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Original article

Physiological responses and exercise preference between the Trikke and the bicycle ergometer

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Abstract

Background/Objective: The positive relationship between health benefits or the wellbeing of individuals and their engagement in physical activity is well-documented. Nevertheless, many Americans show no interest or perceive that "exercise is boring" as one of the reasons for not exercising. For these reasons, it is important to promote fun and enjoyment aspects of the activity to motivate people to participate in physical activity. The purpose of this study was to examine the physiological responses and the perception of enjoyment between the Trikke and the bicycle ergometer.
Methods: Thirty college students (15 males and 15 females) aged 18–45 years old voluntarily participated in the study and showed up on three occasions. The first session involved a 5-minute instructional video and practice on the Trikke. Participants were then randomized into sessions which involved either riding the Trikke or the bicycle ergometer. Participants of each group performed a 20-minute ride at 75–80% of maximal predicted heart rate.
Results: Results of mixed design analysis of variance (ANOVAs) indicated that VO_2, energy expenditure, and rate of perceived exertion (RPE) of the participants were significantly ($p < 0.001$) higher when using the bicycle ergometer than the Trikke, and female participants were able to manipulate the Trikke more efficiently than their male counterparts.
Conclusion: Participants were more efficient in using the Trikke than the bicycle ergometer. The Trikke may be an enjoyable alternative for those individuals, particularly women, who have lost interest in traditional forms of exercise.

Keywords: Energy expenditure; Oxygen consumption; Physical inactivity; Rate of perceived exertion

Introduction

The benefits of physical activity are well-documented. There is tremendous evidence supporting the positive relationship between health benefits or the wellbeing of individuals and their engagement in physical activity. For example, it has been demonstrated that physical activity can reduce the risk of coronary heart disease, hypertension, diabetes, and osteoporosis as well as some forms of cancer.[1–4] The American College of Sports Medicine and the Centers for Disease Control and Prevention recognize that considerable health benefits can be achieved by engaging in physical activity for at least 30 minutes 3–5 days a week, if not all days a week, performed at a metabolic equivalent of task (MET) level of 3–6.[5] In fact, a considerable reduction of most causes of mortality has been found with an energy expenditure of 1050 Kcal/wk.[6] Additional benefits of physical activity include the improvement of cardiorespiratory and muscular fitness, strength, and flexibility[7] and the reduction of depression and anxiety symptoms.[8]

In spite of the known benefits of participating in physical activity, it is estimated that 31% of the world's population is

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physically inactive, and over 80% of adolescents (13–15 years old) do < 60 minutes of moderate to vigorous physical activity each day.[9] Even for those who participate in exercise programs, the dropout rate is 45%.[10] Conventional exercise training programs emphasize the nature of the exercise protocol itself such as the time, duration, intensity, and type of exercise.[11] Most recent researchers, however, support the notion that other factors such as pleasure and affective responses should be included in exercise prescription.[12,13] For example, Salmon et al,[14] showed that there was a strong positive relationship between preference or enjoyment and the degree of activity among 1332 adults. After studying a group of male police officers, Soremsen[15] concluded that enjoyment was the most significant determinant of physical activity and fitness. Merrill et al[16] surveyed 675 participants in the World Senior Games and found that what motivated physically active individuals to do physical activity was recreational enjoyment or fun, whereas sedentary individuals were mostly motivated by improving their quality of life.

With the recognition of the importance of exercise at any age, Trikke Tech Inc. (Buellton, CA, USA) has developed a human powered transportation (the "Trikke") that requires no pedaling.[17] According to the company, the three-wheel Trikke can engage the rider's muscles of the upper legs, buttocks, upper arms, and shoulders by standing and carving back and forth. It is a full body workout that combines both strength training and cross training for maximal cardiovascular benefits without impact.[18] Many Americans claim loss of interest or perceive that "exercise is boring" are stated as reasons for not exercising. In order to increase the participation in physical activity, it is important to intrigue interest and enjoyment with the activity. To the best of our knowledge, no study has been done to compare both the physiological and psychological benefits of exercise equipment. The purpose of this study was to assess the physiological responses and the perception of enjoyment between the Trikke (a nontraditional exercise equipment) and the bicycle ergometer (a traditional exercise equipment). Specifically, the following physiological variables of the participants were measured: exercise heart rate, rate of perceived exertion (RPE), VO_2, and energy expenditure. Meanwhile, we also compared the outcomes of the males with those females. The purpose to establish those sex differences would be useful for personal trainers and personnel in the health-fitness industry when planning physical activity programs and exercise descriptions.

