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Cardiovascular Disease Risk Profile of NCAA Division III Intercollegiate Football Athletes: A Pilot Study

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Abstract

Objectives: Concerns about the long-term cardiovascular health implications of American football participation have been investigated at the professional and Division I levels, but limited research is available at the less resourced Division III level. Therefore, the objective was to assess the cardiovascular disease risk profile of NCAA Division III intercollegiate football athletes. **Methods**: Eighty-nine varsity football athletes (age=19.6±1.7 years, height=1.81±0.07m, weight=92.7±16.2kg; n=21 linemen, n=68 non-linemen) at a private Division III university volunteered to participate. During a preseason pre-participation physical examination, all participants completed a health history screening form (to assess personal and family history of cardiac related pathologies), and were assessed for height, weight, body mass index (BMI), and blood pressure (BP). Linemen only additionally gave a blood sample for fasting blood glucose and cholesterol analysis, and were assessed for waist and hip circumference, metabolic syndrome, and percent body fat (%BF). These measures were reported as averages and frequencies of elevated cardiovascular. Independent t-tests compared linemen to non-linemen, all other data was presented descriptively. **Results**: On average, linemen were significantly taller, heavier, had a higher BMI and higher systolic BP than non-linemen (all $P<0.05$); there was no difference in diastolic BP between the groups ($P=0.331$). The average anthropometric and cardiac risk characteristics for linemen were largely within normal ranges, however analyzed individually, a substantial number of participants were at elevated risk (BMI ≥30=85.7%, %BF ≥25=71.4%, waist circumference ≥1=42.9%, hypertension=9.5%, high density lipoproteins <40mg/dL=42.9%, and triglycerides ≥150mg/dL=6.7%; metabolic syndrome

prevalence=19%). **Conclusions**: Similar to research in elite athletics, linemen at a single Division III university have elevated cardiovascular disease risk. Physicians and other healthcare providers should consider this elevated risk during pre-participation physical examinations and in planning educational or dietary programming targeted to promoting cardiovascular health.

Introduction

Football is one of the most popular sports in America at the high school, collegiate and professional levels, however, concerns have been raised about the long-term health implications of football participation. Of particular concern is how changes in body composition over the course of a football career may impact future cardiovascular health. In the early 1990's, these health concerns prompted the National Football League (NFL) Players Association to request an investigation into player morbidity and mortality [1]. This investigation found that, as a whole, retired players had decreased overall mortality compared to the general population. However, linemen and those with elevated playing-time body mass index (BMI) were at a significantly elevated risk for cardiovascular disease mortality compared to other retired players and to the general population [1].

Since this report, significant attention has been given to the body composition, cardiovascular disease risk, markers of metabolic syndrome, and dietary patterns of football athletes [2-6]. The health of offensive and defensive linemen is of particular concern due to correlations between body composition and cardiovascular disease risk factors in this subset of athletes [4, 6, 7]. In a study of retired NFL players, those with a playing-time BMI $\geq$30 kg/m^2 [8] were at an increased risk of cardiovascular disease risk factors and cardiovascular disease mortality compared to other retired players [9]. While research comparing football athlete's cardiovascular disease risk to the general population has reported mixed findings, the increase in risk for linemen compared to other positions is consistent in the literature [1, 2, 9]. Thus, there appears to be a clear link between body composition and cardiovascular health even in groups of current and former elite football athletes whose relatively high level of physical activity might be thought to mitigate risk.

The vast majority of research investigating the health and risk profile of football athletes has been conducted on professional and National Collegiate Athletic Association (NCAA) Division I athletes, perhaps due to the higher profile and resource-rich nature of these programs. The risk profile of Division III football athletes, on the other hand, is sparsely documented. This is despite the fact that 35% of all NCAA football athletes in 2014-15 participated at the Division III level, a total of 25,609 athletes [10]. While their overall body size may be smaller, Division III football players still undergo similar patterns of body compositional changes as Division I and II athletes throughout their careers [11, 12]. Thus, healthcare professionals providing care for these athletes should still be concerned about the potential short and long-term health risks of sport-specific adaptations in body composition.

