Activity Adherence and Physical Function in Older Adults with Functional Limitations

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ABSTRACT
FIELDING, R. A., J. KATULA, M. E. MILLER, K. ABBOTT-PILLOLA, A. JORDAN, N. W. GLYNN, B. GOODPASTER, M. P. WALKUP, A. C. KING, W. J. REJESKI, and for the LIFE STUDY INVESTIGATORS. Activity Adherence and Physical Function in Older Adults with Functional Limitations. Med. Sci. Sports Exerc., Vol. 39, No. 11, pp. 1997–2004, 2007. Purpose: Lifestyle Interventions and Independence for Elders Pilot (LIFE-P) was a trial to examine the effects of a physical activity intervention (PA) compared with a health education control (SA) on measures of disability risk in sedentary older adults (N = 424). We examined adherence to the LIFE-P PA intervention for the first 12 months of the trial. Methods: The PA intervention consisted of walking, strength, flexibility, and balance training supplemented with behavioral skills training modules, and it used a phased, center-based schedule of adoption (3× wk−1, weeks 1–8), transition (2× wk−1, weeks 9–24), and maintenance (1× wk−1, weeks 25 to end of trial) while transitioning to primarily home-based physical activity. SA consisted of weekly (weeks 1–26) transitioning to monthly health education workshops. Results: Participation in moderate-intensity physical activity increased from baseline to months 6 and 12 in PA compared with SA (P < 0.001). At 12 months, PA participants who reported ≥ 150 min wk−1 of moderate activity demonstrated a significantly greater improvement in their Short Physical Performance Battery score compared with participants who reported < 150 min wk−1 of moderate activity (P < 0.017). For the PA arm, center-based attendance was 76.3%, and 49.8%, and 28.6, respectively. Conclusions: Adherence to physical activity in LIFE-P was associated with greater improvement in SPPB score and was consistent with adherence in physical activity trials of shorter duration in this subgroup of older adults. Older individuals at risk for disability can adhere to a regular program of physical activity in a long-term randomized trial. Key Words: EXERCISE, AGING, RANDOMIZED TRIAL, COMPLIANCE, RETENTION

Although several randomized trials have suggested a positive effect of regular physical activity on improving physical function and/or reducing symptoms of disability in healthy older individuals and those at risk for mobility disability (1,5,8,19), a definitive clinical trial in this population has been lacking. To provide information to guide the design of a definitive trial, the Lifestyle Interventions for Elders Pilot (LIFE-P) was conducted as a multicenter randomized controlled trial in older individuals at risk for mobility disability who were randomized into a multimodal physical activity intervention (PA) or “successful aging” health education attention-control program (SA) for a minimum of 1 yr (23). A critical issue in designing a trial of this type is whether older adults can reasonably participate and adhere to a regular program of physical activity for a prolonged duration. Previous long-term trials (> 6 months) of physical activity among older adults have suggested that adherence to physical activity interventions is relatively high (60–85%) (7,11,13,16–19,22). However, adherence has not been universally evaluated in physical activity intervention trials, and in some cases participants who have withdrawn from trials have been excluded from these estimates (15). In addition, participants have not always been specifically characterized with respect to their physical functioning at study enrollment, and thus evaluation of adherence to physical activity in older individuals with deficits in physical functioning is limited. Finally, whether there is a relationship between adherence to physical

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Activity and improvements in physical functioning in older individuals at risk for mobility disability remains unknown.

Because adherence to physical activity may be compromised by health status, functional limitations, and comorbidities in individuals at risk for disability, we sought to examine adherence to the physical activity intervention in participants enrolled in the LIFE-P trial. Furthermore, we hypothesized that the magnitude of improvement in physical functioning was related to physical activity adherence.

METHODS

Overview. The Lifestyle Interventions and Independence for Elders pilot (LIFE-P) was designed to help plan a definitive phase 3 randomized controlled trial to examine the efficacy of a program of physical activity, compared with attention control, on the incidence of major mobility disability. A complete description of the LIFE-P study design has been reported previously (23). Briefly, participants were observed for an average of 1.2 yr, and the major findings from LIFE-P were that the structured PA intervention resulted in clinically meaningful improvements in physical performance compared with the health education SA control group (20).

