THE ACUTE EFFECT OF MOUTH ONLY BREATHING ON TIME TO COMPLETION, HEART RATE, RATE OF PERCEIVED EXERTION, BLOOD LACTATE, AND VENTILATORY MEASURES DURING A HIGH-INTENSITY SHUTTLE RUN SEQUENCE

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ABSTRACT

Meir, R., Zhao, G-G., Zhou, S., Beavers, R., and Davie, A. The acute effect of mouth-only breathing on time to completion, heart rate, rate of perceived exertion, blood lactate, and ventilatory measures during a high-intensity shuttle run sequence. J Strength Cond Res 28(4): 950–957, 2014—This study investigated the effect of restricting nasal breathing during a series of 20-m shuttle runs. Ten male participants (mean age = 21.7 ± 2.4 years, height = 1.80 ± 0.62 m, mass = 79.2 ± 10.4 kg, sum of 4 skinfolds = 54.5 ± 7.8 mm) were required to either (a) dive on the ground and complete a rolling sequence (condition = GRD) or (b) complete the shuttles while staying on their feet and tagging the line with 1 foot, at the end of each 20-m segment (condition = STD). The shuttle runs were completed with and without a nose clip (no clip = nc; with a clip = clip) under 4 different trial conditions in a randomized order (GRDnc; GRDclip; STDnc; and STDclip), requiring the participants to return on 4 separate occasions separated by 5–7 days. Heart rate was recorded throughout each trial, and the rate of perceived exertion (RPE) was measured at the completion of each shuttle sequence. Prettrial and posttrial lactate and respiratory function measures were also recorded. The general linear model with repeated measures analysis indicated that there was a significant effect for Roll (GRD > STD) (p < 0.05) but not for Clip (p > 0.05) on total time to completion in the trials. There was no significant interaction of the conditions (Roll × Clip) for RPE (p > 0.05). Similarly, there was no significant effect for blood lactate measured 3 minutes post the last shuttle for Roll (p > 0.05) and Clip (p > 0.05). There was a significant main effect on the HR across all 6 time points (i.e., pre, intervals 1–4 and 10 minutes post) (p ≤ 0.05) and for Roll (GRD > STD) (p ≤ 0.05), but not for Clip (p > 0.05). No significant effect of Roll or Clip was found for any of the recorded ventilation measures (p > 0.05). On the basis of these findings, the use of restricted nasal breathing, while performing a high-intensity shuttle sequence as a method of increasing the acute training effect on athletes, is questionable, so strength and conditioning coaches should carefully consider their rationale for using such a training strategy.

KEY WORDS nose clip, restricted ventilation, high-intensity training

INTRODUCTION

The majority of research procedures within the sport science discipline can be categorized into 2 typical pathways. These are (a) the sport scientist identifies a problem and develops a research project that seeks to solve the problem and (b) the sport scientist observes a practice within the sports training environment and then seeks to establish if this practice has validity. It is through such a process that sport scientists work to extend their understanding and knowledge of how the human organism responds and adapts to training, and in the process works toward developing strategies that will help athletes to excel at their chosen sport.

Sport conditioning techniques to improve fitness are as novel and varied as they are many. Countless coaches and athletes have developed “new” training techniques simply based on a combination of their experience, an understanding of the basic principles of sports training, and their understanding of the demands of the sport (9). However, some of these practices have not necessarily had their validity and effectiveness tested using sound research methods, although this is not to suggest that these approaches do not have relevance and value within the context of the sports training environment.
An example of such a novel approach is the use of restricted nasal breathing observed in combat sports, such as boxing and mixed martial arts (MMAs). In this environment, athletes apply techniques such as breathing through a standard swimming snorkel, and wearing a nose clip, to restrict nasal breathing in an endeavor to increase the stress on athletes’ training for competition. Such practices seem to be used in the belief that they will help to improve the athlete’s sport-specific fitness. In support of such a rationale is the evidence that breathing effort during exercise has the capacity to influence whole-body perceived exertion and performance (6). Yet, there appears to be little specific research that has examined the pros and cons of such a strategy in the sport science literature. Further, what research that does exist focuses on the differences between mouth and nasal breathing compared with nasal breathing only.

