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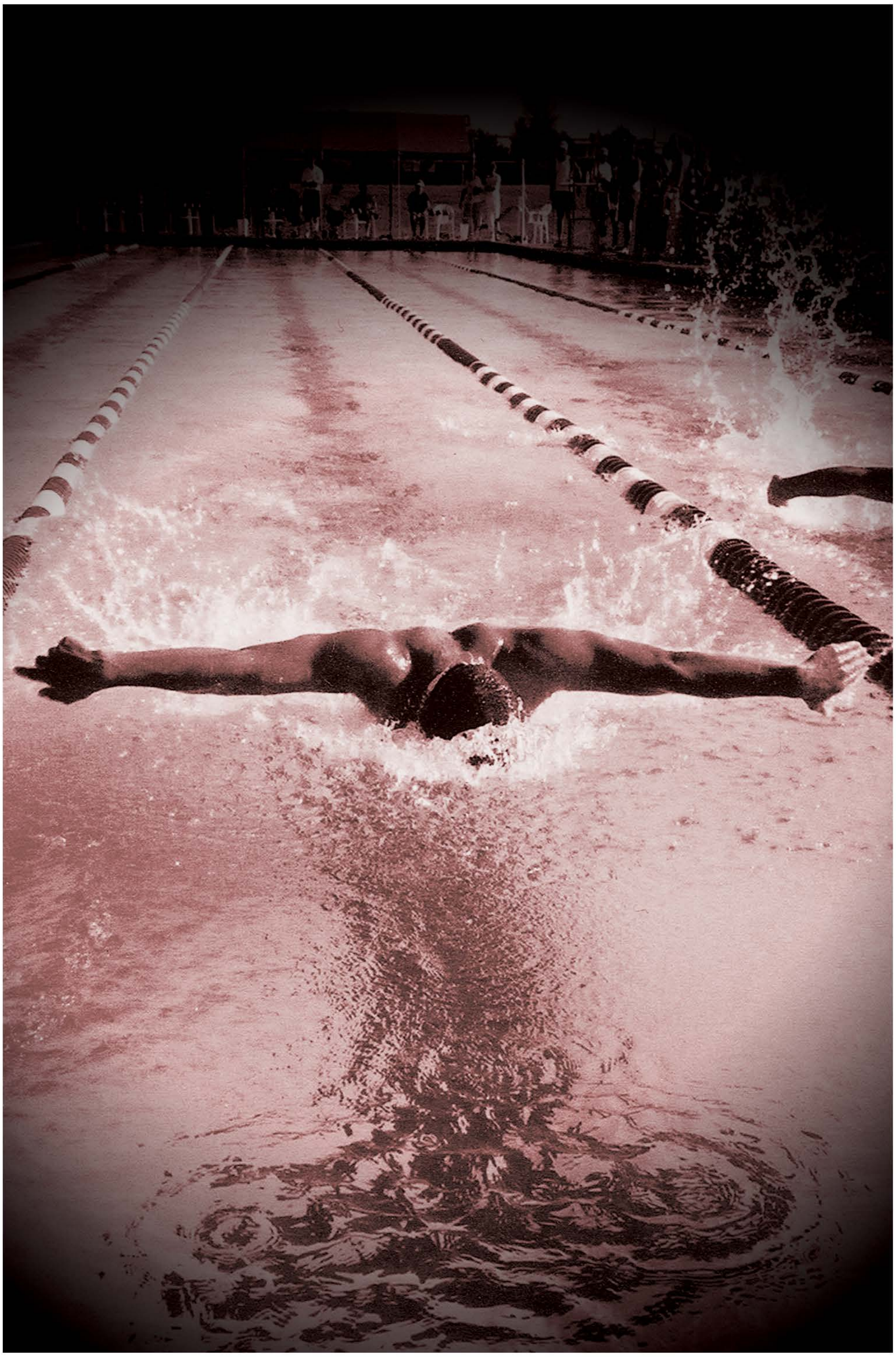

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Dear Readers,

we are so pleased to inform all that the home page of our Society, the Montenegrin Sports Academy has been renewed this spring and it is available at www.csakademija.me. Hence, you can find all information regarding to our journals and the annual conference at this address.

I am so honored to inform you that our new home page has been favorably accepted by various kinds of users, from students to senior experienced scholars, especially in that it has provided the users with direct link to a scientific paper retrieval function which is able to search papers in our journals: Sport Mont and Montenegrin Journal of Sports Science and Medicine that is available in English. This improvement will increase the visibility of both journals, especially Montenegrin Journal of Sports Science and Medicine that is known for one of the leading journals in the area of social sciences in Montenegro and wider. We have decided to renew our home page for globalization and further development of Montenegrin Sports Academy as well as our scientific journals and the conference.

I would also remind all the potential authors as always that Montenegrin Journal of Sports Science and Medicine also provides an ideal forum for exchange of information on aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side, in various formats: original papers, review papers, editorials, short reports, peer review - fair review, as well as invited papers and award papers.

In recent years, the Montenegrin Journal of Sports Science and Medicine has continued to show important advances in both the content and quality of its published articles, and the volume of submissions has increased substantially. Since the last issue, over 80 manuscripts have been processed (peer- and editorial-reviewed, and accepted or rejected). Now indexed in 47 databases, Montenegrin Journal of Sports Science and Medicine has kept recognition as one of Montenegrin leading scientific journals in the area of sports science and medicine.

Finally, we wish to encourage more contributions from the scientific community and industry practitioners to ensure a continued success of our journal. Authors, reviewers and guest editors are always welcome. We also welcome comments and suggestions that could improve the quality of our journal.

Thank you for reading us and we hope you will find this issue of MJSSM informative enough.

Editor-in-Chief
Prof. Duško Bjelica, PhD

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Office Sitting Made Less Sedentary – A Future-forward Approach to Reducing Physical Inactivity at Work

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ABSTRACT

Excessive sitting is detrimentally associated with major lifestyle diseases. Attempts at intervening the prolonged sitting time at work offer possibilities for a healthier lifestyle. The aim of the study was to evaluate the impact of using a seat-cycle (S-C) compared to the office-chair (O-C) in reducing prolonged sitting in the office. Twenty-one (mean age = 48±12.4 years) office workers (10 men and 11 women; mean BMI = 24.1±4.6 kg/m²) volunteered to participate in an 11-week crossover design study. Participants were randomly assigned into two groups- each started with different conditions: the office-chair (O-C) or the seat-cycle (S-C) intervention for 4 weeks with a 2-week 'washout' period in-between before switching over. Self-reported sleep quality, lower back pain, daytime sleepiness and several anthropometric measurements were obtained under the two conditions. Participants spent on average 5.79±1.51 hrs sitting in the office, and used the seat-cycle for an average of 22.8 minutes daily at work. Significant improvements ($p<0.05$) were noted in a pre-to-post setting for resting systolic blood pressure (124.9±12.57 mmHg vs 120.5±13.56 mmHg); sleepiness ratings between 1300–1400 hrs (1.91±0.71 vs 1.56±0.57); lower back pain score (0.95±1.02 vs 0.57±0.68) and sleep quality (4.81±2.16 vs 3.38±2.04) after the S-C intervention. The use of the S-C provides desk-bound workers a potential way to interrupt prolonged sitting at work and further research is recommended to support such interventions at the workplace.

Key words: *sedentary office workers, prolonged sitting, workplace intervention.*

Introduction

Employees report spending a majority of office time sitting and are at greater risk of developing sedentary lifestyles (Miller & Brown, 2004). Sedentary behaviours are defined by posture (sitting or lying) and low energy expenditure (1.0–1.5 METs), apart from sleeping (Owen, Healy, Matthews, & Dunstan, 2010). Prolonged sitting is negatively associated with musculo-skeletal symptoms and risks of detrimental cardio-metabolic health, especially when accumulated in uninterrupted bouts (Neuhaus, Healy, Dunstan, Owen, & Eakin, 2014). Population-based accelerometer studies in North America show that only 1–5% of the waking day of an adult, who sleeps an average of eight hours, is spent in moderate-to-vigorous physical activity (MVPA) with the remaining time spent in sedentary activities (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). The situation in Singapore is dire as a global survey of working hours in 2011 among developed countries showed that Singaporean workers worked the longest hours in the world (AsiaOne, 2013). The Health Promotion Board (HPB) of Singapore recommends 150 minutes of aerobic activity at moderate intensity spread throughout the week for good health (Health Promotion Board, 2011b) and it was reported that the proportion of adults aged 18 to 69 who engaged in regular leisure-time exercise only rose from 17% to 19% in 2004 to 2010 (Mintistry Of Health, 2010). Singapore's Minister for Culture, Community and Youth cited the Sports Participation Survey for 2013 and 2014 that showed the nation's overall participation rate in sports has risen to more than 60%, up from 42% in 2011 (AsiaOne, 2015). While it appears that more adult Singaporeans are taking part in physical activities, a recent finding from HPB revealed that there are 1.7 million of Singaporeans already at risk of obesity-related diseases (Health Promotion Board, 2014). In addition to the increased risk of these lifestyle-related diseases, the lack of physical activity (PA) is suggested to be associated with poorer sleep quality amongst adults (Wennman et al., 2014), and an increase in lower back pain (Hurwitz, Morgenstern, & Chiao, 2005).

According to Singapore's National Health Survey 2010, 10.8% of the adults aged between 18 and 69 were classified as obese compared to 6.9% in 2004 (Ministry Of Health, 2010). The prevalence of obesity was highest in the 30–39 years age group at 12.3% with this demographic comprising mainly of working adults. Sedentariness at work among adults over time is linked to an increased risk of obesity (McCrady & Levine, 2009) and poor metabolic health. Furthermore, some studies show that among sedentary male adults, those who sat for more than four hours daily are more susceptible to lifestyle chronic diseases (George, Rosenkranz, & Kolt, 2013). HPB Singapore has been encouraging companies to introduce Workplace Health Promotion (WHP) programmes such as physical activities for workers to be more physically active and there is an increased prevalence of these programmes in the past decade with 45.1% of private companies adopting programmes in 2003, rising to 56.3% in 2010 (Health Promotion Board, 2011a). Decreasing time spent being sedentary at work and encouraging office workers to adopt healthy lifestyles form an important approach at addressing adult obesity in Singapore.

Novel workstation modifications (such as treadmill desks), which help to break up prolonged sitting time such as the use of standing desks (Alkhajah et al., 2012) have shown positive results and potential benefits in the long term. However,

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substituting prolonged sitting with standing all day is reported to give rise to other health problems such as musculoskeletal pain and venous insufficiency in the legs (McCulloch, 2002). Also treadmill desks may be impractical for most office workers due to its size and cost. At present, apparently no research has examined the use of a seat-cycle (*S-C*) to replace the normal office-chairs (*O-C*) to break up sedentary sitting time at work. Seat cycles are a potentially feasible option to reduce sedentariness at work without a major disruption of office work practices. The aim of the present study was to investigate the effectiveness of using a seat cycle in replacement of the office chair for improving health outcomes of office employees in a worksite in Singapore.

Methods

Participants

Twenty-one office staff (10 males and 11 females; mean age = 48±12.4 years; mean BMI = 24.1±4.6 kg/m²) from an educational institution in Singapore volunteered to participate in the study. A briefing session was conducted to inform participants about the study procedures. A Physical Activity Readiness Questionnaire (Singapore, 2011) and consent forms were completed and signed prior to the commencement of the study. A familiarization session on the use of the seat-cycle was also accomplished. Participants were excluded if they were pregnant or had any medical conditions. The study was approved and cleared by the university board for ethics involving the use of human subjects (IRB-2013-03-005). The physical characteristics of the participants are summarized in Table 1.

Seat-cycle

The seat-cycle chair measures 57cm x 39cm x 76cm with attached pedals with low resistance. Data for the cross-over design study were collected between May and September, 2014.

Protocol

An 11-week study consisted of a 1 week pre-intervention phase followed by two, 4-week experimental phases in a randomized, crossover study design, involving the use of the *O-C* and the *S-C*, respectively. A 2-week washout period separated the experimental phases. Each participant went through both intervention phases and their results were compared. A schematic representation of the study is shown in Figure 1.

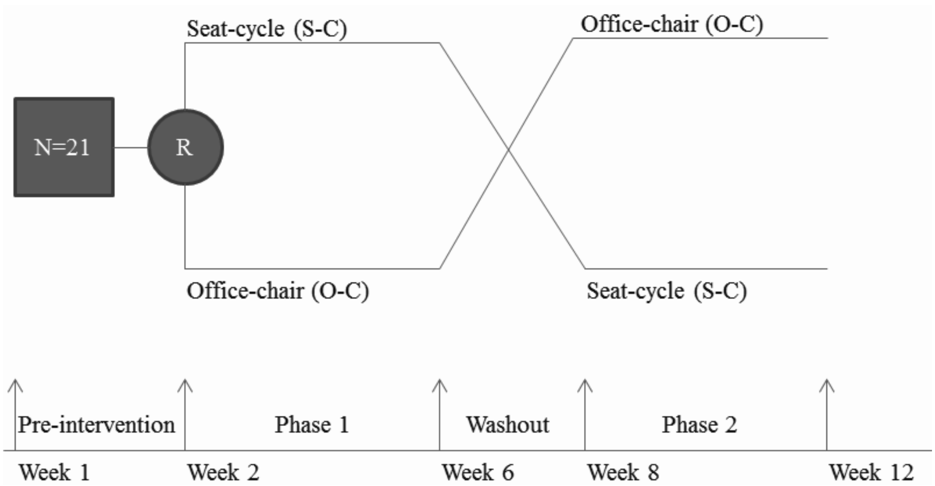

Figure 1. Schematic representation of the study

Twenty-one participants using a cross-over design were monitored on the following:

Participants completed hourly Stanford Sleepiness Scale (Hoddes, Zarcone, Smythe, Phillips, & Dement, 1973) (SSS) rating when in the office (0900–1700 hours) daily throughout the study. The Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) (PSQI) questionnaire and Roland-Morris Disability Questionnaire (Roland & Fairbank, 2000) (RDQ) were administered at the end of each phase.

Week 1 (Monday-Friday): *Pre-intervention*- Participants were familiarised to complete the SSS on the hour while at work in the office and the PSQI and RDQ questionnaires at the end of the week.

Week 2-6 (Monday-Friday): Group 1- *(S-C phase):* The seat-cycle was provided and the workstations were modified such that the computer screen was at eye level whilst seated for each participant. Participants were instructed to cycle at a self-selected cadence so as to minimise disruption to their work.

Group 2- *(O-C phase)*: Participants continued with the normal work conditions with a desk and office chair.

Week 6-8 (Monday-Friday): *Washout period*- The seat-cycles were removed from Group 1. Both groups continued with the normal work condition of a desk and office chair set up.

Week 8-12 (Monday-Friday): Group 1 continued with the normal work condition of a desk and office chairs *(O-C phase).* Group 2 had the seat-cycle set up at the workstation *(S-C phase).*

Measurements

An accelerometer (Actitrainer 3 axis; Actigraph, Pensacola, USA) was attached to one of the pedals of the seat cycle to measure the cycling time of each participant daily throughout the period of monitoring. ActiLife version 4.5.0 (Actigraph) was used to extract the raw data. The data were exported to Microsoft Excel 2010 and further processed to compute the total daily amalgamated cycle time between 0900 and 1700 hours. Body stature, body mass, resting blood pressure and heart rate of the participants in the pre-and post-intervention conditions, were measured according to the methods described in *Exercise Physiology Laboratory Manual 7th Ed* (Beam & Adams, 2014).

