ORIGINAL RESEARCH

Prevalence of Metabolic Syndrome Among College Football Linemen

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ABSTRACT

OBJECTIVE: To determine the prevalence of metabolic syndrome among Canadian amateur football players.

METHODS: University football players from Saskatchewan were invited to participate in this study. Each subject underwent screening for blood pressure using a BpTRU monitor, and serum cholesterol and fasting blood glucose using a Cholestech LDX analyzer. Waist circumference was recorded and body composition was measured by dual-energy x-ray absorptiometry. Results were compared between linemen and non-linemen using independent sample t-tests for continuous data and chi-square for dichotomous variables.

RESULTS: Out of 39 players who consented to participate, 14% of linemen (3/21) and no non-linemen satisfied metabolic syndrome criteria. Compared to non-linemen, linemen had a higher waist circumference (108.0 vs. 82.9 cm; p<0.001), higher total body fat composition (26.4% vs. 11.2%; p<0.001), lower mean high-density lipoprotein cholesterol (0.93 vs. 1.12 mmol/L; p=0.021) and higher fasting blood glucose (5.22 vs. 4.77 mmol/L; p<0.001).

CONCLUSION: Despite their young age and participation in an elite-level athletic program, many collegiate-level football linemen had features of metabolic syndrome. Although our study focused on a single team, we suspect these trends may be consistent across the country.

KEYWORDS: football players, metabolic syndrome, obesity

RÉSUMÉ

OBJECTIF : Déterminer la prévalence du syndrome métabolique parmi des joueurs de football amateur canadiens.

MÉTHODES : Des joueurs de football universitaire de la Saskatchewan ont été invités à participer à cette étude. Chez chaque sujet, on a procédé à la mesure de la tension artérielle au moyen d'un tensiomètre BpTRU et au dosage du cholestérol sérique et de la glycémie à jeun au moyen d'un analyseur Cholestech LDX. Le tour de taille a été mesuré et la composition corporelle a été déterminée par absorptiométrie biphotonique à rayons X. On a comparé les résultats obtenus chez les joueurs de ligne et les autres joueurs au moyen de tests t effectués sur des échantillons indépendants pour les données continues et au moyen du chi carré pour les variables dichotomiques.

RÉSULTATS : Parmi les 39 joueurs ayant accepté de participer à l'étude, 14 % des joueurs de ligne (3/21) répondaient aux critères de syndrome métabolique, par rapport à aucun des autres joueurs. Par rapport aux autres joueurs, les joueurs de ligne avaient un tour de taille supérieur (108,0 par rapport à 82,9 cm; p < 0,001), une masse adipeuse totale supérieure (26,4 par rapport à 11,2 %; p < 0,001), un taux moyen de cholestérol à lipoprotéines de haute densité inférieur (0,93 par rapport à 1,12 mmol/L; p = 0,021) et une glycémie à jeun supérieure (5,22 par rapport à 4,77 mmol/L; p < 0,001).

CONCLUSION : Malgré leur jeunesse et leur participation à un programme athlétique de haut niveau, beaucoup des joueurs de ligne présentaient des caractéristiques de syndrome métabolique. Bien que l'étude ait été menée auprès d'une seule équipe, les auteurs sont d'avis que les tendances observées pourraient être les mêmes partout au pays.

MOTS CLÉS : joueurs de football, syndrome métabolique, obésité

INTRODUCTION

American-rules football is the most popular spectator sport in the United States (US), and is becoming increasingly popular in Canada (1,2). In Saskatchewan, the age limit to begin organized football has significantly decreased over the past decade, and football is increasing in popular-

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ity among school-aged children (3). In football, increased body mass is generally viewed as advantageous, especially among those who play the position of lineman (4). The desire for size appears to be increasing as well: today's players are much larger physically compared to those of years past (5,6). These trends are also already apparent in youth football players compared to age-matched controls (7,8). Unfortunately, increased body mass among these young football players is often a result of adipose tissue rather than muscle (9).

