ORIGINAL ARTICLE

Coronary risk in a cohort of Paralympic athletes

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Objective: To determine the prevalence of coronary risk factors in Paralympic athletes and evaluate their risk of coronary events.

Method: An observational prospective cross sectional study of 79 consecutive Brazilian Paralympic athletes (mean (SD) age 27.8 (6.7) years (median 26 years)). There were 56 men and 23 women, 67 with physical and 12 with visual disabilities. The occurrence of systemic hypertension, hypercholesterolaemia, diabetes mellitus, smoking, familial antecedents, obesity, and hypertriglyceridaemia was investigated. The risk of coronary events was calculated using the American Heart Association *Coronary risk handbook*, and also the 10 year probability of a coronary event using the Framingham risk score.

Results: The prevalence of risk factors was: systemic hypertension, 11%; familial antecedents, 10%; smoking, 9%; hypertriglyceridaemia, 6%; hypercholesterolaemia, 1.3%; obesity, 4%; diabetes, 0%. They occurred in 51% of the Paralympic athletes: one factor (41%), two factors (4%), and three factors (6%). The risk of coronary events was absent in 80%, slight in 17%, and moderate in 3%. This could only be evaluated in 81% of the athletes, as 8% had amputations, 9% were young, and 2% had unknown familial antecedents. The Framingham risk score ranged from -14 to +6, predicting a 10 year probability of a coronary event of 3.3 (3.8%).

Conclusion: This study shows a reasonably high prevalence of coronary risk factors (51%), despite a low probability of coronary events in Paralympic athletes. The lipid and blood pressure profiles were similar in ambulatory and wheelchair athletes.

Coronary heart disease (CHD) is an important cause of mortality in the world. The main coronary risk factors (CRFs) are cigarette smoking, hypercholesterolaemia, high density lipoprotein (HDL)-hypcholesterolaemia, systemic hypertension, familial antecedents of premature CHD, diabetes mellitus, hypertriglyceridaemia, obesity, and physical inactivity.

Active populations have a low prevalence of CRFs. Sedentary disabled people have a higher occurrence of CHD.¹ Paralympic athletes constitute a special group of athletes. They face the sort of emotional stress and economic difficulties that can endanger health. They also have associated diseases and cardiovascular overload caused by abnormal walking.

This report evaluates the prevalence of CRFs and the coronary risk in a prospective cross sectional study in Brazilian Paralympic athletes.

As far as we know, this is the first report on CRFs in Paralympic athletes with different disabilities.

METHODS

Participants

Eighty athletes, 59 men (75%) and 21 women (25%) (mean (SD) age 27.8 (6.7) years (range 15-49)) were chosen by the Brazilian Paralympics Committee for the Brazilian team. One athlete was excluded because he lived abroad. The sports represented were football (18), swimming (15), jumping (11), sprinting (six), judo (four), marathon running (two), cycling (one), and pentathlon (one). Of this cohort, 17 athletes (22%) participated only in sports activities, whereas 62 (78%) also participated in other activities. Their disabilities were visual (12 cases, 15%) and physical (67 cases, 85%), including poliomyelitis sequelae (27 cases, 34%), cerebral palsy (21 cases, 27%), spinal cord injury (SCI; 11 cases, 14%; level of injury: C4-6 (one), C6-7 (one), T2-3 (two), T5-6 (one), T7 (one), T12 (three), L (two)), amputation (six cases, 8%; sites of amputation: right/left thigh (three); left thigh (one); left leg (one)), sequelae of acute idiopathic polyneuropathy (one case, 1%), and congenital absence of left thigh (one case, 1%).

The number of training hours a week were: 0-6 (31 athletes, 40%); 7-12 (27 athletes, 34%); 13-18 (nine athletes, 11%); 18-24 (three athletes, 4%); >25 (nine athletes, 11%). This ranged from less than one hour a week (21 year old male footballer with cerebral palsy) to 50 hours a week (24 year old male, professional, physically disabled athlete, field events—jumping).

Previous participation in sports activities ranged from three to 300 months (median 60 months): 0-59 months (36 athletes, 46%); 60-119 months (27 athletes, 34%); 120-179 months (nine athletes, 11%); 180-239 months (six athletes, 8%); ≥240 months (one athlete, 1%).

