Body Density Disparities among Female Athletes of Different Running Events Estimated by 7-Site Skinfold Equation

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Abstract

The study aimed at investigating body density disparities among female athletes specializing in different running event categories such as, short-distance sprints, middle-distance runs, and long-distance endurance races. Body density of athletes analyzed using the 7-site skin-fold equation. Anthropomorphic measurements were conducted following the guidelines of the International Society for the Advancement of Kin anthropomorphic, and body density estimated from it. Descriptive statistics, one-way Analysis of Variance, and post hoc tests employed to explore differences among the groups. Results indicate significant disparities in body density found among groups, underscoring the importance of training programs designed for athletes based on their event category.

Introduction

Female athletes participating in various running events, including short-distance sprints, middle-distance runs, and long-distance endurance races, often exhibit different physiological characteristics. Research has shown that these differences are influenced by various factors, including genetics, training regimes, and nutritional strategies, which together shape the athletes' body composition (Maughan, 2003). Assessing body density is crucial for understanding these differences, which can inform training and performance optimization strategies. This study investigates body density disparities among female athletes across different running events, employing the 7-site skin-fold equation for estimation.

Body density, a key indicator of body composition, is crucial for athletes' performance, particularly in running events where optimal body composition can

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significantly impact efficiency and speed. The 7-site skin-fold equation is a commonly used method for estimating body density, offering a non-invasive and relatively accurate assessment. This literature review explores body density disparities among female athletes engaged in short, middle, and long-distance running events.Body density, defined as the ratio of body mass to body volume, is an important factor in athletic performance. It reflects the relative proportions of lean body mass and fat mass. Previous studies have suggested that athletes specializing in power events like sprints tend to have higher body density values, which is indicative of greater muscle mass and lower fat mass, whereas endurance athletes exhibit lower body density due to the minimal fat and lean muscle mass required for prolonged exertion (Tesch, 1983). Higher body density typically indicates lower body fat, which can enhance athletic performance by reducing excess weight and improving muscle efficiency (Heyward, V. H., & Wagner, 2004).

The 7-site skin-fold equation is a widely accepted method for estimating body fat percentage and body density. The sites measured include the chest, abdomen, thigh, triceps, sub-scapular, suprailiac, and maxillary regions. This technique, when performed correctly, has been shown to provide an effective measure of subcutaneous fat distribution, a key aspect of overall body composition (Wells, J. C. K., & Davies, 1998). This method has been validated against more direct measures of body composition, such as hydrostatic weighing and dual-energy X-ray absorptiometry (DEXA), showing good reliability and validity in various populations (Jackson, A. S., & Pollock, 1985).

The disparities in body density among female athletes across different running events may highlight the specific physiological adaptations required for optimal performance in each category. Research has indicated that sprinters typically have more muscle mass relative to body fat, while middle-distance runners achieve a balance of muscle and fat to support both speed and endurance, and long-distance runners often present the lowest body density values due to the emphasis on efficiency and endurance (Bishop, D., Jones, E., & Woods, 2008). Again according to the study from Beattie, K., Kenny, I. C., Lyons, M., & Carson, (2014) from Sprinters, with their emphasis on power and speed, exhibit the highest body density values due to greater muscle mass. Middle-distance runners show intermediate body density values, reflecting their need for a balance of speed and endurance. Long-distance runners, focusing on endurance, exhibit the lowest body density values due to minimal body fat and muscle mass optimized for prolonged activity.

Understanding these disparities can aid coaches and sports scientists in designing training programs. However, there is a lack of studies conducted to estimate body density of female runners from different distances in the Ethiopian athletes' context. Recent studies on Ethiopian athletes have focused predominantly on performance metrics and physiological factors, with limited emphasis on body composition (Ayele, M., Tadesse, A., & Mulugeta, 2020). Therefore the purpose of the study was to determine Ethiopian female athletes' body density in their respective running category and how they significantly differ from one event category to the other using the 7-site skin-fold equation.

Objectives of the study

The study was aimed at investigating body density disparities among female athletes specializing in different running events such as, short-distance sprints, middle-distance runs, and long-distance endurance races using the 7-site skinfold equation. More specifically:

- To estimate body density of athletes competing in short-distance sprint events.
- To evaluate body density of athletes participating in middle-distance running events.
- To assess body density of athletes engaged in long-distance endurance races.
- To analyze body density variations across different running event categories.