The majority of Division III research has consisted of performance and body composition measures (e.g. BMI, body fat percentage, girth, 40-yard sprint) rather than chronic disease risk factors [11, 13, 14]. To our knowledge, only Buell et al. [7] has reported a broader panel of cardiovascular disease risk factors (specifically, those associated with metabolic syndrome) in this population. Metabolic syndrome is a cluster of factors that increase risk for cardiovascular disease and other metabolic disorders, commonly including abdominal obesity, dyslipidemia, elevated blood pressure (BP), glucose intolerance, proinflammatory state and prothrombotic state [15]. Buell et al. [7] sampled football athletes from all three NCAA divisions. Interestingly, differences were found between divisions for several variables, but the presence of metabolic syndrome was fairly consistent between divisions at 48.6% overall. Unfortunately, the authors do not report descriptive data (means and standard deviations) for the majority of their variables, thus Division III specific norms are still lacking.

These values would be of particular interest to healthcare professionals responsible for both pre-participation cardiovascular screening and long-term health of athletes. It is recommended that physicians conducting pre-participation screening utilize physical examination findings, cardiac screening questions and known risk profiles to aid in the detection of cardiovascular anomalies and decrease the risk of sudden death [16]. Additionally, since very few Division III football players will continue to play competitively past their collegiate careers, programs that address the long-term health of these individuals and help them transition out of competitive athletics could have positive implications on their health for years to come. However, before this can be done more information is needed on the cardiovascular disease risk factors of this population.

Thus, the purpose of this research was to collect pre-season data of physical characteristics (i.e. body composition and selected cardiovascular disease risk factors) of NCAA Division III football players. Since similar information on a comprehensive cardiovascular profile has not been collected in this population, we decided to utilize a single institution as a pilot study to assess the feasibility and need for a larger trial.

Methods

Participants

A convenience sample of all football athletes at one NCAA Division III university was recruited. From a roster of approximately 102 players, 89 athletes volunteered to participate (n=21 linemen, n=68 other positions). All football athletes were invited to participate in the main research study. Linemen were additionally recruited to participate in an additional branch of the study which involved collection of additional variables, such as lipid profiles, body fat percentage and glucose levels.

Returning athletes were recruited via an announcement made at a team meeting in the spring of 2014, then sent a reminder email prior to their fall 2014 physical exam. New athletes were recruited via an email introducing the study sent approximately one week before reporting for fall sports, and a group announcement made prior to their scheduled physical exam. The university Institutional Review Board approved this study. All participants gave informed consent prior to participation.

Data Collection Procedures

Primary data collection occurred during regularly scheduled pre-season physical exams in a university health center. Participants were given a packet of questionnaires to complete while they waited to be called to the vitals station or doctors exam room. The questionnaires included a Health History Screening Form, Food Frequency Questionnaire (FFQ), and Nutritional Knowledge Questionnaire. Results from the FFQ and Nutrition Knowledge questionnaire are reported elsewhere.[17] The Health History Screening Form asked participants to report a family or personal history of various health issues that might indicate or affect cardiovascular disease risk (e.g. a personal history of tobacco use, or a family history of stroke).

At the vitals station, participant height, weight and BP were recorded by pairs of trained athletic training students utilizing the procedures described below. Participant height was measured using a measuring tape mounted on a wall to ±0.5 in and converted to cm. Weight was measured on a standard bathroom scale to ±0.5 lbs. and converted to kilograms (kg). Body mass index (BMI) was calculated as body weight (kg) divided by height (m) squared. BMI of 18.5 – 24.9 kg/m^2, 25.0 – 29.9 kg/m^2, and ≥30 kg/m^2 was designated as normal weight, overweight, and obese respectively [8]. Seated BP was recorded using a standard or extra-large adult cuff (sized

per manufacturer instructions) with a sphygmomanometer and stethoscope, resting time prior to BP measurement was not controlled.

Linemen who opted into the additional data collection set up an appointment the morning after their physical exam for additional data collection. Linemen were instructed to report to their appointment having fasted for at least 8 hours and to be well-hydrated. Upon arrival, participants completed the following measures: waist circumference, hip circumference, percent body fat, and gave a blood sample.