Questionnaires

i) Stanford Sleepiness Scale (SSS)
The SSS is a self-rating 7-point scale used to quantify perceived changes in sleepiness for any time period of the day or night (Hoddes et al., 1973). The validated scale has been used in studies to collect subjective measures of workers' sleepiness levels (Kato, Shimada, & Hayashi, 2012). In the present study, participants rated their level of sleepiness on a scale of 1 (active, vital, alert or wide awake) to 7 (Sleep onset soon and having dream-like thoughts) on the hour when they were physically present in the office.

ii) Pittsburgh Sleep Quality Index (PSQI)
The PSQI questionnaire is a survey-type instrument used to assess sleep quality during the previous month (Buysse et al., 1989). It consists of 19 self-rated questions and five questions answered by the bed partner or roommate. On the self-rated items, respondents indicate the amount of sleep they get and rate the extent to which various factors interfered with their sleep on a four-point Likert-type scale (0 = not at all, 3 = three or more times per week) (Beaudreau et al., 2012). The scoring was calculated as a numeric index using a template in accordance to the published work of Buysse et al. (1989). A final score of more than 5 indicated poor sleep quality.

iii) Roland-Morris Disability Questionnaire (RDQ)
The RDQ is a health status questionnaire completed by patients with lower back pain to access their physical disabilities (Roland & Fairbank, 2000). Participants completing the RDQ were instructed to check mark the statements that most applied to them. The RDQ has been used in studies to access the lower back pain of office workers (del Pozo-Cruz et al., 2012). In the present study, the RDQ was used to assess short-term changes in lower back pain in response to the intervention. The higher numerical scores indicate a higher severity of the lower back pain.

Statistical analyses

Descriptive statistics of key variables were described and pre-to-post measurements were analysed by paired-sample t tests using SPSS version 21 and statistical significance was defined as $P<0.05$. The effect sizes (ES) for variables which had significant differences between pre to post measurements were calculated using Cohen's d, where 0.2 is indicative of a small effect, 0.5 a medium and 0.8 a large effect (Cohen, 1992). Pearson product-moment correlation coefficient (r) was used to measure linear correlation between cycling time on the seat-cycle and the significant pre-post differences. Post-hoc statistical power of the group analyses were calculated using G*Power 3.1.

Results

The physical characteristics of the participants are summarised in Table 1.

Table 1. Physical characteristics of participants

Variables	Means ± SD
N	21
Age (years)	48 ± 12.4
Height (m)	1.65 ± 0.08
Body mass (kg)	65.2 ± 11.1
BMI (kg/m²)	24.1 ± 4.6
Waist to Hip ratio	0.83 ± 0.08

RDQ scores, PSQI, anthropometric and physiological measurements obtained during the pre and post of *O-C* and *S-C phases* were analysed. These data are summarised in Table 2.

Table 2. Pre and post measurements of participants for the Office-chair (*O-C*) and Seat-cycle (*S-C*) phases

	Phase	Pre	Post
Resting Heart Rate (bpm)	*O-C*	70.36±10.66	71.93±13.72
	S-C	69.14±10.03	67.48±11.09
Resting Systolic Blood Pressure (mmHg)	*O-C*	120.35±12.69	120.64±13.19
	S-C	124.9±12.57	120.53±13.56*
Resting Diastolic Blood Pressure (mmHg)	*O-C*	74.9±9.63	73.07±10.41
	S-C	76.67±9.41	74.35±11.06
Body mass (kg)	*O-C*	65.36±11.00	65.14±10.76
	S-C	65.09±10.92	65.42±10.80
Waist-Hip Ratio	*O-C*	0.84±0.08	0.81±0.09
	S-C	0.80±0.09	0.83±0.08
Body Mass Index	*O-C*	24.13±4.58	24.33±4.54
	S-C	24.33±4.60	24.14±4.54
Roland-Morris Disability Questionnaire (RDQ) scores	*O-C*	0.9±1	0.81±0.98
	S-C	0.95±1.02	0.57±0.68*
Pittsburgh Sleep Quality Index (PSQI)	*O-C*	4.29±2.15	4.81±2.5
	S-C	4.81±2.16	3.38±2.04*

Data were shown as Mean ± SD
**pre-to-post differences are significant at p<0.05*

There were significant improvements ($p<0.05$) in resting systolic blood pressure (124.9±12.57 mm/Hg to 120.53±13.56 mmHg, ES = 0.33), RDQ score (0.95±1.02 to 0.57±0.68, ES = 0.44) and PSQI (4.81±2.16 to 3.38±2.04, ES = 0.68) between the pre and post conditions of the *S-C phase*. Mean hourly SSS ratings from 0900–1700 hours during the *O-C* and *S-C phases* were 1.59±0.49 and 1.48±0.57, respectively. The average hourly levels of sleepiness reported during the *O-C* and *S-C phases* are shown in Figure 2. The differences in the average hourly sleepiness ratings during the two phases were greatest between 1300–1600 hours (i.e. 1.74±0.57 during the *O-C* and 1.52±0.52 during the *S-C phases)*. Significant differences in the average sleepiness ratings between the two conditions were observed at 1300–1400 hours (1.91±0.71 to 1.56±0.57, $p<0.05$, ES = 0.55).

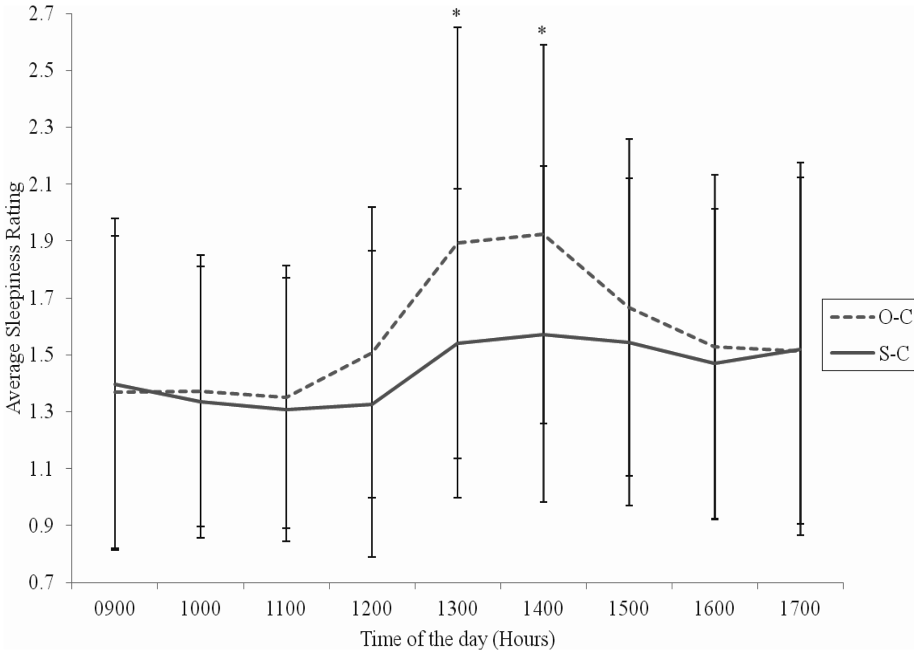

Figure 2. Average daily hourly Stanford Sleepiness Scale ratings for each phase

Legend: * Significant differences ($p<0.05$) in pre-post sleepiness ratings; O-C: Office-chair; S-C: Seat-cycle; Sleepiness ratings- higher scores indicate higher levels of sleepiness.

Data derived from the hourly SSS ratings throughout the study showed that participants spent a daily average of 5.79±1.51 hours at work in the office. During the *S-C phase*, participants spent an average of 5.65±1.97 hours presumably, sitting in the office, of which, an average of 22.8 minutes was spent cycling on the seat cycle on a daily basis. As such, time spent cycling on the seat cycle was about 7% of the total monitored time, with the remaining 93% of the monitored time spent presumably sitting during the *S-C phase*.

There were no significant correlations ($p>0.05$) found between the time spent cycling on the seat-cycle and significant pre-to-post differences of the variables. However, there was a significant correlation (r = -0.449; $p<0.05$) between the pre-to-post difference in the PSQI and SSS ratings at 1400 hours.

Discussion

Results of the present study showed that using a seat cycle at work is beneficial to the health of office workers in terms of (i) lower resting systolic blood pressure, (ii) lower back pain scores, (iii) better sleep quality and (iv) lower sleepiness ratings at 1400 hours. These data are meaningful as the effect sizes for the differences in variables from the pre-to-post conditions are in the moderate range (i.e. ES = 0.33 ~ 0.68). With modern advancements and dependence on technology, manual labour has been greatly reduced, causing a negative impact on health. The office workers spent on average, a large amount of time daily (5.65±1.97 hours) presumably sitting in the office on regular 8-hour (0900–1700 hours) workdays during the *S-C phase*. Despite spending only about 7% of the total office time cycling on the seat-cycle, significant improvements were observed in their resting systolic blood pressure, sleepiness ratings during 1300–1400 hours, lower back pain score and sleep quality index. Studies show that there is usually a post-lunch spike in sleepiness level (Bes, Jobert, & Schulz, 2009) which could explain the sudden rise in the average SSS ratings between 1300–1600 hours during the *O-C phase*. These ratings decreased significantly during 1300–1400 hours of the *S-C phase* suggesting a possible positive impact of cycling on the seat-cycle in improving alertness at work.

Prolonged sitting leads to detrimental health effects such as increased risks for venous thrombosis and it is suggested that short, frequent light-intensity walking breaks were effective at reducing these risk (Howard et al., 2013). Results of the present study suggest that using a seat cycle to break up sedentary office time was effective in terms of improving alertness, lower back pain conditions and sleep quality. Sedentary office jobs can also lead to much lower energy expenditure of 2000 kcal daily less than active jobs (Koepp et al., 2013). Unpublished work from our study showed significant increases in MET values (up to 2.4 times of baseline values) when cycling and while reading on the seat-cycle in an office setting which suggested an increase in energy expenditure (Byrne, Hills, Hunter, Weinsier, & Schutz, 2005). This demonstrated the usefulness of using a seat cycle in place of an office chair in increasing PA levels at work.

Occupational sedentariness is associated with several health complications and modifying the workplace for successful solutions requires multiple innovative approaches (Koepp et al., 2013). In the present study, participants spent about 7% of their office time cycling on the seat-cycle which showed that a single change of the work environment (i.e. introduction of a seat cycle) may not be substantial in influencing a significant change in sitting behaviour for office workers. A pilot study conducted at a Tasmanian workplace showed that employees were five times more likely to complete a movement break every hour of the work day when passive computer prompts were used as compared to active prompts (Cooley & Pedersen, 2013). Researchers in the USA reported increased usage of stairs through an interactive activity of allowing employees to incorporate their own history and thoughts into paintings which in turn helped to decorate the stairwells (Swenson & Siegel, 2013). The existing literature on reducing prolonged sitting behaviour suggests a combination of interventions or activities might be required to contribute to the sustainability of reducing prolonged sitting at work. Such multipronged strategies to reduce prolonged sitting at work should be explored in Singapore for future research.

Limitations of the present study

The duration of the present study was relatively short. Koepp et al. (2013) reported that participants in an intervention study adapted to the new treadmill desks only after the first three months, hence the 4-week intervention in the present study may not be sufficient long to effect a substantial change in behaviour. We also acknowledge the small sample size of the present study, which is reliant on volunteers. Nonetheless, the post-hoc statistical power analysis of the results yielded power of 54 to 60% for resting systolic blood pressure, RDQ scores and SSS ratings at 1300–1400 hours; and a high power of 82% for sleep quality. Throughout the study, we did not objectively measure the PA of the participants for the periods when participants were not using the seat-cycle. Therefore in the present study, we could not account for the amount of physical activity engaged during the 'non-use time' of the seat-cycle and hence unable to determine for certain whether the results were caused directly by the intervention or were due to any 'spill-over' effects of the physical activities engaged when not using the seat-cycle.

Conclusion

The seat-cycle is a piece of equipment that can potentially replace the normal office chair as a mean to increase daily PA at work by cutting down on long periods of sitting in the office and is effective in effecting various health outcomes- improved alertness at work, reduced lower back pain and disability, better sleep quality, and an improved resting blood pressure. Future research using a multipronged approach at intervention to reduce prolonged sitting at work to affirm the practicality and health benefits of exercising and working in the office at the same time are highly recommended.

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Acute Effect of Lower-Body Vibration as a Recovery Method After Fatiguing Exercise

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ABSTRACT

The purpose of this study was to compare three recovery methods: control (CON), lower-body vibration (LBV) and LBV+ local muscle cooling (LBVC) on lower-body performance, perceived recovery, and muscle soreness. Physically active male volunteers (n=8) in a repeated-measures, counterbalanced design, completed three sets of squats to fatigue, each recovery treatment, and two Wingate Anaerobic Tests. Rating of perceived exertion (RPE), and heart rate (HR) were measured after fatiguing exercise, recovery treatment and Wingate Anaerobic tests. Peak and mean power, fatigue index, Delayed Onset Muscle Soreness (DOMS), and comfort levels were compared between each treatment. In Wingate 1, no significant differences (p=0.42) were found among CON, LBV, or LBVC regarding peak power (1119±239, 1097±225, and 1146±260 W, respectively), mean power (p=0.32), or fatigue index (p=0.47). In Wingate 2, no significant (p=0.17) differences were found among CON, LBV, or LBVC regarding peak power (1042±228, 1078±233, and 1110±268 W, respectively), mean power (p=0.38), or fatigue index (p=0.15). A significantly better (p=0.01) perceived recovery was observed after LBV (6±1) and LBVC (6±1) compared to CON (4±1). The study findings support psychological but not performance enhancing benefits after the use of LBV and LBVC as recovery methods.

Key words: *peak power, cooling, perceived recovery, Wingate Anaerobic Test.*

Introduction

Vigorous repeated exercise bouts lead to decrease in muscle peak and mean power, depletion of energy stores, and accumulation of metabolic by-products, which will eventually lead to muscle fatigue (Westerbald, Allen & Lännergren, 2002). Adequate recovery is needed to perform well during subsequent competition or training session (Bishop, Jones & Woods, 2008). However, sometimes there is not enough time available to recover adequately between the competitive or training sessions; thus, performance is impaired.

Various recovery modalities individually, or in combination, are often used by competitive athletes to enhance recovery, reduce muscle soreness, and improve performance (Barnett, 2006); however, there is limited research available assessing whole-body vibration (WBV) as a recovery modality. Studies evaluating the effects of WBV as a recovery modality have shown conflicting results. No performance benefits were observed in middle-aged male runners following acute 2x15 min intermittent low-frequency (12 Hz) WBV intervention session on time trial recovery following high intensity interval training session (Carrasco, Sanudo & de Hoyo, 2011). Although, performance was not improved, lower creatine kinase (CK) values were observed following WBV intervention (Carrasco et al., 2011). Also, no improvements in recovery or blood lactate removal were observed after high intensity exercise following low-frequency (20 Hz) WBV (Marin et al., 2012).

Other studies have shown reduced muscle soreness and faster recovery in countermovement jump (CMJ) ability in junior soccer players following cool-down exercises performed on WBV compared to no vibration (Marin et al., 2012). In addition, the application of high-intensity WBV of 50 Hz before down-hill walking reduced muscle soreness, lowered CK levels 24 hours post exercise and improved isometric force production (Bakhtiary, Safavi-Farokhi, & Aminian-Far, 2007). Another study found that application of WBV of 35 Hz before eccentric exercise reduced muscle soreness, lowered CK levels and the pressure pain threshold (Aminian-Far, Hadian, Olyaei, Talebian, & Bakhtiary, 2011). Stretches performed on a WBV plate lowered perceived pain in untrained individuals after a strenuous exercise session compared with static stretches performed without vibration (Rhea, Bunker, Marin, & Lunt, 2009).

Enhanced clearance of metabolic by-products as a result of WBV may help overcome fatigue, decrease recovery time, and help improve athletic performance (Tiidus, 1999, Weerapong, Hume & Kolt, 2005). Increased peripheral circulation, muscle and skin blood flow as previously observed following WBV (Lohman, Scott, Maloney-Hinds, Betts-Schwab, & Thorpe, 2007, Lythgo, Eser, Groo, & Galea, 2009, Maloney-Hinds, Petrofsky, & Zimmerman, 2008), may augment delivery of oxygen and nutrients and help remove accumulated metabolic by-products resulting from exercise (Tiidus, 1999, Weerapong et al., 2005). Although there seem to be more positive than negative results for WBV in recovery and performance, it remains unclear whether WBV would be a useful recovery modality used to enhance athletic performance and alleviate muscle soreness following fatiguing exercise.