Early research (1) examined the effects of a respiratory head canopy system compared with wearing a mask covering the mouth and nose, and a mouthpiece plus nose clip, on respiratory measures of subjects while resting in a supine position. With the use of a mask, or the use of a mouthpiece plus nose clip, there was an increase in tidal volume (TV mask only = 479 ml [32%]; TV mouthpiece plus nose clip = 416 ml [15.5%]) compared with a canopy (TV canopy = 362 ml). Increases were also seen in minute ventilation (VE) for mask only (VE = 7.7 L·min⁻¹) and mouthpiece plus nose clip (VE = 6.7 L·min⁻¹) when compared with a canopy only (VE = 5.97 L·min⁻¹). However, no significant change was seen in the respiratory frequency (RF) for the 3 conditions. The combination of a stable RF with increased TV when wearing the mask, or mouthpiece plus nose clip, suggests that there was a modest increase in stress on participants under these conditions.

Morton et al. (8) compared maximal oxygen consumption with oral and nasal breathing in 20 subjects (age, 18–55 years; 11 men and 9 women), to determine the maximum (treadmill) exercise intensity at which they could perform while breathing through the nose-only compared with mouth-only and mouth plus nose breathing. They found that the pattern of nose-only breathing at maximal work showed a small reduction in tidal volume (TV = 2.55 L) and large reduction in breathing frequency (RF = 32 b·min⁻¹) when compared with mouth-only breathing (TV = 2.68 L; RF = 43.9 b·min⁻¹). In addition, FEO₂ (i.e., the fractional concentration of oxygen in expired gas = 16.13%) was reduced in nose-only breathing with an increase in FECO₂ (i.e., the fraction of expired carbon dioxide = 5.16%) compared with mouth-only breathing (FEO₂ = 17.2%; FECO₂ = 4.28%). There was no statistically significant difference between mouth-only breathing and mouth plus nose breathing for these measured variables. This research established that while breathing through the nose-only, the subjects were still able to attain a work intensity that produced a training effect, and the mouth-only breathing did not affect VE.

The respiratory system has generally been considered not to impose any limits on healthy individuals during exercise. McConnell (6) states that this proposition has been based on the belief that (a) oxygen transport is not limited by diffusion of oxygen in the lungs at sea level; (b) human beings have a significant breathing reserve, even during maximal exercise; and (c) respiratory muscles are highly evolved and specialized and show no sign of fatigue during exercise. However, McConnell (6) also states that our understanding of the respiratory system and how it responds to exercise has advanced considerably over the past 10–12 years, and as a result, each of these assumptions (points a–c above) is questionable. In fact, it is argued that the respiratory system will respond positively to specific training, thus producing an ergogenic effect (6). McConnell (6) has rationalized that a weak or fatigued muscle will result in an increased perception of fatigue, compared with a stronger muscle that is less fatigued, which then poses the question of whether strengthening of the respiratory muscles may reduce the perception of fatigue during heavy exercise, and hence benefit athletic performance.

In light of the above, it appears that a closer examination of the impact of restricted nasal breathing during a simple sports-conditioning activity is justified, given that there is evidence that such a technique is used within some sports-conditioning environments. Therefore, the aim of this study was to examine a range of physiological responses during a common high-intensity sports-conditioning drill (i.e., completing a series of 20-m shuttle runs), where nasal breathing is unimpeded (i.e., participants breath through the mouth and nose) or restricted (i.e., participants wear a nose clip and breath through the mouth only). It was hypothesized that the application of a nose clip would have no significant influence on the selected physiological variables during the conditioning drills (Null hypothesis).

**Methods**

**Experimental Approach to the Problem**

This research used a simple high-intensity 20-m shuttle run sequence as the training stimulus with the participants either wearing or not wearing a nose clip to restrict nasal breathing. A shuttle run stimulus was selected because it is a very common, simple sports training movement that could be used indoors and is frequently used in sports-conditioning programs for a wide range of sports. No form of special training is required to perform such a movement.

The independent variables for this research were twofold, that is, (a) shuttle runs with the use of a nose clip to restrict nasal breathing and (b) shuttle runs with the act of dropping to the ground and performing the defensive roll as described below. The primary purpose of this research was to establish the impact of applying a nose clip, to restrict the participant’s breathing to the mouth only, while performing a simple and frequently used sports-conditioning drill, that is, a 20-m shuttle run with the participants either tagging the line with their
foot or dropping to the ground to perform a rolling action from the front chest to the back and return, as described and validated \((r = 0.744)\) previously by Holloway et al. \((5)\). The addition of the second independent variable was used to replicate a common whole-body movement used in sports such as rugby union, rugby league, and American Football. This required participants to go from an upright posture to one where they dropped to the ground and performed a rolling sequence (defensive body roll) at each end of the 20-m shuttle grid.