Waist circumference was measured according to National Institute of Health (NIH) guidelines [18]. In brief, it was measured to the nearest 0.1 cm using an anthropometric measuring tape. Measurements were taken in a horizontal plane at the visible narrowing of the waist after exhaling. If no narrowing was visualized, the measurement was taken at the level of the 12^{th} rib. The average of two measurements (agreement within ± 1.0 cm) was used. Hip (or buttocks) circumference was measured according to methods described by Heyward [19], with measurement taken at the level of the maximum extension of the buttocks to the nearest 0.1 cm. The average of two measurements (agreement within ± 1.0 cm) was used. Waist to hip ratio was calculated by dividing the average waist circumference by hip circumference. Percent body fat was assessed using bioelectrical impedance analysis via a Tanita TBF-300A pedal to pedal device (Tanita Co., Japan). A trained researcher (CJW or ELA) collected all waist circumference, hip circumference and percent body fat measurements.

For the blood sample, the participant's finger was first cleaned using an alcohol wipe then pricked with a disposable lancet. Approximately 40 µL was collected in a capillary tube, then transferred onto a Cholestech LDX System Cassette (Alere, Inc., Waltham, MA) and analyzed for blood lipids [low-density lipoprotein (LDL), high-density lipoprotein (HDL), total

cholesterol, and triglycerides] and blood glucose using the Cholestech LDX. A single trained researcher (ELA) collected and analyzed all blood samples.

Risk Category Definitions

BMI ≥30 kg/m^2 [8], body fat ≥25% [8], waist ≥102cm [18], and waist to hip ratio ≥1 [19] were considered elevated risk. According to the methods of Tucker et al. [5], prehypertension was defined as systolic BP ≥120mmHg but <140mmHg, OR diastolic BP ≥80mmHg but less than 90mmHg; hypertension was defined as both systolic BP ≥140mmHg and diastolic BP ≥90mmHg. Fasting blood glucose ≥100 mg/dL was considered impaired, and ≥126 mg/dL was considered glucose intolerance [5, 15]. From the blood sample analysis, HDL <40 mg/dL was considered a marker of metabolic syndrome, high LDL was defined as ≥160 mg/dL, triglycerides ≥150 mg/dL were considered dyslipidemia, total cholesterol >200 mg/dL was defined as borderline high, and total cholesterol ≥240 mg/dL was defined as high [15, 20, 21]. Additionally, the presence of metabolic syndrome (and number of symptoms) was determined using previously established criteria [7, 15].

Data Analysis

Differences in demographic variables between positions were analyzed using independent t-tests in IBM SPSS Statistics 20 (Armonk, New York). Alpha was set *a priori* at p=0.05. Frequencies of "yes" and "no" responses on the Health History Form data were reported for the whole sample. Cardiovascular disease risk factors of the lineman sub-sample are reported alongside previously published norms for NFL linemen [5]. The variables and risk categories were selected because they represent common cardiovascular disease risk factors and metabolic syndrome characteristics, and have been previously tracked in similar research on elite athletes [5]. Continuous variables are presented both descriptively and as frequencies after the data were

dichotomized into normal and elevated risk categories. Blood sample analysis for triglycerides and LDL produced invalid test results in 7 participants, leading to a pre-season n=15.

Results

A total of 89 Division III football athletes from a single university participated in the study. Twenty-one were classified as linemen and 68 were non-linemen. Demographic data is reported in Table 1 and Table 2. There was no significant difference in age or diastolic BP between linemen and non-linemen ($P>0.05$; Table 1). Linemen were significantly taller, heavier, had a higher BMI and higher systolic BP than non-linemen (all $P<0.05$; Table 1).

The self-reported health history and behaviors for all participants are reported in Table 3. Linemen anthropometric and cardiovascular characteristics are reported in Table 4, and prevalence of cardiovascular disease risk factors in Table 5. The prevalence of metabolic syndrome amongst linemen was 19% (n=4). Fourteen percent (n=3) had zero markers of metabolic syndrome, 33% (n=7) had 1 marker, 33% (n=7) had 2 markers) and 19% (n=4) had 3 markers.

Discussion

The current study provides data on the cardiovascular disease risk profile of a single Division III football team. Data were collected as a pilot study to assess the feasibility and need for a larger multi-institution trial. This data highlights the general profile of the entire team, which includes data that would be available during a standard pre-participation exam (e.g. weight, BMI, BP, and self-reported health history). Additional variables, some of which are not part of standard pre-participation exams, were collected on a subset of linemen. These variables included important measures of metabolic syndrome and cardiovascular disease risk such as body fat percentage, lipid profile, waist circumference, and fasting glucose.