Table 1 gives the major relevant characteristics of the subjects. Athletes with visual impairment had a mean (SD) age of 26 (6) years, weight of 68 (14) kg, height of 169 (7) cm, and body mass index (BMI) of 24 (3).

To evaluate differences between wheelchair and ambulatory athletes, 32 participants were divided into two groups:

- Group I (n = 19), ambulatory athletes (all male) with cerebral palsy (n = 12) or poliomyelitis sequelae (n = 7); 12 were footballers and seven field athletes (jumping)
- Group II (n = 13), wheelchair athletes (five men) with poliomyelitis sequelae (n = 11) or limb amputation (n = 2).

The study followed the policy statement regarding the use of human subjects, and informed written consent was obtained.

Procedures

The athletes were evaluated two to three months before the Paralympics at the Exercise Physiology Laboratory of the Federal University of São Paulo. Clinical evaluations were performed by three experienced doctors. A questionnaire was

Abbreviations: AHA/CRH, American Heart Association *Coronary risk handbook*; BMI, body mass index; CHD, coronary heart disease; CRF, coronary risk factor; HDL, high density lipoprotein; LDL, low density lipoprotein; SCI, spinal cord injury

Table 1 Clinical data and risk factor profile for 79 Brazilian Paralympic athletes

Variable	Mean	SD	Median
Age (years)	27.8	6.7	26
Male	27.0	5.9	25
Female	29.4	11.8	31
Weight (kg)	62.2	12.8	62
Male	65.2	12.2	66
Female	54.9	11.7	52.5
Height (cm)	166.6	9.8	167
Male	166.7	24.3	169
Female	151.6	35.2	157
Body mass index (kg/cm ²)	22.0	4.2	21.9
Male	21.2	6.0	22.1
Female	18.1	8.3	20.8
Training (hours/week)	12.0	9.5	9.5
Previous sport participation (months)	76.1	58.3	60
Cholesterol (mg/dl)	171.2	30.0	170
HDL-cholesterol (mg/dl)	46.7	11.5	45
Glucose (mg/dl)	88.5	8.2	88
Triglycerides (mg/dl)	86.8	55.1	68
Systolic blood pressure (mm Hg)	118.8	17.1	120
Paraplegics (n=9)	124	25.6	125
Quadriplegics (n=2)	107.5		
Diastolic blood pressure (mm Hg)	60.4	11.0	70
Paraplegics	67.5	12.9	65
Quadriplegics	67.5		

There were 56 men (71%) and 23 women (29%).

used to assess smoking behaviour and familial antecedents of CHD, hypertension, and diabetes. CHD antecedents were considered to be present if there had been myocardial infarction or sudden death in a first degree relative (male < 55 years old and female < 65 years old).² Blood tests included glucose, triglycerides, total cholesterol, low density lipoprotein (LDL)-cholesterol, and HDL-cholesterol. The following were investigated: hypertension; hypercholesterolaemia; diabetes; cigarette smoking; familial antecedents of CHD; obesity; hypertriglyceridaemia.

Blood pressure was measured with a properly calibrated and validated sphygmomanometer in a secluded room. Subjects sat quietly in a chair for at least five minutes. At least two measurements were taken with the arm supported at heart level. Systolic blood pressure was assessed in phase I, and diastolic blood pressure in phase V. Criteria for hypertension were: 120–139/80–89 mm Hg (pre-hypertension); 140–159/90–99 mm Hg (stage I); $\geq 160/100$ mm Hg (stage II).³

A 15 ml venous blood sample was drawn from the antecubital vein after a 12 hour fast and 24 hours after the last bout of exercise. Samples were analysed using automated colorimetric and fluorimetric methods (VITROS Chemistry Products; Ortho-Clinical Diagnostics, Rochester, New York, USA). The coefficients of variation for each assay were 1.3% (total cholesterol), 2.9% (HDL-cholesterol), 1.5% (triglycerides), and 1.7% (glucose). LDL-cholesterol was estimated using the Friedwald equation.^{3a} Dyslipidaemia criteria were: total cholesterol ≥ 240 mg/dl; HDL-cholesterol <40 mg/dl; triglycerides ≥ 200 mg/dl.⁴ A fasting plasma glucose concentration ≥ 126 mg/dl was considered to indicate diabetes mellitus; glucose concentrations of 100 and 125 mg/dl were classified as pre-diabetic.⁵

