The Effects of Gamma-Oryzanol Supplementation During Resistance Exercise Training

Andrew C. Fry, Elizabeth Bonner, David L. Lewis, Robert L. Johnson, Michael H. Stone, and William J. Kraemer

To determine the effectiveness of gamma-oryzanol supplementation, weight-trained males were randomly divided into supplemented (G-O) and control placebo (Con) groups. The G-O group ingested 500 mg · day⁻¹ of gamma-oryzanol according to the manufacturer’s instructions. Test batteries were administered before (T1), after 4 weeks (T2), and after 9 weeks (T3) of a periodized resistance exercise program. Both groups demonstrated significant increases in 1 repetition maximum muscular strength (bench press and squat) and vertical jump power, with no differences between the groups. No differences between groups were observed for measures of circulating concentrations of hormones (testosterone, cortisol, estradiol, growth hormone, insulin, β-endorphin), minerals (calcium, magnesium), binding protein (albumin), or blood lipids (total cholesterol, triglycerides, HDL-cholesterol). Resting cardiovascular variables decreased similarly for both groups. These data suggest that 9 weeks of 500 mg · day⁻¹ of gamma-oryzanol supplementation does not influence performance or related physiological parameters in moderately weight-trained males.

Key Words: muscle strength, muscle power, endocrine, blood lipids, cardiovascular, nutrition

A prominent and controversial issue in sports during recent years has been the use of anabolic steroids. Recent substantiation of their effective enhancement of strength, speed, and recovery rate has been countered by evidence of undesirable and dangerous side effects when abused (12). The dangers of steroid use and economic potential for a safe replacement have prompted research into nutritional supplementation. Gamma-oryzanol is one of many substances currently marketed with claims of danger-free enhancement of physical strength, recovery rate, and physique.

Gamma-oryzanol is a two-part molecule composed of a 5 sterol mixture (plant sterol) with a ferulic acid ester. Although claims for anabolic effects for plant sterols abound, the ferulic acid ester appears to be the active portion, while

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the sterol portion is cleaved in the liver and excreted (5). Ferulic acid, or 3-methoxy-4-hydroxycinnamic acid, is one of several common plant phenolic acids. Ferulic acid reportedly serves as a precursor for several plant compounds, including structural lignin and the flavonoids (4). Like other plant sterols, such as beta sitosterol, gamma-oryzanol is poorly absorbed. Animal tracer studies suggest that less than 10% of the dose is absorbed by the body (6). Absorption of this fat-soluble molecule can be improved, however, by emulsification or by addition of nonionic detergents. Gamma-oryzanol is cleaved in the liver by nonspecific esterases to ferulic acid and the sterol portion. While the sterol is excreted into the bile and eventually the feces, the ferulic acid has been shown to be absorbed by all tissues, with the highest concentrations of ferulic acid reportedly in intestinal, liver, spleen, adrenal, and brain tissues (4). Recently, the active and highly absorbable ferulic acid portion has been separated from the gamma-oryzanol molecule and marketed as a separate supplement. Unsubstantiated reports in the lay literature suggest that dietary ferulic acid is 90% bioavailable, 30 times more so than gamma-oryzanol (5).

An enhancement of norepinephrine and beta-endorphin has been proposed to account for the diverse effects of gamma-oryzanol ingestion (4). Reports of several studies have indicated significant increases in norepinephrine after gamma-oryzanol administration (4).

Gamma-oryzanol–induced increases in norepinephrine are thought to be due to a reduced degradation by catechol-O-methyltransferase (COMT). Because the structure of ferulic acid is very similar to the norepinephrine metabolite normetanephrine, a feedback inhibition of COMT degradation of norepinephrine is hypothesized. Such an augmentation of norepinephrine levels could potentially influence many physiological systems. Such alterations of the endocrine system have been suggested to account for the proposed performance-enhancing properties of gamma-oryzanol.