Participant recruitment. Details about specific study inclusion and exclusion criteria have been reported previously (20,23). Briefly, subjects were eligible for the study if they were between the ages of 70 and 89 yr, sedentary (defined as spending less than 20 min wk⁻¹ in regular structured physical activity), scored ≤ 9 on the Short Physical Performance Battery (10), and were able to walk 400 m within 15 min.

A total of 424 participants were randomized into PA or SA arms at four sites (Cooper Institute, Stanford University, University of Pittsburgh, Wake Forest University) and observed for 12–18 months. All participants signed an informed consent, and the study was approved by the institutional review boards of all participating institutions.

Successful aging intervention. The SA health education control was designed to provide attention and health education. Study participants attended weekly classes for the first 26 wk and then monthly until the end of the trial. Classes included health topics that were relevant to older adults such as nutrition, medication use, foot care, and preventive medicine. All SA participants received basic information about physical activity participation, and each class was concluded with a short, instructor-led, upper-extremity stretching program. Regular telephone contact was made to encourage participation and follow-up on missed sessions.

Physical activity intervention. The physical activity intervention included walking, strength, flexibility, and balance training, and the intervention was structured in three phases (Table 1).

In the adoption phase, three supervised center-based physical activity sessions per week were conducted. These sessions were used to initiate the walking program and to introduce participants to the strength, stretching, and balance portions of the program in a safe and effective manner (40–60 min). This was supplemented with 10 scheduled, 30-min, group-based behavioral skills training sessions. When appropriate, home-based physical activity was added to supplement the center-based sessions. Monthly telephone contacts were also used throughout the intervention to discuss physical activity participation. In the transition phase, the number of center-based sessions was reduced to two times per week and home-based walking/strengthening/flexibility activities were increased. In the maintenance phase, participants were encouraged to perform home-based physical activity a minimum of 5 d wk⁻¹, and one weekly, center-based session was offered. The maintenance phase was continued until the final closeout assessment visits (12–18 months).

Mode, frequency, and intensity of physical activity. Activity was progressively increased during the first 2–3 wk of the intervention. Walking was employed as the primary mode of physical activity (goal of 150 min wk⁻¹ at a moderate intensity). In addition, participants were instructed to complete a 10-min program of lower-extremity strength training, which included leg squat, standing leg curl with ankle weights, knee extension with ankle weights, side hip raise with ankle weights, and toe stands (two sets of 10 repetitions). Lower-extremity flexibility exercises and a structured balance training program were also undertaken by all participants. The flexibility exercises included nonballistic stretching of the lower extremities, and they lasted approximately 5 min. The balance training program consisted of five separate progressive levels of difficulty and was modeled after a previously reported program for older adults (9). Balance activities included hip circles, one-legged sink stands, toes raises, and side steps.

Participants were instructed to walk at a perceived exertion (RPE) intensity of 13 (somewhat hard, range 12–14) and to perform strength training at an intensity of 15–16 (3).

| TABLE 1. Lifestyle Interventions and Independence for Elders Pilot (LIFE-P) physical activity schedule. |
|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|
| Phase                                             | Center-Based Physical Activity                   | Behavioral Group Counseling Sessions               | Home-Based Physical Activity                      | Telephone Counseling Contact                      |
| Adoption (weeks 1–8)                             | Three times each week                             | Eight scheduled meetings, immediately after a scheduled center-based physical activity session | Up to two times per week                          | One time per month                               |
| Transition (weeks 9–24)                          | Two times each week                               | Two scheduled meetings                             | Three times per week                              | One time per month                               |
| Maintenance (week 25 to end of the trial)        | Offered once per week                             |                                                   | Five or more times per week                        | One time per month                               |


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In addition, participants were instructed to continue their walking, strengthening, flexibility, and balance exercises at home. To record participation in home-based physical activity, participants kept a paper log that was returned to intervention staff at monthly intervals. Participants were instructed to record the number of minutes walked per day and the frequency of strength training sessions per week.

