©Journal of Sports Science and Medicine (2005) **4,** 608-616
http://www.jssm.org

Young investigator
Research article

ANTHROPOMETRIC COMPARISON OF WORLD-CLASS SPRINTERS AND NORMAL POPULATIONS

Niels Uth ✉

Department of Sport Science, University of Aarhus, Aarhus N, Denmark

Received: 30 May 2005 / Accepted: 25 August 2005 / Published (online): 01 December 2005

ABSTRACT
The present study compared the anthropometry of sprinters and people belonging to the normal population. The height and body mass (BM) distribution of sprinters (42 men and 44 women) were statistically compared to the distributions of American and Danish normal populations. The main results showed that there was significantly less BM and height variability (measured as standard deviation) among male sprinters than among the normal male population (US and Danish), while female sprinters showed less BM variability than the US and Danish normal female populations. On average the American normal population was shorter than the sprinters. There was no height difference between the sprinters and the Danish normal population. All female groups had similar height variability. Both male and female sprinters had lower body mass index (BMI) than the normal populations. It is likely that there is no single optimal height for sprinters, but instead there is an optimum range that differs for males and females. This range in height appears to exclude people who are very tall or very short in stature. Sprinters are generally lighter in BM than normal populations. Also, the BM variation among sprinters is less than the variation among normal populations. These anthropometric characteristics typical of sprinters might be explained, in part, by the influence the anthropometric characteristics have on relative muscle strength and step length.

KEY WORDS: Sprint running, height, body mass, anthropometry.

INTRODUCTION

Running times are a function of reaction time, acceleration potential, maximal running velocity and the ability to maintain velocity as fatigue progresses (Ross et al., 2001). These factors are clearly influenced by metabolic (Allemeier et al. 1994; Barnett et al. 2004; Dawson et al. 1998; Jacobs et al., 1987; Mero et al., 1981) and neural factors (Casabona et al., 1990; Jönhagen et al. 1996; Mero et al., 1992; Nummela et al., 1994; Ross et al., 2001), however, anthropometric factors also play an important role (Mann et al., 1984; Mero and Komi, 1985).

A muscle's maximal force is, generally speaking, proportional to its physiological cross-sectional area (Izquierdo et al., 2001; Powell et al., 1984). If we consider two geometrically and qualitatively similar individuals, we would expect all linear dimensions to be proportional. Accordingly, we would anticipate body mass (BM) to be proportional to height cubed (since mass equals density times volume), and muscle strength to be proportional to height squared (since area scales with height squared). In fact, it has been reported that muscle strength (measured as weight lifted) varied almost exactly with height squared in world weightlifting champions (Ford et al., 2000). Consequently, muscle strength relative to BM, i.e. the relative muscle strength (RMS), should be inversely proportional to height. In other words, we would expect RMS to decrease with increasing height.

In sprint running, the center of mass (COM) is accelerated during the early part of the race before reaching a plateau between 40 and 60 m into the race (Delecluse et al., 1995). During each step, the COM is accelerated both vertically and horizontally by the application of large forces during the stance phase, after the body is slowed by air resistance (horizontally) and negatively accelerated by gravity (vertically) prior to foot-ground contact. The acceleration of the body is proportional to the force produced but inversely proportional to the body mass, according to Newton's second law. Therefore, in theory, the ability to accelerate the BM should be closely related to RMS. This implies an inverse relationship between height and performance in disciplines such as sprint running (Figure 1).

Although being tall may have disadvantages for sprinters, it may provide some advantages as well. A taller runner's longer limbs will enable longer step length (Winter, 1990), which could be advantageous since running speed is a function of step frequency and step length. Accordingly, one may expect a smaller stature to be a disadvantage in sprint running. In sprint running, one may therefore expect a smaller proportion of world-class sprinters to be short in stature compared to the normal population.

While it is unclear whether there is an optimum body height, these theoretical considerations suggest that there should be an optimum height at which sprint performance is best. Therefore one would expect less height variability among sprint runners than among normal populations. The purpose of the present study was to describe differences in height and BM, and their variability, between world-class sprinters and normal populations in order to test the hypothesis that there is less height and BM variability among world-class sprinters than among normal populations.

METHODS

Height and BM data (IAAF Statistics, 1980-2004) of 42 men and 44 women from the all-time 100m top-50 lists (International Association of Athletics Federations, http://www.iaaf.org/statistics/toplists) were compared to those of American (724 male and 663 female) and Danish (1336 male and 1306 female) 20-30 year-old residents. There are many Americans among the world-class sprinters. Therefore, it was considered appropriate to compare the sprinters with the American population. However, in order to validate the results against a second population, the sprinters were also compared to Danish normal population. Even supposing some ´trained sprinters` might be included in the ´normal population`, the number would be very small and therefore its effect could be considered negligible. Accordingly, the two samples ´sprinters` and ´normal population` can be considered different.