It has previously been shown that pre-cooling leg muscles with ice packs improved peak power output during intermittent exercise performance (Castle et al., 2006) and mean power output during high intensity cycling (Marsh & Sleivert, 1999). It was hypothesized, that local muscle cooling decreases skin

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and increases muscle blood flow which increases the delivery of needed nutrients and clearance of metabolic by-products, thus improving performance (Marsh & Sleivert, 1999). Therefore, the addition of local muscle cooling to vibration intervention during recovery could help enhance recovery and improve performance.

The purpose of the present study was to evaluate the effects of lower body vibration (LBV) and LBV plus local muscle cooling (LBVC) as recovery modalities on lower-body peak and mean power, perceived recovery, and muscle soreness following fatiguing exercise. We hypothesized that LBV and LBVC would provide benefits compared to control, increasing peak and mean power, perceived recovery and decreasing muscle soreness after fatiguing exercise.

Methods

Randomized cross-over, repeated measures design was used to evaluate the effects of LBV, LBVC or no treatment (CON) during recovery and performance trials. Before testing session participants provided written informed consent, completed the Physical Activity Readiness Questionnaire (PAR-Q) (Canadian Society for Exercise Physiology, 2002), and a current health status and training status questionnaire (American College of Sports Medicine, 2009). In addition, baseline data were obtained. Following baseline collection participants completed three performance trials in random order, separated by at least 5 days. Each trial consisted of: warm-up, three sets of back squats with 40% of body weight to volitional fatigue, one of three recovery treatments and two 30 second Wingate Anaerobic Tests (WAT). Power analysis suggested that with the sample size (n=8), we would be able to detect an effect for lower-body peak power of 150 W with an alpha level at 0.05 and power of 0.8 (Piface, by Russell V. Lenth, Version 1.72).

Participants

The study included eight physically active males (age 28±3 years; height 180±7 cm; body mass 85±17 kg; relative body fat 11±6%). The study protocol was submitted to and approved by local Institutional Review Board for testing human subjects. Participants were asked to refrain from vigorous physical activity for 72 hours after the session so as not to affect perceived muscle soreness response. Also, participants were asked to avoid heavy food consumption and energy drinks at least 4 hours before each session. Prior to the testing sessions, study design and procedures were explained, informed consent was obtained, screening procedures were completed, and height, weight, and percent body fat were recorded. Weight and height were determined using a beam scale (Detecto, USA). Body composition was assessed using three site skinfolds measured at the chest, thigh, and abdomen (Jackson & Polock, 1978). Relative body fat was estimated using the sum of skin folds and age (Jackson & Polock, 1978).

Performance Trials

Before back squat exercise, a warm-up was performed on the cycle ergometer for five minutes at a self-selected work rate. After the warm-up, three sets of back squats using an Olympic bar with ~40% of body weight were performed to volitional fatigue or until they could no longer maintain proper technique or cadence, with two minutes of rest between sets. A three-second cycle was used to perform squats, 1.5 s for the eccentric and 1.5 s for the concentric phase. Cadence was set at 40 beats per minute to control the pace. The total number of squats performed in all sets was recorded.

Immediately after the squats, recovery treatment was administered. Within next few minutes after the recovery treatment, two WATs were performed on an electronically-braked cycle ergometer (Velotron, Racer Mate, Seattle, WA) in order to evaluate peak anaerobic power (highest mechanical power generated), fatigue index (decline in power over the time from peak power to the end of the test) and total anaerobic capacity (total work performed during 30-s). The test started with a 20-s warm-up and then a 30-s "all-out effort" involving pedaling as fast as possible with resistance of 0.095 kp per kilogram of body weight (Tanaka, Bassett, Swensen, & Sampredo, 1993). Participants rested on cycle ergometer for four minutes before performing the second WAT. Participants were provided the same motivational encouragement to complete the test at their maximum effort.

Recovery Treatments

Recovery treatment was delivered for each trial, in counterbalanced order. The vibration treatment was delivered using a whole-body vibration plate (VibePlate, Lincoln, NE). Participants were seated with feet placed on the vibrating plate to avoid any weight-bearing effects. *LBV Treatment* - Vibration loading was 10-minutes of vertical vibration at a frequency of 35 Hz with amplitude of 2 mm, similar to that of Carrasco et al. (2011) *CON Treatment* – The protocol was the same 10-min duration as for LBV treatment; however, during the control-treatment the platform was not vibrating. *LBV and Cooling Treatment* - The protocol was the same as for the LBV treatment with the addition of cooling applied to the quadriceps and hamstrings muscle by a gel ice wrap. Ice wraps (IceWraps.Net, Lumberton, NJ) were placed around both quadriceps and hamstrings.

Perceptual Measures

Rating of perceived exertion (RPE) and heart rate (HR) were obtained immediately after warm-up, after each set of back squats, and after each WAT. Participants were asked to rate sessions using Borg's 15-point scale (6-20) (Borg, 1982). HR was recorded using a chest strap and watch (Polar Electro Inc., Lake Success, NY) immediately after warm-up, after each set of back squats, and after each WAT.

The scale similar to OMNI scale (0-10) was used to determine each participant's perceived recovery after each recovery treatment (0 - very poorly recovered to 10 - very well recovered) (Laurent et al., 2011). In addition, participants were asked to evaluate their recovery method experience and characteristics such as comfort, pain, intensity, time and change in performance ability. Visual Analogue Scale (VAS) 100-mm was used to record participants' responses for each of these. The left end was anchored by the words "not at all" representing the least amount of that quality and the right end was anchored by the words "very much" representing the most amount of that quality. Delayed Onset Muscle Soreness (DOMS) in the lower extremities was self-reported 24, 48 and 72 hours after the fatiguing squat session using VAS.

Statistical Analyses

Differences among the recovery treatments were analyzed using repeated-measures analyses of variance (ANOVAs) (SPSS Version 16.0, SPSS Inc., Chicago, IL, USA). Differences among the recovery treatments were assessed for these dependent variables: peak power, mean power, fatigue index, perceived recovery, and DOMS (24, 48 and 72 hours later). Repeated measures two-way ANOVA was used to analyze peak power (3x2), mean power (3x2), and fatigue index (3x2), DOMS (3x3), RPE and HR (3x6). Additionally, separate one-way ANOVAs were used to analyze number of squats, and perceived recovery. Least Significant Difference (LSD) post-hoc multiple comparisons were used in order to determine individual differences among the three different types of treatments for each analysis. Alpha was set at 0.05.

Results

Number of squats significantly declined after each set ($p<0.05$) (Table 1); however, it was not significantly different between the three conditions ($p=0.80$) indicating the same volume for all three sessions. A significant time effect was observed for peak power and mean power ($p<0.05$), but not for fatigue index ($p=0.75$). Peak and mean power were significantly higher for Wingate 1 compared to Wingate 2 as participants had only four minutes for recovery between the tests. However, no significant treatment or time x treatment effect was observed for peak power ($p = 0.27$, $p= 0.30$ respectively), mean power ($p=0.44$, $p=0.17$ respectively), or fatigue index ($p= 0.33$, $p= 0. 29$ respectively). Group means for Wingate 1 and 2 peak power are presented in Figure 1 and group means for mean power, fatigue index, HR, and RPE are presented in Table 1.

Table 1. Comparison of Physiological Variables of Fatiguing Exercise and Performance Test for LBV, LBVC and CON trials. (Mean ± SD)

	CON	LBV	LBVC
Set 1			
Squat (Nr)	70 ± 34	83 ± 71	77 ± 53
RPE (6-20)	16 ± 2	16 ± 1	15 ± 2
HR (b/min)	162 ± 18	164 ± 21	167 ± 15
Set 2			
Squat (Nr)	51 ± 41	42 ± 22	50 ± 31
RPE (6-20)	17 ± 1	18 ± 1	17 ± 2
HR (b/min)	166 ± 17	167 ± 16	173 ± 16
Set 3			
Squat (Nr)	46 ± 42	43 ± 32	45 ± 33
RPE (6-20)	18 ± 2	18 ± 1	18 ± 1
HR (b/min)	172 ± 11	172 ± 17	175 ± 12
Wingate 1			
Mean Power (W)	610 ± 86	589 ± 57	604 ± 68
Fatigue Index (%)	27 ± 10	25 ± 9	27 ± 9
RPE (6-20)	19 ± 1	19 ± 1	19 ± 1
HR (b/min)	181 ± 6	178 ± 12	180 ± 9
Wingate 2			
Mean Power (W)	535 ± 49	530 ± 46	544 ± 58
Fatigue Index (%)	25 ± 9	26 ± 9	28 ± 10
RPE (6-20)	20 ± 0	20 ± 1	19 ± 1
HR (b/min)	181 ± 5	177 ± 10	179 ± 7

Note: CON-control; LBV-lower-body vibration; LBVC-lower-body vibration + cooling; Nr-number; HR-heart rate; RPE-rating of perceived exertion.

Repeated measures ANOVA revealed no significant treatment, or time x treatment, effect for RPE and HR ($p=0.08$ and $p=0.69$, $p=0.90$ and $p=0.16$ respectively). There was a significant time effect for RPE and HR ($p<0.001$) see Table 1. As would be expected RPE and HR were significantly higher after fatiguing exercise and the WAT compared to warm-up. In addition, RPE and HR were higher after Wingate 2 compared to Wingate 1 indicating increased physiological and psychological strain.

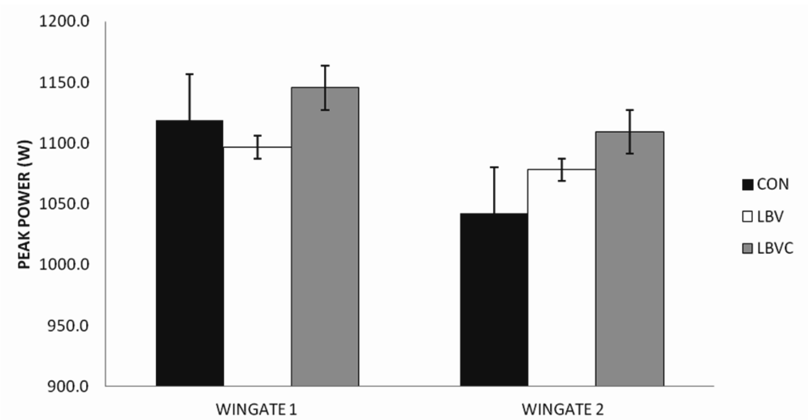

Figure 1. Peak power for Wingate anaerobic test 1 and 2 for CON, LBV, and LBVC recovery treatments (Mean±SD). CON-control, LBV-lower-body vibration, LBVC-lower-body vibration + cooling, W-watts

In addition, no significant treatment or time x treatment was observed for muscle soreness (p=0.82 and p=0.82 respectively). However, a significant time effect was observed in 24, 48 and 72 hours after recovery treatments (p<0.001). Muscle soreness gradually declined as time progressed following each session (Figure 2).

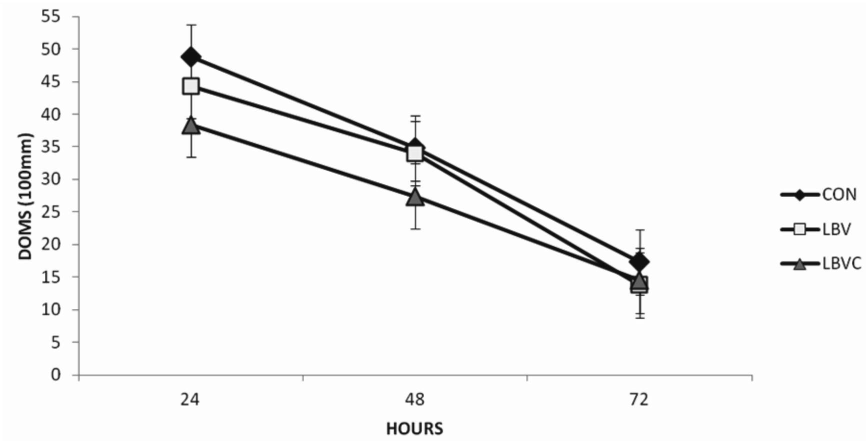

Figure 2. Delayed-onset muscle soreness (DOMS) Response 24, 48 and 72 hours for CON, LBV and LBVC recovery treatments (Mean±SD). CON-control, LBV-lower-body vibration, LBVC-lower-body vibration + cooling, mm-millimeters

Perceived recovery was significantly different (p=0.01) among the three treatment conditions (Figure 3). Participants felt better recovered following LBV and LBVC compared to CON. Participants reported that LBV and LBVC helped them recover better and improved their perceived performance ability compared to CON. Most participants reported that they would likely choose LBV and LBVC following an intense training session.

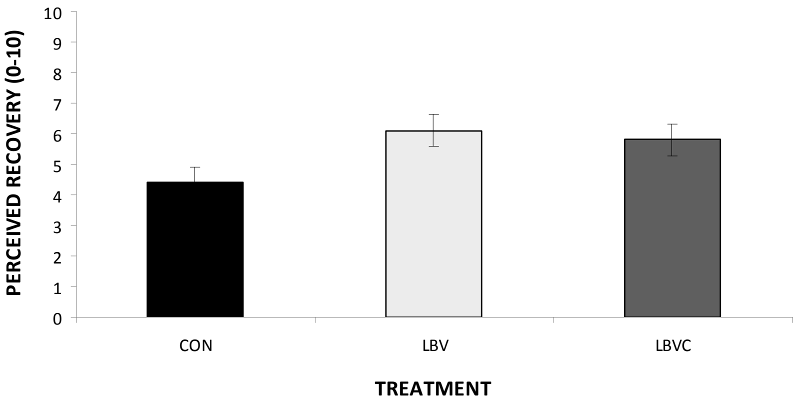

Figure 3. Perceived recovery response for CON, LBV and LBVC recovery treatments (Mean±SD). CON-control, LBV-lower-body vibration, LBVC-lower-body vibration + cooling. * LBV and LBVC significantly higher compared to CON (p< 0.05).

Discussion

Sufficient recovery is needed for an athlete to perform his or her best during competition or a training session. Despite evidence from previous studies (Bakhtiary et al., 2007, Marin et al., 2012) suggesting potential benefit, we found no significant mean improvements in peak power, mean power and fatigue index for either WAT after a single 10-min bout of LBV or LBVC recovery treatments, compared to no vibration and no cooling.

Findings of the present study supported the previous findings of Carrasco et al. (2011) and Edge et al. (2009) in cycling and running performance. Previous study (Carasco et al., 2011), evaluated the effect of LBV on recovery after 2 min of fatiguing cycling exercise and found no differences in cycling exercise test to exhaustion, distance covered, cycling velocity, blood lactate or maximum heart rate following 15 min low intensity (20 Hz, 4 mm) LBV treatment compared to no vibration. In addition, no significant improvements were observed in running a 3-km time trial, blood lactate, muscle damage or muscle inflammation markers following WBV treatment (Edge et al., 2009). In Edge's study (2009), low intensity WBV (12 Hz, 6 mm) was applied while alternating between standing and sitting, after exhaustive treadmill and outdoor running exercises.

Because in previous studies, lower vibration frequencies were insufficient to enhance recovery after fatiguing exercise and improve running or cycling performance; in the present study we chose a higher vibration frequency plus the addition of cryotherapy in one trial with no improvement observed during recovery.

On the other hand, using a similar vibration frequency observed improved recovery in CMJ ability following WBV intervention among soccer players (Marin et al., 2012). Participants performed CMJ, maximal voluntary isometric contraction (MVIC) during leg extension, and a repeated-sprint ability test followed by a WBV cool-down. In contrast to the present study, stretching exercises were performed during 15 min recovery period which may have aided in recovery and performance. In addition, Bakhtiary et al. (2007) observed lower MVIC force and higher CK levels in their no-vibration group compared to 50 Hz vibration group. In addition, vibration treatment was applied directly to the muscle before eccentric exercise. Similar findings were observed by another study (Aminian-Far et al., 2011). Less reduction in maximum isometric and isokinetic torque and lower CK levels were observed when 60s WBV treatment (35 Hz, 5 mm) was performed before exercise. Thus, it may be suggested that higher intensity and peak amplitude vibration applied locally prior to the exercise may be needed in order to elicit positive benefits of WBV on performance.

