Physical Analysis of Capacity of Sprint and Middle Distance Runners

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Physical Analysis of Capacity of Sprint and Middle Distance Runners

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This study aims to analyse the physiological variations that underlie the performance of elite sprinters and middle distance runners. This type of analytic observational study with cross sectional study design was adopted to analyse physiological components in elite short runners (n = 33) and medium distance runners (n = 10). Both groups measured height, weight, resting pulse, lung capacity, VO2max, peak pulse rate, recovery speed, leg strength, and leg power. There was a significant difference in the BMI variable (p = 0.004), where sprint runners showed higher results. Significant differences were also found in variables and VO2max (p = 0.004), where intermediate distance runners showed higher results. Variable lung capacity, recovery speed, and leg power in middle distance runners are higher; there must be no significant difference. Variable resting pulse, peak pulse and leg strength in sprint runners are higher; there should be no significant difference. The two groups differ in their respective physiological capacities because the characteristics of the two running numbers are different as a result of the training they are going through.

Key words: Physical Analysis, Sprint Capacity, Middle Distance

Preliminary

Running is one of the most popular sports in the world. This can be seen from the very rapid development of enthusiasts who run from professional to recreational events. The large number of variations in running contributes to its popularity – individuals can participate in a variety of numbers including road, sprint, medium distance, long distance to marathon running. The difference in the number of races in running will form different physical abilities and training programs, including sprinters and mid-range runners.

The International Association of Athletics Federation (IAAF) athletic sporting parents set the sprint number category to a distance of 400m, with the distance categories at the Olympics being 100, 200, and 400m. The duration of the sprint run is less than one minute, with a 100m running number lasting approximately 10 seconds. Medium distance running numbers consist of 800 and 1500m. The duration of mid-range runs ranges from <2 min to ~8 min. Running is interesting to learn, because running is also a core capacity that underlies performance in many sports.

The physiological abilities of athletes differ from various types of sports and the number of races. In sprint runners and mid-range runners in physiological factors some differences can be observed (Thomson MA, 2017). In sprint runners, large amounts of fast twitching muscle fibres are needed to accelerate in the transition period, whereas for long distance runners, large amounts of slow twitching muscle fibres are needed to maintain their speed during a relatively long race (Costill et al. 1976). Through long-term training, physiological adaptations will be formed in athletes. Even more than that, Nakamoto and Mori (2012) revealed athletes learn to acquire not only specific physical functions related to performance characteristics.

For all running disciplines, performance depends on the time needed to cover the transition distance, which can also be expressed as the average speed for the duration of the run. Running speed is determined by the ratio of metabolic power and energy to run. Where this metabolic power ratio differs substantially from sprint to ultra-marathon events, variations in aerobic and anaerobic energy production during running have been observed (Di Prampero et al. 1986). This variation is greater directly proportional to the distance of running increasingly further. It has been reported that aerobic capacity is higher in long distance runners than sprint runners (Kusy and Zieliñski, 2015).

It is known that the physiological abilities of athletes differ according to individual characteristics and are highly dependent on their genetic traits (Francis, 1992; Maruo et al., 2018). However, some studies reveal genetic predisposition not only to include anthropometric characteristics and proportion of muscle fibre types, but also the capacity to adapt to training (Smith, 2003; Del Coso et al., 2019). In general, good performance is formed from polygenetics, with the contribution of various genetic variants to additives (Haugen, 2019). This is what motivates researchers to analyse the physiological variations that underlie the performance of elite sprint and intermediate distance athletes, determining several measurements such as lung capacity, VO2Max, recovery speed, leg strength, leg power. It should be noted that this research ignores genetic factors.

Method

Analytic observational research with cross sectional study design was adopted to analyse the physiological components of elite short and medium distance runners. Population was running athletes who have participated in national level tournaments and who undergo training camps.

