Baltic Journal of Health and Physical Activity 2018; 10(4): 61-71
Journal of Gdansk University of Physical Education and Sport
e-ISSN 2080-9999

ORIGINAL

doi: 10.29359/BJHPA.10.4.05

The effects of concurrent visual versus verbal feedback on swimming strength task execution

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background: The aim was to compare the effects of two different types of concurrent feedback administration on biomechanical performance during a swimming-specific task.

Material and methods: A counterbalanced repeated measures design was used to compare the execution of the butterfly stroke (the propulsion phase only) on a modified Smith machine. Twenty repetitions were performed in each condition of feedback (visual vs. verbal). Fourteen college swimmers (age x̄ = 22.21 ±1.85 years, height x̄ = 173.71 ±8.65 cm, mass x̄ = 71.32 ±10.64 kg) were recruited. An incremental force test was administered for each participant to determine the mean propulsive velocity in which maximal power was produced. Feedback addressed correct execution velocity of the pulling movement that corresponded to the maximal power production as determined in an incremental force test.

Results: *T* testing revealed no statistically significant differences between the verbal and visual feedback conditions. Visual feedback elicited a correct response in 76.11% of total feedback compared with 72.06% in the verbal feedback condition.

Conclusions: Considering total feedback response, the visual feedback condition elicited 4.05% more correct responses than verbal feedback. However, this difference did not attain statistical significance and, therefore, the underlying hypothesis could not be confirmed.

Key words: visual, verbal, feedback, swimming task, generated force.

article details

Article statistics: **Word count:** 3,746; **Tables:** 1; **Figures:** 3; **References:** 44

Received: May 2018; **Accepted:** September 2018; **Published:** December 2018

Full-text PDF: http://www.balticsportscience.com

Indexation: Celdes, Clarivate Analytics Emerging Sources Citation Index (ESCI), CNKI Scholar (China National Knowledge Infrastructure), CNPIEC, De Gruyter - IBR (International Bibliography of Reviews of Scholarly Literature in the Humanities and Social Sciences), De Gruyter - IBZ (International Bibliography of Periodical Literature in the Humanities and Social Sciences), DOAJ, EBSCO - Central & Eastern European Academic Source, EBSCO - SPORTDiscus, EBSCO Discovery Service, Google Scholar, Index Copernicus, J-Gate, Naviga (Softweco, Primo Central (ExLibris), ProQuest - Family Health, ProQuest - Health & Medical Complete, ProQuest - Illustrata: Health Sciences, ProQuest - Nursing & Allied Health Source, Summon (Serials Solutions/ProQuest, TDOne (TDNet), Ulrich's Periodicals Directory/ulrichsweb, WorldCat (OCLC)

Funding: This project DEP 2014-59707-P „SWIM: Specific Water Innovative Measurements applied to the development of International Swimmers in Short Swimming Events (50 and 100M)" was financed by the Spanish Ministry of Economy, Industry and Competitiveness (Spanish Agency of Research) and European Regional Development Fund.

This article is part of an international thesis belonging to the Program of PhD in Biomedicine (B11.56.1), from the University of Granada, Granada, Spain. Research was co-funded by a grant from „Young Scientists Research" 65/22/M/2016 received from University School of Physical Education in Wroclaw, Poland.

Conflict of interests: Authors have declared that no competing interest exists.

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INTRODUCTION

Many of the methods designed to improve motor task efficiency are based on the classical information theory. This theory posits that environmental stimuli are processed between receptors and their correlative effectors, generating a response. In locomotor activity, a motor response is the reaction to information received from, e.g., exteroreceptors (hearing, sight) and proprioceptors (vestibular receptors, muscles joints, skin) [1]. Moreover, the resulting locomotor activity can be used to provide additional information on the motor pattern or behavior for additional modification. This mechanism is known as feedback. Feedback can be defined as the return of information about the result of skill execution [1].

The literature identifies two types of feedback: i) intrinsic feedback is sensory information derived from receptors. It permits the regulation of movement as well as the augmentation of pre-structured motor programs by the “feelings” associated with the movement [2]; ii) extrinsic feedback, when the correct execution of a motor action is evaluated by external sources, i.e., verbal and visual ones [3]. Intrinsic feedback may not necessarily induce the correct execution of a motor task. For this purpose, extrinsic feedback can augment intrinsic feedback by providing information on the movement technique, efficacy, and effectiveness, reinforcing behavior or raising an athlete’s performance level. Another important variable is the timing of feedback. Feedback can be either concurrent (provided during the movement), immediate (provided just after the movement), or delayed (provided after some elapsed period of time) [4].