The dependent variables were heart rate (HR), blood lactate (BL), rating of perceived exertion (RPE), time and respiratory measures of forced vital capacity (FVC), forced expiratory volume in the first second (FEV\(_1\)), the ratio of FEV\(_1\)/FVC (percent), VE, RF, and TV. These variables were selected as best representing the influence of the independent variables on participants' physiological responses during a high-intensity 20-m shuttle run sequence.

Subjects

Ten male volunteers, who were registered rugby league, rugby union, or touch football players, participated in this study. Using a priori power analysis (G*Power 3; a freeware provided by Franz Faul, University Kiel, Kiel, Germany), it was predicted that 10 participants were sufficient for detecting within-factor differences using analysis of variance with repeated measures, with the assumption of effect size = 0.4, alpha = 0.05, power = 0.8, and 4 measures. All the participants were actively engaged in regular twice-weekly team training with the club that they were registered with; all the participants had a minimum of 2 years' playing experience in a regional community-based competition. All testing sessions were conducted at the same time of the day (between 2 and 4 PM) during the months of April and May 2012. The physical characteristics of the participants who completed all the tests were as follows (mean and \(SD\)): age = 21.7 ± 2.4 years, height = 180.3 ± 6.2 cm, body mass = 79.2 ± 10.4 kg, and sum of 4 skinfolds (triceps, subscapular, biceps, and iliac crest) = 54.5 ± 7.8 mm. All the participants were asked to attend a familiarization session 1 week before testing where the test procedures were demonstrated and information sheets were handed out. Upon expressing a willingness to participate in this project, the participants were asked to sign an informed consent form and complete a standard preparticipation health screening questionnaire. Before each test occasion, the participants were asked if they were free from any form of upper or lower respiratory tract infection; all the participants were nonasthmatic. The participants were advised that they could withdraw from this project at any time without any adverse consequences. All the procedures were approved by the Southern Cross University Human Research Ethics Committee (approval number: ECN-10–215).

Procedures

Each participant was required to complete a series of shuttle runs during each of 4 different trial conditions. The participants completed the 4-trial conditions in a randomized order, separated by 5–7 days in an attempt to control potential learning effects or physiological adaptation. The 4-trial conditions were as follows:

Condition 1 (GRDnc): completed while not wearing a nose clip, and completing a shuttle run sequence in a 20-m grid requiring the participants to drop to the ground on their chest, roll onto their back, and then roll back to their chest before regaining their feet (i.e., a defensive roll sequence, see Holloway et al. \([5]\) for complete description) at each 20-m line of a marked grid (Figure 1). Upon completing the ground roll, they got to their feet as quickly as possible and ran back up the grid for the required number of repetitions.

Condition 2 (GRDclip): completed while wearing a nose clip and completing the same shuttle run sequence and body roll as described in condition 1.

Condition 3 (STDnc): completed while not wearing a nose clip and completing a shuttle run sequence in a 20-m grid requiring the participants to remain on their feet. Each time they reached the end of the 20-m grid, they "tagged" the line with 1 foot, turned, and ran back up...
the grid completing this process for the required number of repetitions.
Condition 4 (STDclip): completed while wearing a nose clip and completing the same shuttle run sequence as described in Condition 3.

The participants were asked to abstain from heavy training in the 48 hours before each test occasion and to abstain from caffeine beverages and solid food in the 3 hours immediately before testing. They were also required to consume 500 ml of water in the 30 minutes immediately before testing.

Each shuttle was commenced and concluded with the participants lying face down on the ground at the start or finish line (Figure 1). One complete shuttle covered a 40-m distance from the start or finish line. The total distance covered under each condition was 400 m, comprising a series of intervals in the order of 1 x 40 m, 1 x 80 m, 1 x 120 m, and 1 x 160 m, each separated by a 60-second rest period. The participants remained in a prone position on the floor throughout the rest period. The total time to completion for each test was recorded with a handheld stopwatch. Immediately upon assuming a prone position on the floor after each shuttle interval, the participant’s HR and RPE were recorded. Heart rate was recorded continuously during each trial condition using a Polar RS800CX HR monitor (Polar Electro, Kempele, Finland). When completing more than one 40-m shuttle sequence, the participants simply “ran through” the start or finish line completing the required number of 40-m intervals for that particular sequence. Resting and posttest (at 3 minutes) blood samples were taken using a finger prick method for the analysis of whole BL concentration using a Lactate-Plus analyser (Nova Biomedical, Waltham, MA, USA). At the end of the last shuttle sequence, and after the final HR and RPE were recorded, the participants were asked to get up and move to a chair where they sat quietly for the remainder of the data collection process.

