|  |  |  |
| --- | --- | --- |
| Navigating the Maze of Deception in Endurance Sports: A Systematic Review |  | For correspondence: bdelucia@springfieldcollege.edu |

De Lucia, B. J.1, Hutchinson, J. C.1, & Bottino, A.

Springfield College1, 263 Alden St, Springfield, MA 01109

*Please cite as*: De Lucia, B. J., Hutchinson, J. C., & Bottino, A. (2024). Navigating the Maze of Deceptive Feedback in Endurance Sports: A Systematic Review. *SportRχiv*

# ABSTRACT

Endurance exercise bouts require prolonged exertion and the precise regulation of energy expenditure. Without accurate knowledge of the task demands and performance metrics (e.g., speed, distance), individuals may struggle to establish or maintain effective pacing strategies. Providing deceptive information about the task can be a useful experimental tool for exploring the phenomenon of pacing and endurance performance. The purpose of this systematic review was to synthesize existing research on the effect of deception on performance outcomes in endurance tasks. An electronic search was performed across 4 databases and 27 studies met the inclusion criteria for the review. Studies investigated deception of time, split pace, power output, anticipated difficulty, speed, previous performance, and competitors’ knowledge within cycling, running, and/or triathlon tasks. Various methodologies, including different types and percentages of deception, were utilized across studies in review. Time deception of ≤ 5% does not appear to influence endurance performance across cycling and running trials, but 10% can influence pacing strategy. Competitor deception appears to improve endurance performance, however the effects of split pace and speed deception had conflicting findings within the literature. Due to the discrepancies across studies and most studies being on cyclists, future research should consider the effects of deceptive feedback in various endurance tasks beyond cycling, as well as in more diverse samples.

**Keywords:** Endurance exercise, pacing, deception, quantitative performance

# INTRODUCTION

Endurance sports are characterized by their demand for sustained effort and strategic energy management. Successful endurance performance therefore involves a delicate balance of maximizing physical effort within homeostatic constraints. This balance is achieved through pacing, which has been defined as “the goal directed distribution and management of effort across the duration of an exercise bout” (Edwards & Polman, 2013, p. 1058). Pacing enables an athlete to optimize performance (e.g., complete a given distance in the lowest amount of time), whilst avoiding premature fatigue or overexertion. During exercise, athletes must make pacing decisions based on internal afferent and external performance feedback which are interpreted in relation to the anticipated workload remaining.

The integration of internal afferent feedback and external performance feedback influences pacing and therefore performance in an endurance task. Internal feedback comes from the afferent sensory feedback system, which provides the brain with information about the body's internal state, such as temperature and metabolic conditions. The sense of the body's internal physiological state, known as interoception (Craig, 2008), allows for the sensory processing and prediction of internal bodily states (Hutchinson & De Lucia, in press). External feedback comes from the environment outside of the body and includes training metrics such as current speed or distance, average pace, and split times. This information is considered in conjunction with knowledge of the likely demands of the endurance task, as well as past experience (Smits et al., 2016). Knowledge of the distance and/or time remaining in a task allows performers to distribute their energy appropriately, make strategic pacing decisions, and optimize their performance.

A useful experimental tool for exploring the phenomenon of pacing and endurance performance is the use of deception interventions. Deception is the act of intentionally misleading participants by giving them false information (APA 2024). In the context of endurance exercise, this includes false performance feedback and/or misleading information about the task that is given before, during, or following exercise (Baumrind, 1985). The use of deception provides researchers with an opportunity to manipulate athletes' perceptions, offering valuable insights into pacing strategies, psychological and physiological responses, and endurance performance. These insights can advance our theoretical understanding of pacing and performance, which may potentially be applied to improve training methods and enhance endurance performance. However, to the authors’ best knowledge, extant scholarship provides no definitive indication about what type of deception is most optimal for athletic performance.

A review conducted by Jones et al. (2013) investigated the physiological and psychological effects of deception on pacing and performance during treadmill and cycling exercise. Jones et al. described a variety of deceptive interventions that differed according to timing, frequency, and type of deception. However, they determined that the varied methodologies utilized across included studies made it difficult to reach any definitive conclusions about how pacing strategy and performance are affected by deception (Jones et al., 2013). Moreover, Jones et al. (2013) noted that inclusion of untrained participants who are “unaccustomed to the exercise and have no previous experience or pacing schemas may limit our understanding of how trained athletes respond to deception interventions” (p. 1255).

The current review will expand on that of Jones et al. (2013) by incorporating more recent literature on deceptive feedback, while also maintaining a more narrowed focus on quantified performance outcomes (i.e., time/speed, distance, or power) in trained participants.

Therefore, the purpose of this systematic review is to synthesize existing research on the effect of deception on endurance performance outcomes in trained participants.

# METHODS

A systematic review was conducted across four databases (SPORTDiscus, APA PsychInfo, Academic Search Complete, and PubMed) to examine the prevalence and effects of various types of deception on athletes and active individuals using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The following search terms were used: ("False-performance feedback" OR “False performance feedback” OR "Inaccurate Performance Feedback" OR “Accurate Performance Feedback” OR “Accurate feedback” OR "Mislead\* Performance Evaluation” OR “Mislead\* Performance” OR "Inaccurate feedback" OR Decep\* OR “Correct feedback” OR “Incorrect feedback” OR “False feedback” OR “Manipul\* feedback”) AND (Cycl\* OR Run\* OR Triath\* OR Endurance).

The review was conducted between September 2023 to January 2024. There were no restrictions on dates of publication. The researcher assessed the articles retrieved from each search based on reading the title and abstract, followed by assessment of the full text when inclusion criteria were met. After database searches were completed, a subsequent search for additional sources was done by reviewing the references that were included in the study to ensure that all relevant articles that fit inclusion criteria were assessed within the review.

**Inclusion and Exclusion Criteria**

To meet inclusion criteria, the study needed to (a) be published in a peer-reviewed journal; (b) provide deceptive information on at least one of the following aspects of performance: time, distance, power output (PO), speed/pace, previous performance, competitor presence, and anticipated task difficulty (c) measure at least one performance outcome (i.e., time/speed, distance, or PO); and (d) involve an endurance task. For the purpose of this review, an endurance task will be operationally defined as “whole-body, dynamic exercise that involves continuous effort and lasts for 75 s or longer” (McCormick et al., 2015, p. 998). Studies were excluded if they (a) provided only qualitative feedback (Marquez et al., 2002; Mauger et al., 2011; Motl et al., 2006; Hu et al., 2007; Stoate et al., 2012), (b) were not considered endurance tasks (Ansley et al. 2004; Billaut et al., 2001), (c) used other forms of deception such as temperature (Castle et al., 2012), oxygen concentration (Davies et al., 2019), or manipulation of RPE scores (Pires & Hammond, 2012) and (d) did not measure a performance outcome (Baden et al., 2004; Baden et al., 2005; Coquart et al., 2011; Eston et al., 2012; Hampson et al., 2004).

**Quality Appraisal**

A risk of bias assessment was completed to evaluate the methodological precision of the studies that met inclusion criteria. The Revised Cochrane risk-of-bias tool (ROB-2) for randomized crossover trials (Higgins et al., 2021) and for randomized trials (Sterne et al., 2019) were used to complete a risk of bias assessment for each article (*N* = 27). The tools included the following items: Risk of bias from the randomization process, period and carryover effects (crossover trials only), deviations from the intended interventions, missing outcome data, measurement of the outcome, and selection of the reported results.

**Inclusion and Exclusion Criteria**

To meet inclusion criteria, the study needed to (a) be published in a peer-reviewed journal; (b) provide deceptive information on at least one of the following aspects of performance: time, distance, power output (PO), speed/pace, previous performance, competitor presence, and anticipated task difficulty (c) measure at least one performance outcome (i.e., time/speed, distance, or PO); and (d) involve an endurance task. For the purpose of this review, an endurance task will be operationally defined as “whole-body, dynamic exercise that involves continuous effort and lasts for 75 s or longer” (McCormick et al., 2015, p. 998). Studies were excluded if they (a) provided only qualitative feedback (Marquez et al., 2002; Mauger et al., 2011; Motl et al., 2006; Hu et al., 2007; Stoate et al., 2012), (b) were not considered endurance tasks (Ansley et al. 2004; Billaut et al., 2001), (c) used other forms of deception such as temperature (Castle et al., 2012), oxygen concentration (Davies et al., 2019), or manipulation of RPE scores (Pires & Hammond, 2012) and (d) did not measure a performance outcome (Baden et al., 2004; Baden et al., 2005; Coquart et al., 2011; Eston et al., 2012; Hampson et al., 2004).

**Quality Appraisal**

A risk of bias assessment was completed to evaluate the methodological precision of the studies that met inclusion criteria. The Revised Cochrane risk-of-bias tool (ROB-2) for randomized crossover trials (Higgins et al., 2021) and for randomized trials (Sterne et al., 2019) were used to complete a risk of bias assessment for each article (*N* = 27). The tools included the following items: Risk of bias from the randomization process, period and carryover effects (crossover trials only), deviations from the intended interventions, missing outcome data, measurement of the outcome, and selection of the reported results.

# Results

**Literature Search**

The original search yielded a total of 1849 articles. After completing title and abstract screening, 1761 articles were removed due to not meeting the inclusion criteria. The remaining 88 articles were read to assess for inclusion and underwent a hand search of references, yielding 6 additional articles. Of the 94 articles assessed for further review, 53 were identified as duplicates and removed, leaving 41 articles for a full-text review. Out of the 41 articles, 27 met the inclusion criteria and 14 did not. Included articles were published within a 21 year range from 2001 to 2021 with most being published after 2011 (*n* = 20). The final count of studies reviewed was 27 (see **Figure 1**).