Subjects were selected based on the criteria: (1) have won at least provincial level tournaments; (2) still actively practising at least 3 times a week or are undergoing training camps; (3) willing to permit measurements. There were 33 short distance runners and 10 medium distance runners, consisting of men and women in each group. Subjects were measured for body weight, height, and body mass index (BMI) was calculated. The resting pulse is measured before the subject takes any test. Lung capacity is seen by measuring forced vital capacity (FVC) with a sprirometer. FVC is the volume of air that can be forced off after maximum inspiration, measured in litres. VO2Max measurements are performed with the Quark CPET test, when this test is taking the maximum pulse data. Recovery speed is measured by the pulse difference immediately after the VO2Max test with 5 minutes rest. Leg strength is measured with a leg dynamometer, and leg power with a force plate. Analysis of the mean and standard deviation (SD) data of all outcome variables was calculated and the difference test for each variable was calculated using the Mann Whitney test with SPSS (IBM: SPSS version 20.0). VO2Max measurements are performed with the Quark CPET test, when this test is taking the maximum pulse data. Recovery speed is measured by the pulse difference immediately after the VO2Max test with 5 minutes rest. Leg strength is measured with a leg dynamometer, and leg power with a force plate. Analysis of the mean and standard deviation (SD) data of all outcome variables was calculated and the difference test for each variable was calculated using the Mann Whitney test with SPSS (IBM: SPSS version 20.0). VO2Max measurements are performed with the Quark CPET test, when this test is taking the maximum pulse data. Recovery speed is measured by the pulse difference immediately after the VO2Max test with 5 minutes rest. Leg strength is measured with a leg dynamometer, and leg power with a force plate. Analysis of the mean and standard deviation (SD) data of all outcome variables was calculated and the difference test for each variable was calculated using the Mann Whitney test with SPSS (IBM: SPSS version 20.0).

Results

Table 1: Characteristics of Subjects

Variable	Short distance runners (n = 33)	Medium distance runners (n = 10)
Age	24.52 ± 5.60	23.5 ± 4.14
Height (cm)	163.48 ± 7.77	160.80 ± 8.32
Weight (kg)	58.27 ± 7.85	51.70 ± 8.48

Table 2: Descriptive Statistics and Test Variables

Variable	Runner group	*Mean ± SD*	*Z*	*P.*
BMI (kg / m2)	*Sprint*	21.71 ± 1.55	-2.846	0.004 *
	Intermediate	19.87 ± 1.83		
Resting pulse rate (dpm)	*Sprint*	72.61 ± 10.89	-0.187	0.852
	Intermediate	73.20 ± 12.02		
FVC (litre)	*Sprint*	2.97 ± 0.70	-1.093	0.275
	Intermediate	3.21 ± 0.63		
% FVC reference	*Sprint*	86.41 ± 21.44	-0.403	0.687
	Intermediate	87.75 ± 21.33		
VO2max (cc / kg / bb)	*Sprint*	43.52 ± 8.55	-2.875	0.004 *
	Intermediate	52.41 ± 4.94		
Peak pulse rate (dpm)	*Sprint*	183.33 ± 13.31	-1.684	0.463
	Intermediate	172,40 ± 21.98		
Recovery Speed (dpm)	*Sprint*	84.79 ± 15.10	-0.734	0.092
	Intermediate	100.40 ± 51.55		
Foot Strength (kg)	*Sprint*	107.90 ± 45.52	-0.403	0.687
	Intermediate	103.90 ± 38.88		
Foot power (watts)	*Sprint*	84.61 ± 18.25	-0.245	0.807
	Intermediate	86.60 ± 21.61		

Discussion

Some physiological factors look different according to the characteristics of the number and the exercise program. The measurement results of the two groups on all variables look not much different; this is possible because the research subjects are elite athletes who have practised for years and may have reached the peak for the development of their physiological abilities.

