

The effects of frequency of encouragement on performance during maximal exercise testing

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The aim of this study was to determine the effects of frequency of verbal encouragement during maximal exercise testing. Twenty-eight participants (12 males, 16 females) aged 20.9 ± 1.5 years (mean \pm s) performed a maximal exercise test ($\dot{V}O_{2\max}$) on a treadmill without any verbal encouragement. The participants were matched according to their pre-test $\dot{V}O_{2\max}$ and placed into either a control group or one of three experimental groups. They performed a second exercise test (post-test) 1 week later. During the second test, the control group received no verbal encouragement; the 20 s (20E), 60 s (60E) and 180 s (180E) encouragement groups received verbal encouragement every 20, 60 and 180 s, respectively, beginning with stage 3 of the exercise test. Relative $\dot{V}O_{2\max}$, exercise time, blood lactate concentration, respiratory exchange ratio (RER) and ratings of perceived exertion (RPE) were not significantly different from the first test to the second test for the control group without verbal encouragement and the 180E group that received infrequent encouragement. Post-test values were significantly higher than pre-test values for the 20E and 60E groups. The post-test values of the 20E group were significantly higher than their pre-test values for relative $\dot{V}O_{2\max}$ ($P < 0.001$), exercise time ($P < 0.0001$), blood lactate concentration ($P < 0.05$), RER ($P < 0.01$) and RPE ($P < 0.0001$); this was also the case for the 60E group for relative $\dot{V}O_{2\max}$ ($P < 0.01$), blood lactate concentration ($P < 0.05$), RER ($P < 0.05$) and RPE ($P < 0.05$). The results suggest that frequent verbal encouragement (every 20 s and 60 s in the present study) leads to significantly greater maximum effort in a treadmill test than when no encouragement is given or when the encouragement is infrequent (i.e. every 180 s).

Keywords: exercise, lactate, maximal oxygen uptake, verbal encouragement.

Introduction

Maximal exercise testing is a standard procedure in exercise physiology for the assessment of cardiovascular function. Maximal oxygen consumption ($\dot{V}O_{2\max}$) derived from the exercise test is of interest to researchers and clinicians primarily because of its diagnostic and predictive value. The measurement of $\dot{V}O_{2\max}$ often provides the baseline assessment upon which an exercise prescription is established and it may subsequently serve to determine the effectiveness of a specific training regimen. The assessment of $\dot{V}O_{2\max}$ might also reveal the presence and extent of cardiovascular disease. Regard-

less of the purpose for the maximal exercise test, it is essential to establish an accurate baseline value for $\dot{V}O_{2\max}$ because of the health-related decisions that typically follow its determination.

A common feature of most maximal exercise testing is the use of 'encouragement'. Encouragement refers to verbal statements such as 'Great job!' and 'Keep going!' that are routinely given during the test to obtain a maximal effort from the participant. Factors such as encouragement, drugs and mental distraction, which could affect expressions of strength, were originally studied by Campos *et al.* (1929), who observed that fatigue in dogs was ameliorated during lifting after the administration of injections of adrenaline. Ten years later, Lehman *et al.* (1939) determined that the stimulant Pervitin induced up to a three-fold increase in performance on a cycle ergometer. They reported that

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Pervitin did not improve any physiological mechanisms, but rather served as a central excitant that inhibited the perception of dyspnoea and fatigue. To help explain the mechanisms responsible for muscle fatigue, other researchers reported that cheering during maximal voluntary contractions (MVCs) appeared to result in altered psychological conditions that diminished muscular fatigue (McNair *et al.*, 1996). Another study revealed that fatigue established during repeated dynamic contractions was significantly reduced when the mental activity of solving mathematical problems was introduced (Asmussen and Mazin, 1978). These observations suggest that at least part of the muscle fatigue noted during repeated MVCs is developed within the central nervous system.