**Medical suspension from physical activity.** Participants were placed on suspended status if they missed three or more consecutive sessions of center-based physical activity (adoption and transition), or two or more weeks of home-based PA (maintenance) because of a health event. Participants were allowed to “restart” the PA intervention after suspension, after receiving medical clearance from their primary care physician and the development of a modified physical activity plan by the study interventionist.

**Measures of adherence.** To confirm and objectively validate levels of participation in physical activity, the Community Healthy Activities Model Program for Seniors (CHAMPS) physical activity questionnaire was assessed at baseline, at 6 months, and at 12 months by assessors blinded to the treatment assignment (25). Participants were asked to report weekly frequency and duration of various physical activities for the prior 4-wk period.

Because our primary aim was to increase participation in moderate-intensity walking in this group to a minimum of 150 min·wk⁻¹ in addition to strength and balance training three times per week, we used the CHAMPS to specifically examine participation in moderate physical activity, defined as activities ≥3.0 METs (25). To adequately synthesize all of the goals of the LIFE-P physical activity intervention, we quantified participation in physical activity above and below the threshold of 150 min·wk⁻¹ of moderate activity.

Attendance at center-based physical activity sessions was reported as the percentage of possible sessions relative to the total number of possible sessions in each study phase, excluding facility closings (e.g., holidays, weather emergencies, etc.). Attendance was also calculated excluding sessions missed because of suspended status. During maintenance, adherence was also assessed by completion of the home activity logs. The dose of physical activity was examined by evaluating the intensity and duration of physical activity throughout the trial.

**Measurement of physical functioning.** Physical functioning was assessed using the Short Physical Performance Battery, as described previously (10). Briefly, the SPPB score is based on timed measures of standing balance, walking speed, and ability to rise from a chair. Each of the three performance measures was assigned a score ranging from 0 to 4, with 4 indicating the highest level of performance and 0 indicating a subject’s inability to complete the test. A summary score (range 0–12) was subsequently calculated by adding the three scores.

**Statistical analyses.** The present analyses focuses only on the first 12 months of the trial. Percent attendance was calculated per participant by dividing the number of sessions attended by the expected number of sessions. Dose of physical activity was calculated per participant for those sessions that the participant attended. Linear regression, controlling for site, was used to compare attendance at center-based sessions and self-reported physical activity between groups, defined by whether they turned in home-based logs. Residuals were inspected for departures from normality, and transformation of percent attendance was not required. Results are reported as means ± SD unless otherwise noted.

The intervention effect on change in moderate-intensity physical activity from the CHAMPS was assessed at 6 and 12 months, using the Wilcoxon rank–sum test to account for skewness of the distribution of this measure. A mixed-effects general linear model was used to test whether the change from baseline SPPB score was different for PA participants who performed ≥150 min of moderate-intensity physical activity per week compared with those participants who performed <150 min, according to data from CHAMPS obtained for the interval just before the 6- or 12-month SPPB measurement. Covariates included in the models were site, gender, and whether the participant was placed on suspended status at any time during the particular time interval. No transformation of SPPB scores was
needed for this analysis, because the residuals from the model approximated a normal distribution. This model allowed for estimation of mean differences for both the 6- and 12-month visits. SAS software was used to perform these analyses.

RESULTS

Participant enrollment and retention. Two hundred thirteen participants were randomized to the PA intervention arm (68.5% women, 24.9% nonwhite, mean age = 76.5 ± 4.2 yr). Three participants withdrew initially from the PA intervention before attending any scheduled physical activity sessions. Two hundred eleven participants were randomized to the SA intervention (69.2% women, 26.6% nonwhite, mean age = 77.0 ± 4.3 yr). During the trial, a total of 91 PA participants (42.7%) were placed on suspended status, and 48 of these (53% of suspended participants) successfully restarted the PA intervention. By month 12 of the PA intervention, a total of 116 participants (54%) were still participating in PA, as evidenced by either completing a home-based log or attending a center-based physical activity session within 2 wk of their 1-yr study anniversary.

Adherence to successful aging. Attendance to the weekly SA sessions was 70.1 ± 21.8% during weeks 1–26 and 73.3 ± 31.5% during weeks 27–52.