**Data Extraction**

A data extraction template was created (see **Table 1**) that highlights vital information from each article included in the review (*N* = 27). Articles in the table are categorized according to the type of variable that was manipulated. **Table 1** displays results of each included study, with participant information, exercise protocol, type of feedback given, variable(s) manipulated, key variable(s) measured, and key findings. A summary of sample characteristics across included studies and a visual display of deception percentages across experimental conditions are available in the supplementary materials.

**Table 2** presents the risk of bias assessment. The overall risk of bias was considered low if all domains were classified as low risk, and as ‘some concern’ if some concern was noted in one or more domain, but not classified as high risk in any domain, and as ‘high’ if at least one domain was classified as high risk, or there were multiple domains with some concerns (Higgins et al., 2021). Risk of bias was conducted independently by the first and third author. Where necessary, discrepancies in assessment were reviewed by the second author. The initial level of agreement between the first and third author was 96.30% (Cohen’s kappa = 0.780), indicating substantial agreement (Viera et al., 2005). After discrepancies were assessed by the second author, and discussed as a group, authors reached 100% agreement. Twenty-four studies (88.9%) were assessed as ‘low risk’, two (7.4%) were assessed as ‘some concern’ and one (3.7%) was assessed as ‘high risk’.

**Time Deception**

Time deception refers to the manipulation of time feedback whereby the times communicated to participants during the task (either by display clock or verbally) are faster or slower than the actual elapsed time of the exercise bout. Studies by Beedie et al. (2012), Thomas and Renfree (2010), Puleo and Abraham (2018), Morton (2009), Terra et al. (2021), and Waldron et al. (2014) explored the effects of time deception on athletic performance.

Beedie et al. (2012) observed no significant differences in PO or time to completion (TTC) during cycling time trials (TTs) across conditions of positive (5% faster) or negative (5% slower) deceptive feedback in competitive male cyclists. Likewise, Waldron et al. (2014) observed no significant effects of a time deception that was 2% faster than baseline (BL) on PO or TTC in well-trained cyclists. Puleo and Abraham (2018) reported similar findings in treadmill running, where positive (5% faster) or negative (5% slower) deception failed to enhance average running pace.

Studies by Thomas and Renfree (2010), Terra et al. (2021), and Morton (2009) involved a greater degree of time deception to investigate how perceived time influences performance and effort distribution. All three studies utilized conditions where the clock ran accurately, 10% faster, or 10% slower, however, the type of exercise task varied across the studies. Thomas and Renfree (2010) reported that trained male cyclists were significantly faster during the last 1k of a 10k TT in a negative (10% slower) condition compared to the positive (10% faster) condition. Furthermore, the magnitude of the end spurt (i.e., the speed during the final 10% of the trial relative to the first 90%) was significantly greater in the negative condition compared to the positive condition. Terra et al. (2021) investigated running performance in individuals who received only time feedback. Participants completed three runs that they were told were 60-min, but the clock was modified (10% faster or slower) in two of the runs so that the end times were 54, 60, and 66 min. When examining the last 10 min of each trial, Terra et al. found that speed and distance were significantly greater in the positive (faster) condition compared to the negative (slower) condition. However, the accurate condition did not differ significantly from the 10% faster or slower conditions for either metric (2021). Finally, Morton (2009) used a time to exhaustion cycling task and revealed that endurance times were significantly longer when the clock ran 10% slower, compared to accurate and fast clock conditions. Due to the large differences in time to exhaustion between male and female participants, a separate follow-up analysis was conducted which showed that the calibration effect was only significant in males and not in females.

Collectively, these studies suggest that time deception ≤ 5% has no influence on athletic performance across cycling and running trials (Beedie et al., 2012; Puleo & Abraham, 2018; Waldron et al., 2014). However, time manipulation of 10% appears to influence pacing dynamics toward the end of TTs, although the reported differences are in opposing directions (Thomas & Renfree, 2010; Terra et al., 2021; Morton, 2009). Furthermore, 10% clock manipulations appear to positively influence endurance time in males, but not females (Morton, 2009).

**Split Pace Deception**

Split pace deception refers to deceptive feedback provided at designated time or distance intervals. Faulkner et al. (2011) and Albertus et al. (2005) investigated the effects of deceptive split distance feedback on performance in treadmill running and cycling TTs, respectively. Faulkner et al. (2011) assessed individuals under the following conditions: (a) accurate feedback, (b) no feedback, (c) delayed feedback (late 1k split), and (d) premature feedback (early 1k split), averaging ~15% deception across the two deceptive conditions. Findings showed a significantly slower TTC in the no-feedback condition compared to the accurate and delayed feedback conditions. However, there was no difference in TTC between the other conditions. Albertus et al. (2005) used a 5% distance deception with well-trained cyclists. Participants received accurate feedback, increased (+5%), decreased (-5%), and randomized distance deception at 1k intervals across four 20k cycling TTs. Results revealed no significant difference in TTC between conditions, and similar PO profiles across conditions suggested that deceptive feedback did not impact pacing strategies.

Two studies investigated the effects of deceptive split time feedback. Wilson et al. (2012) gave participants inaccurate feedback, showing their time per mile to be 5% faster or 5% slower than true values, at 1-mile intervals during a 10-mile cycling TT. Participants also completed the TTs under accurate and no feedback conditions. No differences in TTC or PO were found across the four conditions. Puleo and Abraham (2018) provided recreational runners with deceptive split-time feedback at 5-min intervals during a 30-min treadmill run. Participants were able to self-select their running pace, but all treadmill display information was hidden. Findings revealed no significant differences in running pace accurate, false positive (+5%), false negative (-5%) or no feedback conditions. In summary, four studies assessed the impact of split pace deception on endurance performance, and all found no difference in performance between accurate and deceptive feedback conditions.

**Power Output**

Three studies examined PO deception, all within a cycling bout of exercise. Stone et al. (2017) deceived cyclists into thinking they were competing against a computer-generated avatar representing their baseline (BL) performance, but the avatar was set at a PO that was either 2% or 5% higher than each participants’ BL output. Participants completed the TT faster and with higher PO in the 2% condition compared to BL, but no differences were observed between the 2% and 5% conditions or between the 5% and BL conditions for either TTC or PO.

Taylor and Smith (2017) explored 5% PO deception during the cycling segment of a triathlon. Trained male triathletes completed 3 simulated sprint-distance triathlons (0.75k swim, 500kJ bike, 5k run). The first trial established a personal best BL time; during the remaining two trials, athletes maintained a cycling PO 5% greater than their BL prior to completing the run as quickly as possible. However, participants were only informed of this cycling strategy for one of the two trials; in the other trial participants were misinformed that cycling PO would equal that of their BL. Results showed no differences in cycling performance across the two experimental conditions. However, compared to BL performances, significantly faster running performances were observed following the deceptive cycling condition but not following the non-deceptive cycling condition. Notably, there was a significant increase in speed during the last 600m of all the trials which is consistent with the end-spurt phenomenon (Tucker et al., 2006).

Shei et al. (2016) also considered the impact of awareness of a PO deception on trained cyclists. Four TTs were completed; a familiarization and baseline trial, then an unaware deceptive condition, followed by an aware deceptive condition. Due to the study design the order of conditions was not counterbalanced. No significant differences in mean PO were found between the unaware deceptive condition and BL. However, 10 cyclists improved in both deceptive conditions compared to BL, showing a faster TTC and higher PO, with no significant difference between known and unknown deception. In addition, pacing strategies were unchanged for these participants.

In summary, Stone et al. (2017) found that cyclists completed a cycling TT faster and with greater PO when competing against an avatar with 2% higher PO than BL, but no differences were observed between 2% or 5% deception levels. Taylor and Smith (2017) observed no differences in TT performance with 5% PO deception in a sprint distance triathlon, although deception in cycling led to faster running performances compared to BL. Finally, Shei et al. (2016) found that cyclists improved their performances when aware and unaware of the deception (+2% PO) compared to BL performance. However, there were no significant performance differences across the aware and unaware deceptive conditions.

**Anticipated Difficulty**

Brick et al. (2019) investigated the effects of anticipated difficulty deception during a 3000m TT in trained runners. In the accurate condition, participants knew ahead of time that the treadmill incline would increase to 7% for the final 800m. Whereas in the deceptive condition, they were told the incline would stay at 0% throughout the run, but at 1800m, they were informed it would increase to 7% for the last 800m. Runners in the deceptive condition ran faster compared to when they knew about the incline beforehand. Specifically, the deceptive condition resulted in a 13.96 s faster performance in the initial 2200m of the run. Thus, when participants were unaware of the incline in advance, they were less conservative with their pace. This demonstrates that anticipated task difficulty can influence pacing as well as overall performance.

**Distance Deception**

Paterson and Marino (2004), Nikolopoulos et al. (2001), and Wingfield et al. (2018) all investigated the effects of deception of distance in well-trained cyclists through a series of TTs with varying distances. Paterson and Marino (2004) asked cyclists to complete three TTs: a 30k ride (TT1), followed by rides of either 36k, 24k, or 30k (TT2), and a final 30k ride (TT3). Participants were told that all trials were 30k. The times to complete TT1 and TT3 were compared, and results suggested that the deception in TT2 influenced the cyclists’ performances in the final TT. Relative to TT1, the long-distance (36k) group significantly increased PO and improved their TTC on TT3. In contrast, the short-distance (24k) group decreased PO during TT3 and were significantly slower on TT3 compared to TT1. There were no significant differences between TT1 and TT3 in the control group.

