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Assessment of physical fitness among non-athlete adolescents: Effect of familiarization sessions

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Assessment of physical fitness among non-athlete adolescents: Effect of familiarization sessions

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C Statistical Analysis
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E Manuscript Preparation
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abstract

Background: The validity and reliability of fitness tests are described in the literature; however, the effects of familiarization sessions on motor performance have not yet been studied. The aim of this study was to analyze the effects of four familiarization sessions on physical fitness performance among adolescents.

Material and methods: Twenty adolescents performed sprint, agility, flexibility, explosive strength, muscular endurance, and balance tests on four separate days with an interval of 72h.

Results: Considering the first and the fourth sessions, there were significant differences in mean values for push-up, curl-up, and Flamingo tests ($p<0.05$). Intraclass Correlation Coefficient (ICC) varied from 0.65 to 0.97, except for the Flamingo test (0.22). The magnitude based inference revealed a likely beneficial effect of familiarization on agility (87.8%), push-ups (91.2%), curl-ups (94.4%), and a very likely effect on the Flamingo test (97.0%). When comparing the second and the third sessions with the first one, values of ICC were similar or higher, while a likely beneficial effect of familiarization was found in the second session for the Flamingo test (78.8%), and in the third session for curl-ups (91.3%), push-ups (77.1%), and the Flamingo test (94.8%).

Conclusions: The familiarization procedure should be considered prior to agility, muscular endurance, and balance test assessments.

Key words: exercise test, learning, youth, reproducibility of results.

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INTRODUCTION

Physical fitness can be defined as the ability to carry out daily tasks with vigor and alertness, without undue fatigue (efficiently and effectively), and with ample energy to enjoy leisure-time [1,2]. Body composition, cardiovascular fitness, flexibility, muscular endurance, and strength can prevent the emergence of health disorders and are classified as health-related physical fitness. Added to those already mentioned, agility, balance, coordination, power, reaction time, and speed are considered skill-related physical fitness factors since they are determinants to sport performance [2]. Due to these characteristics, physical fitness tests have been widely used to assess health, motor development, talent identification in sports, effect of physical training, and ergogenic effects among children and adolescents [3–6].

When using physical fitness tests, it is indispensable to analyze the validity and test-retest reliability of the tests. In general, field tests of physical fitness present acceptable validity and reliability and can be used among young people [7–11]. Another methodological aspect that should be considered is the effect of a familiarization procedure [4], which is the amount of learning sessions that stabilize performance in a test. A familiarization procedure with the practice of a movement enables acquisition of a new motor skill through the following phases: learning, consolidation, and retention [12–14]. Changes in performance through practice involve repetition and are task dependent; they can occur minutes after the first session for simple tasks or require more time for complex tasks [12–14]. The absence of improvement in performance across repetitions indicates the retention phase of the motor skill, which remains for long periods [12,13]. With regard to physical fitness, the retention phase suggests that improvements in performance cannot be attributed to learning, but to other aspects, such as a training effect.

The literature describes that among children (10.8 years), three (for agility), four (for vertical jump), and six familiarization sessions (for long jump) are required [15]. Another study demonstrated a significant increase in motor performance in vertical jump, push-ups, curl-ups, running speed, and agility in the second session of familiarization among children (5.89 years) compared to the first one [16]. This evidence indicates relevant information, since a lack of information regarding the familiarization procedure of physical fitness tests is common in experimental studies [5,17–25]. The absence of a familiarization process can result in methodological bias since it prevents knowledge as to whether part of the intervention effect can be attributed to familiarization in the retest. Some studies have described from two to three familiarization sessions [26,27] that the sample were familiarized with physical fitness test performance [28,29], that participants performed practice attempts without information on the number of attempts [30], or that participants were taught the proper technique [31]. Furthermore, the familiarization procedure has been reported for the intervention (resistance exercise) and one-repetition maximum testing but not for motor tests [18].

To our knowledge, only two studies have been conducted aimed at analyzing the effect of physical fitness familiarization sessions in children [15, 16], and this information needs to be better understood regarding adolescents [4]. Due to differences related to physical, cognitive, and motor development, as well as previous motor experience, the results from children samples cannot be generalized to adolescents. Thus, the aim of this study was to analyze the effects of four familiarization sessions on physical fitness performance of adolescents. The results of the present study will improve knowledge regarding the familiarization process among adolescents and, if necessary, will guide teachers and researchers to adopt this procedure in physical fitness assessments.