Although encouraging statements are routinely used in maximal exercise testing, few studies of the effects of verbal encouragement on $\dot{V}O_{2\max}$ have been reported (Butts *et al.*, 1982; Moffatt *et al.*, 1994; Chitwood *et al.*, 1997). The study by Moffatt *et al.* (1994) was a comparative analysis of the effects of encouraging statements in trained and untrained individuals. The importance of encouragement during testing was assessed in volunteers who completed two graded exercise tests, one with verbal encouragement and one without. For untrained non-athletes, verbal encouragement resulted in significantly higher values of relative $\dot{V}O_{2\max}$, exercise time on a treadmill, respiratory exchange ratio (RER), heart rate at exhaustion and post-exercise blood lactate concentration. Verbal encouragement for the highly competitive cross-country runners produced less of an effect and only generated significant increases in exercise time and heart rate. One problem with the study of Moffatt *et al.* (1994) was that they did not provide details about the encouragement provided. It is unclear what type of encouraging statements were delivered or the rate of encouragement, the duration of encouraging statements or the temporal distribution of encouraging statements.

More recently, Chitwood *et al.* (1997) studied the influence of verbal encouragement during the assessment of $\dot{V}O_{2\max}$ in individuals with Type A and Type B personalities. The Type A and Type B individuals performed two maximal tests, one with verbal encouragement and one without. Verbal encouragement led to significantly greater exercise duration, $\dot{V}O_{2\max}$ and RER for Type B individuals when compared with the 'no-encouragement' trial. The investigators concluded that the Type A personalities were independent of external motivation, whereas individuals with a Type B personality required persistent verbal prompting to extend exercise time to reach a true physiological maximum. However, as in the study by Moffatt *et al.* (1994), details about the type, rate and temporal distribution of encouraging statements were not provided.

Finally, Butts *et al.* (1982) compared verbal encouragement and no encouragement in 20 intercollegiate female cross-country runners. They found no significant differences in $\dot{V}O_{2\max}$, RER or pulmonary ventilation between the silent and verbal encouragement conditions. They did find significant differences in exercise duration and heart rate when encouragement was provided. However, only a brief abstract was reported and no procedural details of providing encouragement were provided.

Although the use of encouraging statements is a ubiquitous feature of maximal exercise testing, few studies have examined the effects of frequency of encouragement on exercise performance. Those that have reported the effects of encouragement have not provided sufficient procedural details to evaluate these effects. Furthermore, no study has systematically varied the frequency of verbal encouragement. The aim of this study was to determine the effects of frequency of verbal encouragement on exercise performance.

The participants in the present study performed two exercise tests. The first test was conducted without any verbal encouragement. The second test was performed with either no encouragement or with encouragement every 20, 60 or 180 s, depending upon the group. Several measures of metabolic performance were taken. We hypothesized that frequent statements of encouragement during bouts of aerobic exercise enhance the likelihood of a maximal effort. Specifically, we anticipated that, for all dependent variables ($\dot{V}O_{2\max}$, exercise time, blood lactate concentration, RER and RPE), there would be no significant differences between the pre-test and post-test scores for those who received no verbal encouragement, but that the post-test scores would be significantly higher than the pre-test scores when participants were given encouragement every 20, 60 or 180 s. Furthermore, we hypothesized a direct relationship between the rate of verbal encouragement and the participant's performance; that is, 20 s of encouragement should produce higher scores than 60 s of encouragement and 60 s of encouragement should produce higher scores than 180 s of encouragement.

Methods

Participants

The 28 participants (12 males, 16 females) were aged 18–22 years (20.9 ± 1.5 years; mean \pm s). All participants were students from Bloomsburg University of Pennsylvania. They were all healthy and were not engaged in a regular programme of exercise training at the time of testing. The participants signed an informed consent form and completed a medical and health

questionnaire before testing began. The Bloomsburg University Institutional Review Board approved the research protocol for the study.

Procedure

All testing was conducted in the Exercise Physiology Laboratory at Bloomsburg University. Each participant visited the laboratory on two occasions at the same time of day, 1 week apart. During the first visit, they completed the informed consent and medical and health questionnaire. At this time, the procedures of the study were explained to them. They were not given any information about the major independent variable (frequency of encouragement) but were simply asked to be present on two occasions to perform a treadmill exercise test. Height, body mass and skinfold thickness were determined. Skinfold thickness was measured using a Lange skinfold caliper (Cambridge Scientific Industries, Cambridge, MD) to the nearest millimetre. Body density was estimated from the method of Jackson and Pollock and percent body fat was determined from the sum of three skinfolds for each sex (Jackson and Pollock, 1978; Jackson *et al.*, 1980).