In a study by Wingfield et al. (2018), male cyclists believed they were completing three 30k TTs, but actual distances were 26k, 30k, and 36k. Due to differences in actual distance, data was converted to a percentage based on the distance covered for interpretation. For the longer (36k) condition, PO was lower in comparison to the 30k condition. In contrast, Nikolopoulos et al. (2001) found that male cyclists rode at similar PO during time trials they perceived to be the same distance (40k), but which varied in actual distance from 34 to 46 km. In follow-up TTs, after the deception in the first part of the study was revealed, participants completed an additional 34 km and 46 km TT in which the actual and perceived distance was the same (i.e., accurate conditions). When compared to the same distances earlier completed under deception (i.e., believing they were cycling 40k) TTC and PO was not significantly different (Nikolopoulos et al., 2001).

It is difficult to draw overall conclusions regarding distance deception due to methodological differences and mixed findings. Despite these differences, a common thread across all three studies is that participants remained unaware of the deception until debriefed, even with distance manipulations of up to 20%.

**Speed & Previous Performance Deception**

Nine studies examined the effects of speed or previous performance deception on endurance performance. Three studies incorporated speed deception, using either an incorrectly calibrated cycle computer (Micklewright et al., 2010), deceptive optic flow (Parry et al., 2012) or imposed speed (Taylor & Smith, 2014). The remaining studies used a computer avatar to provide deceptive information relative to a prior performance.

Micklewright et al. (2010) used a within- and between-participants experimental design in which participants performed three 20k TTs while being provided with three different types of feedback. The first two TTs were performed with either no feedback, accurate feedback, or +5% deceptive feedback, depending on group allocation. In the third trial (TT3) all groups were provided with accurate performance feedback. When analyzing differences between TT2 and TT3, the no-feedback group showed increased mean PO, cadence, and speed. The deceptive feedback group exhibited higher PO and speed during the first 5k of TT3, suggesting that the prior deception influenced the cyclist’s pacing strategy. No other significant differences were noted. Parry et al. (2012) used video of cycling course footage that either represented actual speed or was varied by +/-15%. Parry et al. found that mean PO was higher in the -15% condition compared to the faster and accurate conditions.

The effects of deceptive pace on cycling performance using an avatar were assessed by Ducrocq and colleagues (2017). Participants followed a dynamic avatar across three cycling TTs at their previous record and two faster conditions (+2% and +5%). Significant improvements in TTC, PO, and muscle activation were observed in the +2% condition compared to an accurate feedback trial. However, no additional benefits were found when deception of speed was increased to +5%. Ansdell et al. (2018) had participants complete three TTs while displaying two avatars on the screen; one was their current performance and another was either their accurate BL performance or 2% faster (deceptive condition) than BL. Performance was significantly improved compared to BL when competing against the faster avatar, but not against an accurate avatar.

Jones et al. (2016a; 2016b) investigated the effects of a 2% speed deception over four cycling TTs using slightly different methodologies. In the first study (Jones et al., 2016a) following two BL TTs, participants performed against a virtual avatar they believed to be representing their fastest BL, then completed a final TT without an avatar. The avatar for the control group accurately showed their fastest BL pace whereas the deceptive group avatar was set at 2% faster than their fastest BL. Findings revealed faster performance times for participants in both groups when racing against the avatar compared to the other TTs. However, performance time in the final TT did not differ from fastest BL indicating that the deception effect was not sustained when the avatar was removed. The same design was repeated by Jones et al (2016b), however, in this case the deception group was informed of the deceptive nature of the avatar prior to the final TT. Again, both groups performed faster when racing against the avatar compared to the other TT conditions, but no significant differences were found between fastest BL and the final TT.

Focusing on PO deception, Stone et al. (2012) examined male cyclists over four TTs using Velotron 3D software. The first TT served as a habituation and the second as a BL for future trials. During the third and fourth trials participants raced against an avatar that they believed represented their BL performance, however one avatar was an accurate representation while one was set to 102% of the participants' BL PO (+2% deception). Cyclists completed the deception condition significantly faster compared to BL and the accurate condition and completed the accurate condition faster than BL. Mean PO during deception was significantly greater than both BL and accurate conditions, but there was no significant difference between BL and accurate conditions.

While the aforementioned studies provided deception across the entirety of the TT’s, Williams et al. (2016) took a slightly different approach. Male cyclists completed five TTs with avatar conditions that included accurate feedback, 5% faster, and 5% slower than BL. Cyclists were instructed to maintain the same pace as the avatar for the first 4k of the 16.1km TT. For the remaining 12.1k, the avatar was removed, and participants were instructed to complete the trial as fast as possible. Surprisingly, given the manipulated start, there was no effect of condition on TT performance.

Taylor and Smith (2014) studied triathletes across three sprint-distance triathlons (0.75k swim, 20k bike, 5k run). Following a BL trial, participants replicated the swim and bike BL performance, but were deceived with their running speed. During the first 1.66k of the run a speed as imposed that was either 3% faster or slower than BL, although participants believed it to be their BL speed. After the first 1.66k participants were instructed to complete the remainder of the run as fast as possible during which they could manipulate treadmill speed. No statistically significant differences were found for overall run time or triathlon performance between conditions. However, magnitude-based inferences suggested the +3% run was ‘likely faster’ than the -3% run and ‘possibly faster’ than the BL run, with the differences likely to be competitively meaningful (Taylor & Smith, 2014).

Deceptions of speed and previous performance were investigated primarily in cycling tasks, with just one study using a sprint triathlon. Micklewright et al. (2010) found no effect of +5% speed deception on subsequent TT performance, although PO and speed were greater for the first quarter of the subsequent TT. In contrast, Parry et al. (2012) reported greater mean PO when a video display was manipulated to be 15% slower compared to other conditions. In studies using a deceptive avatar, a +2% deception resulted in faster TTs compared to BL in the majority of studies (Ducrocq et al. 2017; Jones et al. 2016a; 2016b; Stone et al. 2012) but not in the study by Ansdell et al. (2018). No additional benefits were found when deception increased from +2% to +5% (Ducrocq et al. 2017).

**Competitor Deception**

The influence of competitor deception on cycling performance and pacing was assessed in active males by Corbett et al. (2012). Participants completed three familiarization TTs followed by an experimental TT and a simulated race against an avatar in a counterbalanced order. Participants believed that the avatar represented another competitor, but the avatar represented their fastest familiarization TT. Results revealed that participants cycled faster when informed they were racing against a competitor compared to other conditions. No differences in performance times were observed between the familiarization and TT conditions. The cycling pace in the competitor condition initially mirrored that of the familiarization TTs with a higher exercise pace in the second half of the trial suggesting an alteration in pacing strategy. PO was also greater for the second half of the competitor condition relative to the familiarization trials.

Williams et al. (2015) also investigated the effects of a deceptive competitor avatar on cycling TT performance. Participants performed a familiarization TT followed by TTs under three conditions: with a self-avatar display, no visual display, and a competitive avatar they believed represented a competitor of similar ability, but which represented their fastest previous performance. Like Corbett et al. (2012), Williams et al. (2015) found that participants had a faster TTC when led to believe they were competing against another individual. Mean speed and PO were also greater in the competition condition when compared to the other conditions.

# Discussion

This review examined existing literature on the effects of deception on performance outcomes of trained individuals within an endurance task. The types of deceptive feedback included in the review were time, split pace, PO, anticipated difficulty, distance, speed and previous performance, and competitor deception (see supplementary Figure S1). Out of 27 articles, the most common type of deception assessed were time (six articles) and speed/previous performance (nine articles). Competitor deception and anticipated difficulty deception were the least common in the literature.

Overall, studies investigating deception of speed and previous performance have produced mixed results, with some finding performance improvements (Ansdell et al., 2018; Ducrocq et al., 2017; Jones et al., 2016b; Micklewright et al., 2010; Parry et al., 2012; Stone et al., 2012) and others reporting no significant benefits (Jones et al., 2016a; Taylor & Smith, 2014; Williams et al., 2016; Shei et al., 2016). Likewise, conflicting findings were found when investigating deception of distance, split pace and PO. Studies involving deception of time yielded more consistent results. Findings consistently showed that time deception ≤ 5% has no influence on performance across cycling and running trials, though differences emerged (in opposing directions) for deceptive time manipulations of 10%. Both studies that assessed the effects of competitor deception on reported that deception improved performance (Corbett et al., 2012; Williams et al., 2015). However, Jones et al. (2016a; 2016b) concluded that the presence of the avatar rather than the manipulation of performance beliefs facilitated an improvement in cycling TT performance.

While most studies in the review used deception during the endurance task, some of the included studies looked at carryover effects following deception. Paterson and Marino (2004) reported that both a positive and negative distance deception significantly influenced cyclists’ performances in a subsequent TT. Prior deception also influenced cyclist’s subsequent pacing strategy (Micklewright et al., 2010). Shei et al. (2016) concluded that participants who improved their performance with a +2% PO deception could sustain performance improvements even after they had been informed about the deception with a similar pacing strategy. Nonetheless, other studies reported no significant carryover effects of deception on subsequent performance (Jones et al., 2016b; Nikolopoulos et al., 2001).