MATERIAL AND METHODS

Sample and ethical aspects

Twenty adolescents (10 boys and 10 girls) participated voluntarily in the current study. The adolescents were enrolled in the Federal Institute of Education, Science and Technology of São Paulo, Brazil. The inclusion criteria were: aged between 15 and 17 years old; not having performed any of the physical tests analyzed in this study; not being enrolled in any training regimen as commonly performed by athletes; not presenting any health problem that prevented participation in any procedure of the study. The exclusion criteria were any change in prior or between test session behaviors, such as the use of a stimulant substance, vigorous exercise, and sleep deprivation. Furthermore, any health disorder such as muscular injury, acute pain, diarrhea, fever, malaise, or another reported symptom that could affect physical performance was considered.

Before data collection, the adolescents were invited to participate in the study, and the aims, procedures, risks, and benefits were presented. Those who agreed to participate in the study signed informed written assent, and their parents' signed informed written consent, both containing the objectives, procedures, risks, and benefits of the study, as well as the researchers' contact details. The study was approved by the Ethics Committee for Research involving human beings of the Federal Institute of Education, Science and Technology of São Paulo, Brazil, process 3.193.081. The guidelines of Resolution No 466/2012 of the Brazilian National Health Council were followed.

Procedures

All procedures were performed in a sports court at the school where the participants were enrolled. Nine physical fitness tests were carried out: 10 and 20m sprints (speed), T-drill (agility), sit and reach (flexibility), long and sextuple jumps (explosive strength), 90° push-ups (upper limb endurance), curl-ups (abdominal endurance), and Flamingo (balance). On the first day, information regarding the procedures of each test was provided, and all tests were performed by an instructor with experience in fitness evaluation. This procedure was adopted for participants to visualize the execution of the tests. Each test was performed four times by the participants, with intervals of at least 72h between days of evaluation and only one test per day was performed. Another test was performed only when all familiarization days of the previous test had ended. All participants were advised to maintain their regular daily activities, not to change diet or sleep patterns, and not to perform any vigorous physical effort or to consume stimulant substances during data collection. Furthermore, any behavior or health related changes that could influence test performance were required to be reported to researchers. It was also recommended that participants wear the same shoes during the familiarization sessions, except for the flexibility and balance tests, which were performed without shoes. Prior to each test assessment, the participants performed the same structured warm-up that consisted of 10 minutes of light running and dynamic exercises, described previously [32]. A pilot study with five participants with similar characteristics to the sample, but not included in this study, was conducted to analyze the participants' acceptance and motivation to perform the study procedures, adjust the specified instruction for each test, and adjust the time required to perform the tests.

Testing

Speed

Speed was assessed using 10 and 20m sprint times. The participants positioned themselves at the starting line and after a visual signal ran to the finish line at 10 or 20 meters. The

time was recorded using a stopwatch (HS-70W-1DF, Casio, Shibuya, Japan) with a precision of tenths of a second. The better of two attempts was recorded. The reliability of these tests is high among young people as described elsewhere [33] as well as the validity of the manual time measurement [10].

Agility

The modified T-test was used to assess agility according to procedures described by Sassi et al. [34]. From the standing initial position (A), the participant sprinted 5m forward (B), 2.5m from the right side run (C), 5m from the left side run (D), 2.5m from the right side run (B), and ran 5m backward (A). Each point (A, B, C and D) was demarked with cones and the participant was required to touch the cones with their hands. The better of two attempts was recorded.

Flexibility

Flexibility was assessed using the sit and reach test proposed by Wells and Dillon [35]. The test requires a sturdy box measuring 30.5 x 30.5 x 30.5 cm with an extension of 23 cm. The participant sits down in front of the box with the knees below the box extension, with both legs extended and the soles of both feet supported on the side of the box below the extension. With the arms extended forward and the hands placed down on the upper surface of the extension scale, the participant inclines the trunk and reaches as far as possible along the graduated tape, remaining for one second. The better of two attempts was recorded.

