RESEARCH ARTICLE

DOI: 10.54392/ijpefs2511

IJPEFS International Journal of PHYSICAL EDUCATION, FITNESS AND SPORTS

Three-Year Analysis of Overweight and Obesity in Central Alabama Children

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DOI: https://doi.org/10.54392/ijpefs2511

Received: 16-11-2024; Revised: 06-01-2025; Accepted: 13-01-2025; Published: 23-01-2025

Abstract: Obesity among children and adolescents is on the rise and are associated with high blood pressure, lipid abnormalities, diabetes, and sleep apnea. The purpose of this study was to investigate the prevalence of overweight and obesity in children and adolescents from Central Alabama over three years. Additionally, this study examined the association between obesity and the following variables: resting heart rate, systolic and diastolic blood pressure, and blood glucose. The data set used in this study included 1,198 male and female children between the ages of 5 and 14 living in Central Alabama. Body Mass Index (BMI) Percentile, resting heart rate, systolic and diastolic blood pressure, and blood glucose were collected annually from 2015 to 2017. BMI percentile was used to determine the prevalence of obesity both overall and by age group (younger vs. older) and by sex for each year. One-way analysis of covariance examined the relationship between BMI percentile (underweight, normal, overweight, or obese) and resting heart rate, systolic and diastolic blood pressure, and blood glucose when controlling for sex. The relationships were assessed using the group overall and separately by age (younger vs. older) and sex. Older children in the study, particularly older females, were likelier to have BMIs in the top quartile for percentiles. Males were more likely to have higher glucose scores than females. The data indicates that children's BMI percentiles continue to rise as they age, which may lead to poor outcomes later in life.

Keywords: Obesity, Overweight, Children, Adolescents, Body Mass Index

1. Introduction

Childhood overweight and obesity constitute a global challenge to child health and well-being, with widespread increases in childhood obesity prevalence and little progress toward meeting goals related to reducing it (Global Nutrition Target Collaborators, 2025). Furthermore, there is a prevalence of obesity varies among ethnic groups, age, sex, education levels, and socioeconomic status, particularly within the United States. A report published by the National Center for Health Statistics using data from the National Health and Nutrition Examination Survey provides the most recent estimates from 2017 to 2020 on obesity prevalence by sex, age, race, and overall estimates (Bryan Stierman *et al.,* 2021). The figures are alarming; the obesity rate among children and adolescents ages 2 to 19 was 19.7% in the United States, affecting more than 14 million (Bryan Stierman *et al.,* 2021).

Examining ethnic differences in rates of obesity, Stierman *et al.* (2021) found that the prevalence of obesity among non-Hispanic black (24.8%) and Hispanic (26.2%) children and adolescents aged 2 to 19 years was higher than among both non-Hispanic white (16.6%) and non-Hispanic Asian (9.0%) children and adolescents. However, there were no significant differences in the prevalence of obesity between non-Hispanic white and non-Hispanic Asian children and adolescents or between non-Hispanic black and Hispanic children and adolescents (Bryan Stierman *et al.,* 2021). Obesity rates among males and females between the ages of 2-19 were 20.9% and 18.5%, respectively (Stierman *et al.,* 2021).

In regional and state-level studies of disease prevalence and disease forecasting, the US Burden of Disease and Forecasting Collaborators (2024) cited high BMI as a substantial, but modifiable, factor limiting increases in life expectancy and contributing to the high chronic disease burden found in the United States. Concerningly, these researchers also found that the United States, both as a whole and by individual states, does not rank highly in forecasted health outcomes compared to other countries with similar characteristics. Without substantial action towards reducing modifiable risk factors such as obesity, the United States is projected to fall even further behind on global health outcomes. A further consideration in the investigation of childhood obesity and health outcomes relates to differences found in children growing up in rural versus urban areas. Considerable health disparities, including rates of obesity, exist between rural and urban children, with rural children ranking worse on a wide variety of health concerns compared to their urban counterparts (Workman, 2025). This is of particular concern in states such as Alabama, where 55 of 67 counties can be classified as rural areas, home to over 2 million people, or 42.3% of the total state population (Alabama Department of Public Health, 2024).