Materials and methods

Participants

Thirty young college students (15 males and 15 females) aged 18–45 years old voluntarily participated in the study. Prior to participation, each individual completed a consent form approved by the Institutional Review Board, Cleveland State University (Cleveland, Ohio) after they were informed of the procedures and possible risks involved in the study. In addition, the participants were asked to complete the American Heart Association/American College of Sports Medicine Preparticipation Questionnaire to make sure only individuals with a low risk status participated in the study. None of the participants had prior experience in using the Trikke. Demographic characteristics (age, height, and body weight) of the participants are presented in Table 1.

Protocol

Participants were required to show up on three different occasions. In the first meeting, a 5-minute instructional video on the Trikke was shown to the participants. After the video, the participants were provided with the opportunity of practicing on the Trikke T8 (Trikke Tech Inc.) with protective gear (e.g., a helmet as well as elbow and knee pads). They could practice as long as they liked until they felt comfortable and were familiar with the maneuver of the Trikke. Upon completion of the practice session, participants were randomly scheduled to the next two sessions, which involved either riding the Trikke T8 (Trikke Tech Inc., see Figure 1) or the Monark Ergomedic 828 E bicycle ergometer (Monark Exercise AB, Vansbro, Sweden, see Figure 2). There was a minimum of 24 hours rest for the participants between these two sessions.

In both sessions, participants were equipped with a Polar heart rate monitor (Polar Electro Inc., Lake Success, NY, USA) and a COSMED K4 oxygen/carbon dioxide portable analyzer (COSMED, Rome, Italy, see Figures 1 and 2). They then performed a 20-minute ride on each of the machines at 75–80% of maximal predicted heart rate, which was expressed as 220-age.[19] The Trikke session was performed in an indoor gymnasium whereas the ergometer session was conducted in the Human Performance Laboratory at the researchers' University. A research assistant showed the Borg Scale 6–20 chart[20] to each participant every 5 minutes throughout each exercise protocol, and their RPE was recorded.

Questionnaire

Upon completion of both exercise protocols, the participants were asked to complete the Exercise Preference Questionnaire (EPQ), which was developed by the researchers for the purpose of this study. The EPQ had nine items (see Table 2), and item responses were based on a 5-point Likert scale (e.g., 1 = "very strongly disagree", 3 = "neutral", and 5 = "very strongly agree"). In an effort to reduce response bias,[21] the EPQ included two negatively worded items: "The Trikke is boring." and "The Trikke is not for me."

Table 1
Demographic characteristics of the participants.

Variable	Total (N = 30)	Male (n = 15)	Female (n = 15)
	Mean ± SD	Mean ± SD	Mean ± SD
Age (y)	25.1 ± 5.1	24.0 ± 3.3	26.3 ± 6.3
Height (cm)	171.7 ± 9.5	177.8 ± 5.8	165.7 ± 8.6
Body weight (kg)	73.4 ± 13.6	81.7 ± 11.9	65.1 ± 9.7

SD = standard deviation.

Figure 1. The Trikke T8.

Figure 2. The Monark Ergomedic 828 E Bicycle Ergometer.

Statistical analysis

Version 22.0 of the IBM SPSS for Windows (IBM Corporation, Armonk, NY, USA) was used for all data analysis. Factorial 2 × 2 mixed-design analysis of variance (ANOVA) were used to examine the effects of exercise equipment (within-group factor) and sex (between-group factor) on the physiological variables: exercise heart rate, RPE, VO_2, and Kcal/min. One-sample *t*-test was used to examine the significance of the EPQ mean scores, whereas univariate ANOVA

Table 2
One sample t-test examining the ranking and mean differences of the exercise preference questionnaire (EPQ) items.