Explosive strength

Two tests were adopted to evaluate explosive strength, long jump and sextuple long jump. For both tests, a measuring tape was used on the ground. The participants positioned themselves with feet together at the starting line. To perform the long jump, it was necessary to perform a countermovement jump, and the distance was measured from the starting line until the back of the landing heel. The procedures of the sextuple jump were similar to the long jump; however, the participant was required to perform six unilateral jumps, alternating the legs, and landing as far as possible from the starting line. The better of two attempts was recorded. The reliability of the tests is high, with an intraclass coefficient correlation of 0.90 [33].

Muscular endurance

The curl-up and 90° push-up tests were used to evaluate muscular endurance, adopting the procedures described by Welk et al. [36]. Push-up: The participant remained in a prone position on the mat, with hands placed slightly wider than the shoulders, fingers stretched out, legs straight apart, and tip of the toes touching the ground. The participants were required to push-up and flex the elbows until 90° maintaining legs and back straight, performing as many repetitions as possible. Curl-up: The participant started in a supine position on the mat, with knees at an angle of 140°, feet on the ground, legs slightly apart, arms parallel to the trunk, with palms down on the mat. At the fingertips, a 12 cm wide measuring tape was inserted under the legs. The movement consisted of slow curl-ups, sliding fingers across the measuring tape until fingers reach the other side and returning to the initial position until the head touched the mat. The participants performed as many repetitions as possible. An electronic device was used to control the velocity of the repetition of one push-up or curl-up in each three seconds.

Postural balance

Postural balance was assessed using the Flamingo test [37]. An apparatus 3cm wide, 5 cm high, and 50cm long was used to conduct the test. The participant was positioned with one foot under the apparatus, holding the opposite leg flexed close to body, with eyes open

and head in an anatomical position. The participant was required to remain in the same position for one minute and each fall (touch on the ground or being unable to hold the leg) of the apparatus was counted as one point, and time was stopped. Before starting, the participants chose their preferred leg to perform the test.

Statistical analysis

Descriptive statistics were performed using mean, standard deviation, confidence interval of 95% (CI95%), and interquartile range, when appropriate. The intraclass correlation coefficient and the CI95% were used to analyze the reliability of measures, and the following classification was adopted: values less than 0.5 indicate poor reliability, values between 0.5 and 0.75 moderate reliability, values between 0.75 and 0.9 good reliability, and values greater than 0.90 excellent reliability [38]. Student's T-test for independent samples was performed to compare physical fitness between participants who practice sports and those who do not practice sports. The comparison of physical fitness between the four days of familiarization was performed using Analysis of Variance for Repeated Measures. The Greenhouse-Geisser correction was adopted when appropriate, and Bonferroni Post-hoc was used when a significant difference ($P<0.05$) was detected. Mean and percentage differences between days 1 and 4 were also calculated. The effect sizes between the first and fourth days of familiarization were calculated according to Cohen´s procedures (Mean post – mean pre/mean standard deviation) and interpreted using the following thresholds: <0.2, trivial; 0.2–0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; 2.0–4.0, very large; and >4.0, nearly perfect [39]. Finally, a magnitude-based inference was conducted between days of familiarization according to procedures proposed by Batterham and Hopkins [40], using a specific spreadsheet. The smallest worthwhile change was determined by multiplying standard deviation of pre-values by 0.3 (small effect). The probability of finding differences in the variables tested was estimated, with qualitative thresholds as follows: <1%, almost certainly not; 1–5%, very unlikely; 5–25%, unlikely; 25–75%, possible; 75–95%, likely; 95–99%, very likely; >99%, almost certain [41]. All analyses were conducted using the statistical software package IBM SPSS 21 (SPSS Inc. Chicago, IL) and Microsoft Office Excel for Windows® software (Washington, United States).

RESULTS

The sample was composed of 20 adolescents (10 boys and 10 girls) with a mean age of 15.46 ±0.61 yrs, height 1.68 ±0.08 m, and weight 62.09 ±15.23 kg. The participants presented habitual moderate to vigorous physical activity of 281.67 ±281.93 minutes/week, and six participants were considered physically active according to the WHO guideline (60 minutes of moderate to vigorous physical activity daily). Furthermore, all participants reported participating in physical education classes twice a week, and eight adolescents were informal sport practitioners (infrequent practice). No differences were found between adolescents who practice sports and those who did not practice sports in any of the analyzed fitness tests ($P>0.05$).