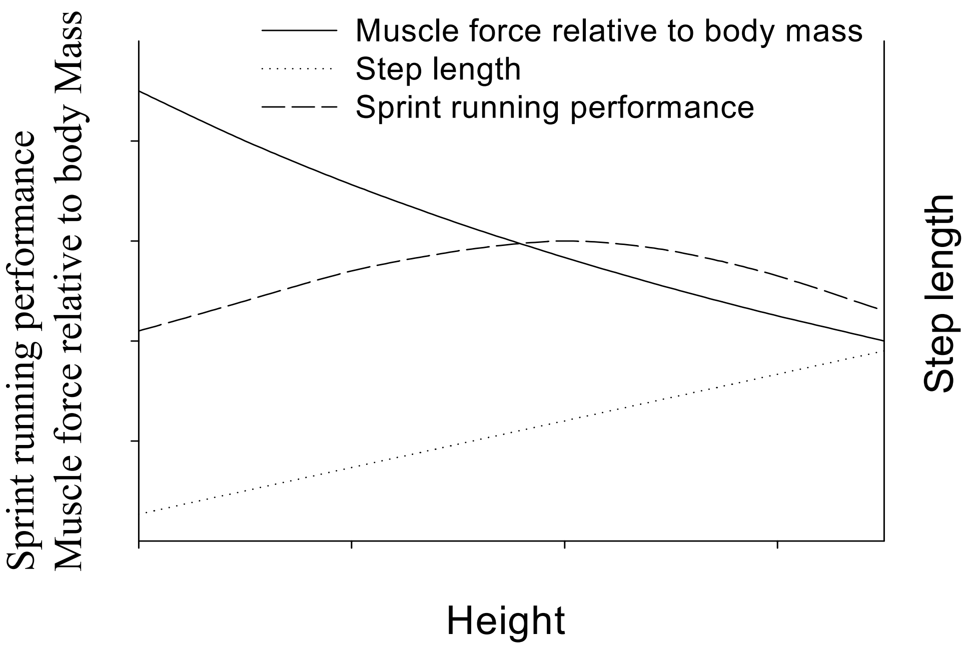

Figure 1. Theoretical relationship between muscle force, step length and sprint running performance versus height. Relationship between muscle force relative to body mass and height (solid line). Step length versus height (dotted line). Sprint running performance versus height (dashed line).

Table 1. Characteristics of male world-class sprinters, young American and Danish normal population.

		Sprinters	USA	DK	Statistical Difference ($p < 0.05$)
Height (m)	mean	1.80	1.77	1.82	USA < Sprinters = DK
	SD	.06	.08	.07	Sprinters < DK < USA
Body mass (kg)	mean	77.0	83.4	79.8	Sprinters = DK < USA
	SD	6.6	19	13	Sprinters < DK < USA
BMI ($kg \cdot m^{-2}$)	Mean	23.7	26.6	24.1	Sprinters = DK < USA
	SD	1.5	5.2	3.4	Sprinters < DK < USA

USA = American normal population, DK = Danish normal population.

The anthropometric data of the sprinters were obtained in part from numerous internet searches and other sources – too many to cite individually. Hence the height and BM data from the sprinters are presented in full in Appendix 1 (men) and 2 (women). The age range of 20-30 years was selected in order to maximize the match of the comparing groups. The American data are public-use data from National Health and Nutrition Examination Surveys (NHANES 1999-2002). The Danish data were part of a study conducted by the Danish National Institute of Public Health (formerly known as The Danish Institute for Clinical Epidemiology) (Kjøller and Rasmussen, 2002).

BMI calculations

The body mass index (BMI= $BM \cdot height^{-2}$) is the recommended screening tool for overweight and obesity. A large muscle mass can yield high BMIs even though body fat is not excessive, because the BMI fails to distinguish between the proportions of body fat and lean tissue. Nevertheless, BMI can be used to describe the compactness of a person. Thus it can be a useful anthropometric parameter. Since both height (determinant for limb lengths) and BM (determinant for muscle mass and hence strength) impact running speed, the interaction of body height and BM is important.

Statistical analysis

Q-Q plots were made to test if data sets followed a normal distribution. In these cases, in which the assumption of normality was accepted, group variability (SD) was compared by using a two-tailed F-test, and group mean was compared by using one-way analysis of variance. For all variables, the sprinters and two normal populations were compared. In addition, male sprinters were compared to female sprinters. The p-values were adjusted for multiple testing (Bonferroni correction). Statistical significance was set at $p < 0.05$ for all analyses.

RESULTS

Comparison of male groups

The results for the males are presented in Table 1. The male Americans were significantly shorter than male sprinters and male Danes ($p < 0.01$). But there was no significant difference in the mean height of male sprinters and male Danes. The male sprinters had less height variability (i.e. SD) than the male Danes ($p < 0.01$) who had less height variability than the male Americans ($p < 0.01$).

The male sprinters had lower mean BM than the male Danes ($p < 0.01$), and both these groups were lighter than the male Americans ($p < 0.001$). The male sprinters had less BM variability that male Danes ($p < 0.001$) who had less BM variability than male Americans ($p < 0.001$).

The male sprinters had a significantly lower mean BMI than male Americans ($p > 0.001$). But there was no significant difference in the mean BMI of male sprinters and male Danes ($p = 0.11$). The male sprinter showed less BMI variability than the male Danes ($p < 0.001$) who showed less BMI variability than the male Americans ($p < 0.001$). Thus, in general, the sprinters are lighter in BM and have lower BMI than normal populations and the height, BM and BMI variation among sprinters is less than the variation among normal populations.

