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Review of Anthropometric Characteristics of Runners

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1. Introduction

Anthropometric measurements are a series of systematized measures that quantitatively express the dimensions of the human body and skeleton. Anthropometric measurements include body weight, height, skinfolds measurement, circumferences, and various body diameters. The use of these measurements vary, but either individually or combined they allow for reasonable predictions of body composition in non-obese subjects. For example, weight provides a simple measurement of body mass and thus total energy content. Skinfolds measurements reflect the relative amount of fat for a given body site and may be used to describe regional adiposity. Finally, weight combined with skinfolds measurement and body diameters can accurately estimate the amount of fat-free mass and fat mass. Anthropometry is the most common used method of physique and body composition assessment in athletic population.

2. Anthropometry Profile and Runners Performance

Several anthropometric and body composition values are known to be associated with running performance in elite Caucasian middle and long-distance (Arrese & Ostariz, 2006) and ultramarathon (Knechtle, Schulze, & Kohler, 2008) runners. For example, body height and mass (Maldonado, et al., 2002), fat and fat-free mass (Winter & Hamley, 1976), arm circumference (Knechtle, et al., 2008), different lower limb skinfolds and circumferences (Arrese & Ostariz, 2006; Legaz & Eston, 2005; Tanaka & Matsuura, 1982) and also sum of three (Kong & de Heer, 2008) and six (Legaz & Eston, 2005) skinfolds have been related to running performance. Runners with a proportionally smaller amount of body mass concentrated in the extremities, particularly in the legs, would perform less work moving their body segments during running if all other factors are unchanged (Myers & Steudel, 1985). Therefore, leg mass and the distribution of leg mass might be important characteristics of distance runners' performance (Myers & Steudel, 1985).

Despite a number of studies describing different anthropometric parameters related to running performance over different distances (Knechtle, et al., 2006; Kong & de Heer, 2008; Arrese & Ostariz, 2006; Legaz & Eston, 2005; Maldonado, et al., 2002; Tanaka & Matsuura, 1982), there is paucity of studies investigating the associations between specific anthropometric ratios of lower limb and running performances in different running events. However, there is a study (Lucia, et al., 2006) that has described leg length ratio to body height in top level Spanish distance runners in comparison with one of the best Eritrean runners.

Numerous evident have shown body size and strength contributes to motor performance. The increase in strength is related to increase in total muscle mass (Ostojic, Mazic, & Dikic, 2006). Significant positive correlation between strength and performance indicate that stronger individuals were the individuals who performed better (Ball, Massey, Misner, Mckeown, & Lohman, 1992). However, the pattern of improvement of strength and physical performance is not uniform in all tasks. Strength may be important to the successful performance of some motor performances but not as important to others. It is likely that performance related to power events would show a similar trend to that of strength. Physique and body structure has generally been found to have a significant relation to physical performance (Gabbett & Georgieff, 2007). However, physique does not markedly influenced performance except at the extreme of the continuum. High degree of endomorph definitely limited physical performance capacity, while a high degree of mesomorphy are more adapted to motor performance. Nevertheless, correlations between physique, strength and performance are at best moderate and not sufficiently high for predictive purposes (Malina, 1975).

Correlations between skinfold thicknesses and performance are consistently negative suggesting the negative effect of fatness on motor performance (Vucetic, Matkovic, & Sentija, 2008). Body fatness influenced physical performance both mechanically and metabolically (Boileau & Lohman, 1997). Mechanically, excess fatness is detrimental to performance involving acceleration of body weight because it adds non-force producing mass to the body. Metabolically, excess fatness increases the metabolic cost of performing work in activities requiring movement of the total body mass. Thus, one would expect that in most type of performance involving translocation of the body mass a low relative fatness to be advantageous in both mechanical and metabolic sense. It should be noted that correlation type analyses relating a specific body dimension to and motor performance may has its limitation.

Anthropometric factors influencing strength and performance are themselves related, thus, a set of selected anthropometric dimensions would account for a significant variation in physical performance (Slaughter, Lohman, & Boileau, 1982). Using the step-down regression procedure, height, upper arm circumference, abdominal and calf skinfolds were identified as significant predictors of physical performance. Analysis of canonical correlation on two sets of variables, anthropometric and physical performance also indicated that children with greater weight, thigh volume, and height will perform well on performance measures requiring high intensity work production (Docherty & Gaul, 1991).

