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Original Article

Grains and Potato Consumption in Association with Anthropometric Measures and Blood Pressure in Iranian Children and Adolescents: The CASPIAN-IV Study

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Abstract

Background: This study was aimed to investigate the association of consuming white rice and potato, as well as the bread type with anthropometric measures and blood pressure (BP) in a national sample of Iranian children and adolescents.

Methods: This nationwide study was conducted in 2011-2012 among 14,880 students, aged 6-18 years, selected by multistage cluster sampling from 30 provinces of Iran. Weight, height, waist circumference (WC), hip circumference (HC), waist -to-hip ratio (WHR), waist-to- height ratio (WHtR), as well as systolic and diastolic blood pressure (SBP, DBP) were measured. The self-reported frequency consumption of white rice and potato (daily or non-daily), as well as consumed bread type were asked.

Results: The mean (SD) age of participants was 12.47 (3.36). They were consisted of 50.76% girls and 75.57% urban residents. The intake of white rice had significant positive association with anthropometric indices and SBP levels (*P*-value<0.05). In crude and adjusted models, white rice consumption was significantly associated with BMI (0.29(0.06-0.51 and 0.19(0.02-0.35)). Likewise, significant association existed between the type of the bread and anthropometric indices (except for WHR). Potato consumption was significantly associated with anthropometric indices (except for WHR and WHtR) and BP levels. In adjusted model, potato consumption had significant positive association with BMI. For every increase in the frequency of daily consumption of white rice, 0.19 units were added to BMI.

Conclusion: White rice consumption increases the risk of general and abdominal obesity in children and adolescents. Consequently, for prevention and control of obesity, the consumption of refined grains should be limited by moderating nutrition policies.

Keywords: Grains, High blood pressure, Obesity, Anthropometric indices, Iran

Introduction

A nutrition transition is currently being experienced in majority of developing countries including Iran. Moreover, nutrition-related non-communicable diseases are increasing worldwide (1). Among them, obesity is considered, at least in part, because of nutritional transition (2). The prevalence of overweight and obesity has increased in the past three decades (3). The prevalence of overweight and obesity is increasing rapidly among children in developing countries (4). Currently, one-third of children and adolescents aged 2-19 years are classified as overweight or obese (5). Childhood obesity is associated with physical and mental health problems and obese children are more likely to be overweight or obese during adulthood (6). Due to the importance role of diet, considerable evidence indicates that different components of the diet (energy, food groups and nutrients) are associated with obesity (7, 8). This association encourages researchers to examine the relationship between dietary patterns and obesity (9). Several studies have reported an inverse association between the consumption of whole grain foods and body weight (10-13). High intake of fiber in fruits, vegetables and grains is highly important in the diet. Previous studies have shown that while leading to lower energy intake, the consumption of whole grains reduces hunger and increases satiety (14, 15).

Nowadays many grains are consumed after removal of the outer layers (16). White rice is one of the main foods that is consumed all around the world (17); it is a refined carbohydrate with a high glycemic index and glycemic load (18). The dietary Guidelines for Americans 2010 recommended whole grains as one of food groups in all age categories (19). The consumption of whole grains has been recommended as a weight control strategy. However, by increasing satiety; whole grains may have beneficial effects on weight loss (20). Some studies have examined the effects of whole grains compared to refined grains on body weight in middle aged women and men (15, 21).

As limited evidence exist on the association of whole grain intake with body weight of children and adolescents (22), this study was conducted to investigate the association of the intake of whole grains and refined grain with anthropometric measures and blood pressure (BP) in a large sample of children and adolescents.

Material and Methods

Study population

A totally number of 14,880 children and adolescents aged 6-18 years invited subjects were assessed. This study was as the fourth survey of a national school-based surveillance program, entitled "*Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable Disease (CASPIAN-IV)*" study was conducted in 2011-2012 in 30 provinces of Iran. The details of aim and protocol of this study is published previously (23). We completed two sets of questionnaires for students and the parents. These questionnaires were obtained from Global School Health Survey (GSHS), and then have been converted into Persian. The reliability and validity of them has been previously assessed (24).

Demographic data

Demographic data (as age, sex, family size, physical activity (PA) , and family socio-economic status (SES), as well as parental occupation and education level were collected by trained health care providers.

