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Original Article

Effects of Korean Versus Western Diets on Reproductive Function in Young Korean Men: A 12-Week Randomized Parallel Clinical Trial

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Background: Studies report that diet may have contributed to a 50-60% decrease in human sperm quality over the past few decades. Unhealthy lifestyles affect the structure of spermatozoa, affecting the male reproductive potential. This study aimed to compare the effects of Korean and Western diets on reproductive function in young male Koreans.

Methods: Study participants were provided either the Korean Diet (KD group) or the Western Diet (WD group) for 12 weeks. Semen quality parameters such as volume, motility, cell count, and sex hormone levels were evaluated. Sexual function was assessed using the International Index of Erectile Function and the Male Sexual Health Questionnaire. Efficacy and safety evaluations were conducted at baseline, 8 weeks, and 12 weeks.

Results: The KD group demonstrated a significantly increased sperm motility after 8 weeks relative to baseline but decreased after 12 weeks. In contrast, sperm motility in the WD group significantly decreased after 8 weeks compared with baseline and remained constant after 12 weeks. Statistically, a near-significant difference was observed between groups ($p = 0.057$). Similarly, free testosterone levels in the KD group increased after 12 weeks compared with baseline, whereas that in the WD group decreased. The free testosterone levels in the KD group were significantly higher than those in the WD group ($p = 0.020$). There were no statistically significant differences in other sex hormone and sexual function questionnaires between the groups. None of the participants reported any severe side effects, and no significant alterations in clinical diagnostic test values were detected.

Conclusion: The results of the study strongly reveal that KD positively affects sperm motility and male hormone levels in young men, indicating potential benefits for reproductive function.

Keywords: Korean diet, Reproductive function, Semen motility, Semen quality, Western diet

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INTRODUCTION

Sperm count, a key determinant of sperm quality, has been steadily declining worldwide. In 1940, the average global sperm count stood at 110 million per 1 mL of semen. However, between 1973 and 2011, a significant decrease of approximately 50%-60% was observed among men from Western countries [1]. It's estimated that up to 50% of infertility issues are driven by diminished sperm count, motility, and malformed sperm [2,3]. Additionally, increasing reports of reproductive system disorders, such as testicular and prostate diseases, have heightened interest in male reproductive function. Further, hypospermia, reduced sperm concentration in semen, and insufficient structurally normal sperm are common anomalies associated with male infertility [4]. These disorders are believed to account for over 90% of male infertility cases. Moreover, multiple environmental factors have been identified as contributors to infertility, including tobacco and alcohol consumption, emotional stress, prolonged exposure to high temperatures, wearing tight clothing, a sedentary lifestyle, radiation, and exposure to Persistent organic pollutants [5-9]. On the contrary, there are several known treatments for infertility, ranging from clomiphene citrate to antioxidant agents like vitamin E and glutathione, but their efficacy remains ambiguous. Emerging research suggests that diet and overall lifestyle are pivotal in maintaining optimal reproductive function [4,10-13]. Young adults, particularly college students, often skip breakfast and maintain irregular eating patterns [14]. Also, choices gravitate towards convenience, resulting in the increased intake of processed foods [15]. This kind of processed foods is characterized by high calories, excessive saturated fatty acids, and foods with a high glycemic index, predispose individuals to chronic ailments like obesity, type 2 diabetes, and dyslipidemia. Importantly, high intake of animal fats and saturated fatty acids is linked to elevated oxidative stress [16], which is implicated in hormonal imbalances and diminished male fertility [17]. Despite the influence of diet on male fertility is recognized, the precise biochemical mechanisms that modulate sperm quality remain elusive. The Western diet (WD) is increasingly viewed as detrimental to male fertility, whereas the Korean diet (KD), rich in vegetables, fermented foods, beans, fish, and various seasonings [18], is believed to be protective on reproductive function. In addition, the majority of studies to date focused on the influence of functional food supplements and medications to improve sperm function. However, the absence of research on the impact of the traditional KD on the reproductive health of adult males led to an investigation into the effects of KD and WD on the reproductive functions in young men.

MATERIALS AND METHODS

1. Subjects

Institutional Review Board (IRB) of Jeonbuk National University Hospital reviewed and approved this study (CBNUH_CTCF2_IRB 2008-01-004). All clinical trial procedures were carried out in line with the Declaration of Helsinki and the Clinical Trial Management Standards, adhering to the regulations of Korean Good Clinical Practice. The dietary intervention for this study spanned 12 weeks, from May 23, 2008, to September 17, 2008. A total of 63 volunteers provided written consent to participate in this study. Following a screening test, 20 individuals who met both the inclusion and exclusion criteria were selected to participate in the study.

Selection criteria for the trial are as follows:

1) Healthy males aged between 19 and 30 years.

2) For the group with abnormal semen results (indicating reduced reproductive function), participants were selected if they had:

a) A sperm counts of 20 million or fewer per 1 mL.

b) Motility of 50% or less.

c) A single ejaculate volume of 2.5 mL or less.

3) For the group with normal semen results, participants were chosen if they did not meet any criteria of the abnormal semen findings group.

4) Participants who, after receiving a detailed explanation of this study and fully understanding it, and voluntarily decided to participate and provided written agreement to adhere to the study's precautions.