Comparisons of female groups

The results for the females are presented in Table 2. The female Americans were significantly shorter than the female sprinters ($p < 0.001$) and female Danes ($p < 0.001$). But there was no significant difference in the mean height of the female sprinters and female Danes ($p = 0.67$). All female groups had similar height variability ($p = 0.30$-0.40).

The female sprinters were significantly lighter than the female Danes ($p < 0.001$) who were significantly lighter than the female Americans ($p < 0.001$). Likewise, the female sprinters had significantly lower BM variability than the female Danes ($p < 0.001$) who had significantly lower BM variability than the female Americans ($p < 0.001$).

The female sprinters had a significantly lower mean BMI than female Danes who had a significantly lower mean BMI than the female Americans. Likewise, the female sprinters showed

Table 2. Characteristics of female world-class sprinters, young American and Danish non-athletes.

		Sprinters	USA	DK	Statistical Difference ($p < 0.05$)
Height (m)	Mean	1.68	1.63	1.69	USA < Sprinters = DK
	SD	.07	.08	.07	DK = Sprinters = USA
Body mass (kg)	Mean	58.1	66.2	71.1	Sprinters < DK < USA
	SD	5.2	23	12	Sprinters < DK < USA
BMI ($kg·m^{-2}$)	Mean	20.4	26.7	23.1	Sprinters < DK < USA
	SD	1.4	6.7	4.0	Sprinters < DK < USA

USA = American normal population, DK = Danish normal population.

less BMI variability than the female Danes who showed less BMI variability than the female Americans. Thus, in general, the sprinters are lighter in BM and have lower BMI than normal populations and the BM and BMI variation among sprinters is less than the variation among normal populations.

Comparisons of male and female sprinters

The male sprinters were significantly taller ($p < 0.001$) and heavier ($p < 0.001$) than the female sprinters, but there was no significant difference in the height ($p = 0.18$) or BM ($p = 0.13$) variability. The male sprinters had higher BMI ($p < 0.001$) than the female sprinters. There was, on the other hand, no difference in the BMI ($p = 0.43$) variability between the male and female sprinters.

DISCUSSION

Differences between sprinters and normal populations

The present analysis revealed a tendency toward less height, BM, and BMI variability among sprinters than among the normal populations. These results suggest the existence of a limited optimum range for height, BM and BMI for sprinters. The normal populations from both the U.S. and Denmark showed significantly higher BM than the sprinters. This result may be explained by higher body fat levels among the normal population given that sprinters often have lower body fat levels (Abe et al., 2001; Kumagai et al., 2000; WHO, 1998). However, in the present study, no fat measurement was performed.

The fact that sprinters have very low BM variability when compared to normal populations suggests that very low or very high BM could be a limiting factor in sprint running. High BM will handicap a sprinter because it takes higher force to accelerate a larger mass. On the other hand, strong sprinters should have more muscle mass and therefore be heavier than less strong sprinters. Hence, sprinters with a very low BM would probably have less muscle mass and thus be too weak. Moreover, the results of the present study point towards the sprinters' BMIs being less variable when compared to the BMI of the normal populations. This result indicates that sprinters also have an optimum range for BMI that differs for males and females. Height, BM and BMI seem to be important anthropometric parameters for sprinters.

Gender differences

The male sprinters were heavier, taller and had a higher BMI than the female sprinters. Therefore, it may be concluded that there does not exist an optimum inter-gender height, BM or BMI for sprinters. In fact, regarding mean height, only the American normal population differed statistically from the sprinters. For a given height a male sprinter would, on average, be approximately 10 kg heavier than a female sprinter (see Figure 2). A significant correlation has been found between strength and muscle cross-sectional area although there does not seem to be a significant gender difference in the strength to cross-sectional area ratio (Miller et a1., 1993). These data suggest that the greater strength of the men primarily is caused by their larger muscles.

It has been reported that mechanical power output during a single short-term maximal exercise is greater in men than in women even when the differences in fat-free mass of whole body as well as BM are normalized (Froese and Houston, 1987; Gratas-Delamarche et al., 1994; Mayhew and Salm, 1990). When the results of the present study are taken into account it seems reasonable to speculate that there is a connection between the gender difference in BM and performance. Since high muscle strength (and therefore muscle mass) is required to perform well in the sprint events, the male sprinters may benefit both from their larger muscle mass (Cureton et al., 1988) and the influences of the principal muscle-building hormone, testosterone, on the development of anaerobic working potential (Kraemer et al., 1991). The male sprinters may therefore be heavier and perform better than the female sprinters simply because they have more muscle mass.