The weekly frequency of extracurricular PA, at least 30 minutes per day was reported by the students. The PA level was classified as <2 times/week, 2-4 times/week and >4 times/week (24).

To assess the screen time (ST) -the leisure time spent on watching TV, working with computers and playing video games- were asked as the hours per day. Mean ST of more than 2 hours per day was considered to be high, i.e. a sedentary lifestyle (23).

About family SES, variables including family assets e.g. personal computer and private car, and residential property ownership as well as parental education and occupational status were summarized in one main component using principle component analysis. The main component categorized into tertiles. The first, second, and third tertiles were considered as low, moderate, and high SES, respectively.

Measurements

Weight, height, waist circumference (WC), hip circumference (HC), waist-to-height ratio (WHtR), waist -to-hip ratio (WHR), and BP were measured by standard protocols using calibrated equipment. Weight was measured with minimal clothing without shoes with 0.1 kg precision. Height was recorded with a precision of 0.1 cm without shoes. Body mass index (BMI) was calculated by dividing weight (kg) per height square (m^2); BMI >= 95th percentile was considered as "obesity" (25). WC was measured using a non-elastic tape on the distance between the smallest area below the rib cage and the iliac crest to the nearest 0.1 cm (26). The widest part of the hip was measured to obtain the hip circumference to the nearest 0.1 cm (26). WHtR was calculated by dividing WC (in cm) by height (in cm). WHtR>0.5 was considered as abdominal obesity (27).

Blood pressure (BP) was measured using a mercury sphygmomanometer on the right arm twice after a 5 min rest in a sitting position; then the mean of the two measurements was reported as the BP (28). BP, systolic blood pressure (SBP), diastolic blood pressure (DBP) were categorized into two groups: normal pressure (< 95th percentile) and elevated BP (≥95th percentile) (29).

White rice and whole bread were considered as refined grains and whole grains, respectively. The frequency of white rice and potato consumption (daily or non-daily) was reported by each of the subject. They also reported the type of bread consumed usually.

Statistical analysis

Qualitative and quantitative variables are presented as number (%) and mean (SD) respectively. Comparison of qualitative variables with living area, potato and white rice consumption and type of bread categories was performed using Chi-square test. Mean of quantitative variables across living area, potato and white rice consumption and type of bread categories was compared using *t* test. The linear regression analysis was conducted to examine the association of consuming white rice, bread and potato with elevated BP and anthropometric indices and BP. Three following models were used for adjusting the role of possible confounders: Model I, the crude association (without adjustment) was assessed; Model II adjusted for age, sex, living area, PA, ST and SES; and

Model III, BMI was additionally adjusted for DBP and SBP. The result of linear regression is presented as β (95% CI). *P* value of less than 0.05 was considered as statistically significant. Data were analyzed in the Stata Corp. 2011 (Stata Statistical Software: Release 12. College Station, TX: Stata Corp LP. Package).

Ethical notes

After a complete explanation about the objectives and methods of current study, verbal and informed written consent were obtained from the parents and the students, separately.

Results

Of total students, 13,486 children and adolescents (participation rate of 90.6%) were assessed in the current study. The mean (SD) age of participants was 12.47 (3.36). They were consisted of 50.76% girls and 75.57% urban residents. Demographic data of the participants are shown in Table 1 It shows that no difference existed in PA level between rural and urban populations.

Consumption of whole bread and refined bread were reported by 36.73% and 63.27% of students, respectively. Moreover, 71.54% of participants consumed white rice on a daily basis; the corresponding figure was 18.94% for potatoes consumption.

Table 1: Demographic data of participants according to the region: the CASPIAN-IV Study