A handheld spirometer (Spiropalm 6MWT; COSMED, Rome, Italy) was used to measure resting FVC and FEV<sub>1</sub>. These measurements were taken after the measurement of resting BL and with the participants sitting quietly and free from distractions. After a further 60 seconds of rest, 2 minutes of natural breathing was recorded (VE, RF, and TV). At the completion of each trial condition, and immediately after the seated blood sample was collected, 2 minutes of natural breathing was recorded, once again while the participants sat quietly and without distractions. At 5-minute posttrial completion, the FVC and FEV<sub>1</sub> were recorded. Finally at 10-minute postcompletion of the trial condition resting, the HR was recorded.

All the trials were conducted indoors (temperature = 22.4 ± 1.8°C; relative humidity = 59.4 ± 11.1%; atmospheric pressure = 1,012.9 ± 7.5 mbar) with the participants wearing shorts, t-shirt, and trainers on a regular basketball court. A standardized warm-up lasting approximately 10 minutes was completed before each test occasion that included using a combination of static and dynamic movements and concluding with 1-2 low intensity shuttle sequences, either with or without defensive body roll depending on the trial condition to be completed.

Statistical Analyses
General linear model with repeated measures (GLMRM, SPSS version 19) was performed to determine (a) the main effects of exercise (Prepost), addition of ground roll (Roll), application of nose clip (Clip), and the 4 incremental shuttle runs (Interval), for the measured dependent variables; and (b) 2-way interactions of Prepost × Roll, Prepost × Clip, Roll × Clip, Interval × Roll, and Interval × Clip; and (c) 3-way interactions of Prepost × Roll × Clip and Interval × Roll × Clip, for the measured dependent variables.

The alpha level for statistical significance was set as 0.05. If a significant main effect or interaction was detected, post hoc comparisons with Bonferroni adjustment were performed to identify the location of the difference.

RESULTS
Total Exercise Time
The total exercise time was the sum of the time recorded for the 4 incremental runs in each of the 4 protocols (Table 1). The GLMRM detected a significant main effect for Roll [F(1, 9) = 1,016.128, p ≤ 0.05]; however, there was no significant effect for Clip [F(1, 9) = 0.006, p > 0.05]. Further, 2-way GLMRM for Clip × Roll demonstrated no significant interaction between these 2 factors [F(1, 9) = 0.223, p > 0.05].

Rate of Perceived Exertion
The RPE was measured after each shuttle interval for all 4 conditions (Table 1). The GLMRM detected a significant main effect of Interval [F(3, 27) = 263.509, p ≤ 0.05], a near significant effect of Roll [F(1, 9) = 5.037, p = 0.051] and no significant effect of Clip [F(1, 9) = 3.73, p > 0.05]. Both were detected. Post hoc comparisons with Bonferroni adjustment indicated that the RPE measured after the second, third, and fourth shuttle intervals was significantly higher than that after the previous run under all 4 conditions. Two-way GLMRM for Interval × Roll [F(3, 27) = 2.344, p > 0.05], Interval × Clip [F(3, 27) = 0.123, p > 0.05], and Roll × Clip [F(1, 9) = 0.068, p > 0.05] all demonstrated no significant interaction.

Three-way GLMRM for Interval × Clip × Roll demonstrated a significant interaction within the 3 factors [F(3, 27) = 11.921, p ≤ 0.05]. Post hoc analysis with Bonferroni adjustment showed that the RPE measured after the second, third, and fourth shuttle intervals was significantly higher than that after the previous run regardless of whether the nose clip was used. Further, the RPE for the GRDnc condition was significantly higher than that for the STDclip condition within the first and fourth shuttle intervals. Similarly, the RPE for the GRDnc condition was significantly higher than
<table>
<thead>
<tr>
<th>Condition</th>
<th>Time (s)</th>
<th>RPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inter’ 1 (40 m)</td>
<td>Inter’ 2 (80 m)</td>
</tr>
<tr>
<td>STDnc</td>
<td>10.09 ± 0.64</td>
<td>18.46 ± 0.74</td>
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<tr>
<td>STDclip</td>
<td>10.18 ± 0.35</td>
<td>18.68 ± 0.80</td>
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<tr>
<td>GRDnc</td>
<td>18.87 ± 1.17</td>
<td>36.28 ± 2.32</td>
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<tr>
<td>GRDclip</td>
<td>18.74 ± 1.46</td>
<td>36.12 ± 2.78</td>
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</tbody>
</table>