Much of the information related to dietary use of gamma-oryzanol and sometimes reported by supplementation proponents is not found in the mainstream scientific literature but can be found in a review of the subject (4). It has been claimed that doses of gamma-oryzanol as low as 25 mg · day⁻¹ promote positive changes in muscular strength and body composition measures in humans, with doses of up to 900 mg · day⁻¹ being used in humans with no side effects reported (4). Unpublished reports suggest that gamma-oryzanol supplementation may augment body mass while decreasing fat weight (5). Accounts of animal research suggest that 600–1,500 mg · day⁻¹ of ferulic acid, aimed at nitrosamine inhibition, is effective and without side effects (4). Animal studies of gamma-oryzanol have shown no side effects even with doses of 1,000 mg · day⁻¹ (5). These reports suggest that gamma-oryzanol and ferulic acid are nontoxic and without side effects at doses greater than 1,000 times typical dietary supplement levels.

The use of gamma-oryzanol as a nutritional supplement for strength athletes is widespread, as indicated by the large number of nutritional companies marketing the product and by its ready availability at commercial outlets. There are very few data, however, concerning the efficacy of such supplementation with resistance exercise in humans. Therefore, the purpose of this investigation was to determine if dietary gamma-oryzanol supplementation during a 9-week periodized strength training program would significantly alter muscular strength and power, body composition, hormonal concentrations, and resting cardiovascular measures.
Methods

Subjects and Supplementation

Twenty-two college-age males volunteered for this study. All subjects had been weight training for ≥1 year prior to the study and were capable of performing a parallel barbell squat with ≥1.3 × body mass. They provided informed consent prior to participating. To test the effects of gamma-oryzanol supplementation, subjects were randomly assigned to supplemented (G-O; n = 11) and control placebo (CON; n = 11) groups. In a double-blind design, G-O subjects ingested 500 mg of gamma-oryzanol (manufacturer’s recommended dosage), and CON subjects ingested a lactose placebo supplement. All supplementation was ingested in the presence of an investigator. Descriptive data for the subjects are listed in Table 1.

Procedures

Resistance exercise was performed 4 days per week by all subjects (i.e., Sunday, Monday, Wednesday, Thursday). Training volume (sets × repetitions) and relative intensity (% 1 repetition maximum; RM) were varied weekly using a periodized schedule to optimize the training response. The training program is described in Figure 1.

Testing was performed over 3 days before the training program began (pretest) and during Weeks 5 (midtest) and 10 (posttest) of the study. The schedule of testing is described in Figure 1.

![Figure 1](image_url)