Experimental protocol

Pre-test. During the first maximal exercise test, no verbal encouragement was provided. This test was used to establish a baseline for each participant. A resting blood sample was obtained for the determination of blood lactate concentration before each maximal test. A Quinton Q50 Series 90 treadmill (Quinton Instruments, Seattle, WA) was used to conduct the exercise test. Heart rate was monitored during the test with a Polar Vantage NV (Port Washington, NY) heart rate monitor. Expired gases were collected and analysed by open-circuit spirometry at 20 s intervals using a SensorMedics V-Max 229 metabolic cart (Yorba Linda, CA). This metabolic cart has a fast-response oxygen analyser that uses high-sensitivity paramagnetic technology to measure the percentage of expired oxygen ($F_{E}O_2$), an infrared absorption analyser for the determination of fractional percentage of expired carbon dioxide ($F_{E}CO_2$) and a mass flow sensor for measuring expired volume (\dot{V}_E). The analyser was calibrated with gases of known concentrations according to the manufacturer's guidelines before each test session.

An Accusport® Portable Lactate Analyser (Sports Resource Group, Hawthorne, NY) was used to determine plasma lactate concentration. The Accusport® has been shown to be both valid and reliable (Naik *et al.*, 1996; Warych *et al.*, 1996; Wigglesworth *et al.*, 1996). The Borg (6–20) 15-point category scale was used to measure ratings of perceived exertion (RPE) (Borg,

1970). Timing of the onset and end of encouragement was accomplished by two solid-state timing modules (Coulbourn Instruments, Allentown, PA). An analog-display sound-level meter (Radio Shack, The Tandy Corp., Fort Worth, TX) was used to ensure that the intensity of verbal encouragement remained between 85 and 90 dB.

A modified Bruce treadmill protocol was used to elicit a maximal effort in less than 12 min. At the end of each 3 min exercise stage, RPE and blood samples were obtained. Ratings of perceived exertion were recorded by having the participant point to the number that best represented their perception of effort using the Borg 15-point category scale. The RPE scale was in full view of the participant throughout the test. A fingerprick blood sample was placed on an analysis test pad, which was immediately placed in the Accusport® Portable Lactate Analyser for determination of blood lactate concentration using reflectance photometry (Naik *et al.*, 1996; Warych *et al.*, 1996; Wigglesworth *et al.*, 1996).

The exercise test ended when the participant either attained $\dot{V}O_{2max}$ or until exhaustion. We used the commonly applied criteria for having achieved $\dot{V}O_{2max}$. The exercise test was considered maximal if the participants achieved any three of the following five criteria: (a) a plateauing of $\dot{V}O_2$ ($<2.0 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) with an increase in exercise intensity; (b) $RER \geq 1.1$; (c) blood lactate concentration $>8 \text{ mmol} \cdot \text{l}^{-1}$; (d) attainment of heart rate within $\pm 10 \text{ beats} \cdot \text{min}^{-1}$; and (e) $RPE \geq 18$ (Howley *et al.*, 1995; Klein *et al.*, 1997).

Group assignments. After obtaining baseline $\dot{V}O_{2max}$ during the first test, the participants were rank-ordered from highest to lowest $\dot{V}O_{2max}$. They were then divided into successive groups of four per group (i.e. the first four had the highest $\dot{V}O_{2max}$, the second four had the next highest $\dot{V}O_{2max}$, and so on). One participant from each group of four was randomly placed either into a control group or one of three experimental groups: encouragement every 20 s (20E), 60 s (60E) or 180 s (180E). This form of assignment ensured that all groups were matched on overall fitness during the second test.

Post-test. The participants in all four groups were tested a second time using the same exercise protocol as in the pre-test. This test was identical to the first test except that the three experimental groups received encouragement; the participants in the control group did not receive any verbal encouragement in either the first or second test. Verbal encouragement was initiated at the start of stage 3 of the exercise protocol. Our rationale for not starting the encouragement sooner was that the first two stages of exercise were relatively easy (i.e. not intense) and that the encouragement would have appeared superfluous. The 20E group received

verbal encouragement every 20 s throughout the test, with each bout of encouragement lasting 5 s. The 60E group received 5 s of verbal encouragement every 60 s; the 180E group received verbal encouragement every 180 s. Verbal encouragement consisted of a set of encouraging statements read from a prepared text. The statements included: 'Way to go!', 'Come on!', 'Good job!', 'Excellent!', 'Come on, push it!', 'Keep it up!', 'Push it!' and 'Let's go!' The volume of verbal encouragement was monitored continuously using a sound level meter and, although the verbal statements were rehearsed by the investigators before all tests, there was no guarantee that the intonation was constant across encouragement bouts. Hand clapping was simultaneously used with the verbal statements.

