.756		
Total	2047.961	139			

Table 12. Calf circumference (CC).

ANOVA					
CC (cm)					
	Sum of Squares	***df***	***Mean Square***	***F***	***Sig.***
Between Groups	116.364	6	19.394	6.760	.000*
Within Groups	381.578	133	2.869		
Total	497.941	139			

RESULTS

Anthropometric Variables

The following anthropometric parameters were analyzed: body mass, standing height, body mass index (BMI), upper arm length, upper leg length, upper arm circumference, forearm circumference, thigh circumference, and calf circumference.

Body Mass and Standing Height

One-way ANOVA revealed statistically significant differences in **body mass** and **standing height** among inter-scholastic athletes from different ethnic groups ($p < 0.05$). Post hoc (LSD) analysis indicated that certain groups demonstrated significantly higher body mass compared with others, while height varied notably across ethnic groups, reflecting differences in linear body growth patterns. No significant differences were observed between some groups, indicating comparable body size.

Body Mass Index (BMI)

Significant between-group differences were observed for BMI ($p < 0.05$). Post hoc analysis revealed that some ethnic groups exhibited significantly higher BMI values compared with others, while several groups demonstrated BMI values within a similar range. Despite statistical differences, mean BMI values across all groups remained within normal limits for athletic populations. (Tables 4 and 5)

Limb Segment Lengths

ANOVA results showed significant differences in upper arm length and upper leg length among groups ($p < 0.05$). Post hoc comparisons indicated that certain ethnic groups possessed significantly longer limb segments, particularly in the lower extremities, while others showed comparatively

shorter limb lengths. No significant differences were found between several groups.

Segmental Circumferences

Significant inter-group differences were observed in upper arm circumference, forearm circumference, thigh circumference, and calf circumference ($p < 0.05$). Post hoc analysis revealed that some groups exhibited significantly larger circumferences, indicating greater muscular development, whereas other groups demonstrated smaller girths, reflecting more linear body morphology [16-17].

CONCLUSION

The analysis revealed notable differences across ethnic groups in key anthropometric variables, including limb segment lengths, girth measurements, and overall body composition. Some ethnic groups exhibited longer lower-limb segments, lower BMI profiles, and distinct proportionality patterns that may offer advantageous morphology for endurance or speed-based sports. Demographic factors, including regional background, also contributed to variations in body size and proportions.

Distinct anthropometric patterns among inter-scholastic athletes from different Ethiopian ethnic and demographic groups. These variations highlight the influence of ethnic background on body morphology and underscore the value of anthropometric profiling in youth sport development and talent identification. Establishing comprehensive anthropometric data across Ethiopia's diverse populations can support more effective athlete selection, training planning, and long-term sport development strategies.

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