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Letter to editor

Effects of a Vented Mouthguard on Performance and Ventilation in a Basketball Field Setting

Dear Editor-in-chief

Mouthguards (MG) have possible effects on performance and breathing. Due to the use of MG some studies reported increases in aerobic capacity, or decreases in cardio-respiratory parameters (Bailey et al., 2015; Garner, 2015; Piero et al., 2015). Other studies found no relevant effects (Bourdin et al., 2006; Collares et al., 2014; Golem et al., 2017). However, previous studies are inconsistent with respect to their designs and with regard to the special requirements of team ball sports. For these reasons, we would like to use this letter to the editor to report new results investigating cardiorespiratory parameters without and with a mouthguard measured in a highly specific basketball course.

We recruited ten professional male first league basketball players (age: 25.1 ± 4.6 years, height: 1.99 ± 0.1 m, weight: 99.6 ± 14.4 kg) who were free of injuries, and any orthopedic, metabolic, or cardiorespiratory diseases. The subjects completed a basketball specific course (BSC) at medium and high load with and without a "vented" boil-and-bite “Nike adult max intake” mouthguard (Nike, Beaverton, OR, USA; VentMG) in a randomized order. The tests were performed on one day. The highly specific basketball course included all relevant elements of a game based on the statistics of the National Basketball League (NBA, season 2013/2014; Schulze et al., 2017). The running distance between the course elements was set according to the average mileage of the players during a game. An audio signal paced the duration of rounds and breaks. The target speed was set by marks on the ground, which had to be reached in the moment of the signal. According to pre-tests, the measuring error was less than 1 second per round. The mean test duration was 14 minutes. The medium intensity load (Test 1) corresponded to the average of the NBA games. For the high intensity level (Test 2), the intensities were increased by 20%, and breaks reduced by 24%. Each test consisted of four runs (run 1 - 4 and run 5 - 7), and each run consisted of two rounds (Table 1). Heart rate (HR), oxygen uptake (VO_2), ventilation (VE), tidal volume (VT), breathing rate (BR), carbon dioxide output (VCO_2) were all recorded continuously. The spiroergometric data (K4b², Cosmed, Italy) were measured breath-by-breath. The VO_2 and VCO_2 values were calculated from the end-expiratory gas concentrations and ventilation. The ventilation values were calculated as the product of BR and VT. The "medium" and "high" values were calculated from the load times of the tests. All “maximum” values were calculated for the last 10 seconds of Test 2. The blood sampling for lactate measurements (20 µl) were done prior to the warm-up, immediately after each test, and during each break.

Analysis of the results (Table 2) by paired t-tests revealed that the VO_2 values were significantly higher by approximately 6% in high and maximum load with the VentMG. In contrast, VE was 5% to 7% lower in high and maximum load. Corresponding to the lower ventilation, the end-expiratory O_2 and CO_2 difference was increased. All these results correspond to the longer inspiration and expiration times. The share of anaerobic energy expenditure was significantly reduced because Lac and RQ were both lower. The lower maximum lactate values corresponded to the increase in VO_2 (Table 2). The metabolic rate corresponding to the VO_2 values during maximum load was 30.8 ± 5.7 kcal (NoMG) and 32.6 ± 5.5 kcal (VentMG) ($p< 0.002$). Total (aerobic and anaerobic) metabolic rate was 32.3 ± 5.2 kcal and 33.1 ± 6.5 kcal, indicating that VentMG caused no relevant additional energy consumption. The peak exercise values could not be reached since the exercise intensity was limited by the course protocol. However, the VO_2 and VE values clearly show that the energy conversion efficiency was not affected by the VentMG, and that the breathing economy was even improved. The exercise ventilation is a marker of the muscle excitation and the resulting respiratory drive via C3/4 afferent nerves. Therefore, the VentMG may have induced decreased muscle strain and muscle reflexes to the respiratory center (Busse et al., 1991). A further explanation could be the better stabilization of the jaws by the VentMG, causing an improved movement economy. Thereby jaw clenching may support the whole-body stabilization in addition to the core muscles. A resulting lower local muscle activity would also be consistent with the lower lactate values and decreased RQ.

In conclusion the maximum load was not affected by the mouthguard, investigated in a basketball-specific exercise course in first league athletes. The lower ventilation for given VO_2 values with mouthguard use may be an effect of the improved biomechanics. However, further studies are needed to evaluate the cause and effect relationship, e.g. the effects of concurrent potentiation activation due to modified remote voluntary contractions by different modes of jaw clenching.

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References

Bailey, S.P., Willauer, T.J., Balilionis, G., Wilson, L.E., Salley, J.T., Bailey, E.K. and Strickland, L.T. (2015) Effects of an over-the-counter vented mouthguard on cardiorespiratory responses to exercise and physical agility. *Journal of Strength and Conditioning Research* **29**, 678-684.

Bourdin, M., Brunet-Patru, I., Hager, P.E., Allard, Y., Hager, J.P., Lacour, J.R. and Moyen, B. (2006) Influence of maxillary mouthguards

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on physiological parameters. *Medicine & Science in Sports & Exercise* **38**, 1500-1504.