The performance in fitness tests on each day of familiarization is described in Table 1. There were no significant differences between the four days of tests for 10 and 20m sprints, agility, flexibility, long jump, or sextuple jump. However, significantly higher performances were observed in the push-ups, curl-ups, and the Flamingo test on the third and fourth days of familiarization compared to the first one ($P<0.05$). For the push-up test, the fourth day was also different compared to the second one ($P<0.05$).

Table 1. Comparison of performance in fitness tests on the four days of familiarization

Variables	Day 1	Day 2	Day 3	Day 4
10m sprint (s)	2.09 (0.18)	2.05 (0.15)	2.07 (0.16)	2.03 (0.15)
20m sprint (s)	3.56 (0.29)	3.57 (0.29)	3.45 (0.84)	3.55 (0.32)
Agility (s)	6.85 (0.35)	6.72 (0.21)	6.81 (0.37)	6.62 (0.42)
Flexibility (cm)	30.97 (8.69)	31.07 (9.08)	30.52 (8.73)	31.32 (8.53)
Long jump (m)	1.69 (0.37)	1.71 (0.42)	1.70 (0.40)	1.69 (0.41)
Push-up (rep)	14.50 (9.21)	16.25 (12.48)	18.60 (12.32)*	19.05 (12.61)*†
Curl-up (rep)	26.70 (7.21)	27.25 (7.11)	30.50 (7.52)*	31.10 (7.45)*
Balance (att)	5.85 (3.43)	4.45 (3.37)	3.55 (2.37)*	2.95 (2.35)*
Sextuple jump (m)	12.08 (1.44)	12.24 (1.53)	12.21 (1.61)	12.19 (1.46)

Values expressed as mean (standard deviation). * P<0.05 versus day 1; † P<0.05 versus day 2. s = seconds; m = meters; rep = repetitions; = att = attempts.

Table 2 describes the results of the intraclass correlation coefficient, the absolute and relative differences of the fourth day compared to the first day of familiarization, and the effect sizes of the differences. According to the cut-offs adopted in the present study, the Flamingo test presented poor reliability, while 10m sprint, curl-ups, and agility tests presented moderate reliability. Good reliability was found for long jump, push-ups, and 20m sprint tests, while the flexibility and sextuple jump presented excellent reliability. Higher relative differences were found for push-ups, curl-ups, and the Flamingo test while lower values were described for 20m sprint, long jump, and sextuple jump. The tests that presented higher magnitudes of effect sizes were agility, push-ups and curl-ups (trivial), and general balance (small).

Results of the intraclass correlation coefficient between sessions one and two and one and three were, respectively: 10m sprint (0.76 and 0.75), 20m sprint (0.91 and 0.70), agility (0.66 and 0.73), flexibility (0.99 and 0.97), long jump (0.98 and 0.99), push-up (0.93 and 0.88), curl-up (0.90 and 0.81), balance (0.78 and 0.54), and sextuple jump (0.95 and 0.93); data not shown in tables.

Table 2. Intraclass correlation coefficient, relative and absolute differences, and effect sizes considering the first and the fourth days of familiarization

Variables	ICC (CI95%)	Relative difference % (IR)	Absolute difference mean (CI95%)	Effect size
10m sprint (s)	0.73 (0.32–0.89)	-2.21 (-2.53/6.47)	-0.06 (-0.13/0.01)	0.37
20m sprint (s)	0.80 (0.51–0.92)	0.02 (-3.90/5.96)	-0.008 (-0.12/0.11)	0.02
Agility (s)	0.75 (0.51–0.89)	-1.84 (-7.91/0.85)	-0.23 (-0.44/-0.03)	0.57
Flexibility (cm)	0.97 (0.03–0.98)	3.63 (-2.53/6.47)	0.35 (-0.65/1.35)	0.04
Long jump (m)	0.84 (0.66–0.93)	0.29 (-6.79/7.59)	-0.005 (-0.11/0.10)	0.02
Push-up (rep)	0.79 (0.51–0.90)	25.83 (15.70/50.00)	4.55 (1.59/7.50)	0.41
Curl-up (rep)	0.65 (0.31–0.84)	11.32 (3.81/25.46)	4.40 (2.20/6.59)	0.56
Balance (att)	0.22 (0.23–0.59)	-59.60 (-95.83/-28.75)	-2.90 (-4.28/-1.51)	0.84
Sextuple jump (m)	0.92 (0.81–0.97)	-0.44 (-2.04/2.30)	0.11 (-0.16/0.38)	0.07

