Chapter 1
A Preliminary Study on Female Runners and Their Body Composition

Ekta Kapri, Ekta Melkani, Manju Mehta, and D. K. Sharma

1 Introduction

A good sport demands physically active, skilled, and technical person, who has comprehension regarding training, health fitness, and certification for nutrition basics (Saravanapriya 2019). Practice of any sport activity and physical exercise enhances the individual's physical fitness (Van Gent et al. 2007). Regular physical exercises, such as running, throwing, and jumping, increase rate of physical development and boost the athletic performance. Apparently, the performance of athletes needs specific biological profile with exceptional biomotor ability (Gabbett et al. 2008; Thorland et al. 1988; Bompa & Buzzichelli 2018). Among all of these physical activities running is the best way to get fit. It is one of the most popular sports activity practiced by amateur and professional. Any sport needs passionate player be it man or woman. Involvement of women in sports at some stage in the arena has been elevated around the twentieth century (Saravanapriya 2019 and Women's sports). A study on female athletes by Mayoclinic suggested that normal running can make muscles strong, stimulates growth hormone, enhances performance, and enhance life expectancy (Saravanapriya 2019). Elite and world-class female athletes involved in elite, middle, long distance and ultra marathons have positive effects of exercise on health. Having different physique compared to non-athletic individuals and with varied anthropometric and body compositions (Javed et al. 2013; Molla 2017). Body fitness and physique both have a significant relation to physical performance both mechanically and metabolically (Gabbett and Georgiell 2007; Boileau and Lohman 1997). In athletics, physical performance and strength are significantly related to athlete's anthropometry, and therefore a set of anthropometric dimensions were being suggested for examining the body composition of runners, such as body mass, body

E. Kapri (✉) · E. Melkani · M. Mehta
Department of Family Resource Management, COHS, CCSHAU, Hisar, India

D. K. Sharma
Departmwent of AP&FE, COA&E, CCSHAU, Hisar, India

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height, body mass index, body fat, length of the upper leg, length of limbs, circumference of thigh, and total skin fold thickness of the lower limb that could provide a general anthropometric assessment of the athletes (Slaughter et al. 1982; Bale et al. 1986; Carter and Yuhasz 1984; Legaz and Eston 2005; Tanaka and Matsuura 1982; Sharwood et al. 2002). In the high-level competitions, anthropometric profiles indicate whether or not the athlete would be suitable for the competition (Koley et al. 2010). It is observed in the studies that frequent running make changes to body composition (helps to increase lean muscle and decrease subcutaneous fat) (Saravanapriya 2019). Somatotype of a running athlete can determine one's running ability and indicates the running type. Somatotype fall into three categories: ectomorph (lean body mass), mesomorph (muscular body), and endomorph (soft muscle tissue) which are pure body types and the best combinations of two or more body types (Braverman 2018). Body composition affects the energy needed for physical strength in various sports (Koley et al. 2010). Long distance runner women having ecto-mesomorph and meso-endomorph body types exhibit better performance (Bale et al. 1985, 1986). High level of running tanning (competitive training) decrease the sum skinfolds and athletes' running performance related to physiological, anthropometrical, and training variables that are dependent upon the gender, length, and duration of performance (Anderson 1996; Morgan et al. 1989; Legaz and Eston 2005). Under the light of the above points, the present study aimed to examine the type of runners and the association among anthropometric parameters of female runner. More research is required on female runners' physical fitness such as somatotype, aerobic capacity, cardiovascular capacity, and muscular capacity.

2 Method

The study had been conducted on the female runners in the campus of CCSHAU, Hisar, Haryana. The objective of the study was to examine the type of runners and investigate the association among anthropometric parameters of the female runners. The study is based on primary data. Twenty female students were selected on the basis of their involvement in the running activities. All selected students were practicing either recreational running or competitive running, but few of them were regular. An interview schedule was prepared for collecting the primary data. On the basis of the interview schedule, out of these 20 runners, only 5 competitive runners were purposively selected. Those runners were practicing their running daily (morning and evening), having good physical health, and also involved in athletic competitions frequently. Anthropometric data of the five female runners were collected for further study. Body mass, body height, and thicknesses of skinfolds were measured and collected data were calculated by using an anthropometric method.

Body height was determined to the nearest 1 cm using an anthropometric rod. Body mass index (kg/m^2) was calculated from body mass and body height. Skinfold thicknesses were measured at the seven sites: chest, mid-axillary, triceps, subscapular, abdominal, suprailiac, and front thigh. Skinfold data was obtained using a skinfold

caliper (Harpenden) recorded to the nearest 0.2 mm. The measurements were made three times on the right side and the mean of the three measurements was used for the analyses.