*RPE = rate of perceived exertion; HR = heart rate.
†Significant at $p \leq 0.05$ compared with RPE1/HR1 within the same condition.
§Significant at $p \leq 0.05$ compared with RPE3/HR3 within the same condition.
‡Significant at $p \leq 0.05$ BLpost compared with BLpre.
¶Significant at $p \leq 0.05$ compared with STDnc within the same interval.
#Significant at $p \leq 0.05$ compared with STDnc.
**Significant at $p \leq 0.05$ compared with STDclip.
††Significant at $p \leq 0.05$ compared with STDclip within the same interval.
for the STDnc condition within shuttle intervals 3 and 4, as was the STDclip condition compared with the STDnc condition for shuttle interval 4 (all \( p \leq 0.05 \)).

**Blood Lactate**

Whole BL was measured preexercise and 3 minutes postexercise for all 4 conditions (Table 1). The GLMRM detected a significant main effect of exercise (Prepost) [\( F(1, 9) = 1.006,116, p \leq 0.05 \)]; however, no significant effect of Roll [\( F(1, 9) = 1.349, p > 0.05 \)] and Clip [\( F(1, 9) = 1.892, p > 0.05 \)] was detected.

Two-way GLMRM for Prepost \( \times \) Roll [\( F(1, 9) = 0.11, p > 0.05 \)], Prepost \( \times \) Clip [\( F(1, 9) = 0.712, p > 0.05 \)], and Roll \( \times \) Clip [\( F(1, 9) = 0.929, p > 0.05 \)] all demonstrated no significant interaction. Similarly, 3-way GLMRM found no significant interaction for Prepost \( \times \) Roll \( \times \) Clip [\( F(1, 9) = 0.366, p > 0.05 \)].

**Heart Rate**

Heart rate was measured after each shuttle interval for all 4 conditions (Table 1). The GLMRM detected a significant main effect of Interval [\( F(3, 27) = 177.007, p \leq 0.05 \)] and Roll [\( F(1, 9) = 13.871, p \leq 0.05 \)] however, no significant main effect of Clip [\( F(1, 9) = 1.377, p > 0.05 \)] was detected.

Post hoc comparisons with Bonferroni adjustment indicated that the HR measured after the second, third, and fourth intervals was significantly higher than that after the previous run, regardless of the 4 conditions. The conditions involving the defensive body roll generally demonstrated a significantly higher HR than that without the body roll.

The two-way GLMRM for Interval \( \times \) Clip [\( F(3, 27) = 0.125, p > 0.05 \)] and Roll \( \times \) Clip [\( F(1, 9) = 0.120, p > 0.05 \)] demonstrated no significant interaction; however, a significant interaction of Interval \( \times \) Roll was detected [\( F(3, 27) = 14.681, p \leq 0.05 \)]. Post hoc comparisons with Bonferroni adjustment indicated that the HR values at the second, third, and fourth intervals were significantly higher than that after the previous run under both GRD and STD conditions, whereas the HR at the end of intervals 1 and 2 under the GRD condition was higher than that under the STD condition.

Three-way GLMRM for Interval \( \times \) Clip \( \times \) Roll demonstrated no significant interaction among the 3 factors during the exercise [\( F(3, 27) = 0.505, p > 0.05 \)].

Furthermore, a GLMRM analysis that includes the HR measured at preexercise and 10 minutes postexercise demonstrated that the preexercise (mean = 67.2 \( \text{b} \cdot \text{min}^{-1} \)) and postexercise (110.2 \( \text{b} \cdot \text{min}^{-1} \)) HRs were significantly (\( p \leq 0.05 \)) lower than HR after every shuttle interval, and the HR measured at 10 minutes postexercise was still higher compared with the preexercise HR for all 4 conditions (\( p \leq 0.05 \)).