Exclusion criteria for the trial are as follows:

1) Individuals currently consuming medications related to sexual function, health supplements, or foods containing grapefruit as it known to improve testosterone levels and has aphrodisiac properties.

2) Individuals with heart diseases (such as heart failure, angina, or myocardial infarction) or lung diseases.

3) Individuals experiencing sexual dysfunction due to specific diseases or medications.

4) Those who have been diagnosed with and treated for cancer within the past 3 years.

5) Those who have undergone male hormone replacement therapy in the last 3 months.

6) Patients diagnosed with hypogonadism, male breast cancer, or benign prostatic hyperplasia.

7) Subjects with significant neurological or psychological history or those currently suffering from conditions like depression, schizophrenia, epilepsy, alcoholism, drug addiction, anorexia, bulimia, etc.

8) Individuals with a history of stroke or transient ischemic attack.

9) Those who have taken medications within the past 3 months that might influence male hormones, such as oral steroids or thyroid hormones, or drugs that affect absorption, metabolism, or excretion, or those who have participated in other clinical trials. Those consuming other medications with a potential for abuse.

10) Subjects whom the researcher deems unlikely to comply with study protocols.

2. Study design

This investigation is an 12-week open-label, randomized, parallel-group comparison clinical trial to compare the influence of KD and WD on sexual function. A total of 20 subjects who met the selection criteria were equally divided into two groups based on semen findings (semen count and motility): abnormal and normal. Participants were randomly divided in a 1:1 ratio within these groups, with 5 individuals assigned to the KD and 5 to the WD (Supplementary Fig. 1). All participants from each dietary group visited the Clinical Trial Center for Functional Foods (CTCF2) daily to consume three provided meals at the set times: 7:00 AM for breakfast, 12:00 PM for lunch, and 6:00 PM for dinner. This diet regimen continued for 12 weeks. The study's dietary plan incorporated a 14-day menu cycle. Considering the target demographic (males aged 19 to 30), the daily caloric intake was set at an estimated 2,600 kcal, including meals and snacks. The diet was formulated based on the recommended food ingredients for young men, including cereals, fish, eggs, legumes, meat, vegetables, dairy products, and fat. Meals, standardized by the researcher, were individually portioned and provided to participants. The average daily energy and nutrient details are tabulated in (Table 1). Ingredients used in the clinical trial diet were sourced from the same area to maintain quality and uniformity. A professional nutritionist reviewed all ingredient purchases, and a standard recipe was consistently used to prepare food. All the subjects were assessed on their first visit (week 0), week 8 (2nd visit), and week 12 (3rd visit).

Table 1. Nutrients content provided in each intervention diet group per day

Nutrients	Korean diets	Western diets
Energy (kcal)	2,600	2,600
Carbohydrate (g)	390	325
Carbohydrate (%)	60	50
Protein (g)	130	130
Protein (%)	20	20
Fat (g)	58	87
Fat (%)	20	30
Cholesterol (mg)	300	300
Fiber (g)	30	20

1) Korean diet

The KD emphasized a rice-centric approach, with daily caloric and macronutrient ratios of 60:20:20 for carbohydrates:protein:fat. Here, the main staple was rice, and each meal was accompanied by three dishes, including soup, kimchi, sauce, and side dishes (raw or cooked vegetables, grilled items, or dried seasonings). To truly capture the essence of a rice-centered diet, staple foods and side dishes were strictly separated. In this diet, foods made from wheat, such as bread and noodles, were excluded, as were milk and dairy products.

2) Western diet

The WD group was provided with a caloric intake similar to the KD group, but the macronutrient distribution (%) was adjusted to reflect the WD dietary pattern of 50:20:30 for carbohydrate:protein:fat. WD is a wheat-centric diet where bread, toast, soups, noodles, cereals, dumplings, sandwiches, corn, potatoes, and sweet potatoes are served. Accompaniments comprised salads made with vegetables and fruits, pickles, nuts, dairy products, and fruit juice.

3. Subject compliance

To mitigate the influence of lifestyle changes on the study outcomes, participants instructed to consume only the offered test diet and asked to maintain their regular physical activity. Dietary adherence was monitored by surveying the dietary intake during the study period. To track dietary intake, subjects diligently recorded their daily food consumption in a specified diary. Additionally, subjects were asked to self-report any medication use, symptoms, or side effects, change in lifestyle habits, and adherence to each specified diet regimen.

4. Outcome measures

Efficacy and safety assessments were carried out for all participants at the beginning (week 0), after 8 weeks, and 12 weeks of participation in the study. During each visit, participants underwent a physical examination, semen analysis, and sex hormone testing. In addition, all the subjects completed a sexual function-related questionnaire and were monitored for any adverse reactions.

1) Semen quality parameters

Participants were required to abstain from sexual activity for at least 2 days before semen collection through mastur-

bation. All collections took place in a consistent environment (a dark room equipped with audio-visual materials and maintained at a specific temperature) between 8:00 AM and 12:00 PM before engaging in any strenuous physical activities. The semen volume was quantified in mL, while the sperm count was measured in millions of sperm per mL. To ensure the accuracy of the test, analysis was conducted within 30 minutes to 1 hour following the collection. During this interval, the semen was maintained at body temperature (37°C).

