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Racial differences in hemoglobin and plasma volume variation: implications for muscle performance and recovery

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ABSTRACT

Objective: To examine the effect of race differences on sprint performance, Hemoglobin (Hb), Hematocrit (Ht) and plasma volume (PV) variation in response to repeated sprint exercise.

Design: Thirty-six healthy, moderately trained men and women (20.8 ± 0.2 year-old) volunteered to participate in this study. They were allocated to one of the four groups according to their gender and race: Black men's group (BM, $n = 9$), White men's group (WM, $n = 9$), Black women's group (BW, $n = 9$) and White women's group (WW, $n = 9$). All participants performed the running-based anaerobic sprint test (RAST), which consists of six 35-m sprints with 10 s of recovery in-between. Six venous blood samples were collected to determine Hb, Ht and PV levels at rest, after warm-up, immediately post- and at 5, 15 and 30 min post-RAST. Blood lactate is also sampled during the 3rd minutes of recovery.

Results: The best running time was significantly shorter ($P = .002$) in BW compared to WW. We have observed significantly higher Hb ($P = .010$) and Ht ($P = .004$) levels in BW compared to WW during the 5th minute of recovery. During RAST, the PV decreased significantly ($P = .007$) in WM only. Black groups had lower ($P < .05$) lactate levels compared to the white subjects. During recovery, PV increase was significantly ($P = .003$) higher in WW compared to BW during the 5th minute of recovery.

Conclusion: This study demonstrated that sprint and repeated sprint performances were different between white and black women. Differences in anaerobic performance between the groups were associated with racial differences in lactate levels and blood count among women's group during recovery time. Hence, it is important to take into account this race-related difference in hematological parameters in responses to intense efforts.

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Ethnicity; repeated intense efforts; aerobic capacity; blood volume; dehydration

A. Introduction

Individuals of West Sub-Saharan African ancestry have dominated international sprint competitions since the 1970s, as they hold the sprint records in (100, 200 and 400 m)

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in both sexes (International Association of Athletics Federations). The causal mechanisms that lie behind this West Sub-Saharan African supremacy are not well understood and could be social and environmental factors and/or genetic and biomechanical differences Entine (2001). For Ceaser and Hunter (2015), differences in sprint performances competitions are essential due to differences in muscle fiber type between non-Hispanic Black and non-Hispanic White individuals. These last authors reported also that these differences are specific to race and may explain health disparities among racial and ethnic groups.

However, while data are available for sprint competition, performance disparities between West Sub-Saharan African and Caucasian athletes in response to repeated sprint (RS) are sparsely studied. Definitely, repeated-sprint ability (RSA) is an important fitness component for the team-sport athletes (Padulo et al. 2015). Team-sports have a high sequences of repeated short high-intensity efforts (i.e. ≤20 s) separated by short recovery periods (i.e. ≤60 s) (Valente-dos-Santos et al. 2012). Numerous studies have reported significant correlations between maximal oxygen uptake (VO_{2max}), recovery capacity (Glaister 2005) and RS performance (Tomlin and Wenger 2001; Svensson and Drust 2005). McGawley and Bishop (2015), found an increase in the amount of oxygen uptake (VO_2) throughout RS. Thus, aerobic capacity may be a determinant factor for performance in RS.

Ceaser and Hunter (2015) reported that higher aerobic capacity is associated to lower adiposity and reduced prevalence of obesity and cardiometabolic disease. In this latter review, authors demonstrated that low oxygen delivery rate to muscle may contribute to alteration in aerobic capacity and metabolic requirements during exercise. Because, the oxygen delivery and consumption rate depends essentially on blood volume and flow change, it became necessary to investigate hemoglobin, hematocrit and plasma volume shift during physical activity. During exercise, the blood vessels dilate to warrant sufficient blood flow and supply of oxygen and nutriments to the working muscles. This phenomenon is accompanied with change in plasma content and concentration (i.e. water, proteins, glucose, electrolytes, and hormones) under the influence of Starling forces. Hence, we assume that change in plasma volume will systematically affect aerobic capacity and RS performance in different race/ethnic groups.