In the present study, ten minutes of treatment may have been too short for participants to recover from fatiguing exercise. However, athletes frequently perform multiple events, or play in multiple innings or quarters during competition and have only 15 min to recover and get ready for the next event or second half of the game.

Most of the previous studies evaluated the effects of WBV as a pre-activation warm-up routine before squat jump or CMJ where participants were standing or doing exercises on the WBV plate, whereas we used passive recovery with participants sitting in the chair with their feet-only on the plate. In the present study, passive application was used so as not to elicit additional fatigue due to increased muscle metabolic demand caused by WBV treatment. No benefits were observed of adding cooling to LBV treatment in the present study.

This study found that DOMS was not different after 24, 48 and 72 hours post exercise sessions among the recovery treatments. The muscle soreness peaked at 24 hours for all three recovery treatments and proportionally decreased thereafter. Although, there was a trend toward slightly lower perceived muscle soreness seen after LBVC recovery treatment, it did not reach statistical significance. The current findings are inconsistent with previous research (Aminian-Far, et al., 2011, Bakhtiary et al., 2001, Kosar, Candow, & Putland, 2012, Marin et al., 2012, Rhea et al., 2009) who found significantly lower levels of reported perceived muscle soreness 12, 24, 48 and 72 hours when vibration treatment was administered before or immediately after exercise. Reduced muscle pain and improved performance were observed among soccer players while performing traditional cool-down combined with stretching exercises performed on vibration platform (Marin et al., 2012). Other studies observed reductions in muscle soreness and pain pressure threshold following vibration application prior to eccentric exercise (Aminian-Far, et al., 2011, Bakhtiary et al., 2001).

Psychological responses may play a major role in an athlete's performance. Participants felt moderately recovered after LBV and LBVC compared to somewhat recovered after no vibration. In addition, participants felt that using LBV and LBVC helped them recover better and improved their perceived performance ability. In addition, participants indicated that they would choose LBV and LBVC as a choice of recovery treatment after intense training session. If an athlete feels better recovered, it may help override peripheral signals and perception of fatigue and possibly improve performance. However, no improvements in the group mean performance were observed.

It would be hard to argue that our study lacked sufficient statistical power, despite our relatively small sample. Our observed power differences were very small. In the present study we had sufficient power to readily detect time effects, and thus should have detected any true treatment differences of similar effect size.

The results of the present study indicate that acute exposure to LBV or LBVC did not provide greater benefits as a recovery modality after fatiguing squat exercise. However, due to individual variability, it is important to consider not only group means but also individual results. Therefore, we recommend that coaches and athletes test the stability of the individual responses to any given recovery treatment and determine whether it helps to overcome fatigue, enhance recovery and improve performance. Due to individual variability recovery treatment duration, intensity and mode need to be determined for each individual athlete in order to provide the most effective recovery routine. In addition, based on the present study participants seemed to feel better recovered and believed that it improved their performance ability. If athletes need to recover in a short period of time LBV or LBVC may have potential psychological benefits but does not appear to aid performance under the conditions of the present study.

In conclusion, LBV or LBVC recovery treatments did not provide greater benefits for peak or mean power after fatiguing exercise compared to no vibration as indicated by group means under the conditions of this study. With a limited amount of literature available, the optimal time, mode and intensity of vibration for use as a recovery modality needs to be determined in order to develop an effective recovery treatment routine.

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Preliminary psychometric validation of the Multidimensional inventory of sport excellence: attention scales and mental energy

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ABSTRACT

Sport psychologist needs to understand how psychological factors affect athletic performance of an individual, considering individual differences among athletes. Each specific problem in working with athletes must be considered depending on complex factors: the type (specificity) of sport; characteristics of the activity (the training or competition); stages of athletes' sports development; gender and age differences, etc. Although there are numerous psychological instruments, which assess psychological characteristics of athletes, it is important to select instruments adjusted to athletes, working style of sports psychologist, available time and other constraints. Here, we have formulated a preliminary version of our own battery of questionnaires, named Multidimensional Inventory of Sport Excellence (MUSI), selecting the items for following psychological characteristics: energizing, maintaining attention, directing attention, wide internal / external attention and narrow internal / external attention. In this phase of the study, participants were stratified only by gender. Sample of 248 participants was examined, of which 103 male athletes (age 24.52 ± 11.80 years) and 145 female athletes (age 16.61 ± 6.69 years), from the Croatian sports clubs, competing in 16 different sports (archery, football, handball, bocce, bowling, cycling, karate, rowing, tennis, volleyball, basketball, synchronized swimming, triathlon, table tennis, chess, badminton). Data were collected from March to June 2014 in Rijeka, during the trainings in sports clubs. Results of Principal Component Analysis and the reliabilities type internal consistency showed that each of sub-questionnaires from battery MUSI have satisfactory reliability and construct validity, giving positive guidance for future adaptation of the questionnaire to specific subpopulations of athletes.

Key words: *diagnosis, practical skills, sports excellence, sport psychologist.*

Introduction

In order to achieve sport excellence, athletes should develop attention skills and have enough mental energy to cope with challenges. "Mental energy" is a term with multiple meanings. It can be used to describe specific biological processes involved in the capacity of brain neurons to do physical work, and it can legitimately be used to refer to mood or motivational and cognitive processes. Since there is no valid, objective measure of any mood, self-reported feelings are recognized as the best method for assessing mood (O'Connor, 2006). Attention allows to "filter out" information, sensations and perceptions that are not relevant at the moment. Instead, athletes should focus on the information which is important. Performing in an athletic event requires an athlete to narrowly focus upon the task at hand in order to achieve success. To learn complex movement sequences, athletes break them into their component parts which are, at first, practiced in isolation and afterwards conducted on competition.

Mental energy

The concept of mental energy is still evolving. It is a term with multiple meanings and can be used to describe specific biological processes involved in the capacity of brain neurons to do physical work and/or it can legitimately be used to refer to mood or motivational and cognitive processes. Thus, the feeling of energy can be classified as a specific, positive mood.

Specifically, the mood of energy refers to feelings of having the capacity to complete mental or physical activities. With that said, various researchers try to find out ways of assessing mental energy. Vigilance and choice reaction time seem to have the necessary psychometric properties for assessing mental energy, including construct, predictive content and face validity (Lieberman, 2006). Tests of reaction time and vigilance are correlated with questionnaires that measure mood states corresponding to mental energy. Such mood states include sleepiness, fatigue, and alertness and are of approximately equivalent sensitivity.

Therefore, the studies which suggest using cognitive tests that assess vigilance, ability to sustain attention, and choice reaction time are optimal for assessment of mental energy. On the other hand, O'Connor (2006) suggests three widely used methods that have strong support as a measure of the mood of mental energy: visual analog scales, the vitality scale of the SF-36 Health Survey, and the vigor scale of (Profile of Mood States – hereinafter POMS) (McNair et al., 1971, in press).

Attention (Concentration)

Attention is a concept studied in cognitive psychology that refers to how we actively process specific information present

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in our environment. It allows one to "filter out" information, sensations and perceptions that are not relevant at the moment and instead focus on the information that is important (Abernethy et al., 1998). Athletes perform in various levels of arousal and, besides that, few of them are aware of the effect that arousal has on focus and performance that arises. Too much arousal undermines the athlete's ability to narrowly focus attention in a quality manner, while too little arousal may introduce unwanted competition between irrelevant and relevant cues. The problem emerges when high levels of arousal lead to the phenomenon of distractibility. Distractibility has the effect of decreasing the athlete's ability to discriminate relevant and irrelevant cues, and to focus upon relevant cues. The athlete who is suffering from distractibility tends to experience sudden and significant decrements in performance.

Performing in an athletic event requires an athlete to narrowly focus upon the task at hand in order to realize success. According to that statement, sport psychologist usually teaches athletes how to narrow their focus in order to reach adequate attention in order to get into „the zone“. Athlete has to practice attention to the point that performance can occur at an automatic level. Given that level of development has been reached, the athlete must then reduce the amount of conscious internal processing of information as much as possible. Anything that forces concentration to become controlled will pull the athlete out of the zone because the conscious control of concentration requires an internal shift. It is important to classify stimuli that require conscious or controlled attention as either task relevant, or task irrelevant.

Task irrelevant stimuli are commonly referred to as distractions (flash from a camera as a football player is about to shoot a penalty, or internal distractions (negative thoughts or feelings). When the athlete is confident, the negative impact of the distraction is short lived and the athlete quickly refocuses attention on task relevant external cues, becoming once again immersed in the situation. To remain in the zone, distractions whether they are task relevant, or irrelevant, need to be kept to a minimum, and recovery from those that do occur needs to be almost instantaneous. Indeed, it is the ability to recover quickly which is probably the single most important factor separating successful athletes from unsuccessful ones (Orlick & Partington, 1990).

Most performance in sport is demanding, requiring athletes to combine very complex motor sequences (e.g., to run, dribble and shoot while reacting to the movements of other football players). To learn such complex sequences, athletes break them into their component parts which are practiced in isolation. After the individual pieces are developed, athlete begins to put them together until he or she is able to execute the entire sequence without mistake. With practice, the athlete learns to combine perceptual information (e.g., information about the location of the goal, other players, etc.) with internal information (e.g., feedback from the body about its position in space), to create patterns that the brain can recognize at a preconscious level (Norman, 1968).

To understand exactly how a person is going to behave, the best sources of data are assessment instruments (questionnaires). Nideffer (1976) developed the Theory of Attentional and Interpersonal Style (TAIS) in his work with elite athletes at the professional and Olympic level. TAIS has been applied extensively in military settings with Navy SEALS and Army Special Forces. The goal was to create an inventory that would be useful in predicting performance and in providing feedback about concentration skills to individuals involved in a wide variety of performance areas. The theory brings together performance relevant constructs in such a way as to accurately predict how people will perform in wide variety of situations. Nideffer (1976) considers concentration along two dimensions: 1) breadth: at any given moment, attention could be either Broad (focused on multiple things simultaneously) or Narrow (focused on one thing); and 2) direction: focus could be either External (focused outside your head) or Internal (focused inside your head).

The purpose of these instruments is to help sport psychologists to predict and understand exactly how an individual will perform under a variety of circumstances. This information is of course very useful for their practical work with the athletes. Therefore, the goal of this research was to determine construct validity (factor structure) and reliability type internal consistence for each of the questionnaires included in this part of the Multidimensional Questionnaire of Sport Excellence. Moreover, the second goal was to determine the correlations among the dimensions in all measuring instruments (questionnaires) in this research.

Methods

Participants

In total 248 athletes, 103 males (mean age 24.52±11.80) and 145 females (mean age 16.61±6.69) were involved in the study. They were recruited from different sport clubs in Croatia. Mean age of sport experience (participation in sport) of the participants was 8.62±6.97 years. The athletes from 16 different sports were included in research: archery (N=1), football (N=17), handball (N=47), bocce (N=2), bowling (N=2), cycling (N=7), karate (N=1), rowing (N=27), tennis (N=3), volleyball (N=57), basketball (N=32), synchronized swimming (N=19), triathlon (N=3), table tennis (N=2), chess (N=1), badminton (N=2). According to sport age category, 99 (39.9%) of them were cadets, 60 (24.2% were juniors), 77 (31.0%) were seniors, while 12 (4.8%) were veterans. According to the level of sport excellence, 37 (14.9%) of them were top Croatian athletes (e.g. national selection), 80 (32.3%) were semi-professionals (they work regularly out of sport, but they are engaged in regular training and national competitions), while 131 (52.8%) are amateurs, engaged in lower levels of competitive sport, or only in recreational sports.

Procedure

Data was collected between March 2014 and July 2014 in the city of Rijeka, Croatia. Participants always filled out the questionnaire anonymously in the presence of a research assistant, or during or during the training, in their respective sports clubs.

Measures

Initial versions of all questionnaires have started from theoretical frameworks and belonging measuring instruments (Profile of Mood States – hereinafter POMS and The Attentional and Interpersonal Style - hereinafter TAIS), but with significant modifications, according to previously mentioned needs, influenced by specific style of work of certain sport psychologists. For the purpose of measuring mental energy, we have formulated the items of Mental Energy Scale according to the vigor scale of POMS (McNair et al., 1971). Mental Energy Scale consists of 14 items based on the self-evaluation of the level of „mental energy“. The subjects have to estimate their own behavior on Likert 5-point scale ranging from strongly disagree (1) to strongly agree (5). The results are defined as a simple linear combination of the estimations for the items. Higher estimation means higher emphasis on certain dimensions of mental energy. Internal consistency for the Profile of Mood States was reported at 0.63 to 0.96 Cronbach alpha rating (McNair et al, in press). For the brief version, POMS-SF, the internal consistency rating was 0.76 to 0.95. The correlation between the sub-scales and the total score in POMS and POMS-SF was 0.84 (McNair et al., in press). In addition, the POMS was correlated with the Functional Assessment of Cancer Therapy scale and the Psychological Well-Being scale, with calculated -0.68 ratings (McNair et al, in press).

For the purpose of measuring attention (concentration) we have developed Maintaining Attention Scale according to TAIS (Nideffer, 1976). Maintaining Attention Scale consists of 12 items based on the self-evaluation of the level of 'adequate concentration'. Extensive Internal Attention Scale consists of 9 items, while Extensive External Attention Scale, as well as Narrow Internal Attention Scale and Narrow External Attention Scale, and consists of 7 items, each. The subjects have to estimate their own behavior on Likert 5-point scale ranging from strongly disagree (1) to strongly agree (5). The results are defined as a simple linear combination of the estimations for the items, which define certain dimension of the attention. Higher estimation means higher attention skills, except in case of Extensive internal attention (lower score means higher developed skills). The group of researchers validated TAIS attention scales using factor analysis, which showed adequate construct validity, while the internal consistency or reliability coefficients found by these investigators for the six attention scales were ranged from .57 to .72 (Van Schoyck & Grasha, 1981; Landers, 1982; Vallerand, 1983; Summers & Ford, 1990; Abernethy et al., 1998).

Statistical Analyses

In the statistical analyses of the data, the software package SPSS 20.0 was used. In the process of determining the main metric properties of the questionnaires, for determining the construct validity of the questionnaires, the method of Principal Component Analysis (PCA) is used (with or without Varimax rotation). Several criteria are combined to obtain final component (factor) solutions: saturation higher than 0.300; Scree Plot; Guttman-Kaiser criterion (eigenvalue higher than 1.00) and interpretability criterion. The results in extracted principal components (factors) in certain questionnaires are expressed as simple linear combinations, and then used in further analysis (correlations). The reliability type internal consistency for all components (factors) revealed was determined using Cronbach's alpha coefficient. The correlation analyses were performed using Spearman rank-correlation coefficients. The significance of differences commented on the probability level $p<0.05$.

Results

Kaiser-Meyer-Olkin's measures of the data matrix's convenience for the factorization and Bartlett's sphericity test showed that the intercorrelation matrix is suitable for factorization, in all questionnaires (Tables 1-6).