Figure 1 — Resistance exercise training protocol. *Core exercise. A light and a moderate set preceded the target sets for all core exercises. RM = repetition maximum.)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Gamma-oryzanol</th>
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<th>Controls</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Mid</td>
<td>Post</td>
<td>Pre</td>
<td>Mid</td>
</tr>
<tr>
<td>Age (years)</td>
<td>19.8 ± 0.87</td>
<td>175.0 ± 6.0</td>
<td>20.0 ± 3.13</td>
<td>176.0 ± 8.0</td>
<td>73.4 ± 7.9</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>79.3 ± 12.2</td>
<td>79.9 ± 11.0*</td>
<td>75.1 ± 8.0*</td>
<td>73.4 ± 7.9</td>
<td>60.7 ± 8.9*</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>66.6 ± 3.5</td>
<td>64.4 ± 7.6*</td>
<td>67.3 ± 4.8</td>
<td>114.3 ± 5.3*</td>
<td>115.9 ± 9.4*</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>59.5 ± 5.5*</td>
<td>120.4 ± 8.9*</td>
<td>120.1 ± 8.9*</td>
<td>66.5 ± 6.1</td>
<td>70.3 ± 10.1*</td>
</tr>
<tr>
<td>Resting SBP (mmHg)</td>
<td>122.2 ± 4.2</td>
<td>117.3 ± 11.5*</td>
<td>120.1 ± 8.9*</td>
<td>77.3 ± 4.8</td>
<td>114.3 ± 5.3*</td>
</tr>
<tr>
<td>Resting DBP (mmHg)</td>
<td>76.9 ± 5.6</td>
<td>74.4 ± 11.3*</td>
<td>72.2 ± 9.1*</td>
<td>64.7 ± 16.5</td>
<td>59.2 ± 18.0*</td>
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<tr>
<td>Σ Skinfolds (mm)</td>
<td>76.2 ± 19.9</td>
<td>67.7 ± 24.7*</td>
<td>68.7 ± 22.2*</td>
<td>177.3 ± 7.7</td>
<td>178.2 ± 8.4</td>
</tr>
<tr>
<td>Σ Girths (cm)</td>
<td>185.7 ± 12.3</td>
<td>187.0 ± 12.9</td>
<td>187.3 ± 13.0</td>
<td>187.3 ± 7.7</td>
<td>178.2 ± 8.4</td>
</tr>
<tr>
<td>Dietary—</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total kcal</td>
<td>3,210 ± 142</td>
<td>3,300 ± 182</td>
<td>3,210 ± 179</td>
<td>3,260 ± 156</td>
<td>3,295 ± 156</td>
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<tr>
<td>% Fat</td>
<td>42.2 ± 3.3</td>
<td>39.2 ± 4.3</td>
<td>40.1 ± 4.3</td>
<td>41.0 ± 4.0</td>
<td>41.5 ± 4.0</td>
</tr>
<tr>
<td>% Carbohydrate</td>
<td>48.8 ± 3.6</td>
<td>51.0 ± 5.0</td>
<td>50.0 ± 5.0</td>
<td>49.5 ± 3.6</td>
<td>51.0 ± 3.6</td>
</tr>
<tr>
<td>% Protein</td>
<td>9.0 ± 1.3</td>
<td>9.2 ± 1.3</td>
<td>9.9 ± 1.3</td>
<td>8.4 ± 1.3</td>
<td>9.0 ± 1.7</td>
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</table>

*Note.* Pre = 0 weeks; Mid = 5 weeks; Post = 10 weeks. HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure. 

\( p < .05; \) *different from Pre, **different from Mid.
Anthropometric evaluations included height, body mass, skinfold thicknesses, and girth measures. Skinfolds were taken in duplicate by the same investigator at the triceps, subscapular, abdominal, suprailiac, and anterior thigh sites (11) with a Lange skinfold caliper (10 g · mm², constant tension). In the event that the two measures differed by ≥2 mm, a third measure was taken, with the mean of the two most similar measures used for final analysis. Tester reliability for these skinfold sites was r ≥ 0.94. The sum of skinfolds (ΣSF; mm) was used for comparisons between the three test times. Girth measurements were taken at the chest, upper arm, and midthigh locations (3, 11) with a metal Lufkin tape. Chest girth was measured at nipple level (approximates fourth intercostal space) during midexpiration. Upper arm girth was determined with the elbow extended and the elbow flexor muscles relaxed (11) and with both the elbow flexed and the elbow flexor muscles maximally contracted (3). Midthigh girth was measured when the subject was in a relaxed state with the knee fully extended.

Resting heart rate was determined by palpation of the radial pulse. Resting blood pressure was monitored with a mercury column sphygmomanometer, using the first and fifth Korotkoff sound (1). Rate–pressure product (heart rate · systolic blood pressure) was determined to estimate myocardial work (13).

Dietary records were kept by all subjects for 3 consecutive weekdays immediately prior to initiation of each test battery. A member of the investigating team thoroughly instructed the subjects on proper methods of recording and determining food portions. This training included instruction on proper use of measuring utensils and food scales (9). Throughout the study, the same investigator analyzed dietary intake records using the Nutritionist III software package (N-Square, Silverton, OR).

