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LONG-TERM EFFECTS OF WEARING THE ELEVATION TRAINING MASK ON PHYSICAL PERFORMANCE IN YOUNG SOCCER PLAYERS

DOLGOROČNI UČINKI UPORABE VADBENE MASKE ZA SIMULACIJO VIŠINSKEGA TRENINGA NA FIZIČNO ZMOGLJIVOST MLADIH NOGOMETAŠEV

ABSTRACT

The aim of the present study was to investigate the effects of the 6-week soccer training in on-session on the physical performance (PP) in 17-19 years old soccer players wearing elevation training mask (ETM) during workout. A total of thirty-six healthy soccer players (mean age 17.81 ± 0.89 years, weight 65.95 ± 5.72 kg, height 177.06 ± 4.56 cm and BMI 22.1 ± 2 kg/m^2) voluntarily participated in the present study. Participants randomly were divided into an experimental group (EG) and control group (CG). EG (n=14) used elevation training mask®2 (set-up as 2750 m altitude, wear in 3 workout a total of 270 min/week), while CG (n=22) didn't use ETM during interventions. Two groups completed the same soccer training program. Alactic anerobic power (ALAnPw), maximal oxygen use, fatigue index, average power output (APO), speed and flexibility of participants were evaluated.

After carried-out a 2x2 ANOVA analysis for changes between pre-test and post-test values of two groups, there were no significant differences (p>0.05) of ALAnPw (F = 0.168, η^2 = 0.002), flexibility (F = 0.030, η^2 = 0.001), fatigue index (F = 0.036, η^2 = 0.001), APO (F = 0.029, η^2 = 0.001), VO_{2max} (F = 0.382, η^2 = 0.011), and Speed (F = 0.023, η^2 = 0.001) between EG and CG.

In conclusion, the use of ETM during soccer practices can increase physical performance of young soccer players. However, these improvements were not more than improvements in conventional conditions.

Key words: physical fitness, simulate hypoxia, exercise

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IZVLEČEK

Namen raziskave je bil preučiti učinke 6-tedenskega nogometnega treninga na fizično zmogljivost (FZ) nogometašev, starih 17–19 let, ki so med treningom nosili višinsko vadbeno masko (VVM). V raziskavi je prostovoljno sodelovalo skupno 36 zdravih nogometašev (povprečna starost 17,81 ± 0,89 let, teža 65,95 ± 5,72 kg, višina 177,06 ± 4,56 cm in BMI 22,1 ± 2 kg/m^2). Merjenci so bili naključno razdeljeni v testno skupino (TS) in kontrolno skupino (KS). Člani TS (n = 14) so uporabljali višinsko vadbeno masko ®2 (nastavljeno na višino 2750 m, na treh vadbah, skupaj 270 min/teden), člani KS (n = 22) pa maske med intervencijami niso uporabljali. Obe skupini sta zaključili enak program nogometnega treninga. Merili smo alaktatno anaerobno moč (ALAnPw), maksimalno porabo kisika, indeks utrujenosti, povprečno izhodno moč (APO), hitrost in fleksibilnost.

Potem ko smo za obe skupini opravili analizo sprememb med vrednostmi pred testom in po testu 2x2 ANOVA, med TS in KS nismo odkrili statistično značilnih razlik (p > 0,05) v ALAnPw (F = 0,168, η^2 = 0,002), fleksibilnosti (F = 0,030, η^2 = 0,001), indeksu utrujenosti (F = 0,036, η^2 = 0,001), APO (F = 0,029, η^2 = 0,001), VO_{2max} (F = 0,382, η^2 = 0,011) in hitrosti (F = 0,023, η^2 = 0,001).

Zaključili smo, da lahko uporaba višinske vadbene maske med nogometnim treningom poveča fizično zmogljivost mladih nogometašev. Vendar pa omenjene izboljšave niso bile več kot zgolj izboljšave v običajnih pogojih.

