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Implications of surgical mask use in physical education lessons

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ABSTRACT

COVID-19 is being a huge challenge for education systems. Mandatory use of face masks in presential classes may lead to psychophysiological impairment of students, which affect lessons. Thus, the aim of the present research was to analyze the effect of mask use in basal psychophysiological status of physical education students prior to a physical education lesson. We analyzed 72 physical education students in two moments prior to two physical education lessons with 48 h between them. Blood oxygen saturation, body, temple and face temperatures, perceived stress and exertion, and heart rate variability were measured. Results showed that the use of surgical masks in physical education students produced a significant increase on subjective stress perception, sympathetic modulation, cardiovascular response, face, and temple temperature while decreasing blood oxygen saturation. We concluded that the use of surgical masks by physical education students induce modifications on the organic status, which could represent a handicap compromising the academic objectives of physical education lessons. This information can help teachers design efficient physical education lessons.

1. Introduction

SARS-Cov-2 is an infectious disease caused by the severe acute respiratory syndrome coronavirus. Its rapid spread and high contagiousness have led to the COVID-19 pandemic [1]. To keep it in check, governments have adopted measures to control the spread of the virus and to keep the medical systems without a collapse. Restrictive measures were taken in public spaces like restaurants, cafes, gyms, as well as in sport and educational centers, being mandatory the use of face mask [2]. In this situation, COVID-19 is being a challenge to education systems.

During the most restrictive phases of the pandemic, in the first waves, education was settled to a "standby" situation in primary and elementary schools, implementing online classes in secondary and university centers [3]. When the curve of the virus flattened, governments allowed a progressive return to normality, thus, schools adopted a mixed education model combining presential and virtual classes. In presential classes, masks are mandatory, hand hygiene is promoted, and frequent ventilation, cleaning of classrooms and social distancing between students of 1.5 m separation are implemented [4]. These measures have supposed important logistical limitations for teachers [5]. In the scenario of mandatory facemask, authors found how its acute use during a 150 min lecture leaded to an increase in sympathetic nervous system modulation with an increased heart rate and decreased blood oxygen saturation [6]. Also, authors found increased reaction times and fatigue perception. However, there is a large controversy regarding the use of protective face masks while exercising. Authors suggest that wearing a mask forms a closed circuit for inspired and expired air which induces a hypercapnic environment due to inadequate oxygen supply and rebinding of carbon dioxide [7]. In this line after light medium intensity protocols, such as treadmill walk at 50–60% predicted maximal heart rate [8], 1 h treadmill walk (5.6 km/h, 0% grade) [9], 30 min cycling, at a steady state at 50% of max load [10], 10 min walk on a treadmill [11] or a 6 min treadmill walk (4 km/h, 10% grade) [12]. A non-significant loss of performance was found, however an acute small effect on the physiological response was observed, consequent with a recent literature review [13].

The impact of mask use on the organic system could represent a handicap, especially in physical education lessons, where students mobilize physiological and cognitive resources to conduct the lessons and may compromise the academic performance of the student. Therefore, it is important to highlight how the acute use of masks modifies the organic status of physical education students, so teachers are able to design efficient physical education lesson. Thus, we conducted the present research to analyze the effect of mask use in basal psychophysiological status of physical education students prior to a physical education lesson. The initial hypothesis was that psychophysiological

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basal conditions of students would be different with the use of masks.

2. Material and methods

2.1. Participants

We analyzed 72 volunteer physical education students (27 women, 45 men, 29.3 ± 16.1 years, 174.4 ± 9.4 cm, 73.7 ± 11.2 kg). The research procedure followed the Declaration of Helsinki (revised in Brazil, 2013) and approved by the Ethics Committee of the University (CIPI/18/074). Before starting the study, all participants were informed about the process to be carried out and gave their written informed consent.

2.2. Procedure

To reach the study aim we conducted 2 evaluations with 48 h between them. Students were randomly distributed in two groups. The first one did the evaluations of the first day with mask and the second without. The other group did it in reverse. Students were instructed to wear the surgical mask as always when they had done the mask evaluation, and the day with no mask evaluation they were instructed to come directly from home to the evaluation, then they did not use mask previously to the evaluation. The data collection was made 15 min before a physical education lesson in an outdoor sports facility, with ventilation, with the participants with safety distances and with all the evaluators wearing personal protective equipment to avoid contagion. The evaluations were conducted at 8:30 a.m, with 22.1 ± 0.5 °C and 40.2 ± 2.3% of humidity with no significant differences between days. The following variables were analyzed.

