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The influence of closed or open grip type during a pull-up test to exhaustion

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Abstract

Study aim: The aim of this study is to assess whether a closed (CG) or open grip (OC) can influence the maximum number of repetitions during the pull-up test to exhaustion.
Material and methods: Ninety-five physically active males (age 23.5 ± 6.2 years, body mass 69 ± 7.9 kg, height 174.0 ± 6.4 cm, BMI 22.9 ± 2.2) randomly performed the pull-up test to exhaustion twice, once for each type of grip, one week apart.
Results: No significant difference (p = 0.092) was found between the maximum number of repetitions performed with the OG (14.2 ± 5.7) or the CG (13.9 ± 5.9). Spearman's correlation showed no significant association between participants' body mass and the number of repetitions (r = 0.128, p = 0.22 for OG; r = 0.157, p = 0.13 for CG).
Conclusions: According to our results, the grip is not relevant in the determination of the performance during a pull-up test to exhaustion. Thus, using one grip instead of another may be recommended independently of performance needs. Grip type may be adapted considering the practised sport, and specific athletic requirements, as well as individual preference.

Keywords: Exercise – Strength training – Bodyweight – Range of Motion

Introduction

According to the ACSM Fitness Trends, bodyweight training started to become popular in 2013 and in 2023 remains in third position after strength training with wearable and free weights [21]. One of the main factors contributing to its popularity is that it does not require large areas and expensive equipment [5, 21]. Therefore, practitioners are able to exercise everywhere (either in parks and open-air gyms or at home). Bodyweight training includes various exercises such as push-ups, pull-ups, planks, squats, and burpees. Among these, bar pull-ups and their progressions are among the most popular exercises to improve back muscle strength. Practising bodyweight exercises can lead to several benefits: it has been reported that it can improve muscle strength of the upper limbs, posture, and body composition [10, 18]. Bodyweight exercises are usually included in admission tests. Military admission tests, for example, present physical challenges in which it is necessary to perform a minimum number of repetitions of bodyweight exercises, with more points attributed to a higher number of repetitions [4, 12, 13]. Bar pull-ups are usually included within those tests, and represent an exercise requiring high strength levels [22]. All these pull-up tests present indications regarding the orientation of the hand (overhand – pronated) and their distance [16], the passing of the chin during the ascending phase and the full extension of the upper limbs in the descending phase (as stated by the International Physical Fitness Test (IPFT) guidelines [25] and the Italian military test rules [13]). IPFT guidelines also state that the thumbs could be positioned either above or below the bar, in an open (OG) or closed grip (CG), without any restriction [25]. To date, no clear indications are provided to select the grip type. Thus, it is necessary to standardize the grip during this test. Additionally, new methods to improve performance could be of interest to participants/athletes and coaches since extra repetitions can make a difference in achieving success during admissions tests and competitions. To the best of

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our knowledge, no studies have investigated the grip type during a pull-up test to exhaustion. We investigated such technical aspects, considering that a different grip could change forearm muscle recruitment and consequently performance. Thus, this observational study investigates whether there may be differences in performance, defined as the maximum number of repetitions, between the two different grips. We hypothesized that a difference may arise if the OG or CG is used.

Material and methods

Study protocol

This is an observational study designed to assess whether a different grip during the pull-up test to exhaustion can influence performance, which is defined as the maximum number of repetitions. The different grips are identified by the different position of the thumbs, which can be placed above or below the bar, and are named open and closed grip (OG and CG), respectively (Fig. 1 shows the thumb position for OG [A] and CG [B], respectively). The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethical Committee of the University of Palermo (n. 45/2021).

Participants

The inclusion criteria for this study were: 1) healthy male individuals, and 2) able to perform at least 5 pull-ups. The exclusion criteria were: 1) any physical limitations or recent injury which could preclude the participant from performing the test, and 2) the impossibility to be tested with the other grip after 1 week. For this observational study, 95 physically active males were tested. Table 1 reports participants' characteristics. Participants had different training experience (1.4 ± 2.1 years of practice) and were recruited in 4 different commercial gyms in Palermo. Trainers provided the list of potential eligible participants.