However, all previous studies have examined the relationship between plasma volume variation (PVV) and anaerobic performance in Caucasian while data concerning 'Black' African individuals are missing. In addition, most previous studies reported differences in blood count between black and white individuals from different socio-cultural environment suggesting lower hematocrit, hemoglobin, and white blood cell counts in black individuals compared with whites ones (Beutler and West 2005). Yet, the origin of these racial differences in hematological parameters is still unknown. Many studies have tried to explain this from differences in iron levels, copper and zinc, and gene (i.e. HBA1 and HBA2) (Beutler and West), but failed to demonstrate any relation between these parameters and race effect on blood count.

In North-Africa, the number of very dark-skinned or 'black' persons is substantial. They are descendants from prehistoric communities, and/or slaves from the Arab Slave Trade in North Africa (Harich et al. 2010). To our knowledge, no research has studied hematologic parameters, plasma volume variation and RS performance in this population. Hence, it was

necessary to investigate the influence of skin-color on sprint, RS performance and plasma volume variation (PVV) in 'Black' and 'White' North-Africans men and women.

B. Methods

B.1. Participants

Thirty-six healthy and moderately trained participants (18 men and 18 women) were recruited to this study. They were all students in the 'Physical Education Institution' of Tunisia. All participants were belonging to the same social environment and living in the same region (North Tunisia) which reduces differences in habitual activities and/or lifestyle. They were informed about the experimental study procedures and the potential risks and discomforts associated with the experiment before giving their written consent to participate. This experimental study was in accordance with the codes of the Declaration of Helsinki, and was approved by the local Ethics Committee on Human Research of the National Centre of Medicine and Science in Sport (NCMSS), Tunisia.

According to skin-color difference, participants were divided into two groups according to the method of classification in the 'Von Luschan's chromatic scale'; thus, the first group was composed by individuals with very light skin color also called 'White' and the second one were composed by individuals with very dark skin color also called ' Black'.

B.2. Inclusion criteria

A medical examination was carried out before the start of the training. It was intended to detect health problems. Eligible subjects were non-smokers and didn't use any specific medication. Subjects with BMI > 25 $kg.m^{-2}$, diabetes mellitus, asthma, or cardiovascular disorders were excluded. In addition, no one had undergo surgery or blood donation during the last 6 months. To assess the physical condition level of participants, we have used the Baecke questionnaire (1982) with the maximal oxygen uptake (VO_{2max}) as criterion measures. All participants reported scores of 150–180 $min.week^{-1}$ of physical activity (130–150 min walking and 15–20 min jogging).

Eligible participants were divided into one of the four groups according to skin-color and sex: Black Women's group (BW, $n = 10$), Black Men's group (BM, $n = 10$), White Women's group (WW, $n = 10$), and White Men's group (WM, $n = 12$). However, during the experimental period, 2 participants dropped out the experimentation (BM: $n = 1$; WW: $= 1$) because of injuries (foot and ankle) and 4 participants had a vasovagal syncope because of the blood sample at rest and at the 5 min of recovery (WM: $n = 3$; BW: $n = 1$). Hence, data were drawn on 9 participants for each group.

B.3. Experimental design

Participants completed 2 indoor trials separated by at least 48 h. The first testing day, they performed maximal graded test (Astrand test, 1954). The second testing day, they performed the running-based anaerobic sprint test (RAST). During this day, blood samples were taken in order to determine hemoglobin, hematocrit and PVV in response to RAST.