Some studies in the current review included deception prior to the start of exercise or at a specific point during the exercise bout. Deception prior to the start of exercise may offer information on how individuals prepare their effort within an endurance task, also known as anticipatory pacing (Jones et al., 2013). Albertus et al. (2005) suggested that if pacing strategies are maintained throughout the entirety of an exercise bout, then they appear to be determined or “hardwired” from the onset of exercise. Therefore, any deceptive feedback provided during exercise will not influence pacing, especially in well-trained and elite populations who likely have robust pacing strategies that are not impacted by deception in distance splits (Albertus et al., 2005). The findings from Puleo and Abraham (2018) suggest that this might also apply to recreational runners. However, contrary evidence comes from studies where deception that is revealed during exercise can influence pacing (Brick et al., 2019; Taylor & Smith, 2017). This suggests pacing reflects a continuous and dynamic decision-making process, rather than a pre-determined strategy.

Studies in which no feedback was provided to participants also offer some insights as to how information provided to participants can influence ongoing pacing adjustments, with participants adopting a more cautious pacing strategy in the absence of information about performance (e.g., Faulkner et al., 2011; Micklewright et al. 2010). This was supported by Faulkner’s observation of an ‘end spurt’ in the three feedback conditions, but not the no-feedback condition (Faulkner et al., 2011). Although not included in the current review (because a performance outcome was not assessed) research involving expected duration deception also suggest a more conservative approach when the duration of the exercise task is unknown (Baden et al., 2005; Eston et al., 2012). A more conservative pacing approach in the absence of external information about a task likely reflects an attempt to maintain metabolic resources during uncertain circumstances (Wingfield et al., 2018).

Similar to the conclusion reached by Jones et al. (2013) in their review, we found that it is difficult to determine the most optimal type of deception for performance. This is largely due to mixed findings in addition to the various methodologies and populations used in the literature. Within the current review, studies included participants who were recreationally active and those who were well trained, including some with competitive racing experience. There is evidence that pacing strategies vary according to performance level in both running and cycling (Abbiss et al., 2013; Lima-Silva et al., 2010). Therefore, while we attempted to limit the effect of experience by only including trained participants in the review, there were still variations that may have impacted the findings.

In swimming, which has been understudied in deception research, pacing profile is not affected by skill level, but rather by the event distance and stroke (McGibbon et al., 2018). Race distance also affects pacing and performance in running and cycling (Abbiss & Laursen, 2008). In the current review, cycling distances ranged from 2k to 40k and running distances varied from 3k to 60min. Another methodological difference across studies was the equipment utilized for endurance performance testing. Of the 21 cycling studies included in the review, 6 allowed participants to use their own bike for the study (Jones et al., 2016a; Parry et al., 2012; Paterson & Marino, 2004; Thomas & Renfree, 2010; Williams et al., 2015; Williams et al., 2016) whereas other used various types of ergometers. Though most studies included familiarization trials, the equipment utilized for testing may impact endurance performance.

Across study conditions, various percentages of deception were utilized. The most commonly used were 5% (13 trials) and 15% (10 trials), whereas 2.5, 3, and 20% were only used in two conditions (see supplementary Figure S2). Wilson et al. (2011) suggest 5% deception is most optimal to ensure that participants will not recognize the deception. Among well trained participants a higher percentage of deception would likely raise suspicion and thus, invalidate the study protocol (Wilson et al., 2011). However, Nikolopoulos et al. (2001; 15% deception) and Wingfield et al. (2018; 20% deception) utilized greater than 5% and confirmed, after the trials, that participants were unaware of the deception. Thus, the parameters for a noticeable amount of deception are not clear. The amount of deception might also vary based on deception type (e.g., distance vs. speed) and participant characteristics (e.g., task familiarity).

**Study Limitations & Future Directions**

There are several limitations pertaining to the current review that must be acknowledged. To start, only 6 out of 27 included studies completed apower analysis to determine and evaluate sample size. One additional study completed an *a priori* power analysis but could not achieve the recommended number of participants. The small sample size of most studies included in the review (52% of studies had a sample size of 10 or fewer participants) suggests the investigations were likely underpowered. An insufficient sample size can result in a lack of validity of the findings, making it difficult to assess the true effects of deception on endurance performance.

Participants in the included studies were highly homogeneous. In 21 (out of 27) studies, participant samples consisted solely of individuals who identified as male. Only six studies used a mixed gender sample, and none studied only females (see supplementary table). As such, females were highly underrepresented in existing deception research, as were other gender identities/expressions. No studies included participants over the age of 40 years, with majority (19 studies) falling within a relatively narrow age range of 26-40 years. None of the included studies reported race or ethnicity information for participants. It is imperative that future research strive to encompass more representative participant samples to develop a more holistic understanding of the ways in which deception impacts endurance performance in different populations.

Another consideration for future research is assessing the effects of deceptive feedback in varied endurance tasks to ensure a nomothetic approach. The majority of extant research has used a cycling task (78% of included studies). While the core principle of managing effort to optimize performance remains consistent across running, cycling, and swimming, there are distinct physical demands, environmental factors, and tactical considerations in each sport that influence adopted pacing strategy. For example, pool swimming involves regular turns that can affect pacing and performance and provide limited opportunity for performance feedback. In contrast, performance feedback while cycling is near constant if using a cycle ergometer. In swimming, the first split represents the fastest section of the race, because of the dive start and underwater component, however this cannot be attained in running and cycling (Demarie et al., 2023). Running and cycling (outside of a lab) can also involve changes in terrain that a performer must adapt to. The study of deception in different environments could help to understand its impact on pacing and performance relative to such sport-specific factors, enabling athletes tailor their training and race strategies to maximize performance in their respective disciplines.

# Contributions

Contributed to conception and design: B.J.D, J.C.H.

Contributed to acquisition of data: B.J.D

Contributed to analysis and interpretation of data: B.J.D, J.C.H, A.B

Drafted and/or revised the article: B.J.D, J.C.H, A.B

Approved the submitted version for publication: B.J.D, J.C.H, A.B

# Funding information

There were no sources of funding or grants received for the current research study to occur.

# Data and Supplementary Material Accessibility

There is no data, or supplementary material available for the manuscript since the study is considered a systematic review.

# REFERENCES

Abbiss, C.R., & Laursen, P.B. (2008). Describing and understanding pacing strategies during athletic competition. *Sports Medicine,* *38*, 239–252. https://doi.org/10.2165/00007256-200838030-00004

Abbiss, C. R., Ross, M. L., Garvican, L. A., Ross, N., Pottgiesser, T., Gregory, J., & Martin, D. T. (2013). The distribution of pace adopted by cyclists during a cross-country mountain bike World Championships. *Journal of Sports Sciences, 31*(7), 787-794. https://doi.org/10.1080/02640414.2012.751118

Albertus, Y., Tucker, R., Gibson, A. S. C., Lambert, E. V., Hampson, D. B., & Noakes, T.

D. (2005). Effect of distance feedback on pacing strategy and perceived exertion during cycling. *Medicine & Science in Sports & Exercise*, *37*(3), 461-468. https://doi.org/[10.1249/01.mss.0000155700.72702.76](https://doi.org/10.1249/01.mss.0000155700.72702.76)

American Psychological Association. (n.d.). Active deception. In APA Dictionary of

Psychology. Retrieved May 14, 2024, from<https://dictionary.apa.org/active-deception>

Ansley, L., Noakes, T., Robson-Ansley, P., & St Clair Gibson, A. (2004). Anticipatory pacing

strategies during supra-maximal exercise lasting more than 30 s. *Medicine & Science in Sports & Exercise*, *36*(2), 309-314. https://doi.org/10.1249/01.MSS.0000113474.31529.C6

Ansdell, P., Thomas, K., Howatson, G., Amann, M., & Goodall, S. (2018). Deception improves

TT performance in well-trained cyclists without augmented fatigue. *Medicine and Science in Sports and Exercise*, *50*(4), 809–816. https://doi.org/[10.1249/MSS.0000000000001483](https://doi.org/10.1249%2FMSS.0000000000001483)

Baden, D. A., Mclean, T. L., Tucker, R., Noakes, T. D., & St Clair Gibson, A. (2005). Effect of anticipation during unknown or unexpected exercise duration on rating of perceived exertion, affect, and physiological function. *British Journal of Sports Medicine*, *39*, 742–746. http://doi.org/[10.1136/bjsm.2004.016980](https://doi.org/10.1136/bjsm.2004.016980)

Baumrind, D. (1985). Research using intentional deception: Ethical issues revisited. *American Psychologist, 40*(2),165–174. doi:10.1037/0003-066X.40.2.165

Baden, D. A., Warwick-Evans, L.A., & Lakomy, J. (2004). Am I nearly there? The effect of

anticipated running distance on perceived exertion and attentional focus. *Journal of Sport and Exercise Psychology*, *26*, 1–17. <https://doi.org/10.1123/jsep.26.2.215>

Beedie, C.J., Lane, A.M. & Wilson, M.G. (2012) A possible role for emotion and emotion

regulation in physiological responses to false performance feedback in 10-mile laboratory cycling. *Applied Psychophysiology and Biofeedback* *37*, 269–277. https://doi.org/10.1007/s10484-012-9200-7

Billaut, F., Bishop, D.J., Schaerz, S., Noakes, T.D (2001). Influence of knowledge of sprint

number on pacing during repeated-sprint exercise. *Medicine & Science in Sports &*

*Exercise, 43*(4), 665–72. https://doi.org/10.1249/MSS.0b013e3181f6ee3b​

Brick, N. E., Fitzpatrick, B. L., Turkington, R., & Mallett, J. C. (2019). Anticipated task

difficulty provokes pace conservation and slower running performance. *Medicine and Science in Sports and Exercise*, *51*(4), 734–743. https://doi.org/10.1249/MSS.0000000000001844

Castle, P. C., Maxwell, N., Allchorn, A., Mauger, A. R., & White, D. K. (2012). Deception of

ambient and body core temperature improves self-paced cycling in hot, humid conditions. *European Journal of Applied Physiology*, *112*, 377-385. https://doi.org/10.1007/s00421-011-1988-y​

Coquart, J. B., Stevenson, A., & Garcin, M. (2011). Causal influences of expected running length

on ratings of perceived exertion and estimation time limit scales. *International Journal of Sport Psychology*, *42*(2), 149-66.

