



Ann Appl Sport Sci InPress(InPress): e1541. e-ISSN: 2322-4479; p-ISSN: 2476-4981



# ORIGINAL ARTICLE

# Effects of Recreational Badminton on Lipid Profiles in Older Adults

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Submitted February 21, 2025; Accepted May 01, 2025.



**KEYWORDS** 

Badminton, Lipoproteins, Lipid Profile, Aging, Intermittent Exercise, Physical Activity.

### ABSTRACT

**Background.** Aging increases the risk of heart disease and metabolic disorders, making physical activity essential for health. Recreational badminton is widely played, yet its effects on lipid profiles in older adults remain unclear. While previous research highlights the cardiovascular benefits of exercise, the role of intermittent sports like badminton in lipid metabolism is underexplored. Objectives. This study examined whether weekly badminton play duration influences key lipid markers in older adults. Methods. This cross-sectional study involved 54 participants aged  $\geq$ 55 years, stratified into high-playtime (HPT; 9.72)  $\pm$  2.16 hr/week), low-playtime (LPT; 3.34  $\pm$  1.53 hr/week), and non-players (CON; n=18 each). Participants fasted for 8-12 hours before blood sampling and anthropometric assessments. Triglycerides (TG), total cholesterol (T-Cho), highdensity lipoprotein (HDL), and low-density lipoprotein (LDL) were analyzed. Badminton duration was assessed using weekly logs and a modified PASE questionnaire. One-way ANOVA with Dunnett's T3 post hoc tests (p<0.05) assessed differences. Results. No significant differences were observed in TG (HPT: 59.2  $\pm$  13.8; LPT: 63.0  $\pm$  16.1 mg/dL), T-Cho (HPT: 203  $\pm$  7.8; LPT: 201  $\pm$ 14 mg/dL), HDL (HPT: 67.8  $\pm$  4.94; LPT: 64.0  $\pm$  7.79 mg/dL), or LDL (HPT: 120  $\pm$  3.49; LPT: 122  $\pm$  7.17 mg/dL); p>0.05. Effect sizes ( $\eta^2 = 0.02-0.05$ ) indicated minimal group differences. **Conclusion.** Given the study's cross-sectional design, causality cannot be inferred. Future longitudinal studies should control for diet and genetics and explore combined training strategies.

## **INTRODUCTION**

Aging and chronic degeneration present considerable challenges to lipid and cardiovascular health, particularly in older adults. As individuals age, physiological changes such as increased arterial stiffness, chronic low-grade inflammation, and reduced lipid metabolism elevate the risk for cardiovascular disease and dyslipidemia (1, 2). Preserving healthy lipid profiles through physical activity is crucial to reduce these risks. Recreational exercise, including sport-based activity, has been proposed as a sustainable method for improving health markers among older populations. Compared to structured endurance training, recreational sports 2

may increase adherence due to their enjoyable and social nature (3). Badminton, classified as a vigorous intermittent sport, combines aerobic and anaerobic components with high movement variability (4). It has shown potential cardiovascular benefits, but its effects on lipid profiles remain underexplored.

Intermittent sports like badminton may engage the cardiovascular system differently than steadystate aerobic training. However, most exerciselipid research focuses on continuous training modes like walking, cycling, and jogging (5-7). This creates a gap in understanding whether intermittent sports can induce similar changes in lipid metabolism. particularly in older individuals. In addition to traditional lipid markers such as total cholesterol, HDL, and LDL, clinicians and researchers increasingly use lipid ratios, specifically the total cholesterol to HDL (TC: HDL) and LDL to HDL (LDL: HDL) ratios, as sensitive predictors of cardiovascular risk. These ratios provide a more integrated reflection of lipid balance and are often more strongly associated with atherosclerotic risk than single lipid markers alone. However, limited evidence exists on how intermittent sport-based activities like badminton influence these atherogenic ratios, especially among aging populations. Unlike walking or cycling, which maintain consistent submaximal aerobic effort, badminton consists of short, high-intensity efforts interspersed with recovery periods. This fluctuating intensity profile results in a lower cumulative aerobic load and may fail to maintain the prolonged heart rate elevation required to enhance lipid oxidation pathways. Moreover, intermittent sports often rely more heavily on anaerobic metabolism and phosphocreatine resynthesis, rather than sustained beta-oxidation of lipids, which is more characteristic of steady-state activities. These physiological distinctions raise questions about whether sports like badminton can elicit comparable effects on lipoprotein regulation and cholesterol clearance (8, 9).