2) Sex hormones analysis

The levels of sex hormones, including total testosterone (TT), sex hormone binding globulin (SHBG), free testosterone (FT), and bioavailable testosterone (BT), were assessed on their first visit (week 0), week 8 (2nd visit), and week 12 (3rd visit). Blood samples for this purpose were drawn from the dorsal vein of the brachium between 7:00 AM and 11:00 AM. The concentrations of TT and SHBG were directly measured. Meanwhile, the values of FT and BT were computed based on the obtained TT, SHBG, and albumin levels using a free and bioavailable calculator developed by hormonology department at the University Hospital of Ghent, Belgium (http://www.issam.ch/freetesto.htm). In addition, the levels of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) were assessed using blood drawn from a branchial vein on third visit (12 week).

3) Sexual Function Questionnaires: IIEF and MSHQ

International Index of Erectile Function (IIEF) [19] and the Male Sexual Health Questionnaire (MSHQ) [20] were utilized during the screening process for evaluation. The IIEF comprises 15 items, with 6 questions focused on erectile function, 3 on sexual intercourse satisfaction, 2 on orgasmic function, 2 on sexual desire, and 2 assessing overall satisfaction with sexual life. The evaluation of sexual function was based on the aggregated scores from each question pertaining to the specific function. On the other hand, the MSHQ is a comprehensive questionnaire on male sexual health with 25 questions, where 3 questions related to erection ability, 7 related to ejaculation, 6 with satisfaction, and an additional 9 questions for other relevant topics. Here, the assessment of sexual function was derived from the cumulative scores of each section, respective to the function in focus. All participants completed the IIEF and MSHQ at the beginning of the study (week 0) and again 12 weeks later.

5. Dietary intake survey

A seasoned nutritionist advised all participants on how to accurately complete their dietary records for the dietary intake assessment of this study. The quantity of food remaining before and after each daily meal provided during the 12-week dietary intervention was measured to validate the participants' dietary intake. This data was utilized for the dietary intake analysis. Participants were thoroughly educated to consume only the test diet provided. Any additional foods consumed due to unavoidable circumstances were diligently recorded in a food diary and incorporated into the analysis. The average daily caloric and nutrient intake was determined using CAN-pro 4.0, a computer-aided nutritional analysis program developed by the Korean Society of Nutrition, Seoul, Korea, and referencing the dietary records obtained during the 12-week study period.

6. Compliance with test diets intake

To evaluate the adherence of participants to the test diet, records were maintained to document the frequency of visits made by subjects to the CTCF2 and their consumption of the provided meals. During intervention period, meals were scheduled to be consumed daily within specified time frames: 7:30-8:30 AM for breakfast, 12:00-1:00 PM for lunch, and 6:00-7:00 PM for dinner. Participants with diet compliance rates below 70% were disqualified. Ideally, subjects were expected to consume the provided meals daily. However, in unavoidable scenarios, participants were permitted to skip the provided meal once a month on weekends (either Saturday or Sunday). In such cases, it was advised that any externally sourced food consumed should closely resemble the trial diet. All such meals were to be documented in dairy. Diet compliance was calculated with the help of following equation,

$$\text{Diet compliance (\%)} = \frac{\text{The number of meals in 12 weeks} - \text{the number of uneaten meals}}{\text{The number of meals in 12 weeks}} \times 100$$

7. Statistical analysis

All statistical analyses were conducted using SAS 9.2 (SAS Institute) and IBM SPSS 20 (IBM Co.). Continuous variables were expressed as mean±standard deviation, while categorical variables were presented as frequencies. The analysis of variance (ANOVA) was applied to continuous variables, and Fisher's exact test was used for categorical ones. The evaluation metrics for effectiveness, such as semen volume, sperm motility, sperm count, sex hormone levels, and scores from the sexual function questionnaire, were analyzed using a linear mixed-effects model to determine the differences between intake groups. Additionally, comparisons were made between normal and abnormal subgroups within each main group. Changes observed within each test group at baseline (0 weeks), 8 weeks, and 12 weeks were analyzed

using ANOVA. All tests were two-tailed, with a significance level set at $p < 0.05$.

8. Sample size estimation

The trial is a pilot study aimed at evaluating the influence of KD and WD on reproductive function in young men. There are limited findings on male reproductive functions. The sample size formulas used for general clinical trial evaluations are typically inapplicable to pilot studies. In light of the limitation, this pilot study was conducted with a participant cohort of 20 individuals.

9. Adverse events and monitoring safety

Safety assessments were performed for study participants, including monitoring for potential adverse reactions, diagnostic medical evaluations, vital sign checks, physical examinations, and electrocardiogram analyses. Blood tests included measurements for white blood cell, red blood cell, hemoglobin, hematocrit, and platelets, in addition to liver function markers such as alkaline phosphatase, gamma-glutamyltransferase, aspartate aminotransferase, and alanine aminotransferase. Key kidney function indicators like total bilirubin, total protein, blood urea nitrogen, and creatine kinase concentrations were evaluated calorimetrically using the Hitachi 7600-110 instrument (Hitachi). Additional assessments comprised albumin, total cholesterol, triglycerides, glucose, and urinalysis. These blood and urine evaluations were conducted at the beginning (week 0), 8th week, and 12th week of the study. Participants consistently consuming the trial food were encouraged to report any adverse events (AEs) proactively. For vital sign monitoring, systolic blood pressure, diastolic blood pressure, and heart rate were recorded during the screening and at each subsequent visit.