Resting blood samples were obtained between 7 and 8:30 a.m. from a superficial antecubital vein, following a 12-hr fast. Thus, subjects did not take their supplements on the mornings of any of the blood samples. Samples were treated with either ethylenediaminetetraacetic acid or lithium heparin or were left untreated for the following analyses. Hematocrit (Hct) was determined using standard microcapillary techniques. Spectrophotometric analyses (Spectronic 20D, Milton Roy, Marietta, GA) using reagents and procedures from Sigma Diagnostics (St. Louis, MO) were used to evaluate plasma total cholesterol and plasma high-density lipoprotein cholesterol using the heparin/manganese precipitant method of Warnick and Albers (20) (500 nm; intra-assay variance = 14.4%), serum triglycerides (405–415 nm; intra-assay variance = 9.5%; recovery = >92%), serum albumin (628 nm; intra-assay variance = 4.1%), serum calcium (575 nm; intra-assay variance = 4.2%), and serum magnesium (520 nm, intra-assay variance = 4.0%). Radioimmunoassays (125I) were used to determine immunoreactivity of plasma β-endorphin, using a preliminary extraction to minimize cross-reactivity with β-lipotropin (<5%) (INC Star, Stillwater, MN; intra-assay variance = 2.0%) and serum cortisol (New England Nuclear, Billerica, MA; intra-assay variance = 5.0%). Radioimmunoassay kits (125I) from Diagnostics Products (Los Angeles, CA) were used to determine immunoreactivity of plasma total testosterone (intra-assay variance = 5.0%), serum estradiol (intra-assay variance = 2.0%), and serum insulin (intra-assay variance = 4.8%). Immunoreactivity was determined with an LKB Pharmacia Clini-Gamma automated gamma counter with an online data-reduction system (Turku, Finland).

Dynamic muscular strength was assessed with 1 repetition maximum (RM) tests for the free weight bench press and parallel back squat (kg) using the procedures
of Stone and O’Bryant (19). To assess lower body power performances, vertical jump height was determined using the Sargent jump test (7). No steps were permitted prior to the jump, which included an arm swing and a preliminary countermovement. Absolute vertical jump height was determined from the difference between standing reach and jump reach (cm). Vertical jump power (W) was estimated using the Lewis formula (7). A modified Wingate cycle power test (2) of 10 s duration was also used to determine lower body power. A modified Monark cycle ergometer, interfaced with a computer, was used to determine peak power (watts) at a frequency of 1 Hz. Resistance for this test was 0.095 kg·kg body weight⁻¹. Lactate responses to the cycle test were determined immediately postexercise and at 10 min postexercise.

**Statistical Analyses**

All data are reported as means ± SD. Data were analyzed with 2 × 3 (Group × Test) repeated-measures analyses of variance (p ≤ .05). Post hoc analyses were performed with the Scheffé test for significance.

**Results**

No significant differences were observed between the G-O and Con groups for any variable at any time (see Tables 1 and 2 and Figures 2–4). Body mass increased, while the sum of skinfolds decreased for both groups. No changes were observed for girth measures (see Table 1). Muscular strength and vertical jump power improved for both groups during the study, indicating the efficacy of the training protocol (see Table 2).

Resting testosterone and cortisol concentrations decreased for both groups by the posttest (see Figure 2). No other hormone, lipid, or other blood variable exhibited training-induced alterations. Cardiovascular responses indicated decreased resting HR, systolic blood pressure, and diastolic blood pressure for both groups. Dietary intake for both groups remained constant throughout the study as indicated by no significant changes for total calories and percentage fat, carbohydrate, and protein intakes.

**Discussion**

The primary finding of this investigation was the lack of any significant physical, performance, or physiological effect due to gamma-oryzanol supplementation with the training and testing protocol used. The proposed mechanisms through which gamma-oryzanol would influence these variables involve enhancement of circulating norepinephrine and/or β-endorphin (4). Previous reports have suggested that sympathetic activity may be enhanced with gamma-oryzanol intake (4), but the potential role of β-endorphin (18) with gamma-oryzanol intake is not supported since β-endorphin was not shown to respond to the gamma-oryzanol supplementation used. Enhancement of either of these compounds could have considerable impact on numerous physiological systems. The lack of any alterations for circulating β-endorphin suggests that the endogenous opioid system was not responsive to gamma-oryzanol intake. In addition, although we did not measure norepinephrine in the present study, the lack of any catecholamine-sensitive physical
Figure 2 — Circulating hormonal concentrations (mean ± SD) for the gamma-oryzanol supplemented group and the placebo group. *Significantly different from pretest ($p < .05$). Several of the SDs for growth hormone are too small to be depicted in the figure. T1 = pretest; T2 = midtest; T3 = posttest.