Body height and weight with a SECA model 714 following previous procedures [6]

Rating of perceived exertion by the Borg Scale (6–20)

Subjective stress perception (0–100) [14]

Blood oxygen saturation by an oximeter OXYM4000 (Quirumed, Madrid) placed in the index finger of the right arm.

Blood glucose concentration by the analysis of 5 μl of capillary finger blood using a portable analyzer. (One Touch Basic, LifeScan Inc. Madrid).

Body Temperature of the temples, face and whole body were measured with a FLIR E8-XT system (Teledyne Flir, Oregon, USA). Hot point was automatically assessed by the system, and a blackout cover was used at the back of the participant to minimize possible errors as in previous research [15]. Three measures were taken, from a frontal perspective whole body temperature and face temperature, then from a side perspective the temple temperature.

Heart Rate Variability (HRV) and Heart Rate (HR) were recorded by a Polar Team Pro-Sensor, Polar Electro, Kempele, Finland) during the 15 min prior to the lesson following the procedures of previous research with participants laying down without talking and with the instructions to relax [16]. The Polar system has a sampling frequency of 1000 Hz being able to register the RR intervals (time interval between R waves of the electrocardiogram) for the analysis of the HRV and the number of beats per minute for the HR analysis. The HRV data collected was analyzed by the Kubios HRV v2.2 software program (University of Kuopio, Kuopio, Finland) with no factor of correction, since the measures obtained were clean and free of noise. The following HRV variables were analyzed [17]:

- Time-Domain. RMSSD (root mean square of successive differences between normal heartbeats, reflects the beat-to-beat variance in HR and is the primary time-domain measure used to estimate the vagally mediated changes reflected in HRV) and PNN50% (The percentage of adjacent NN intervals that differ from each other by more than 50 m, closely correlated with PNS activity) were analyzed.
- Frequency-Domain (Spectral Measures) Analysis. We analyzed the low frequency (LF) and high-frequency (HF) power components in normalized units (n.u). The frequency ranges where, HF: 0.15–0.40 Hz and LF: 0.04–0.15 Hz.
- Nonlinear domain analysis. SD1 and SD2 were measured to reflect the fluctuations of the HRV throw a Poincaré chart, physiologically, on the transverse axis. SD1 reflects parasympathetic activity while SD2 reflect the long-term changes of RR intervals and it is considered as an inverse indicator of sympathetic activity.

2.3. Statistical analysis

The SPSS statistical package (version 21.0; SPSS, Inc., Chicago, Ill.) was used to analyze the data. Normality and homoscedasticity assumptions were checked with a Kolmogorov–Smirnov test obtaining a parametric distribution of variables analyzed. Differences between the two evaluations moments were analyzed by a *T* test for independent variables. The Effect Size was determined by Cohen's D. Level of significance for all the comparisons were set at $p \leq 0.05$.

3. Results

Data are presented as Mean ± SD. Physical education students presented higher values of stress, blood oxygen saturation, temple, face temperature and sympathetic modulation, reflected on lower RMSSD and HF, while higher LF values using surgical mask. Furthermore, mean HR and max HR were also higher on students when using surgical masks. (Table 1)

4. Discussion

Present research aimed to analyze the effect of mask use in basal psychophysiological status of physical education students prior to a physical education lesson. The initial hypothesis was confirmed, since differences were found in the psychophysiological variables measured with and without mask.

A significant decrease in blood oxygen saturation was found as an acute effect of surgical mask use. Lower values of blood oxygen saturation while wearing a mask could be explained by the fact that when breathing without any kind of limitation (as masks), the exhaled air rich in CO_2 diffuses in the air, and new air rich in O_2 is then breathed. However, when wearing a mask, the CO_2 exhaled is not diffused in the atmosphere, resting in the mask, making an environment richer in CO_2 and poorer in O_2 than atmospheric air, augmenting inhaled CO_2 [18]. Similar results have been found among university students while attending 150 min lectures with surgical masks [6] or after 2 h surgery while wearing a FFP2 mask, inducing a 3.5% decrease in blood oxygen saturation (≈94% blood oxygen saturation) [19]. In agreement with this, caution should be taken since classes normally last around 8 h and students could start showing migraines, dyspnea, dizziness [20] and alterations in information processing and concentration [6]. In the case of the present study, the significant decrease of blood oxygen saturation using mask could be relevant during physical exercise, since blood oxygen saturation values could decrease as previous authors have shown [21,22]. Therefore, teachers should be careful with the intensity and volume of physical activity, as well as the type of mask they use for physical education classes. Physical education teachers should encourage cloth or surgical masks [23] (Hopkins et al., 2021) and a face mask rest every two hours should be implemented to avoid psychophysiological alterations that may induce oxygen desaturation. While physical intensity should neither be maximal nor submaximal [24].