Statistical analysis

The research design used in this study was a before-matched-after four-group design. Because the participants were assigned to treatment groups by matching them on their pre-test $\dot{V}O_{2\max}$, the main independent variable (the amount of encouragement) was treated as a repeated factor in all analyses. A 2×4 completely within factor analysis of variance (ANOVA) was used to analyse the data. The two factors were test (pre-test vs post-test) and frequency of encouragement (none, 20 s, 60 s, 180 s). When a significant interaction was obtained between tests and frequency of encouragement, comparisons between pre-test and post-test scores at each frequency of encouragement were conducted with tests of simple main effects. However, *a priori* contrasts using simple main effects were conducted at each frequency of encouragement, even when a significant interaction was not found. We did this because we established the hypotheses before the experiment, predicting that there would be differences between pre- and post-tests in the 20 s, 60 s and 180 s encouragement conditions but not in the 'no encouragement' condition.

Results

Table 1 presents the physical characteristics of the participants. During the second treadmill test, the participants received encouragement at different rates.

The mean (range) number of encouraging statements in the 20E, 60E and 180E groups was 17.4 (13–20), 5.6 (2–8) and 1.6 (1–2), respectively.

Figure 1 shows the effects of different rates of encouragement on relative $\dot{V}O_{2\max}$ and the length of time participants remained on the treadmill during each exercise test. Solid circles represent values for the first treadmill test (pre-test) and open circles values

Table 1. Anthropometric data for the participants (mean \pm s)

Characteristics	Males (<i>n</i> = 12)	Females (<i>n</i> = 16)
Age (years)	20.9 \pm 1.1	20.9 \pm 1.5
Height (m)	1.70 \pm 0.012	1.70 \pm 0.011
Body mass (kg)	75.1 \pm 17.0	70.2 \pm 10.4
BSA (m ²)	1.8 \pm 0.3	1.8 \pm 0.2
BMI (kg·m ⁻²)	25.8 \pm 5.8	28.1 \pm 15.5
Body fat (%)	20.4 \pm 9.6	16.1 \pm 7.1

Abbreviations: BSA = body surface area, BMI = body mass index.

for the second treadmill test (post-test); error bars show the standard deviations within each group. Since the control group (no encouragement) did not receive any encouragement during the post-test, no differences were expected between the pre-test and post-test values for this group. Figure 1 shows that, for $\dot{V}O_{2\max}$ and exercise time, there was little or no difference between pre-test and post-test values for the no encouragement and 180E groups, but that post-test values were higher than pre-test values when participants received encouragement every 20 s and sometimes every 60 s. Our initial hypothesis for the relative measure of oxygen consumption was confirmed. There was a significant interaction between tests (pre-test and post-test) and frequency of encouragement ($F_{3,18} = 3.35$, $P < 0.05$). Tests of simple main effects showed that there was no significant difference in $\dot{V}O_{2\max}$ between pre-test and post-test for the no encouragement condition, but that $\dot{V}O_{2\max}$ was significantly higher during the post-test than the pre-test when participants received encouragement every 20 s ($F_{1,6} = 32.2$, $P < 0.001$) and every 60 s ($F_{1,6} = 12.1$, $P < 0.01$). Contrary to our initial hypothesis, 180 s of encouragement had no effect on $\dot{V}O_{2\max}$. Exercise time was significantly higher, overall, during the post-test than the pre-test ($F_{1,6} = 15.4$, $P < 0.01$). Tests of simple main effects showed that exercise time was significantly higher during the post-test than the pre-test in the 20 s encouragement condition only ($F_{1,6} = 383$, $P < 0.0001$). Thus, for exercise time, our hypothesis was confirmed for the 20 s but not for the 60 s or 180 s encouragement groups, for whom no differences were observed between the pre- and post-test.