	Urban n (%)	Rural N (%)	Total n (%)	*P*- value
Age (yr)	12.81 (12.6-13.01)	11.42 (11.08-11.75)	12.47 (12.29-12.64)	<0.001[a]
Sex				
Boys	5127 (50.31%)	1719 (52.17%)	6846 (50.76%)	0.5
Girls	5064 (49.69%)	1576 (47.83%)	6640 (49.24%)	
Family size				
<4 persons	5247 (52.08%)	1244 (38.95%)	6491 (48.92%)	<0.001[a]
≥4 persons	4828 (47.92%)	1950 (61.05%)	6778 (51.08%)	
Father's occupation				
Unemployed	451 (4.58%)	206 (6.46%)	657 (5.04%)	<0.001[a]
Worker or Employee	4795 (47.92%)	1279 (40.13%)	6074 (46.62%)	
Farmer	487 (4.95%)	748 (23.47%)	1235 (9.48%)	
Self-employed	4108 (41.74%)	954 (29.93%)	5062 (38.85%)	
Mother's occupation				
Non-employed	8773 (87.04%)	3110 (95.02%)	11883 (89%)	<0.001[a]
Employee	966 (9.58%)	94 (2.87%)	1060 (7.94%)	
Other	340 (3.37%)	69 (2.1%)	409 (3.06%)	
Father's education (%)				
Illiterate/Elementary school	799 (8.08%)	672 (20.97%)	1471 (11.24%)	<0.001[a]
Secondary school/ High school	1407 (74.93%)	2381 (74.29%)	9788 (74.77%)	
University	1679 (16.99%)	152 (4.74%)	1831 (13.99%)	
Mother's education (%)				
Illiterate/Elementary school	1258 (12.48%)	1012 (30.81%)	2270 (16.99%)	<0.001[a]
Secondary school/ High school	7722 (76.63%)	2203 (67.06%)	9925 (74.28%)	
University	1097 (10.89%)	70 (2.13%)	1167 (8.73%)	
Sedentary lifestyle				
Watching TV (%)				
≤2 h/day	4791 (47.44%)	1794 (55.27%)	6585 (49.34%)	<0.001[a]
>2h/day	5308 (52.56%)	1452 (44.73%)	6760 (%50.66)	
Working with computer (%)				
≤2 h/day	8788 (88.72%)	3032 (95.5%)	11820 (90.37%)	<0.001[a]
>2h/day	1117 (11.28%)	143 (4.5%)	1260 (9.63%)	
Screen Time				
≤2 h/day	7964 (78.63%)	2935 (89.89%)	10899 (81.38%)	<0.001[a]
>2h/day	2164 (21.37%)	330 (10.11%)	2494 (18.62%)	
Family history				
HTN	5558 (55.09%)	1606 (49.17%)	7164 (53.64%)	<0.001[a]
Dyslipidemia	4706 (46.64%)	1182 (36.14%)	5888 (44.07%)	<0.001[a]
DM	3872 (39.29%)	985 (30.97%)	4857 (37.26%)	<0.001[a]
Obesity	4735 (40.89%)	1344 (41.11%)	6079 (45.47%)	<0.001[a]
Physical activity				
<2 times/week	3519 (34.87%)	1034 (31.74%)	4553 (34.11%)	0.14[a]
2-4 times/week	3683 (36.5%)	1227 (37.66%)	4910 (36.78%)	
>4 times/week	2889 (28.63%)	997 (30.6%)	3886 (29.11%)	
SES				
Low	2327 (24.94%)	1820 (59.40%)	4147 (33.47%)	<0.001[a]
Moderate	3206 (34.37%)	894 (29.21%)	4100 (33.09%)	
High	3796 (40.69%)	347 (11.34%)	4143 (33.44%)	

[a]*P*-value are resulted from Chi-square test
Abbreviation: HTN: Hypertension; DM: Diabetes; SES: Socio Economic Status

Table 2 presents the association of white rice and potato consumption frequency and the type of bread with the mean of anthropometric indices and BP levels. It shows that the mean values of weight, BMI, WC, HC, and SBP were significantly higher among participants who daily consumed white rice, however among those who daily consumed potatoes, these means were lower. Furthermore, in the group who consumed whole grain, the mean levels of weight, BMI, WC and HC were significantly higher than in their other counterparts. The association of white rice and potato intake and type of bread consumption

with the frequency of abdominal and general obesity and elevated BP is presented in Table 3. According to this table, white rice and potato consumption did not have significant association with abdominal and general obesity. However, white rice consumption showed significant association with elevated BP.