Adherence to physical activity. The average weekly time spent in moderate-intensity physical activity from the CHAMPS increased in the PA group from baseline and was different from SA at 6 months (P < 0.001) and 12 months (P = 0.005; Table 2, Fig. 1). The average change in moderate-intensity physical activity in the PA was 102.7 ± 253.7 and 63.2 ± 210.2 min wk⁻¹ at 6 and 12 months, respectively.

In the PA arm, there was no difference in the change in SPPB score at 6 months between participants who reported ≥ 150 and < 150 min wk⁻¹ of moderate activity (Table 3). However, at 12 months, participants who reported ≥ 150 min wk⁻¹ of moderate activity demonstrated a significantly greater improvement in SPPB score (1.22 [CI = 0.82–1.62]) compared with participants who reported < 150 min wk⁻¹ of moderate activity (0.68 [CI = 0.34–1.02]) (P = 0.017, adjusted for site, gender, and medical suspensions).

Center-based attendance. Attendance averaged 76.3 ± 24.5, 65.4 ± 28.6, and 49.8 ± 35.8% in adoption, transition, and maintenance, respectively, and was similar across all study sites (Table 4). Attendance to center-based physical activity during the adoption phase was correlated with attendance in transition (r = 0.37; P < 0.001) and maintenance (r = 0.30; P < 0.001). As expected, the three most frequent reasons reported for a missed center-based session were health/medical-related, “too busy,” or travel. When missed sessions were excluded because of medical suspensions, attendance averaged 79.4 ± 21.4, 71.1 ± 25.8, and 57.6 ± 34.6% across adoption, transition, and maintenance, respectively. A high degree of adherence, defined as the percentage of individuals who attended 70% or more of possible center-based sessions, was observed in 62.4% (70.4% when excluding suspended participants) of PA participants.

Duration and intensity of physical activity. Mean walking time increased from 27.6 ± 8.1 min per session (RPE = 11.9 ± 1.1) in adoption to 33.1 ± 11.6 min per session (RPE = 12.3 ± 1.5) in maintenance (Table 5). The amount of weight used during knee extension increased from 2.5 ± 1.3 kg in adoption to 3.4 ± 1.7 kg in transition and remained stable in maintenance (3.4 ± 2.0 kg) (Table 5). RPE during knee extension averaged 11.9 ± 1.1, 12.2 ± 1.3, and 12.3 ± 1.5 in adoption, transition, and maintenance, respectively.

Home-based physical activity. Because the bulk of physical activity was performed at home during maintenance, we examined the ability of participants to complete the home-based logs during this phase of the trial. Recovery of home-based logs from PA participants was incomplete. In maintenance, 57% of PA participants submitted at least one log to the intervention staff during maintenance. We defined high compliance as participants who submitted four of six logs during maintenance; 45% of all PA participants met this standard.

For those participants completing any home-based logs, they reported 3.6 ± 2.3 and 3.7 ± 2.2 sessions per week of walking in transition and maintenance, respectively. The average time spent walking in these two phases was 127.3 ± 120.5 and 138.0 ± 148.5 min wk⁻¹ in transition and maintenance, respectively. Strength training was performed, on average, 1.6 ± 1.6 and 1.4 ± 1.5 sessions per week during these two phases.

Percent attendance was significantly higher during the transition phase for participants who turned in at least one log during the maintenance phase compared with those who did not turn in any logs (79.5 ± 25.0 vs 45.9 ± 24.2%; P < 0.001; adjusted for clinical site). Furthermore, we

<table>
<thead>
<tr>
<th>Field Center</th>
<th>Adoption</th>
<th>Transition</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooper</td>
<td>75.7 ± 22.0</td>
<td>64.7 ± 32.2</td>
<td>47.4 ± 39.1</td>
</tr>
<tr>
<td>Stanford</td>
<td>82.3 ± 22.0</td>
<td>67.5 ± 26.2</td>
<td>51.5 ± 35.9</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>67.9 ± 31.7</td>
<td>67.7 ± 27.7</td>
<td>50.4 ± 33.7</td>
</tr>
<tr>
<td>Wake Forest</td>
<td>78.8 ± 19.1</td>
<td>61.8 ± 28.6</td>
<td>49.9 ± 35.1</td>
</tr>
</tbody>
</table>
TABLE 5. Summary of physical activity duration and intensity by phase of study (center-based sessions; mean ± SD).