One of the most basic roles of trainers, instructors, and coaches is to provide prescriptive feedback [5]. While this exchange of information is relatively free of complications in dry land conditions, difficulties may arise if encumbered by environmental factors. For example, swimming in a body of water can impede hearing and sight and, therefore, interfere with the feedback process. Over the years, numerous methods have been developed to aid swimmers in this regard, including the use of video recordings to provide examples of the executed movement [6], or devices for wireless verbal communication [7]. Some facilities have installed chronometers in pools to provide swimmers with feedback on the swimming pace [8]. However, video recordings or outright verbal feedback may be insufficient when the training task involves a significant proprioceptive component.

The development of strength is crucial in swimming training. Among many different swim-specific strength training protocols, a key criticism is that the applied loads and training intensities are not always adequately matched to the swimmers’ age and ability [9]. In effect, this may reduce training effectiveness. Furthermore, trainers typically neglect training that focuses on overall physical development, instead focusing on sport-specific exercises and drills. This is unfortunate, as general exercise and low-intensity aerobic training are important in the global development of young athletes and may influence future performance and competitive success. Particularly in the case of young athletes, training that focuses on improving power output should involve individually-determined intensity and load. In swimming, the most immediate and measurable form of biofeedback is the generated muscular force [10]. Hence, the ability to measure the force produced by swimmers could allow for the real-time control of training and therefore optimizing training potential.

Effective swimming training should include several dry land exercises, the most common of which are weight lifting, core stability exercises, and other drills that involve pulling movements to train kinetic chains. Similarly to in-water swimming training, the training load (and the execution velocity of the exercises) should also be tailored to the individual swimmer. One common problem is that while information on training intensity and execution velocity is provided a priori, young and inexperienced swimmers often have problems with maintaining the prescribed intensity level. This can lead to cases of over-training, where the training load can exceed exercise capacity causing injury and performance stagnation or even regression [11]. On the opposite end of the spectrum, not reaching the target load due to inadequate exercise intensity of inappropriate exercise velocity could lead to undertraining and performance attenuation. Hence, real-time feedback of exercise execution is particularly warranted to avoid these detriments.

Hence, the aim of this study was to compare the effects of two different concurrent feedback conditions (visual vs. verbal) on biomechanical performance during a swimming strength task. It was assumed that the visual feedback condition could afford greater improvements than verbal feedback and serve as a more powerful tool for enhancing the task execution.

MATERIAL AND METHODS

PARTICIPANTS

Fourteen healthy, recreational swimmers were recruited. The characteristics of the sample were: age $\bar{x}$ = 22.21 ±1.85 years, body height $\bar{x}$ = 173.71 ±8.65 cm, mass $\bar{x}$ = 71.32 ±10.64 kg. All swimmers were attending a typical swimming program in which a total distance of 10 km was covered per week. Informed consent was obtained from all participants, and the research protocol was approved by the local ethics committee.

EXPERIMENTAL DESIGN

A repeated measures design was used to compare the execution of the butterfly stroke in response to two different randomized feedback conditions (visual vs. verbal). An incremental force test was administered for each participant to determine the mean propulsive velocity in which maximal power was produced. Participants were counterbalanced to control for order effects. Twenty maximal repetitions were then performed in both conditions and feedback was provided in order to achieve a higher number of repetitions within the range of the movement velocity target.

PROCEDURES

Testing was performed in the Swimming Laboratory belonging to the Faculty of Sport Sciences of the University of Granada (Spain). Participants reported to the research laboratory after having refrained from alcohol, caffeine, and strenuous exercise for the previous 48 h. The task under study was the butterfly stroke (propulsion phase only) performed in the horizontal position on a modified Smith Machine. The Smith Machine was connected to the T-Force System (Ergotech, Murcia, Spain), an isoinertial dynamometer connected to a computer that provides real-time information on performance during resistance training. The system automatically distinguishes the repetitions and phases of an exercise, providing data on various biomechanical variables.