Recent studies have begun to examine how games like tennis, futsal, or badminton affect metabolic health. For example, improved aerobic fitness and quality of life have been observed in elderly badminton players, but results on lipidspecific outcomes are inconclusive (10, 11). Moreover, badminton's short burst and rest format may not meet the continuous intensity thresholds needed to stimulate lipid oxidation or lipoprotein regulation (12). In addition to conventional lipid parameters such as total cholesterol, HDL, and LDL, atherogenic lipid ratios, particularly total cholesterol to HDL (TC: HDL) and LDL to HDL (LDL: HDL), are increasingly used to assess cardiovascular risk. These ratios provide a more integrative view of lipid balance and have been shown to predict outcomes more sensitively than absolute lipid values alone in aging populations (13, 14). However, few studies have investigated how recreational badminton participation might influence these clinically relevant lipid ratios.

Emerging evidence suggests the aerobic threshold, rather than maximal effort, is critical for modifying lipid profiles (15). However, few studies have examined recreational badminton's effects on cholesterol subfractions, triglyceride concentrations, or atherogenic lipid ratios in older adults. Given the limited but growing interest in intermittent sports and lipid modulation, this study addresses a timely and relevant gap in the literature by investigating how weekly badminton play duration affects lipid outcomes in aging populations. Therefore, this study aims to whether determine weekly duration of recreational badminton play is associated with differences in lipid profiles, including TG, T-Cho, HDL, LDL, and the atherogenic ratios TC: HDL and LDL: HDL among healthy older adults. We hypothesized that individuals with greater weekly badminton participation would demonstrate more favorable lipid profiles and lipid risk ratios than those with lower or no engagement.

#### **MATERIALS AND METHODS**

Study Design. This population-based, analytical cross-sectional study was conducted among older adults in Negeri Sembilan, Malaysia. The study was approved by the Research Ethics Committee (REC/06/2022-PG/MR/127) and adhered to the principles of the Helsinki Declaration. Before commencement, it was registered in the UMIN Clinical Trials Registry (UMIN000047240). While this design allows for group comparisons, it does not permit causal inference regarding badminton's effects on lipid metabolism. In addition, this study did not assess or control dietary intake and genetic predisposition.

**Participants.** The sample size was estimated using the statistical formula by Charan & Biswas (8), considering a 95% confidence interval, 5% level of precision, and 1% estimated population

of elderly badminton players based on data from badminton clubs and the Department of Statistics Malaysia (DOSM). A total of 98 individuals were screened, and 54 eligible participants (aged  $\geq$ 55 years) were stratified into three groups: highplaying time (HPT; n=18, 9.72 ± 2.16 hr/week), low-playing time (LPT; n=18, 3.34 ± 1.53 hr/week), and a control group (CON; n=18, nonplayers). Inclusion Criteria: Participants were included if they were recreational badminton players (HPT/LPT groups) and free of diagnosed metabolic, cardiovascular, or pulmonary diseases. Exclusion Criteria: Participants were excluded if they had chronic metabolic disorders, participated in structured exercise programs (e.g., running, cycling, swimming), used dietary supplements or hormone therapy, or had alcohol or drug dependence. Figure 1 shows the process with the number of participants from selection to data completion.



**Figure 1**. Study participant flow diagram illustrating eligibility screening, exclusion criteria, group allocation based on weekly badminton playtime, and the outcome measurements assessed. Participants were stratified into high-playtime (HPT), low-playtime (LPT), and control (CON) groups. Cardiometabolic indices included triglycerides, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and total cholesterol.

**Study Protocol.** Participants arrived at the laboratory at 8:00 AM in a fasting state (8–12 hours of fasting) and were instructed to abstain from caloric intake except for plain water. Upon arrival, they received an explanation of study

procedures and potential risks before providing written informed consent. After 10 minutes of seated rest, anthropometric and blood biomarker assessments were conducted. After testing, participants completed weekly badminton participation logs and the modified Physical Activity Scale for the Elderly (PASE) questionnaire.