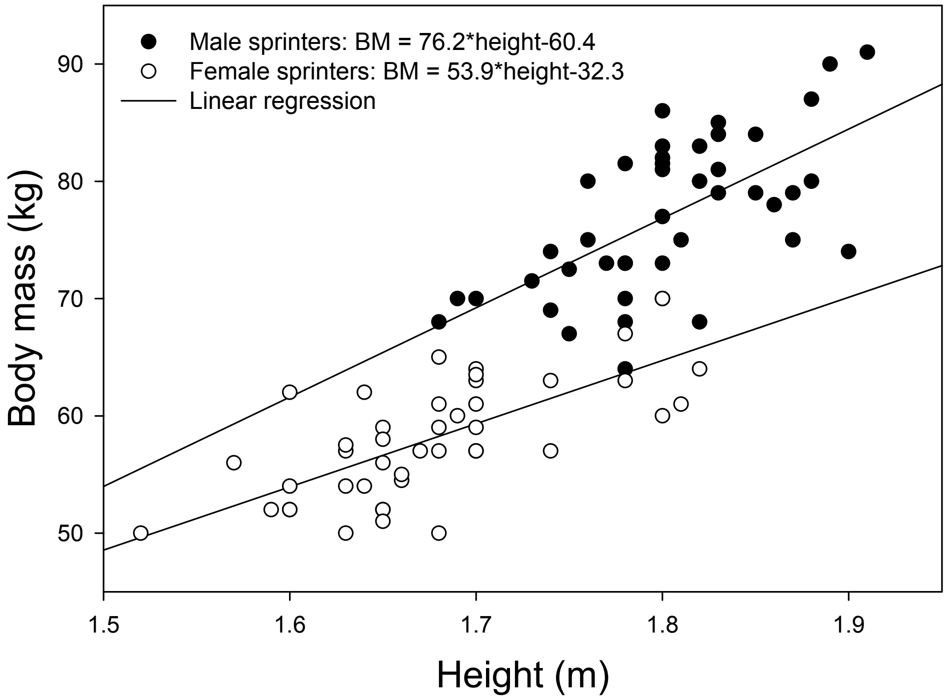

Figure 2. Body mass (BM) versus height for male and female world-class sprinters.

The present study demonstrated less height variability among male world-class sprinters than among American and Danish men. On the other hand, all female groups had similar height variability. Further research is required to disclose if this can be explained by gender differences in the degree of track running specialisation.

Limited height range

All of the world-class sprinters were in the height range of 1.68-1.91 m (men) or 1.52-1.82 cm (women). The fact that the sprinters' height data was normally distributed indicates that both very short and very tall stature may be disadvantageous for sprinters. No mean height difference was observed between the female sprinters (1.68 m) and the Danish women (1.69 m), however, there was a significant height difference ($p < 0.0001$) between the American women (1.63 m) and the female sprinters. In other words, there might be very little likelihood that future top sprinters would be outside of this height range. Even though the present study indicates that very tall or short stature may reduce the chance of being a successful sprint runner, several world-class sprinters are taller than 1.87 m (i.e. Linford Christie, Carl Lewis, Joshua J. Johnson and Asafa Powell), which corresponds to the top 10% of the male U.S normal population and the top 23% of the male Danish normal population. Likewise several world-class sprinters were shorter than 1.71 m (i.e. Andre Cason, Leonard Myles-Mills and Coby Miller), which corresponds to the bottom 20% of the male U.S normal population and the bottom 5% of the male Danish normal population. Therefore, there is a small chance that a future male world-class sprinter may be taller than 1.91 m or shorter than 1.68 m.

Limitations of the study

The sprinters were compared to two populations at specific time points. Other time points might give different results, especially regarding BM, as people tend to be fatter (Hill and Melanson, 1999; Ogden et al., 2004). The mean height has also increased during the last decades. However, while among the American adult population, mean BM have increased more than 10 kg, mean height has increased less dramatically (2-3 cm) during the 40 years (Ogden et al., 2004). To test if the same happened among the sprinters, they were assigned to groups, old (men: 1983-1999; women: 1984-1994) and recent (men: 1999-2005; women: 1995-2005), of approximately equal size according to the date of their best performance. No statistical height, BM or BMI difference was observed between the groups (men: $BM_{old/recent}$ = 75.7/77.7 kg, p = 0.18, $height_{old/recent}$ = 179.2/181.4 m, p=0.20, $BMI_{old/recent}$ = 23.6/23.8 kg·m^{-2}, p=0.57; women: $BM_{old/recent}$ = 57.6/58.7 kg, p = 0.52, $height_{old/recent}$ = 168.5/167.0 m, p = 0.47, $BMI_{old/recent}$ = 20.3/21.0 kg·m^{-2}, p = 0.10). Therefore, no data was excluded due to the date of the performance even though some of the athletes performed in the 1980s and early 1990s, which is earlier than the normal populations (the U.S. data were from 1999-2002).

Although the U.S. has the greatest representations in the group of sprinters, comparisons against another population might turn out differently. However, comparison against the Danes who are completely unrepresented gave relatively similar results, thus suggesting that the findings are valid.

CONCLUSIONS

It is likely that there is no single optimal height for sprinters, but instead there is an optimal range that differs for males and females. This range in height appears to exclude people who are very tall and very short in stature. Sprinters are generally lighter in body mass than normal populations. Also, the body mass variation among sprinters is less than the variation among non-athletic populations. These anthropometric characteristics typical of world-class sprinters might be explained, in part, by the influence the anthropometric characteristics have on relative muscle strength and stride length.