RESULTS

1. Baseline demographics

In this study, 63 volunteers were screened, of which 20 met the eligibility criteria and were enrolled for the trial. The selected participants were subsequently categorized into normal and abnormal groups based on their semen count and motility. These groups were further randomly divided in a 1:1 ratio between KD and WD within these groups. The study includes 4 groups, with 5 in KD normal, 5 in KD abnormal, 5 in WD normal, and 5 in WD abnormal. One individual from the KD abnormal group withdrew the consent, bringing to a final data analysis sample size of 19 participants. The detailed screening and selection flow is described in (Supplementary Fig. 1). The general demographics and characteristics of the participants are provided in Table 2. The average age of the participants in KD normal, KD abnormal, WD normal, and WD abnormal was 25.6±2.2, 26.3±2.5, 25.2±1.5, and 26.0±2.5 years, respectively. There were no significant differences between the KD and WD groups. Likewise, the KD and WD groups had no statistically significant difference in other demographic parameters such as weight, height, BMI, and habits like drinking and smoking. During the 12-week study period, the compliance rate for the KD group was 77.8% up to the 8th week but dropped to 67.6% between the 9th and 12th weeks. Similarly, the compliance rate for the WD group was 87.5% up to the 8th week but dropped to 81.7% between the 9th and 12th weeks (Supplementary Table 1).

2. Semen quality parameters

The semen volume, motility, and sperm count of participants at baseline (0 weeks), 8 weeks, and 12 weeks are presented in Table 3. The semen volume trends for the KD and WD groups were similar, and no significant difference was observed between the groups ($p > 0.05$). In the KD group,

Table 2. General demographic characteristics of the subjects

Variable	KD group (n = 9)			WD group (n = 10)			p-value[a]
	Normal (n = 5)	Abnormal (n = 4)	Total (n = 9)	Normal (n = 5)	Abnormal (n = 5)	Total (n = 10)	
Age (yr)	25.6 ± 2.2	26.3 ± 2.5	26.3 ± 2.5	25.2 ± 1.5	26.0 ± 2.5	26.0 ± 2.5	0.894
Height (cm)	170.7 ± 6.9	180.0 ± 2.6	174.8 ± 7.1	176.9 ± 4.5	176.7 ± 8.2	176.8 ± 6.2	0.179
Weight (kg)	64.7 ± 7.1	77.8 ± 11.9	70.5 ± 11.2	74.0 ± 8.3	80.7 ± 16.0	77.3 ± 12.5	0.180
Body mass index (kg/m^2)	23.1 ± 3.1	23.5 ± 2.5	23.0 ± 3.1	24.8 ± 3.9	23.7 ± 3.1	24.7 ± 3.9	0.785
Smoking (pack of cigarettes/week)	0.8 ± 1.8	1.8 ± 2.1	1.8 ± 2.1	0.6 ± 1.3	1.4 ± 1.9	1.4 ± 1.9	0.755
Drinking[b] (bottle/week)	0.6 ± 0.9	1.0 ± 0.7	1.0 ± 0.7	0.2 ± 0.4	1.3 ± 1.0	1.3 ± 1.0	0.187

Values are presented as mean±standard deviation.
KD: Korean diet, WD: Western diet.
[a]Analyzed by independent t-test analysis of variance.
[b]Bottle of soju containing 19% alcohol.

Table 3. Changes in semen analysis and sex hormones of subjects during the clinical trial intervention period

	KD group (n = 9)				WD group (n = 10)				p-value[b]
	Week 0	Week 8	Week 12	p-value[a]	Week 0	Week 8	Week 12	p-value[a]	
Volume (mL)	2.8 ± 0.9	3.4 ± 1.4	3.1 ± 0.7	0.429	2.8 ± 1.2	3.4 ± 1.5	3.2 ± 1.4	0.446	0.979
Motility (%)	54.6 ± 20.0	64.6 ± 22.1	55.0 ± 18.7	0.098	53.7 ± 23.7	45.7 ± 21.6	53.1 ± 16.3	0.387	0.057
Cell count (M/mL)	66.8 ± 34.7	75.4 ± 53.1	105.5 ± 49.2	0.063	66.4 ± 38.1	76.9 ± 55.3	85.6 ± 42.6	0.450	0.557
FSH (mlU/mL)	2.48 ± 0.5	2.85 ± 0.9	2.92 ± 0.8	0.430	3.46 ± 1.1	4.00 ± 1.6	3.83 ± 1.3	0.670	0.658
LH (mlU/mL)	3.94 ± 1.3	4.59 ± 1.5	4.75 ± 1.9	0.522	3.87 ± 0.9	5.13 ± 2.1	3.85 ± 0.9	0.092	0.101
Testosterone (ng/mL)	6.36 ± 2.0	5.66 ± 2.1	6.31 ± 2.4	0.743	6.11 ± 1.7	5.62 ± 1.2	4.46 ± 1.4	0.047	0.125
Free testosterone (pg/mL)	13.5 ± 2.9	16.8 ± 3.4	17.5 ± 4.8	0.080	14.1 ± 1.7	16.9 ± 2.3	13.2 ± 3.0	0.006	0.020
SHBG (nmol/L)	32.8 ± 13.4	31.6 ± 10.1	32.6 ± 13.2	0.975	25.9 ± 8.4	25.3 ± 9.8	24.5 ± 10.2	0.947	0.769
Free testosterone (ng/mL)	0.14 ± 0.06	0.12 ± 0.04	0.14 ± 0.06	0.655	0.15 ± 0.04	0.13 ± 0.02	0.10 ± 0.02	0.009	0.144
Bioavailable testosterone (ng/mL)	3.52 ± 1.41	3.00 ± 0.96	3.47 ± 1.57	0.670	3.65 ± 0.99	3.36 ± 0.55	2.60 ± 0.58	0.010	0.116