A modified version of the Physical Activity Scale for the Elderly (PASE) was used to estimate total weekly activity and to validate badminton playtime. The original PASE, which quantifies physical activity in older adults based on leisure, household, and occupational tasks, was adapted to badminton-specific frequency reflect and duration in more detail. Questions related to household and work activities were excluded, while new items specifying "number of badminton sessions per week" and "average duration per session" were added. This badminton-modified PASE showed acceptable internal consistency ( $\alpha$ =0.79) in a small pilot sample prior to study implementation.

Although sessions were not directly observed, badminton participation logs were complemented by qualitative data on session characteristics. Recreational badminton typically involves highmovement variability and intermittent bursts of effort lasting 4–10 seconds per rally, followed by brief rest intervals. Heart rate responses during play can reach 75–85% of HRmax, suggesting vigorous-intensity exertion (6). Players in the HPT group reported playing 4–5 days/week, averaging 2 hours/day, typically in a doubles format. No structured monitoring of rally duration or intensity was performed, which limits physiological precision.

# Measurements.

Anthropometric Characteristics. Anthropometric measurements were taken following standardized guidelines. Height and weight were assessed using a validated stadiometer (Seca 220, Hamburg, Germany), and BMI (kg/m<sup>2</sup>) was calculated using standard formulas.

**Blood Biomarker Analysis.** A certified medical technologist collected Venous blood samples using 2 mL Vacuette® tubes (no additives) and 6 mL Vacutainer® tubes (EDTA-containing). A 10  $\mu$ L aliquot of whole blood from no-additive Vacuette® tubes was analyzed for triglycerides (TG), total cholesterol (T-Cho), and high-density lipoprotein cholesterol (HDL) using the PTS Panels® Lipid Panel (CardioChek PA, PTS Diagnostics, USA). In contrast, low-density lipoprotein cholesterol (LDL) was calculated using Friedewald's formula. Whole blood from EDTA-containing tubes was left at room

temperature for 20 minutes before being centrifuged at 4,000 rpm for 8 minutes using a Hettich EBA 20 centrifuge (Germany). Extracted serum was analyzed for fasting glucose, uric acid (UA), and C-reactive protein (CRP), with CRP samples diluted 21-fold per manufacturer's guidelines.

**Badminton Playing Time and Group Stratification.** Participants were ranked by weekly badminton playtime. The median cutoff (7.05 hrs/week) was used to divide the sample into HPT and LPT groups, based on the 18th and 19th ranked individuals (6.6 and 7.5 hrs/week, respectively).

**Statistical** Analysis. Differences in badminton playing history were analyzed using an independent samples t-test. A one-way repeated measures analysis was conducted using Brown-Forsythe and Welch ANOVA to examine differences in physical attributes (height, weight, BMI, age), total weekly badminton playtime, and blood lipid biomarkers (TG, T-Cho, HDL, LDL). Post hoc comparisons were performed using Dunnett's T3 multiple comparison test. Statistical analyses were conducted using GraphPad Prism (version 9.0, GraphPad Software Inc., La Jolla, USA), with statistical significance set at p < 0.05.

# RESULTS

A total of 54 participants were included in the study, with HPT (n=18), LPT (n=18), and CON (n=18). Table 1 presents the physical and anthropometric characteristics of the participants. No significant differences were observed across the three groups for age (p=0.326), BMI (p=0.390), or other baseline anthropometric characteristics, indicating comparability at baseline. However, as expected, badminton frequency, session duration, and total playtime were significantly greater in the HPT group than the LPT group, confirming successful group stratification. Participants in the HPT group had significantly greater playing experience (28.6  $\pm$ 1.33 years) compared to the LPT group (24.3  $\pm$ 3.03 years), but this difference was not statistically significant (p>0.05). The HPT group played more frequently per week (4.72  $\pm$  1.13 days) and spent more hours per day ( $2.14 \pm 0.56$ hrs/day) compared to the LPT group  $(2.28 \pm 1.02)$ days;  $1.51 \pm 0.50$  hrs/day), with statistically significant differences (p<0.05).