For the first measuring instrument (Mental Energy Scale), applied on Croatian sample(s) of athletes, the application of PCA (Table 1), as well as the scree plot, indicate a steep drop of eigenvalues, that revealed one-component structure. In males (M±SD for the entire scale was 3.86±0.71), only principal component accounts about 44%, while in females (3.79±0.74), only principal component accounts about 51% of the total variance explained. Basic descriptives (means and standard deviations) and communalities are presented in the Table 1, where it is obvious that all means have values above theoretical average (3.00). Reliability type internal consistency (Cronbach's alpha) of this scale is very high and thus very satisfactory. Variance is explained by somewhat higher values in females than in males. For the second measuring instrument (Maintaining Attention Scale), applied on Croatian sample(s) of athletes, the application of PCA with Varimax rotation (Table 2), as well as the scree plot, indicate a steep drop of eigenvalues, that revealed two-component structure (for males and females), with factors named: Maintaining attention skill (3.53±0.59 for males and 3.67±0.79 for females) and Awareness about the state of attention (3.65±0.65 for males and 3.53±0.63 for females). For males, two components explained about 45% of the total variance (44% for females). Insight into descriptives and communalities (Table 2) shows that all means have values above theoretical average (3.00). Reliability type internal consistency (Cronbach's alpha) of two dimensions of this scale are very low (Maintaining attention skill) and low (Awareness about the state of attention), but still satisfactory. One item saturated only second factor for males (I know why my concentration falls during performance). For the third measuring instrument (Extensive Internal Attention Scale), applied on Croatian sample(s) of athletes (2.60±0.88 for males and 2.58±0.81 for females), application of PCA (Table 3), as well as the scree plot, indicate a steep drop of eigenvalues that revealed one-component structure. Only principal component accounts about 48% of the total variance explained for males, and 40% for females. Insight into descriptives and communalities (Table 3) shows that all means have values bellow theoretical average (3.00). Reliability type internal consistency (Cronbach's alpha) of this scale (in males and females) is medium high and thus satisfactory. One item saturated principal component only for females (I have a feeling that I am analyzing too much different aspects of performance). For the fourth measuring instrument (Extensive External Attention Scale), applied on Croatian sample(s) of athletes (3.66±0.59 for males and 3.71±0.70 for females), application of PCA (Table 4), as well as the scree plot, indicate a steep drop of eigenvalues that revealed one-component structure. Only principal component in males accounts about 48% of the total variance explained, the same as for females. Insight into descriptives and communalities, offers the information that all means except one have values above theoretical average (3.00). Reliability type internal consistency (Cronbach's alpha) of this scale is low, but still satisfactory. Two items more saturated single principal component only for males (Table 4). For the fifth measuring instrument (Narrow Internal Attention Scale), applied on Croatian sample(s) of athletes, application of PCA with Varimax rotation (Table 5), as well as the scree plot, indicate a steep drop of eigenvalues that revealed two-component structure, with factors named: Awareness about the attention during performance (3.80±0.78 for males and 3.76±0.78 for females) and Internal speech (3.36±0.93 for males and 3.32±0.84 for females). All two components accounted about 55% of the total variance explained (males) and 51% for females. Insight into descriptives and communalities, offers the information that all means, except last one, have values above theoretical average (3.00). Reliability type internal consistencies (Cronbach's alpha) of both dimensions of this scale (for males and females) are very low, but still satisfactory. One item saturated second component only for females (In some situations I have to take into account the position of the body during the performance). For the sixth measuring instrument (Narrow External Attention Scale), applied on Croatian sample(s) of athletes (3.93±0.88 for males and 3.84±0.63 for females), application of PCA (Table 6), as well as the scree plot, indicate a steep drop of eigenvalues that revealed one-component structure. Only principal component accounts about 30% of the total variance explained (males) and 39% for females. Insight into descriptives and communalities offers the information that all means have values above theoretical average (3.00). Reliability type internal consistency (Cronbach's alpha) of this scale is very low, but still satisfactory (for males and females). One item saturated principal component only for males (The best outcome is usually when you do not think much).

Correlations between the dimensions

In the following two analyses we have used obtained latent dimensions, expressed in simple linear combinations, to calculate the correlations among these latent dimensions of psychological characteristics (Table 7), as well as to establish their correlations with three independent variables: age and sport experience. Out of 28 correlations between variables of MUSI, included in this study, 21 were statistically significant (four negative-directed, while the others were positive), just equally for males and females. All significant correlations were low to medium sized, both in males and females. In males and females, Mental energy, Maintaining attention skill, Awareness about attention during performance and Extensive external attention negatively and significantly correlated with Extensive internal attention.

There were no statistically significant correlations between certain psychological characteristics and athletes' age and time spent in training certain type of sports (both in males and females).

Discussion

Basic psychometric properties, construct validity and reliability are examined in six questionnaires, which are used for the first time, separately for male and female athletes. Eight latent dimensions are revealed after application of factor (in fact, PCA) analysis, named leading by the dominant content of the items which saturate each dimension: Mental Energy, Maintaining Attention Skill, Awareness about State of Attention, Extensive Internal Attention, Extensive External Attention, Awareness about Attention during Performance, Internal Speech and Narrow External Attention. All the questionnaires showed satisfactory validity and reliability, while factor structures are very similar for males and females. This finding can lead us to a presumption that the same versions of the questionnaires could be used in males and females, especially after this preliminary application. Namely, when The insight into correlations provide the conclusion that all dimensions revealed in this study are not associated with age of athletes or their time spent in sport (experience). Moreover, intercorrelations between these dimensions of attention and mental energy show that all dimensions are mostly positively (low to medium sized) correlated, except the Extensive internal attention (which is in fact positively related to other characteristics, because lower score in this scale means higher Extensive internal attention). Distractibility scores for male athletes suggest that the pattern of their concentration errors is fairly consistent. More often than not, their mistakes occur because they think too much, become distracted by their own thoughts. Females on the other hand, are just as likely to become distracted by external events (e.g. what their opponent is doing), as they are by their own thoughts. Previous studies show that scores in similar concentration scales indicate that concentration skills are improving with age (Nideffer & Bond, 2012), while males have in general somewhat higher means in attention features, as compared with females (Nideffer, 1976; Nideffer et al., 2012; Nideffer & Bond, 2012). Although in our research, because of separate factoring, we can't have clear conclusions about gender differences, we can estimate that differences between means in certain attention aspects in males and females are minimal. Moreover, the age differences are not obvious, too. These findings can arise from heterogeneous samples of athletes in our study: for example, the group of older triathletes shows a significantly higher level of concentration of attention than younger (Kovářová & Kovář, 2010). However, second explanation could be the fact that we have developed specific measuring instruments, included in MUSI.

The advantage of this research is the application of these (new) questionnaires for the first time, with the preliminary insight in their main psychometric properties. On the other hand, these instruments have a purpose to be adjusted to the working style of sports psychologists, but taking into account available time (all these instruments need short time to administering). The main shortcoming of the research is the fact that initial validation of the questionnaires was stratified only by gender, among all relevant factors mentioned before: type (specificity) of sport; characteristics of the activity (the training or competition); level of sport excellence; stages of athletes' sports development; age differences, etc. The number of participants was not representative: it is disproportional, according to different types of sports, especially when additionally considering age groups that athletes belong to, levels of sport excellence, etc. However, we have emphasized that this is only preliminary validation of certain measuring instruments, which have to be improved and adjusted, according to all abovementioned criteria, for example: male senior elite basketball players or female junior semi-professional volleyball players, etc. Applying these questionnaires from MUSI on such stratified samples is one of the main directions in future research. Practical implication of this study could be focused on using this orientation standards (average values, such as means and standard deviations), arising from this initial application of the questionnaires, to estimate attention and mental energy in certain group of athletes. This could be useful information for sport coaches, as well as for sport psychologists, as the start point to develop individualized training programs to improve these skills, especially in elite training centers around the world (Nideffer & Bond, 2012).

Conclusions

Construct validity and reliability were preliminarily examined in six questionnaires, separately for male and female athletes. Eight latent dimensions are revealed after the application of PCA analysis, named: Mental Energy, Maintaining Attention Skill, Awareness about State of Attention, Extensive Internal Attention, Extensive External Attention, Awareness about Attention during Performance, Internal Speech and Narrow External Attention. All the questionnaires showed satisfactory validity and reliability (in range from minimum to high sized). All revealed factor structures were very similar for males and females, so it could be recommended that in future research the same versions of the questionnaires could be used in males and females. None of the dimensions revealed in this study are not statistically significantly associated with age or sport experience of athletes, while most of correlations between the di-

Table 1. Mental Energy Scale: descriptive characteristics and results of Principal Components Analysis (PCA) with belonging reliability, applied on the sample of male and female athletes

	Males				Females			
Items	r	h^2	Mean	Std. Dev.	r	h^2	Mean	Std. Dev.
I feel the energy in the body and readiness for competition. / Osjećam energiju u tijelu i spremnost za natjecanje.	.757	.643	4.245	0.838	0.802	.643	4.029	0.943
I feel the energy that makes me brave. / Osjećam energiju koja me čini hrabrim.	.726	.419	3.842	1.027	0.648	.419	3.762	1.144
I feel the energy that makes me tough. / Osjećam energiju koja me čini izdržljivim.	.779	.645	4.040	0.958	0.803	.645	3.775	0.978
Because of the energy in the body do not have a sense of fatigue./ Zbog energije u tijelu nemam osjećaj umora.	.584	.341	3.604	1.167	0.584	.341	3.378	**1.192**
I can manage my energy during the competition./ Mogu upravljati svojom energijom tijekom natjecanja.	.402	.270	3.559	1.068	0.519	.270	3.376	1.125
I enjoy the competition when I feel the energy./ Uživam u natjecanju kad osjetim energiju.	.717	.489	4.392	1.026	0.699	.489	**4.285**	1.075
When I feel the energy in my body, I can easier deal with the pressure./Kad osjetim energiju u tijelu lakše se nosim s pritiskom.	.559	.364	3.971	1.164	0.603	.364	3.759	1.156
When I feel more ready energy / and I accept the challenge./ Kad osjetim energiju spremniji/a sam prihvatiti izazov.	.750	.571	4.099	1.005	0.755	.571	**4.132**	0.977
When I feel the energy, errors less affect on my performance./ Kad osjetim energiju pogreške manje utječu na moje izvođenje.	.609	.528	3.745	1.114	0.727	.528	3.545	1.053
When I feel the energy, I do not fear of mistakes./ Kad osjetim energiju ne bojim se pogreške.	.623	.585	3.755	1.147	0.765	.585	3.535	**1.153**
When I feel the energy, I can easier accept mistakes./ Kad osjetim energiju lakše prihvatim pogreške.	.537	.345	3.559	1.157	0.587	.345	3.563	1.120
When I feel the energy I'm not afraid of negative outcomes. / Kad osjetim energiju ne bojim se negativnog ishoda.	.633	.703	3.941	1.088	0.838	.703	3.566	1.123
When I perform with the energy in the body, I can more easily accept the consequences./ Kad nastupam s energijom u tijelu lakše prihvaćam posljedice.	.775	.545	3.673	1.193	0.738	.545	3.796	1.069
When I feel the energy in the body, I can easier accept the outcome of the competition./ Kad osjećam energiju u tijelu lakše prihvaćam ishode natjecanja.	.716	.700	3.752	1.126	0.836	.700	3.809	1.035
Kaiser-Meyer-Olkin Measure / Bartlett's Test of Sphericity	.872		583.350** (df=91)		.920		1023.837** (df=91)	
Eigenvalue / Variance Explained	6.161		44.01%		7.147		51.05%	
Reliability (Cronbach's alpha)	0.895				0.921			

Legend: r=correlation of the variable with principal component; h^2= comnunalities.

Table 2. Maintaining Attention Scale: descriptive characteristics and results of Principal Components Analysis (PCA) with Varimax rotation, with belonging reliabilities, applied on the sample of male and female athletes

	Males					Females				
Items	f1	f2	h^2	Mean	Std. Dev.	f1	f2	h^2	Mean	Std. Dev.
I have a feeling that I can be concentrated long enough during performance./ Imam osjećaj da mogu dovoljno dugo biti koncentriran/a za vrijeme izvođenja.	**.762**		.594	3.814	1.031	**.710**		.512	3.704	1.050
There are only few things that we can disrupt concentration./ Malo je stvari koje mi mogu poremetiti koncentraciju.	**.798**		.637	3.353	1.174	**.773**		.599	3.345	1.149
I can recognize when my concentration low down./ Mogu prepoznati kada mi padne koncentracija.		**.702**	.524	3.775	1.098		**.598**	.382	**3.958**	1.070
I can easily restore concentration on my performance./ Mogu lako vratiti koncentraciju na izvođenje.	**.653**		.436	3.647	0.971	**.765**		.650	3.550	1.075
I am aware on my thinking, feeling and bodily sensations that may disturb my concentration during performance./ Svjestan/na sam vlastitih misli, osjeća i tjelesnih senzacija koje mogu poremetiti moju koncentraciju za vrijeme izvođenja.		**.494**	.244	3.608	1.016		**.657**	.434	3.479	1.128
I am aware on external factors (reaction of spectators, referee decisions, weather conditions, monitoring the results) that can disturb my concentration during performance./ Svjestan/na sam vanjskih faktora (reakcije gledatelja, sudačke odluke, vremenski uvjeti, praćenje rezultata na semaforu) koji mogu poremetiti moju koncentraciju za vrijeme izvođenja.		**.660**	.445	3.598	**1.188**		**.474**		3.333	**1.291**
At any time, I know what is important for my performance and in what should be focused /U svakom trenutku znam što je bitno za moje izvođenje i na što trebam biti fokusiran/a.	**.689**		.562	3.608	1.016	**.625**		.404	3.873	1.078
During most of the performance, I'm oriented on technical and/or tactical aspects of performance./ Veći dio izvođenja usmjeren/a sam na tehničke i/ili taktičke aspekte izvođenja.		**.361**	.230	3.598	**1.188**		**.625**	.395	3.587	0.995
I can easily shift the focus from irrelevant to the essential aspects of performance./ Lako mogu prebaciti fokus s nebitnih na bitne aspekte izvođenja.	**.652**		.510	**3.950**	0.942	**.607**		.371	3.634	1.133
I am aware that the error is result of the worse concentration./ Svjestan sam da je greška rezultat pada koncentracije.		**.681**	.467	3.657	1.000		**.688**	.474	**3.951**	1.047
My fault during the execution does not hinder the focus on the essential./Moje greške tijekom izvođenja ne otežavaju fokus na bitno.	**.699**		.529	**3.851**	1.014		**.585**	.430	2.811	**1.283**
I know why I my concentration fall during performance./ Znam zbog čega mi pada koncentracija za vrijeme izvođenja.		**.571**	.380	3.255	**1.248**	-	-	-	-	-
Kaiser-Meyer-Olkin Measure / Bartlett's Test of Sphericity	.758		306.22** (df=66)			.748		273.39** (df=55)		
Eigenvalue	3.230	2.329				2.819	2.056			
Variance Explained	26.92%	19.40%				25.63%	18.69%			
Reliability (Cronbach's alpha)	0.500	0.627				0.505	0.599			

Legend: r=correlation of the variable with principal component; h^2= comnunalities; f1= Maintaining attention skill; f2= Awareness about the state of attention

Table 3. Extensive Internal Attention Scale: descriptive characteristics and results of Principal Components Analysis (PCA), with belonging reliabilities, applied on the sample of male and female athletes

	Males				Females			
Items - **males**	r	h^2	Mean	Std. Dev.	r	h^2	Mean	Std. Dev.
During the the performance I'm thinking about errors./Tijekom izvođenja razmišljam o greškama.	0.540	.292	**3.129**	1.246	0.505	.255	**3.211**	1.341
During the performance I feel I am not aware of what is happening./ Tijekom izvođenja imam osjećaj da nisam svjestan što se događa.	0.725	.526	2.455	**1.382**	0.653	.426	2.329	**1.373**
I have a feeling that during the performance I'm confused in my thoughts./ Imam osjećaj da se zapetljam tijekom izvođenja u svojim mislima.	0.753	.566	2.559	1.339	0.738	.545	2.490	1.321
I cannot recognize myself while performing./ Ne mogu sam/a sebe prepoznati tijekom izvođenja.	0.769	.592	2.129	1.155	0.586	.344	1.971	1.148
My feelings have occupied me so that I can't focus attention on performance./ Moji osjećaji me okupiraju tako da ne mogu usmjeriti pažnju na izvođenje.	0.711	.505	2.297	1.245	0.690	.475	2.090	1.211
My thoughts strayed to something unrelated to performance./ Misli mi odlutaju na nešto nevezano za izvođenje.	0.755	.571	2.720	**1.364**	0.689	.475	2.254	1.302
Some errors cannot be out of my mind during the performance./ Pojedine greške ne mogu izbaciti iz glave tijekom izvođenja.	0.521	.271	**3.010**	1.206	0.572	.328	3.049	1.280
Everyday worries occupy me during performance./ Okupiraju me svakodnevne brige tijekom izvođenja.	0.707	.499	2.471	1.460	0.639	.409	2.184	**1.366**
	-	-	-	-	0.574	.330	**3.071**	1.215
Kaiser-Meyer-Olkin Measure / Bartlett's Test of Sphericity	.842		256.706** (df=28)		.815		310.186** (df=36)	
Eigenvalue / Variance Explained	3.822		47.78%		3.586		39.85%	
Reliability (Cronbach's alpha)		0,840				0.808		