<table>
<thead>
<tr>
<th>Mode of Activity</th>
<th>Intensity</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption Walking</td>
<td>RPE = 11.9 ± 1.1</td>
<td>27.6 ± 8.1 min per session</td>
</tr>
<tr>
<td>Strength training (knee extension)</td>
<td>RPE = 11.5 ± 1.5</td>
<td>N/A</td>
</tr>
<tr>
<td>Balance training (% completed)</td>
<td>93.7 ± 11.3%</td>
<td>N/A</td>
</tr>
<tr>
<td>Transition Walking</td>
<td>RPE = 12.2 ± 1.3</td>
<td>32.0 ± 9.2 min per session</td>
</tr>
<tr>
<td>Strength training (knee extension)</td>
<td>RPE = 11.9 ± 1.5</td>
<td>N/A</td>
</tr>
<tr>
<td>Balance training (% completed)</td>
<td>94.5 ± 10.3%</td>
<td>N/A</td>
</tr>
<tr>
<td>Maintenance Walking</td>
<td>RPE = 12.3 ± 1.5</td>
<td>33.1 ± 11.6 min per session</td>
</tr>
<tr>
<td>Strength training (knee extension)</td>
<td>RPE = 11.8 ± 2.2</td>
<td>N/A</td>
</tr>
<tr>
<td>Balance training (% completed)</td>
<td>87.6 ± 22.6%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

compared self-reported physical activity by CHAMPS at 12 months with compliance submitting home-based logs. Participants who completed and turned in one or more home-based log during the maintenance phase of the intervention reported a significantly greater frequency of moderate (7.8 ± 6.2 vs 4.7 ± 7.6; P = 0.002) physical activity on the CHAMPS compared with participants who did not turn in a log.

DISCUSSION

The major finding of the present analyses from LIFE-P was that in older, previously sedentary adults at high risk for physical disability, adherence to moderate-intensity physical activity was greater in the PA group, relative to the SA group, and that this difference was sustained through 12 months of the trial. Attendance at center-based physical activity sessions was consistent with previous studies of physical activity in older adults. In addition, adherence to physical activity in the latter phases of the trial (12 months) was associated with greater improvements in physical functioning. However, self-reporting of home-based physical activity using activity logs was incomplete, with log completion associated with higher adherence in the center-based phase of the trial. Finally, attendance to center-based physical activity sessions was consistent across all four study sites, suggesting that this type of physical activity intervention can be delivered successfully across multiple sites in a randomized clinical trial.

Participants who reported greater physical activity participation at 12 months had a greater improvement in physical functioning, as measured by the SPPB, compared with participants who reported less physical activity. These data are suggestive of a possible dose/response relationship between participation in physical activity and improvements in physical functioning in older adults with baseline deficits in physical functioning. These results are also consistent with observations of an association between adherence to physical activity and improvements in performance-based measures of physical functioning in older adults with osteoarthritis of the knee (7,26). The observed improvement in SPPB in the group of participants participating in < 150 min·wk⁻¹ (0.46 SPPB units) of moderate activity was consistent with a small, clinically meaningful change, and the observed improvement in SPPB in the group of participants participating in ≥ 150 min·wk⁻¹ (1.35 SPPB units) of moderate activity was consistent with a substantial, clinically meaningful change in physical functioning (21).

Adherence to physical activity in randomized trials of older adults has not been reported consistently, with some trials excluding participant withdrawals in their adherence calculations, resulting in an upward bias of reported physical activity adherence. In other trials, where adherence was calculated using intent-to-treat principles, adherence has been similar to that reported in the present study (15). The unadjusted center-based adherence in LIFE-P ranged from 49 to 76%, with the highest adherence occurring in the adoption phase and the lowest occurring in maintenance when attendance was optional, which is consistent with adherence reported in similar trials. Attendance to center-based PA sessions was moderately correlated across the study phases, suggesting that identification of poor adherence in the adoption phase may be one useful strategy to target potential subsequent noncompliance early in the intervention. Despite the apparent less-than-optimal adherence across previous trials and in LIFE-P, all of these studies have demonstrated significant benefits of physical activity on physical functioning (2,7,17,20). More recently, the Diabetes Prevention Program has demonstrated in a younger cohort that a lifestyle intervention involving weight loss and physical activity promotion can be sustained for 4 yr and can result in both improvement in physical activity and prevention of diabetes, despite only 58% of the participants meeting the goal of at least 150 min of physical activity per week at their last visit (14). An age-stratified analysis of the results of the DPP reveals that adherence to the physical activity component of the intensive lifestyle intervention (≥ 150 min·wk⁻¹ of physical activity) was achieved in 48% of participants 60–85 yr, compared with 38% in 45- to 59-yr-olds and 34% in 25- to 44-yr-olds, during the approximately 3-yr follow-up (4). These results are remarkably consistent with the reported adherence in the present study.