The nutritional indicator was BMI. Weight and height were measured by specially trained health technicians, using standard equipment. Some subjects were classified as overweight (BMI ≥ 25 – kg/m^2) or obese (BMI ≥ 30 kg/m^2).⁶

Coronary risk was predicted from the American Heart Association *Coronary risk handbook* (AHA/CRH) score.⁷ Coronary risk was classified as absent (0–8 points), potential (9–17 points), moderate (18–40 points), high (41–59 points), in the danger range (60–67 points), and in the maximal

danger range (68 points). The Framingham risk score was used to determine the 10 year coronary event expectation.⁸

Statistical analysis

Results were expressed as mean (SD) and median. Student's *t* test was used to compare variables between the ambulatory (group I) and wheelchair (group II) athletes. The Fisher test was used to evaluate the difference in prevalence of hypertension between the two groups. $p < 0.05$ was considered significant.

RESULTS

There was no cardiovascular disease in 65 participants (8%). Aortic regurgitation was diagnosed in one case (1%) and asymptomatic chronic Chagas disease in another.

Tables 1–3 show the prevalence and mean values of variables.

Values for athletes with visual impairment were as follows: blood pressure, 121 (11)/72 (9) mm Hg; glucose, 91 (56) mg/dl; triglycerides, 67 (34) mg/dl; total cholesterol, 183 (43) mg/dl; HDL-cholesterol, 50 (9) mg/dl; LDL-cholesterol, 117 (40) mg/dl. There was one case of hypertension, one case of hypercholesterolaemia, one case of obesity, one case of tobacco use, and in two cases there were familial antecedents.

Familial antecedents of coronary artery disease were found in eight cases (10%). Two subjects were adopted and therefore familial antecedents could not be sought.

Tobacco use was recorded in seven cases (9%); six athletes smoked fewer than 10 cigarettes a day, and one smoked 10–20 cigarettes a day. Two participants were recent ex-smokers.

Hypertension was detected in nine athletes (11%). Stage II hypertension occurred in two (3%) and was controlled. Stage I hypertension was registered in seven cases (8%). Blood pressure reached 142.86 (6.05)/80.71 (8.37) mm Hg in those cases. Pre-hypertension was found in 33 participants (42%). Their mean (SD) arterial pressure was 125.60 (5.02)/69.17 (9.40) mm Hg. Another patient showed the white coat effect without hypertension. Blood pressure and the prevalence of hypertension showed no significant differences between groups I and II.

Total cholesterol was high in one athlete (1%), borderline in 11 (14%), and desirable in 67 (85%). Low HDL-cholesterol concentrations occurred in 20 athletes (25%). A desirable HDL-cholesterol concentration was found in nine cases (11%). Hypertriglyceridaemia was found in five athletes (6%); four had triglyceride concentrations >200 mg/dl (5%). There were no cases of triglyceride concentration >400 mg/dl. There was no difference in the lipid profiles of groups I and II.

Diabetes mellitus was not recorded in this cohort. Pre-diabetes was noted in eight athletes (10%). In 27 subjects (34%), there were diabetic familial antecedents. Mean glucose concentration was higher in group I, but it remained within the normal range.

BMI was determined in 73 cases (92%) as follows: <20 kg/m^2 , 18 cases (23%); 20–25 kg/m^2 , 42 cases (53%); 25–30 kg/m^2 (overweight), 10 cases (13%); >30 kg/m^2 (obese), three cases (4%). In six athletes with amputations, the BMI could not be assessed. Despite a higher weight and height of athletes in group I than in group II, there was no difference in mean BMI between the groups.

CRFs were present in 40 participants (51%). Their prevalence ranged from 0 to 3 risk factors by athlete: no factors ($n = 39$, 49%); one factor ($n = 32$, 41%); two factors ($n = 3$, 4%); three factors ($n = 5$, 6%).

There were no significant correlations between the variables involved in the main CRFs and physical training (hours/week) (table 4).

The AHA/CHR score showed that coronary risk was absent in 80% of athletes, slight in 17%, and moderate in 3%.