The large proportion of football players (particularly linemen) who are overweight or obese (4,5,9-15) is concerning given the links between obesity, diabetes and/or cardiovascular disease (16-19). Indeed, studies have shown the presence of elevated systolic blood pressure (BP) (10,20), adverse lipid profiles (13,21) and metabolic syndrome (9,11,14,15) among football linemen in the US. However, the extent to which football players in Canada differ from their counterparts in the US is not known. Canadian collegiate football programs are much smaller than US collegiate programs in terms of viewership and sponsorship—US programs generated revenues in excess of US$3 billion in 2009 (22). As such, competition is much more intense in American collegiate football programs, and, anecdotally, Canadian collegiate and professional football players are generally smaller than their US counterparts.

The University of Saskatchewan is home to one of the most recognized collegiate football programs in Canada. The individuals who play for this team must be enrolled full-time in an undergraduate or graduate program at the university, and they may play for a maximum of 5 years. Although the vast majority will never have the opportunity to play at the professional level, players nevertheless undertake intensive training programs to improve their football prowess. An important goal for many linemen is to increase their body mass and strength during their 5 years of eligibility, but for non-lineman players—especially those who play receiver or defensive-back positions—speed and agility are more important. We aimed to determine whether Canadian college football linemen exhibit characteristics of metabolic syndrome despite their young age and whether they consume significantly more dietary calories compared to their non-linemen teammates.

METHODS

During the 2009 Huskie football training camp held at the University of Saskatchewan, an information session was held for all players describing the purpose of this study. After the meeting, players were asked if they were interested in participating, at which time a consent letter was provided. The goal was to recruit as many linemen as possible and an equal number of non-linemen for comparative purposes.

Risk factor screening

After an overnight fast (minimum of 8 hours) the players arrived at the study site for screening. Upon arrival, the players were instructed to sit quietly for a period of at least 5 minutes. After the mandatory rest period, BP was checked using a BpTRU blood pressure monitor (BpTRU Medical Devices, Coquitlam, British Columbia) using the appropriate cuff size. The accuracy of the BpTRU monitor has been validated in previous studies (23-26). Myers et al found no significant differences between 24 hour mean awake ambulatory BP and values obtained at 2 minute intervals with the BpTRU monitor (26). Players were instructed to sit quietly in an upright position with both feet flat on the floor with the BP cuff at heart level. An initial reading was performed on each arm, and the arm with the highest reading was then used for a series of 6 consecutive BP measurements. The BpTRU monitor discards the first BP reading and averages the subsequent 5 BP readings.

Players' total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), triglycerides, low-density lipoprotein cholesterol (LDL-C), non-HDL-C, TC:HDL-C ratio and fasting blood glucose (FBG) were then determined using the Cholestech LDX analyzer (Cholestech Corporation, Hayward, California). Carey et al found significant correlations between the Cholestech LDX and a hospital reference lab for TC (r=0.92), HDL-C (r=0.92), LDL-C (r=0.86) and triglycerides (r=0.93), all $p<0.001$ (27). The Cholestech LDX is considered to be a suitable point-of-care device and has been validated in previous studies (27-29).

The players also had their height, weight and waist circumference (WC) recorded. WC was measured at the top of the iliac crest with a Lufkin Executive Thinline tape (Cooper Industries, Houston, Texas) by the same investigator (BA) for all players (30). After all of the physical measurements were taken, a medication history was performed by a pharmacist to record any current medications/supplements, medical conditions or immediate family history of cardiovascular disease or diabetes.

Body composition

Within 2 days of risk factor screening, body composition was measured using dual-energy X-ray absorptiometry (DXA) (Hologic Discovery Wi, Bedford, Massachusetts). The DXA scan measured lean and fat tissue mass, along with percent body fat for different zones in the body. The use of DXA has been validated in adolescent athletes and exhibits correlation to air displacement plethysmography for the measurement of body composition (31,32). DXA was used to determine which subjects exhibited >25% body fat, a previously referenced indicator of athlete obesity (4,5,9,15,32).

Dietary history

All players completed a 3 day dietary history to assess total caloric intake, as well as intake of specific indicators, including sodium, fibre, sugar and saturated fat. A 3 day dietary history has been previously used as an assessment tool of dietary habits of collegiate football players (33). A registered dietitian demonstrated to each subject how to measure foods and estimate food quantities. Subjects viewed food models and were instructed to record all food and drink consumption over a 3 day period (2 weekdays and 1 weekend day). The dietitian was readily accessible to answer any questions the players had with respect to their food intake.