**Blood Lipid Profile.** Table 2 summarizes the comparisons of lipid biomarkers among the three

groups. Analysis of variance (ANOVA) revealed no statistically significant differences in triglycerides (TG), total cholesterol (T-Cho), high-density lipoprotein (HDL), or low-density lipoprotein (LDL) levels between the HPT, LPT, and CON groups (p>0.05). Specifically, the HPT group demonstrated TG levels of 59.2  $\pm$  13.8 mg/dL, T-Cho of 203  $\pm$  7.8 mg/dL, HDL of 67.8  $\pm$  4.94 mg/dL, and LDL of 120  $\pm$  3.49 mg/dL, which were not significantly different from values in the LPT or CON groups.

In addition to traditional lipid biomarkers, TC:HDL and LDL:HDL ratios were also calculated to provide further insight into cardiovascular risk. The TC: HDL ratio averaged  $2.99 \pm 0.45$  in the HPT group,  $3.14 \pm 0.52$  in the LPT group, and  $3.13 \pm 0.49$  in the CON group. The LDL: HDL ratio was  $1.77 \pm 0.29$ ,  $1.91 \pm 0.41$ ,

and  $1.90 \pm 0.37$  for the respective groups. These ratios did not differ significantly between groups (p>0.05), indicating that recreational badminton playtime did not substantially influence atherogenic lipid ratios among older adults.

In addition to standard lipid parameters, atherogenic lipid ratios (TC:HDL and LDL:HDL) were also calculated (Table 3). No significant group differences were observed, though slightly lower average ratios were noted in the HPT group.

**Group Comparison and Statistical Findings.** Post hoc analyses confirmed no significant differences in lipid biomarkers between the HPT, LPT, and CON groups. The null hypothesis, which states that no differences exist in lipid profiles among elderly recreational badminton players based on play duration, was accepted.

Table 1. Physical and Anthropometric Characteristics of the participants.

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Parameter	HPT ( <i>n</i> =18)	LPT (n=18)	CON ( <i>n</i> =18)	<i>p</i> -value
Age (years)	$64.2\pm2.81$	$63.3\pm2.59$	$64.9\pm2.89$	0.326
Weight (kg)	$64.8 \pm 4.52$	$67.2 \pm 4.58$	$66.3 \pm 6.39$	0.287
Height (cm)	$165 \pm 3.95$	$165 \pm 3.58$	$164 \pm 3.48$	0.478
BMI (kg/m <sup>2</sup> )	$23.9 \pm 1.46$	$24.8 \pm 2.34$	$24.6\pm2.31$	0.390
Playing experience (years)	$28.6 \pm 1.33$	$24.3\pm3.03$	-	
Badminton playing frequency (day/week)	$4.72 \pm 1.13$	$2.28 \pm 1.02$	-	
Badminton playing hours (hrs/day)	$2.14\pm0.56$	$1.51\pm0.50$	-	
Total badminton playing time (hrs/week)	$9.72 \pm 2.16$	$3.34 \pm 1.53$	-	

Values are expressed as mean  $\pm$  standard deviation (SD). HPT: High badminton playtime group; LPT: Low playtime group; CON: Control group. P-values refer to one-way ANOVA comparisons among HPT, LPT, and CON groups for age, weight, height, and BMI only. No statistical comparisons were conducted for badminton-related variables as CON participants did not engage in badminton activity.

#### Table 2. Comparison Between Groups on Blood Metabolic Biomarkers.

Parameter	HPT	LPT	CON	HPT vs. LPT	HPT vs. CON	LPT vs. CON
(mg/dL)	( <i>n</i> =18)	( <i>n</i> =18)	( <i>n</i> =18)	t (p)	t (p)	t (p)
Triglycerides	$59.2 \pm 13.8$	$63.0\pm16.1$	$71.4 \pm 18.4$	0.76 (0.45)	2.20 (0.07)	1.43 (0.16)
HDL	$67.8 \pm 4.94$	$64.0\pm7.79$	$61.9\pm8.65$	1.74 (0.09)	2.50 (0.06)	0.76 (0.45)
LDL	$120 \pm 3.49$	$122 \pm 7.17$	$126 \pm 10.2$	1.09 (0.31)	2.45 (0.06)	1.42 (0.17)
T-Cho	$203 \pm 7.8$	$201 \pm 14$	$205 \pm 15$	0.40 (0.69)	0.53 (0.59)	0.75 (0.46)

Values are expressed as mean  $\pm$  standard deviation (SD). HPT: High-playtime group; LPT: Low-playtime group; CON: Control group. T-Cho: Total cholesterol; HDL: High-density lipoprotein; LDL: Low-density lipoprotein. *t*: Welch's independent sample t-test value; p: Significance level from between-group comparison. No comparisons reached statistical significance (p>0.05 for all contrasts). Data reflect fasting lipid profiles collected at a single time point.