IMT measurements showed significantly different, higher results on sprint runners compared with medium distance runners. This is possible because the mean weight and height of the sprint runner subjects were higher, besides that in the middle distance runner group there were 2 subjects whose IMT status was underweight. In mid-range running, athletes must maintain high running speeds (Spencer and Gastin, 2001) at longer distances than sprinters. This is related to the metabolic energy processes that play a role.

In the resting pulse rate the two groups showed a mean that was not significantly different. This is possible because elite athletes undergo regular training with heavy intensity so that both groups have a resting pulse that is not different. The intensity and frequency of sports performed by athletes determine the level of strengthening of the inspiratory muscles by increasing the volume and capacity of the lungs. Exercise increases the endurance and strength of athletes' breathing muscles, reduces resistance in the respiratory tract, and increases lung elasticity and alveolar expansion by promoting expansion of lung volume and capacity (Khosravi et al. 2013). A slow heart rate is more efficient, and the need for oxygen makes the heart beat faster than the same cardiac output (Foss et al. 1998).

Vital capacity is a reflex of the ability of lung tissue elasticity, or stiffness of the movement of the thoracic wall. The main factors that affect vital capacity are the anatomical shape of the body, position during measurement of vital capacity, respiratory muscle strength and lung and chest skeletal development (Guyton and Hall, 2014). Lung capacity was measured by forced vital capacity (FVC) and % FVC reference, the two groups showed results that were not significantly different. But higher results are shown in medium distance runners. In mid-range running, athletes must maintain high running speeds at and above the maximum aerobic speed (Spencer and Gastin, 2001). So that it takes a greater maximum aerobic speed capability, this is shown in the measurement of FVC and VO2max middle distance runners as greater than sprint athletes. Aerobic capacity is an important aspect of medium distance runner performance, especially with increasing distance (Mytton et al., 2015; Thomson MA, 2017). In addition to being superior in aerobic capacity, mid-range runners also need sprint performance in the final round of the 1,500m race which often determines medallists on the international stage (Mytton et al., 2015). Whereas sprint runners rely heavily on anaerobic metabolism to support high strength output. The shortest sprint event (duration <15 seconds) mainly depends on the ATP-PCr system to supply the ATP needed for muscle contraction, whereas anaerobic glycolysis gives a greater percentage of ATP needed as the distance increases (In Prampero et al. 2015). Thus, medium range runners show better lung capacity.
Respiratory function depends on various factors, including the nervous system, respiratory muscle strength, and lung dimensions (Azad et al. 2011). As noted previously that lung capacity was found to be higher in intermediate distance runners, the same thing was shown in VO2Max measurements where there were significantly different results between the two groups. VO2Max is the highest value at which a person can consume oxygen during exercise. VO2max is a well-known physiological parameter used in cardiovascular health and cardiorespiratory endurance measurement (Pakkala et al. 2011; Doijad et al. 2013). This is possible because middle-distance athletes have adapted from the training process with a distance that is longer than the sprint. The anaerobic and aerobic energy production variations are higher, so that respiratory muscle strength, lung capacity, and cardiorespiratory endurance are better. The 800 metre run is a very demanding event that requires a large contribution from the aerobic and anaerobic systems, due to its relatively high value on oxygen absorption (VO2) (Spencer and Gastin, 2001). In middle distance running, the main speed can be seen through the fact that speed at anaerobic threshold, ventilation threshold, and VO2max have been

identified as predictors of medium distance running performance in beginner and elite athletes (Zacharogiannis and Farrally 1993; Abe et al. 1998). The same thing was expressed by Alexander (2016); the most significant factor that determines the high efficiency of speed and ability of female runners is the lack of injury, positive dynamics of physical conditions in the competition period and the highest level of fitness for the start of the season. Unlike sprint running with predominant anaerobic energy, it is not superior in the ability to consume oxygen. This is possible due to the results of the peak pulse in sprint runners that are higher than middle distance runners. With better aerobic capacity, the work of the cardiovascular system of medium range runners is more efficient so that the pulse rate does not reach its peak in a short time. Intermediate distance athletes show excellent physiological abilities, including a combination of V̇O2peak and high anaerobic capacity, coupled with lower oxygen consumption at submaximal speeds (e.g. when running economically) (Spencer and Gastin, 2001).