or physiological adaptations in response to the gamma-oryzanol supplementation protocol suggests that alterations in circulating norepinephrine concentrations did not occur.

Contrary to what had been previously suggested (5), body weight and indicators of body composition (Σ SF girths) were not influenced by gamma-oryzanol ingestion. Similar increases in muscular strength and power were observed for both groups, indicating that improvements were simply the result of an effective training program, not the gamma-oryzanol supplementation. That gamma-oryzanol supplementation did not influence muscular strength and power is also contrary to what has been previously suggested (4).
Figure 3 — Circulating concentrations of calcium, magnesium, and albumin (mean ± SD) for the gamma-oryzanol supplemented group and the placebo group. No significant differences were observed between groups or across time for any variable (p > .05). T1 = pretest; T2 = midtest; T3 = posttest.

It has been proposed that numerous endocrine variables may be influenced by gamma-oryzanol ingestion. Many of these proposed alterations depend in part on changes in the adrenergic regulatory system. However, no significant changes were observed in either group for resting concentrations of testosterone, cortisol, estradiol, growth hormone, insulin, or β-endorphin. In addition, single time-point concentrations for luteinizing hormone and follicle-stimulating hormone suggest no alterations for these trophic hormones (unpublished data). Although many of the endocrine variables measured exhibit diurnal variations, all blood samples were taken at a similar time of the day, thus minimizing the effect of diurnal variations. These findings are of great interest, since many of these hormones or compounds can either directly or indirectly contribute to the anabolic–catabolic status of an
individual (16) and were thought to be possible contributing factors to an anabolic effect of gamma-oryzanol. Overall, the lack of any significant endocrine responses to gamma-oryzanol supplementation would explain, in part, the lack of any supplementation effect on physical characteristics, body composition, or muscular strength and power. In addition, no effect of gamma-oryzanol ingestion was observed for calcium, magnesium, or albumin, all of which could have an indirect effect on muscular growth or performance. Although β-endorphin may not directly influence these variables, it can profoundly augment sympathetic activity (18), which in turn would have a great impact on numerous physiological systems regulating muscular strength and growth and body composition. Cardiovascular parameters were monitored as indirect indicators of sympathetic activity. If circulating concentrations of norepinephrine were augmented, changes in resting cardiovascular performances would be evident. This was not the case, as both the supplemented and the placebo groups demonstrated similar decreases in cardiovascular responses.
<table>
<thead>
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<th>Variable</th>
<th>Gamma-oryzanol</th>
<th>Controls</th>
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<tr>
<td></td>
<td>Pre</td>
<td>Mid</td>
</tr>
<tr>
<td>1 RM</td>
<td></td>
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<tr>
<td>Bench press (kg)</td>
<td>86.9 ± 10.8</td>
<td>92.1 ± 12.0*</td>
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<tr>
<td>Squat (kg)</td>
<td>111.4 ± 24.7</td>
<td>126.9 ± 25.1*</td>
</tr>
<tr>
<td>Vertical jump</td>
<td></td>
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<tr>
<td>Height (cm)</td>
<td>55.4 ± 8.5</td>
<td>58.1 ± 7.8*</td>
</tr>
<tr>
<td>Est. power (W)</td>
<td>1253.6 ± 179.6</td>
<td>1299.8 ± 185.5*</td>
</tr>
<tr>
<td>Wingate test</td>
<td></td>
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<tr>
<td>Mean power (W)</td>
<td>898.6 ± 150.1</td>
<td>959.1 ± 110.7*</td>
</tr>
<tr>
<td>Peak power (W)</td>
<td>1001.7 ± 186.5</td>
<td>1086.4 ± 130.4*</td>
</tr>
<tr>
<td>Total work (J)</td>
<td>9434.3 ± 1642.6</td>
<td>10,129.7 ± 1162.4*</td>
</tr>
<tr>
<td>Blood</td>
<td></td>
<td></td>
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<tr>
<td>Hct (%)</td>
<td>46.5 ± 3.3</td>
<td>48.5 ± 2.7</td>
</tr>
<tr>
<td>Lactate (mmol·L⁻¹)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>0.96 ± 0.37</td>
<td>1.03 ± 0.47</td>
</tr>
<tr>
<td>IP</td>
<td>4.88 ± 1.59</td>
<td>4.21 ± 1.17</td>
</tr>
<tr>
<td>10 min post</td>
<td>5.10 ± 0.89</td>
<td>5.30 ± 1.22</td>
</tr>
</tbody>
</table>