Table 3. Atherogenic Li	pid Ratios Amon	g High-Playtime.	, Low-Playtime, ai	nd Control Grou	ps
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Lipid Ratio	HPT ( <i>n</i> =18)	LPT ( <i>n</i> =18)	CON (n=18)	<i>p</i> -value
TC: HDL Ratio	$2.99\pm0.45$	$3.14\pm0.52$	$3.13\pm0.49$	0.481
LDL:HDL Ratio	$1.77\pm0.29$	$1.91\pm0.41$	$1.90\pm0.37$	0.525

Values are expressed as mean ± standard deviation (SD). TC: Total cholesterol; HDL: High-density lipoprotein; LDL: Low-density lipoprotein. P-values refer to one-way ANOVA comparisons among high-playtime (HPT), low-playtime (LPT), and control (CON) groups.

### DISCUSSION

The present study investigated the impact of recreational badminton playtime on lipid profiles among older adults. Results showed no statistically significant differences in triglycerides (TG), total cholesterol (T-Cho), high-density lipoprotein (HDL), or low-density lipoprotein (LDL) levels across groups stratified by playtime. These findings suggest that although badminton promotes physical activity, its typical duration and intermittent structure may not elicit the aerobic stimulus required for lipid metabolism enhancement. Physiologically, the stop-and-go nature of badminton with short rallies and recovery periods contrasts with the sustained effort seen in continuous aerobic exercises like walking or cycling. Moderate-intensity activity is better documented to improve lipid transport, lipoprotein lipase activity, and HDL-C efflux capacity (9, 13). This may explain why steadystate modalities produce more consistent lipid benefits, while badminton's intermittent load may be insufficient. These findings align with emerging evidence that the lipid response to exercise varies depending on modality, duration, and intensity. Yun et al., (9) found that continuous aerobic training was more effective than resistance or intermittent activity in improving lipid profiles among older populations. Similarly, Braga et al., (13) emphasized that regular physical activity enhances HDL cholesterol metabolism, particularly through improved cholesterol efflux and reverse transport mechanisms. Fan et al., (15) further demonstrated that combining aerobic and resistance training led to greater LDL and total cholesterol improvements than either modality alone in older adults. These findings suggest that while recreational badminton supports physical activity engagement, its intermittent format may lack the volume or intensity required to elicit favorable lipid changes without complementary interventions.

In addition to standard lipid biomarkers, this study evaluated atherogenic ratios TC: HDL and LDL: HDL as surrogate indicators of cardiovascular risk. Although these ratios are sensitive predictors, no significant differences were found between groups. These results align with prior findings that sport-based physical activity, when unstructured or performed at variable intensity, may not meaningfully alter blood lipoproteins unless combined with greater volume or dietary changes (12, 14). Despite these observations, several limitations must be acknowledged. As a cross-sectional design, this study does not permit causal inference; results reflect associations only. Importantly, the study did not control for dietary intake, a major determinant of lipid levels. Participants' macronutrient composition, caloric intake, and use of cholesterol-lowering medications or supplements were not assessed. No food frequency questionnaire (FFQ) or dietary recall was used, making it impossible to account for the confounding role of diet.

Furthermore, the badminton exposure was using a modified self-reported PASE questionnaire, which, although practical, may be vulnerable to recall and social desirability bias. No objective measures of session intensity, heart rate, or duration per rally were recorded, limiting the ability to interpret the actual training load or cardiovascular stress imposed by the sport. Recent systematic reviews emphasize lipid responsiveness to exercise is highly individual and dependent on exercise mode, frequency, and baseline cholesterol status (9, 11, 13). These studies suggest that while moderate-to-vigorous activity is beneficial, structured protocols with dietary control are most likely to yield measurable lipid changes.