REFERENCES

Abe T., Fukashiro S., Harada Y. and Kawamoto K. (2001) Relationship between sprint performance and muscle fascicle length in female sprinters. *Journal of Physiological Anthropology and Applied Human Science* **20,** 141-147.

Allemeier, C.A., Fry, A.C., Johnson P., Hikida R.S., Hagerman F.C. and Staron R.S. (1994) Effects of sprint cycle training on human skeletal muscle. *Journal of Applied Physiology* **77,** 2385-2290.

Barnett C., Carey M., Proietto J., Cerin E., Febbraio M.A. and Jenkins, D. (2004) Muscle metabolism during sprint exercise in man: influence of sprint training. *Journal of Science and Medicine in Sport* **7,** 314-322.

Casabona A., Polizzi, M.C. and Perciavalle, V. (1990) Differences in H-reflex between athletes trained for explosive contractions and non-trained subjects. *European Journal of Applied Physiology and Occupational Physiology* **61,** 26-32.

Cureton K.J., Collins M.A., Hill D.W. and McElhannon, F.M. (1988) Muscle hypertrophy in men and women. *Medicine and Science in Sports and Exercise* **20,** 338-344.

Dawson, B., Fitzsimons, M., Green, S., Goodman, C., Carey, M. and Cole, K. (1998) Changes in performance, muscle metabolites, enzymes and fibre types after short sprint training. *European Journal of Applied Physiology and Occupational Physiology* **78,** 163-169.

Delecluse, C.H., van Coppenolle, H., Willems, E., Diels, R., Goris, M., van Leemputte, M. and Vuylsteke, M. (1995) Analysis of 100 meter sprint performance as a multidimensional skill. *Journal of Movement Studies* **28,** 87-101.

Ford, L.E., Detterline, A.J., Ho, K.K. and Cao, W. (2000) Gender- and height-related limits of muscle strength in world weightlifting champions. *Journal of Applied Physiology* **89,** 1061-1064.

Froese, E.A. and Houston M.E. (1987) Performance during the Wingate anaerobic test and muscle morphology in males and females. *International Journal of Sports Medicine* **8,** 35-39.

Gratas-Delamarche, A., Cam, R.L., Delamarche, P., Monnier, M. and Koubi H. (1994) Lactate and catecholamine responses in male and female sprinters during a Wingate test. *European Journal of Applied Physiology* **68,** 362-366.

Hill, J.O. and Melanson, E.L. (1999) Overview of the determinants of overweight and obesity: current evidence and research issues. *Medicine and Science in Sports and Exercise* **31,** 15-21.

NHANES, National Health and Nutrition Examination Surveys (1999-2002) Information on the NHANES survey design, the data collection methods and the public-use microdata files. Available from URL: http://www.cdc.gov/nchs/nhanes.htm

Izquierdo, M., Hakkinen, K., Anton, A., Garrues, M., Ibanez, J., Ruesta, M. and Gorostiaga, E.M. (2001) Maximal strength and power, endurance performance, and serum hormones in middle-aged and elderly men. *Medicine and Science in Sports and Exercise* **33,** 1577-1587.

Jacobs, I., Esbjornsson, M., Sylven, C., Holm, I. and Jansson, E. (1987) Sprint training effects on muscle myoglobin, enzymes, fiber types, and blood lactate. *Scandinavian Journal of Sports Sciences* **19,** 368-374.

Jönhagen, S., Ericson, M.O., Nemeth, G. and Eriksson, E. (1996) Amplitude and timing of electromyographic activity during sprinting. *Scandinavian Journal of Medicine and Science in Sports* **6,** 15-21.

Kjøller, M. and Rasmussen N.K. (2002) Sundhed og sygelighed i Danmark 2000 & udviklingen siden 1987. Copenhagen: Statens Institut for Folkesundhed. (in Danish).

Kraemer, W.J., Gordon, S.E., Fleck, S.J., Marchitelli, L.J., Mello, R., Dziados, J.E., Friedl, K., Harman, E., Maresh, C. and Fry, A.C. (1991) Endogenous anabolic hormonal and growth factor responses to heavy resistance exercise in males and females. *International Journal of Sports Medicine* **12,** 228-235.

Kumagai, K., Abe, T., Brechue, W.F., Ryushi, T., Takano, S. and Mizuno M. (2000) Sprint performance is related to muscle fascicle length in male 100-m sprinters. *Journal of Applied Physiology* **88,** 811-816.

Mayhew, J.L. and Salm P.C. (1990) Gender differences in anaerobic power tests. *European Journal of Applied Physiology* **60,** 133-138.

Mann, R.V., Kotmel, J., Herman, J., Johnson, B. and Schultz, C. (1984) Kinematic trends in elite sprinters. In: *Proceedings of the International*

Symposium of Biomechanics in Sports. Sports biomechanics. Terauds, J., Barthels, K., Kreighbaum, E., Mann, R. and Crakes, J. Del Mar. California: Academic Publishers, pp. 17-33.

Mero, A. and Komi, P.V. (1985) Effects of supramaximal velocity on biomechanical variables in sprinting. *International Journal of Sport Biomechanics* **1,** 240-252.