Figure 2 shows the effects of different rates of encouragement on blood lactate concentration, RER and RPE during the two exercise tests. All three measures were significantly higher, overall, during the post-test than the pre-test ($F_{1,6} = 14.4$, $P < 0.01$; $F_{1,6} = 13.5$, $P < 0.01$; $F_{1,6} = 30.6$, $P < 0.001$, respectively). Tests of simple main effects confirmed our initial hypothesis: blood lactate concentration was significantly higher during the post-test than the pre-test in the 20E and 60E conditions ($F_{1,6} = 9.83$, $P < 0.05$; $F_{1,6} = 6.48$,

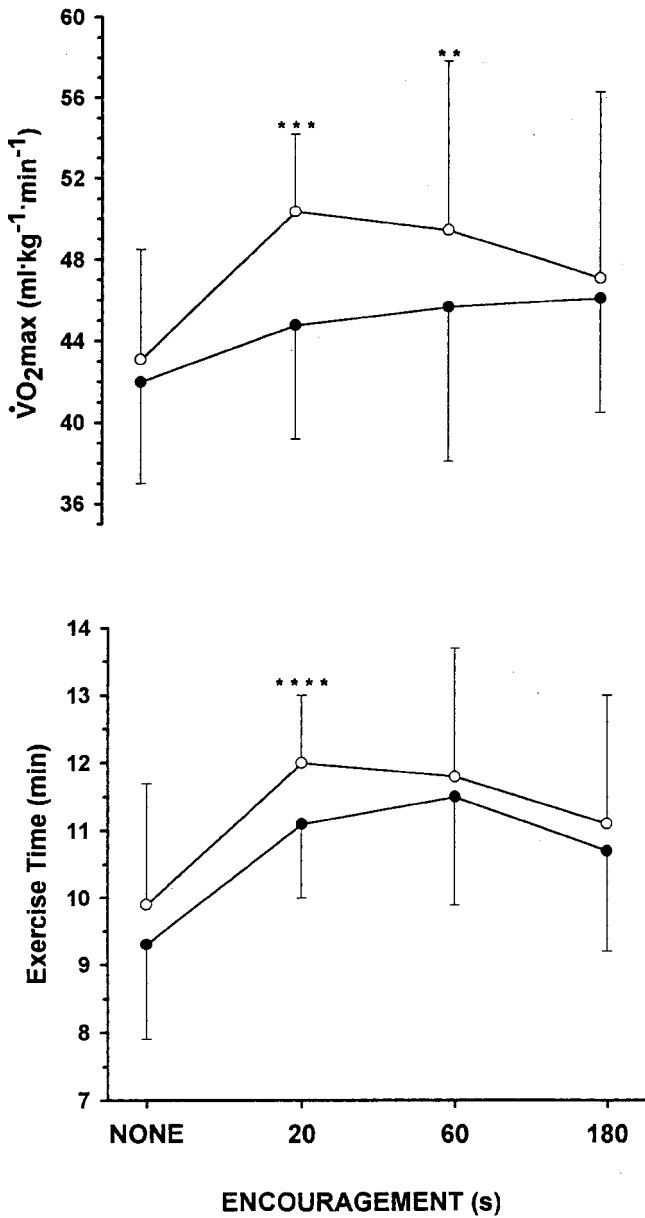


Fig. 1. Exercise time and $\dot{V}O_{2max}$ during the first maximal exercise test (pre-test, ●) and the second maximal exercise test (post-test, ○). Means and standard deviations are presented for groups receiving no encouragement (NONE) and encouragement every 20, 60 or 180 s during the post-test. Asterisks indicate that the post-test values were significantly higher than the pre-test values: ** $P < 0.01$, *** $P < 0.001$, **** $P < 0.0001$.

$P < 0.05$, respectively). Similarly, RER was significantly higher during the post-test than the pre-test in the 20 s and 60 s encouragement conditions ($F_{1,6} = 12.7$, $P < 0.01$; $F_{1,6} = 11.0$, $P < 0.05$, respectively). Ratings of perceived exertion were significantly higher during the post-test than the pre-test in the 20E, 60E and 180E conditions ($F_{1,6} = 48.6$, $P < 0.0001$; $F_{1,6} = 6.19$,