Body mass index was calculated with

$$\text{Quetelet index} = \frac{\text{Mass (kg)}}{\text{Height}^2\text{(mt)}}$$

Lean body mass was calculated with:

$$\text{Fat weight} = \frac{\text{Body weight} \times \text{Fat\%}}{100} \quad \%\text{Fat} = \frac{4.95}{\text{D}} - 4.5 \times 100 \text{ (Siriequation)}$$

where

D = Body density. According to Jackson and Pollock formula of body density for female.

D = 1.097–(0.0004697 × Sum of SF) + 0.00000056 × Square of the sum of skin fold sites)–0.00012828 × Age (yr).

2.1 Statistical Analysis

Spearman's correlation coefficient (r_s) is a non-parametric test, which measures the strength and direction of the association between two ranked variables. Spearman's correlation determines the strength and direction of the monotonic relationship between your two variables. Spearman's rank correlation formulas were used to find how strong a relationship among the anthropometric variables. The formulas return a value between +1 and −1, where +1 indicates a perfect association of ranks, −1 indicates a perfect negative association of ranks, and a result of zero indicates the weaker association between the ranks. MS Excel 2007 was used for statistical analysis.

3 Results

1. Type of runners:

   Running is performed over longer distances, for endurance, and with primarily aerobic metabolism examples such as jogging, road racing, and marathon (Novacheck 1997). The study categorized runners as beginners, intermediate runners, and competitive runners. Beginners and intermediate runners were further categorized into the interval and slow-continuous runners; competitive runners categorized into a sprint (100, 200 & 400 mt), middle-distance (up to 3000 mt), and long-distance runners (at least 3 km.). The study revealed that

35% were beginners and they had started running from the last 2 to 6 months. Out of these beginners, 71.4% were interval runner and 28.6% were doing slow-continuous running. About 30% of students were intermediate runners and practicing running for the last year. Out of these intermediate runners, half were interval runners and another half were slow-continuous runners. Another 35% of students were competitive runners and practicing running from at least 2 years up to 6 years (some of these were runners from their school time). Twenty percent of them were sprint runners (100 and 200 mt.) and 15% were middle-distance runners (1500 mt), no one was found in the category of long-distance running.

2. Anthropometric profile competitive runners

   For the collection of anthropometric data, competitive runners were purposively selected. They were practicing their running regularly, participated in athletic competitions frequently, and also have good physical health. Anthropometric measurements are a series of systematized measures of the physical properties that quantitatively express the dimensions of the human body size and shape. It is an indirect method of assessing body composition and body composition is an important indicator for evaluating health (Roche et al. 1996; Mondal and Mridha 2015). Anthropometric measurements include body weight, height, skinfold measurement, circumferences, and various body diameters. The weight provides a simple measurement of body mass and skinfold measurement describes the regional fat deposition (adiposity). Therefore, weight combined with skinfold measurement and body diameters can determine the amount of fat-free mass and fat mass (Molla 2017).

3.1 General Profile

The study carried out in the university campus found that 55 percent of female runners were 21–25 years old followed by 16–20 years (35%) and 26–30 years (10%). Study further found that 60 percent female runners were having height in between 1.6 and 1.7 mt followed by 1.5 and 1.6 mt (35%) and 1.7 and 1.8 mt (5%). About the body weight 80% runners were having body weight in between 51 and 60 kgs and 20% were having 41 and 50 kgs.

3.2 Anthropometric Profile

Based on the first objective, out of 20 female runners, 5 competitive runners were purposively selected for the anthropometric study.

Table 1 shows anthropometric data of five female runners involved in competitive running. The mean, standard deviation for age, height, weight, BMI, and body composition are presented in Table 1. The age of the selected competitive runners in

Table 1 Competitive runner's anthropometric profile

Variables	Mean ± SD
Age (yr)	20 ± 1.58
Weight (kg)	49.6 ± 2.79
Height (mt.)	1.59 ± 0.05
BMI (kg/m^2)	19.55 ± 1.35
Triceps (mm)	11.02 ± 1.71
Subscapular (mm)	13.62 ± 5.11
Chest (mm)	19.62 ± 2.03
Mid-axillary (mm)	16.56 ± 3.38
Suprailiac (mm)	15.72 ± 4.82
Abdominal (mm)	16.26 ± 4.28
Thigh (mm)	20.18 ± 5.92
FAT%	15.12 ± 2.56
Fat wt (kg)	7.53 ± 1.55
LBW (kg)	42.06 ± 1.94

the study varies from 18 to 22 years (20 ± 1.58) with mean weight 49.6 ± 2.79 kg, considered as normal body weight (Nuttall 2015), and height was 1.59 ± 0.05 mt. As a report by World Health Organization 1995, BMI splits into four categories: underweight (BMI < 18.5), normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), and obesity (BMI ≥ 30), and BMI in the present study on female runners falls into normal weight category (19.55 ± 1.35 kg/m^2). Data of seven skinfolds were used to calculate the available fat weight, fat%, and lean body mass. American Council on Exercise categorizes fat percentage into: essential fat (10–14%), athletes (14–21%), fitness (21–25%), average (25–32%), and obese (above 32%) (Muth 2009); in present study, the mean fat percentage of female runners was found to be 15.12 ± 2.56% and lean body weight was 42.06 ± 1.94 kg, and therefore female runners fall into athletes category.