Ključne besede: telesna pripravljenost, simulacija hipoksije, vadba

INTRODUCTION

In recent years, improving physical performance (PP) of athletes is gaining importance. Many training methods have been developed to improve PP, especially in sports with long duration and high intensity such as soccer (Hills et al., 2018; Iaia et al., 2015; Kobal et al., 2017). The altitude training (AT) is one of these training methods (Dodd & Newans, 2018; Millet, Roels, Schmitt, Woorons & Richalet, 2010; Porcari et al., 2016). AT was initially used in order to improve the endurance and VO_{2max} capacities of athletes. However, subsequent scientific studies emphasized that this training method has positive effects on other motor capacities such as strength and speed, also (Girard, Brocherie & Millet, 2017; Vogt & Hoppeler, 2010).

There are different methods for performing altitude training. Generally, athletes carry out altitude camps or practices for up to 3 weeks at 2000-3000 m elevations before the season. Many soccer teams go to their domestic or foreign camps. The purpose of altitude training is to increase the motivation of soccer players and to benefit from the positive effects of altitude on condition. However, it is a significant disadvantage that the cost of implementing AT camps is very high. In addition, some studies mentioned that the effect of AT has lost in several days/weeks after athletes returned to low altitude, near to sea level (Constantini, Wilhite & Chapman, 2017; Lundby & Robach, 2016; Stray-Gundersen, Levine, 2008).

In order to increase PP, instead of to train and/or to live at high altitude, sports scientists began to use respiratory muscle training methods. The respiratory system is one of the factors limiting the PP of athletes. Enright and Unnithan (2011) conducted a study of respiratory muscle training at different pressures of 8 weeks. The researcher found that sustained maximal respiratory pressures of 60% and 80% increased the working capacity and power output of the subjects (Enright & Unnithan, 2011). Romer, McConnell and Jones (2002) examined the effect of respiratory muscle training on endurance performance and respiratory muscle fatigue of cyclists. The study concluded that 6-week respiratory muscle training can improve performance (Romer, McConnell & Jones, 2002). Kido et al. (2013) conducted 6-week breathing resistance training using ReBNA elevation training mask with valves ventilation resistance. Researchers reported higher improvement of VO_{2peak} than the control group which didn't use ReBNA. However, only 5 subjects participated in this study (Kido et al., 2013). Thus it was stated that sports scientists need more well-designed studies about to increase respiratory muscle resistance and PP.

Recently, elevation training masks (ETM), which simulate hypoxia, have increased in popularity among athletes. ETM is a new training tool used for respiratory muscle training (Jagim et al., 2018; Millet et al., 2010; Porcari et al., 2016; Romero-Arenas, Lopez-Perez, Colomer-Poveda & Marquez, 2019). Although ETMs have been very expensive at the beginning, the cost has decreased with the development of technology. The ETM covers the nose and mouth. It has flux valves which can be adjusted to increase the resistance of respiratory system. Flux valves are designed to limit the amount of air entering the mask and can limit oxygen uptake at different levels. ETM is designed to simulate training at an altitude of about 914 to 5.486 m (Elevation Training Mask [ETM], 2019). In some studies, although it was stated that worn ETM increased ventilatory threshold (VT) and power output (PO), still there was no consensus among sports scientists that it was really effective. In addition, it is observed that the researches carried out with ETM were mostly related to aerobic capacity and anaerobic power and non-athletes. There are limited studies examining the effect of exercise programs combined with ETM on other physical properties of athletes (Biggs, England, Turcottte, Cook & Williams, 2017; Jagim et al., 2018, Kido et al., 2013; Millet et al., 2010; Porcari et al., 2016). In our knowledge, there aren't studies about ETM worn during on-season training in soccer.

The aim of the present study was to investigate the effects of the 6-week soccer training in on-session on the PP in 17-19 years old soccer players wearing ETM during workout. The hypothesis of the study was the soccer group wearing the ETM would have greater increases in alactic anerobic power, maximal oxygen uptake, fatigue index, average power output, speed and flexibility when compared to the group not wearing ETM.