Busse, M.W., Maassen, N. and Konrad, H. (1991) Relation between plasma K+ and ventilation during incremental exercise after glycogen depletion and repletion in man. *The Journal of Physiology* ***443**, 469-476.*

Collares, K., Correa, M.B., Mohnsam da Silva, I.C., Hallal, P.C. and Demarco, F.F. (2014) Effect of wearing mouthguards on the physical performance of soccer and futsal players: a randomized crossover study. *Dental Traumatology* **30**, 55-59.

Garner, D.P. (2015) Effects of various mouthpieces on respiratory physiology during steady-state exercis in college-aged subjects. *General Dentistry* **63**, 30-34.

Golem, D.L., Davitt, P.M. and Arent, S.M. (2017) The effects of over-the-counter jaw-repositioning mouthguards on aerobic performance. *The Journal of Sports Medicine and Physical Fitness* **57**, 865-871.

Piero, M., Simone, U., Jonathan, M., Maria, S., Giulio, G., Francesco, T., Gabriella, C., Laura, A., Eva, B., Gianni, M., Francesco, C. and Giovanni, G. (2015) Influence of a custom-made maxillary mouthguard on gas exchange parameters during incremental exercise in amateur road cyclists. *Journal of Strength and Conditioning Research* **29**, 672-677.

Schulze, A., Kwast, S. and Busse, M. (2017) Vented mouthguard effects on cardiopulmonary parameters in basketball: a pilot study. EC *Dental Science* **15**, 182-190.

Table 1. Basketball specific elements and the duration of rounds and breaks. Test 1 was performed with medium intensity. Round A (elements 1-4) focused on the coordinative, agility and ball handling movements. Round B (elements 5-7) reflected the running specific game situations. In Test 2, the intensities were increased by 20%, and breaks reduced by 24%. Each test consisted of two rounds.

Element	Movement description	Time (s)
1 (Round A)	4 m speed steps forward, backward left side, right side	6.00
2 (Round A)	receiving a throw in and dribble 26 m forward, 5 m backwards, coverdribbling 3 m, drive and lay up	11.70
3 (Round A)	two vertical jumps on each corner of the basket board, slide 4 m	10.00
4 (Round A)	defense slide 6 m, ends with back pivot zig zag sprint: 3 x 6 m sprint, each ends with back pivot, followed by 15 m sprint	11.50
5 (Round B)	20 m zig zag dribbling	7.00
6 (Round B)	pass, followed by 7 m sprint, ends with back pivot, catch and shot	7.00
7 (Round B)	6 m run to free throw line, receiving pass and shot, followed by 22.5 m sprint	8.16

	Round A	Round Break	Round B	Round Break	Time of Motion	Duration per Test
Test 1 (s)	39.20	11.36	22.16	22.70	245.04	381.04
Test 2 (s)	32.00	6.00	17.00	20.00	196.00	300.00

Table 2. Exercise results without breaks.

Parameter	Intensity	Mean (SD) VentMG	Mean (SD) NoMG	p-value
Oxygen consumption (ml/min)	Medium	3622 (629)	3434 (894)	n.s.
	High	3956 (668)	3738 (695)	0.002
	Maximum	4393 (674)	4125 (670)	0.0005
Heart rate (bpm)	Medium	145.5 (10.13)	147.0 (10.83)	n.s.
	High	158.2 (12.29)	154.9 (14.61)	n.s.
	Maximum	164.3 (10.46)	159.6 (19.98)	n.s.
Ventilation (l/min)	Medium	94.26 (16.75)	99.12 (20.07)	n.s.
	High	117.1 (21.16)	126.5 (23.00)	0.038
	Maximum	127.7 (23.67)	134.2 (23.78)	0.049
Respiratory rate (1/min)	Medium	38.19 (6.6)	43.9 (7.3)	0.014
	High	45.4 (8.6)	50.5 (7.2)	0.005
	Maximum	47.3 (9.2)	51.2 (9.0)	0.037
VT (1/min)	Medium	2.56 (0.50)	2.38 (0.60)	0.049
	High	2.64 (0.42)	2.57 (0.50)	n.s.
	Maximum	2.76 (0.48)	2.68 (0.49)	n.s.
FeO2 (vol %)	Medium	16.11 (0.61)	16.62 (0.61)	0.002
	High	16.57 (0.63)	17.05 (0.44)	0.002
	Maximum	16.47 (0.64)	16.83 (0.78)	0.02
FeCO2 (vol %)	Medium	4.61 (0.47)	4.24 (0.56)	0.001
	High	4.54 (0.51)	4.21 (4.2)	0.0005
	Maximum	4.61 (0.52)	4.26 (0.42)	0.003
Te (s)	Medium	0.89 (0.19)	0.76 (0.11)	0.012
	High	0.75 (0.16)	0.66 (0.11)	0.005
	Maximum	0.71 (0.12)	0.63 (0.11)	0.006
Ti (s)	Medium	0.79 (0.10)	0.70 (0.12)	0.013
	High	0.66 (0.08)	0.60 (0.10)	0.004
	Maximum	0.62 (0.09)	0.59 (0.10)	n.s.
Respiratory quotient	Medium	0.95 (0.06)	0.98 (0.07)	n.s.
	High	1.06 (0.07)	1.13 (0.06)	0.002
	Maximum	1.05 (0.07)	1.08 (0.08)	0.017
Blood lactate (mmol/l)	Pre-Test	0.97 (0.16)		
	Medium	2.32 (1.03)	2.23 (1.12)	n.s.
	High	3.2 (1.61)	3.80 (2.11)	0.027