Group mean responses for time, RPE, and selected physiological responses are presented in Table 1.

All mean (SD) respiratory responses pre and post each condition are presented in Table 2.

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**Table 2.** Mean (\( \pm SD \)) for measured ventilation variables for each condition \( (N = 10) \).

<table>
<thead>
<tr>
<th>Condition</th>
<th>FVCpre (L)</th>
<th>FEV1pre (L)</th>
<th>FVCpost (L)</th>
<th>FEV1post (L)</th>
<th>TVpre (ml)</th>
<th>VEpre (L)</th>
<th>TVpost (ml)</th>
<th>VEpost (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STDnc</td>
<td>4.94 ± 0.6</td>
<td>823.2 ± 9.5</td>
<td>4.94 ± 0.6</td>
<td>823.2 ± 9.5</td>
<td>123 ± 11.1</td>
<td>32.6 ± 3.6</td>
<td>123 ± 11.1</td>
<td>32.6 ± 3.6</td>
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*Significant at \( p \leq 0.05 \) post vs. pre.
Restricted Nasal Breathing as a Training Strategy

Forced Vital Capacity
The FVC was measured preexercise and postexercise in each of the 4 conditions. The GLMRM detected no significant main effects of Prepost [F(1, 9) = 2.756, p > 0.05], Roll [F(1, 9) = 0.187, p > 0.05], and Clip [F(1, 9) = 0.126, p > 0.05]. Two-way GLMRM demonstrated no significant interaction for Prepost × Roll [F(1, 9) = 0.250, p > 0.05] and Roll × Clip [F(1, 9) = 0.115, p > 0.05]. However, a significant interaction of Prepost × Clip was detected [F(1, 9) = 5.438, p ≤ 0.05]. Post hoc test with Bonferroni adjustment found that the FVC was lower in the STD trials with nose clips on compared with the trials without applying the nose clip. The three-way GLMRM found no significant Prepost × Roll × Clip interactions [F(1, 9) = 2.203, p > 0.05].

Forced Expiratory Volume in the First Second/Forced Vital Capacity
The FEV1/FVC (percent) was measured preexercise and postexercise in each of the 4 conditions. The GLMRM detected no significant main effects of Prepost [F(1, 9) = 0.000, p > 0.05], Roll [F(1, 9) = 0.023, p > 0.05], and Clip [F(1, 9) = 0.186, p > 0.05]. Two-way GLMRM for Prepost × Roll [F(1, 9) = 1.058, p > 0.05], Prepost × Clip [F(1, 9) = 0.854, p > 0.05], and Roll × Clip [F(1, 9) = 0.914, p > 0.05] all demonstrated no significant interaction. Similarly, 3-way GLMRM for Prepost × Roll × Clip demonstrated no significant interaction between the 3 factors [F(1, 9) = 0.484, p > 0.05].

Ventilation
Ventilation was measured preexercise and postexercise in each of the 2 conditions. The GLMRM detected a significant main effect of Prepost [F(1, 9) = 280.565, p ≤ 0.05], with the postexercise values higher than preexercise values. However, no significant main effect of Roll [F(1, 9) = 2.340, p > 0.05] and Clip [F(1, 9) = 1.576, p > 0.05] was detected. Two-way GLMRM detected no significant interaction for Prepost × Roll, and Prepost × Clip, nor for the 3-way interactions for Prepost × Roll × Clip [F(1, 9) = 0.082, p > 0.05].

Respiratory Frequency
The RF was measured preexercise and postexercise in each of the 2 conditions. The GLMRM detected a significant main effect of Prepost [F(1, 9) = 180.878, p ≤ 0.05], with the postexercise values higher than preexercise values. However, no significant main effect of Roll [F(1, 9) = 4.669, p > 0.05], and Clip [F(1, 9) = 0.951, p > 0.05] was detected. Two-way GLMRM detected no significant interactions for Prepost × Roll, Prepost × Clip or Roll × Clip, neither for the 3-way interaction for Prepost × Roll × Clip [F(1, 9) = 1.238, p > 0.05].

Tidal Volume
Tidal volume was measured preexercise and postexercise in each of the 2 conditions. The GLMRM detected a significant main effect of Prepost [F(1, 9) = 210.292, p ≤ 0.05], with the postexercise values being higher than the preexercise values. However, no significant main effect of Roll [F(1, 9) = 0.462, p > 0.05] or Clip [F(1, 9) = 1.313, p > 0.05] was detected. The two-way GLMRM detected no significant interactions for Prepost × Roll, Prepost × Clip, Roll × Clip, neither for 3-way interactions for Prepost × Roll × Clip [F(1, 9) = 0.721, p > 0.05].