*Note. Pre = 0 weeks; Mid = 5 weeks; Post = 10 weeks. Hct = hematocrit.

*p < .05, different from Pre.
Thus, the resting cardiovascular responses did not support a gamma-oryzanol supple-
mentation effect on the sympathetic system, contrary to earlier suggestions (4).

It has been established that chronic endurance exercise training augments sympa-
thetic activity in response to maximal exercise (14), and preliminary evi-
dence indicates that this is the case for resistance exercise as well (8). As such,
 improved maximal physical performances are accompanied by elevated concen-
trations of circulating catecholamines (8, 14). Elevated exercise-induced concen-
trations of testosterone are also evident after chronic resistance exercise training
(15, 17), with such increases appearing to be positively correlated with changes in
muscular strength (10). Since no performance differences were observed between
the gamma-oryzanol and the placebo groups, we speculate that the exercise-induced
endocrine environment was similar for both groups. If there were differences in
the sympathetic or hormonal environments in response to exercise, this would
suggest a differential sensitivity to the circulating concentrations of catecho-
lamines or the various hormones. Although there is little reason to believe that such
differential sensitivity would exist, authors of future studies may wish to monitor
exercise-induced sympathetic and endocrine responses. Although it has been
claimed that gamma-oryzanol supplementation augments sympathetic activity (4),
these data do not support such a mechanism of action for humans. A number of the
variables monitored in the present study are under adrenergic regulation and would
seemingly be affected by altered adrenergic activity, although this was not appar-
ent. Additional study directly measuring resting and exercise-induced circulating
catecholamine concentrations in response to gamma-oryzanol supplementation may
be needed to clarify the existence of such a proposed mechanism.

No effect of gamma-oryzanol supplementation was evident for blood lipid
concentrations. Since plant sterols have been shown to inhibit intestinal absorp-
tion of dietary cholesterol (6), gamma-oryzanol has been suggested to lower total
cholesterol and increase high-density lipoprotein cholesterol concentrations (4). It
has been proposed that a threshold of 300 mg · day⁻¹ of gamma-oryzanol ingestion
may be necessary to achieve a beneficial alteration of blood lipids (4), but the
dosage used in the present investigation (500 mg · day⁻¹) did not produce such a
response. Since the subjects in the present study exhibited normal blood level con-
centrations, it may be that only those individuals with abnormally high blood lipid
concentrations would be affected.

In summary, gamma-oryzanol supplementation of 500 mg · day⁻¹ did not
cause any undesirable side effects (e.g., gastrointestinal discomfort), nor did it
influence measures of muscular strength and power or body composition. Further-
more, circulating concentrations of various hormones, minerals, and binding pro-
teins were similarly unaffected. The lack of a gamma-oryzanol influence on rest-
ing cardiovascular parameters suggests that sympathetic activity was not altered.
Previously suggested theories of gamma-oryzanol ingestion altering either norepi-
nephrine or β-endorphin concentrations were not supported with the present supple-
mentation protocol.

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