The study began with the participants performing a dry land warm-up. Subsequently, an incremental force test was administered individually with the purpose to determine an individual range of load for every subject to perform the test. In this phase, the participant had to perform thirty maximal repetitions with increasing load (5, 10, 15, 20, 25, 30 kg). The participants were asked to perform the complete movement at maximal velocity, return to the starting position in a controlled manner, maintain the position for 1 s and perform a second repetition. The test was aborted if the participant was unable to complete a repetition. If the participant completed the test with the final 30 kg load (with increasing power), the load was increased by successive 5 kg increments. Three minutes of rest were given between trials. The individual selected the load accomplished with the maximal power that could be produced by lifting the increasing range of loads, and was determined through the linear encoder aforementioned (T-Force System, Ergotech, Murcia, Spain). Next, the range of velocity which corresponded to this load was obtained. This allowed the proper pull load within a range of mean propulsive velocity to be obtained for each participant and thus prescribe similar exercise intensity for all participants.

This pull load was then used in the proper experiment in which twenty repetitions were performed as close as possible to the individually obtained range of velocity. Hence, the goal was for the participant to maintain control over pulling velocity and therefore generate similar force. At the test outset, the participants were blinded to the applied pull load but provided feedback on the velocity they needed to achieve. Two conditions of feedback were randomly applied on the subjects. In the first condition, visual feedback was displayed on a monitor connected to the T-Force System (Fig. 1). Feedback was provided on the screen in the form of a bar chart (increase–decrease). The chart illustrated the attained velocity by the height of the bar and also by color (green if executed correctly and red if executed incorrectly). In the second condition, verbal feedback on the target velocity was provided concurrently to the task execution by one experimenter. In this condition, the experimenter observed the T-Force System monitor and provided immediate verbal feedback using one of three terms: ”faster” if velocity was below the prescribed range, ”slower” if the velocity was above the prescribed range, and”okay” if velocity was maintained within the prescribed range. These terms were adopted in order to minimize unnecessary information and preserve short-term memory potential [12]. The time of rest between repetitions was determined as the time to see or hear the feedback command.

Only in the visual feedback condition was the magnitude of execution velocity presented. This provided a double form of feedback; beside the relay that correct velocity was being maintained by showing the green color, the participant could also see how velocity fit within the prescribed range. This double form of feedback allowed for more precise control of execution velocity in successive repetitions that was not afforded in the verbal feedback condition. In the verbal condition, information was provided only if the velocity was correct (”okay”) or incorrect (”faster” or ”slower”).

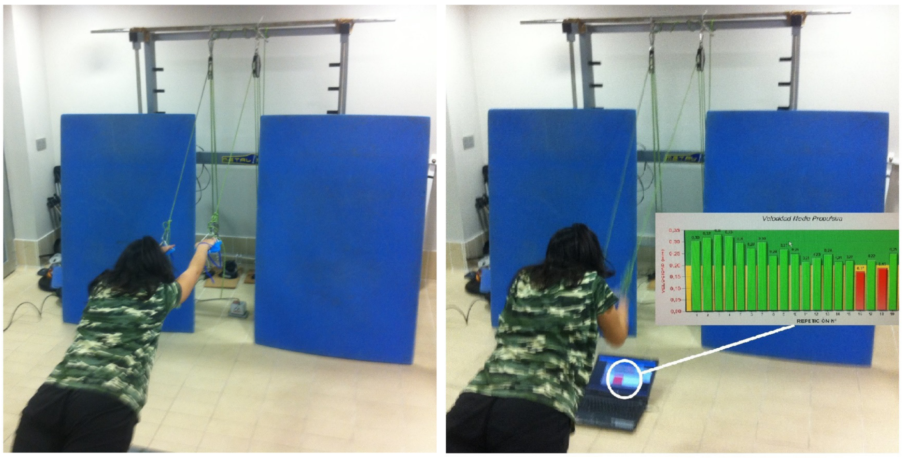

Fig. 1. The Smith Machine device showing both conditions (left: verbal feedback, right: visual feedback)

Measurements

Data were collected on the attained velocity of each pulling movement in response to verbal and visual feedback. The response was treated as a binary (zero–one), in which the task was either correctly (within the prescribed range of velocity) or incorrectly (outside of the prescribed range) executed. This dichotomous response format was used to examine the results and determine execution efficiency in response to the provided feedback. This allowed a comparison of the two feedback conditions. Additional analysis was also performed to extract how many cases of this double form of feedback were provided.

The participants also subjectively assessed the difficulty of the task by using the Borg Rating of Perceived Exertion (RPE). Participants rated the intensity level in both conditions on a sliding scale of 0–10, where level 0 describes the state of rest (heart rate 60 beats per min) and level 10 that corresponds to maximum effort (heart rate 200 beats per min) [13].