The speed of recovery in mid-range athletes is better, although not significantly different from sprint athletes. Sprint-related fatigue is caused by disorders of the central nervous system and peripheral factors in skeletal muscle (Girard, 2011). It is estimated that from the accumulation of oxygen deficit measures, the relative contribution of the anaerobic energy system (from stored adenosine triphosphate, stored phosphocreatin, and anaerobic glycolysis) is around 80% for a 100m sprint (Duffield, 2004). This is possible because of the increased production of lactic acid and intracellular acidosis that can cause cell damage, so that sprinters need more time to recover.

Leg strength is a variable that determines the athlete's performance. The importance of leg strength is illustrated by the finding that age is associated with muscle atrophy, and loss of muscle strength is associated with longer contract times, decreased ground reaction force (GRF), and decreased running speed (Korhonen et al. 2009). Leg strength in the two groups showed a mean that was not significantly different. But the sprint runner group showed higher results. The ability to produce strength during sprint sprints tends to depend on leg strength, power, and stiffness, because these factors are shown to correlate with sprint ability (Chelly and Denis 2001; Bret et al. 2002). The maximum speed observed in sprint runs is achieved by the mechanical ability to apply high vertical GRF in a short contact time (Thomson MA, 2017). To create high strength output, sprint runners rely heavily on anaerobic metabolism, as well as the large cross-sectional area of type II fibres in the leg extensor muscles (Mero et al., 1981; Thomson MA, 2017). Skeletal muscle characteristics underlie force demands with critical determinants of sprint performance consisting of muscle mass, fibre type composition, and fascicle length (Kumagai et al. 2000). Muscle strength factors that are influenced by the interaction of neuromuscular and anaerobic characteristics may be a better determinant of the performance of endurance athletes at the elite level (Noakes, 1988).

Medium distance running requires relatively greater muscle strength than an athlete's capacity to provide pure aerobic metabolism. Thus, there are strong anaerobic components especially in the 800 and 1500 m events (Lacour et al. 1990b; Brandon 1995). It is well known that sprinting mainly relies on anaerobic metabolism, with medium distance running there is an increasing demand for aerobic metabolism. The maximum speed that can be maintained under aerobic conditions has been identified to be significantly correlated with medium distance running performance (Lacour et al. 1990a). Medium distance running performance is characterised by biomechanical and physiological parameters, with each possible unique combination leading to a higher level of performance (Thomson MA, 2017).

Greater power results are shown by middle distance runners, although there is no significant difference. Medium distance runners require high mechanical power output – this is very important to increase running speed at medium range. Although in middle distance runners the GRF reaction is lower than for sprint runners (Di Prampero et al. 1993; Thomson MA, 2017). Mid-range elite runners demonstrate local muscle adaptation, together with large anaerobic capacity, supporting production of high power output (Thomson MA, 2017). Local muscle adaptations that occur (such as in developing capillary tissue and increased muscle cell metabolism potential), together with increased anaerobic capacity, produce greater mechanical power needed for running (Di Prampero et al. 1993).

Factors that determine high efficiency in developing speed and strength abilities
of female hurdlers

BOLOTIN

ALEXANDER
1
; BAKAYEV VLADISLAV
2
Factors that determine high efficiency in developing speed and strength abilities
of female hurdlers

Conclusion

Physiological ability is determined from various factors, and varies based on the characteristics of the race numbers and the training program. Sprint runners are superior in leg strength, resting pulses and peak pulses. While medium distance runners are superior in lung capacity, VO2max, recovery speed, and foot power. The two groups differ in their respective physiological capacities because the characteristics of the two running numbers are different as a result of the training they are going through.

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