Obesity rates, according to the 2020 – 2021 National Survey of Children's Health in the State of Alabama, are 22.1% (Child and Adolescent Health Measurement Initiative, 2022). As childhood obesity is associated with immediate health risks, including high blood pressure, lipid abnormalities, diabetes, and sleep apnea, among others (Hardy & Urbina, 2021; Jung & Yoo, 2018; Narang & Mathew, 2012; Pulgaron & Delamater, 2014; Bryan Stierman et al., 2021), it is imperative to monitor the prevalence and progression of obesity in children in order to help identify at-risk populations and develop interventions. Therefore, the purpose of this study was twofold; the primary aim was to investigate the prevalence of obesity rates in children and adolescents from Central Alabama over three years. Additionally, this study examined the association between obesity and resting heart rate, systolic and diastolic blood pressure, and blood glucose from children and adolescents who resided in underserved counties in Central Alabama.

2. Materials and Methods

2.1 Research design

This is a three-year longitudinal study where data was collected by an interprofessional group of faculty and students from the College of Nursing & Health Sciences of the (the institution's name will be disclosed following peer review) (Langham et al., 2017). The Healthy Kids Data Set is a regionally representative longitudinal assessment designed to create health reports for school systems about the overall health of the students enrolled in their schools. The schools participating in Healthy Kids were rural and medically underserved (Alabama Public Health, 2022a; Alabama Rural Health Association, 2010). Data related to obesity are reported in this analysis and are from the years 2015-2017.

2.2 Definitions

Age was recorded by years and months, and age categories were created; these categories were ≤ 8 yr., 9 to 12 yr., and ≥ 13 yr. Raw BMI (BMI = weight in kg • height in m^2) scores were converted to percentiles. BMI percentile categories were defined as normal (< 85th percentile), overweight (85th to < 95th percentiles), and obese (≥95th percentile) (Centers for Disease Control and Prevention; Hammer, Kraemer, Wilson, Ritter, & Dornbusch, 1991). Race and gender were reported on the day of testing by nursing students. Hispanic origin was not collected.

2.3 Participants

There are 1198 data entries across three years of data collection. Some individuals had data collected for all three years, some two years, and a few just for one year. In 2015, the number of subjects was 527; in 2016, there were 605 subjects, and in 2017, 462. Again, these are not all unique subjects, but a count is given of the number of subjects used in each analysis year. Most subjects in the sample were African American (98%). Data was collected at five schools: three elementary schools, and two middle schools. In 2015, the average age of the elementary school subjects was 8.25 ± 1.84 yr., and the average age of the middle school subjects was 13.35 ± 1.01 yr. The data showed almost an even distribution of Males (47%) and Females (53%).

2.4 Measures

Overweight individuals were defined as those with a BMI between the 85th and 95th percentiles for age and sex. Obese individuals were defined as those with a BMI ≥ 95th percentile for age and sex. Standardized procedures for measuring height and weight were performed. Individuals with blood glucose values between 80 and 100 mg•dL^{-1} (i.e., 4.44 mmol•l^{-1} and 5.55 mmol•l^{-1}) were considered normal, although strict fasting glucose procedures were not followed during data collection. A heart rate between 70 and 100 beats per minute (bpm) was considered normal, while values above 100 bpm were considered elevated. Systolic blood pressure was considered normal between 90 and 115 mmHg, while diastolic blood pressure was considered normal between 60 to 80 mmHg.

2.5 Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics, version 28 (IBM Corp., Armonk, NY). Descriptive statistics are presented as the mean and standard deviation (M ± SD) for BMI Percentile, glucose, systolic, and diastolic blood pressure across the three years. An independent samples t-test compared mean differences between males and females on these newly computed variables. ANCOVA examined the effect of age and gender on the data set. Statistical significance was set at $P \leq 0.05$.

3. Results and Discussion

The Centers for Disease Control and Prevention (CDC) classifications for BMI percentiles of normal (<85th Percentile), overweight (85th < 95th Percentile), and obese (> 95th Percentile), by year and sex are presented in Table 1. Two individuals' data were removed due to severe data input process irregularities. Table 1 includes the number of subjects in each age by group, BMI status groups, glucose level, systolic blood pressure (SBP), and diastolic blood pressure (DBP). BMI was higher for females than males in the year of data collection. For each year, over 30% of male BMIs were greater than the 85th Percentile. In 2016 and 2017, 46% of females had a BMI in the 85th percentile or greater. When one combines the number of individuals in the overweight or obese categories (shown in parentheses in Table 1), 35% were overweight or obese in 2015. The percentages increased to 42% in 2016 and 43% in 2017.