Statistical analysis

Data were processed using the Statistica 9.0 software package (StatSoft, USA). Prior to using a parametric test, the normality of data distribution was assessed. Statistically significant differences between the two conditions were determined using Student's t test. The level of significance was set at $p \leq 0.05$. Additionally, effect sizes were calculated using Cohen's d function as a supplement to the p value. Cohen's d is interpreted as: small ($d = 0.20$ to 0.49), moderate ($d = 0.50$ to 0.79) and large ($d \geq 0.80$) [14]. Data are presented in the text as percentages (percentage of a correct or incorrect motor response) to characterize the correct or incorrect response to the provided feedback.

Results

The results indicate that visual feedback resulted in a correct response in 76.11% of total feedback compared with 72.06% in the verbal feedback condition (Tab. 1, Fig. 2). More detailed analysis revealed that the feedback indicating the need to increase execution velocity (”faster”) elicited a correct response in 5.66% of total feedback in the visual condition and 8.50% in the verbal condition. Feedback indicating the need for decreased execution velocity (”slower”) elicited a correct response in 5.66% of total feedback in the visual condition and 4.45% in the verbal condition. Feedback indicating correct execution velocity (”okay”) elicited a correct response in 64.77% of total feedback in the visual condition and 59.10% in the verbal condition (Table 1, Fig. 3). The double form of feedback in the visual condition accounted for 12% (number of motor response equal to 30) of total feedback. T testing (p value) revealed no statistically significant differences between the verbal and visual feedback conditions; additionally, values of Cohen’s *d* effect sizes (*d* value) have been included: total feedback p = 0.524019, *d* = 0.15 (small effect size); ”faster” p = 0.337049; *d* = 0.36, ”slower” p = 0.427336; *d* = 0.01, ”okay” p = 0.527324; *d* = 0.19 (small effect size for all). No significant differences were observed in the Borg RPE between the two conditions (verbal: mean 5.23, SD 1.58; visual: mean 5.15, SD 1.46), (p = 0.890783; *d* = 0.05).

Table 1. Percentage effectiveness of verbal and visual feedback on execution velocity

Terms	Response	Verbal feedback (%)	Motor response (number)	$\bar{x}$	±	Verbal feedback (%)	Motor response (number)	$\bar{x}$	±
Total	Correct	72.06	178	13.69	4.84	76.11	188	14.46	4.85
	Incorrect	27.92	69	5.31	5.04	23.88	59	4.54	5.04
“Faster”	Correct	8.50	21	1.62	1.69	5.66	14	1.08	1.27
	Incorrect	11.33	28	2.15	4.20	1.61	4	0.31	0.57
“Slower”	Correct	4.45	11	0.85	1.23	5.66	14	1.08	1.21
	Incorrect	3.23	8	0.62	1.94	4.45	11	0.85	1.68
“Okay”	Correct	59.10	146	11.23	6.23	64.77	160	13.31	4.86
	Incorrect	13.36	33	2.54	2.11	17.81	44	3.38	4.87

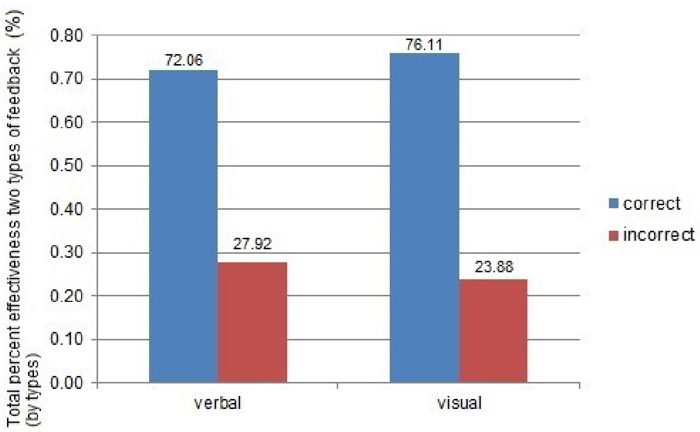

Fig. 2. Total percentage effectiveness of verbal and visual feedback on execution velocity