Self-reported health history and behaviors

While a substantial number of participants reported a family history of pathologies related to poor cardiovascular health and obesity, few participants reported a personal history of these pathologies. As young, relatively healthy, physically active adults, this trend would be expected. However, it is interesting to note that while only 9.5% of linemen indicated a personal history of heart problems and 0% indicated abnormal cholesterol, this contrasts with actual prevalence found in the linemen subgroup of 9.5% having hypertension, 42.9% having low HDL, and 6.7% having high triglycerides. Thus, it appears that more individuals had cardiovascular disease risk factors than were aware of their risk.

Blood pressure and lipid profile of linemen

Although values for Division III are largely absent, significant research into blood measures such as lipids (e.g. total cholesterol, LDL, HDL, and triglycerides) have been done in other football samples. Jonnalagadda, Rosenbloom, and Skinner [22] observed a trend for increased total cholesterol in Division I linemen. After eight weeks of training, Kirwan et al. [6] observed a significant increase in total cholesterol and LDL, but no change in triglycerides and HDL among a group of redshirt freshmen. Conversely, Haskins, Bernhardt, and Koscik [23] compared 30 collegiate football linemen to 10 age- and size-matched sedentary controls and found similar total cholesterol, LDL, HDL and triglycerides between groups, though the athletes had lower at-risk LDL than the controls. The current pilot study provides preliminary norms for Division III football athletes. Future work should verify these values in a broader sample, and investigate links between BP and lipid profiles, dietary habits, and access to nutritional support services (e.g. registered dietitian nutritionist) as might be available in Division I or professional athletics.

Lineman average BP, frequency of hypertension and prehypertension were similar when descriptively compared to past research in NFL linemen [5]. Lineman had significantly higher systolic BP than non-linemen, indicating that a slightly higher risk of hypertension, which may merit physician attention during the pre-participation physical examination process. The prevalence of metabolic syndrome in the linemen sample was found to be 19%, which is lower than previously reported in the literature (48%) despite the use of identical criteria [7]. It is unclear why lower prevalence was found in the current study; future research should investigate the prevalence of metabolic syndrome in a larger, multi-institution sample.

Anthropometric characteristics of linemen

Similar to previous research, linemen in the current study were larger than non-linemen [4, 5, 24]. As expected, the average size (height, weight and BMI) of the current sample of DIII linemen is considerably smaller than previously reported norms in NFL linemen [5], and slightly smaller than Division I and II athletes [4, 7]. Our linemen were similar in size to previous reports at the DIII level [11], providing limited evidence that our linemen may be representative to the larger DIII population. The average body fat percentage aligns with past research in football populations (20.8-28.3%) [5, 7]. Interestingly, while not statistically compared, the percentage of linemen with a body fat >25% appears higher in our sample (71.4%) than previous research (14.1%) [5]. Clinically, this may indicate that elevated cardiovascular disease risk due to excess body fat is more prevalent at the Division III level where conditioning and fitness norms differ from more elite levels of football.

Limitations and Considerations

In this pilot study, data was collected from a single institution. While there is evidence that football athletes at this institution follow previously published norms, results are not

necessarily representative of all Division III football programs. Additionally, due to data collection at a single time-point, we cannot establish whether differences between lineman and non-lineman might have existed prior to participation in football, or resulted from sport-specific adaptation. We also asked participants to self-identify their ethnicity because of the potential for increased cardiovascular risk in certain ethnic populations. Data is presented descriptively (Table 2) but no subgroup analyses were conducted because this was not an aim of the current study. Results should be interpreted in light of the ethnic characteristics of the current sample. Future research should include a selection of programs across different geographical areas.