METHOD

Participants

A total of thirty-six healthy soccer players (mean age 17.81 ± 0.89 years, weight 65.95 ± 5.72 kg, height 177.06 ± 4.56 cm and BMI 22.1 ± 2 kg/m^2) voluntarily participated in the present study. All participants have been playeing in U17 and U19 team of Bursapor Club (I Division) at least for 3 years. The other inclusion criteria were that players haven't been injured since last 6 month and last 3 months haven't used any medications which affect their performance. The study was conducted on the second competitive season on February and March 2018 at Bursaspor Vakıfkoy Orhan Ozselek Soccer facilities (altitude 100 m). The research was approved by Bursa Uludag University Medical Faculty Ethics Committee (2018-10/13) and conducted in accordance with the Helsinki Declaration. All volunteers provided written informed consent before participation.

Experimental Design

Participants randomly were divided into an experimental group (EG) and control group (CG). EG (n=14) used elevation training mask®2 (ETM) during interventions (Training Mask LLC, Cadillac, Michigan). While CG (n=22) didn't use ETM during interventions. The ETM and its use during soccer training is shown in Figure 1. Before start research, researchers give knowledge to participants about interventions. EG has familiarized with ETM for a week before interventions. All participants maintained a normal daily diet and sleeping habits. Two groups completed the same a 6-week soccer training program. Participants workout especially soccer training 5 times/week plus 1 official match/week, each practice lasted 90 min (Table 1). Only in 3 workout / week, EG wore ETM, a total of 270 min/week. ETM used by EG is set-up as 2750 m altitude. Changes of PP were measured by pre and post-interventions. The PP of participants was evaluated by 1) Stationary Vertical Jump Test, 2) **Running-Based Anaerobic Sprint Test, 3)** Yo-Yo Intermittent Recovery Test Level 2, 4) Sit & reach test and 5) 30 m Sprint test.

Fig 1. Elevation Training Mask and using it during the workout

Table 1. General Training Program Following by Participants

Training	Monday	Tuesday*	Wednesday	Thursday*	Friday	Saturday/Sunday
Type	Technic-tactic	Technic-tactic	Condition	Technic-tactic	Match practice	Official Match*
Duration	90 min	90 min	90 min	90 min	90 min	90 min
Intensity	60%	70-80%	70-80%	60%	80-100%	80-100%
Recovery	Active	Active	Passive	Active	Active	Active

*: EG didn't wear ETM during the workout.

Measurements

Body weight and height: Body weight was measured to the nearest kilogram on a digital scale with the participant wearing lightweight clothing and without shoes. Height was measured to the nearest 0.1 cm with a wall-mounted measuring tape. Body mass index was calculated by dividing the weight in kilograms by the height in meters squared (kg/m^2) (Arabaci, 2008).

Vertical Jump: Laser operated optoelectronic jump height measurement equipment (EMZ-10) was used to measure stationary vertical jump distance. The equipment recorded values within1 cm precision. The vertical jump test involved a 2-footed vertical jump from a stationary position with the intention of attaining maximum height ((Musayev, 2006). Subjects were instructed to maintain their hands on the their hips and keep the their legs straight once they had left the ground. Before each jump, subjects were verbally encouraged to jump as high and as straight up as possible. Shuffling of feet or steps was not allowed. Consequently, each jump was closely observed to ensure that subjects used maximum performance. Anaerobic Power was calculated by Lewis Formula (Mathews, & Fox, 1979). Formula expressed is: Average Anaerobic Power = √4.9 x body weight (kg) x √vertical jump distance (m) x 9.81.

Maximal oxygen uptake (VO_{2max}): VO_{2max} was determined by Yo-Yo Intermittent Recovery Test Level 2 (YYIRT2). The aim of YYIRT2 test is to determine the aerobic capacity of intermittent athletes included soccer players. The test was conducted according to Bangsbo protocol (Bangsvo, 1994; Bangsbo, Iaia & Krustrup, 2008; Krustrup et al., 2003).

Running-Based Anaerobic Sprint Test (RAST): RAST has been designed to evaluate anaerobic performance of athletes. RAST is similar to the Wingate Anaerobic 30 cycle Test (WANT) in that it provides coaches with measurements of power. The Wingate test is more specific for cyclists, while the RAST provides a test that can be used with running athletes. The test involves six 35 m. sprints, with a 10-second recovery between each sprint. RAST is used to calculate the Average Power Output and Fatigue Index. Test reliability was high r = 0.90 Sprint time was measured with an optoelectronic photocell. The formulas expressed are (Arabaci, 2009; Zacharogiannis, Paradisis & Tziortzis, 2004).