Methodology

The study adopted a cross-sectional design, recruiting female athletes specializing in short-distance (100m to 400m), middle-distance (800m to 3000m), and long-distance (5000m and above) running events. The athletes were selected based on their ranking at the national level, ensuring that the sample represented top-tier competitors with diverse training backgrounds. A total of 35 female athletes consisting short distance (n=12), middle distance (n=11), and long distance (n=12) were drawn as a sample purposively selecting those who won trophies at Ethiopian athletics championships. Skinfold measurement obtained from seven anatomical sites using standardized techniques. The 7-site skin-fold equation employed to estimate body density. Relevant demographic and training data collected for selection and category. The 7-Site Skin-fold Equation used is:

Body Density = 1.097 - (0.00046971 x Sum of skinfolds) + (0.00000056 x Square of the sum of skinfold sites) - (0.00012828 x Age), where the skinfold sites (measured in mm) are: Chest, Axilla, Triceps, Subscapular, Abdominal, Suprailiac and Thigh (Jackson, A. S., Pollock, M. L., & Ward, 1980), based on a sample aged 18-55. Anthropometric measurements were conducted following the guidelines of the "International Society for the Advancement of Kinanthropometry," 2001) and body density estimated from it. Descriptive statistics, one-way Analysis of Variance, and LSD post hoc tests employed to explore differences among the groups.

Result and Discussion

The descriptive analysis of body density of female athletes regarding with their respected running events (SDR, MDR, LDR) is given in Table 1.

Table 1. Descriptive Result of Athletes Body Density

Variable & Unit	SDR (n=12)		MDR (n=11)		LDR (n=12)	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Body Density (g/cm^{3})	1.06	0.008	1.07	0.006	1.07	0.003

**SDR- Short Distance Runners, MDR- Middle Distance Runners, LDR- Long Distance Runners, SD-Standard Deviation*

As shown in Table 1, short distance runners possessed a mean (SD) value of 1.06(0.008) g/cm^3 body density, middle distance runners exhibited a mean (SD) value of 1.07(0.06) g/cm^3 body density and long distance runners have shown a mean (SD) value of 1.07(0.003) g/cm^3 body density. (Figure 1 demonstrates a visual descriptive figure)

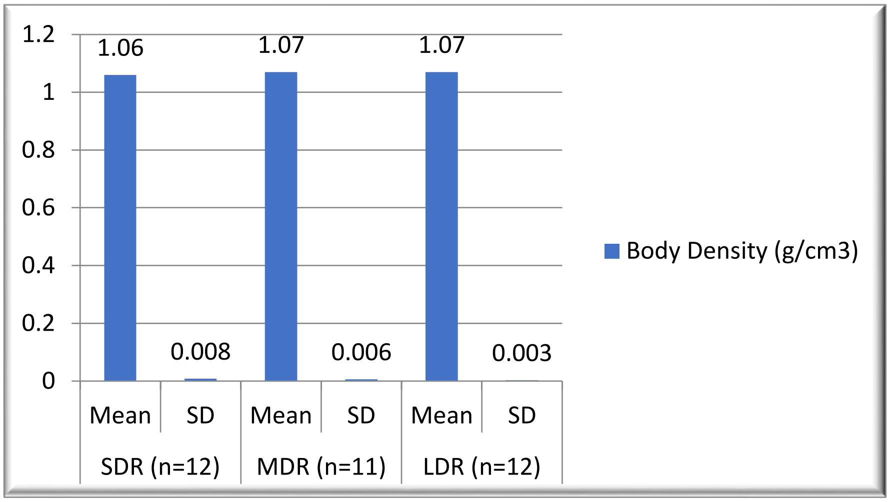

Figure 1 Descriptions of body density of short, middle and long distance female runners

To determine the statistical differences of body density difference between groups, the obtained data was examined with one way analysis of variance (ANOVA). When the obtained "F-ratio" found to be significant at 0.05 levels, LSD test was used as post hoc test to further locate the significant mean differences between paired means. Table-2 presented the result of the group variance in body density.

Table 2. Analysis of Variance of Body Density among Female SDR, MDR and LDR

Variables	SS_B	SS_W	MS_B	MS_W	F	P
Body Density	.001	.001	.000	.000	7.080*	.003

* $p < 0.05$

Table 2 described the statistical difference of the body density of female athletes across different running even category. From the results of the distribution of means and standard deviations of the selected variables, one way analysis of variance was computed to see the significant differences among three groups of runners at 0.05 levels. Significant differences were noted in body density ($p < 0.05$).