Additionally, there were limitations in the data collection protocol. Specifically, initial anthropometric data (height, weight, and BP) was collected at four stations, each manned by athletic training students. Although trained in the data collection task, some variability in measurement could have been present, especially for BP which is known to have inter-rater variability. While it would have been ideal research control to have one assessment station with a single individual collecting all measures, this would have been practically unfeasible considering the volume of athletes and time limitations. Additionally, it would not mimic common practice in team pre-participation physicals, which commonly use multiple evaluators. For the additional measures on linemen, body fat was analyzed using a bioelectrical-impedance method, which is a less accurate measurement than plethysmography (e.g. BodPod) or DEXA scanning. Unfortunately, these more accurate measures were not available at the time of the study, and since skinfold measurements are known to vary greatly based on individual technique and skill, we chose bioelectrical-impedance as the most consistent available option.

Conclusions

Similar to previous research in professional and Division I athletics, linemen at a single Division III university have elevated cardiovascular disease risk compared with non-linemen. While average linemen values were largely within target ranges, when analyzed at the individual level, multiple participants fell into elevated risk categories. Physicians and other healthcare providers should consider linemen's elevated risk when performing pre-participation physical exams. In addition, football linemen may benefit from additional educational and dietary programming targeted at decreasing modifiable cardiovascular disease risk factors.

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Table 1. Demographic and Anthropometric Characteristics of NCAA Division III Football Athletes

	Linemen, n=21		Non-Linemen, n=68		All Athletes, n=89		Independent t-test between positions	
Descriptor	**M**	**SD**	**M**	**SD**	**M**	**SD**	**Statistic[a]**	**P-value**
Age, years	19.7	1.4	19.6	1.8	19.6	1.7	t=-0.236	0.814
Height, cm	183.9 [b]	5.5	179.6	6.6	180.6	6.5	t=-2.673	0.009
Weight, kg	114.6 [b]	13.1	86.0	9.9	92.7	16.2	t=-10.739	<0.001
BMI, kg/m^2	33.9 [b]	3.7	26.6	2.5	28.3	4.2	t=-10.357	<0.001
Systolic BP, mmHg	130.6 [b]	10.5	124.1	8.2	125.6	9.2	t=-2.944	0.004
Diastolic BP, mmHg	76.2	10.2	74.2	7.6	74.7	8.3	t=-0.977	0.331

Abbreviations: M = mean, SD = standard deviation, BMI = body mass index, BP = blood pressure

[a] Degrees of freedom = 87 for all analyses except age, where degrees of freedom = 86 due to 1 missing value

[b] Significant difference between linemen and non-linemen positions

Table 2. Sample Ethnicity and Year in College

	Linemen		Non-Linemen		All Athletes	
	N	%	N	%	N	%
Self-Identified Ethnicity						
Hispanic or Latino	0	0.0	3	4.5	3	3.4
Hawaiian	0	0.0	1	1.5	1	1.1
Black or African American	1	5.0	8	11.9	9	10.3
Asian	0	0.0	2	3.0	2	2.3
White	16	80.0	43	64.2	59	67.8
Mixed	3	15.0	10	14.9	13	14.9
Year in College						
1st year	10	50	28	42.4	38	44.0
2nd year	3	15	14	21.2	17	19.8
3rd year	5	25	11	16.7	16	18.6
4th year	1	5	10	15.2	11	12.8
5th year	1	5	3	4.5	4	4.7

Table 3. Self-Reported Health History and Behaviors of n=89 NCAA Division III Football Athletes

	Linemen, n=21				**Non-Linemen**, n=68				**All Athletes**, n=89			
	Yes		**No**		**Yes**		**No**		**Yes**		**No**	
History Category	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Family[a] history of….												
Heart attack	4	19.0	17	81.0	13	19.1	55	80.9	17	19.1	72	80.9
Heart disease	2	9.5	19	90.5	5	7.4	63	92.6	7	7.9	82	92.1
High blood pressure	9	42.9	12	57.1	22	32.4	46	67.6	31	34.8	58	65.2
Stroke	5	23.8	16	76.2	10	14.7	58	85.3	15	16.9	74	83.1
Kidney disease	1	4.8	20	95.2	0	0.0	68	100.0	1	1.1	88	98.9
Diabetes	6	28.6	15	71.4	17	25.0	51	75.0	23	25.8	66	74.2
Personal History of…												
Tobacco Use	3	14.3	18	85.7	1	4.4	65	95.6	6	6.7	83	93.3
Heart disease or any heart problems	2	9.5	19	90.5	1	1.5	67	98.5	3	3.4	86	96.4
Circulation problems	0	0.0	21	100.0	0	0.0	68	100.0	0	0.0	89	100.0
Kidney disease or problems	0	0.0	21	100.0	0	0.0	68	100.0	0	0.0	89	100.0
High Cholesterol	0	0.0	21	100.0	2	2.9	66	97.1	2	2.2	87	97.8
Hypoglycemia (i.e. low blood sugar)	0	0.0	21	100.0	0	0.0	68	100.0	0	0.0	89	100.0

[a] Family history included parents, grandparents, aunts and/or uncles.