Values are presented as mean±standard deviation.
KD: Korean diet, WD: Western diet, FSH: follicle-stimulating hormone, LH: luteinizing hormone, SHBG: sex hormone binding globulin.
[a]Repeated measures analysis of variance.
[b]p-values for the group time interaction were calculated via repeated measures analysis of variance.

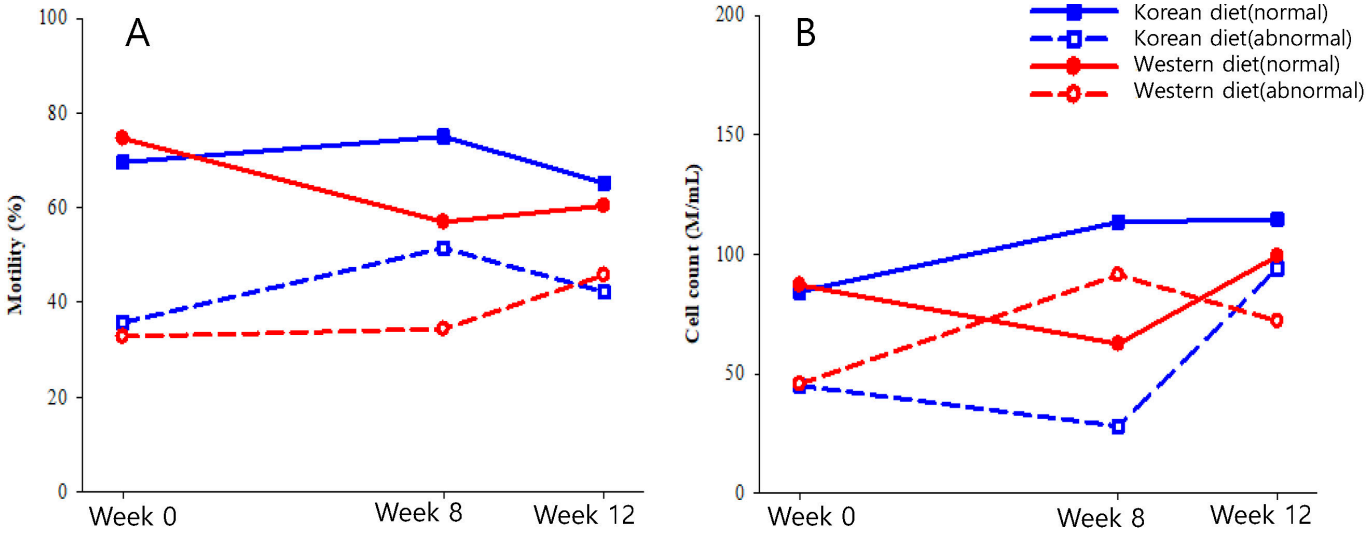

Fig. 1. Comparison of semen quality between normal and abnormal semen groups. (A) Semen mortality and (B) semen cell count.

sperm motility increased after 8 weeks of intervention compared to baseline levels. However, it reduced to baseline levels after 12 weeks. In contrast, the motility of the WD group decreased after 8 weeks of intervention compared to baseline levels but recovered to baseline levels after 12 weeks of intervention. Interestingly, an upward trend in sperm count was observed in the KD and WD groups. However, after 12 weeks, the KD groups had higher sperm counts than the WD groups. However, there was no significant difference between the KD and WD groups ($p > 0.05$).