Regular physical training is known to speed up the rate of development of physical performance (Gabbett, Johns, & Riemann, 2008). Increased in physical performance, in turn, can be consistent with success in many sport activities. For example, competitive-level performance may require that high forces be generated rapidly in order to achieve sufficiently high velocity in movements such as throwing, jumping, kicking, or sprinting (Thorland, Johnson, Tharp, & Housh, 1988). Evidently, high performance athletes require specific biological profiles with outstanding biomotor ability and strong psychological traits. Biometric quality or anthropometric measurements of an individual are important asset for several sports, and therefore, considered among the main criteria for success in many sports (Bompa, 1999). However, which physique characteristics are important for success in different types of physical performance? Theoretically, it would be expected that those who are successful to have the appropriate structures commensurate with their physical performance task. Research showed overwhelming evidence showing differences in body size between athletes in different sports, whether measured by weight, height, lengths, breadths, girths, or skinfolds; between sports or within sports (Bayios, Bergeles, Apostolidis, Noutsos, & Koskolou, 2006; Gabbett & Georgieff, 2007; Ziv & Lidor, 2009).

Kalra (1986) studied 30 middle distance and thirty long distance runners from different colleges of Delhi University. The anthropometrical measurements, physical and physiological variables of all subjects were tested and the results showed that the performance in long distance running was found to be significantly correlated with cardio respiratory endurance, weight, leg length, resting pulse rate, and body composition. Performance was not significantly correlated with muscular strength, endurance, calf girth, thigh girth and blood pressure. The performance of middle distance runners was found to be significantly correlated with muscular strength, endurance, but not related with height, weight, leg length, thigh length, fore leg length, calf girth, thigh girth, blood pressure and body composition.

Ansari and Singh (2007) conducted a study on physical and physiological differences between elite middle and long distance runners of India. For the purpose of this study three sample groups of different categories of runners from various National level competitions (1st group comprises of 14 elite 800 m runners, 2nd group comprises of 17 elite 1500 – 5000 m runners and 3rd group comprises of 19 elite 5000 – 10000 m runners) were selected. Analysis of variance was applied to assess the significant difference in the physical and physiological variables of the three groups. Statistical analysis of this study indicated that the 800 m runners' were greater in mean weight, stature, sitting stature, shoulder breadth, hip breadth, upper arm length, fore arm length, thigh length, lower leg length, biceps muscle girth, calf muscle girth, sum of five skin fold, endomorphic rating, mesomorphic rating ,thigh length – lower leg length index, hip breadth – stature index, heart rate and vital capacity than 1500 – 5000 m and 5000-10000m runners. Whereas 5000-10000 m runners were greater in mean ponderal index than the 800m and 1500-5000m runners. However no significant differences were found in humerus bi-epicondyler diameter, femur biepicondyle diameter, ectomorphic rating, sitting height – stature index, upper arm length – lower arm length index and shoulder breadth – stature index of 800 m 1500-5000m and 5000 – 10000 m runners of India.

2.1 Height and Weight Measures of Runners

Height and Weight can significantly influence success in sports depending on how the design of the sport is linked to factors that are height and weight biased due to physics and biology. The balance of the intricate array of links will determine the degree to which height and weight plays a role in success. Kohlrausch (1929) studied the athletes who participated in the 1928 Olympic Games at Amsterdam and he discovered that the best sprinters in the world were 64.5kg in weight and 1.72m in height, with a weight/height index of 2.17 as average measurements. The 400 meters runners were slightly taller (1.76m), slightly heavier (65.2 kg), and more linear (2.10). The middle distance runners' averaged 66.5kg in weight, 1.50m in height, 2.19 for body built. The long distance runners' averaged 60.2kg in weight, 1.70m tall, 2.10 for body built. Jumpers were found to be tall with long legs and quicker. Vaulters, hurdlers and middle distance runners were quite similar in built.

Sidhu et al. (1990) observed 105 university athletes and noted that the sprinters were average in age 20.68 years old, in height they were 170.65 cm tall and in weight they were 57.44 kg heavy. Middle distance runners were 19.78 years old, 169.51 cm long and 57.34 kg heavy, whereas long distance runners were 20.99 yr, 169.63 cm long and 56.26 kg in respect of age, height and weight.