Table 1. Variables by year and sex

	Males			Females		
	2015	**2016**	**2017**	**2015**	**2016**	**2017**
All	173	199	151	235	293	204
Age group, yr.						
< 8	65	72	54	93	99	66
8 < 12	49	82	56	82	133	96
< 12	59	45	41	60	61	42
BMI Category						
< 85th Percentile	146 (66.7)	170(63.0)	115 (61.5)	181 (62.2)	194 (52.7)	142 (53.6)
85th-< 95th Percentile	31 (14.2)	38 (14.1)	34 (18.2)	45 (15.5)	62 (16.8)	48 (18.1)
> 95th Percentile	42 (19.2)	62 (23.0)	38 (20.3)	65 (22.3)	112 (30.4)	75 (28.3)
Glucose Level (mg•dL^{-1})						
<100	95 (81.9)	190 (80.2)	125 (77.2)	114 (86.4)	290 (86.8)	199 (79.3)
>100	21 (18.1)	47 (19.8)	37 (22.8)	18 (13.6)	44 (13.2)	52 (20.7)
Diastolic BP (mmHg)						
40-80	97 (81.5)	236 (87.4)	162 (85.3)	116 (87.2)	339 (90.2)	230 (83.6)
>80	22 (18.5)	34 (12.6)	28 (14.7)	17 (12.8)	37 (9.8)	45 (16.4)
Systolic BP (mmHg)						
80-115	58 (48.7)	200 (74.1)	104 (54.7)	76 (56.3)	284 (75.5)	146 (53.1)
>115	61 (51.3)	70 (25.9)	86 (45.3)	59 (43.7)	92 (24.5)	129 (46.9)

Note: Each cell contains the number of individuals in that category. In parentheses is the percentage by sex

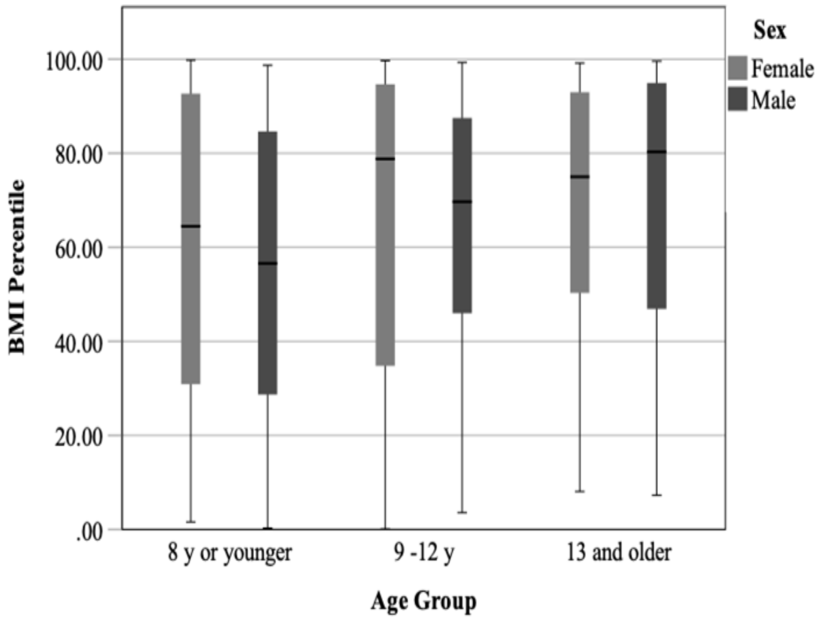

Figure 1. Clustered boxplot of BMI Percentile by age group and by sex (2015).