1. Spearman's Rank Correlation

Spearman's rank correlation is non-parametric version of Pearson's correlation coefficient, which helps to assess the relationship between two variables.

Table 2 shows rank correlations among the anthropometric variables. According to Spearman's rank correlation, it was found that age has a positive rank association with weight, height, BMI, and fat % ($r_s = 0.61$, $r_s = 0.91$, $r_s = 0.74$, and $r_s = 0$, respectively). The study shows a strong association between age and height of the female runners but there was no association between the age and fat percentage of the female runners. Chinedu et al. (2017) also found that there was strong correlation ($p < 0.001$) between age and the anthropometric parameters: weight ($r = 0.69$), height ($r = 0.31$), and BMI ($r = 0.61$). In the present study, the weight of the female runners has a strong association with BMI and fat weight ($r_s = 0.95$ and $r_s = 0.94$). BMI also

Table 2 Spearman's rank correlation among variables $n = 5$

Variables	Weight	Height	BMI	Fat %	Fat wt
Age	0.61	0.91	0.74	0	0.31
Weight	–	0.82	0.95	0.74	0.94
BMI	0.95	0.86	–	0.66	0.84

r_s = Spearman's rank correlation coefficient
BMI = Body mass index, wt = Weight

has a positive relationship with weight, height, fat%, and fat weight ($r_s = 0.95$, $r_s = 0.86$, $r_s = 0.66$, and $r_s = 0.84$, respectively). BMI and body weight have a strong association. The present study supported by Vuvor and Harrison (2017) found that body weight was correlated with body fat ($r = 0.67$).

4 Discussion

The study concludes that among all sports, running is the most popular recreational and competitive activity. The study includes beginners, intermediate, and competitive runners, and these runners practice running for different purposes, like for recreation, to improve their health, to improve their physical stamina, and to improve their performance timing. Beginners and intermediate runners were mainly interval runners and slow-continuous runners, whereas competitive runners range from sprint (100, 200, and 400 mt), middle-distance (up to 3000 mt), and long-distance runners (at least 3 km). Competitive runners were selected for anthropometric study because of their constant and regular involvement in running. The anthropometric profile of competitive runners was further selected to determine their body composition. All of these runners had been practicing for more than 2 years and took part in inter- and intra-university athletic meets. The study revealed that age, weight, and BMI were positively associated. Skinfold measurement to determine the presence of fat in different body parts helps to assess fat weight and fat% in the body. A runner having a low-fat percentage falls into the athletic category which indicates good health and leads to good race performance (Bale et al. 1986). An investigation by Ismail and Zawiak (1996) found that athletes with low body fat% can uptake maximum oxygen (VO_{2max}). The study further revealed that body weight and BMI have a perfect association among body weight, fat weight, and fat percentage. Ilman et al. (2015) concluded that the relation between BMI and body fat percentage was influenced by gender and age.

5 Conclusion

Present study concludes that the anthropometric variable helps to assess the body composition of the female runners. Anthropometric property has a marked effect on athlete's health and performance. This information will be helpful for the future study on long-distance runners and individual practicing other sports.