	Rank	Mean (± SD)	*p*
I will try the Trikke again if I have the chance.	1	4.90 (± 0.88)	< 0.001**
I find the Trikke more fun than a stationary bike.	2	4.80 (± 1.13)	< 0.001**
The Trikke is easy to use.	3	4.57 (± 0.77)	< 0.001**
I would rather play with the Trikke than a scooter.	4	4.47 (± 0.86)	< 0.001**
The Trikke is boring.	5	2.60 (± 1.07)	< 0.001**
The Trikke is not for me.	6	2.73 (± 1.14)	0.001**
I would rather exercise with the Trikke than a stationary bike.	7	4.17 (± 1.15)	0.003*
I would rather ride the Trikke than a bike.	8	4.00 (± 1.29)	0.042*
I will consider buying a Trikke in the future.	9	3.70 (± 0.99)	0.277

* $p < 0.05$.
** $p < 0.001$.
SD = standard deviation.

was employed to compare mean differences between female and male participants. In addition, Cronbach α was used to assess the internal consistency of the EPQ items. Level of statistical significance was set at $p < 0.05$. Unless otherwise indicated, all data are presented as mean ± standard error.

Results

Exercise heart rate

Results of the mixed-design ANOVA indicated that there was no significant equipment × sex interaction ($F_{1,28} = 0.730$, $p = 0.400$) as well as no main effects for both equipment ($F_{1,28} = 0.800$, $p = 0.379$) and sex ($F_{1,28} = 0.288$, $p = 0.596$). This indicated that exercise heart rates were not influenced by either the type of equipment or sex of the participants.

RPE

Results indicated there was no significant equipment × sex interaction ($F_{1,28} = 1.595$, $p = 0.217$) and no significant main effect for sex ($F_{1,28} = 0.981$, $p = 0.330$). However, significant main effect was found for equipment ($F_{1,28} = 29.569$, $p < 0.001$). A close examination of the data showed that the mean RPE of the participants was significantly ($p < 0.001$) lower when exercising with the Trikke (11.657 ± 0.301) than using the bicycle ergometer (13.020 ± 0.232). The results of the equipment × sex interaction on RPE are depicted in Figure 3.

Oxygen consumption (VO_2)

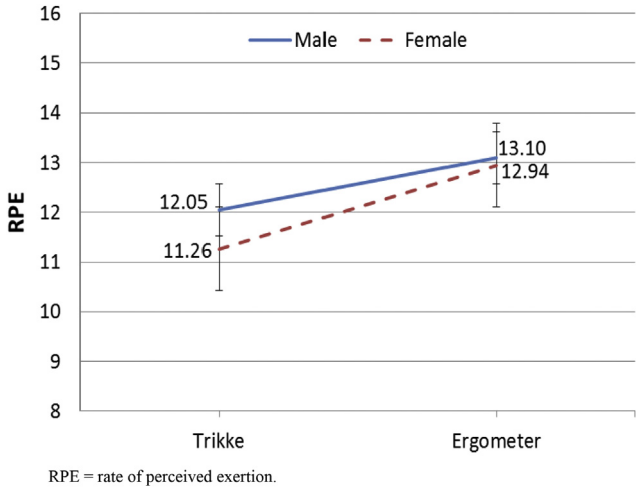
According to the results, there was a significant equipment × sex interaction ($F_{1,28} = 8.988$, $p = 0.006$). Likewise, there were significant main effects for both equipment ($F_{1,28} = 36.337$, $p < 0.001$) and sex ($F_{1,28} = 8.368$, $p = 0.007$). Upon investigation of the data, it was found that the mean VO_2 of the participants was significantly ($p < 0.001$) lower when exercising with the Trikke (22.357 ± 0.710 mL/kg/min) than working with the bicycle ergometer (24.863 ± 0.831 mL/kg/min); whereas the mean VO_2 of female participants (21.457 ± 1.053 mL/kg/min) was significantly ($p < 0.01$) lower than the males (25.763 ± 1.053 mL/kg/min). Overall, females had significantly ($p < 0.01$) lower VO_2 than their male counterparts on both the Trikke and bicycle ergometer conditions. The results of the equipment × sex interaction on VO_2 are depicted in Figure 4.