Analysis

The variables of interest were those characteristics that define metabolic syndrome: elevated WC (population-specific), elevated triglycerides, reduced HDL-C, elevated BP and elevated blood glucose (34). An analysis was performed comparing the presence of these characteristics among linemen and non-linemen. Secondary endpoints included individual metabolic risk factors, caloric intake and body composition. Independent sample t-tests were used for continuous data and chi-square tests (Fisher's exact) for dichotomous variables. All data were analyzed using SPSS version 17.0 (SPSS Inc, Chicago, Illinois). The study protocol was approved by the University of Saskatchewan Research Ethics Board, and all players provided informed consent prior to participation.

RESULTS

The University of Saskatchewan Huskie football team has 92 football players, of which 39 provided informed consent. This group included almost all linemen (offensive and defensive) (21/28; 75.0%), and a similar number of non-linemen (n=18), consisting of defensive backs, running backs, wide receivers and a quarterback. The mean age of participants was 21.4 years (SD 2.3), and the mean year of eligibility was 2.6 (SD 1.3). Compared to non-linemen, the linemen exhibited a higher body mass index (BMI) (35.6 vs. 26.4 kg/m^2, p<0.001), were younger and had almost a full extra year of eligibility. The characteristics of all players are presented in Table 1.

At least 1 feature of metabolic syndrome was evident in 18 of 21 linemen (85.7%) and 4 of 18 non-linemen (22.2%) (p<0.001). Furthermore, 3 of 21 linemen (14.3%), all under the age of 22, met the diagnostic criteria for metabolic syndrome (3 of 5 criterion) (34). A further 8 of 21 linemen (38.1%) exhibited 2 of the 3 risk determinants necessary to fulfill the criteria for metabolic syndrome (vs. no non-linemen, p<0.001). The number of subjects exhibiting each risk determinant is presented in Table 2.

Overall, linemen exhibited significantly higher WC than non-linemen (mean 108.0 vs. 82.9 cm, p<0.001). An elevated WC (>102 cm) was observed in 15 of 21 linemen (71.4%) and no non-linemen (p<0.001). Further, linemen exhibited significantly higher FBG levels compared to non-

Table 1. Characteristics of players

Variables	*Linemen (n=21)*	*Non-linemen (n=18)*	*p value*
Age, y	20.6 (2.0)	22.2 (2.3)	0.027
Eligibility, y	2.2 (1.4)	3.1 (1.1)	0.042
Height, cm	188.1 (6.1)	182.3 (5.3)	0.003
Weight, kg	125.6 (9.5)	87.6 (7.1)	<0.001
Body mass index, kg/m^2	35.6 (3.5)	26.4 (2.4)	<0.001
Body fat, %*	26.4 (4.5)	11.2 (3.5)	<0.001
Waist circumference, cm	108.0 (9.1)	82.9 (3.8)	<0.001
Family history of diabetes, n (%)	5 (23.8)	1 (5.6)	0.190†

Data are mean (SD) unless otherwise indicated
*Measured by DXA
†Fisher's exact test

Table 2. Criteria for clinical diagnosis of metabolic syndrome

Measure	*Categorical cut points*	*Linemen (n=21) n (%)*	*Non-linemen (n=18) n (%)*	*p value*
Elevated WC	≥102 cm (males)	15 (71.4)	0	<0.001*
Elevated triglycerides	≥1.7 mmol/L	2 (9.5)	0	NA†
Reduced HDL-C	<1.0 mmol/L (males)	12 (57.1)	4 (22.2)	0.052*
Elevated BP	Systolic ≥130 mm Hg and/or diastolic ≥85 mm Hg	1 (4.8)	0	NA†
Elevated FBG	≥5.6 mmol/L	3 (14.3)	0	NA†

From Alberti et al (34) and National Institutes of Health (35)
*Fisher's Exact Test
†Not sufficient for statistical analysis

BP = blood pressure
FBG = fasting blood glucose
HDL-C = high-density lipoprotein cholesterol
WC = waist circumference

linemen (mean 5.22 vs. 4.77 mmol/L; p<0.001), and 3 of 21 linemen (14.3%) exhibited impaired FPG (>5.6 mmol/L) vs. none of the non-linemen (36). Linemen had lower mean HDL-C (0.93 vs. 1.12 mmol/L, p=0.021) and higher mean LDL-C (2.53 vs. 2.05 mmol/L, p=0.008); similar trends were observed for TC/HDL-C ratio and non-HDL-C (Table 3). Overall, 12 of 21 linemen (57.1%) had HDL-C <1.0 mmol/L compared to 4 of 18 non-linemen (22.2%) (p=0.052). No significant differences between linemen and non-linemen were observed with respect to BP, total cholesterol or triglycerides (Table 3).