Legend: r=correlation of the variable with principal component; h^2= comnunalities

Table 4. Extensive External Attention Scale: descriptive characteristics and results of Principal Components Analysis (PCA), with belonging reliabilities, applied on the sample of male and female athletes

	Males				Females			
Items - **males**	r	h^2	Mean	Std. Dev.	r	h^2	Mean	Std. Dev.
I think I have good spatial orientation bit for my sport./ Mislim da imam dobru prostornu orijentaciju bitnu za moj sport.	.681	.464	4.186	0.887	.650	.464	3.896	0.914
During performance, I can notice also the other things around me./ Uz izvođenje mogu primijetiti i druge stvari oko mene.	.367	.135	3.725	1.064	-	-	-	-
If necessary, I can simultaneously monitor multiple stimuli which are important for successful performance./ Po potrebi mogu istovremeno pratiti više podražaja bitnih za uspješno izvođenje.	.741	.549	3.840	0.896	.688	.135	3.608	1.028
I can well adapt my performance to environmental conditions./ Mogu dobro prilagoditi svoje izvođenje uvjetima u okolini.	.697	.486	3.794	1.037	.701	.549	3.771	0.973
I am able to assess all the relevant external factors on my performance./ Mogu dobro procijeniti sve bitne vanjske faktore na moje izvođenje.	.718	.516	3.598	0.967	.671	.486	3.461	1.004
I know how to adjust my own performance to external factors in order to be successful./ Znam kako prilagoditi vlastito izvođenje vanjskim faktorima da bi ono bilo uspješno.	.846	.716	3.608	1.036	.741	.516	3.514	1.055
Kaiser-Meyer-Olkin Measure / Bartlett's Test of Sphericity	.781		154.379** (df=15)		.751		122.541** (df=10)	
Eigenvalue / Variance Explained	2.866		47.77%		2.386		47.72%	
Reliability (Cronbach's alpha)		0.673				0.624		

Legend: r=correlation of the variable with principal component; h^2= comnunalities

Table 5. Narrow Internal Attention Scale: descriptive characteristics and results of Principal Components Analysis (PCA) with Varimax rotation, with belonging reliabilities, applied on the sample of male and female athletes

	Males					Females				
Items - **males**	f1	f2	h^2	Mean	Std. Dev.	f1	f2	h^2	Mean	Std. Dev.
I can follow the course of my thoughts during the competition (performance)./ Mogu pratiti tijek svojih misli tijekom natjecanja (izvođenja).	**.722**		.522	3.812	1.102	**.676**		.465	3.789	1.044
I repeat to myself what to do during the performance./ Ponavljam u sebi što trebam raditi tijekom izvođenja.		**.836**	.699	3.386	1.319		**.819**		3.190	1.378
I notice that I speak negative things to myself during the performance./ Mogu primijetiti da si govorim negativne stvari tijekom nastupa (izvođenja).	-.360	**.553**	.435	2.686	1.421	-.447	**.594**	.552	2.769	1.500
I can recognize my negative feelings during the performance./ Mogu prepoznati svoje negativne osjećaje tijekom izvođenja.	-	**-**	-	-	-		**.497**	.259	3.350	1.218
In some situations I have to take into account the position of the body during the performance./ U nekim situacijama moram voditi računa o položaju tijela tijekom izvođenja.		**.776**	.635	4.000	1.053		**.667**	.470	3.811	1.261
I can make a brief analysis of my performance./ Mogu napraviti kratku analizu svog izvođenja.	**.735**		.545	3.804	1.081	**.792**		.652	3.783	1.022
I quickly learn from my mistakes./ Brzo učim na greškama.	**.677**		.467	3.792	1.033	**.685**		.491	3.631	1.078
Kaiser-Meyer-Olkin Measure / Bartlett's Test of Sphericity	.497			70.493** (df=15)		.593			124.880** (df=21)	
Eigenvalue	1.683	1.620				1.789	1.770			
Variance Explained	28.05%	26.99%				25.56%	25.29%			
Reliability (Cronbach's alpha)	0.543	0.547				0.547	0.559			

Legend: r=correlation of the variable with principal component; h2= comnunalities; f1= Awareness about the attention during performance; f2= Internal speech

Table 6. Narrow External Attention Scale: descriptive characteristics and results of Principal Components Analysis (PCA), with belonging reliabilities, applied on the sample of male and female athletes

	Males				Females			
Items	r	h^2	Mean	Std. Dev.	r	h^2	Mean	Std. Dev.
Some things I am doing ‘unconsciously’, but successful./ Neke stvari odradim „nesvjesno“ i na kraju budu uspješne.	.609	.370	3.980	0.921	.734	.539	3.859	1.069
Some acts I perform automatically./ Neke radnje izvodim automatski.	.613	.376	4.265	0.807	.715	.512	4.191	1.007
Some operations I perform instinctively./ Neke radnje izvodim instinktivno.	.427	.182	4.059	0.899	.623	.389	3.826	1.136
I can focus only on one aspect of the action during the performance./ Mogu se fokusirati na jedan aspekt radnje tijekom izvođenja.	.513	.263	3.545	1.145	.667	.446	3.574	1.135
I feel like I'm constantly focused on the essential aspects of performance./ Imam osjećaj da sam stalno fokusiran na bitne aspekte izvođenja.	.523	.273	3.588	1.018	.529	.280	3.348	1.042
At any time, I’m ready to react quickly./ U svakom trenutku spreman sam reagirati brzo.	.636	.404	4.137	1.015	.422	.178	3.958	0.971
The best outcome is usually when you do not think much./ Najbolji ishod obično bude kad ne razmišljam puno.	.480	.231	3.971	1.067	-	-	-	-
Kaiser-Meyer-Olkin Measure / Bartlett's Test of Sphericity	.590		79.654** (df=21)		.726		124.840** (df=15)	
Eigenvalue / Variance Explained	2.099		29.99%		2.343		39.05%	
Reliability (Cronbach's alpha)	0.597				0.637			

Legend: r=correlation of the variable with principal component; h2= comnunalities;

Table 7. Correlations (Spearman) among all the components in all questionnaires in male and female athletes

	Males								Females							
	Mental Energy	Maintaining attention skill	Awareness about state of attention	Extensive Internal Attention	Extensive External Attention	Awareness about attention during perfomance	Internal speech	Narrow External Attention	Mental Energy	Maintaining attention skill	Awareness about state of attention	Extensive Internal Attention	Extensive External Attention	Awareness about attention during perfomance	Internal speech	Narrow External Attention
Mental Energy	1	**.492****	**.324****	**-.275****	**.416****	**.373****	.024	**.565****	1	.485**	**.229****	**-.246****	**.523****	**.373****	.054	**.544****
Maintaining attention skill		1	**.320****	**-.420****	**.585****	**.513****	.029	**.500****		1	.058	**-.539****	**.780****	**.558****	-.020	**.500****
Awareness about state of attention			1	.119	**.529****	**.321****	**.190****	**.468****			1	**.385****	**.261****	**.173****	**.397****	**.376****
Extensive Internal Attention				1	**-.199****	**-.350****	**.497****	-.095				1	**-.362****	**-.316****	**.519****	-.104
Extensive External Attention					1	**.473****	.010	**.567****					1	**.569****	-.004	**.624****
Awareness about attention during perfomance						1	-.034	**.492****						1	.011	**.543****
Internal speech							1	.067							1	.085
Narrow External Attention								1								1

Legend: * Correlation significant with $p<0.05$ (two-tailed); ** Correlation significant with $p<0.01$ (two-tailed) mensions of attention and mental energy are statistically significantly and mostly positively (low to medium sized) correlated, except with the dimension Extensive internal attention (reverse coded).

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Effect of Menthol on Respiratory and Perceptual Responses to Exercise in Firefighter Protective Gear

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ABSTRACT

Impaired respiration reduces firefighters' work capacity. This study evaluated the effect of menthol lozenge on respiratory and perceptual responses during exercise in a hot environment. Ten participants wearing firefighter protective gear performed two repeated exercise and rest trials in a counter-balanced order. Exercise consisted of two bouts of 20-min treadmill exercise at 60% of maximal oxygen uptake and one bout of 20-min stepping exercise at a wet bulb global temperature of 35°C. Participants either took 10-mg menthol or control lozenges prior to the beginning of each exercise bout. Respiratory gas exchange, heart rate, thermal sensation, and breathing comfort were continuously recorded. Menthol lozenges significantly increased pulmonary ventilation (menthol: 45.0±6.6 $L\cdot min^{-1}$ vs. control: 41.4±5.8 $L\cdot min^{-1}$ and menthol: 52.7±9.7 $L\cdot min^{-1}$ vs. control: 46.5±7.0 $L\cdot min^{-1}$, for the 1st and 2nd treadmill exercise, respectively) and oxygen consumption (menthol: 26.7±2.0 $ml\cdot kg^{-1}\cdot min^{-1}$ vs. control: 25.2±2.3 $ml\cdot kg^{-1}\cdot min^{-1}$ and menthol: 28.8±2.3 $ml\cdot kg^{-1}\cdot min^{-1}$ vs. control: 26.9±1.9 $ml\cdot kg^{-1}\cdot min^{-1}$, for the 1st and 2nd treadmill exercise, respectively) ($p<0.05$). The effect of menthol on respiration disappeared during the stepping exercise ($p>0.05$). The ventilatory equivalents though were not different throughout the exercise ($p>0.05$). Ratings of thermal sensation and breathing comfort were not different ($p>0.05$). It was concluded that menthol could alter breathing pattern and increase respiratory responses during strenuous exercise in the heat. There was no favorable effect of menthol on respiratory or perceptual responses under exercise-heat stress.

Key words: *Firefighter, protective clothing, respiration, oxygen consumption.*

Introduction

The high metabolic demand of firefighting is a complex result of strenuous muscular work, heavy equipment (Gledhill & Jamnik, 1992), impermeable protective clothing ensemble (Romet & Frim, 1987), and challenging environments (Smith, Petruzzello, Kramer, & Misner, 1997). In addition, hazardous work environments require firefighters to wear a self-contained breathing apparatus (SCBA) for respiratory protection. SCBA could result in a sharp decrease in pulmonary ventilation (VE) and oxygen consumption (VO_2) (Eves, Jones, & Petersen, 2005; Louhevaara, Smolander, Tuomi, Korhonen, & Jaakkola, 1985) hence a substantial reduction in maximal work capacity (Eves et al., 2005).

Menthol is of great interest for two practical reasons. First, the oral cavity is a major airway entrance during strenuous exercise and when menthol is administrated orally, it reduces sensation of respiratory discomfort (Eccles, 2003). Menthol ingestion has been shown to induce bronchodilation (Wright, Laude, Grattan, & Morice, 1997), and this mechanistic influence on the airways expansion has been suggested to be via inhibition of sensory afferents and relaxation of airway smooth muscle (Ahijevych & Garrett, 2004; Maher et al., 2014). Previous study (Mundel & Jones, 2010) investigating swilling a menthol solution on exercise capacity in the heat found that fatigue was delayed and VE increased. Considering the impaired respiration greatly reduces firefighters' maximal exercise performance (Eves et al., 2005; Louhevaara et al., 1985), this may provide a situation where menthol has practical applications. Second, when menthol is applied to the mucosal surfaces it triggers a cool sensation (Eccles, 2003) which is perceived as refreshing and stimulating during exercise (Mundel & Jones, 2010). Menthol might provide relief effect from thermal and/or breathing discomfort during strenuous exercise in the heat. Therefore, menthol ingestion is clearly appealing from both physiological and perceptual point of view.

Accordingly, this study evaluated the effect of menthol on respiratory and perceptual responses to exercise in firefighter protective gear in a hot environment. Reducing stressors could be of great importance for firefighter's health, safety, and performance.

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Methods

Participants

Ten physically active male volunteered for this study. This study was conducted in autumn season and participants were unacclimatized to heat during the study period. Heat acclimation could cause adaptation of exercise ventilation during hyperthermia hence may mask potential effects of menthol on respiration (Beaudin, Clegg, Walsh, & White, 2009). A minimum aerobic fitness of 40 ml·kg^{-1}·min^{-1} was required in order to participate in this study (Bilzon, Scarpello, Smith, Ravenhill, & Rayson, 2001). Mean ± standard deviation (SD) characteristics of the participants were: age 24±4 yr, height 179±6 cm, weight 76.3±15.3 kg, body fat percentage (Pollack, Schmidt, & Jackson, 1980) 8±5%, and VO_{2max} 52.8±5.3 ml·kg^{-1}·min^{-1}. This study was approved by the university's Institutional Review Board and all participants provided written consent before participation.

Experimental design

An outline of the study design is shown in Figure 1. The first laboratory visit entailed assessment of participants' VO_{2max} and maximal heart rate (HR_{max}), as well as establishing the individualized workload by spirometry (Parvo 2400, ParvoMedics, Sandy, UT). Briefly, the treadmill exercise consisted of 4 bouts of 4 min of walking on a motor-driven treadmill (Model 18-60 Treadmill; Quinton Instrument Co., Seattle, WA) to elicit a metabolic rate of 60% VO_{2max} followed by 1 min of 10 arm curls (bar weighing 4.5 kg). The stepping exercise consisted of 4 bouts of constant-cadence stepping exercise; each bout consisted of 4-min stepping at a rate of 25 steps·min^{-1} on a 40-cm high platform, followed by 1-min of 10 arm curls. The stepping exercise was intended to simulate stair climbing, a common activity for firefighters.

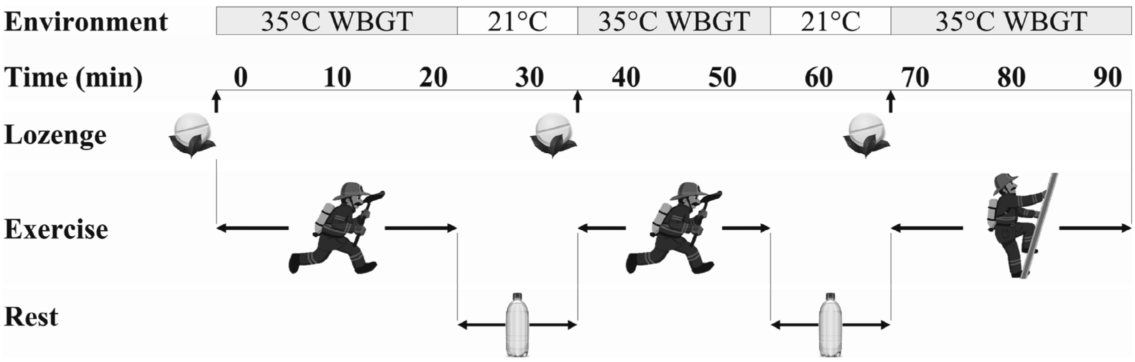

Figure 1. Schematic overview of the experimental protocol (see text for explanation).

Trials were conducted on a weekly basis in a counter-balanced order. Each participant performed their trials at the same time of day and week to avoid any circadian variations' influence. Data were collected in a heat chamber and a laboratory area. Participants exercised in a heat chamber at a wet bulb global temperature of 35°C (wet bulb 31°C, dry bulb 45°C, globe 43°C; 40% relative humidity) and rested in a controlled laboratory with ambient temperature of 21±1°C and relative humidity of 45±3%.