Table 4. Anthropometric and Cardiovascular Disease Risk Characteristics of NCAA Division III Football Linemen

	Division III Linemen			NFL offensive linemen[a]		NFL defensive linemen[a]	
Characteristic	**M**	**SD**	**Range**	**M**	**Range**	**M**	**Range**
Height, cm	183.9	5.47	172.5-192	195	194-196	191	191-192
Weight, kg	114.6	13.11	91.4-135.5	143	142-145	131	128-134
BMI, kg/m^2	33.8	3.75	27.5-41.5	37.8	37.3-38.3	35.7	34.9-36.6
% Body Fat	29.9	6.35	19.5-39.5	25.8	24.9-26.6	20.8	19.3-22.2
Waist, cm	102.0	8.17	86.0-118.5	117	115-119	107	104-109
Waist:hip ratio	0.90	0.05	0.8-1.0	0.92	0.91-0.93	0.89	0.88-0.91
Systolic BP, mmHg	130.6	10.48	112-148	132	130-134	127	124-129
Diastolic BP, mmHg	76.2	10.22	60-98	79	78-81	75	73-77
Lipids, mg/dL							
HDL	39.9	8.51	24.0-54.0	43	41-46	47	44-49
LDL[b]	116.1	25.82	72.0-159.0	115	109-122	116	108-125
Total cholesterol	169.5	28.44	127.0-225.0	179	171-186	185	176-193
Triglycerides	93.9	42.34	53.0-217.0	119	103-135	111	93-128
Fasting glucose, mg/dL	81.7	6.07	74.0-98.0	87	84-89	86	83-90

Abbreviations: M = mean, SD = standard deviation, BMI = body mass index, BP = blood pressure; HDL = high density lipoproteins; LDL = low density lipoproteins

[a] As reported in Tucker et al. 2009

[b] pre-season n=15 due to invalid test results

Table 5. Prevalence of Cardiovascular Disease Risk Factors in NCAA Division III Football Linemen

	Division III		NFL[a]	
Characteristic	↑ **risk** (%)	**nL risk** (%)	↑ **risk** (%)	**nL risk** (%)
BMI ≥30 kg/m^2	85.7	14.3	57.6	42.4
% Body fat ≥25	71.4	28.6	14.1	85.9
Waist, >102 cm	42.9	57.1	31.0	69.0
Waist:hip ratio ≥1	0.0	100.0	5.1	94.9
Prehypertension[b]	66.7	33.3	64.5	35.5
Hypertension [c]	9.5	90.5	13.8	86.2
HDL, <40 mg/dL	42.9	57.1	26.9	73.1
LDL, ≥160 mg/dL [d]	0.0	100.0	7.2	92.8
Triglycerides, ≥150 mg/dL [d]	6.7	93.3	13.7	86.3
Total cholesterol, ≥200 mg/dL	23.8	76.2	25.8	74.2
Total cholesterol, ≥240 mg/dL	0.0	100.0	4.7	95.3
Fasting glucose, 100-125 mg/dL	0.0	100.0	6.7	93.3
Glucose Intolerance, ≥126 mg/dL	0.0	100.0	0.3	99.7
Smoking	14.3	85.7	0.1	99.9

Abbreviations: nL = normal, BMI = body mass index, BP = blood pressure; HDL = high density lipoproteins; LDL = low density lipoproteins

[a] As reported in Tucker et al. 2009

[b] Prehypertension defined as systolic BP ≥120 mmHg & <140 mmHg, OR diastolic blood pressure ≥80 mmHg & <90 mmHg

[c] Hypertension defined as both systolic BP ≥140 mmHg and diastolic BP ≥90 mmHg

[d] pre-season n= 15 due to invalid test results