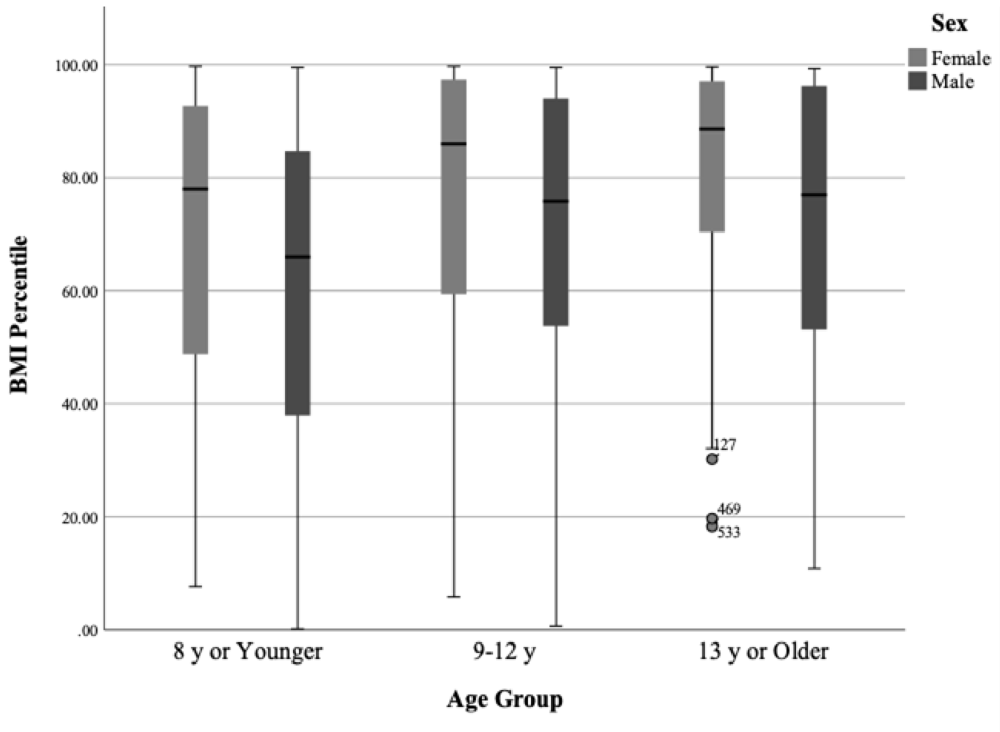

Figure 2. Clustered boxplot of BMI Percentile by age group and by sex (2016).

The participant's BMI percentile report with the data stratified by age categories and sex are presented in box and whisker plots (Figures 1 to 3). Figure 1 represents data collected in 2015. In the last set of boxes and whiskers, individuals aged 13 or older had BMIs in the 40^{th} percentile or higher, with the median clustering around the 80^{th} percentile. In 2016, subjects with lower BMIs were now outliers in the 13-year-old group for females. In 2017, the median BMI for all age groups was above the 60^{th} percentile, with the 13-year-old or older group median above the 80^{th} percentile.

The descriptive statistics for the BMI percentiles when combining males and females are shown in Table 2. The mean and median percentiles were lowest in 2015 and continued to increase in 2016 and 2017. Table 2 shows that the median BMI percentiles from 2015 to 2016 increased from 69.2 to 81.5.

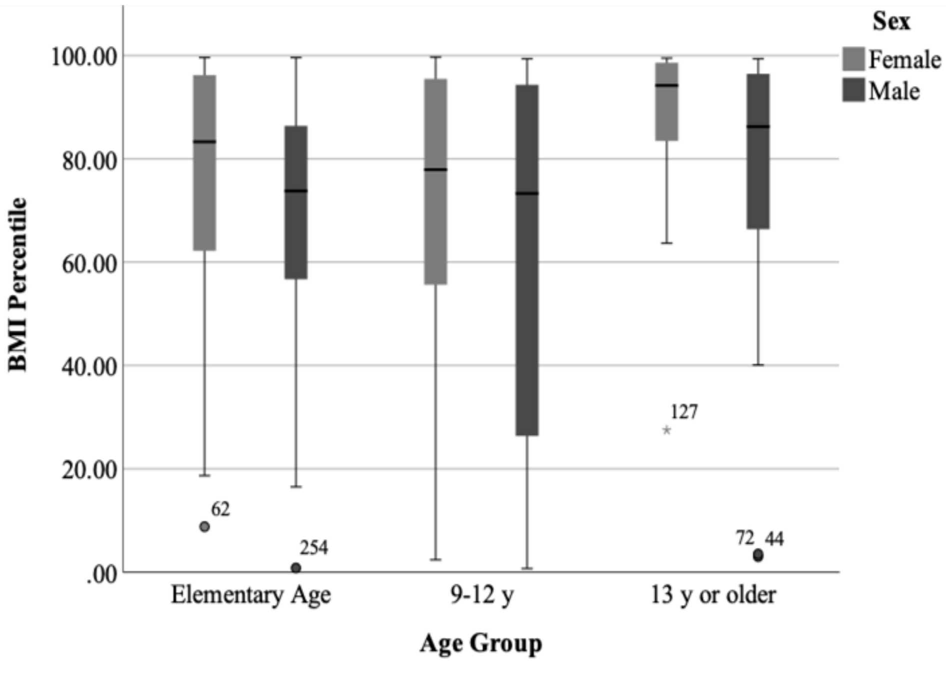

Figure 3. Clustered boxplot of BMI Percentile by age group and by sex (2017)