Participants took one menthol or control lozenge prior to each treadmill/stepping exercise. Each menthol lozenge (Chloraseptic Sore Throat Lozenges, Prestige Brands, Irvington, NY) contained 10 mg of menthol and 6 mg of benzocaine. The control lozenge (Cepacol Fizzlers, Combe Inc., White Plains, NY) contained 6 mg of benzocaine. Participants were told to keep menthol lozenge naturally dissolved in the mouth as this would allow the lozenge to last for about 20 min. The control lozenge typically melted in 1 min as reported by participants.

Participants donned a heart rate (HR) monitor (Polar Electro Inc., Lake Success, NY), wore an air cushioned gas measuring face mask and firefighter protective clothing (coat, pants, gloves) and a SCBA tank (Survivair Respirators Inc., USA). A cotton t-shirt and shorts were worn under the clothing ensemble. Running shoes were worn instead of firefighting boots to avoid unnecessary discomfort. After dressing, participants took one lozenge and entered the heat chamber performing the 1st 20-min treadmill exercise; thereafter, participants exited the heat chamber and undertook a 15-min rest period in a seated position. Room temperature tap water was provided *ad libitum* during rest periods. A second lozenge was provided, then participants repeated the 2nd treadmill exercise and rest period. Thereafter, participants took a third lozenge on the same protocol schedule and performed the stepping exercise.

Measurements

Respiratory gas exchange (Parvo 2400, ParvoMedics, Sandy, UT) and HR were continuously collected throughout the exercise periods. VE, VO_2, and breathing frequency (f_b) were calculated for an average 20-min sample. Fluid intake was recorded. Ratings of thermal sensation (TS) (Young, Sawka, Epstein, Decristofano, & Pandolf, 1987) and breathing comfort (BC) (Abadie & Carroll, 1993) were recorded every 10 min throughout the exercise periods. These scales were each presented on large charts, and participants pointed to indicate their current rating.

Statistical analysis

A two-way repeated-measures ANOVA was used to compare menthol and control for respiratory variables, HR, TS, and BC, with Tukey's *LSD* post-hoc test. Fluid intake was compared with the Student's *t*-test. To determine the responders and non-responders to the menthol treatment, individual VE data were also compared by computing the least mean difference yielding a $p<0.05$ at a power of 80% using the mean observed standard deviation. All values were reported as mean (±SD). Alpha level was set at 0.05.

Results

There were one menthol trial and one control trial stopped near the end of the stepping exercise (5 min earlier) due to participants' volition. No difference of fluid intake was found: menthol 1535±909 ml vs. control 1394±546 ml (p>0.05). Heart rate responses are presented in Figure 2. At the end of the 20-min stepping exercise, mean heart rates corresponded to 94±6% and 95±5% of HR_{max}, for menthol and control, respectively. There were no significant differences between the two conditions (p>0.05).

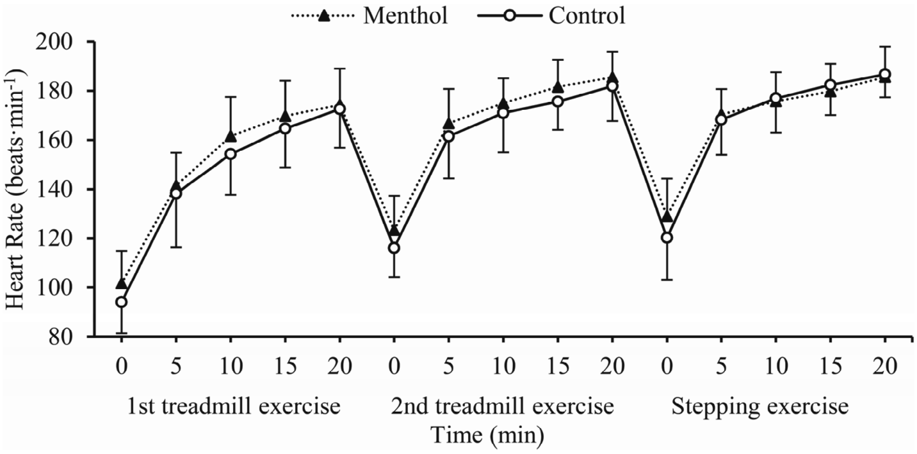

Figure 2. Mean (± standard deviation) heart rate responses.

Respiratory responses are presented in Table 1. VE and VO_2 were significantly higher for menthol compared to control during the 1st and 2nd treadmill exercise (p<0.05). Menthol significantly increased f_b by a mean of 5 breaths·min^{-1} compared to control during the 2nd treadmill exercise (p<0.05). VE/VO_2 was not different (p>0.05) throughout the trials.

Table 1. Pulmonary Ventilation (VE), Oxygen Consumption (VO_2), Breathing Frequency (f_b), and Ventilatory Equivalent (VE/VO_2)

Respiration	1st treadmill exercise		2nd treadmill exercise		Stepping exercise	
	Menthol	Control	Menthol	Control	Menthol	Control
VE (L·min^{-1})	45.0±6.6*	41.4±5.8	52.7±9.7*	46.5±7.0	46.8±6.9	43.6±4.4
VO_2 (ml·kg^{-1}·min^{-1})	26.7±2.0*	25.2±2.3	28.8±2.3*	26.9±1.9	25.0±3.6	24.2±3.4
f_b (breaths·min^{-1})	29±7	27±4	34±9*	29±4	32±6	30±6
VE/VO_2	27.3±4.2	26.4±2.5	29.4±4.2	27.8±2.8	30.5±4.5	29.4±3.7

*Significantly different from control, p<0.05.

Analysis of individual data (Figure 3) revealed that seven of the ten participants responded to the menthol treatment during the 1st treadmill exercise, five responded during the 2nd treadmill exercise, and three responded during the stepping exercise. There was no treatment effect on perceptual responses (Figure 4) (p>0.05).

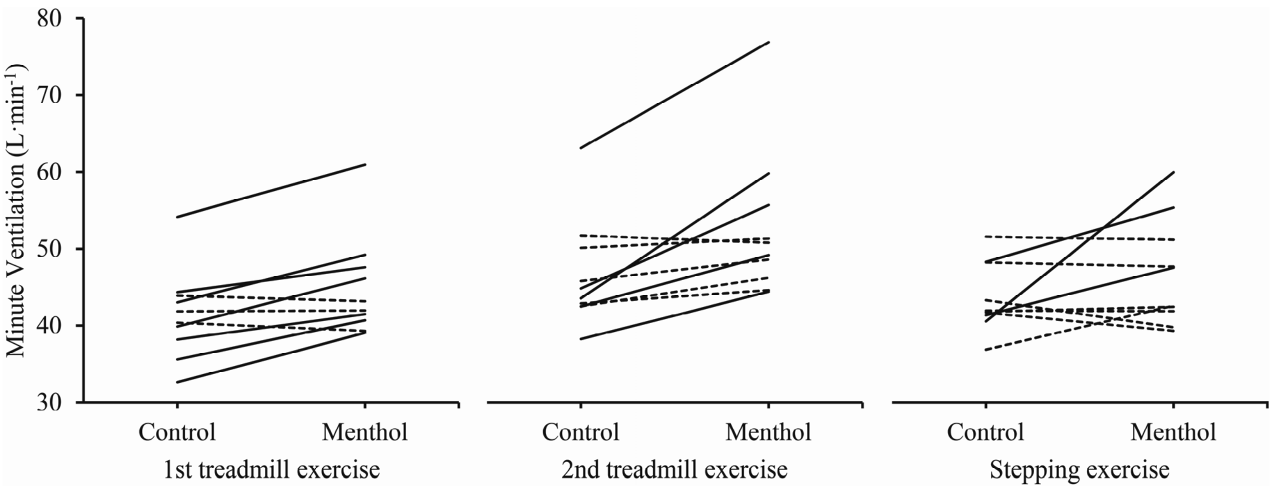

Figure 3. Individual responses to the menthol treatment on pulmonary ventilation.
The solid line represents responder, and the dotted line represents non-responder.

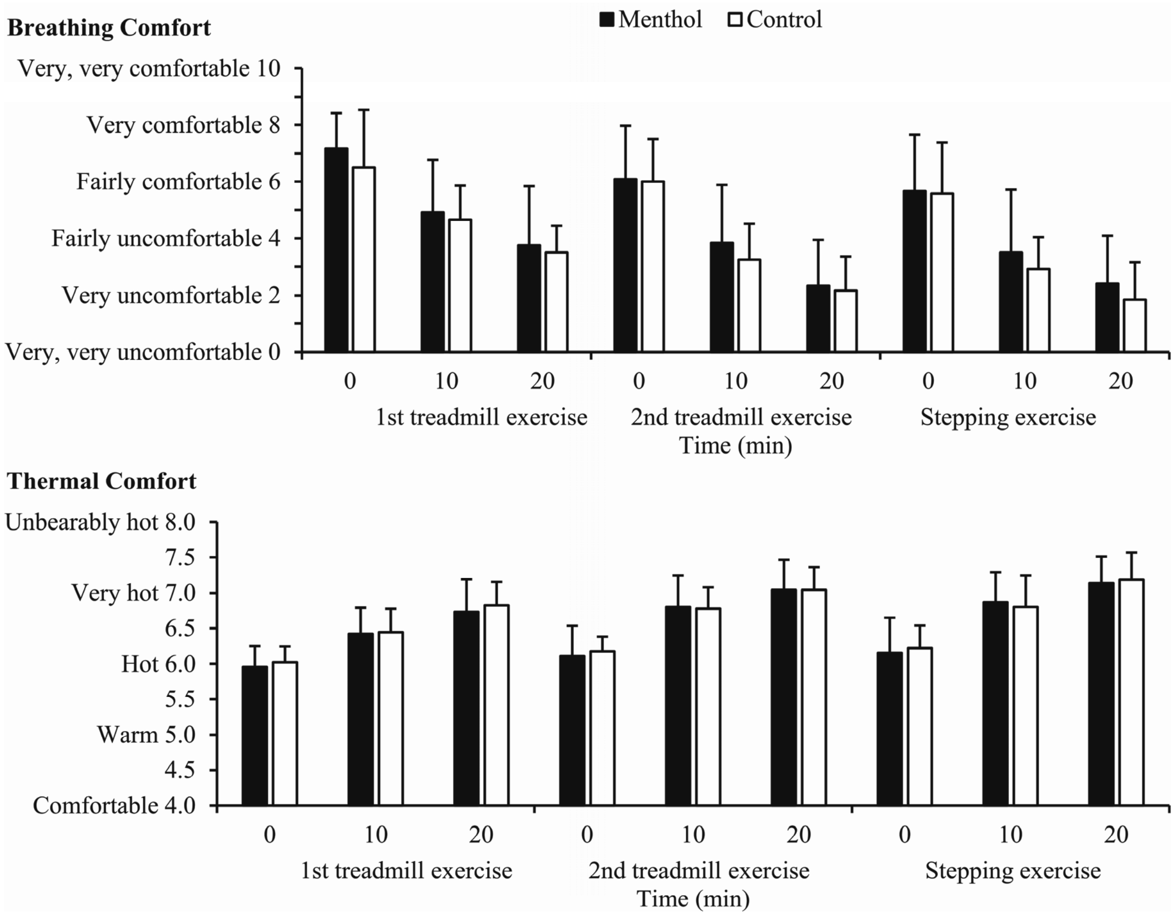

Figure 4. Mean (± standard deviation) ratings of breathing comfort and thermal sensation.

Discussion

In this study, repeated exercise-heat stress resulted in comparable cardiovascular and respiratory strains to previous reports of field firefighting activities (Holmer & Gavhed, 2007; Smith, Manning, & Petruzzello, 2001). Previous study reported an increase in VE by 8 $L·min^{-1}$ following menthol swilling whereas no change in VO_2 (Mundel & Jones, 2010). Though we found VE increased by 3.6 $L·min^{-1}$ (+8%) and 6.2 $L·min^{-1}$ (+13%) during the 1st and 2nd treadmill exercise, VO_2 correspondently increased by 1.5 $ml·kg^{-1}·min^{-1}$ (+5.6%) and 1.9 $ml·kg^{-1}·min^{-1}$ (+7.1%) and the ventilatory equivalences were not different, suggesting the metabolic cost increased following the menthol treatment. In addition, oral administration of menthol has been suggested to reduce the effort of breathing (Mundel & Jones, 2010) and induce subjective sensation of improved airflow (Eccles, Jawad, & Morris, 1990) whereas our participants did not show better breathing comfort. These findings suggest that there is no physiological or perceptual advantage in our test condition.

It is unclear of the mechanism accounting the unexpectedly increase in the energy cost of breathing. A possible explanation for this result would be the pattern of menthol delivery. Previous study (Mundel & Jones, 2010) had their participants swilling menthol solution for a short time and cool fluid (19°C) was available, and menthol swilling was repeated every 10 min during the exercise period. Whereas in our study, menthol was delivered via lozenge and no fluid was available during the exercise periods. As exercise ensued, participants reported that the menthol lozenge became unpleasant due to its sweetness. This became obvious after the 2nd treadmill exercise, when participants were already sweating profusely and reported being thirsty. Repeated menthol swilling accompanied with cool fluid consumption may favor respiratory responses during exercise-heat stress.

Repeated workouts are a common scenario for firefighters to change the SCBA gas tank. Individual data offer additional insight on the treatment effect during repeated exercise. Menthol appears to exert its effect on VE initially and tended to be not effective after a short period of time. When the responders and non-responders were added together across the three exercise bouts (10 participants in 3 exercise bouts = 30 exercise occasions) the total number of responders was 15/30, suggesting a null effect. It is unclear to why the physiological action of menthol diminished as exercise ensued. It is possible that menthol induces earlier onset bronchodilation (Wright et al., 1997), as exercise ensues and the airways open up, this effect dissipates thereby reducing the effect of menthol over time. Because the inhibitory effect of menthol on the airway smooth muscle contraction is highly dependent on temperature, with higher temperature suppressing its effect (Ito et al., 2008), it is also possible that the thermal burden resulting from strenuous exercise, protective clothing, and the environment caused menthol's effect to transiently diminish during the course of exercise. While it is disadvantageous to observe an increase in VO_2 under constant workload, menthol initially stimulated VE in several individuals. Considering firefighter protective clothing and SCBA induce impaired respiration and negatively impact on maximal aerobic performance (Eves et al., 2005), the stimulative effect of menthol on respiration still warrants further investigation. In short, current results could not clearly explain whether such responses were due to the pharmacological effect of menthol or the specific pattern of delivery.

Occupational workers frequently report breathing discomfort whilst performing physical activity with respirator, which can be attributed to buildup of facial heat within respirator, specifically due to elevations in facial skin temperature (Roberge, Kim, & Coca, 2012). Improving breathing comfort provides practical work stress relief. Further, strenuous exercise in the heat is also related to deterioration in positive moods such as calmness and alertness (Zhang et al., 2014). Comfort is therefore an important consideration while addressing the physiological strain. Menthol can induce a sensation of coolness (Eccles, 2003) and oral administration of menthol reduced the breathing discomfort during loaded breathing (Nishino, Tagaito, & Sakurai, 1997). However, neither ratings of thermal sensation nor breathing comfort supported those notions. It is plausible that the high heat content of air in our enclosed chamber area (a load of 35°C WBGT) coupling with the prolonged exercise may have overwhelmed any cool and/or refreshing effect of menthol. During the experimental time, heated room air was breathed throughout the 60-min exercise, and participants reported the air cushioned mask as wet and uncomfortable. The combination of heat and humidity was suggested as primary factors for mask and breathing's acceptability (Nielsen, Gwosdow, Berglund, & DuBois, 1987; Roberge et al., 2012). Specifically, a heat energy content of 70-80 $Kj \cdot kg^{-1}$ air or more could impact on the breathing effort and a warm and humid air of 33°C considerably decreased the mask acceptance (Nielsen et al., 1987). It has been reported that the expired respiratory air temperature was 35.6±0.7°C under a dry-heat condition (45°C ambient temperature and 20% relative humidity) (Livingstone, Nolan, Cain, & Keefe, 1994). Under a humid-heat condition (45°C ambient temperature and 100% relative humidity), the expired respiratory air temperature reached critically high value of 41.8±0.8°C (Livingstone et al., 1994). In our test environment, the dry bulb temperature was 45°C and the relative humidity was 40%. Within the tight fit gas collection mask, it is logical to assume very higher micro-environment temperature and humidity within the respirator. The expired air temperature in our participants are plausibly well above the suggested critical air heat content hence severely impacted on the breathing comfort.