Corbett, J., Barwood, M. J., Ouzounoglou, A., Thelwell, R., & Dicks, M. (2012). Influence of

competition on performance and pacing during cycling exercise. *Medicine & Science in*

*Sports & Exercise*, *44*(3), 509-515. https://doi.org/10.1249/MSS.0b013e31823378b1

Craig, A. D. (2008). Interoception and emotion: A neuroanatomical perspective. *Handbook of*

*Emotions*, *3*(602), 272-88.

Davies, M. J., Clark, B., Garvican-Lewis, L. A., Welvaert, M., Gore, C. J., & Thompson, K. G.

(2019). The potential to change pacing and performance during 4000-m cycling time trials using hyperoxia and inspired gas-content deception. *International Journal of Sports Physiology and Performance*, *14*(7), 949–957. <https://doi.org/10.1123/ijspp.2018-0335>

Demarie, S., Pycke, J. R., Pizzuti, A., & Billat, V. (2023). Pacing of human locomotion on

land and in water: 1500 m swimming vs. 5000 m running. *Applied Sciences*, *13*(11),

6455. <https://doi.org/10.3390/app13116455>

Ducrocq, G. P., Hureau, T. J., Meste, O., & Blain, G. M. (2017). Increased fatigue

response to augmented deceptive feedback during cycling time trial. *Medicine and Science in Sports and Exercise*, *49*(8), 1541–1551. https://doi.org/10.1249/MSS.0000000000001272

Edwards, A. M., & Polman, R. C. J. (2013). Pacing and awareness: brain regulation of physical activity. *Sports Medicine*, *43*, 1057-1064. https://doi.org/10.1007/s40279-013-0091-4

Eston, R., Stansfield, R., Westoby, P., & Parfitt, G. (2012). Effect of deception and expected

exercise duration on psychological and physiological variables during treadmill running

and cycling. *Psychophysiology*, *49*(4), 462-469. <https://doi.org/10.1111/j.1469-8986.2011.01330.x>

Faulkner, J., Arnold, T., & Eston, R. (2011). Effect of accurate and inaccurate distance feedback

on performance markers and pacing strategies during running. *Scandinavian Journal of*

*Medicine & Science in Sports*, *21*(6), e176-e183. <https://doi.org/10.1111/j.1600-0838.2010.01233.x>

Hampson, D. B., Gibson, A. S. C., Lambert, M. I., Dugas, J. P., Lambert, E. V., & Noakes, T. D.

(2004). Deception and perceived exertion during high-intensity running bouts. *Perceptual and Motor Skills*, *98*(3), 1027-1038. <https://doi.org/10.2466/pms.98.3.1027-1038>

Higgins, J. P. T., Li, T., Sterne, J., et al. (Eds.). (2021). Revised Cochrane risk of bias tool

for randomized trials (RoB 2) additional considerations for crossover trials. Retrieved from<https://www.riskofbias.info/welcome/rob-2-0-tool/rob-2-for-crossover-trials>

Hu, L., Motl, R. W., McAuley, E., & Konopack, J. F. (2007). Effects of self-efficacy on physical

activity enjoyment in college-aged women. *International Journal of Behavioral*

*Medicine*, *14*, 92-96. https://doi.org/10.1007/BF03004174

Hutchinson, J.C. & De Lucia, B. (in press). Attention allocation during exercise performed at

various intensities. In M. Bigliassi & E. Filho (Eds.). *Sport and Exercise*

*Psychophysiology*. Springer.

Jones, H. S., Williams, E. L., Bridge, C. A., Marchant, D., Midgley, A. W., Micklewright, D., &

Mc Naughton, L. R. (2013). Physiological and psychological effects of deception on

pacing strategy and performance: A review. *Sports Medicine*, *43*, 1243-1257.

https://doi.org/10.1007/s40279-013-0094-1

Jones, H. S., Williams, E. L., Marchant, D. C., Sparks, S. A., Bridge, C. A., Midgley, A. W., &

Mc Naughton, L. R. (2016a). Deception has no acute or residual effect on cycling time trial performance but negatively effects perceptual responses. *Journal of Science and Medicine in Sport*, *19*(9), 771–776. https://doi.org/10.1016/j.jsams.2015.12.006

Jones, H. S., Williams, E. L., Marchant, D., Sparks, S. A., Bridge, C. A., Midgley, A. W., Mc

Naughton, L. R. (2016b). Improvements in cycling time trial performance are not sustained following the acute provision of challenging and deceptive feedback. *Frontiers in Physiology*, *7*, 221884. <https://doi.org/10.3389/fphys.2016.00399>

Lima-Silva, A. E., Bertuzzi, R. C., Pires, F. O., Barros, R. V., Gagliardi, J. F., Hammond, J.,

Kiss, M.A., Bishop, D. J. (2010). Effect of performance level on pacing strategy during a 10-km running race. *European Journal of Applied Physiology*, *108*, 1045-1053. https://doi.org/10.1007/s00421-009-1300-6

McCormick, A., Meijen, C., & Marcora, S. (2015). Psychological determinants of whole-body

endurance performance. *Sports Medicine*, *45*(7), 997–1015.

https://doi.org/10.1007/s40279-015-0319-6

McGibbon, K. E., Pyne, D. B., Shephard, M. E., & Thompson, K. G. (2018). Pacing in swimming: A systematic review. *Sports Medicine*, *48*, 1621-1633. https://doi.org/10.1007/s40279-018-0901-9

Marquez, D.X., Jerome, G.J., McAuley, E. (2002). Self-efficacy manipulation and state anxiety

responses to exercise in low active women. *Psychology and Health*. *17*(6):783–91.

<https://doi.org/10.1080/0887044021000054782>

Mauger, A. R., Jones, A. M., & Williams, C. A. (2011). The effect of non-contingent and

accurate performance feedback on pacing and time trial performance in 4-km track cycling. *British Journal of Sports Medicine*, *45*(3), 225–229. <https://doi.org/10.1136/bjsm.2009.062844>

Micklewright, D., Papadopoulou, E., Swart, J., & Noakes, T. (2010). Previous experience

influences pacing during 20 km time trial cycling. *British Journal of Sports Medicine*, *44*(13), 952-960. https://doi.org/[10.1136/bjsm.2009.057315](https://doi.org/10.1136/bjsm.2009.057315)

Motl, R. W., Konopack, J. F., Hu, L., & McAuley, E. (2006). Does self-efficacy influence leg

muscle pain during cycling exercise?. *The Journal of Pain*, *7*(5), 301-307.

<https://doi.org/10.1016/j.jpain.2005.11.009>

Morton, R. H. (2009). Deception by manipulating the clock calibration influences cycle

ergometer endurance time in males. *Journal of Science and Medicine in Sport*, *12*(2), 332-337. <https://doi.org/10.1016/j.jsams.2007.11.006>

Nikolopoulos, V., Arkinstall, M.J., & Hawley, J.A. (2001). Pacing strategy in simulated cycle

time- trials is based on perceived rather than actual distance, *Journal of Science and Medicine in Sport*, *4*(2): 212-219. <https://doi.org/10.1016/S1440-2440(01)80031-1>

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... &

Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting

systematic reviews. *British Medical Journal*, *372.* <https://doi.org/10.1136/bmj.n71>

Paterson, S., & Marino, F. E. (2004). Effect of deception of distance on prolonged cycling

performance. *Perceptual and Motor Skills*, *98*(3), 1017-1026. <https://doi.org/10.2466/pms.98.3.1017-1026>

Parry, D., & Micklewright, D. (2014). Optic flow influences perceived exertion and distance

estimation but not running pace. *Medicine & Science in Sports & Exercise*, *46*(8), 1658-1665. https://doi.org/[10.1249/MSS.0000000000000257](https://doi.org/10.1249/mss.0000000000000257)

Pires, F. O., & Hammond, J. (2012). Manipulation effects of prior exercise intensity

feedback by the borg scale during open-loop cycling. *British Journal of Sports Medicine*, *46*(1), 18–22. https://doi.org/10.1136/bjsm.2010.079053

Puleo, N. A., & Abraham, K. A. (2018). External feedback does not affect running pace in

recreational runners. *International Journal of Exercise Science*, *11*(5), 384.