Table 3. Cardiovascular and metabolic properties

Variables	*Linemen (n=21)*	*Non-linemen (n=18)*	*p value*
Systolic BP, mm Hg*	109.2 (10.1)	106.1 (9.0)	0.309
Diastolic BP, mm Hg *	64.6 (8.5)	63.6 (5.5)	0.668
Pulse, bpm*	68.0 (6.9)	60.5 (8.5)	0.004
TC, mmol/L†	3.86 (0.54)	3.65 (0.70)	0.325
HDL-C, mmol/L†	0.93 (0.22)	1.12 (0.28)	0.021
LDL-C, mmol/L†	2.53 (0.49)	2.05 (0.41)	0.008
TC/HDL-C ratio†	4.38 (1.26)	3.17 (0.66)	0.001
Non-HDL-C, mmol/L†	2.93 (0.61)	2.38 (0.45)	0.005
Triglycerides, mmol/L†	1.05 (0.60)	0.83 (0.17)	0.188
FBG, mmol/L†	5.22 (0.30)	4.77 (0.24)	<0.001

Data are mean (SD)

*Measured by BpTRU electronic BP machine
†Measured by Cholestech LDX. Test results were not available for all players. Recorded results were obtained for TC (n=37), HDL-C (n=38), LDL-C (n=31), triglycerides (n=33), TC/HDL-C (n=36), non-HDL-C (n=36)

BP = blood pressure
FBG = fasting blood glucose
HDL-C = high-density lipoprotein cholesterol
LDL-C = low-density lipoprotein cholesterol
TC = total cholesterol

DXA scan results indicated that the differences in BMI and WC were largely a result of excess adipose tissue. Linemen had a significantly higher percentage of body fat compared to non-linemen (26.4% vs. 11.2%; p<0.001); results were similar for the abdominal region (28.6% vs. 11.3%; p<0.001). Only 7 of 21 linemen (33.3%) had a body fat percentage <25%, while all non-linemen fell below this threshold. Similarly, only 6 of 21 linemen (28.6%) had <25% body fat in the abdominal region, while all of the non-linemen fell under this threshold.

A medical history was performed for all participants, and there were no statistically significant differences between linemen and non-linemen with respect to family history of hypertension or atherosclerosis. There was a trend toward a family history of diabetes in linemen (5 linemen vs. 1 non-lineman, p=0.190). However, there was no correlation between those with higher FBG and family history of diabetes.

Interestingly, we found no significant difference between the mean number of calories consumed per day between linemen and non-linemen (3630 [SD 1060] vs. 3286 [SD 777] kcal, respectively, p=0.263) based on a 3 day dietary history. Likewise, no significant differences were observed with respect to intake of sodium, fibre, sugar, cholesterol or saturated fat.

A post-hoc analysis was performed, whereby players were stratified based on percentage body fat rather than position. Players with <25% body fat were compared to those with ≥25% body fat, but this comparison yielded virtually identical results to what was observed with linemen vs. non-linemen (data not shown). When the analysis was restricted to linemen only and stratified by percentage body fat, significant differences were observed in WC (112 [SD 7.83] vs. 100.14 [SD=5.71] cm, p=0.002) and HDL-C (0.84 [SD 0.17] vs. 1.10 [SD 0.22] mmol/L, p=0.009).

DISCUSSION

This is the first Canadian study to evaluate the prevalence of metabolic syndrome among collegiate football players attending a major university in Canada. Interestingly, 3 of 21 linemen (14.3%), all under the age of 22, satisfied 3 of the 5 criteria for metabolic syndrome, while 8 of 21 (38.1%) satisfied 2 of the criteria. Previous studies in US collegiate football players have shown that 28% to 49% of linemen exhibit the characteristics of metabolic syndrome (9,15,37). It is possible that the lower prevalence observed among Canadian players is because only 1 lineman had elevated BP according to the metabolic syndrome criteria, whereas observed BP was much higher in US linemen (15,38).