Average Power Output = Weight × Distance ^{2} ÷ Time ^{3} (Watts)

Fatigue Index = (Maximum power – Minimum power) ÷ Total time for the 6 sprints

Sit & reach test: Subjects sat with the soles of their feet against the test box, with their hips flexed to about 90° to assume an upright sitting position. Subjects were instructed to flex their hip joints and vertebral column (with possible contributions from shoulder joint flexion and scapular elevation) to reach forward as far as possible. A centimeter scale was printed on the top surface of the box (Arabaci, 2008).

30 m sprint: This test involves sprinting for 30 meters as fast as possible from a stationary standing start position, with no swinging movements. Since this is a very short distance to cover, subjects were expected to perform at 100% maximum efficiency. Each of the subjects performed the 30 m sprint test 2 times with 3-minute intervals. The better value was recorded. Sprint time was measured with an optoelectronic photocell (Arabaci, 2008).

Statistical Analysis

The data were analyzed using SPSS 23.0 for Windows (SPSS Corp, Chicago, IL, USA). Descriptive statistics were carried out, expressed as mean and standard deviation. Shapiro-Wilk test was used for verification of data normality. Mauchly's test of Sphericity assumption was used. Baseline (pre-test) descriptive and test scores between the two groups were compared using Independent t-test. For evaluation the effectiveness of the high altitude training mask intervention Two-way ANOVA (analysis of variance for repeated measures) was applied. In addition, Effect Size was also calculated and evaluated with Partial Eta Squared value (η^2), which was considered small (.01), medium (.06) and large (.14). Alpha was set at $p < 0.05$ to achieve statistical significance for all analyses.

RESULTS

Thirty-six young soccer players carry-out 18 practice in 6 weeks. There was no significant difference (p>0.05) between age, height, weight, and BMI of experimental and control groups (Table 2).

Table 2. Descriptive characteristics of participants.

	EG (n=14)	CG (n=22)	t	TOTAL (n=36)
	Mean ± SD)	Mean ± SD)		Mean ± SD
Age (year)	17.6 ± 0.6	18.1 ± 0.9	0.846	17.8 ± 0.8
Height (cm)	174.1 ± 0.5	172.3 ± 0.3	0.735	173.4 ± 0.4
Weight (kg)	66,7 ± 5.2	65,5 ± 6.1	0.624	65,9 ± 5.7
BMI (kg/m2)	22,2 ± 1.8	22,1 ± 2.1	0.115	22,1 ± 2

Table 3. Changes in physical performance variables during soccer training.

Variables	Group	Pre-test (Mean ± SS)	t	Post-test (Mean ± SS)	Change (%)	F	p	PES (η2)
ALAnPw (kg/m/sec)	EG	88.21±10,2	0.116	88.64±10,3	0.5	0.168	0.684	0.002
	CG	88.64± 11,2		89.05±11,3	0.5			
Flexibility (cm)	EG	27.36±5,5	0.585	28.14±5,5	2.9	0.030	0.864	0.001
	CG	28.45±5,5		28.91±5,3	1.6			
APO (watts)	EG	610.50±97,4	0.711	633.54±82,8	3.8	0.029	0.866	0.001
	CG	634.80±101,5		653.38±112,4	2.9			
Fatigue Index (watts/sec)	EG	11.66±3,6	0.511	12.44±3,6	6.7	0.036	0.851	0.001
	CG	10.67±5,7		11.72±5,4	9.8			
VO_{2max} (mL/min/kg)	EG	56.1±2.5	1.641	57.4±2.2	2.3	0.382	0.541	0.011
	CG	57.7±2.2		58.4±3.1	1.2			
Speed (sec)	EG	4.43±0,3	0.386	4.41±0,3	0.4	0.023	0.881	0.001
	CG	4.47±0,3		4.46±0,3	0.2			

PES: Partial Eta Squared, APO: Average Power Output, ALAnPw: Alactic Anaerobic Power