Table 2: Association among Anthropometric data and blood pressure and whole and refined grain: the CASPIAN-IV Study

	White Rice Consumption		Type of Bread		Potato Consumption	
	Daily Mean (CI95%)	**Non-daily** Mean (CI95%)	**Whole grain** Mean (CI95%)	**Refined grain** Mean (CI95%)	**Daily** Mean (CI95%)	**Non-daily** Mean (CI95%)
BMI (Kg/m²)	18.93 (18.84-19.02)	18.64 (18.5-18.78)	19 (18.88-19.13)	18.76 (18.67-18.85)	18.54 (18.38-18.7)	18.92 (18.84-19.01)
P- value	<0.001		0.002		0.0001	
WC (cm)	67.31 (67.07-67.55)	66.35 (65.98-66.72)	67.76 (67.42-68.1)	66.63 (66.38-66.89)	66.42 (65.97-66.87)	67.2 (66.98-67.43)
P- value	<0.001		<0.001		0.003	
HC (cm)	81.11 (80.79-81.42)	80.07 (79.48-80.65)	81.54 (81.05-82.03)	80.4 (80.06-80.75)	79.75 (79.21-80.29)	81.08 (80.75-81.4)
P- value	0.001		<0.001		<0.001	
WHtR	0.457 (0.456-0.458)	0.454 (0.452-0.456)	0.458 (0.457-0.460)	0.455 (0.454-0.456)	0.456 (0.453-0.458)	0.456 (0.455-0.458)
P- value	0.01		0.002		0.79	
WHR	0.185 (0.184-0.185)	0.188 (0.187-0.189)	0.185 (0.184-0.186)	0.186 (0.185-0.187)	0.187 (0.185-0.188)	0.185 (0.185-0.186)
P- value	<0.001		0.34		0.1	
SBP (mmHg)	101.7 (101.4-101.9)	101.1 (100.6-101.5)	101.6 (101.3-102.1)	101.4 (101.1-101.7)	100.6 (100.1-101.2)	101.7 (101.4-101.9)
P- value	0.01		0.97		<0.001	
DBP (mmHg)	64.8 (64.5-65.0)	65.1 (64.7-65.5)	64.9 (64.5-65.2)	64.9 (64.6-65.1)	64.2 (63.7-64.6)	65.0 (64.8-65.2)
P- value	0.14		0.41		<0.001	

[a]*P*-value are resulted from T-test/Abbreviation: BMI: Body Mass Index; WC: Waist Circumference; HC: Hip Circumference; WHtR: Waist to Height Ratio; WHR: Waist to Hip Ratio; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure

Table 3: Association among Anthropometric data and blood pressure and whole and refined grain: the CASPIAN-IV Study

	White Rice		Type of Bread		Potato	
	Daily n (%)	**Non-daily** n (%)	**Whole grain** n (%)	**White** n (%)	**Daily** n (%)	**Non-daily** n (%)
BMI						
Underweight	1105 (11.67)	498 (13.23)	570 (11.75)	1032 (12.38)	316 (12.63)	1289 (12.03)
Normal	6300 (66.55)	2484 (65.98)	3209 (66.14)	5540 (66.77)	1679 (67.11)	7090 (66.19)
Overweight	915 (9.66)	363 (9.64)	492 (10.14)	780 (9.35)	237 (9.47)	1043 (9.73)
Obese	1147 (12.12)	420 (11.16)	581 (11.97)	982 (11.78)	270 (10.79)	1289 (12.03)
***P*- value**	*P* = 0.08		*P* = 0.44		*P* = 0.33	
Abdominal obesity						
No	7670 (80.79)	3072 (81.18)	3898 (79.96)	6803 (81.4)	2050 (81.71)	8675 (80.71)
Yes	1824 (19.21)	712 (18.82)	977 (20.04)	1554 (18.6)	459 (18.29)	2074 (19.29)
***P*- value**	*P* = 0.65		*P* = 0.09		*P* = 027	
SBP						
Normal	9414 (99.07)	3741 (99.07)	4834 (99.14)	8276 (99.07)	2484 (99)	10613 (99.09)
High SBP	88 (0.92)	35 (0.92)	42 (0.86)	78 (0.93)	25 (0.99)	98 (0.91)
***P*- value**	*P* = 0.99		*P* = 0.7		*P* = 0.69	
DBP						
Normal	9234 (97.32)	3618 (95.92)	4697 (96.41)	8109 (97.22)	2430 (97.12)	10337 (96.85)
High DBP	254 (2.67)	154 (4.08)	175 (3.59)	232 (2.78)	72 (2.87)	338 (3.14)
***P*- value**	*P* = 0.001[a]		*P* = 0.05[a]		*P* = 0.51	
HTN						
Normal	9170 (96.64)	3594 (95.28)	4664 (95.73)	8055 (96.56)	2414 (96.44)	10302 (96.16)
High blood pressure	319 (3.36)	178 (4.71)	208 (4.26)	287 (3.44)	89 (3.55)	409 (3.8)
***P*- value**	*P* = 0.003[a]		*P* = 0.06		*P* = 0.57	