Procedures and randomization

Once participant eligibility was confirmed, an informed consent form was requested to be signed. Anthropometric measures (height and weight), date of birth (to calculate age), and information on previous sports practised were taken before a 5 min bodyweight warm-up. Afterward, each participant was tested twice, once for each type of grip, one week apart. During the first day, to randomize the order in which participants performed one grip over the other, a coin was tossed to determine the grip used by the first participant on the list provided by the trainer. The subsequent participants' grip was determined by alternating the type of grip.

Table 1. Participants' characteristics

Variables	Mean ± SD
Age [years]	23.5 ± 6.2
Height [cm]	174.0 ± 6.4
Weight [kg]	69 ± 7.9
BMI [kg · m^{-2}]	22.9 ± 2.2

Pull-up test to exhaustion

For the pull-up test to exhaustion, participants had only one attempt per type of grip due to the nature of this test. A bar height to avoid floor contact with the feet was selected for each participant (minimum height 2.15 m). The diameter of the bar was standard at 33 mm. The test was performed with hands pronated. Randomly, subjects were asked to perform the test with an OG or CG, as shown in Figure 1. The starting position was as follows: the width of the hands was slightly wider than the width of the shoulders [15, 19] and the upper and lower limbs completely extended (avoiding bending or crossing the legs) [2]. A repetition was considered valid when: during the ascendant (concentric) pull-up phase the participant's chin passed above the bar and if during the descent (eccentric) phase the arms

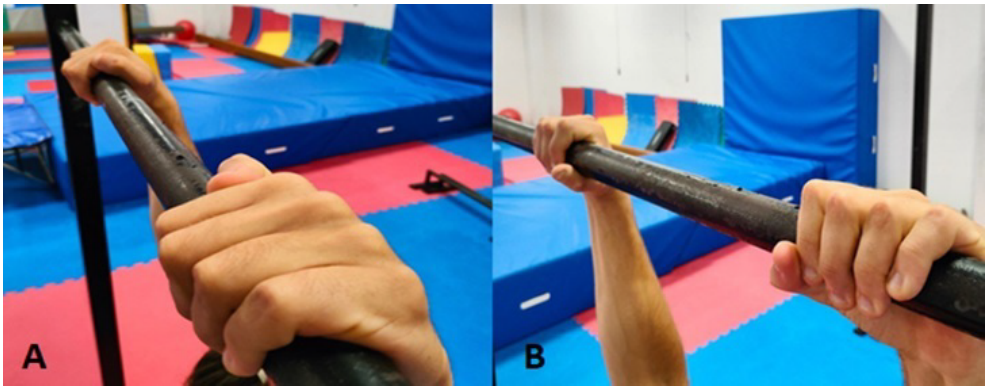

Figure 1. Two types of grips were used during the pull-up test to exhaustion: "open grip – OG" (A) and "closed grip – CG" (B)

reached full extension, returning to the starting position. A repetition was considered null if the above conditions were not fulfilled or if the subject swung his legs during the concentric phase. Participants were allowed to rest for a maximum of 2 seconds between repetitions, maintaining both hands in contact with the bar and without foot contact with the floor (as described previously by other authors [17]). Considering that velocity may influence performance during the pull-up test to exhaustion [19], no indication about pace was given to participants. The end of the test was identified when the subject was no longer able to perform a full repetition during the concentric phase [15]. The different grip used, OG or CG, was the independent variable. The maximum number of repetitions was the dependent variable.

Materials

A wall stadiometer was used to measure height: the subject was asked to stand with their shoulders and heels against the wall, after which their height was measured. The participants were requested not to wear shoes when their weight and height were taken. A commercially available digital scale was used to measure participants' weight (SECA 807, SECA GmbH & co. kg. 22089, Hamburg Germany). In addition to shoes, during weight measurement, participants were asked not to wear any type of accessories or objects in the pockets or clothes not worn during the pull-up test to exhaustion.

Statistical analysis

The sample size was calculated using G*Power (version 3.1.9.7) [9]. The required sample size was 90 participants, assuming an effect size of 0.3, α error at 0.05 and 0.80 statistical power to identify the difference between the two grips. Jamovi software was used for statistical analysis (The jamovi project (2022). *jamovi* (Version 2.3) [Computer Software]. Retrieved from https://www.jamovi.org). The Anderson-Darling test [7] was performed to assess the normality assumption. The Wilcoxon rank test was applied for the non-normally distributed data, in order to test the difference between the two grips, with alpha set at <0.05. The Spearman correlation test was used for the correlation between weight and the maximum number of repetitions. GraphPad Prism (version 8.0.2) was used to generate Figure 2.