1) Comparison of semen characteristics between normal and abnormal semen groups

In the KD group, semen analysis results indicated that after 8 weeks of intervention, semen volume, motility, and sperm count increased in the normal participants. However, the trend did not continue for 12 weeks. Interestingly, sperm counts showed an increasing trend in KD normal and KD abnormal groups till 12 weeks. Nevertheless, within the KD group, no significant differences were observed in semen volume, motility, or sperm count between the normal and abnormal categories. In the WD normal group, motility and sperm counts decreased in the 8th week and increased slightly by the 12th week. In contrast, the participants in the WD abnormal group, all three metrics, semen volume, motility, and sperm count, showed an increasing trend (Fig. 1). Within the WD group, sperm count changes between the normal and abnormal categories were significantly dif-

Table 4. Changes in subjects' sexual function and male sexual health evaluation indicators (IIEF, MSHQ) during clinical intervention

Variable	KD group (n = 9)			p-value[a]	WD group (n = 10)			p-value[a]	p-value[b]
	Week 0	Week 8	Week 12		Week 0	Week 8	Week 12		
IIEF									
Erectile function	19.1 ± 11.5	14.9 ± 13.2	16.9 ± 12.0	0.420	12.8 ± 12.0	11.6 ± 11.2	14.8 ± 11.6	0.540	0.724
Sexual intercourse satisfaction	6.3 ± 4.8	4.7 ± 5.5	6.0 ± 5.9	0.524	2.1 ± 4.5	2.8 ± 4.5	4.0 ± 5.2	0.743	0.497
Orgasmic function	6.1 ± 3.9	4.0 ± 4.8	4.4 ± 4.5	0.841	4.0 ± 4.8	3.6 ± 4.7	6.2 ± 4.6	0.640	0.390
Sexual desire	6.4 ± 1.3	5.4 ± 1.7	5.9 ± 2.1	0.742	6.4 ± 2.2	5.8 ± 1.2	6.3 ± 1.7	0.624	0.867
Overall satisfaction	6.9 ± 1.2	6.0 ± 2.2	6.1 ± 2.2	0.824	6.5 ± 1.5	6.2 ± 0.8	6.8 ± 1.0	0.248	0.554
MSHQ									
Erection	13.2 ± 2.3	13.6 ± 1.7	14.1 ± 1.8	0.631	13.3 ± 1.2	13.9 ± 1.3	13.6 ± 1.6	0.628	0.497
Ejaculation	30.0 ± 4.5	30.9 ± 2.2	29.7 ± 5.6	0.829	28.1 ± 6.1	30.3 ± 2.2	30.8 ± 3.7	0.342	0.521
Sexual satisfaction	22.3 ± 2.7	21.8 ± 3.6	23.0 ± 4.4	0.771	21.4 ± 3.2	19.3 ± 3.4	19.7 ± 2.5	0.287	0.444

Values are presented as mean±standard deviation.
KD: Korean diet, WD: Western diet, IIEF: International Index of Erectile Function, MSHQ: Male Sexual Health Questionnaire.
[a]Repeated measures analysis of variance.
[b]p-values for the group time interaction were calculated via repeated measures analysis of variance.

ferent (p = 0.033). Furthermore, a significant was observed in motility and counts between KD and WD groups after 8 weeks (p = 0.077).

2) Sex hormones

The changes in sex hormones, such as TT, FSH, LH, BT, FT, and SHBG were evaluated on the 8th week and 12th week. No significant differences were observed in the TT, FSH, LH, and SHBG levels between the two groups except for FT levels. Specifically, the KD group showed a consistent rise from baseline (week 0) to week 12 (p = 0.080). However, the KD group showed a rise and fall pattern. All the observations on hormone levels are presented in Table 3.

3) Sexual Function Questionnaires: IIEF, MSHQ

All the sexual health indicators as per IIEF and MSHQ are listed in Table 4. No significant statistical differences were found between the KD and WD groups across all IIEF and MSHQ items.

3. Dietary intake during the period of dietary intervention

The average dietary intake of participants over the 12-week dietary intervention is outlined in Table 5. Participants in the KD group had an average daily caloric intake of 1,386.7±315.3 kcal, while those in the WD group consumed 1,531.1±467.0 kcal on average. Although the WD group seemed to have a slightly higher caloric intake, the difference between the groups was not statistically significant. There was no significant difference in the carbohydrate intake in both groups. However, the KD group's carbohydrate consumption ratio was 60.1%, noticeably higher than the 51.1% of the WD group, resulting in a significant difference