Energy expenditure

Results showed that there was a significant equipment × sex interaction ($F_{1,28} = 5.073$, $p = 0.032$). Similarly, there were significant main effects for both equipment ($F_{1,28} = 37.066$, $p < 0.001$) and sex ($F_{1,28} = 41.130$, $p < 0.001$). Further examination of the data revealed that the mean Kcal/min of the participants was significantly ($p < 0.001$) lower when exercising with the Trikke (8.047 ± 0.270 Kcal/min) than working on the bicycle ergometer (8.957 ± 0.287 Kcal/min); whereas the mean Kcal/min of female participants (6.783 ± 0.379 Kcal/min) was significantly ($p < 0.001$) lower than the males (10.220 ± 0.379 Kcal/min). Overall, females had significantly ($p < 0.05$) lower Kcal/min than their counterparts on both the Trikke and bicycle ergometer conditions. The results of the equipment × sex interaction on Kcal/min are depicted in Figure 5.

EPQ

The overall Cronbach α of the nine-item EPQ was 0.859, indicating the high reliability of the scale. Results of the one sample *t*-test indicated all the items of the EPQ were significantly ($p < 0.05$) different from the midpoint except one item: "I will consider buying a Trikke in the future" (Table 2). Results of the univariate ANOVA analysis showed no significant ($F = 3.848$, $p = 0.060$) sex differences in all the EPQ mean scores.



RPE = rate of perceived exertion.

Figure 3. The interaction between sex and equipment on RPE.

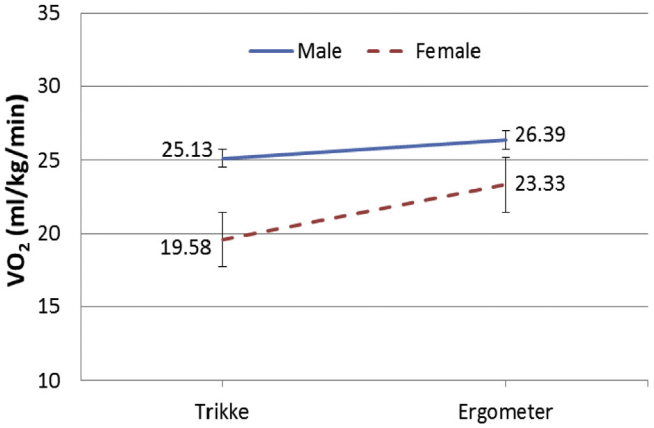


Figure 4. The interaction between sex and equipment on VO_2.

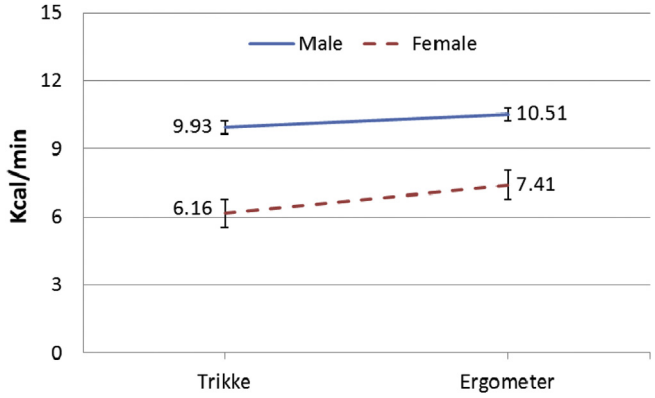


Figure 5. The interaction between sex and equipment on Kcal.

Discussion

This study examined the physiological responses and exercise preference between the Trikke and the bicycle ergometer among female and male participants. Comparisons were made for exercise heart rate, RPE, VO_2, and Kcal/min. In general, all the physiological responses of the bicycle ergometer were higher than that of the Trikke. The following section compares each of those physiological responses between the two exercise protocols, and then is followed by a comparison of sex differences.

Exercise heart rate

The overall exercise heart rates of all the participants were slightly higher when they worked on the bicycle ergometer (mean = 145 bpm) than on the Trikke (mean = 143 bpm), though such difference was not significant. This would be expected because under both protocols, the participants had to maintain 75–80% of their maximal predicted heart rate (220–age). The exercise heart rate was slightly higher in female than male participants in both the Trikke and bicycle ergometer conditions, though such difference was not significant. The results of this study are inconsistent with the study by Kravitz et al,[22] who found females had significantly higher exercise heart rates than males across all four modes of self-selected submaximal exercise: treadmill running, simulated cross-country skiing, cycling, and aerobic riding. This can be explained by the lower stroke volume of females, who require a higher heart rate for a given cardiac output, compared with that of males[23,24] and by the greater percentage of body fat in women than in men.[25]