Among athletes from Rome, Tokyo, Munich and Montreal Olympic, the short and middle distance runners and jumpers were, as a whole, younger, but the long distance runners and throwers were older. These data indicated that the participants in events which need great muscular strength reached the climax in the early period, whereas the participants in events, which needed much endurance or technique, had delayed climax, which continued longer. As the distance progressively increased from 100 m to 200m, 400m and 800m, the runners gradually become a little taller and leaner. But in Munich and Montral Olympics, the 400m men were taller than the other three groups. The tendency of increasing leanness was observed from sprinters to the long distance athletes, in all the Olympics referred. Regarding 1500m, 5000m and 10000m runners, they gradually become somewhat less tall as well as lean. The walkers were as large as the sprinters but leaner. On the other hand, the hurdlers and steeple chasers were found to be large and lean than the sprinters (Hirata, 1966).

Speaking of physique of athletes, Tanner (1964) in his study also concluded that the sprinters were short and muscular men as compared to middle distance runners. Their shortness was mainly due to short trunks not due to short legs. The 110m hurdlers were large, long legged sprinters. They were as muscular as the 100m sprinters but they had long legs than sprinters. The leg length proportionally was same as those of 400m runners. The 400m runners were large legged, broad shouldered in relation to their hips, and fairly heavy muscled whereas long distance runners were small, short legged, narrow shouldered and inferior in musculature. The 5km walkers were found to be similar to 1500 runners.

Eiben (1981) examined 125 women athletes who were participating in European Athletic Championship. It was noticed that the women sprinter athletes had small dimensions in each anthropometrical character as compared to other women athletes. Their legs were longer as compared to their trunk. Their heights were found shorter due to small trunk. The results indicated that sprinters had less muscular upper extremities but the lower extremities mainly the lower legs were found to be much muscular and stronger. Hurdler runners had same stature as sprinters. They also had longer legs with shorter thighs but their trunks were a little longer than the sprinters, whereas middle distance runners had longer and narrower trunks.

In the study carried out by Costill et al. (1970) on 114 marathon runners during 1968 United State Olympic Marathon runners; it was found that the average age of the marathon runners was 26.1 year, average height was 175.7 cm, body weight was 64.2kg and body fat percentage was 7.5%.

Malhotra et.al. (1972) studied the functional capacity and body composition of the throwers, jumpers, sprinters, and middle and long distance runners. The track men and jumpers were found to have a higher lean body mass with less fat content than the throwers who were tall and heavily built. The middle and long distance runners had highest and the throwers, the lowest maximum oxygen intake capacity values in terms of body weight and lean body mass. Similarly, the trackmen had lower maximum heart rate than the other groups of athletes. The jumpers and throwers had stronger muscle power, however, the latter were strong in arm and shoulder muscle strength too.

2.2 Skinfold, Girth and Breadth Measures of Runners

Skinfold, girth and breadth measurements are becoming more and more popular amongst personal trainers due to the fact that they do not require expensive equipment or years of training to perfect and produce reliable measurements. Skinfold analysis is a common field assessment used by Sport Science professionals to predict body fatness. The technique is based on the fact that 50-70% of stored fat lies between the skin and muscle, referred to as subcutaneous fat. According to the American College of Sports Medicine, skinfold measurements of body fat are up to 98% accurate, especially, when performed by a trained and skilled person (Lupash, 2009).

Skinfold sum provides an index to determine adiposity. For example, subcutaneous fat reflects the amount of fat present in the adipose tissue. In fact, 40- 60% of body fat is in the subcutaneous region (Wang et al., 2000). On the other hand, particular skinfold determinations provide information concerning local fat depots and fat distribution in the body. Skinfold values can be easily and directly obtained using calipers. The information provided can be quickly interpreted, allowing the comparison between different groups

Significant differences were observed in skinfold thickness in arithmetic means of different sport-groups. On the study of 28 track runners and marathon runners, Novak et al. (1968) observed that 400 m runners and 800 m runners had significantly higher skin folds at triceps and subscapular sites than the marathon runners. When the sum of triceps, subscapular, iliacrest, umbilical, thigh and calf were calculated from the mean, the values declined from 1500-3000 m runners (33.7mm) to 400m to 800m runners (33.5 mm) to 5000-10000m runners (28.7mm) and to marathoners (22.6mm).