Results

The characteristics of the 95 individuals included in this observational study are summarized in Table 1. Briefly, participants were physically active young adults

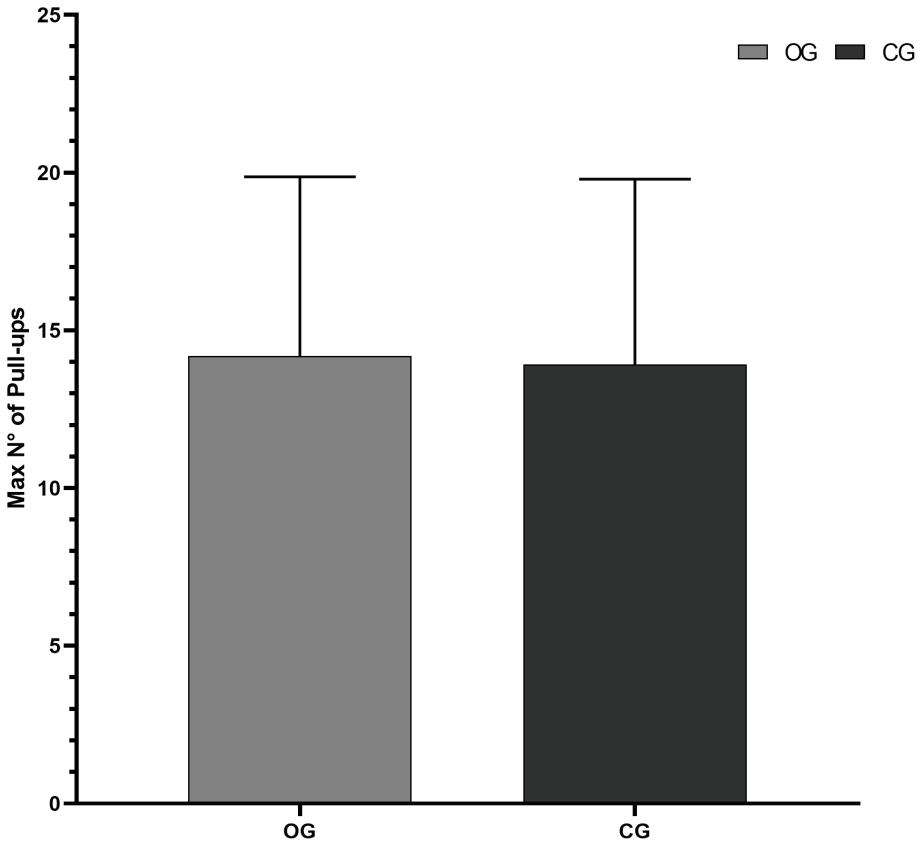

Figure 2. Maximum number of repetitions for Open Grip (OG) and Closed Grip (CG), respectively

Table 2. Results summary

Variables	Repetition	p	Mean difference	SE
OG CG	14.2 ± 5.7 13.9 ± 5.9	0.092	0.500	0.161
	Spearman's R	p		
Reps OG vs Weight	0.128	0.22		
Reps CG vs Weight	0.157	0.13		

OG = open grip; CG = closed grip; Reps OG = repetitions performed with an open grip; Reps CG = repetitions performed with a closed grip.

(23.5 ± 6.2 years old), male, with a BMI of 22.9 ± 2.2 kg · m^{-2} on average. Summarized results, reported as mean ± SD, mean difference, and SE, are presented in Table 2. No significant difference was found between the OG maximum number of pull-up repetitions (14.2 ± 5.7) and the CG maximum number of pull-up repetitions (13.9 ± 5.9) (p = 0.092) (Table 2; Figure 2). Spearman's coefficient showed no significant correlation between the number of pull-up repetitions performed and participants' body mass for either group (r = 0.128, p = 0.22 for OG; r = 0.157, p = 0.13 for CG) (Table 2). The results indicate that grip does not influence pull-up performance, and neither does participants' weight.