ICC = Intraclass correlation coefficient; CI95% = 95% confidence interval; % = Difference expressed in percentages; IR = Percentiles 25 and 75 of interquartile range; s = seconds; m = meters; rep = repetitions; = att = attempts.

Table 3 presents the results of magnitude-based inferences for each studied test, considering the mean differences between days of familiarization. The analysis of the smallest worthwhile change revealed a possible beneficial effect of the familiarization process for 10m sprint and a likely beneficial effect for agility, push-up, and curl-up tests.

The balance test presented a very likely probability of having a beneficial effect of the familiarization process, while for 20m sprint, flexibility, long jump, and sextuple jump the effect was classified as very likely negligible.

Furthermore, the results for the second and third sessions compared to the first one showed a likely beneficial effect of familiarization in the second session for the Flamingo test (78.8%), and the third session for curl-ups (91.3%), push-ups (77.1%), and the Flamingo test (94.8%); data not presented in tables.

Table 3. Magnitude-based inferences of each test studied considering the smallest worthwhile change between first and fourth days of familiarization

Variables	Beneficial or Substantially Beneficial	Negligible or Trivial	Harmful or Substantially Harmful
10m sprint (s)	56.8	43.0	0.2
20m sprint (s)	0	100	0
Agility (s)	87.8	12.0	0.2
Flexibility (cm)	0	100	0
Long jump (m)	0.2	99.7	0.1
Push-up (rep)	91.2	8.8	0
Curl-up (rep)	94.4	5.6	0
Balance (att)	97.0	3.0	0
Sextuple jump (m)	18.5	74.6	6.9

Magnitude-based inferences according to procedures described by Batterham and Hopkins [37].

DISCUSSION

The main findings were that the familiarization procedure resulted in increased performance in modified the T-drill, push-ups, curl-ups, and the Flamingo test, while no effects were found for 10 and 20m sprint, sit-and -reach, long jump, and sextuple jump tests.

The results of the present study partially corroborate the information available in the literature. Among children, it was found that at least three familiarization sessions are necessary for polygon backward and polygon with turn, four sessions for vertical jump, and six for long jump. The only test for which performance did not differ compared to the initial session was the toe touch [15], as occurred in the present study for the sit-and-reach test. In another study aimed at investigating the familiarization effect on motor tests of preschool children, significant differences were described in the second session of measurement compared to the first in countermovement jump, push-ups, curl-ups, running speed, and agility, while no differences were found for squat jump or sit-and-reach tests [16].

The comparison of the results of the present study with those that investigated samples of children is difficult due to differences attributed to human development. No effect of familiarization was expected among adolescents due to their better motor experiences, competence, and, consequently, higher stage of motor development; however, an increase in performance was found after familiarization sessions for some of the analyzed tests. In fact, adolescents have a better profile of the above-described characteristics compared to children, and some of the motor tasks assessed by the tests are specific, although there is probably a transference of motor skills. For example, even though none of the participants had previously performed any of the tests proposed in this study, the movements required to perform the sit-and-reach test are commonly performed during physical education

classes in stretching exercises, while 10 and 20m sprints are required during a variety of sports game. The same occurs for long and sextuple jumps, which are movements commonly performed in athletic contents during classes [42]. On the other hand, the movements required for the execution of push-ups, curl-ups, and the Flamingo test are specific and are not regularly included in the routine of physical education classes, which could explain the positive effect of familiarization sessions.