All participants were asked to abstain from alcohol consumption and strenuous exercise, during 48 h prior to each test. Participants were asked also to avoid diuretic beverages

such as, coffee, tea or energetic drinks, and to maintain their normal diet and fluid intake with a minimum of 1.5 L per day of water consumption. A standard breakfast was also prepared by the CNMS' nutritionist and consumed 2 h prior to testing. The breakfast included 10 kcal per kg, 55%, of which came from carbohydrates, 33% from lipids and 12% from proteins.

B.4. Evaluations

Anthropometric measurements were completed for all participants. They included measurements of body mass and height (Table 1). Body mass was measured to the nearest 0.1 kg, with the subject in light clothing and without shoes, using an electronic scale (Kern, MFB 150K100, Germany). Height was determined to the nearest 0.5 cm with a measuring tape fixed to the wall. All measurements were performed by the same expert in accordance with the positions and techniques established by the International Biological Program. Percentage of body fat was determined using a Harpenden skinfold caliper according to Durnin and Womersley method (1974), involving four skinfold sites, triceps, biceps, sub-scapular and supra-iliac. The fat-free mass was calculated by subtracting the fat mass from the body mass.

During the first testing day, participants performed the Astrand-Ryhming test (ART) to determine the maximal oxygen uptake (VO_{2max}). This submaximal test was used to reduce/avoid risk of discomfort or related symptom to hypertension especially in black groups. It was simple to administer and appropriate for ECG and blood pressure monitoring during exercise. In addition, the use of ART could avoid interference of high load on RAST's performance after 48-hours (Lamberts 2009). The test was performed on an electrically braked cycle ergometer (Ergoline: ER900, Ergoline, Jaeger, Würzburg, Germany), and the VO_{2max} was estimated using the Astrand method (1954) which uses the heart rate (HR) and power output values. Monitoring heart rate (S810, Polar Instruments Inc., Oulu, Finland) was used to determine heart rate during rest and exercise.

Table 1. Anthropometric data and maximal oxygen uptake.

	BM($n = 9$)	WM($n = 9$)	BW($n = 9$)	WW($n = 9$)
Age (Year)	20.1 ± 0.8	20.8 ± 1.9	19.3 ± 1.6	21.1 ± 1.2
High (Cm)	182.8 ± 7.6**	176.6 ± 6. 6*	166.3 ± 4.3	168.0 ± 6.1
Body Mass (Kg)	72.4 ± 8.2*	69.9 ± 8.2*	61.4 ± 5.4	62.8 ± 12.1
Body Fat (%)	10.8 ± 2.4**	10.8 ± 3.2**	24.5 ± 7.2	25.5 ± 5.4
Lean Mass (Kg)	64.4 ± 6.4**	60.9 ± 6.7**	46.1 ± 4.1	46.3 ± 6.3
BMI ($Kg.M^{-2}$)	21.8 ± 2.9	21.9 ± 2.7	22.3 ± 3.9	22.2 ± 3.6
VO_{2max} ($mL.Min^{-1}.Kg^{-1}$)	56.2 ± 5.2*	57.1 ± 3.9*	45.6 ± 5.7	47.3 ± 6.2
Thigh Length (cm)	44.4 ± 1.9*	46.1 ± 2.1	40.8 ± 2.7	42.1 ± 2.3
Upper Thigh Cir. (cm)	54.6 ± 6.6	56.2 ± 1.3	55.5 ± 3.8	55.9 ± 3.2
Mid-Thigh Cir.(cm)	53.0 ± 6.9*	53.2 ± 1.5	49.8 ± 2.7	50.0 ± 4.1
Lower Thigh Cir.(cm)	39.2 ± 4.0	41.5 ± 3.5	38.1 ± 2.7	39.1 ± 5.2
Calf Cir.(cm)	8.3 ± 1.2*	9.1 ± 4.2*	6.7 ± 1.1	6.8 ± 1.3
Anterior Thigh Skinfolds (cm)	7.6 ± 2.1**	7.2 ± 3.0**	16.1 ± 4.2	15.9 ± 4.6
Posterior Thigh Skinfold(cm)	6.4 ± 1.2**	6.3 ± 2.1**	20.1 ± 7.3	19.8 ± 1.5

Data are means (±SD) BMI: body mass index ($kg.m^{-2}$); Maximal Oxygen consumption: VO_{2max}($mL.min^{-1}.kg^{-1}$); Cir: Circumference; BM: black men; WM: white men; BW: black women; WW: white women.
*Significant difference according to sex. $P < .05$.
**$P < .01$.
†Significant difference according to race. $P < .05$.