Discussion

According to our results, using a different type of grip does not affect the performance during the pull-up test to exhaustion in active male practitioners. The body mass of the tested subjects does not seem relevant in the determination of the maximum number of repetitions.

Differences between the tests performed with a different grip could have been expected if the tested subjects had performed the pull-up test to exhaustion with the grip they normally prefer to use during training sessions, according to the specificity principle [8]. According to this principle, exercise adaptations are not only specific to intensity, energy expenditure, and muscle involvement but also to the angle at which joints are working [8]. However, considering our results, the grip type does not seem to be a sufficient parameter to cause performance variations. Other parameters, not related to grip type, could be related to muscle activation instead. During the pull-up exercise, there are substantial differences in muscle activation when the width between hands or the forearm orientation (intended according to supinated or pronated pull-ups) changes. In fact, differences are present both for a smaller bending of the elbow and for the different working planes of the humerus [1, 11, 22]. Urbanczyk et al. [22] reported that during wide pull-ups the latissimus dorsi was more active than in pronated shoulder width pull-ups (in which biceps brachii and brachialis activation was prevalent) and supinated pull-ups (in which rotator cuff activation was prevalent). Lusk et al. [11] found that wide-width lat pull-down did not significantly influence the latissimus dorsi activation, which seems to be more active with a pronated than a supinated grip, although analysed during lat pull-down exercise (performed using a lat machine). Further, Dickie et al. [1] examined the electromyographic muscle activity during different types of pull-ups: prone, supine, and neutral. The authors observed that middle trapezius activity was higher during pronated pull-ups (compared to neutral) [1]. Moreover, muscle activation was similar during all types of pull-ups, while different activation was noted between eccentric and concentric phases [1]. In detail, greater activation of the pectoralis major, biceps brachii and brachioradialis was seen during the concentric phase compared to the eccentric phase [1]. It is important to note that these studies did not examine the forearm muscle activation responsible for hand movements (and grip). In this observational study, we did not measure muscle activation. However, despite changing the type of grip, the width of the hands and forearm orientation (which may be responsible for changes in forearm muscle activity) did not differ. Therefore, the humerus worked mainly by performing an extension on the sagittal plane. We can assume that those bigger muscles, involved in the performance determination, were working on the same orientation and activation, causing no difference in the maximum number of repetitions. In conclusion, although several parameters may influence performance during pull-ups (according to different muscle activation), the use of an OG or CG does not seem to be relevant.

The rationale behind the necessity to test the two types of grip rests on the potential influence of the grip in changing forearm muscle activation. At the level of the forearm, all the flexor and extensor muscles of the fingers involved in gripping activity are inserted [6]; therefore, a different type of grip could induce different forearm muscle activation. Although a difference in forearm muscle activation may be present, it may not be enough to change performance outcomes, as demonstrated by our results. Further

studies are hence required to confirm forearm muscle activity and the benefits of using different grips.

It may be necessary to perform future studies on the type of grip with electromyographic analysis of the specific muscles involved in the grip action. Trainers could be interested in exercises or progressions which can strengthen muscles in an increasingly targeted manner, according to athletic needs. Considering our results, different advice on the use of a different grip during pull-ups should only be suggested when a different need of forearm/grip technique is necessary. For example, in sports in which it is required to have a closed fist (thumb under the bar) such as in karate [23] or other fighting sports, pull-ups may be prescribed as strength exercise with a CG. On the other hand, for those sports in which an OG is frequently used, such as in climbing [24], opting to train OG pull-ups as an isolated exercise progression or to improve muscular endurance, may be preferred. This consideration is especially valid for elite climbers who usually present higher muscular endurance during pull-ups [14]. Considering our non-significant results on the maximum number of repetitions, the type of grip should be selected according to the preference and for technique purposes, whereas specific grip type should be suggested to prepare for a specific competition or test (e.g. military admission tests) when restrictions are present.