Abbreviation: BMI: Body Mass Index; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HTN: Hypertension
[a]*P*-value are resulted from chi-square test

According to Table 4, in crude and adjusted models, we did not find any significant association for the frequency of white rice consumption with DBP and SBP, but significant association was documented for white rice consumption with BMI and WC. For every increase in the frequency of daily consumption of white rice, 0.19 and 0.65 units were added to BMI and WC, respectively.

Table 4: β (95% CI) of anthropometric and BP measures for consuming refined and whole grain

	BMI β (95% CI)[a]	WC β (95% CI)	HC β (95% CI)	DBP β (95% CI)	SBP β (95% CI)
White Rice (Daily/Non-daily)					
Model I[1]	0.29 (0.06, 0.51)	0.95 (0.294, 1.62)	1.04 (0.07, 2.00)	-0.32 (-0.97, 0.33)	0.61 (-0.13, 1.36)
Model II[2]	0.19 (0.02, 0.35)	0.652 (0.17, 1.13)	0.63 (-0.01, 1.27)	-0.44 (-1.08, 0.19)	0.39 (-0.26, 1.05)
Model III[3]	…….	…….	…….	-0.28 (-0.96, 0.39)	0.44 (-0.23, 1.12)
Bread (whole/Non)					
Model I	0.24 (0.01, 0.47)	1.12 (0.44-1.8)	1.13 (0.2-2.06)	0.007 (-0.65-0.67)	0.197 (-0.54-0.93)
Model II	0.12 (-0.03, 0.29)	0.72 (0.27-1.17)	0.57 (-0.02-1.16)	-0.18 (-0.79-0.43)	-0.13 (-0.75-0.49)
Model III	……..	……..	……..	-0.24 (-0.89-0.41)	-0.33 (-0.98-0.32)
Potato (Daily/Non-daily)					
Model I	-0.38 (-0.6 , -0.17)	-0.78 (-1.4, -0.16)	-1.32 (-2.14, -0.51)	-0.84 (-1.45 , -0.23)	-1.05 (-1.78, -0.32)
Model II	-0.18 (-0.35, -0.02)	-0.17 (-0.63, 0.29)	-0.46 (-0.98, 0.07)	-0.56 (-1.14, 0.02)	-0.55 (-1.2, 0.11)
Model III	……	……..	……..	-0.41 (-1.02, 0.21)	0.46 (-1.16, 0.22)

[1]Without adjusted (crude models),[2]Adjusted for age, sex, region, SES and physical activity and screen time
[3]Additionally adjusted for BMI for DBP and SBP
Abbreviation: BMI: Body Mass Index; WC: Waist Circumference; HC: Hip Circumference; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure
[a] All resulted from regression test

Moreover, in the crude model we found significant association of whole bread consumption with BMI, WC and HC; however in the adjusted model, significant association was only observed between the type of bread and WC, so that for every increase in the frequency of whole bread consumption, WC increased by 0.72 units.

As presented in Table 4, in the crude model, the frequency of potato consumption had significant association with anthropometric indices and elevated BP, whereas in the adjusted model, it had significant association with BMI, i.e. for every increase in daily consumption of potato, BMI decreased by 0.18 unit.