On the second testing day, all participants performed the running-based anaerobic sprint test (RAST) (Zagatto, Beck, and Gobatto 2009), which was used to measure RSA (Keir, Theriault, and Serresse 2013). Before the RAST, participants warmed up during approximately 15 min (jogging at 50–60% HR_{max} with stretching exercises and 5×50 meters sprint). The RAST consisted of 6×35 m maximal sprints interspaced by 10 s of active recovery between each sprint. The recovery between each sprint was composed of a 5–8 meter of slow run, not a walk or slow jogging, but more of a fast trot. Sprint times were recorded on a digital chronometer connected to photoelectric cells (Brower Timing Systems, USA). The best sprint time or the highest value recorded during RAST(S_{BEST}), mean time (MT) value obtained for the six sprints and power (W) were calculated. The power output in each sprint was calculated by the formula of Draper and Whyte (1997):

$$\text{Power} = (\text{Body Weight} \times \text{Distance}^2)/\text{Time}^3$$

We calculated the peak power (W_{max}), mean power (W_{mean}), and the fatigue index (FI= (Maximum power – Minimum power)/Total time for the 6 sprints)). The RAST outcomes have a test and retest intra class correlation higher than 0.92 (Zagatto, Beck, and Gobatto 2009).

Systolic and diastolic blood pressure were measured at sitting position to detect whether a disorder in body status before and after exercise. Blood pressure measurements were taken at rest before RAST and at the end of RAST (maximum 30-second interval from cessation of exercise) using an automatic blood pressure monitor Omron Model HEM-737AC (Omron Healthcare, Inc., Vernon Hills, IL) recommended by the European Society of Hypertension.

Upon arriving, before the RAST, all participants rested in the sitting position for about 15 min to measure blood pressure, and then a heparinized catheter (Insyte-W, 1.1 mm o.d. × 30 mm) was inserted into an antecubital vein. 5 min later, the first blood sample (5 mL) was taken to determine Hematocrit (Ht) and Hemoglobin (Hb) baseline concentration. Then, five blood samples were collected as soon as possible (average of 50 s), after the 15 min warm-up, at the end of RAST, and at 5, 15 and 30 min of recovery. The samples were immediately placed in a vacutainer tube containing Ethylenediaminetetraacetic acid (EDTA) as an anticoagulant. All blood samples were collected between 9:00 and 11:00 am. The test was performed on the 200 m indoor track with a temperature of (22–23C) and humidity of (40–50%).

Ht and [Hb] were determined directly in quadruplicate, automatically by using standard laboratory procedures (Automat MS9-5, France). And the PVV were calculated (Dill and Costill 1974):

$$\text{PVV} \quad (\%) = 100 \times \left(\frac{\text{Hbx}}{\text{Hby}} \times \frac{(1 - \text{Hty} \times 10^{-2})}{(1 - \text{Htx} \times 10^{-2})} \right) - 100$$

Where x refers to rest values for Ht (%) and [Hb] (g/100 mL), and y refers to the subsequent values for Ht and [Hb] at the end of exercise, after the warm-up period or during the recovery.

Blood sample was collected from the finger (20 μL) at the third minute of recovery and placed in Eppendorfs for measurement of the peak blood lactate concentration ($[La]_{max}$).