Shei, R. J., Thompson, K., Chapman, R., Raglin, J., & Mickleborough, T. (2016). Using

deception to establish a reproducible improvement in 4-km cycling time trial performance. *International Journal of Sports Medicine*, 37(5), 341-346. <https://doi.org/10.1055/s-0035-1565139>

Smits, B. L., Polman, R. C., Otten, B., Pepping, G. J., & Hettinga, F. J. (2016). Cycling

in the absence of task-related feedback: Effects on pacing and performance. *Frontiers in Physiology*, *7*, 348. https://doi.org/10.3389/fphys.2016.00348

Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates,

C. J., Cheng, H. Y., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueira, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., McAleenan, A., … Higgins, J. P. T. (2019). RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ (Clinical research ed.)*, *366*, l4898. https://doi.org/10.1136/bmj.l4898

Stoate, I., Wulf, G., Lewthwaite, R. (2012). Enhanced expectancies improve movement

efficiency in runners. *Journal of Sports Science*. *30*(8), 37–41.

<https://doi.org/10.1080/02640414.2012.671533>

Stone, M. R., Thomas, K., Wilkinson, M., Stevenson, E., St. Clair Gibson, A., Jones, A. M., &

Thompson, K. G. (2017). Exploring the performance reserve: Effect of different magnitudes of power output deception on 4,000 m cycling time-trial performance. *PloS One*, *12*(3), e0173120. [https://doi.org/10.1371/journal.pone.017312](https://doi.org/10.1371/journal.pone.0173120)

Stone, M., Thomas, K., Wilkinson, M., Jones, A., St Clair Gibson, A., & Thompson, K. (2012).

Effects of deception on exercise performance: Implications for determinants of fatigue in humans. *Medicine & Science in Sports & Exercise*, *44*(3), 534-541. https://doi.org/[10.1249/MSS.0b013e318232cf77](https://doi.org/10.1249/mss.0b013e318232cf77)

Taylor, D., & Smith, M. F. (2014). Effects of deceptive running speed on physiology, perceptual

responses, and performance during sprint-distance triathlon. *Physiology & Behavior*, *133*,

45-52. <https://doi.org/10.1016/j.physbeh.2014.05.002>

Taylor, D., & Smith, M. F. (2017). The influence of mid-event deception on psychophysiological

status and pacing can persist across consecutive disciplines and enhance self-paced multi-modal endurance performance. *Frontiers in Physiology*, *8*, 6. <https://doi.org/10.3389/fphys.2017.00006>

Thomas, G., & Renfree, A. (2010). The effect of secret clock manipulation on 10 km cycle

time trial performance. *International Journal of Arts and Sciences*, *3*(9), 193-202.

Terra, A., Paulucio, D., Machado, M., Bishop, D. J., Koch, A. J., Alvarenga, R., & Pompeu, F.

A. (2021). Effect of unaware clock manipulation on pacing strategy and performance in recreational athletes. *Applied Sciences*, *11*(17), 8062. <https://doi.org/10.3390/app11178062>

Viera, A. J., & Garrett, J. M. (2005). Understanding interobserver agreement: the kappa statistic.

*Faily Medicine*, *37*(5), 360-363.

Waldron, M., Villerius, V., & Murphy, A. (2014). Augmenting performance feedback does

not affect 4 km cycling time-trials in the heat. *Journal of Sports Sciences*, *33*(8), 786–794. <https://doi.org/10.1080/02640414.2014.962579>

Wingfield, G., Marino, F. E., & Skein, M. (2019). Deception of cycling distance on pacing

strategies, perceptual responses, and neural activity. *European Journal of Physiology*, *471*, 285-299. https://doi.org/10.1007/s00424-018-2218-9

Williams, E. L., Jones, H. S., Sparks, S. A., Marchant, D. C., Midgley, A. W., Bridge,

C. A., & McNaughton, L. R. (2016). Deceptive manipulation of competitive starting strategies influences subsequent pacing, physiological status, and perceptual responses during cycling time trials. *Frontiers in Physiology*, *7*, 536. https://doi.org/10.3389/fphys.2016.00536

Williams, E. L., Jones, H. S., Sparks, S. A., Marchant, D. C., Midgley, A. W., & Mc Naughton, L. R. (2015). Competitor presence reduces internal attentional focus and improves 16.1 km cycling time trial performance. *Journal of Science and Medicine in Sport*, *18*(4), 486-491. <https://doi.org/10.1016/j.jsams.2014.07.003>

Wilson, M. G., Lane, A. M., Beedie, C. J., & Farooq, A. (2012). Influence of accurate and

inaccurate ‘split-time’ feedback upon 10-mile time trial cycling performance. *European Journal of Applied Physiology*, *112*(1), 231-236. <https://doi.org/10.1007/s00421-011-1977-1>

**Figure 1**

*PRISMA Flow Diagram of Study Selection Process*

Identification

Records from database search (*n* = 1849)

Removed during title and abstract screening (*n* = 1761)

Title and abstract screening (*n* = 1849)

Screening

Additional records found within hand search

(*n* = 6)

Duplicates removed (*n* = 53)

Eligibility

Full-text articles to assess for inclusion

(*n* = 88)

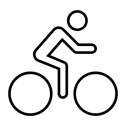
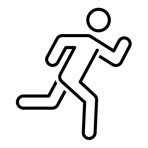
Did not meet inclusion criteria (*n* = 15)

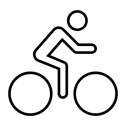
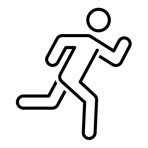
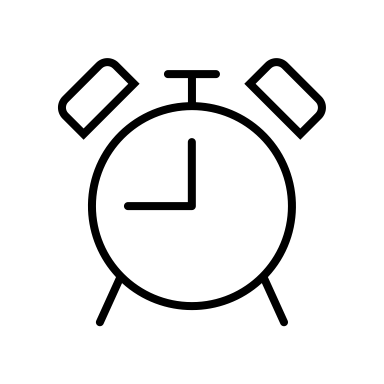
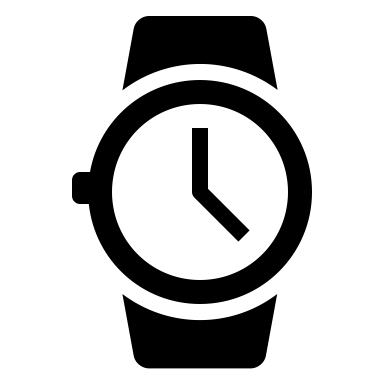
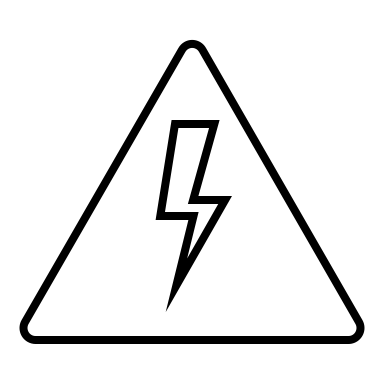
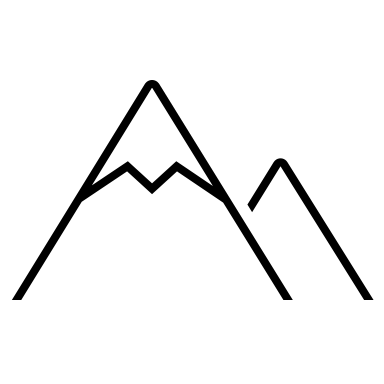
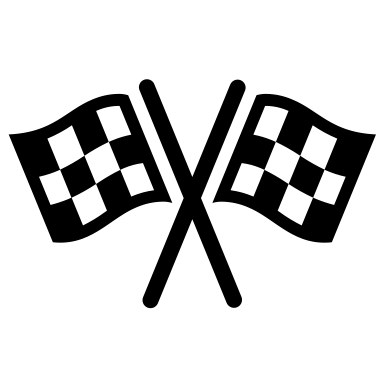
Met inclusion criteria (*n* = 27)