Because many barriers exist to participation in physical activity, including intercurrent illness and facility access, we also examined adherence to PA excluding sessions missed because of documented medical suspensions and center closings. As described previously, center-based adherence improved throughout the trial when medical suspensions
were excluded. Given the frequency of intercurrent illness in this population, these estimates may more reasonably reflect the true capability of participants to engage in the center-based component of the trial. In fact, one randomized trial of physical activity in older individuals has reported development of new medical conditions to be one of the strongest predictors of participation/adherence (12), and in LIFE-P, illness/health problems were the most common reason for a missed center-based session. Therefore, a specific protocol targeting medical suspensions and restarting the PA intervention was implemented in LIFE-P and facilitated the restart of a majority of suspended participants (53%). For those who did not restart PA, the suspension was typically associated with an adverse event (67%, 29/59 suspensions), of which the majority (25/29) were determined to be unrelated to the PA intervention.

In general, participants met the targeted duration and intensity goals for PA. By the transition phase, with a combination of center- and home-based PA, a majority (56%) were meeting the goal of 150 min of physical activity per week. Although the prescribed intensity for the strengthening exercises was not met, there were measurable increases in the training weight used from adoption to transition, suggesting that the strength training was progressing as expected. There are several possible explanations for why the intensity goal of the strength training portion of the intervention was not met. This may have been related to the limited prior experience of these participants with resistance training and their low level of muscle strength and physical functioning at baseline. In addition, because this was a group-based intervention, individual monitoring of the strength training program and individual oversight of the appropriate training intensity was not possible. In supervised, randomized trials of resistance training in older individuals, improvements in muscle strength were only realized when the training stimulus was of a sufficiently high intensity (24). At present, the benefits of lower-intensity strengthening, particularly with respect to changes in physical functioning and prevention of disability, in a long-term physical activity intervention in older participants remain unknown.

Our ability to capture home-based physical activity in LIFE-P using physical activity logs was limited, suggesting that alternative approaches for collecting information on physical activities undertaken outside of center-based sessions are strongly indicated for functionally limited older adults. Although the use of pedometers and other forms of electronic monitoring provide an easy-to-use alternative to paper logging, these approaches have been unreliable in a significant proportion of functionally limited older adults (6). Participants who completed and turned in the home-based logs adhered better to the center-based physical activity sessions, suggesting that those who are less compliant with such self-monitoring strategies are also generally less adherent to the physical activity intervention.

In conclusion, adherence to center-based PA in LIFE-P was consistent with similar trials in older adults and was appropriate when considering the prevalence of existing comorbidities and intercurrent illness in this population. Importantly, greater adherence and participation in physical activity was associated with better outcomes on the SPPB. We were also encouraged that combined center-based and home-based physical activity remained above 50% at 1 yr, and this suggests that retention to physical activity in this population is feasible. A limitation in the present trial was the lack of compliance with reporting of home-based physical activity using activity logs. Examples that may be implemented to facilitate the recall of home-based physical activity may include brief interview-based recall of home-based activities at weekly center physical activity sessions or via regular staff-initiated phone contacts, as well as continued exploration of objective ambulatory monitoring devices in the older, gait-impaired sample being targeted. Future trials should develop and rely on more objective strategies to capture home-based participation in physical activity, particularly in studies of older adults. The physical activity intervention employed in LIFE-P represents a feasible, sustainable program that can be implemented across multiple clinical sites for older individuals at risk for disability.

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