Table 2 Prevalence of coronary risk factors in 79 Paralympic athletes

Coronary risk factor	Criterion	Prevalence	Reference
Systemic hypertension			15
Stage 1	140–159/90–99 mm Hg	7 (8)	
Stage 2	≥160/100 mm Hg	2 (3)	
Tobacco use		7 (9)	
Hypercholesterolaemia	≥240 mg/dl	4 (5)	7
HDL-hypocholesterolaemia	<40 mg/dl	21 (27)	
Diabetes mellitus	≥126 mg/dl	0 (0)	1
Familial antecedent 1st degree*		12 (15)	8
Hypertriglyceridaemia	≥200 mg/dl	4 (5)	7
Obesity	BMI > 30	3 (3.5)	6

Values in parentheses are percentages.

*Familial antecedent of myocardial infarction or sudden death in first degrees relatives (male < 55 years and female < 65 years).

BMI, Body mass index; HDL, high density lipoprotein.

Coronary risk was not assessed in athletes aged <20 years (9%), those with unknown familial antecedents (2%), or athletes with amputations (8%), because of the interference with BMI.

The Framingham risk score was evaluated in 31 subjects aged 29 or above. It ranged from −14 to +6, corresponding to a 10 year coronary event expectation of 1–10% (3.3 (3.8)%). However, the score could not be applied to 48 younger athletes (61%), aged 15–29 years (23.13 (3.39) years).

DISCUSSION

There are few data on CRF prevalence in Paralympians, and only for athletes with SCI.^{1 5 9–19} This study looks at Paralympians with different disabilities, 14% of which have SCI. As far as we know, this is the first report on CRFs in Paralympic athletes with other disabilities.

In disabled sedentary people, the lack of physical activity, the increased body weight, the associated diseases, and the lifestyle make them prone to coronary artery disease.¹ Demirel *et al*¹⁵ studied a cohort of athletes with SCI similar to our sample, which included 69 subjects (77% male, mean (SD) age 33.9 (11.37) years). They reported cigarette smoking in 54%, hypertension in 0%, high total cholesterol in 32%, low HDL-cholesterol in 52%, and diabetes in 7%.

We found a different CRF profile (table 2). CRFs were found in 51% of the Paralympians. The most common was smoking (9%), an uncommon risk in able bodied athletes. It can be hypothesised that CRF prevalence was related to physical activity.

Blood pressure

Endurance activities prevent the development of hypertension and cause a decrease in blood pressure in hypertensive patients.²⁰ Static exercises produce considerable increases in blood pressure and slight increases in cardiac output.²¹ Daily exertion includes components of isometric exercise mainly in wheelchair athletes. The upper limbs and thoracic muscles maintain body posture. Their work causes clear increases in blood pressure. Haddad *et al*¹⁰ showed significant decreases in blood pressure in disabled athletes after upper limb training. In this study, we found nine hypertensive athletes (11%). However, the mean blood pressure was normal, and there were no significant differences between ambulatory and wheelchair athletes.

Lipid profile

Sports activity and improvements in physical capacity are significantly associated with favourable changes in lipid

Table 3 Clinical data and risk factor profile in ambulatory (group I) and wheelchair (group II) athletes

	Group I	Group II	p Value
Number	19	13	
Sex (male)	19 (100%)	5 (38%)	
Age (years)	25.2 (6.8)	31.2 (4.6)	0.005
Training (hours/week)	6.4 (3.7)	11.8 (10.1)	NS
Training (years)	44.0 (50.3)	93.5 (68.9)	0.03
Weight (kg)	65.7 (12.2)	56.3 (12.6)	0.038
Male	65.7 (12.2)	58.0 (13.9)	
Female		55.3 (11.7)	
Height (cm)	171.5 (6.5)	162.2 (10.9)	0.011
Male	171.5 (6.5)	170.0 (9.4)	
Female	157.3 (9.0)		
BMI (kg/m ²)	22.3 (4.1)	19.6 (6.9)	NS
Male	22.3 (4.1)	15.4 (8.9)	
Female	22.3 (3.9)		
Total cholesterol (mg/dl)	159.7 (25.1)	170.9 (28.6)	NS
HDL-cholesterol (mg/dl)	44.4 (14.0)	49.7 (12.0)	NS
LDL-cholesterol (mg/dl)	97.3 (20.5)	103.9 (31.1)	NS
Triglycerides (mg/dl)	84.2 (50.8)	84.4 (88.5)	NS
Glucose (mg/dl)	91.4 (5.7)	85.4 (7.8)	0.027
Systolic BP (mm Hg)	122.4 (17.8)	112.9 (15.6)	NS
Diastolic BP (mm Hg)	69.5 (9.2)	67.5 (1.0)	NS
Systemic hypertension	3 (16%)	1 (8%)	NS

Values are number (%) or mean (SD).