Table 5. Nutrient intake by the subjects during the intervention period

Nutrient	KD group (n = 9)	WD group (n = 10)	p-value[a]
Energy (kcal)	1,386.7 ± 315.3	1,531.1 ± 467.0	0.316
Carbohydrates (g)	199.3 ± 34.8	231.8 ± 67.5	0.128
Total carbohydrates (%)	60.1 ± 9.3	51.1 ± 6.2	0.034
Total protein (%)	16.1 ± 2.2	15.2 ± 2.6	0.829
Total lipids (%)	24.2 ± 8.0	24.1 ± 7.2	0.584
Total lipids (g)	39.4 ± 21.3	41.5 ± 20.7	0.324
Plant lipids (g)	18.7 ± 9.4	16.3 ± 10.1	0.210
Animal lipids (g)	20.1 ± 14.2	25.2 ± 15.6	0.048
Protein (g)	56.5 ± 18.1	58.0 ± 20.0	0.124
Plant protein (g)	18.7 ± 9.4	16.3 ± 12.1	0.030
Animal protein (g)	30.7 ± 19.1	33.1 ± 19.8	0.008
Fiber (g)	21.7 ± 2.3	12.2 ± 3.8	0.001
Vitamin A (μg RE)	492.0 ± 290.2	538.8 ± 215.1	0.540
β-Carotene (μg)	2,265.5 ± 1391.0	2,082.4 ± 914.8	0.128
Vitamin D (mg α-TE)	1.9 ± 0.4	2.2 ± 0.9	0.620
Vitamin E (mg)	14.2 ± 8.6	11.5 ± 8.8	0.001
Vitamin C (mg)	64.5 ± 10.1	49.8 ± 25.3	0.023
Vitamin B_6 (mg)	1.8 ± 0.6	1.6 ± 0.8	0.524
Folate (μg)	332.4 ± 39.3	156.4 ± 38.3	0.001
Vitamin B_1 (mg)	0.9 ± 0.2	0.9 ± 0.5	0.210
Vitamin B_2 (mg)	0.8 ± 0.3	0.9 ± 0.5	0.311
Ca (mg)	353.9 ± 148.3	452.9 ± 336.5	0.210
Na (mg)	3,279.7 ± 797.2	3,102.1 ± 1,185.0	0.751
K (mg)	1,968.2 ± 655.9	1,707.3 ± 432.5	0.048
P (mg)	716.2 ± 195.9	810.9 ± 340.5	0.958
Zn (mg)	7.4 ± 1.8	7.6 ± 4.1	0.142
Iron (mg)	11.5 ± 6.1	9.0 ± 2.8	0.168
Cholesterol (mg)	219.8 ± 177.7	261.9 ± 192.1	0.010
Total fatty acids (g)	22.6 ± 5.2	61.5 ± 8.5	0.105
Saturated fatty acids (g)	7.4 ± 1.6	18.4 ± 3.9	0.008

Values are presented as mean±standard deviation.
KD: Korean diet, WD: Western diet.
[a]Analyzed by independent t-test between groups.

($p < 0.034$). The protein and fat intake remained similar between the two groups. The WD group had a notably higher intake of animal fats compared to the KD group, with the difference being statistically significant ($p < 0.030$). The daily cholesterol ($p < 0.01$) and saturated fatty acid ($p < 0.105$) intakes were also significantly higher in the WD group than in the KD group. Moreover, there was a distinct difference in daily dietary fiber intake. The KD group consumed an average of 21.7±2.3 g, whereas the WD group took in 12.2±3.8 g ($p < 0.01$). Notably, the KD group had a higher daily intake of several nutrients, including vitamin E ($p < 0.01$), vitamin C ($p < 0.023$), folate ($p < 0.001$), and vitamin K ($p < 0.05$) than the WD group, marking a significant disparity between the groups.

4. Adverse events and safety monitoring

All participants were diligently monitored for AEs at each visit. As a safety evaluation, hematological, blood-biochemical, and urine analyses were conducted at baseline (visit 1), after 8 weeks (visit 2), and after 12 weeks (visit 3). The average values of serum liver function, renal function, blood sugar levels, glycemic lipid composition, and blood biochemical indicators between the KD and WD groups remained within the normal range. These results suggest that there are no clinically significant changes detected during the intervention period. All the observations of diagnostic laboratory tests done during the intervention period are listed in Supplementary Table 2.

DISCUSSION

Diet plays a crucial role in reproductive function, impacting both physical health and emotional well-being. A nutritious and well-balanced diet contributes significantly to fertility, hormonal balance, and overall sexual health. Diet and nutrition can enhance or impair sperm quality [21-23]. The impact is contingent on the quantitative and qualitative attributes of the diet, especially the caloric composition of each macronutrient (carbohydrate, protein, and fat). The effect of diet on reproductive function may also vary depending on the fatty acid, carbohydrate, and protein profiles of the specific diet. Unfortunately, the lack of evidence on the impact of KD on reproductive function and sexual health prompted the present trial. This research aimed to investigate the effect of KD and WD intake on reproductive and sexual functions in young men. To our knowledge, this trial is the first open-label, controlled, randomized, parallel-design study on this specific area of investigation. Historically, caffeine, theophylline, kallikrein, arginine, cyclic adenosine 3’5’-monophosphate, acetyl-L-carnitine, and platelet-activating factor have been identified as sperm motility boosters. Vitamin E and selenium supplements have also contributed to this effect. Our findings revealed that in the KD group, sperm motility increased significantly at 8 weeks compared to the baseline but showed a modest decline by week 12. In contrast, the WD group’s sperm motility remained relatively unchanged throughout the intervention period. In the KD group, sperm motility fluctuated, with an increase in the 8th week followed by a decline by the 12th week. This fluctuation can be attributed to compliance percentage. When compliance with KD is high (–78% on the 8th week), sperm motility remains high (–64%), while when it is low (–67% on the 12th week), sperm motility becomes low (–55%). Unhealthy dietary habits, characterized by high-fat diets and resultant obesity, are known to negatively affect sperm structure and even influence offspring development. Notably, infertile men have displayed dietary inadequacies such as irregular meal patterns, a lack of antioxidants, or a diet with excessive energy density [4]. Furthermore, spermatogenesis is adversely impacted by trans fats and saturated fatty acids, commonly found in WD [13]. Elevated consumption of trans fatty acids has been linked not only to decreased sperm quality but also to reduced sperm concentration in ejaculate [24]. In line with these findings, our study revealed that the KD group had significantly lower intakes of animal fat, protein, saturated fatty acid, and cholesterol than the WD group. Also, KD has higher amounts of antioxidant vitamins like E, C, folate, and dietary fiber. Thus, sperm quality in KD subjects is better than in the WD subjects. Given the broader research context, it is evident that unhealthy, high-calorie diets and excessive intake of saturated and trans fatty acids detrimentally affect sperm quality and, by extension, the fertilization process [16,25-31]. However, healthy dietary patterns correlate positively with improved sperm quality [4,10,23,32]. Moreover, our findings suggest that the KD could be pivotal in preserving and potentially enhancing male fertility. Diet-induced oxidative stress and infertility are well-recognized factors contributing to subpar semen quality and fertility. This mechanism, in conjunction with diminished antioxidant activity and sperm mitochondrial dysfunction, ranks among the chief causes of male infertility [12]. Specifically, oxidative stress is implicated in 30%-80% of male infertility cases. Reactive oxygen species compromise sperm motility and hinder their capacity to bind with oocytes [33]. Heightened intake of omega-6 fatty acids, pro-inflammatory foods, low antioxidant foods, and foods with a high glycemic index can exacerbate oxidative stress. Moreover, glucose metabolism profoundly influences spermatogenesis, and hyperglycemia has detrimental effects on sperm motility and the fertilization process [10]. In the context of obesity, the hypothalamic-pituitary-gonadal axis undergoes dysregulation. Exces-