Since significant differences were obtained, additional explorations of the differences among means was required in order to provide specific descriptions on which means are significantly different from each other. Thus, the data were further subjected to statistical treatment and post hoc LSD test was applied (see the Table 3).

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Table 3. Results of Post-Hoc Test in between Female SDR, MDR and LDR

Variables	Mean Differences (SDR Vs MDR)	Mean Differences (SDR Vs LDR)	Mean Differences (MDR VS LDR)
Body Density	-.00939*	-.00583*	.00356

** Mean difference is significant at the p< 0.05 level*

The result of the post hoc test in Table 3 above indicated that short distance runners have significantly higher lower body density than middle and long distance runners. No statistical significant differences observed between middle and long distance runners in their body density.

Discussion

According to Beattie et al., sprinters, with their emphasis on power and speed, exhibit the highest body density values due to greater muscle mass (Beattie, K., Kenny, I. C., Lyons, M., & Carson, 2014). *This finding is consistent with other research that shows that sprinters tend to have a more muscular physique due to the anaerobic nature of their training, which promotes the development of lean muscle mass over time (Fletcher, J., & Bunn, 2014).* In contrary with this finding the present study found Ethiopian short distance runners shown significantly lower body density than middle and long distance runners. This may be requiring further study as the possible causes of this unexpected result, such as differences in the training regimes, diet, or even genetic factors influencing body composition. *Additionally, environmental factors, such as altitude, which affects the metabolism of athletes in Ethiopia, could be contributing to variations in body composition among sprinters (Millet, G. P., Vleck, V. E., & Bentley, 2010).*

Similarly Beattie, K., Kenny, I. C., Lyons, M., & Carson, (2014) found that middle-distance runners show intermediate body density values, reflecting their need for a balance of speed and endurance. This aligns with other studies indicating that middle-distance runners need to maintain a combination of lean muscle mass and low body fat to optimize their performance in events such as the 800m and 1500m, where both speed and stamina are crucial (Noakes, 2012). Long-distance runners, focusing on endurance, exhibit the lowest body density values due to minimal body fat and muscle mass optimized for prolonged activity (Beattie, K., Kenny, I. C., Lyons, M., & Carson, 2014). Research by (Folland, J. P., Allen, S. J., Black, M. I., & Welle, 2008) also supports this notion, showing that long-distance athletes generally possess a leaner

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physique with a higher proportion of slow-twitch muscle fibers, which is advantageous for endurance performance.

In the present study there is no statistical significant differences obtained between middle and long distance runners in their body density among female Ethiopian athletes. This finding contrast with studies conducted in other populations, where middle-distance runners generally exhibit higher body density compared to long-distance runners, likely due to greater muscle mass developed through more intense training (Tesch, 1983). This discrepancy may be attributed to cultural and environmental factors that influence the training and physiological adaptation of Ethiopian athletes, such as the unique altitude at which they train, which may lead to different adaptations in muscle and fat distribution. Further investigation is required to clear such discrepancies. *Moreover, it is important to consider that body density alone may not fully capture the complexity of an athlete's performance. Other measures such as body fat percentage, muscle fiber composition, and VO2 max, which reflect aerobic and anaerobic fitness, also play crucial roles in performance outcomes (Bouchard, C., Blair, S. N., & Haskell, 2012). Therefore, future studies should incorporate these variables alongside body density to provide a more comprehensive understanding of body composition and its relationship to running performance.*

Conclusion

In conclusion, Ethiopian short distance runners possessed an average value of 1.06 g/cm^3 body density, and both middle and long distance runners exhibited body density of 1.07 g/cm^3. In comparison, short distance runners have shown significantly lower body density than middle and long distance runners and there is no statistical significant difference obtained between middle and long distance runners in their body density among female Ethiopian athletes.

The study contributes to the understanding of body density disparities among female athletes across different running events, utilizing the 7-site skinfold equation for estimation. By considering these differences, coaches and sports scientists can optimize training strategies to enhance performance and minimize injury risks in female runners.

It adds valuable insights into the body composition characteristics of Ethiopian female athletes and highlights the need for further research to explore the impact of training and nutritional strategies on body density and overall performance.

Ethics Statement

The study conducted according to the recommendation of APA ethical guidelines and informed consent was obtained from participants, coaches, clubs and federation as per the declaration of Helisinki.

Conflict of Interest

The authors of this study state that there is no any conflict of interest.

Acknowledgement

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