Included

Final count of studies reviewed (*n* = 27)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Reference** | **Participant Information** | **Exercise Protocol** | **Experimental Conditions**  **Table 1**  *Key Finding of Prior Endurance Deceptive Studies* | **Variable Manipulated** | **Variable(s) Measured** | **Key Findings** |
| Beedie et al. (2012)  Cycling outline | *N* = 7  Regularly active M | 4 x 10-mile TTs | **DEC(P)**: Clock displayed 5% faster than elapsed time  **DEC(N):** Clock displayed 5% slower than elapsed time | Time  Alarm clock outline | -TTC  -PO | -NSD in mean PO, and TTC between conditions |
| Morton (2009)  Cycling outline | *N* = 12  (M = 6, F = 6)  Trained members of the University Soccer Club | 3 x TTE | **ACC:** Accurate time displayed  **DEC(N):** Clock displayed 10% slower than elapsed time  **DEC(P):** Clock displayed 10% faster than elapsed time | Time  Alarm clock outline | -TTE | -M participants reached TTE later in DEC(N) compared to DEC(P) and ACC  -NSD differences in TTE across conditions for F participants |
| Puleo and Abraham (2018)  Run outline | *N* = 10  (M = 4, F = 6)  Recreational runners | 4 x 30-min. | **NFB:** Not informed of their running pace, but informed of elapsed time at 5 min. intervals  **ACC:** Informed of the elapsed time and average running pace at 5 min. intervals  **DEC(P):** False FB at 5 min. intervals (5% faster than elapsed time)  **DEC(N):** False FB at 5 min. intervals (5% slower than elapsed time) | Time/Pace  Alarm clock outline | -Speed | -NSD difference in average speed across NFB, ACC, DEC(P) and DEC(N) |
| Terra et al. (2021)  Run outline | *N* = 10  Recreationally active M | 3 x ‘60 min’ at various times | **ACC**: Informed 60 min., completed 60 min.  **DEC(P):** Informed 60 min., completed 66 min. (10% deception)  **DEC(N):** Informed 60 min., completed 54 min. (10% deception) | Time  Alarm clock outline | -Distance  -Speed | -DEC(P) achieved ↑ distances due to the longer trial duration. When only the last 10 min were examined, DEC(N) achieved a ↑ speed and distance than DEC(P)  -NSD were found in ACC compared to DEC(P) and DEC(N) with respect to speed |
| Thomas and Renfree (2010)  Cycling outline | *N* = 8  Well-trained M cyclists | 3 x 10k TTs | **ACC:** Accurate time displayed  **DEC(P):** Clock displayed 10% faster than elapsed time  **DEC(N):** Clock displayed 10% slower than elapsed time | Time  Alarm clock outline | -Time  -Speed | -NSD difference in TTC across conditions  -↑ in speed during the last 1k of TT in the DEC(P) compared to DEC(N) |
| Waldron et al. (2014)  Cycling outline | *N =* 9  Well-trained M cyclists in a hot environment (30oc) | 3 x 4k TTs | **ACC**: Accurate time displayed  **DEC(P):** Clock displayed 2% faster than BL | Time  Alarm clock outline | -Time  -PO | -NSD difference in TTC, PO between ACC vs. DEC(P)  -NSD in physiological response or perceptual response between conditions |
| Albertus et al. (2005)  Cycling outline | *N* = 15  Moderately trained M | 4 x 20k TTs | **ACC:** Accurate 1k distance splits  **DEC(P):** Distances were increased by 25m increments. Starting at 0.775k, cyclists were informed they cycled 1k  **DEC(N):** Distances were decreased by 25m increments. Starting at 1.225k, cyclists were informed they cycled 1k  **DEC(R)**: Distances were randomly assigned to increased or decreased FB (25-250m) for each 1k split | Split Pace  Watch with solid fill | -Time  -PO | -NSD of cycling speed and TTC between conditions |
| Faulkner et al. (2011)  Run outline | *N* = 13  University M sport team athletes | 4 x 6k TTs | **ACC:** Accurate FB (distance)  **NFB:** No FB given  **DEC(P):** Delayed FB; 1k = 1.25, 2=2.40, 3=3.45, 4=4.40, 5k=5.25 (~11.84% deception)  **DEC(N)**: Premature FB;1k=.75, 2=1.60, 3=2.55, 4= 3.60, 5= 4.75 (~18.47% deception) | Split Pace  Watch with solid fill | -Time  -Velocity | -TTC did not vary between DEC(P) and DEC(N), but was slower in NFB  -Running velocity ↑ throughout all conditions |
| Wilson et al. (2012)  Cycling outline | *N* = 7  Well-trained M cyclists | 4 x 10-mile TTs | **ACC:** Accurate physiological and performance FB  **NFB:** No performance or physiological data given  **DEC(P) or DEC(N):** False positive OR false negative FB (5% faster OR slower than elapsed time) at 1-mile markers | Split Pace  Watch with solid fill | -Time  -PO | -NSD difference between conditions for TTC or PO |
| Taylor and Smith (2017)  A black background with a black square  Description automatically generated with medium confidenceCycling outline  Run outline | *N* = 10  Competitive M triathletes | 3 x sprint- distance triathlons TTs | **ACC:** CyclingPO was 5% greater than baseline (informed before trial)  **DEC(N):** CyclingPO was 5% less than baseline (deceived during trial) | Power  High voltage outline | -Time  -PO | -NSD in cycling TTC across conditions  -ACC and DEC(N) had ↓ in TTC and ↑ in PO compared to BL  -TTC in 5k ↓ in the DEC(N) compared to BL |
| Stone et al. (2017)  Cycling outline | *N* = 10  Trained M cyclists | 3 x 4k TTs | **DEC(P1):** Mean PO displayed was 2% faster than baseline  **DEC(P2):** Mean PO displayed was 5% faster than baseline | Power  High voltage outline | -Time  -Speed  -PO | - Faster TTC with a ↑ PO for DEC(P2) than BL  -NSD difference in TTC between DEC(P1) and DEC(P2) |
| Shei et al. (2016)  Cycling outline | *N =* 14  Trained M cyclists | 4 x 4k TTs | **DEC(P) unaware:** PO displayed was 2% faster than PO of BL  **DEC(P) aware:** PO displayed was 2% faster than PO of BL | Power  High voltage outline | -TTC  -PO | -10 participants in DEC(P) compared to BL had ↓ in TTC and an ↑ in PO, but no difference between DEC(P) and DEC(N). |
| Brick et al. (2019)  Run outline | *N* = 28  (M = 23, F = 5)  Trained runners | 3 x 3k TTs | **ACC:** Informed prior to trial that incline would increase for the final 800 m  **DEC:** Informed gradient would remain 0%, then at 1800 m were informed it would increase for the final 800 m until finish | Incline  Mountains outline | -Time  -Speed | -Speed and time were ↓ in the ACC condition compared to DEC during the first 2200m |
| Nikolopoulos et al. (2001)  Cycling outline | *N* = 6  Well-trained M cyclists/ triathletes | 7 x ‘40k’ TTs at various distances | **ACC:** Informed the correct distance of the trial (40k)  **DEC(N):** Informed the distance of trial was 40k but was 34k (15% deception)  **DEC(P):** Informed the distance of trial was 40k, but was 46k (15% deception) | Distance Race Flag with solid fill | -Time  -PO | -PO did not vary between conditions  -TTC was longer for DEC(P) compared to other conditions |
| Paterson and Marino (2004)  Cycling outline | *N* = 21  (M = 17, F = 4)  Endurance-trained cyclists | 3 x ‘30k’ TTs at various distances | **DEC(P) Group:** 30k → 36k → 30k  (20% deception for TT2)  **DEC(N) Group:** 30k → 24k → 30k (20% deception for TT2)  **ACC Group:** 30k → 30k → 30k | Distance Race Flag with solid fill | -Time  -PO | - NSD in TTC across groups  -DEC(P) Group ↓ in TTC in TT3 compared to TT1  -DEC(N) Group ↑ in TTC in TT3 compared to TT1  -ACC: NSD between TT1 and TT3 |
| Wingfield et al. (2018)  Cycling outline | *N =* 10  Well-trained M cyclists | 3 x ‘30k’ TTs at various distances | **ACC:** Informed the correct distance of the trial (30k)  **DEC(N):** Informed the distance of the trial was 30k, but it was 26k (20% deception)  **DEC(P):** Informed the distance of the trial was 30k, but it was 36k (20% deception) | Distance Race Flag with solid fill | -Time  -PO | -PO ↓ in DEC(P) compared to ACC |
| Ansdell et al. (2018)  Cycling outline | *N =* 10  Well-trained M cyclists | 4 x 4k TTs | **ACC:** Virtual avatar displayed speed accurately represented BL  **DEC(P):** Virtual avatar displayed speed 2% faster than BL | Speed & Previous Performance  Stopwatch outline | -Time | -TTC ↓ in DEC(P) compared to BL  -NSD difference in TTC for ACC vs. DEC(P) |
| Ducrocq et al. (2017)  Cycling outline | *N*  = 11  (M = 8, F = 3)  Recreationally active | 3 x 5k TTs | **ACC:** Accurate speed  **DEC(P1):** Virtual avatar was displayed speed 2% faster than BL  **DEC(P2)**: Virtual avatar was displayed speed 5% faster than BL | Speed & Previous Performance  Stopwatch outline | -Time  -PO | -PO ↑ and TTC ↓ in the DEC(P1) in comparison to ACC |
| Jones et al. (2016a)  Cycling outline | *N* = 20  Trained M cyclists with race experience | 4 x 16.1 k TTs | **-Deceptive Group (DG)**  **DEC(P):** Virtual avatar 2% faster than BL  **NFB:** Distance-only FB with no virtual avatar displayed (ride-alone)  **-Control Group (CG)**  **ACC:** Virtual avatar accurately represented BL  **NFB:** Distance-only FB with no virtual avatar displayed (ride-alone) | Speed & Previous Performance  Stopwatch outline | -Time  -PO | -In the DG, DEC(P) had a ↓ in TTC compared to BL  -NSD between DEC(P), NFB and BL with respect to TTC  -PO ↑ in DEC(P) compared to BL and NFB, but NFB had a ↑ PO than BL |
| Jones et al. (2016b)  Cycling outline | *N =* 20 M  Trained M cyclists with race experience | 4 x 16.1 k TTs | **ACC:** Virtual avatar displayed speed accurately represented BL  **NFB:** Distance-only FB with no virtual avatar displayed  **DEC(P):** Virtual avatar displayed speed 2% faster than BL | Speed & Previous Performance  Stopwatch outline | -Time | -Both groups performed faster in DEC(P) compared to the fastest BL and subsequent trial  -NSD difference in TTC between ACC and NFB |
| Micklewright et al. (2010)  Cycling outline | *N* = 29 M  Competitive M cyclists | 3 x 20k TTs | **-No FB Group (NFB)**  **NFB:** No performance FB  **ACC:** Accurate performance FB (time, distance, power, speed)  **-Accurate FB Group (AFB)**  **ACC**: Accurate performance FB was displayed (e.g., time, distance, power, speed)  **ACC**: Accurate performance FB was displayed (e.g., time, distance, power, speed)  **-Deceptive FB Group (DFB)**  **DEC(P):** Speed and distance were displayed 5% faster than actual speed and distance. PO was not displayed.  **ACC:** Accurate FB of performance was displayed (e.g., time, distance, power, speed) | Speed & Previous Performance  Stopwatch outline | -Time  -PO | -NFB: A faster TTC, as well as a ↑ in PO during the final 5k was observed  -AFB: NSD in performance or pacing was observed  -DFB: TTC ↓ and PO ↑ during the last 16-20k |
| Parry et al. (2012)  Cycling outline | *N* = 15  Competitive M triathletes or cyclists | 3 x 20k TTs | **ACC:** Speed accurately represented current speed  **DEC(N):** Speed displayed was 15% slower via altering the optic flow  **DEC(P):** Speed displayed was 15% faster via altering the optic flow | Speed & Previous Performance  Stopwatch outline | -Time  -PO | - In DEC(N) participants cycled at a ↑ PO and cadence  -NSD in PO between ACC and DEC(P) |
| Taylor and Smith (2014)  Cycling outline  A black background with a black square  Description automatically generated with medium confidence  Run outline | *N* = 8  (M = 7, F = 1)  Competitive triathletes | 3 x sprint-distance triathlons TTs | **ACC:** Speed displayed during the tri-run accurately represented BL  **DEC(P):** Speed displayed during the tri-run was 3% faster than BL  **DEC(N):** Speed displayed during the tri-run was 3% slower than BL | Speed & Previous Performance  Stopwatch outline | -Time | -NSD in TTC across conditions |
| Stone et al. (2012)  Cycling outline | *N* = 9  Trained M cyclists | 3 x 4k TTs | **ACC:** Virtual avatar displayed speed accurately represented BL  **DEC(P):** Virtual avatar displayed speed 2% faster than BL | Speed & Previous Performance  Stopwatch outline | -Time  - PO | -DEC(P) had a ↓ in TTC compared to BL and ACC  -DEC(P) had a ↑ PO than ACC at 90% of the total distance |
| Williams et al. (2016)  Cycling outline | *N* = 10  Competitive M cyclists | 5 x 16.1k TTs | **ACC:** Speed displayed accurately represented BL  **DEC(P):** Speed displayed was 5% faster than BL  **DEC(N):** Speed displayed was 5% slower than BL | Speed & Previous Performance  Stopwatch outline | -Time  -PO | -NSD difference in TTC and PO between conditions |
| Corbett et al. (2012)  Cycling outline | *N* = 14  Regularly active M | 2 x 2k TTs | **ACC:** Computerized self-image was on a screen; accurate distance was displayed, other variables were hidden  **DEC:** Informed they were competing against another (computerized) competitor, but it was their best previous TT performance | Competitor deception  Cycling outlineCycling outlineCycling outline | -Time  -PO | - TT performance and PO was faster ↑ in DEC  -↑ PO during the latter part of the test in DEC |
| Williams et al., (2015)  Cycling outline | *N =* 12  Competitive M cyclists | 5 x 16.1k TTs | **DEC(P1):** Virtual avatar displayed was 2% faster than BL  **DEC(P2):** Virtual avatar displayed was 5% faster than BL  **DEC(P1+P2):** Two virtual avatars, one 2% faster than BL, and another 5% faster than BL | Competitor deception  Cycling outlineCycling outlineCycling outline | -Time  -PO | -Regardless of condition, TTC was ↓ when participants thought they were competing against someone else  -PO was ↑ higher in the DEC(P1+P2) condition compared to DEC(P2) |