Blood lactate concentration was determined using an enzymatic lactate analyzer (Microzym, Cetrix, France). Corrected plasma lactate ([La]c) were measured using the formula of Berthoin et al. (2002):

$$[\mathrm{La}]\mathrm{c} = \frac{([\mathrm{La}]\,\mathrm{p} \times 100)}{(100 - \mathrm{PVV})}$$

Where PVV (%) is the percentage of change in plasma volume and [La]p is plasma lactate concentration.

B.5. Statistical analysis

Statistical analyses were carried out using SPSS for Windows (version 16.0; SPSSInc, Chicago, USA). Data were expressed as mean values ± standard deviation (SD). Normal distribution of the data was verified by Kolmogorov-Smirnov test. Statistical differences of time course and between groups were made by two-way analysis of variance for repeated measures (RM-ANOVA). A power value >0.5 is determined in all parameters.

We determined that a sample size of $n = 9$ per group would be large (Cohen 1988) and sufficient to detect an increase in hemoglobin, hematocrit and plasma volume. When significant differences were found, Bonferroni post-hoc tests were used to determine pair wise differences. $P < .05$ was used as the criterion tor significance.

C. Results

Table 1 gives descriptive statistics for anthropometric measurements and VO_{2max} of the participants. We did not observe any significant ($P > 0.05$) difference between black and white groups for anthropometric data and VO_{2max} levels measured during the maximal graded test.

Table 2 shows results of physical performance measured during RAST. S_{BEST} and mean time measured for the six sprints (MT) values were respectively ($P = .002$) and ($P = .001$) shorter in BW compared to WW.

Fatigue index (FI) was significantly higher in WW compared to BW ($P = .001$) and in WM compared to BM ($P = .002$). In addition; $[\mathrm{La}]c_{max}$ were significantly ($P < 0.05$) lower in blacks compared to white groups.

Table 2. Physical performances, fatigue index and peak blood lactate concentration.

	BM($n = 9$)	WM($n = 9$)	BW($n = 9$)	WW($n = 9$)
S_{BEST} (seconds)	5.0 ± 0.2**	5.1 ± 0.1**	5.6 ± 0.3†	6.1 ± 0.5
MT (seconds)	5.4 ± 0.3**	5.5 ± 0.2**	6.1 ± 0.4†	6.7 ± 0.6
W_{max} (W)	714.3 ± 109.4**†	643.1 ± 98.8**	424.8 ± 51.6†	365.30 ± 127.3
W_{mean} (W)	587.6 ± 110.5**	526.2 ± 92.7**	336.3 ± 34.5	277.1 ± 98.7
FI (%)	33.5 ± 13.2†	39.9 ± 14.4	36.7 ± 10.5†	46.0 ± 15.1
$[\mathrm{La}]p_{max}$ (mmol L^{-1})	11.8 ± 2.3†	15.4 ± 3.2	12.5 ± 3.9	13.3 ± 2.3
$[\mathrm{La}]c_{max}$ (mmol L^{-1})	10.6 ± 1.3†	13.8 ± 4.1	11.5 ± 4.0†	13.5 ± 2.5

Data are means (±SD) BM: black men, WM: white men, BW: black women, WW: white women, S_{BEST}: Best Sprint Performance recorded, MT: Mean time for 6 sprints, W_{max}: maximum power, W_{mean}: mean power, FI: fatigue index, $[\mathrm{La}]p_{max}$: peak plasma lactate concentration, $[\mathrm{La}]c_{max}$: peak corrected plasma lactate concentration;

*Significant difference according to sex: BM vs. BW, WM vs. WW. $P < .05$.

**$P < .01$.

†Significant difference according to race: BM vs. WM, BW vs. WW. $P < .05$.

Table 3 shows the RAST outcome measured during each sprint. Sprints running time were respectively shorter ($P = .004$, $P = .006$, $P = .007$, $P = .004$ and $P = .003$) during the first, third, fourth, fifth and sixth sprint in BW compared to WW.