Mero, A., Komi, P.V. and Gregor, R.J. (1992) Biomechanics of sprint running. A review. *Sports Medicine* **13,** 376-392.

Mero, A., Luthanen, P., Viitaslo, J.T. and Komi, P.V. (1981) Relationship between the maximal running velocity, muscle fibre characteristics, force production and force relaxation of sprinters. *Scandinavian Journal of Sports Sciences* **3,** 16-22.

Miller, A.E., MacDougall, J.D., Tarnopolsky, M.A. and Sale, D.G. (1993) Gender differences in strength and muscle fiber characteristics. *European Journal of Applied Physiology and Occupational Physiology* **66,** 254-262.

Nummela, A., Rusko, H. and Mero, A. (1994) EMG activities and ground reaction forces during fatigued and nonfatigued sprinting. *Scandinavian Journal of Sport Sciences* **26,** 605-609.

Ogden, C.L., Fryar, C.D., Carroll, M.D. and Flegal, K.M. (2004) Mean body weight, height, and body mass index, United States 1960-2002. *Advance Data* **27,** 1-17.

Powell, P.L., Roy, R.R., Kanim, P., Bello, M.A. and Edgerton, V.R. (1984) Predictability of skeletal muscle tension from architectural determinations in guinea pig hindlimbs. *Journal of Applied Physiology* **57,** 1715-1721.

Ross, A., Leveritt, M. and Riek, S. (2001) Neural influences on sprint running: training adaptations and acute responses. *Sports Medicine* **31,** 409-425.

Winter, D.A. (1990) *Biomechanics and motor control of human movement*. 2nd Edition. New York. Wiley-Interscience. 51-74.

WHO, World Health Organisation. (1998) Obesity: preventing and managing the global epidemic, Rep. WHO Consult. World Health Organisation: Geneva.

AUTHOR BIOGRAPHY

Niels UTH

Employment

PhD Student, Department of Sport Science, University of Aarhus, Denmark.

Degree

MSc

Research interest

Biomechanics

E-mail: nielsuth@idraet.au.dk

KEY POINTS

- The male sprinters were less variable in height, body mass and body mass index than the normal populations
- The sprinters were lighter than the normal populations.
- The sprinters were taller than the American normal population.
- The female sprinters were less variable in body mass and body mass index than the normal population.

✉ **Niels Uth**

Department of Sport Science, University of Aarhus, Katrinebjergvej 89C, DK-8200 Aarhus N, Denmark.

Appendix 1. Male top-50 Sprinters.