The study is not without limitations. First, the major design weakness is not utilizing SCBA respirator for the respiratory evaluation. The increased respiratory loads whist firefighting are attributed to a variety of factors, including SCBA regulator as its resistance induces the breathlessness (Eves et al., 2005; Louhevaara et al., 1985). The current respiratory evaluation was conducted at ambient barometric pressure with no flow resistance during breathing and it may lead to underestimation of breathing stress. Second, the breathing air content from actual SCBA tank is usually cool and dry, hence, it is unclear how the perceptual responses with the menthol treatment might be altered in field environments. Third, while there is no major difference in the breathing pattern between firefighters and civilians (Donovan & McConnell, 1999), the current experiment was conducted on fit, young, and unacclimatized participants. It is possible however, older firefighters would experience greater cardiorespiratory strain (Choi, Shin, Lee, & Chung, 2014; Prieto, Gonzalez, Del Valle, & Nistal, 2013; Walker, Driller, Argus, Cooke, & Rattray, 2014). The opposite may be found in acclimatized firefighters who are familiar with the clothing ensemble and joint upper-lower body work regime. Fourth, this study used a menthol lozenge containing additional benzocaine, hence, may have impacted on respiration.

In conclusion, current results did not find physiological advantages of menthol during repeated exercise with firefighter protective gear in the heat. The increase in VO_2 together with the lack of a positive perceptual responses would not be useful for firefighters. While it is unclear about the causes of the unexpected increase in VO_2, it might be worthwhile to further explore menthol's stimulative effect on respiration. Impaired respiration is a detrimental factor for firefighters' health and performance. A modest improvement in respiration may be of practical importance in emergency situations. It is necessary for industry and exercise physiologists to continue exploring solutions to alleviate this occupational stressor.

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Review
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Performance-enhancing effects of dietary nucleotides: do mitochondria play a role?

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A B S T R A C T

Nucleotides are group of natural biomonomeric molecules and novel dietary supplements with performance-enhancing attributes. However, their mechanisms of action and target biological structures are poorly understood and identified. This short paper overviews the possible role of mitochondria during the utilization of nucleotides for exercise performance. Mitochondria-related effects of nucleotides have been identified, along with obstacles for dietary nucleotides delivery to the organelle.

Key words: *Nucleotides, Mitochondria, Exercise performance, Bioenergetics, DNA repair.*

Introduction

Nucleotides are complex organic biomolecules composed of a nitrogen-containing base, ribose or deoxyribose, and one or more phosphate groups. They build the structure of nucleic acids (such as DNA and RNA) and energy-rich molecules (e.g. adenosine triphosphate, ATP), and act as signaling molecules and/or metabolic co-factors in human metabolism. Utilization of these essential compounds seems to be tissue-dependent, and cells with higher energy requirements (e.g. skeletal muscle, brain) and/or vigorous DNA replication (e.g. immune cells, enterocytes) process more nucleotides (Van Buren et al., 1994). In addition, heavy exercise may increase the person's need for nucleotides due to elevated turnover during work and recovery (Bangsbo et al., 1993). Although nucleotides can be synthesized or salvaged in the human body, increased requirements during stress-related conditions (such as exercise, inflammation or malnutrition) should be secured through the diet, with extra nucleotides might provide additional physiological advantage. Several studies reported beneficial effects of dietary nucleotides in athletic environment. McNaughton and co-workers (2007) reported that a chronically ingested nucleotide supplement blunts the response of the hormones associated with physiological stress in 30 moderately trained male subjects. Same group (McNaughton et al., 2006) found that dietary nucleotides offset post-exercise cortisol response associated with demanding endurance exercise, suggesting possible stress-relief effects of the formulation. Ostojic and co-workers (2012) found that 50 mg/day of sublingual nucleotides positively affected several immunity indicators (e.g. serum immunoglobulin A, natural killer cells count, cytotoxic activity, salivary lactoferrin) in young active males when administered for 14 days. Time to exhaustion was significantly improved in healthy males supplemented with nucleotides for two weeks (315.4 ± 20.8 s vs. 330.5 ± 18.6 s, P = 0.04) (Ostojic et al., 2013). In addition, specific nucleotide formulation (480 mg/day during 30 days) improved post-exercise recovery, and counteract the impairment of immune function after heavy exercise (Riera et al., 2013). Although the previous studies were small pilot studies and showed some design flaws, it seems that dietary nucleotides might positively affect exercise performance. However, the exact mechanism of nucleotides' action remains subject to debate, and no target tissue and/or cellular compartment has been identified so far. Since mitochondrion plays an essential role in energy conversion and metabolic signaling during exercise (Willis et al., 1994), the organelle might be a specific spot for possible action of dietary nucleotides. Here we discuss obstacles and opportunities for dietary nucleotides delivery to mitochondria.

Does dietary nucleotides affect mitochondria?

Mitochondrion is a place of turbulent utilization of nucleotides. Several metabolic reactions may affect nucleotides promotion and degradation, such as oxidative phosphorylation through ATP production, cellular proliferation regulation, and mitochondrial genome replication (Kaasik et al., 2001). In normal conditions, the recycling of nucleotides inside the organelle is likely balanced between endogenous synthesis (from amino acids, glucose, or DNA and RNA salvaged remains) and nucleotides breakdown to nucleosides and uric acid (Carver et al., 1995). However, in energy-demanding situations (such as heavy exercise), mitochondrial nucleotides pool might be depleted, with additional nucleotides needed to complement a deficit. In this case, externally supplied nucleotides (or its building blocks) should be transported via mitochondrial biomembranes, and delivered to the specific location inside the organelle. Several mitochondria-related effects of exogenous nucleotides have been identified, with a possible relevance for exercise performance improvement. Orally administered nucleotides decrease acetoacetate:beta-hydrodybutyrate ratio, an indicator of mitochondrial redox state, suggesting less oxidative stress and restored mitochondrial function after cellular injury (Perez et al., 2004). In addition, the concentrations of ATP (along with adenosine diphosphate and monophosphate) and adenine nucleotides, which are the carriers of electrons and the final acceptors of the energy generated during the mitochondrial energy coupling process, were superior after nucleotides administration.

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Therefore, the utilization of dietary nucleotides might enhance the efficacy of oxidative phosphorylation, electron transport, and the turnover between oxidized and reduced forms of nicotinamide adenine dinucleotide, which would stimulate the production and storage of energy in the cell (Perez et al. 2004). Furthermore, dietary nucleotides normalized activities of mitochondrial enzymes (e.g. ATPase, citrate synthase, malate dehydrogenase) in isolated mitochondria after chronic stress (Arnaudet et al., 2003), suggesting earlier recovery of altered mitochondrial function after nucleotides intake. Finally, exogenous nucleotides might enhance reparation of damaged mitochondrial DNA that can appear as a consequence of heavy exercise (Jafari et al., 2005). However, no animal or human interventional studies so far monitored mitochondria-related effects of oral nucleotides during or after exercise. In addition, several issues can limit nucleotides delivery to the organelle. Theoretically, nucleotides are transported through facilitated diffusion or specific sodium-dependent carrier mediated mechanisms (Gutierrez-Castrellon et al., 2007; Klingenberg, 2008). However, it remains unclear does dietary nucleotides reach mitochondria due to several barriers and/or obstacles recognized (e.g. low bioavailability after oral administration, poor resistance of nucleotides to acidic environment, high negative charge of molecules that might impact transport through bilayer membranes, additional ATP needed for facilitated transport) (Bacha et al., 2013). Although nucleotides positively affect mitochondrial function in vitro, more studies are needed to assess mitochondria-related ergogenic effects of these compounds in the clinical environment.

Conclusion

Dietary nucleotides are semi-essential nutrients that provide metabolic, immunological, and physiological benefits during and after heavy exercise. Mitochondria could be a target subunit for exogenous nucleotides, with these compounds might positively effect energy production, oxidative stress regulation and DNA repair in the organelle. However, more studies are needed to evaluate nucleotides delivery and uptake by mitochondria after oral administration in vivo.

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Transfer of Learning on a Spatial Memory Task between the Blind and Sighted People Spatial Memory among Blind and Sighted

Original Scientific Paper

Transfer of learning on a spatial memory task

Selcuk Akpinar[1], Stevo Popović[1,2], Sadettin Kirazci[1]

[1]Middle East Technical University, Physical Education and Sports Department, Ankara, Turkey
[2]University of Montenegro, Faculty for Sport and Physical Education, Niksic, Montenegro

Corresponding author:
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University of Montenegro
Faculty for Sport and Physical Education
Narodne omladine bb, 84000 Niksic, Montenegro
E-mail:

Word count: 2,980

Abstract word count: 236

Number of Tables: 3

Number of Figures: 3

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- ✓ **Methods**

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- ✓ *Table position of the research football team*

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- ✓ In one study (Reilly, 1997), soccer players…
- ✓ In the study by Reilly (1997), soccer players…
- ✓ In 1997, Reilly's study of soccer players…

Works by two authors
- ✓ Duffield and Marino (2007) studied…
- ✓ In one study (Duffield & Marino, 2007), soccer players…
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- ✓ In one study (Krustrup et al., 2003), soccer players…

Two or more works in the same parenthetical citation: Citation of two or more works in the same parentheses should be listed in the order they appear in the reference list (i.e., alphabetically, then chronologically)
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Journal article (online; electronic only):

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Conference paper:

Pasadilla, G. O., & Milo, M. (2005, June 27). *Effect of liberalization on banking competition*. Paper presented at the conference on Policies to Strengthen Productivity in the Philippines, Manila, Philippines. Retrieved August 23, 2006, from http://siteresources.worldbank.org/INTPHILIPPINES/Resources/Pasadilla.pdf

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Book:
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- ✓ **Table 1.** Repeated Sprint Time Following Ingestion of Carbohydrate-Electrolyte Beverage

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Table footnotes should be written below the table.

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- ✓ *Note.* CI: confidence interval; Con: control group; CE: carbohydrate-electrolyte group.

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- ✓ ^{a}One participant was diagnosed with heat illness and n = 19.^{b}n =20.

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- ✓ *P<0.05,†p<0.01.

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- ✓ Table 1 (first letter in all capitals and no full stop)
- ✓ ...as shown in Tables 1 and 3. (citing more tables at once)
- ✓ ...result has shown (Tables 1-3) that... (citing more tables at once)
- ✓ ....in our results (Tables 1, 2 and 5)... (citing more tables at once)

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- ✓ **Figure 1.** Changes in accuracy of instep football kick measured before and after fatigued. SR – resting state, SF – state of fatigue, *p>0.01, †p>0.05.

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- ✓ ….in our results (Figures 1, 2 and 5)... (citing more figures at once)

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The project is within the HERD (Higher education, research and development) program for maritime sector intended for the Western Balkans. The project, worth around 1.4 million euros, is aiming toward improving human resources competence in the maritime sector in Montenegro through the transfer of knowledge and experience from the Norwegian experts, primarily off-shore business in which they are among the most competent in the world.

Delegation from Montenegro on study visit in Norway

So far, the project has provided the following major activities: a joint Norwegian-Montenegrin maritime training center for is established at the Maritime Faculty Kotor, center for cooperation and innovation in the maritime industry at the Maritime Faculty Kotor is established, research equipment for marine engineering and electro-technical laboratory is provided, specialized training for the teaching staff of the Faculty is enabled, developing English language teaching materials is provided, harmonization of curricula with the requirements of International Maritime Organisation STCW Convention, exchange of experience between Norwegian and Montenegrin pilot services in order to increase the safety of navigation, the exchange of experiences between port authorities and the authorities, organisation of a number of thematic workshops is provided as well.

The project is of great importance to the University of Montenegro/Maritime faculty Kotor in efforts to become recognizable institution in the Mediterranean region.

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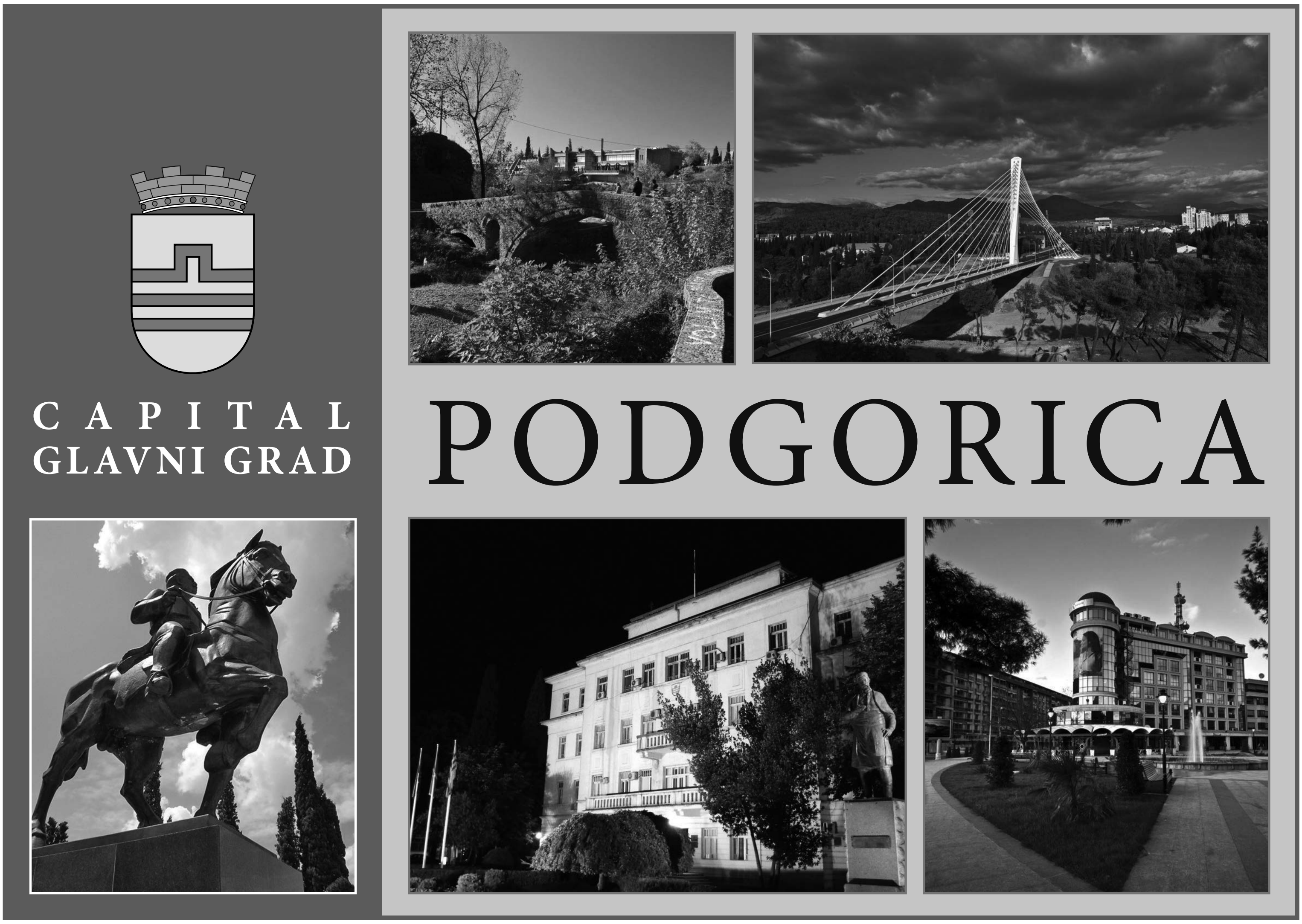
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