Table 4 shows plasma Ht and [Hb] concentration determined at rest after warm-up, at the end of RAST and after 5, 15 and 30 min of recovery. We observed significantly higher [Hb] ($P = .010$) and Ht ($P = .004$) in BW compared to WW during the 5th minute of recovery. This result was accompanied by a significant ($P = .000$) difference from the resting values in BW during the 5 and 15 min of recovery.

The Figure 1 shows PVV measured at the end of warm-up, RAST and during recovery for all groups. The PV decreased at the end of warm-up and RAST and increased during recovery for all groups. The PV decrease was higher at the end of RAST for all groups when comparing with warm-up, but was only significant for WM (−12.6 ± 8.9%, $P = .007$). Interestingly, the PV increase during recovery (at 5 min of recovery) was significantly higher ($P = .003$) in WW (+1.1 ± 5.3%) compared to BW (−10.11 ± 6.1%).

D. Discussion

It is important to note, first, that most previous researches about racial/ethnic disparities on physical performances have never been studied from female angle. Second, the majority of these results were observed in South African (Coetzer et al. 1993), Scandinavians (Saltin et al. 1995), or East African individuals (Saltin et al. 1995) but never in North African individuals. Hence, this study is the first to report that Black North African women (BW) had significantly lower S_{BEST} and FI compared to WW. Black groups had also lower FI and $[La]c_{max}$ compared to white groups. Hematocrit and hemoglobin were significantly higher in BW compared to WW at the 5th minutes of recovery. Interestingly, significant differences on PVV were observed between WW and BW at the 5th minute of recovery.

'Anaerobic performance superiority' observed in our study suggest that black population possess number of characteristics that are acquired through gender (Weber and Schneider 2000), muscle mass (Perez-Gomez et al. 2008), properties of muscle fiber types (Komi et al. 1977), training status and lifestyle (Makrides, Heigenhauser, and Jones 1990), substrate availability and accumulation of reaction products (Harley et al. 2009), aerobic capacity (Hill 1999), and genetic characteristics (Bouchard et al. 1992). Hence, we supposed that sprint/repeated sprint performances disparities may be related to racial differences in any or all of the factors mentioned above.

Table 3. Running duration (seconds) measured after each sprint during repeated sprint exercise.

	Sprint 1	Sprint 2	Sprint 3	Sprint 4	Sprint 5	Sprint 6
BM ($n = 9$)	5.1 ± 0.2*	5.1 ± 0.3**	5.4 ± 0.2*	5.4 ± 0.4**	5.7 ± 0.3*	5.6 ± 0.4**
WM ($n = 9$)	5.1 ± 0.1**	5.1 ± 0.1**	5.4 ± 0.2**	5.5 ± 0.3**	5.8 ± 0.4**	6.0 ± 0.7**‡
BW ($n = 9$)	5.6 ± 0.3†	5.9 ± 0.4	6.0 ± 0.4†	6.3 ± 0.5†	6.4 ± 0.5†	6.6 ± 0.6†‡
WW ($n = 9$)	6.2 ± 0.5	6.1 ± 0.5	6.5 ± 0.6	6.9 ± 0.6	7.1 ± 0.7*	7.5 ± 0.8‡

Data are means (±SD) BM: black men, WM: white men, BW: black women, WW: white women; *: Significant difference according to sex: BM vs. BW, WM vs. WW.

*$P < .05$,

**$P < .01$.

†Significant difference according to race: BM vs. WM, BW vs. WW. $P < .05$.

‡Significant difference from the first sprint. $P < .05$.

Table 4. Hemoglobin concentrations and Hematocrit values measured during repeated sprint exercise.