Table 2. Descriptive statistics for BMI Percentiles

	M ± SD	**Median**	***N***
BMI Percentile 2015	63.1 ± 31.1	69.2	507
BMI Percentile 2016	71.0 ± 27.5	79.3	638
BMI Percentile 2017	72.0 ± 27.3	81.5	452

Table 3. ANCOVA 2016 summary table

Source	***SS***	***df***	***MS***	***F***	***p***	η^2
Between Treatments	16907.902[a]	5	3381.580	4.841	<.001	.048
Sex	6399.524	1	6399.524	9.162	.003	.019
Age Group	9748.005	2	4874.002	6.978	.001	.028
Error	333882.520	478	698.499			
Total	2788689.410	484				

Table 4. Glucose levels classification by year and sex

Glucose Levels (mg•dL^{-1})		**Sex**		**Total**
		Female	**Male**	
2015	Normal (<100 mg•dL^{-1})	114	95	209
	Abnormal (>100 mg•dL^{-1})	18	21	39
2016	Normal (<100 mg•dL^{-1})	290	190	480
	Abnormal (>100 mg•dL^{-1})	44	47	91
2017	Normal (<100 mg•dL^{-1})	199	125	324
	Abnormal (>100 mg•dL^{-1})	52	37	89

Table 5. Descriptive statistics for averaged variables

	Sex	M ± SD	N
BMI Percentile	Female	70.26 ± 27.68	543
	Male	66.47 ± 28.64	470
Glucose (mg•dL^{-1})	Female	89.98 ± 14.40	478
	Male	94.64± 29.50	400
Systolic Blood Pressure (mmHg)	Female	110.07± 10.98	508
	Male	110.66 ± 11.50	436
Diastolic Blood Pressure (mmHg)	Female	72.03 ± 8.58	508
	Male	71.85 ± 9.56	436

The ANCOVA determined whether sex was a significant factor for BMI percentile when controlling for age for each year. The CDC's guidelines about age and development were used to create the age groups. We could only look at the data in 2016; the other two years violated some of the assumptions to complete an ANCOVA. The ANCOVA results 2016 (Table 3) indicate a main effect for sex ($F_{(1, 478)}$= 9.162, p = 0.003, η^2 = 0.019). The covariate of age significantly influenced the dependent variable of BMI percentile ($F_{(1,478)}$ = 6.98, p = 0.001, η^2 = 0.028). For the BMI Percentage, females (*M* = 70.27 ± 27.68) had a higher BMI percentile than males (*M* = 66.47 ± 28.64). The independent samples t-test examined statistically significant differences between males' and females' BMI percentile in each year of data collected (2015-2017). Females had a statistically significant higher BMI percentile than males in the total dataset ($t_{(1011)}$ = 2.141, p = 0.033, η^2 = 0.135).

The results of the glucose analysis are presented in Table 4. Among both sexes, more than 30% of the sample had glucose levels above 100 mg•dL^{-1} or abnormal levels. In 2015 and 2016, the glucose values over 100 mg•dL^{-1} were 15.7% and 15.9%, respectively. In 2017, more than 20% of males and females in the sample had a glucose reading >100 mg•dL^{-1}. The males (*M* = 94.64 ± 29.50 mg•dL^{-1} or 5.25 ± 1.64 mmol•l^{-1}) had higher glucose levels than females (*M* = 89.98 ± 14.40 or 4.99 ± 0.80 mmol•l^{-1}). Even though the average glucose values were within normal limits, males had a significantly higher glucose than females ($t_{(876)}$ = -3.043, p = 0.002, η^2= 0.206).

The results of the SBP and DBP are presented in Table 1. In 2016, 25% of males and females had a SBP > 115 mmHg. In 2015 and 2017, 40% of males and females had a SBP > 115 mmHg. The percentage of males with a DBP > 80 mmHg tended to be higher in males than females over three years but was insignificant. Finally, table 5 shows the averaged values of the dependent variables studied.