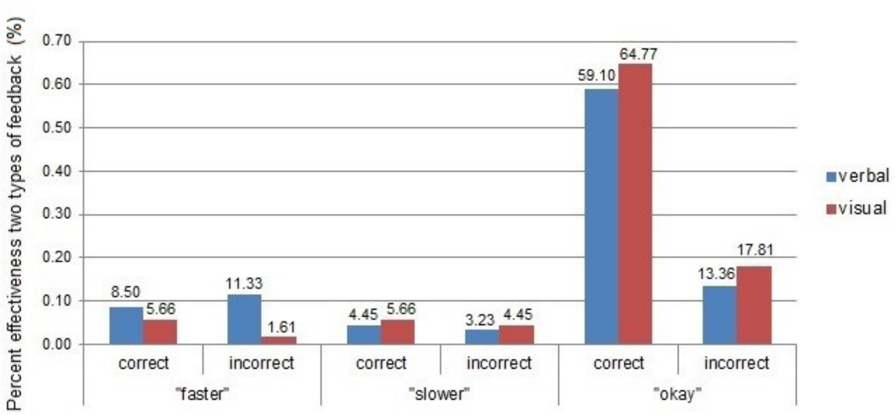

Fig. 3. Percentage effectiveness of the two types of feedback on execution velocity by type

DISCUSSION

The aim of this study was to compare the effects of two feedback conditions that could provide real-time information on execution velocity in a swimming task. Considering the total feedback response, the visual feedback condition was more effective than verbal feedback as it elicited 4.05% more correct responses. However, this difference did not attain statistical significance and, therefore, could not confirm the underlying hypothesis as the applied method could not clearly indicate which feedback condition was more effective.

Despite the fact that the presented investigation did not give a clear opinion on the dominance of one type of information over the other, it showed a possibility of using both methods in dry land workout among swimmers, which is considered a practical value of this study. Both verbal and visual information can help swimmers achieve training goals in dry-land training, such as maintaining the specific range of generated force or generate proper power.

The traditional verbal method is most often used, but it can be substituted by methods of visual feedback. Currently, many devices used during training have displays. Examples are cycloergometers, rowing ergometers, and treadmills giving immediate feedback on the basic parameters of the effort, i.e. HR, calories expenditure, exercise time, splits time, speed, acceleration, generated strength, power, etc. Many of these parameters appear immediately, and it is interesting which of them most effectively motivate athletes to increase their performance.

The presented results correspond with many other studies. Stastny et al. [15] also used visual information during the Wingate test. The main finding of this study was that the presence of visual feedback affected power output in the initial stage of the Wingate test, but did not affect power output when subjects were already fatigued during the final stage. In other studies, Campanella et al. [16] and Hopper et al. [17] show that the use of visual feedback resulted in greater peak power output compared to no visual feedback. By contrast, Zatoń [18, 19] in her numerous investigations emphasized the more important role of verbal information rather than visual during the control of swimmers' movement. As shown, results trying to resolve the dominance of one type of information over another are not coherent.

The results are nonetheless worthy of review, particularly in light of the fact that research has found that vision dominates the other senses. Visual information is often regarded as the most important perceptual modality when interacting with the environment [20]. In racing, it is common to see how athletes are able of modifying their race pace when they interact with other opponents. In swimming, variations on the swimming patterns such as: leg kicking, arm stroke technique or velocity of swimming are frequent in races in which opponents are able to see one another, even when they are fatigued. However, the literature has noted that visual feedback strategies can either facilitate or impair movement execution. On the one hand, visual feedback can significantly enhance the learning process for athletes, such as in the identification of errors that the coach believes to be important [21]. On the other hand, this form of feedback can be ineffective in improving skill performance due to the complexity of the information that needs to be transmitted, failure to provide adequate instructions, or deficient information that could aid error detection [22]. In considering an athlete's skill level, Gaudagnoli et al. [23] reported that visual feedback has an initial negative impact on a novice learner.

On the opposite end of the spectrum, a number of studies have provided strong evidence in support of verbal feedback as the most effective information delivery method [24]. Boyce [25] stressed the advantages of this feedback modality in the teaching–learning process of motor tasks as it can complement motor imagery with additional information. In the athletic realm, verbal information and auditory perception have been found to significantly contribute to elite performance in sports [15, 26]. However, verbal feedback requires caution in its implementation as its effectiveness depends on the correct interpretation of the supplied information. Studies have highlighted the role of criteria such as semantics, pragmatics, and syntax in providing effective feedback [19].