BMI, Body mass index; BP, blood pressure; HDL, high density lipoprotein; LDL, low density lipoprotein; NS, non-significant ($p > 0.05$).

Table 4 Correlations between the variables involved in the main coronary risk factors and physical training (hours/week) in 79 Paralympic athletes

Variable	Pearson coefficient
Total cholesterol	-0.141
HDL-cholesterol	0.128
LDL-cholesterol	-0.135
Triglycerides	0.012
Systolic blood pressure	0.076
Diastolic blood pressure	0.059
Body mass index	0.055

HDL, high density lipoprotein; LDL, low density lipoprotein.

profile. The literature suggests a potential association between increased physical activity and increased HDL-cholesterol in patients with SCI.¹⁶ The modality, frequency, intensity, and duration of the exertion and the physiological mechanism of this association remain unclear. Washburn and Fignon¹⁶ proposed a hypothetical model of consecutive events: (1) SCI; (2) muscle paralysis and autonomic decentralisation; (3) inability to voluntarily exercise a large muscle mass; (4) decreased physical activity; (5) decreased exercise tolerance, fitness, and mobility; (6) change in body composition, increased fat mass, and decreased lean body mass; (7) increased insulin resistance and hyperinsulinaemia; (8) increased hypertriglyceridaemia; (9) decreased HDL-cholesterol; (10) increased coronary risk; (11) increased secondary cardiovascular disabilities; (12) increased functional impairment; (13) deconditioning and decreased functional capacity.

In patients with SCI who did exercise training during the first two years after injury, Dallmeijer *et al*¹¹ found decreases in total cholesterol, LDL-cholesterol, triglycerides, and apoprotein A, and a tendency for increases in HDL-cholesterol and the ratio apoprotein A/apolipoprotein B. In well trained paraplegics, Bostom *et al*¹² found a significant relation between peak aerobic power and risk factors. Dearwater *et al*¹³ reported higher HDL-cholesterol concentrations in highly trained athletes with SCI than in sedentary subjects. However, total cholesterol and triglyceride concentrations were similar in the two groups. Brenes *et al*¹⁴ recorded higher HDL-cholesterol concentrations in athletes with SCI (42.7 (6.9) mg/dl) than in sedentary men with SCI (34.8 (6.8) mg/dl). Total cholesterol concentration was lower in the athletes (151 (27) mg/dl) than in the sedentary men (172 (39) mg/dl). There were no differences in triglyceride concentration. However, in patients with SCI who did low intensity training, lipid concentrations remained unaltered, but significant changes did occur after moderate intensity training.⁹ In contrast, Eisenmann *et al*²² found that the lipid profile of young distance runners was similar to that of youth in the general population except for HDL-cholesterol.

As we expected, our Paralympians had similar total cholesterol, HDL-cholesterol, and triglyceride concentrations to other disabled athletes with SCI, despite the fact that the prevalence of SCI was only 14%.^{14, 15} However, their lipid concentrations were lower than the patients with SCI.¹⁵ These findings may be associated with the sports activity. However, we found no correlation between HDL-cholesterol and physical training. In general, in cross sectional studies, relations between training status and lipid profile are confounded by differences in active muscle mass as a result of different injuries.¹¹

Obesity

Active wheelchair sportspeople are heavier with a higher BMI than able bodied controls. The changes in body mass are a

consequence of increased muscle mass, as shown by the sum of four skinfolds.¹¹ In our cohort, the prevalence of overweight (13%) and obesity (3%) was relatively low. There may be a relation between low BMI and favourable lipid profile. Dallmeijer *et al*¹¹ showed that the adipose tissue in people with SCI may in part be responsible for the unfavourable lipid profile.