3.1 Discussion

Stierman *et al.* found that 19.7% of children aged 2 through 19 had obesity, defined as a body mass index greater than or equal to the 95th percentile for age and sex. There was no difference in obesity by sex. Obesity increased with increasing age groups. The highest prevalence of obesity was among non-Hispanic Black and Hispanic children. Interestingly, obesity rates decreased with increasing family income (B. Stierman et al., 2021). Obesity rates, according to the 2020 – 2021 National Survey of Children's Health in Alabama, are 22.1% (Child and Adolescent Health Measurement Initiative, 2022). A review by Kumar and Kelly (Kumar & Kelly, 2017) reported that nearly 33% of children may be overweight or obese. In our study 2015, 2016, and 2017, we found obesity rates in males to be 19.2%, 23.0%, and 20.3%, respectively. For the same three years, we found that obesity rates for females were 22.3%, 30.4%, and 28.3%.

A novel finding of our 3-year study found that females had a significantly higher BMI percentile than males. Though it is alarming the number of females whose BMI percentiles are greater than 60%, one needs to consider that as females reach puberty, there is an increase in fatty breast tissue. This could result in higher female BMI percentiles, but it does not fully accounts for the differences and the generally higher percentiles of females (Taylor, Grant, Williams, &

Goulding, 2010). Another finding in our study from 2015 – 2017 was a general upward trend in the BMI percentile with age. However, in 2016, age significantly contributed to a higher BMI percentile in both males and females. This was similar to another study (Stierman et al., 2021).

Observational studies show increasing numbers of overweight and obese children and adolescents with type 1 diabetes (Libman, Pietropaolo, Arslanian, LaPorte, & Becker, 2003). Even though we did not directly investigate type 1 diabetes in our study. We found in our study that 30% of glucose levels were above 100 mg•dL^{-1}, which may be a sign of impaired glucose metabolism. One limitation of note is that we are not aware if the subjects were fasting or not when the glucose readings were taken. Most likely, they were not fasting, and this should be considered when reading and interpreting the scores.

High blood pressure in adolescents has become a significant health concern over the years, especially in populations that are overweight and obese (Hansen, Gunn, & Kaelber, 2007; Hardy & Urbina, 2021). In a report from the American Academy of Pediatrics (Flynn et al., 2017), high blood pressure was more prevalent in boys than girls, and they reported that blood pressure was higher in African-American children than in other ethnic groups. In our study, the average blood pressure for males and females was within normal limits. Furthermore, the blood pressures in this study did not differ between males and females.

Rural children also have relatively fewer opportunities to access fresh vegetables and various nutritious food ingredients than urban children, compared to children in metropolitan and urban areas (Chung & Romney, 2012; Golden et al., 2016), which is also an important determinant of child obesity. Eighty-two percent of Alabama's counties are rural, and nearly the entire state is medically underserved (Alabama Public Health, 2022b; Alabama Rural Health Association, 2010). This could significantly contribute to higher obesity rates in African Americans in this location and Alabama.

4. Conclusions

Our findings underscore the importance of obesity prevention and management efforts to help promote healthy behaviors, particularly for children in rural, medically underserved areas. These efforts could include screening for BMI, food security, and other social determinants of health provided by healthcare providers in cooperation with local schools or other organizations that serve local youth. There should be a focus on increasing access to adolescent weight management programs and food assistance resources. These resources should help promote healthy eating, physical activity, and prevention of chronic disease. Given the concerning trend of increasing BMI during the years examined in this study, additional monitoring and follow-up of children in Central Alabama is warranted, particularly with recent findings showing detrimental post-pandemic lockdown changes in rates of obesity, diet, and physical activity among children. Future studies should also include some form of intervention, like an exercise program or nutrition plan for parents, to name a couple.

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Author Contribution Statement

T.L.R. Beziat - Methodology, Validation, Investigation, Data collection, Writing - Original Draft, A.R. Russell - Data curation, Validation, Formal analysis, Writing - Original Draft, G. Langham - Methodology, Data collection, Writing - Review & Editing. J. K. Taylor- Methodology, Data collection, Writing - Review & Editing. All the authors read and approved the final version of the manuscript.

Informed Consent

The consent form was signed before the commencement of the study.

Conflict of Interest

The authors declare that there was no conflict of interest.

Does this article pass screening for similarity?

Yes

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