Discussion
This project aimed to establish if restricting nasal breathing and forcing participants to only breathe through their mouth would have an effect on a range of acute exercise-induced physiological responses. It also examined the impact of this intervention on the RPE. The major finding was that applying a nose clip to confine breathing to the mouth only did not have any significant effect on the selected physiological measures. As a result of these findings, it may be questioned whether there are benefits associated with the use of restricting nasal breathing techniques that are currently being employed as a sports-conditioning strategy.

It has been speculated by others (6,9) that the application of a nasal clip may increase the perception of fatigue during training with such a device, whereas its removal for competition may result in the perception that high-intensity exercise is somewhat easier. Although this speculation on a positive psychological benefit on athletic performance is yet to be proven, the results of this study do not support such an influence during an acute high-intensity training activity. Our findings appear to be in line with those reported by Morton et al. (8) who found no difference in the VE and oxygen consumption variables between mouth-only breathing and mouth-and-nose breathing in an incremental treadmill run to volitional exhaustion. To establish the validity of using a nose clip and its impact on perceived exertion during high-intensity exercise a long-term training study would be warranted.

Strength and conditioning coaches and their athletes are always looking for ways to enhance performance. During submaximal exercise, the major determinant of aerobic performance is the capacity to deliver oxygen to the tissues (3), whereas in high-intensity exercise, the ability to continue working for an extended period is limited by an increasing accumulation of protons (H+), which results in decreased cellular pH and cellular acidosis (10). A good indirect measure of this acidosis is the lactate production that coincides with it (10). The findings in this study, as they relate to the BL level post each shuttle sequence, showed that there was no significantly higher lactate concentration while wearing the nose clip compared with when there was no nose clip, or while performing the defensive body roll compared with no body roll.

It has been observed that in combat sports strategies such as breathing through a snorkel while also restricting nasal breathing, or simply restricting nasal breathing alone, have been used in the belief that this would increase the physiological stress on the athlete and presumably produce...
a beneficial training effect. The assumption in this strategy appears to be that by restricting the volume of air moved through either the nose or mouth, it would result in a reduced arterial oxygen concentration (generalized hypoxia) and slow down the removal of CO$_2$ and other metabolites produced during strenuous exercise.

Such a theory might have some merit, because presumably 1 of the consequences of a reduction in the volume of air being inhaled and exhaled might be an increase in the BL concentration and a slowing of its removal. Such a strategy could be useful in conditioning athletes to tolerate higher cellular acidosis, as indicated indirectly by lactate concentrations, in high-intensity sports such as boxing and MMA. On this basis, it might be presumed that a significant reduction of pulmonary VE may produce a hypoxia effect. Furthermore, the BL, HR, and time to completion of an activity will provide measures of intensity and act as indirect measures of energy system use (9). Restricting nasal breathing could increase the contribution from anaerobic glycolysis to a given activity, if the pulmonary VE was significantly reduced by the application of a nose clip. However, as can be seen from the results of the current research, the application of a nose clip to restrict nasal breathing during high-intensity short duration exercise had no statistically significant effect on the pulmonary VE (immediately post-exercise) and any of the other measures (i.e., HR, RPE, BL, total time) when compared with when not wearing the nose clip. This clearly questions the efficacy of using such a strategy in the conditioning of athletes involved in high-intensity exercise typical of sports such as boxing and MMA. However, it is an area of sports training and conditioning that is worthy of further research.

**Practical Applications**

As argued by Meyers (7), it is the merging of “science and sweat” that will allow athletes to excel. The application of research to the practical sports training environment is now common place, and to this end, it plays an important part in informing coaching practice that is aimed at improving athletic performance (2). Importantly, Haag (4) points out that this process is not a 1-way street and that in fact practice can, and should, also guide research. In this context, this research has observed a practice within the practical field of sports conditioning that was yet to be substantiated as a valid technique for enhancing performance. The evidence here, examining the impact of restricted nasal breathing on a simple sports-conditioning drill, indicates that the acute effects of such a technique on a range of physiological indicators are not evident. As a result, the findings of this research have questioned this practice and recommend that coaches look elsewhere for improvements.

**References**