De Garay et al. (1974) investigated athletes who participated in Mexico Olympic Game. They found that the sum of three skin folds values of all track group was low, but the sprinters were with greater skinfolds than other track athletes. Some of the leanest athletes among them were track athletes, but most were in the long distance runners. The lowest skinfold recording was 11.2 mm for a distance runners but one sprinter was the lowest with 11.7 mm. When comparing athletes between different athletics events, they also found that the jumpers, pole vaulters, javelin throwers and decathelete men had low average skinfolds similar as track athletes, whereas throwers had a higher mean and wider range. The throwers had significantly broader shoulders and longer trunks than other field athletes. They also mentioned that the hips of the jumpers were narrower than throwers.

Singh and Koley (2002) tested skinfold thickness of seventy one sprinters, sixty five long distance runners, twenty six high hurdlers and twenty four low hurdlers of interuniversity, national and international level Indian athletes. The result showed highly significant differences in subscapular skinfold between sprinters and long distance runners and between long distance runners and high hurdlers. There were statistically significant differences in suprailliac skinfold between sprinters and long distance runners. No significant differences were found in between any other groups.

Singh and Ansari (2006) conducted a study on elite middle and long distance runners of India. They noted that no significant differences were found in elbow/biepicondyler humerus breadth, biepicondyle femur breadth between the groups. Kansal (1981) in an attempt to develop scientific criteria for the selection of budding athletes based on their morphological status , studied 246 male students in the age group of 11 to 17 years . Their bisacromial, humerus, bi-condyler breadth and performance in 100 meters running, shot put and standing broad jump were examined. He concluded that the above said body measurement showed significant degree of relationship with individual performance tests. Further with the help of these differential role, preparation of selection criteria for choosing budding athletes at a young age was also attempted. Carter et al. (1982) in their study on Montreal Olympics athletes concluded after examination that the jumpers were heavier and had larger thigh and calf girth than the sprinters and distance runners; they also had larger lower extremity length than the sprinters and larger sum of six skinfold than the distance runners. The distance runners had smaller upper arm and forearm girth than sprinter or jumper, but larger biilliac breadths than sprinters. There were no significant differences in biacromial breadths.

2.3 Anthropometric profiling for performance

The profiling system recommended by the International Society for the Advancement of Kinanthropometry (ISAK; Marfell-Jones, Olds, Stewart & Carter, 2006) is now widely used around the world, and is backed up by an accreditation system demanding rigorous demonstration of accuracy and precision in measurement. “Gold standard” methods of assessing fat and fat-free mass (hydrodensitometry, Dual-Energy X-ray Absorptiometry) are expensive, invasive and complex, and offer little information that simple skinfolding cannot provide. Bioelectrical impedance analysis is too sensitive to hydration status and to other factors to be used for routine profiling.

“Virtual anthropometry” using three-dimensional whole-body scanners (Olds et al., 2007) offers a non-invasive anthropometric assessment which allows new possibilities for quantifying important morphological characteristics such as body surface area, projected frontal area, and limb volumes. Whole-body scanning offers promise in assessing differences in the distribution of mass over the body. The world’s first sports anthropometric survey using 3D scanning took place in March 2007 at the Australian National Rowing Championships.

3. Conclusions

The extent and nature of anthropometric profiling depends on the primary purpose of the measurement. Talent identification, or directing athletes to morphologically appropriate events, depends largely on identifying relatively unalterable characteristics, at least in maturity; and comparing them to reference data. Reference data should be as recent as possible. Accuracy and validity are therefore critical. Profiling should include Skinfolds, girths, bone lengths and breadths.

For monitoring morphological adaptation, the focus should be on plastic characteristics, such as muscle mass and fat mass. The emphasis is on serial measurements, and hence reliability is critical. Skinfolds provide a good index of fatness, and skinfold-corrected girths a simple estimate of muscle mass. Routine profiling should be frequent (months or weeks), and should include skinfolds and girths. Little is gained by attempting to convert skinfolds to percentage body fat using one or more of the several hundred regression equations available.

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