The reliability of fitness performance was analyzed using intraclass correlation coefficients, which ranged from 0.65 to 0.97, except for the Flamingo balance test that presented 0.22. In general, the tests are considered reliable and these results are in line with previous literature demonstrating test-retest reliability of field tests among adolescents [7, 9, 43, 44]. It is important to state that these coefficients are based on the first and fourth days of familiarization, and coefficients based on the first and second days of familiarization were similar or higher. These results indicate that despite presenting adequate reliability, there is an effect of familiarization sessions that should not be disregarded. This affirmation is supported by previous information provided by Lubans et al. [44], who suggested that improvements in fitness performance during test-retest can be attributed to the learning effect and, for this reason, it is necessary to include a more extensive familiarization process to reduce the error associated with these tests. Future studies aimed at investigating the reliability of physical fitness batteries should analyze the familiarization process, in addition to test-retest results among adolescents to provide further information on quality of measurements.

Unfortunately, no measure of muscle activity was performed; however, the information from previous studies enables us to suppose the mechanisms that explain the effect of familiarization session on some of the tests analyzed in the present study. First, motor learning is highly influenced by practice [12–14], and the development of a new skill reflects a new combination of muscle activations that results in improvements in performance [45]. Furthermore, muscle activation is an important neural adaptation of physical training that increases muscle strength over a period of days [46] and occurs due to increases in motor unit firing rate, motor unit synchronization, and agonist–antagonist interaction [46]. Since the participants of the study were not engaged in physical training, short-term neural adaptations could explain the positive effect of familiarization even though some of the tests required strength performance (push-ups and curl-ups). Another hypothesis is that in the initial stage of learning a skill, there is unnecessary muscle activation, which is inhibited due to increases in muscle coordination patterns after practice or feedback [47, 48]. This can also be applied to the studied sample, as one of the inclusion criteria was never having previously performed any of the tests.

The practical application of the present study is added information on the need to consider an adequate familiarization process when using motor tests among non-athlete adolescents. In experimental studies, the absence of adequate familiarization sessions can bias the results, as it is not possible to control the effects of interventions and the possible effects of participant familiarization when retested. According to the present results for muscular endurance, familiarization is relevant when three or more assessments are required in a study design, since a likely beneficial effect was found only in the third session compared to the first. For the Flamingo test, there was a beneficial effect in the second familiarization session, which implies that even in a design with pre-post measures, a familiarization procedure is required. For the agility test, since a beneficial effect was found only on the fourth day, the familiarization should be performed when the design requires four or more assessments. However, in this case, although the effect of familiarization can be disregarded, the results of tests could be lower compared to the situation where complete

familiarization sessions are performed. When physical fitness tests are administered in cross-sectional studies, the tests are administered only once so the familiarization procedure becomes unviable due to the large sample size [4] and other procedures that are commonly performed in this type of study. This could result in underestimation of performance and a lower prevalence of the outcome, when the test has a cut-off as occurs with curl-ups and push-ups [36].

The limitations of the study should be considered when generalizing the results. Four sessions of familiarization were performed, which prevents us from knowing if there is an effect of more days of practice on motor performance. A cardiorespiratory fitness test was not conducted, as it imposes a maximal effort on the cardiorespiratory system of the participants, which prevents repeated performance of the test. The sample size is another relevant limitation, since it prevented stratification of the analysis according to sex, age, maturational status, motor competence, training status, or the level of physical activity. The absence of a physiological or psychological measurement does not allow us to understand if neural mechanisms could explain the effect of familiarization sessions on the increase in test performance or if it can be attributed to other pathways, such as motivation resulting from learning. Future studies should consider these limitations, as well as the gaps left by previous studies that sought to investigate the effect of familiarization on motor performance.

CONCLUSION

All the analyzed tests presented acceptable reliability between days. The results of both traditional statistic inference (analysis of variance) and magnitude-based inference indicate that at least three sessions of familiarization are required for push-ups, curl-ups, and the Flamingo balance test. However, considering the smallest worthwhile change, performing four familiarization sessions is suggested for the agility test, since a possible effect between days was found. For 10 and 20m sprints, sit-and-reach, long jump, and sextuple jump, a single day of familiarization is sufficient, since no mean differences were found and the effect between days was considered negligible. Researchers and teachers should consider the familiarization process to prevent bias related to the learning effect when using physical fitness tests among adolescents.

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