Discussion

Bread and rice are staple foods that are widely used around the world, especially in eastern countries including Iran. Usually rice is processed and refined as white rice. During the refining process, the bran is removed, and only starch remains, which is rich of energy. A large portion of the nutritional value of refined grains is lost during the refining process. This study revealed that consumption of white rice and potato, as well as the type of bread were significantly associated with anthropometric indices of children and adolescents. There is evidence indicating that refined grains increase the risk of obesity and chronic diseases (12, 16). Refined grains and whole grains have different effects on weight gain; this is suggested to be because of differences in postprandial insulin responses and gastric emptying after consuming a high glycemic index (GI) meal (30). However, such associations are still controversial. Most previous studies have been conducted in adult populations, and limited evidence exists in children and adolescents.

For example, a prospective study on 17,881 U.S. male physicians 40 to 84 years of age failed to find any association between weight gain and the consumption of refined grains (14). McKeown et al. showed no association between the consumption of refined grains and metabolic risk factors (31). On the other hand, another study on the Chinese

adults, reported an inverse association between white rice consumption and weight gain (32). However, our findings were consistent with some other studies reporting that the consumption of refined grains can be positively associated with weight gain and higher visceral adipose tissue (33-35).

Both types of breads, i.e. whole grain and refined breads have the similar calorie content. However, whole grain bread has more satiating power than the refined type, which may reduce the intake of other foods (36). Many cross-sectional studies have revealed that high intake of whole grain is associated with lower body weight and abdominal obesity in adults (11, 37-40). Another study on white males aged 27–88 years has documented an inverse association of whole grain consumption with BMI, body weight and WC, without any significant association for refined grains (39). In 34,492 postmenopausal women aged 55-69 years, whole-grain intake was associated with lower BMI and WHR, and refined grain intake was not significantly associated with BMI (41). Likewise, a study in Iranian adults showed significant association between intake of whole grains and lower prevalence of abdominal obesity (37). There was no association between whole-grain bread consumption and WC changes, while consumption of refined breads was positively associated with increased WC in women (50-64 y) (42). Those men (40- 84 years) who consumed ≥ 1 serving/day of whole grain breakfast cereals weighted less than their counterparts who rarely consumed whole grain (14). Higher intake of whole grains might lead to a slight increase in body weight (21, 34, 43). A high intake of whole grains may contribute to a slight increase of weight gain or weight loss in subjects.

In the present study, a significant association was observed between consumption of white rice and SBP, but consumption of whole and refined bread and potato had no significant association with BP. One study showed that the risk of general obesity among individuals who consumed white rice for > 1 serving/day was higher than in those subjects who consumed it for < 1 serving/day. However, WC was greater in subjects who consumed <1 serving/day of white rice (17). SBP and DBP of subjects who consumed > 1 serving/day of white rice were higher than in their other counterparts (17). Another study conducted on 827 subjects (357 men and 470 women) aged 18-74 y, showed that the intake of whole-grain is associated with lower DBP, and higher consumption of refined grains raised DBP (37). A study was conducted on 26,001 adult (aged ≥20 years) and reported that increased consumption of refined grains was significantly associated with higher SBP and DBP (44).

In the current study, we found significant association between consumption of potato and anthropometric indices, except than WHR and WHtR. The mean of weight, BMI, WC, and HC were significantly lower among participants who consumed potatoes on a daily basis.

The starch can be categorized into three categories: rapidly digestible starch (RDS), slowly digestible starch (SDS) and resistant starch (RS). Starchy foods such as potatoes, usually consists of three categories and cannot be easily separated into purified RDS, SDS and RS. Consumption of SDS and RS increases satiety, whereas it reduces hunger and in turn, it might lead to weight loss (45, 46).

Meals containing resistant starch lead to decreased glucose and insulin responses and thereupon might induce the satiety (47).

Study limitations and strengths

The main limitation of this study was its cross-sectional design that does not demonstrate casual associations. The main strengths of the present study are its novelty in the pediatric age group, and studying a large national sample size by using a standard questionnaire. Strength of this study, is considering a large number of potential confounders to reduce their effects on the observed associations.

Conclusion

Higher consumption of refined grains and potato was associated with generalized and central obesity in children and adolescents. Furthermore,

consumption of whole grain bread reduced the risk of abdominal and generalized obesity. Significant association was observed between consumption of refined grains and SBP, but without significant association between types of bread and BP levels. Our findings suggest that limiting the consumption of refined grains can be one of moderating nutrition policies to tackle childhood obesity.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, and/or falsification, double publication) have been considered carefully.

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