References

Anderson T (1996) Biomechanics and running economy. Sports medicine 22(2):76–89
Bale P, Rowell S, Colley E (1985) Anthropometric and training characteristics of female marathon runners as determinants of distance running performance. J Sports Sci 3(2):115–126
Bale P, Bradbury D, Colley E (1986) Anthropometric and training variables related to 10 km running performance. Br J Sports Med 20(4):170–173
Boileau RA, Lohman TG (1977) The measurement of human physique and its effect on physical performance. Orthop Clinics North Am 8(3):563
Bompa TO, Buzzichelli C (2018) Periodization: theory and methodology of training. Human kinetics
Braverman J (2018) Running & body type. Retrieved from https://www.sportsrec.com/7632782/running-body-types. Accessed on 17 June 2020
Carter JL, Yuhasz MS (1984) 8 skinfolds and body composition of Olympic athletes. In: Physical structure of Olympic athletes, vol 18. Karger Publishers, pp 144–182
Chinedu SN, Emiloju OC, Azuh DE, Ogunlana OO, Iheagwam FN (2017) Association between age, gender and body weight in educational institutions in Ota, Southwest Nigeria. Asian J Epidemiol 10(3):144–149
Gabbett T, Georgieff B (2007) Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players. J Strength Conditioning Res 21(3):902–908
Gabbett TJ, Johns J, Riemann M (2008) Performance changes following training in junior rugby league players. J Strength Conditioning Res 22(3):910–917
Ilman M, Zuhairini Y, Siddiq A (2015) Correlation between body mass index and body fat percentage. Althea Med J 2(4):575–578
Ismail MN, Zawiah H (1996) Anthropometric measurements and body composition of selected national athletes. Malaysian J Nutr 2(2):138–147
Jackson AS, Pollock ML (1978) Generalized equations for predicting body density of men. Br J Nutr 40(3):497–504
Javed A, Tebben PJ, Fischer PR, Lteif AN (2013) Female athlete triad and its components: toward improved screening and management. In: Mayo clinic proceedings, vol 88, No. 9. Elsevier, pp 996–1009
Knechtle B, Knechtle P, Schulze I, Kohler G (2008) Upper arm circumference is associated with race performance in ultra-endurance runners. Br J Sports Med 42(4):295–299
Koley S, Singh J, Sandhu JS (2010) Anthropometric and physiological characteristics on Indian inter-university volleyball players. J Human Sport Exercise 5(3):389–399
Laurenson NM, Fulcher KY, Korkia P (1993) Physiological characteristics of elite and club level female triathletes during running. Int J Sports Med 14(08):455–459
Legaz A, Eston R (2005) Changes in performance, skinfold thicknesses, and fat patterning after three years of intense athletic conditioning in high level runners. Br J Sports Med 39(11):851–856
Legaz AA, Gonzlez BJ, Serrano OE (2005) Differences in skin-fold thicknesses and fat distribution among top-class runners. J Sports Med Phys Fitness 45(4):512–517
Molla HG (2017) Review of anthropometric characteristics of runners. J Tourism Hosp Sports 25:25–31

Mondal PB, Mridha S (2015) A study on selected anthropometric characteristics of heightweight matched female athletes and non-athletes. J Sports Phys Educ 2(5):41–45
Morgan DW, Martin PE, Krahenbuhl GS (1989) Factors affecting running economy. Sports Med 7(5):310–330
Muth ND (2009) What are the guidelines for percentage of body fat loss. American Council on Exercise (ACE). Ask the Expert Blog. Retrieved from https://www.acefitness.org/education-and-resources/lifestyle/blog/112/what-are-the-guidelines-for-percentage-of-body-fat-loss/. Accessed on 23 June 2020
Novacheck TF (1997) The biomechanics of running and sprinting. Running Injuries. Philadelphia, PA: WB Saunders, 2:4–19
Nuttall FQ (2015) Body mass index: obesity, BMI, and health: a critical review. Nutr Today 50(3):117
Roche A (1996) Anthropometry and ultrasound. In: Roche A, Heymsfield S, Lohman T (eds) Human body composition. Human Kinetics Press, Champaign, IL, pp 167–189
Rompottie K (1972) A study of stride length in running. Int Track Field 249–256
Samaranayake S (2020) Effects of running on the female body. Retrieved from https://www.runningshoesguru.com/content/effects-of-running-on-the-female-body-by-a-medical-doctor/
Saravanapriya S (2019) Women sports and medicines: case study of Indian women cricket and scientific conception
Sharwood K, Collins M, Goedecke J, Wilson G, Noakes T (2002) Weight changes, sodium levels, and performance in the South African Ironman Triathlon. Clin J Sport Med 12(6):391–399
Siri WE (1961) Body composition from fluid spaces and density: analysis of methods. Tech Measuring Body Compos 61:223–244
Slaughter MH, Lohman TG, Boileau RA (1982) Relationship of anthropometric dimensions to physical performance in children
Tanaka K, Matsuura Y (1982) A multivariate analysis of the role of certain anthropometric and physiological attributes in distance running. Ann Hum Biol 9(5):473–482
Thorland WG, Johnson GO, Tharp GD, Housh TJ (1988) Comparative characteristics of elite junior and senior athletes. Competitive Youth Sports for Children and Youth 129–142
Van Gent RN, Siem D, van Middelkoop M, Van OS AG, Bierma-Zeinstra SMA, Koes BW (2007) Incidence and determinants of lower extremity running injuries in long distance runners: a systematic review. Br J Sports Med 41(8):469–480
Vuvor F, Harrison O (2017) Correlation between body weight and total body fat composition in adults in a community in Ghana. Mat J Nutr Diet 2(1):1–5
Women's sports. Retrieved from https://en.wikipedia.org/wiki/Women%27s_sports#Further_reading. Accessed on 17 June 2020