Our study also showed no correlation between the participants' body mass and the maximum number of repetitions. Ervin et al.'s [3] study had previously investigated a correlation between weight and the maximum number of repetitions in a modified pull-up test in children, observing that increasing weight decreases performance. The main difference from our study is the type of test, which included modified pull-ups performed with the feet touching the ground and the body in a horizontal position. The different results may also be attributed to the age difference between the two populations included, as Ervin et al.'s study focused on children [3] while our study involved young adults. Therefore, weight may be less relevant in the determination of the maximum number of pull-ups in adult populations than in children as well as during standard pull-ups. Similar results were obtained in other studies in which pull-up performance was not correlated with either BMI or anthropometric data in adults [19, 20]. Conversely, the study from Sanchez-Moreno et al. [17] showed a significant negative correlation between the maximum number of pull-ups and participants' body weight. Although including physically active males, with similar training experience to those included in our study, some methodological differences should be taken into account when comparing results. First, the assessment procedure considered valid half repetitions, which occur when at least 90° of elbow flexion was reached. In our study, these repetitions were considered incomplete and excluded from the total count. Additionally, only 25 participants took part in the study, whereas we were able to reach statistical power recruiting a significantly larger sample (95). Moreover, as per our inclusion criteria, participants were required to be able to perform at least five pull-ups, and may have been accustomed to managing their body mass better during pull-ups.

Our study is not without limitations: only active male subjects were tested, so the results cannot be generalized to the female and inactive populations. In addition, we did not perform an electromyographic evaluation. Therefore, we cannot ascertain whether, despite no difference in performance being observed, a different recruitment pattern was expressed during the different grips. Future studies, implementing electromyograph assessments to confirm differences in forearm muscle activation, are needed.

However, this study also has some strengths. First, our large sample size reached the statistical power required. In addition, the heterogeneity of the sample itself comprises active practitioners with different experience and sports backgrounds. Second, the feasibility of the pull-up test can make this study highly replicable. In addition, to the best of our knowledge, this study is the first to assess the type of grip during bar pull-ups.

In conclusion, the current evidence suggests that choosing an open or closed grip does not influence the maximum number of repetitions during the pull-up test to exhaustion. Similarly, body mass does not seem to affect the maximum number of pull-ups in the active adult population. Considering our results, trainers should select a different type of grip according to sport-specific grip needs.

Conflict of interest: Authors state no conflict of interest.

References

1. Dickie J.A., Faulkner J.A., Barnes M.J., Lark S.D. (2017) Electromyographic analysis of muscle activation during pull-up variations. *J. Electromyogr. Kinesiol.,* 32: 30-36. DOI: 10.1016/j.jelekin.2016.11.004.
2. Doma K., Deakin G.B., Ness K.F. (2013) Kinematic and electromyographic comparisons between chin-ups and lat-pull down exercises. *Sports Biomech.,* 12: 302-313. DOI: 10.1080/14763141.2012.760204.
3. Ervin R.B., Fryar C.D., Wang C.Y., Miller I.M., Ogden C.L. (2014) Strength and body weight in US children and adolescents. *Pediatrics,* 134: e782-789. DOI: 10.1542/peds.2014-0794.
4. Farina E.K., Thompson L.A., Knapik J.J., Pasiakos S.M., McClung J.P., Lieberman H.R. (2019) Physical performance, demographic, psychological, and physiological predictors of success in the U.S. Army Special Forces Assessment and Selection course. *Physiol. Behav.,* 210: 112647. DOI: 10.1016/j.physbeh.2019.112647.