***Note.*** ACC = Accurate information; BL = Baseline performance; DEC = Deceptive information; DEC(N) = Negative deception; DEC(P) = Positive deception; FB = Feedback; F = Female; M = Male; NFB = No feedback; NSD = No statistical differences (*p* ≥ 0.05); PO = Power output; DEC(P) = Random deceptive information; TTC = Time to completion; TTE = Time to exhaustion; TT = Time-Trial; ↓ (significantly lower); ↑ (significantly greater). Exercise modalities were as follows: cycling (), running () or a triathlon (A black background with a black square

Description automatically generated with medium confidence ). Types of deception in studies were: time (), split pace (), power output (), incline (), distance (), speed and previous performance.

**Table 3**

*Risk of Bias Interpretation Obtained Using ROB 2*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Author** | **D1a** | **DS** | **D2** | **D3** | **D4** | **D5** | **Overall** |
| Albertus et al. (2005) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Ansdell et al. (2018) | 🟢 | 🟡 | 🟢 | 🟢 | 🟢 | 🟢 | Some concern |
| Beedie et al. (2012) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Brick et al. (2019) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Corbett et al. (2012) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Ducrocq et al. (2017) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Faulkner et al. (2010) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Jones et al. (2016a) | 🟢 | ⚪ | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Jones et al. (2016b) | 🟢 | ⚪ | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Micklewright et al. (2009) | 🟢 | ⚪ | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Morton (2009) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Nikolopoulos et al. (2001) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Parry et al. (2012) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Paterson & Marino (2004) | 🟢 | ⚪ | 🟢 | 🟢 | 🟡 | 🟢 | Some concern |
| Puleo & Abraham (2018) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Shei et al. (2016) | 🟡 | 🟢 | 🟢 | 🟢 | 🟢 | 🔴 | High risk |
| Stone et al. (2017) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Stone et al. (2012) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Taylor & Smith (2014) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Taylor & Smith (2017) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Terra et al. (2021) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Thomas & Renfree (2010) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Waldron et al. (2014) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Williams et al. (2015) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Williams et al. (2016) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Wilson et al. (2012) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |
| Wingfield et al. (2019) | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | 🟢 | Low risk |

***Notes*. D1a** = Risk of bias arising from the randomization process; **DS** = Risk of bias arising from period and carryover effects; **D2** = Risk of bias due to deviations from the intended interventions (effect of assignment); **D3** = Risk of bias due to missing outcome data; **D4** = Risk of bias in measurement of the outcome; **D5** = Risk of bias in selection of the reported results; **Overall** = Overall risk-of-bias judgement. Judgement Interpretation: 🟢 = low risk; 🟡 = some concern; 🔴 = high risk; ⚪ = Not applicable to study.

***Notes*. D1a** = Risk of bias arising from the randomization process; **DS** = Risk of bias arising from period and carryover effects; **D2** = Risk of bias due to deviations from the intended interventions (effect of assignment); **D3** = Risk of bias due to missing outcome data; **D4** = Risk of bias in measurement of the outcome; **D5** = Risk of bias in selection of the reported results; **Overall** = Overall risk-of-bias judgement. Judgement Interpretation: 🟢 = low risk; 🟡 = some concern; ⚪ = Not applicable to study.

**Supplemental Materials**

**Table S1.**

Summary of Sample Characteristics of Deceptive Studies

|  |  |
| --- | --- |
| **Characteristics** | **Samples k (%)** |
| Sample size   * 6-10 2, 3, 12, 15, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27 * 11-20 1, 5, 6, 7, 8, 9, 11, 13, 16, 24 * 21-25 14 * 25+ 4, 10 | 14 (51.9)  10 (37.0)  1 (3.7)  2 (7.4) |
| Gender   * Females only * Males only 1, 2, 3, 5, 7, 8, 9, 10, 12, 13, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27 * Combined 4, 6, 11, 14, 15, 19 * Non-binary * Prefer not to say | 0 (0)  21 (77.8)  6 (22.2)  0 (0)  0 (0) |
| Type of endurance sport   * Running 4, 7, 15, 21 * Cycling 1, 2, 3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 22, 23, 24, 25, 26, 27 * Triathlon 19, 20 | 4 (14.8)  21 (77.8)  2 (7.4) |
| Training status of participants   * Physically active/ recreationally active 5, 6, 15, 21 * Well trained/moderately trained/endurance athlete 1, 2, 3, 4, 12, 14, 16, 17, 18, 22, 23, 26, 27 * Competitive/race experience 8, 9, 10, 13, 19, 20, 24, 25 * University athlete 7, 11 | 4 (14.9)  13 (48.1)  8 (29.6)  2 (7.4) |
| Mean age of participants   * < 18 years * 18-25 1, 5, 6, 7, 11, 12, 16, 27 * 26-40 2, 3, 4, 8, 9, 10, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26 * 41+ | 0 (0)  8 (29.6)  19 (70.4)  0 (0) |

***Note.***k = number of sample populations; 1 = Albertus et al. (2005); 2 = Ansdell et al. (2018); 3 = Beedie et al. (2012); 4 = Brick et al. (2019); 5 = Corbett et al. (2012); 6 = Ducrocq et al. (2017); 7 = Faulkner et al. (2010); 8 = Jones et al. (2016a); 9 = Jones et al. (2016b); 10 = Micklewright et al. (2009); 11 = Morton(2009); 12 = Nikolopoulos et al. (2001); 13 = Parry et al. (2012); 14 = Paterson & Marino (2004); 15 = Puleo & Abraham (2018); 16 = Shei et al. (2016); 17 = Stone et al. (2017); 18 = Stone et al. (2012); 19 = Taylor & Smith (2014); 20 = Taylor & Smith (2017); 21 = Terra et al. (2021); 22 = Thomas & Renfree (2010); 23 = Waldron et al. (2014); 24 = Williams et al. (2015); 25 = Williams et al. (2016); 26 = Wilson et al. (2012); 27 = Wingfield et al. (2019).

**Figure S1.**

*Types of Deceptive Feedback in the Systematic Review*

**Figure S2.**

*Percentages of Deception Across Studies*

*Note.* Some studies used more than one type of deception