A comparison of various cardiometabolic risk factors among linemen and non-linemen highlighted several morphological differences. The linemen were taller, heavier and had a much higher BMI than non-linemen. However, given that BMI is not seen as an accurate predictor of obesity in athletes, WC and body composition were also obtained. The mean WC of non-linemen was 82.9 cm, vs. 108.0 cm for linemen, and 71.4% of linemen had a WC >102 cm, an often-referenced indicator of abdominal obesity. Another indicator of obesity is having ≥25% body fat, and a DXA scan revealed that 36% of players crossed this threshold, all of them linemen. Hence, it is possible that the intermittent energy expended in football is not enough to affect adipose disposition (8). These findings are significant given the intense focus on obesity as a risk factor for the development of metabolic syndrome, diabetes and cardiovascular disease.

The football players studied were physically active; however, the vast majority of linemen exhibited significant

obesity and fat mass. Although it was plausible that these young players may have exhibited the "fat and fit" phenomenon, in which obesity is not accompanied by metabolic disturbances (39), the hypothesis did not appear to hold true in this sample. These athletes, only in their early 20s, already exhibited significant differences in multiple metabolic risk factors for the development of diabetes and cardiovascular disease compared to a comparative group of teammates around the same age.

A study performed by the National Institute for Occupational Safety and Health in the US found an increased rate of cardiovascular mortality among retired professional football linemen (from the National Football League) compared to matched controls (40). It was found that linemen had a 52% greater risk of dying from cardiovascular disease. Upon examining metabolic syndrome determinants and other markers of cardiovascular risk, we observed differences in the lipid profiles between linemen and non-linemen, as well as clear differences in FBG. These trends were virtually identical when players were stratified by percentage body fat rather than position.

Three linemen already fulfilled the criteria for a diagnosis of metabolic syndrome. A larger percentage displayed characteristics that did not meet the criteria, but would nevertheless also warrant further follow-up in a clinical setting, given their young age. Although 5 linemen reported a family history of diabetes (vs. only 1 non-lineman), there was no correlation between those with higher FBG and a family history of diabetes. However, family history was based on participant recall, and given that the mean age of these players was only 21.4 years, it is possible that diabetes has not yet developed or been detected in their parents as of yet.

Limitations

Although we captured the majority of linemen playing on the university football team studied, the sample was too small to make definitive conclusions about the prevalence of cardiovascular and/or metabolic risk factors among university football players. However, we believe our findings signal the need for further screening in this high-risk population. All serum glucose and cholesterol levels were analyzed using a point-of-care device rather than a validated regional laboratory. However, the use of this device would not likely explain the systematic differences between the 2 groups of individuals studied (linemen vs. non-linemen). We used the BpTRU as our sole measure of BP, despite the fact that it has never been validated in this population before. Although previous studies from the US reported significant differences in BP between linemen and non-linemen using manual BP testing, we did not observe noticeable differences. We did not measure glycated hemoglobin or postprandial glucose to further evaluate for dysglycemia, so it is possible that our sole measure of blood glucose (FBG) may have been falsely elevated if some players chose not to fast for the requested 8 hours. However, we do not believe that adequately explains the systematic difference we observed between the 2 groups. Finally, the caloric intake of participants was based on personal recall and recording, and may have been underreported; as well, the precise activity levels of these players were not captured to determine just how physically active they were.

CONCLUSIONS

Although collegiate football players are viewed as elite players engaged in the highest level of Canadian amateur football, those playing the position of lineman exhibit increased characteristics of metabolic syndrome vs. their non-lineman teammates. These observations are important because of the players' young age and the fact that most of them will soon "retire" from active, competitive sport. Given the health implications of obesity and metabolic syndrome, and the desire of these athletes to gain mass for a competitive advantage at a very young age, much work is necessary to inform policy and to educate on the long-term consequences of increased body size.

AUTHOR DISCLOSURES

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AUTHOR CONTRIBUTIONS

KM, DB and BA conceived of and designed the study. KM and DB analyzed and interpreted the data. All authors contributed to the manuscript preparation and revisions.

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