Analysis of the changes in PP variables of the experimental group and control group and from pre-test to post-test are shown at Table 3 and Figure 2-7. There was no significant difference ($p>0.05$) between the control group and experimental group in all variables before training program (pre-test). After carry-out a 2x2 ANOVA analysis for changes between pre-test and post-test values of two groups, we saw there were no significant differences ($p>0.05$) of ALAnPw ($F = 0.168$, $\eta^2 = 0.002$), flexibility ($F = 0.030$, $\eta^2 = 0.001$), fatigue index ($F = 0.036$, $\eta^2 = 0.001$), APO ($F = 0.029$, $\eta^2 = 0.001$), VO_{2max} ($F = 0.382$, $\eta^2 = 0.011$), and Speed ($F = 0.023$, $\eta^2 = 0.001$) between EG and CG.

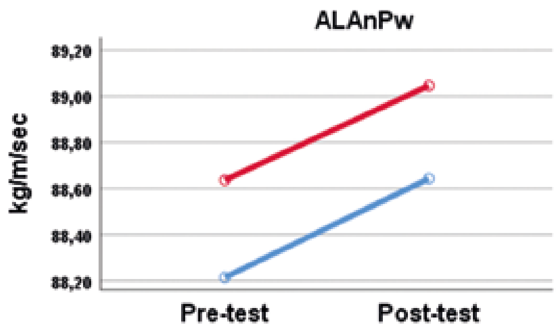

Fig. 2. Pre and post-test values of ALAnPw for EG and CG.