Mark	Wind (m/s)	Athlete	Nat	Birth	Venue	Date	Age (yrs)	Height (m)	Weight (kg)	BMI (kg·m^{-2})
9.77	1.6	**Asafa Powell**	JAM	11/11/1982	Athína	14/06/2005	22.6	1.88	87	24.6
9.78	2	**Tim Montgomery**	USA	28/01/1975	Paris	14/09/2002	27.6	1.78	73	23.0
9.79	0.1	**Maurice Greene**	USA	23/07/1974	Athína	16/06/1999	24.9	1.76	80	25.8
9.84	0.7	**Donovan Bailey**	CAN	16/12/1967	Atlanta, GA	27/07/1996	28.6	1.82	83	25.1
9.84	0.2	**Bruny Surin**	CAN	12/07/1967	Sevilla	22/08/1999	32.1	1.8	81	25.0
9.85	1.2	**Leroy Burrell**	USA	21/02/1967	Lausanne	06/07/1994	27.4	1.8	82	25.3
9.85	0.6	**Justin Gatlin**	USA	10/02/1982	Athína	22/08/2004	22.5	1.85	79	23.1
9.86	1.2	**Carl Lewis**	USA	01/07/1961	Tokyo	25/08/1991	30.2	1.88	80	22.6
9.86	-0.4	**Frank Fredericks**	NAM	02/10/1967	Lausanne	03/07/1996	28.8	1.8	73	22.5
9.86	1.8	**Ato Boldon**	TRI	30/12/1973	Walnut, CA	19/04/1998	24.3	1.76	75	24.2
9.86	0.6	**Francis Obikwelu**	POR	22/11/1978	Athína	22/08/2004	25.8	1.9	74	20.5
9.87	0.3	**Linford Christie**	GBR	02/04/1960	Stuttgart	15/08/1993	33.4	1.89	90	25.2
9.87	-0.2	**Obadele Thompson**	BAR	30/03/1976	Johannesburg	11/09/1998	22.4	1.75	67	21.9
9.87	2	**Dwain Chambers**	GBR	05/04/1978	Paris	14/09/2002	24.4	1.8	83	25.6
9.88	1.8	**Shawn Crawford**	USA	14/01/1978	Eugene, OR	19/06/2004	26.4	1.81	75	22.9
9.91	1.2	**Dennis Mitchell**	USA	20/02/1966	Tokyo	25/08/1991	25.5	1.74	69	22.8
9.92	0.3	**Andre Cason**	USA	20/01/1969	Stuttgart	15/08/1993	24.6	1.7	70	24.2
9.92	0.8	**Jon Drummond**	USA	09/09/1968	Indy., IN	12/06/1997	28.8	1.75	72.5	23.7
9.92	-0.2	**Seun Ogunkoya**	NGR	28/12/1977	Johannesburg	11/09/1998	20.7	1.8	86	26.5
9.92	1	**Tim Harden**	USA	27/01/1974	Luzern	05/07/1999	25.4	1.78	81.5	25.7
9.93	1.4	**Calvin Smith**	USA	08/01/1961	Col. Spr., CO	03/07/1983	22.5	1.78	64	20.2
9.93	-0.6	**Michael Marsh**	USA	04/08/1967	Walnut, CA	18/04/1992	24.7	1.78	68	21.5
9.93	1.8	**Patrick Johnson**	AUS	26/09/1972	Mito	05/05/2003	30.6	1.77	73	23.3
9.94	0.2	**Davidson Ezinwa**	NGR	22/11/1971	Linz	04/07/1994	22.6	1.82	80	24.2
9.94	-0.2	**Bernard Williams**	USA	19/01/1978	Edmonton	05/08/2001	23.5	1.83	81	24.2
9.95	1.9	**Olapade Adeniken**	NGR	19/08/1969	El Paso, TX	16/04/1994	24.7	1.86	78	22.5
9.95	0.8	**Vincent Henderson**	USA	20/10/1972	Leverkusen	09/08/1998	25.8	1.74	74	24.4
9.95	1.8	**Joshua J. Johnson**	USA	10/05/1976	Walnut, CA	21/04/2002	25.9	1.91	91	24.9
9.95	0.6	**Deji Aliu**	NGR	22/11/1975	Abuja	12/10/2003	27.9	1.87	75	21.4
9.95	1.8	**John Capel**	USA	27/10/1978	Eugene, OR	19/06/2004	25.6	1.8	81.5	25.2
9.96	1.2	**Raymond Stewart**	JAM	18/03/1965	Tokyo	25/08/1991	26.4	1.78	73	23.0
9.96	0.8	**Kareem S.Thompson**	USA	30/03/1973	Indy., IN	12/06/1997	24.2	1.83	84	25.1
9.97		**Mark Lewis-Francis**	GBR	04/09/1982	Edmonton	04/08/2001	18.9	1.83	85	25.4
9.97	0.6	**Uchenna Emedolu**	NGR	17/09/1976	Abuja	12/10/2003	27.1	1.83	79	23.6
9.98	0.3	**Daniel Effiong**	NGR	17/06/1972	Stuttgart	15/08/1993	21.2	1.87	79	22.6
9.98	1.4	**Percival Spencer**	JAM	24/02/1975	Kingston	20/06/1997	22.3	1.82	68	20.5
9.98	1.6	**Leonard Myles-Mills**	GHA	09/05/1973	Boise, ID	05/06/1999	26.1	1.69	70	24.5
9.98	0.4	**Jason Gardener**	GBR	18/09/1975	Lausanne	02/07/1999	23.8	1.78	70	22.1
9.98	0.4	**Coby Miller**	USA	19/10/1976	Durham, NC	02/06/2000	23.6	1.68	68	24.1
9.98	0.2	**Kim Collins**	SKN	05/04/1976	Manchester	27/07/2002	26.3	1.8	77	23.8
9.99	0.5	**Brian Lewis**	USA	05/12/1974	Cayenne	04/05/2002	27.4	1.73	71.5	23.9
9.99	1.5	**Mickey Grimes**	USA	10/10/1976	Zürich	15/08/2003	26.8	1.85	84	24.5

Data for three male top 50 athletes (Jim Hines, Melvin Lattany and Silvio Leonard) were not found. Hence, data from these athletes were excluded.

Appendix 2. - Female top-50 Sprinters.