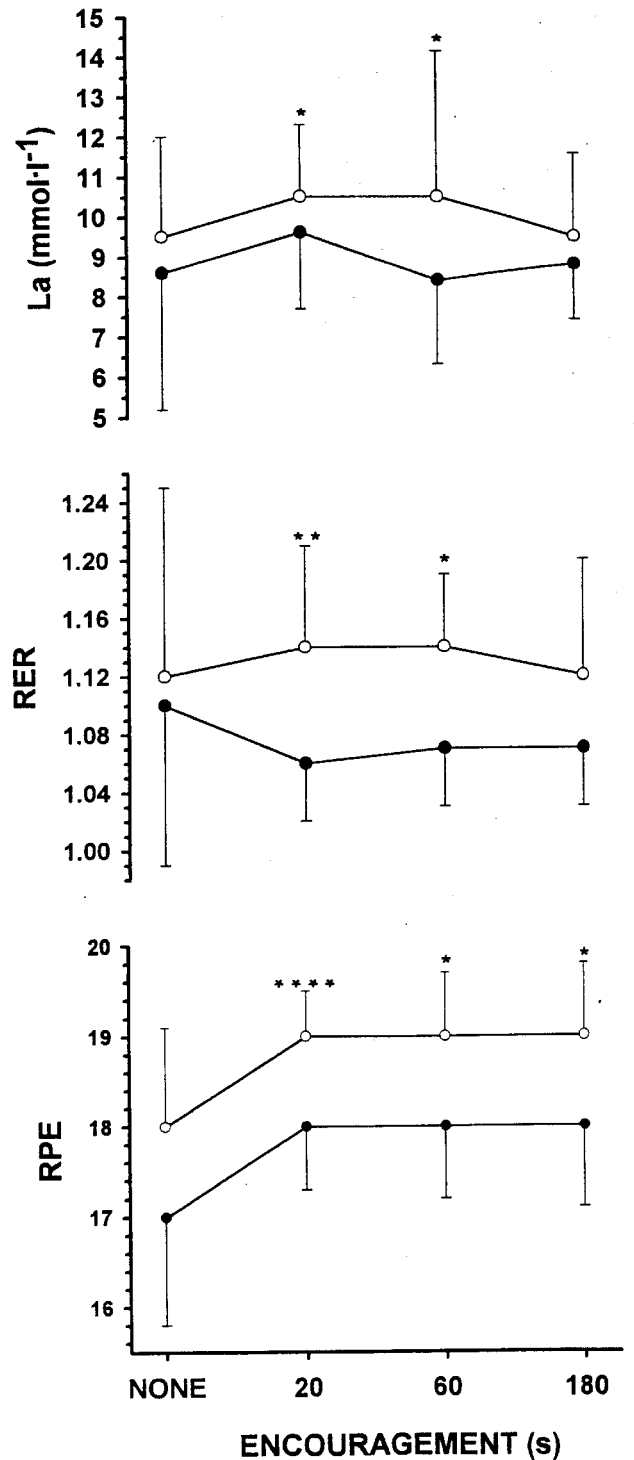


Fig. 2. Blood lactate concentration (La), respiratory exchange ratio (RER) and ratings of perceived exertion (RPE) during the first maximal exercise test (pre-test, ●) and the second maximal exercise test (post-test, ○). Means and standard deviations are presented for groups receiving no encouragement (NONE) and encouragement every 20, 60 and 180 s during the post-test. Asterisks indicate that the post-test values were significantly higher than the pre-test values: * $P < 0.05$, ** $P < 0.01$, **** $P < 0.0001$.

$P < 0.05$; $F_{1,6} = 6.25$, $P < 0.05$, respectively). Contrary to our hypothesis, no significant differences in blood lactate concentration or RER were observed between the pre-test and post-test in the 180E condition.

Discussion

Although the use of encouraging statements during maximal exercise testing is a standard procedure in most exercise physiology laboratories, the effects of these encouraging remarks have not been systematically explored. In the present experiment, all participants performed two maximal exercise tests. During the first test, no encouragement was provided; in the second test, however, the participants were given either no encouragement (the control group) or encouraging statements every 20, 60 or 180 s. Our main finding was that verbal encouragement during maximal exercise testing significantly alters several metabolic and cardiovascular variables. The results also show that verbal encouragement every 20 s and every 60 s significantly increases peak responses, but encouragement every 180 s has relatively little effect. These findings confirmed our initial hypothesis for the 20 s and 60 s conditions, but did not confirm our hypothesis for the 180 s condition. One reason why the 180 s condition failed to produce strong changes in the maximal metabolic variables may have been that the participants in this group only received one or two bouts of encouragement during the exercise test. Since encouraging statements were initiated during the third stage of the exercise test, there was relatively little time remaining in the test to provide encouragement at a rate of once every 3 min. This suggests that starting encouragement at an earlier stage of the test might be beneficial. Another unanswered question involves the effects of verbal encouragement at a rate faster than once every 20 s. Continuous encouragement, for example, might produce a greater maximal response, or it might result in a deterioration in performance – that is, too much encouragement might produce a satiation effect or might interfere with a person's attention to the task of running.