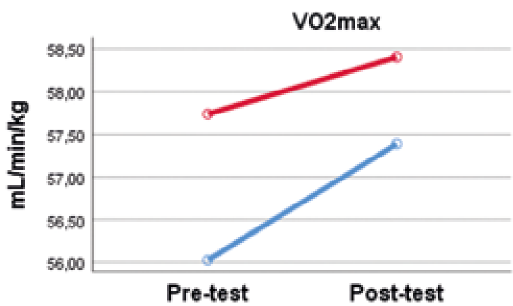

Fig. 3. Pre and post-test values of VO2max for EG and CG

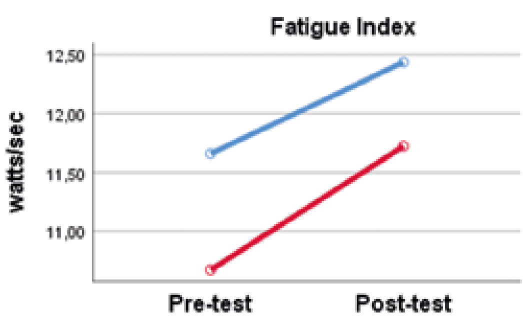

Fig 4. Pre and post-test values of Fatigue Index for EG and CG

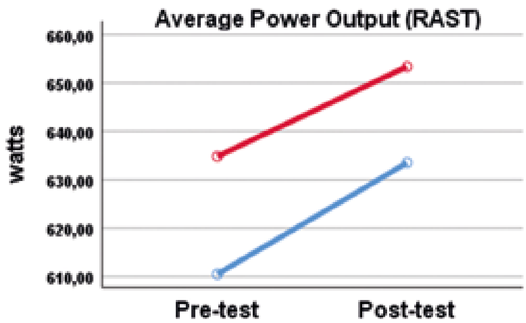

Fig. 5. Pre and post-test values of APO for EG and CG

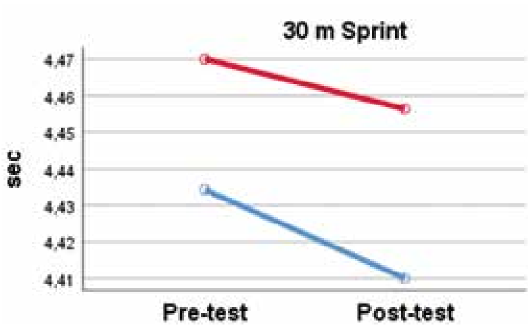

Fig. 6. Pre and post-test values of speed for EG and CG

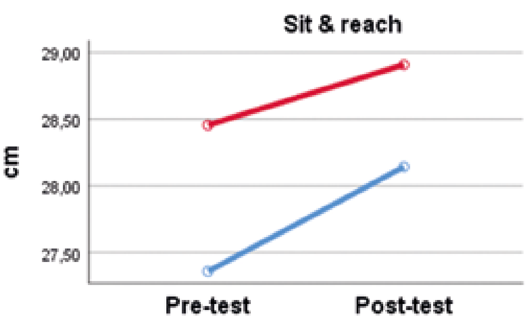

Fig. 7. Pre- and post-test values of flexibility for EG and CG

DISCUSSION

The main aim of the present study was to assess the effect of the 6-weekly, 3 days/week soccer training using the ETM in on-session on the alactic anerobic power, maximal oxygen use, fatigue index, mean power output, speed and flexibility in soccer players aged between 17 and 19 years. It was hypothesized that EG would have greater increases in determined physical characteristics compared to CG.

Initially, ALAnPw (t = 0.116), flexibility (t = 0.585), fatigue index (t = 0.511), APO (t = 0.711), VO_{2max} (t = 1.641), Speed (t= 0.0.386) of two group were similar (p>0.05). At the end of the training program, it was found that these physical characteristics increased in two groups. However, there weren't significant differences between improvements of EG and CG. This could be because EG wore ETM only for 3 workout in a week (270 min/week) and other 3 workout (one of these is an official match) didn't wear ETM. Suggesting that if the ETM induced high elevation conditions, would not be enough to cause more differences than normal elevation conditions. On the other hand, from pre to post – testing increases for the EG were 2.3% for VO_{2max}, 2.9% for flexibility, 3.8% for APO and 0.4% for speed. While from pre to post – testing increases for the CG were only 1.2% for VO_{2max}, 1.6% for flexibility, 2.9% for APO and 0.2% for speed. ALAnPw increases for both EG and CG were similar (0.5%). Only fatigue index is improved more in CG (9.8%) than EG (6.7%). In the present study small improvement in selected physical characteristics of subjects were observed. This could be due to the fact that the subjects were in on-season when the study was performed. Subjects could have been high PP during this period. Kido et al. (2013) reported that carried out combined training with worn ETM on healthy adults achieves greater improvements in maximal performance, cardiorespiratory endurance, and maximal voluntary ventilation than conventional methods (Kido et al., 2013). Also, some previous researches have demonstrated that training in simulated altitude conditions improves cardiorespiratory endurance (Enright & Unnithan, 2011; McMahon, Boutellier, Smith & Spenger, 2002; Shahin, Germain, Kazem, & Guy, 2008; Sturdy et al., 2003; Sutbeyaz, Koseoglu, Inan & Coskun, 2010). While other studies didn't report positive effects (Britto et al., 2011; Litchke et al., 2008; Williams, Wongsathikun, Boon & Acevedo, 2002; Inbar, Weiner, Azgad, Totstetin & Weinstein, 2000). Some studies support but some don't support our findings. Thus there is controversy in current findings.

Grandos et al. (2016) observed that subjects who wore the ETM had a significantly higher rating of perceived exertion (RPE) during 30 minutes of continuous exercise. Additionally, Gething, Passfield and Davies (2004) found that after inspiratory muscle training RPE was significantly decreased (Gething, Passfield & Davies, 2004). These initial findings showed that the subjective determination of PP during simulate elevation training can give different results. Therefore, future studies are needed to determine PP during simulated elevation conditions with both objective and subjective measurements.

The major strength of the present study was to determine chronic changes using ETM of young soccer players' physical characteristics which hadn't been investigated to date.

The first limitation of this study was that participants wore ETM only 50% of the total weekly workout time. To perform interventions in on-season is another limitation. High altitude workouts had to perform in earlier periods of the training season. Thus improvements of PP would be higher. The third limitation is to wear ETM during soccer training could be trouble for young soccer player and negative effected workout quality during training. In future studies changes of PP characteristics during a workout in high altitude conditions and wearing ETM should be investigated and compared. In addition pre, mid and post- season differences of soccer players should be assessed.

In conclusion, the use of ETM during soccer practices can increase alactic anerobic power, maximal oxygen use, fatigue index, mean power output, speed and flexibility of young soccer players. However, these improvements were not more than improvements in conventional conditions. Therefore future studies are needed to clarify workouts with ETMs.

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