Future studies should adopt longitudinal or randomized controlled trial (RCT) designs with stricter monitoring of exercise dosage, dietary intake, and biochemical markers. Interventions combining badminton with endurance or resistance training and nutritional education may better clarify the role of sport-based activities in managing lipid profiles among older adults. Although lipid outcomes were unchanged, badminton participation's physical, cognitive, and social benefits for healthy aging are still important. These findings contribute to the growing dialogue on how different exercise modalities can support cardiovascular health and wellness in aging populations.

# CONCLUSION

This study examined the effects of recreational badminton play duration on lipid profiles in older adults. No significant differences were found among high-playtime, low-playtime, and nonplaying control groups in triglycerides (TG), total cholesterol (T-Cho), high-density lipoprotein (HDL), low-density lipoprotein (LDL), or lipid ratios (TC:HDL and LDL:HDL). These findings suggest that while badminton promotes physical activity and functional engagement, it may not sufficiently influence lipid outcomes when performed in an unstructured and intermittent format.

The intermittent nature of badminton may result in variable cardiovascular engagement, which could limit its effectiveness in modulating lipid metabolism compared to continuous aerobic exercise. However, as this study did not include physiological measures such as heart rate or oxygen consumption, further research is needed to clarify these mechanisms. Additionally, individual variability in lipid response may be influenced by broader factors such as genetic predisposition, as suggested by prior literature, though such variables were not assessed in the current study.

Future studies should adopt longitudinal or randomized controlled trial designs, incorporate objective monitoring of exercise intensity, and better control for dietary intake and genetic factors to understand the relationship between recreational sports and lipid health. Nonetheless, badminton's broader physical and psychosocial benefits for aging populations remain valuable, and it may serve as a complementary component of a more comprehensive lifestyle approach to cardiovascular health.

# **APPLICABLE REMARKS**

- Recreational badminton benefits cardiovascular fitness and mobility, but may not be sufficient for significant lipid profile improvements.
- To optimize cholesterol management, older adults should incorporate aerobic endurance training alongside playing badminton.
- Sports and fitness programs for older adults should include both intermittent and continuous aerobic exercises to maximize metabolic health benefits.
- Healthcare professionals and fitness trainers should encourage holistic lifestyle modifications, integrating exercise with dietary counselling to enhance lipid metabolism.
- Future studies should explore the long-term effects of badminton combined with endurance training and the role of genetic predisposition in lipid metabolism responses.

## ACKNOWLEDGMENTS

The study was supported by a research grant (Grant No: INT16/6/2–040/2021), awarded to Universiti Teknologi MARA by the Badminton World Federation (BWF) Grant 2021–22.

# **AUTHORS' CONTRIBUTIONS**

Study concept and design: Raja Nurul Jannat Raja Hussain. Acquisition of data: Syed Murshid Syed Zubir. Analysis and interpretation of data: Syed Murshid Syed Zubir, Raja Nurul Jannat Raja Hussain, Maisarah Shari, Adam Linoby. Drafting the manuscript: Raja Nurul Jannat Raja Hussain, Maisarah Shari. Critical revision of the manuscript for important intellectual content: Adam Linoby, Maisarah Shari, Raja Nurul Jannat Raja Hussain. Statistical analysis: Syed Murshid Syed Zubir. Administrative, technical, and material support: Maisarah Shari, Adam Linoby. Study supervision: Raja Nurul Jannat Raja Hussain.

#### **CONFLICT OF INTEREST**

The authors declare no conflict of interest.

# FINANCIAL DISCLOSURE

This study has no financial interests related to the material in the manuscript.

### **FUNDING/SUPPORT**

This study was partly supported by grant INT16/6/2–040/2021, Badminton World Federation (BWF) Grant 2021–22.

# ETHICAL CONSIDERATION

The Research Ethics Committee approved the study (REC/06/2022-PG/MR/127) and adhered to the Helsinki Declaration. Before its commencement, the study was registered in the UMIN Clinical Trials Registry (UMIN000047240).

#### **ROLE OF THE SPONSOR**

The funding organizations are public institutions and have no role in the design and conduct of the study, collection, management, and analysis of the data, or preparation, review, and approval of the manuscript.

# ARTIFICIAL INTELLIGENCE (AI) USE

This study agrees with the Journal's policy in this section.

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