We hypothesized a direct relationship between the rate of verbal encouragement and performance; higher metabolic responses were predicted with encouragement every 20 s compared with every 60 s, and higher scores were predicted for encouragement every 60 s compared with every 180 s. The results suggest that such a relationship existed. Clearly, metabolic measures were consistently higher in the 20 s and 60 s conditions than in the 180 s condition. The differences in performance in the 20 s and 60 s conditions were less clear, but the results suggest that performance measures were

higher in the 20 s than in the 60 s condition. First, significant differences between pre-test and post-test scores were observed for five dependent variables in the 20 s condition compared to four dependent variables in the 60 s condition. Secondly, the significance was generally higher in the 20 s than in the 60 s condition. Finally, to examine further the claim that performance was better in the 20 s than in the 60 s condition, a non-parametric analysis of the data was performed. The number of participants within each treatment group that increased their performance on each dependent variable from the pre-test to the post-test was determined. How many participants within each group who showed an increase from the pre-test to the post-test of 3% or more was also determined. According to a one-tailed Sign Test (Siegel, 1956), the probability that all seven participants in a group would increase on some dependent measure from the pre-test to the post-test by chance was $P = 0.008$. When encouragement was provided every 20 s, all seven participants showed improvements in $\dot{V}O_{2\max}$, exercise time and RPE, and six of seven increased their blood lactate concentration. The effects of encouragement every 60 s were not as consistent; all seven participants in the 60 s condition showed consistent increases in $\dot{V}O_{2\max}$ and blood lactate concentration, but only 3/7 and 4/7 showed increases in exercise time and RPE, respectively.

We showed that oxygen consumption was strongly affected by verbal encouragement, especially when provided every 20 s. Maximum oxygen consumption increased 13.3% in the 20E group and 8.6% in the 60E group, respectively. Moffatt *et al.* (1994) reported an increase in $\dot{V}O_{2\max}$ of 5% (42.8 ± 0.6 vs 44.9 ± 0.8 ml·kg⁻¹·min⁻¹), while Chitwood *et al.* (1997) reported an increase of 8.7% in Type B individuals only. Butts *et al.* (1982) reported no significant change in $\dot{V}O_{2\max}$ with verbal encouragement (58.7 vs 58.8 ml·kg⁻¹·min⁻¹). No increases were observed in the control group, suggesting the need for frequent verbal encouragement to obtain a maximal effort.

The 20E group delayed ending exercise by nearly 1 min, which represented an 8.1% increase. Moffatt *et al.* (1994) reported that competitive runners responded positively to encouragement by increasing exercise time by 17.9%. When their untrained, non-athletic counterparts were analysed, verbal encouragement increased exercise time by 15.3%. The Type B personality individuals in the study of Chitwood *et al.* (1997) increased exercise time by 15.7%.

These results are supported further by the number of tests in which the classic criterion of a plateau in oxygen consumption was observed. A separate analysis was performed on those participants who demonstrated a plateau effect in each experimental condition. These included each of the seven participants in the 20E

group, four of seven in the 60E group, four of seven in the 180E group and three of seven in the control group. The results of this additional analysis showed a significant difference in the frequency of achievement of the classic plateau effect between the 20E group and all other groups ($F_{1,6} = 7.29, P < 0.05$).

Ours is only the second study to include blood lactate concentration as a dependent variable during verbally encouraged maximal exercise testing. In the other study, Moffatt *et al.* (1994) reported that competitive runners generated a higher blood lactate concentration when verbal encouragement was provided. The untrained, non-athlete group also generated a significant increase. We observed significant increases in blood lactate concentration when verbal encouragement was provided every 20 s (10.2% increase) and every 60 s (23.3% increase) during the maximal test. These changes in blood lactate concentration coincide with the significant increases in RER we observed in the 20E and 60E groups: an 8.2% increase in the 20E group and a 6.5% increase in the 60E group. The increases in our study are consistent with those reported previously (Moffatt *et al.*, 1994; Chitwood *et al.*, 1997). Moffatt *et al.* (1994) found a significant increase only when verbal encouragement was provided to the untrained, non-athlete group.