Similarly to the present results, research comparing verbal and visual feedback on motor performance has not provided a clear answer on which modality is more effective. This has been attributed to the effects of multiple variables including the skill level, task complexity, and the temporal properties of the feedback [27, 28]. For example, in the learning of a simple task, visual feedback increased performance in acquisition but not retention tests [29, 30]. Contradicting the guidance hypothesis, studies that analyzed more complex tasks observed high positive effects of concurrent visual feedback [31, 32]. Other problems arise from the design of the task, as devising tasks that are objectively quantifiable is not an easy feat. In turn, Amorose and Smith [33] examined learner interpretation of feedback to find that it is dependent upon previous experience with not only the type of administered feedback but also the individual experience.

The present study's use of concurrent feedback on movement execution velocity ("faster", "slower","okay") did not yield any clear findings. Furthermore, the results may have been skewed from the doubling of "okay" feedback in the visual condition (accounting for 12% of total feedback). In addition to information if the execution velocity was correct or not, information was also provided on the attained velocity and how it fit within the prescribed range in a bar chart format. This provided the participant with not only knowledge of results (KR) but also knowledge of performance (KP) [34]. KR indicates the extent to which an action achieves the stipulated goal. This type of feedback provides information on whether the executed movement is successful and not on the movement structure or its characteristics. In contrast to KR, KP is strongly associated with the actions of a movement in which its kinematic, kinetic, and physiological aspects are not easily discernible to the learner.

KP frequently includes references on the correct movement structure (technique) by providing information on what needs to be modified. This focuses the feedback on the most relevant elements and avoids interference from non-essential information or disruptive environmental stimuli [35]. Hence, the inclusion of KP and KR in the visual feedback condition could have contributed to the overall ascendancy of this form of feedback in the present study. Future studies should investigate the impact of feedback that includes a KP and KR component on the execution of a sports-specific motor task.

There are a growing number of swimming training aids for the professional, amateur, and recreational swimmer. These include wireless communication devices that allow for immediate feedback on the swimming technique. The verbal feedback provided by such a device was found to improve performance, reduce errors in the front crawl technique, and prevent the formation of poor habits [7]. Other developments include placement of a chronometer on the pool bottom. An assessment of this training aid found that that it allowed swimmers to improve competitive standing [8, 36], although it does need mentioning that while significant differences were observed between the chronometer condition and no feedback, the interaction between group and feedback condition was not significant. Another development includes the use of a light-emitting diode pacing system to monitor training intensity [37, 38]. Placed on the pool bottom, this lighting system was found to improve swimming speed control. Other aids that exist on the market include an underwater device that provides lap timing and counting information such as the Lap Track (Finis, USA) or the Chrono hand chronometer (SportCount, USA). Similar variants of the above include the Pacer (GBK Electronics, Portugal), Pace2Swim (FADEUP, Portugal), SwimLead (Synerte, Poland), or Swimming Pace Control System (Creosiv, Poland) [39]. The aforementioned devices all provide some form of visual feedback and have been found to improve movement execution.

Visual and verbal feedback have been found to be applicable in other sport contexts [40, 41], from general coaching to rehabilitation. Coaches have successfully adopted various forms of feedback to improve exercise technique and task execution [42, 43]. Therapists have also adopted verbal and visual cues to restore patients' health [44]. For this reason, future research should investigate not only more effective methods of delivering feedback but also ways on how to optimize the conveyed message. Such efforts could enhance not only the availability but also the effectiveness of feedback modalities. The present study provides an example on how visual feedback could be substituted with verbal feedback and vice versa. In addition, the introduction of new technological advancements (e.g. hand-held displays) shows a need for additional research to optimize these devices and the feedback they deliver. This may include a combination of verbal and visual feedback with tailored proportions of each of them. As the present study did not show a clear advantage of one feedback condition over the other, future studies should involve a larger sample size and attempt to limit or simplify the multitude of confounding variables including the type of feedback, task complexity, participant skill level, and feedback timing.

CONCLUSIONS

In conclusion, concurrent visual feedback elicited 4.05% more correct responses than verbal feedback. However, the results must be interpreted with caution due to the lack of statistical significance between the two feedback conditions. Additionally, the visual condition provided the swimmer with both knowledge of results and knowledge of performance. This suggests that an appropriately prepared visual cue can increase execution efficiency.

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Cite this article as:

Szczepan S, Zatoń K, Cuenca-Fernández F, Gay A, Arellano R.
The effects of concurrent visual versus verbal feedback on swimming strength task execution.
Balt J Health Phys Act. 2018;10(4): 61-71.
doi: 10.29359/BJHPA.10.4.05