		BM ($n = 9$)	WM ($n = 9$)	BW ($n = 9$)	WW ($n = 9$)
Hemoglobin (g/100 ml)	Rest	14,46 ± 0.51*	14.53 ± 1.69*	11.86 ± 0.52	11.98 ± 0.60
	Warm-up	14.68 ± 0.72*	15.13 ± 1.30*	12.32 ± 0.68	12.11 ± 0.67
	End of RAST	15.30 ± 0.89*	15.68 ± 1.29**	12.31 ± 0.98	12.22 ± 0.69
	Rec. 5 min	14.87 ± 0.59*	15.50 ± 1.47**	12.44 ± 0.59†	11.81 ± 0.92
	Rec. 15 min	14.79 ± 0.45*	15.10 ± 1.54**	12.10 ± 0.47	11.89 ± 0.92
	Rec. 30 min	14.20 ± 0.61*	14.40 ± 1.28*	11.60 ± 0.33	11.78 ± 1.25
Hematocrit (%)	Rest	43.83 ± 1.92*	44.41 ± 4.52*	35.86 ± 1.61	36.78 ± 1.77
	Warm-up	45.88 ± 1.92*‡	45.51 ± 3.84*	37.78 ± 1.94	37.80 ± 1.09
	End of RAST	46.81 ± 2.57*‡	47.74 ± 4.06**‡	38.66 ± 2.57	38.09 ± 1.29
	Rec. 5 min	45.92 ± 1.87*‡	47.17 ± 4.24**‡	39.71 ± 1.71†‡	37.03 ± 1.22
	Rec. 15 min	45.97 ± 1.96*	45.75 ± 4.58*	38.21 ± 2.10‡	37.19 ± 1.92
	Rec. 30 min	44.16 ± 2.54*	43.59 ± 3.91*	36.94 ± 2.88	36.69 ± 3.13

Data are means (±SD) BM: black men, WM: white men, BW: black women, WW: white women, Rec.: recovery, RAST: Running anaerobic sprint test;
*Significant difference according to sex: BM vs. BW, WM vs. WW, $P < .05$,
**$P < .01$.
†Significant difference according to race: BM vs. WM, BW vs. WW, $P < .05$.
‡Significant difference from resting values, ‡$P < .05$.

First of all, we examined differences in anthropometric measurements to better understand the muscle mass contribution. These results reported no differences across groups (Black vs. White) in body mass (kg), lean mass (kg) and body fat (%). In addition, results of lower limb lengths were similar among the groups. However, because of the poor prognosis of this anthropometric testing approach, we cannot definitely suggest that muscle mass contribution would not affect anaerobic performance differences.

In addition, muscle fiber type is thought to affect sprint performances. In their review, Ceaser and Hunter (2015) explained that non-Hispanic black adult, which had lower maximal aerobic capacity, had higher percentage of fast twitch fibers than white adults.

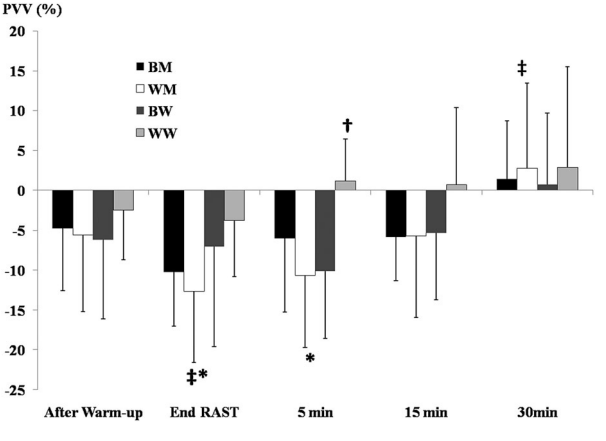

Figure 1. Plasma volume variations (%) determined after warm-up, at the end of RAST, and after 5, 15 and 30 minutes of recovery. Data are means (±SD) PVV: Plasma volume variation (%), BM: black men, WM: white men, BW: black women, WW: white women.
*Significant difference according to sex: BM vs. BW, WM vs. WW, *$P < .05$.
†Significant difference according to skin color: BM vs. WM, BW vs. WW, †$P < .05$.
‡Significant different from "warm-up" values, ‡$P <. 05$.