Diabetes

A high prevalence of impaired glucose tolerance has been reported in people with long-standing SCI.¹⁸ Bauman and Spungen²³ reported abnormal glucose tolerance in sedentary quadriplegics (38%) and sedentary paraplegics (50%). The high concentrations of insulin were associated with decreased HDL-cholesterol and increased cardiovascular risk.¹⁶ Physical activity increases sensitivity to insulin, diminishes glucose release by the liver, and reduces postprandial glycaemia and obesity.¹⁶ It is an independent effect, but is further increased with weight reduction.²² Our Paralympic athletes trained 12.0 (9.5) (median 9.5) hours a week, and had a low BMI; their glucose and triglyceride concentrations were within the reference levels. Despite 27 athletes (34%) having diabetic familial antecedents, no diabetes was recorded. Dearwater *et al*¹³ studied highly trained athletes with SCI and reported similar glucose and insulin concentrations to sedentary subjects with SCI. They suggested that these variables may not be associated with physical activity.

Physical inactivity

The physical inactivity observed in disabled populations is associated with an increased cardiovascular risk.¹ Victims of traumatic SCI are prone to circulatory peripheral impairment due to arteriosclerosis and thrombosis. Their risk of limb amputation is seven times higher than for active people.^{1, 10} Nash *et al*¹⁹ reported the beneficial effects of circuit resistance training on fitness, lipid profile, and cardiovascular risk in paraplegics.

Athlete's heart is a physiological adaptation to physical training.²⁴ Preparticipation screening and assessment of cardiovascular disease in this cohort found clinical and/or electrocardiographic signs of athlete's heart in only 38 cases (51%). However, there were no signs of myocardial hypertrophy on echocardiograms.²⁵ In our cohort, only 22% were professional athletes. Despite the Paralympic participation, they had a low level of training; 40% had performed less than six hours of training a week.

Coronary risk

In our study, there was no coronary risk in 70% of the participants. The risk was potential in 15% and moderate in 3%. The Framingham risk score was assessed in only 31 athletes, aged 29 and above. It showed an expectation of 1–10% of coronary events during the following 10 years. The pretest likelihood of CHD in asymptomatic people can be evaluated from the occurrence and severity of the risk factors.²⁶ The AHA/CRH score can be used to estimate the CHD prevalence in asymptomatic populations. A significant correlation ($r = 0.997$, $p < 0.001$) was reported between prevalence of CHD at autopsy and its estimation by the CRH.⁷ So our athletes can be considered a low risk group for CHD. In fact, when those athletes underwent cardiopulmonary exercise testing, no cases of myocardial ischaemia were recorded.²⁶ In this same group, we published the low occurrence (8%) of late potentials in signal averaged electrocardiograms without cardiac events in a follow up of 22 months.²⁷ It could be hypothesised that the low coronary risk of our Paralympic cohort is associated with their low age and physical training.

For people with SCI, an alternative hypothesis is the involvement of haematological factors in the premature and

What is already known on this topic

- There are few data on the prevalence of coronary risk factors in Paralympic athletes, and only for spinal cord injured athletes.
- A relation between physical activity and lipid profile has been shown.

What this study adds

- A reasonably high prevalence of coronary risk factors was found in Brazilian Paralympic athletes despite a low 10 year probability of CHD events.
- Coronary risk factors were found in 51% of the Paralympians, including systemic hypertension (11%), familial antecedents (10%), smoking (9%), and hypercholesterolaemia (1.3%).
- The risk of coronary events was absent in 80%, slight in 17%, and moderate in 3%.

accelerated atherogenesis such as: (a) a blocker antibody to prostacyclin receptor on the platelet surface; (b) an increased concentration of circulating platelet derived growth factor; (c) lack of the normal inhibition of platelet derived growth factor and platelet stimulated thrombin generation by prostacyclin. Platelet derived growth factor and thrombin are potent mitogenic agents for arterial smooth muscle cells. Thrombin also induces platelet aggregation and fibrin production.¹⁸

Study limitations

The aim of our study was to investigate CRFs in a population including all kinds of Paralympic athletes. The study involved a small sample size and a heterogeneous group of athletes with various disabilities, so it would be very difficult to compare results with those of a non-athlete control group, paired for age, sex, and disability. Otherwise, there is a lack of published epidemiological data on this kind of disabled population.

CONCLUSIONS

The Brazilian Paralympic athletes in this study had a reasonably high prevalence of CRFs despite a low 10 year probability of CHD events. The lipid and the blood pressure profiles were similar in both ambulatory and wheelchair athletes. These data are similar to other findings on athletes with SCI.

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