sive fat accumulation triggers testosterone conversion into estrogen, stimulating steroid and LH hormone production. At the same time, estrogen levels rise, enhancing aromatase activity, which in turn depresses FSH levels, a hormone vital for sperm generation [34-37]. MInguez-Alarcón et al. [38] demonstrated that in healthy men, high intakes of trans fat and omega-6 fatty acids, combined with low omega-3 fatty acid consumption, correlate with diminished testicular endocrine function. These individuals also manifested a reduced ratio of FT to TT and decreased testicular volume. Additionally, when saturated fatty acid consumption increased among healthy men, there was a discernible decline in sperm concentration and semen count [39]. In the present study, no significant variances were noted in the sex hormones TT, FSH, LH, and SHBG across the groups. Yet, in the KD group, FT consistently increased from the baseline to week 12. Contrarily, in the WD group, an increase was noted at week 8, which subsequently diminished by week 12 relative to the baseline. Our study identified several potential reasons why the KD may favorably influence sperm motility. Firstly, the KD predominantly consists of plant-based foods, rich in antioxidants and vitamins, known to mitigate oxidative stress and maintain sperm health. Secondly, characterized by high-protein, low-fat, and high-fiber components, the dietary composition stabilizes blood glucose levels and aids in weight management. Normal blood glucose levels maintain hormonal balance, which can positively affect sperm production and motility. Moreover, by restricting intake of animal fats and cholesterol, the KD can lower serum cholesterol levels. Consequently, the KD encompasses factors that could enhance sperm motility. However, caution is warranted in drawing definitive conclusions solely based on these findings. Further research incorporating diverse factors is essential to robustly substantiate such claims. Recent research posits that men adhering to wholesome diets produce healthier sperm [22]. Specifically, diets deficient in antioxidants were found to adversely affect sperm quality, indicating that diet plays an indispensable role in ensuring optimal sperm formation, maturation, and function in men [23,40]. Recent studies examining the relationship between semen composition and diet in men have indicated that levels of zinc, magnesium, calcium, copper, and selenium are reduced in infertile subjects compared to their fertile counterparts [41,42]. In this study, although there was no marked difference in the intake of these associated minerals between the groups during the clinical intervention period. However, potassium, an essential mineral critical to sperm production and motility, was significantly higher in the KD group than in the WD group. No adverse reactions observed during the trial. In summary, investigation observations support the belief that consistent consumption of KD may increase sperm motility. In addition, KD revealed improved levels of male hormones that result in enhanced sperm motility.

The study features a few of its primary advantages that contribute to the trial's quality. Firstly, the trial diet compliance percentage is high, reflecting the accurate diet pattern followed by the participants. This indicates the quality of the observations in KD and WD subjects. Secondly, the participants were unaware of their fertility status, ensuring objectivity in the study results. Thirdly, this research investigated the relationship between dietary intake and male reproductive function by focusing on varied daily diets rather than diets that concentrate on single foods. However, this study also has some limitations. The primary limitation is that we could not investigate the dietary intake of all study subjects prior to their participation, making it impossible to compare before-and-after dietary intakes. Secondly, the fact that rice-centered Korean meals might not be the preferred choice for young men presented a challenge and might have contributed to lower compliance than the WD. Thirdly, the number of participants in the study was relatively small, limiting our ability to generalize the results from the 12-week dietary intervention.

CONCLUSION

This study suggests that when young men consistently consume a KD centered around rice, their sperm motility may improve. This improvement appears to be directly linked to an increase in male hormone levels. These findings lead to the conclusion that a KD may be more effective than a WD in enhancing male reproductive function and sexual health. Therefore, this research provides significant insights into the impact of diet on male reproductive health.

NOTES

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SUPPLEMENTARY MATERIALS

Supplementary data is available at https://doi.org/10.15280/jlm.2024.14.1.20

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