Mark (s)	Wind (m/s)	Athlete	Nat	Birth	Venue	Date	Age (yrs)	Height (m)	Weight (kg)	BMI (kg·m^{-2})
10.49	0	**Florence G. Joyner**	USA	21/12/1959	Indy., IN	16/06/1988	28.5	1.70	59	20.4
10.65	1.1	**Marion Jones**	USA	12/10/1975	Johannesburg	12/09/1998	22.9	1.80	70	21.6
10.73	2	**Christine Arron**	FRA	13/09/1973	Budapest	19/08/1998	24.9	1.78	67	21.1
10.74	1.3	**Merlene Ottey**	JAM	10/05/1960	Milano	07/09/1996	36.3	1.74	57	18.8
10.76	1.7	**Evelyn Ashford**	USA	15/04/1957	Zürich	22/08/1984	27.4	1.65	52	19.1
10.77	0.9	**Irina Privalova**	RUS	22/11/1968	Lausanne	06/07/1994	25.6	1.74	63	20.8
10.78	1	**Dawn Sowell**	USA	27/03/1966	Provo, UT	03/06/1989	23.2	1.70	57	19.7
10.79	0	**Xuemei Li**	CHN	15/01/1977	Shanghai	18/10/1997	20.8	1.70	61	21.1
10.79	-0.1	**Inger Miller**	USA	12/06/1972	Sevilla	22/08/1999	27.2	1.60	54	21.1
10.82	-1	**Gail Devers**	USA	19/11/1966	Barcelona	01/08/1992	25.7	1.60	52	20.3
10.82	0.4	**Gwen Torrence**	USA	12/06/1966	Paris	03/09/1994	28.2	1.70	57	19.7
10.82	-0.3	**Zhanna Block**	UKR	06/07/1972	Edmonton	06/08/2001	29.1	1.64	62	23.1
10.83	0	**Sheila Echols**	USA	02/10/1964	Indy., IN	16/07/1988	23.8	1.63	50	18.8
10.83	-1	**Juliet Cuthbert**	JAM	09/04/1964	Barcelona	01/08/1992	28.3	1.60	52	20.3
10.83	0.1	**Ekateríni Thánou**	GRE	01/02/1975	Sevilla	22/08/1999	24.6	1.65	56	20.6
10.84	1.3	**Chioma Ajunwa**	NGR	25/12/1970	Lagos	11/04/1992	21.3	1.60	62	24.2
10.85	2	**Anelia Nuneva**	BUL	30/06/1962	Sofia	02/09/1988	26.2	1.67	57	20.4
10.85	0.9	**Kelli White**	USA	01/04/1977	Paris	24/08/2003	26.4	1.63	57	21.5
10.86	0.6	**Silke G. Möller**	GDR	20/06/1964	Potsdam	20/08/1987	23.2	1.68	59	20.9
10.86	0	**Diane Williams**	USA	14/12/1960	Indy., IN	16/07/1988	27.6	1.63	54	20.3
10.86	0.1	**Chandra Sturrup**	BAH	12/09/1971	Nassau	21/07/2000	28.9	1.59	52	20.6
10.86	1.2	**Chryste Gaines**	USA	14/09/1970	Monaco	14/09/2003	33.0	1.70	63.5	22.0
10.89	1.8	**Katrin Krabbe**	GDR	22/11/1969	Berlin	20/07/1988	18.7	1.82	64	19.3
10.90	1.4	**Glory Alozie**	NGR	30/12/1977	La Laguna	05/06/1999	21.4	1.65	51	18.7
10.91	0.2	**Heike Drechsler**	GDR	16/12/1964	Moskva	06/07/1986	21.6	1.81	61	18.6
10.91	1.1	**Savatheda Fynes**	BAH	17/10/1974	Lausanne	02/07/1999	24.7	1.65	58	21.3
10.91	1.5	**Debbie Ferguson**	BAH	16/01/1976	Manchester	27/07/2002	26.5	1.70	64	22.1
10.92	0	**Alice Brown**	USA	20/09/1960	Indy., IN	16/07/1988	27.8	1.57	56	22.7
10.92	1.1	**D'Andre Hill**	USA	19/04/1973	Atlanta, GA	15/06/1996	23.2	1.64	54	20.1
10.93	1	**Tayna Lawrence**	JAM	17/09/1975	Bruxelles	30/08/2002	27.0	1.52	50	21.6
10.93	0.9	**Torri Edwards**	USA	31/01/1977	Paris	24/08/2003	26.6	1.63	57.5	21.6
10.94	1	**Carlette G. White**	USA	04/09/1968	New York,NY	14/06/1991	22.8	1.68	50	17.7
10.96	1.2	**Marie-José Pérec**	FRA	09/05/1968	Dijon	27/07/1991	23.2	1.80	60	18.5
10.96	2	**Galina Malchugina**	EUN	17/12/1962	Moskva	22/06/1992	29.5	1.68	65	23.0
10.96	0.4	**Muriel Hurtis**	FRA	25/03/1979	Annecy	22/06/2002	23.2	1.80	70	21.6
10.97	0.2	**Mary O.Omagbemi**	NGR	03/02/1968	Stuttgart	15/08/1993	25.5	1.65	52	19.1
10.97	0.1	**Pauline D.Thompson**	BAH	09/07/1966	Nassau	21/07/2000	34.0	1.68	57	20.2
10.98	1.6	**Natalya P. Voronova**	URS	09/07/1965	Seoul	24/09/1988	23.2	1.69	60	21.0
10.98	0.6	**Myriam L. Mani**	CMR	21/05/1977	Athína	11/06/2001	24.1	1.66	55	20.0
10.99	1.3	**Valerie B. Hooks**	USA	06/07/1960	Westwood,CA	17/05/1986	25.9	1.70	63	21.8
10.99	0.7	**Beverly McDonald**	JAM	15/02/1970	Doha	07/05/1998	28.2	1.65	59	21.7
11.00	1.5	**Veronica Campbell**	JAM	15/05/1982	Manchester	27/07/2002	20.2	1.68	61	21.6
11.01	0.8	**Pam Marshall**	USA	16/08/1960	Lausanne	15/09/1987	27.1	1.78	63	19.9
11.02	-0.1	**LaTasha Jenkins**	USA	19/12/1977	Athens, GA	05/05/2001	23.4	1.66	54.5	19.8

Data for eleven female top 50 sprinters (Marlies Oelsner-Göhr, Marita Koch, Xiaomei Liu, Ewa Kasprzyk, Bärbel Wöckel, Angella Taylor-Issajenko, Marina Zhirova, Angela Bailey, Annegret Richter, Romy Müller and Lyudmila Kondratyeva) were not found. Hence, data from these athletes were excluded.