RPE

All the participants showed a significant higher RPE when they worked on the bicycle ergometer (13.0 ± 1.2) than on the Trikke (11.7 ± 1.7). This indicated all the participants felt that it was harder, or required a higher intensity of effort, when they were working on the bicycle ergometer. According to the Centers for Disease Control and Prevention, RPE between 12 and 14 on the Borg Scale implies that physical activity is being performed at a moderate level of intensity. This is valid in our case because the participants were working on 75–80% of their maximal predicted heart rate and their Borg Scale ratings were somewhere between 12 and 13. However, when comparisons were made between sexes, neither female nor male participants demonstrated that they had significant different RPE when working on the Trikke or the bicycle ergometer. The findings of the present study are consistent with that of some other studies (e.g., Eynde and Ostyn,[26] Green et al[27]). In their study involving a sample size of over 2000 participants, Eynde and Ostyn[26] found that at a given percentage of heart rate, RPE did not differ between female and male participants during either treadmill or cycle ergometer exercise. Furthermore, Winborn et al[28] found that female and male participants of low and high athletic experiences did not significantly differ in their RPE during submaximal exercise intensities equivalent to 30%, 50%, and 70% of estimated cycle ergometer VO_{2peak}. In a more recent study, Green et al[27] concluded that the overall and differentiated RPE at the respiratory compensation threshold were not significantly different between sexes during cycling or treadmill exercise. When combining all these analyses together, it could be concluded that both sexes were consistent with their perceptions on each of the two exercise protocols; and they both considered that it was easier to work on the Trikke than on the bicycle ergometer.

VO_2

The results of this study indicated that the participants overall consumed significantly more oxygen when they worked on the bicycle ergometer (mean = 24.9 mL/kg/min) as compared with the Trikke (mean = 22.4 mL/kg/min). As there is a linear relationship between VO_2 and exercise intensity, it is concluded that the participants had to put more effort when they were working on the bicycle ergometer than the Trikke. It is also well-documented that there is a strong linear relationship between exercise heart rate and oxygen uptake (e.g., Arngrímsson et al[29], Reis et al[30]). This leads to one interesting question: Why did the participants have to consume more energy on the bicycle ergometer than the Trikke when they were both controlled for 75–80% of their maximal predicted heart rate in both exercise protocols? A possible explanation for this may be because of the nature of the exercise protocols: the bicycle ergometer involves mainly the lower body (in a sitting position) whereas the Trikke involves both the arms and legs (in a standing position). Previous studies indicated that oxygen consumption might be influenced by the proportion of arm work to total rate of work.[31,32] For example, Bergh et al[31] suggested that the relatively low muscular endurance of the arms compared with the legs can limit the increase in oxygen consumption during upper and lower body exercise.

The VO_2 of the male participants was higher than the female participants on both the bicycle ergometer and Trikke exercise protocols. The results were concurred with those of Bhambhani and Maikala,[33] who found that men had significant higher absolute VO_2 than women during the 15- and 20-kg

load-carriage walks. Statistically, significant sex difference in VO_2 was found only when they were exercised with the Trikke (25.1 mL/kg/min for males vs. 19.6 mL/kg/min for females). Generally, females have 15–30% less VO_2 than males of similar fitness.[34] The reasons for such differences include: (1) lower blood volume, fewer red blood cells, and lower levels of hemoglobin, resulting a lower oxygen transport capacity of the blood; (2) smaller heart size, resulting in smaller stroke volumes and higher heart rates for a given cardiac output; and (3) body composition differences, particularly a higher percentage of adipose tissue and lower percentage of working muscle.[35] However, such sex differences in VO_2 will cancel out when control for their fat-free mass.[36] Therefore, the explanation for the sex differences in this study was that the female participants were more efficient in using the Trikke than the male participants under the same conditions, and this assertion can be enforced by the females' lower RPE (mean = 11.3) than their male counterparts (mean = 12.1).