5. Gist N.H., Freese E.C., Ryan T.E. , Cureton K.J. (2015) Effects of Low-Volume, High-Intensity Whole-Body Calisthenics on Army ROTC Cadets. *Mil. Med.,* 180: 492-498. DOI: 10.7205/milmed-d-14-00277.
6. Hägg G.M., Milerad E. (1997) Forearm extensor and flexor muscle exertion during simulated gripping work – an electromyographic study. *Clin. Biomech.* (Bristol, Avon), 12: 39-43. DOI: 10.1016/s0268-0033(96)00049-6.
7. Henderson A.R. (2006) Testing experimental data for univariate normality. *Clin. Chim. Acta,* 366: 112-129. DOI: 10.1016/j.cca.2005.11.007.
8. Hoffman J. (2014) *Physiological Aspects of Sport Training and Performance*. Hum. Kinet., ?
9. Kang H. (2021) Sample size determination and power analysis using the G*Power software. *J. Educ. Eval. Health Prof.,* 18: 17. DOI: 10.3352/jeehp.2021.18.17.
10. Kotarsky C.J., Christensen B.K., Miller J.S., Hackney K.J. (2018) Effect of Progressive Calisthenic Push-up Training on Muscle Strength and Thickness. *J. Strength. Cond. Res.,* 32: 651-659. DOI: 10.1519/jsc.0000000000002345.
11. Lusk S.J., Hale B.D., Russell D.M. (2010) Grip width and forearm orientation effects on muscle activity during the lat pull-down. *J. Strength. Cond. Res.*. 24: 1895-1900. DOI: 10.1519/JSC.0b013e3181ddb0ab.
12. McGee J.C., Wilson E., Barela H., Blum S. (2017) Physical Screening Predictors for Success in Completing Air Force Phase II Air Liaison Officer Aptitude Assessment. *Mil. Med.,* 182: 281-286. DOI: 10.7205/milmed-d-16-00199.
13. Ministero della Difesa, Direzione generale per il personale militare https://www.esercito.difesa.it/concorsi-e-arruolamenti/Documents/BANDO%20VFI%20EI%202023.pdf.
14. Ozimek M., Rokowski R., Draga P., Ljakh V., Ambroży T., Krawczyk M., Ręgwelski T., Stanula A., Görner K., Jurczak A., Mucha D. (2017) The role of physique, strength and endurance in the achievements of elite climbers. *PLoS One,* 12: e0182026. DOI: 10.1371/journal.pone.0182026.
15. Pate R.R., Burgess M.L., Woods J.A., Ross J.G., Baumgartner T. (1993) Validity of field tests of upper body muscular strength. *Res. Q. Exerc. Sport,* 64: 17-24. DOI: 10.1080/02701367.1993.10608774.
16. Ronai P., Scibek E. (2014) The Pull-up. *Strength Cond. J.,* 36: 88-90. DOI: 10.1519/SSC.0000000000000052.
17. Sanchez-Moreno M., Pareja-Blanco F., Diaz-Cueli D., González-Badillo J.J. (2016) Determinant factors of pull-up performance in trained athletes. *J. Sports Med. Phys. Fitness,* 56: 825-833.
18. Thomas E., Bianco A., Mancuso E., Patti A., Tabacchi G., Paoli A., Messina G., Palma A. (2017) The effects of a calisthenics training intervention on posture, strength and body composition. *Isokinet. Exerc. Sci.,* 25: 1-8. DOI: 10.3233/IES-170001.
19. Thomas E., Bianco A., Raia T., Messina G., Tabacchi G., Bellafiore M., Paoli A., Palma A. (2018) Relationship between velocity and muscular endurance of the upper body. *Hum. Mov. Sci.,* 60: 175-182. DOI: 10.1016/j.humov.2018.06.008.
20. Thomas E., Gennaro V., Battaglia G., Bellafiore M., Iovane A., Palma A., Bianco, A. (2021) Upper body strength endurance evaluation: A comparison between the handgrip strength and three body weight tests. *Isokinet. Exerc. Sci*., 29(2): 185-191.
21. Thompson W.R. (2023) Worldwide Survey of Fitness Trends for 2023. *ACSMs Health Fit. J*., 27(1): 9-18. DOI: 10.1249/fit.0000000000000834.
22. Urbanczyk C.A., Prinold J.A.I., Reilly P., Bull A.M.J. (2020) Avoiding high-risk rotator cuff loading: Muscle force during three pull-up techniques. *Scand. J. Med. Sci. Sports,* 30: 2205-2214. DOI: 10.1111/sms.13780.
23. VencesBrito A.M., Rodrigues Ferreira M.A., Cortes N., Fernandes O., Pezarat-Correia P. (2011) Kinematic and electromyographic analyses of a karate punch. *J. Electromyogr. Kinesiol.,* 21: 1023-1029. DOI: 10.1016/j.jelekin.2011.09.007.
24. Vigouroux L., Devise M., Cartier T., Aubert C., Berton E. (2019) Performing pull-ups with small climbing holds influences grip and biomechanical arm action. *J. Sports. Sci.,* 37: 886-894. DOI: 10.1080/02640414.2018.1532546.
25. Wood R.,Pull-Up or Chin-Up Test. https://www.topendsports.com/testing/tests/pullup.htm.

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