Kohn, Essén-Gustavsson, and Myburgh (2007) also suggested a preponderance of fast twitch muscle fibers in black athletes. According to these authors, the skeletal muscle phenotype of black runners is different from the white groups and suggested that the most determinant factor of racial/ethnic differences in human performance is the contribution of fast twitch fibers during sprint. Studies that further evaluate these hypotheses are needed.

Furthermore, products such as lactate and hydrogen ion (H+) concentration may contribute to differences in sprint and repeated sprint performances (Harley et al. 2009). In our study, black participants had lower $[La]c_{max}$ and FI (%) compared to the white subjects. Kohn, Essén-Gustavsson, and Myburgh (2007) reported similar results but suggested that training status could explain disparities in lactate between black and white endurance runners. Therefore, one can only speculate that, in this study, the lower lactate levels measured in blacks athletes may be related to both a lower lactate production and/or a higher lactate clearance. Nevertheless, if we assume that black participants had higher percentage of fast twitch fibers, as described in literature (Ceaser and Hunter 2015; Rogatzki et al. 2015), the lower lactate levels measured in these subjects could possibly be due to higher lactate removal process. Hence, it may be necessary to investigate lactate clearance during repeated sprint exercise in different races.

On the other hand, all participants had similar training status levels (150–180 $min.week^{-1}$ of physical activity) with a moderate levels of VO_{2max} (Men: ~56,65 $mL.min^{-1}.kg^{-1}$ for men and Women: 46,45 $mL.min^{-1}.kg^{-1}$) (Astrand 1960). When compared to each other, there were no differences in estimated VO_{2max} between black and white groups.

The aerobic contribution could reach 30 to 45% during an all-out exercise such as 30s-wingate test (Granier et al. 1995) and represents a greater proportion during a repeated sprint exercise (McGawley and Bishop 2015). Hence, the oxygen capacity transport and blood viscosity (Berthoin et al. 2002; Zouhal et al. 2007) could influence sprint performance and recovery capacity. In this study, hemoglobin and hematocrit levels measured at rest and at the end of RAST were not different between groups, but increased in the BW's group compared to WW during the 5thminute of recovery. To the best of our knowledge there are no data on the racial-differences in blood count in response to maximal exercise or during recovery, but there is also evidence that black individuals (i.e. African-Americans) have lower resting hemoglobin levels compared to White ones (Beutler and West 2005). Mairbäurl (2007) have explained that higher Hb induce higher blood viscosity with greater dehydration, which leads to greater PV reduction. Interestingly, during the 5th minutes of recovery, we observed difference between WW and BW in PVV. This racial difference in PVV could be explained by disparities in body's recovery capacity across the experimental groups. PVV depends on factors such as sweating and concentrations of hormones (i.e. aldosterone and the antidiuretic hormone), electrolytes (i.e. Na^+, Ca^{2+}, H^+ etc.), proteins (i.e. serum albumins, globulins, and fibrinogen), gases (O_2 and CO_2) and metabolites such as lactate and glucose.

There is strong evidence to support the use of lactate level as a direct indicator of activation of short term energy process during strenuous workout (Goodwin et al. 2007; McArdle, Katch, and Katch 2010). In this study, lactate levels were demonstrated to be lower in black compared to white groups. Hence, it is possible that this product is a racial-depend factor that could influence anaerobic performances, but should not be

understood as an essential determinant for best performance among groups classified according to race.

In summary, this study demonstrates, for the first time that repeated sprint performances were higher in black women compared to white ones. Despite similar aerobic capacity, plasma substrates content such as lactate, hemoglobin, hematocrit and plasma volume were distinct between black and white women in response to RAST. Hence, it is of absolute importance to pay attention to these racial differences when analyzing physical performances in women.

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