Each of the treatment groups in the present study generated significantly higher ratings of perceived exertion when compared with baseline. This was the first study of the impact of verbal encouragement on maximal responses to report ratings of perceived exertion. Post-test ratings of perceived exertion revealed an increase of 7.0% for the 20E and 60E groups and an increase of 4.0% for the 180E group.

Psychological analysis

Our results clearly show that verbal encouragement intended to increase a person's maximal effort has profound effects on performance. However, we can only speculate on the mechanisms that were responsible for the increased maximal effort. For example, talking to the participants might have distracted them from the discomfort of the test and made the test less aversive. Szmedra and Bacharach (1998) showed that playing music during exercise may interfere with unpleasant stimuli en route to sensory areas of the brain, resulting in significant changes in metabolic responses and increases in treadmill time. They suggested that music altered the stimulation patterns of the sympathetic division of the autonomic nervous system (Broadbent, 1958; Hernandez-Peon, 1961; Mockel *et al.*, 1994). The suggestion that encouraging statements might distract runners from the discomfort of a maximal effort is reminiscent of the concept of associative and dissociative cognitive strategies of improving athletic per-

formance reported in the literature (Masters and Ogles, 1998; Scott *et al.*, 1999). Using associative strategies, athletes focus attention on the physical sensations of their body such as pain or breathing. Using dissociative strategies, attention is focused away from the physical activity. Dissociation might be accomplished by listening to music or watching a video (Scott *et al.*, 1999) or, in our experiment, by listening to the voice of the experimenter.

A detailed analysis of the verbal statements used in this experiment shows that some of the words are what we typically think of as positive reinforcers for most people, such as 'Way to go!', 'Excellent!' and 'Good job!'. These putative positive reinforcers were provided as long as the participants ran on the treadmill and might be considered response-contingent reinforcers that helped maintain the running response. Other verbal statements provided resembled instructional commands, such as 'Come on!', 'Keep it up!', 'Let's go!' and 'Come on, push it!'. Since most people have a history of following instructions, these statements might lead to a greater response effort because the experimenter is commanding the participant to continue running. This example illustrates the mechanism of instructional control (Catania, 1998).

It is pertinent to ask why a participant is running on the treadmill in the first place and why he or she is likely to keep running into stage 4 of the test rather than quit early at the beginning of stage 3. There are probably multiple sources of behavioural control. Participants probably start the exercise test because they are following a request from the experimenter and students are required to participate in some research as part of their education. However, once the test becomes aversive, a maximal effort for some participants might be maintained by stimuli that others who quit early do not find reinforcing. For some participants, a maximal effort might be positively reinforced by achieving a competitive goal or by looking good to the experimenters observing their performance. A maximal effort might also be negatively reinforced by avoiding the appearance of weakness and of being out of shape and by not falling off the treadmill. From a motivational perspective, any event that increases the value of the stimuli that reinforce running on the treadmill (i.e. achieving a competitive goal, looking good, avoiding failure) should increase performance. Events that alter the effectiveness of reinforcing stimuli are called 'establishing operations' (Catania, 1998). Perhaps encouraging statements like 'Good job!' and instructional commands like 'Come on, push it!' might be thought of as establishing operations that increase the running response by increasing the reinforcing effectiveness of achieving a competitive goal, impressing the experimenters or avoiding failure. It is not unreasonable, for example, to expect that an

experimenter saying 'Good job!' might increase the reinforcing value of achieving a competitive goal. Future research should assess the effectiveness of reinforcement during exercise in children, the elderly and in special populations.

In conclusion, it is difficult to account for the influence of verbal stimuli on behaviour. Most researchers treat verbal encouragement as a standard feature of exercise testing without much thought to its function or effectiveness. We suggest further that a detailed analysis of the functions of verbal encouragement might help to improve test procedures and response efforts. In the final analysis, the stimuli that we classified as 'encouragement' had significant effects on maximal response effort. These encouraging statements might serve as distractors, positive reinforcers, instructional commands to keep running or establishing operations that alter the effectiveness of the other reinforcers that maintain running on the treadmill. The mechanisms by which these effects are mediated are clearly complex and should be addressed in future research.

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