Energy expenditure

The energy expenditure of this study is expressed in Kcal/min. The overall Kcal/min of all the participants were significantly higher when they worked on the bicycle ergometer (mean = 9.0 kcal/min) than on the Trikke (mean = 8.0 kcal/min). The result was consistent with the previous session where the participants consumed significantly more oxygen when working on the bicycle ergometer than on the Trikke. This is no surprise because VO_2 and energy expenditure go hand in hand: as the exercise intensity increases, oxygen uptake increases, and thus more calories are consumed. The Kcal/min was significantly higher for the male participants when compared with the female participants in both the Trikke (9.9 Kcal/min in males vs. 6.2 Kcal/min in females) and the bicycle ergometer (10.5 Kcal/min in males vs. 7.4 Kcal/min in females) conditions. In other words, female participants used approximately two-thirds of the energy cost when compared with their male counterparts under the same conditions. The body weight of male participants (mean = 81.7 kg) in this study were significantly higher than the female participants (mean = 65.1 kg), and it is also taken into consideration that the male participants have more muscle mass and less fat than their counterparts. For these reasons, the male participants should have expected to have a higher energy expenditure than the female participants when control for exercise intensity and exercise mode.

However, muscle mass should not be used to explain the VO_2 and Kcal/min differences between the two exercise protocols because submaximal energy expenditure is not simply a reflection of the amount of muscle mass used during exercise.[22] If muscle mass were the determining factor, then the Trikke, which employ more muscle mass than the bicycle ergometer, would have produced higher energy expenditures. Although the Trikke is weight bearing and engages more muscle mass than that of the bicycle ergometer, it is the bicycle ergometer that resulted in the higher submaximal oxygen consumption for both the female and male participants. The movement pattern of the Trikke, which involves both the upper and lower body muscle groups, may actually decrease metabolic demand, presumably owing to a reduced exercise intensity of the larger, lower body musculature.[22,32,37] Furthermore, the additional arm work to leg work may decrease the contribution of the larger leg musculature to the exercise, thereby lowering exercise intensity.[38]

EPQ

Cronbach α coefficients of the positive (i.e., $\alpha = 0.84$) and negative items (i.e., $\alpha = 0.93$) of the EPQ were higher than 0.70, indicating the nine-item scale had high internal consistency. This means that the extent to which all the items in the EPQ measure the same concept or construct. Nevertheless, the psychometric properties of the EPQ have not been examined by other statistics (e.g., test–retest reliability and sensitivity analysis) and as such, some degree of caution is warranted when interpreting the findings of the EPQ. The purpose of adding two negatively worded items to the EPQ is to reduce response bias. Response bias refers to answer patterns on the questionnaire that do not reflect the participants' actual opinion,[39] and that thus can pose a serious threat to the validity of the self-report questionnaire.[40] An examination of all the questionnaires indicated that there was no acquiescent bias from the participants, who all disagreed that “The Trikke is boring.” and “The Trikke is not for me.” However, all the participants agreed that the Trikke was easy to use and would try the Trikke again. They also preferred the Trikke over other exercise equipment such as the stationary bike or scooter. However, it was inconclusive whether they would consider purchasing a Trikke for themselves (the Trikke T8 model used for the current study cost ~$500).

Conclusion

The main purpose of this study was to assess the physiological responses and the perception of enjoyment between the Trikke and the bicycle ergometer. The second purpose was to investigate whether there was any sex difference among those physiological and psychological responses between the two exercise machines. When control for the exercise intensity (at 75–80% of maximal predicted heart rate), all the participants felt that it was easier to work on the Trikke than the bicycle ergometer. It is concluded that both the psychological (RPE) and physiological (e.g., oxygen uptake) mechanisms play a role in the perceptual differences observed between the Trikke and the bicycle ergometer in the current study. The present study also showed that the general concept of exercising large muscle groups produces greater energy expenditure may be true for all exercise protocols. As all the participants prefer the Trikke over other exercise equipment, it is concluded that the Trikke is fun to work on. Viewing that there are sex differences in exercise preference[41] and females have a large decline rate in physical activity participation than males,[42] the Trikke may be an enjoyable alternative for those females, or other individuals, who have lost interest in traditional forms of

exercise. In short, the additional physiological and psychological information provided in this study may provide insights on how to structure physical activity to maximize enjoyment and exercise adherence.

Conflicts of interest

All authors have no conflicts of interest to declare.

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