Regarding total body temperature, no significant differences were observed between the use or not of masks. However, with the use of surgical masks, we found significant increases in face and temple temperature. The increase on face temperature with surgical mask could be due to impaired respiratory and dermal mechanisms of

Table 1
Differences in study variables with and without using surgical mask.

Variable	Without mask	With mask	T	p	Cohen's D	95% confidence Interval Lower	Upper
RPE (6–20)	7.5 ± 1.2	7.7 ± 1.8	0.927	0.355	-0,10	-0.27	0.75
Subjective stress perception (0–100)	20.3 ± 20.6	27.7 ± 21.1	-1.967	0.005	0,30	-13.25	0.03
Blood glucose (mg/dl)	98.1 ± 9.6	95.7 ± 8.4	-1.650	0.101	0,30	-5.27	0.47
BOS (%)	98.5 ± 0.3	96.9 ± 0.5	2.647	0.009	-0,04	0.095	0.655
Temple temperature (°C)	33.8 ± 1.0	33.2 ± 1.6	-2.808	0.006	0,05	-1.02	-0.18
Face temperature (°C)	36.1 ± 0.7	37.2 ± 0.9	2.749	0.007	-0,04	0.1	0.62
Whole body temperature (°C)	35.3 ± 1.0	35.6 ± 1.1	1.709	0.090	-0,03	−-0.05	0.64
Mean HR (bpm)	73.2 ± 19.7	82.8 ± 29.4	-2.39	0.018	0,04	-17.49	-1.66
SDNN (ms)	33.1 ± 10.6	31.8 ± 7.2	-0.911	0.364	0,01	-4.17	1.54
Max HR (bpm)	118.1 ± 39.5	99.6 ± 22.3	-3.626	0.000	0,06	-28.67	-8.44
Min HR (bpm)	66.8 ± 22.3	61.9 ± 14.7	-1.611	0.109	0,03	-10.83	1.1
RMSSD (ms)	26.1 ± 6.2	21.2 ± 6.0	-1.987	0.049	0,03	-3.9	-0.01
PNN50 (%)	4.3 ± 3.0	3.8 ± 3.5	-0.906	0.366	0,01	-1.54	0.57
HF (n.u.)	29±18.5	21.4 ± 11.2	-3.084	0.002	0,05	-12.36	-2.71
LF (n.u.)	71.2 ± 18.5	78.6 ± 11.2	3.027	0.003	-0,05	2.57	12.23
SD1 (ms)	16.4 ± 4.5	15.1 ± 4.2	-1.844	0.067	0,03	-2.67	0.09
SD2 (ms)	42.7 ± 14.6	42.2 ± 9.5	-0.239	0.811	0,04	-4.36	3.42

RPE, (rate of perceived exertion); Mean HR, (mean heart rate); BOS (Blood Oxygen Saturation); SDNN, (standard deviation of NN interval); Max HR, (maximum heart rate); Min HR, (minimum heart rate); RMSSD, (root-mean square differences of successive heartbeat intervals); PNN50, (percentage of successive RR intervals that differ by more than 50 ms); HF, (highfrequency band); LF, (low frequency); SD1, (transverse axis); SD2, (longitudinal axis); ms, (milliseconds); n.u., (normalized units).

thermoregulation through impairment of convection and evaporation [25]. Similar findings were obtained by other researchers when fitting a surgical mask for 1 h [32] or after 30 min [33] while an increase of 1.76 °C in the skin covered by the mask was measured when performing a light treadmill exercise protocol [34] As for temple temperature, it would be explained by heat radiation processes, as previous authors have reported [15,25]. The face is important for body thermoregulation since it is extremely sensitive to heat having a high concentration of thermoreceptors and it is two to five times more effective at suppressing sweating and thermal discomfort than other parts of the body [26]. Thus, impaired thermal homeostasis and increased thermal discomfort are expected during physical education classes. Removing the face mask has been stated to rapidly decrease facial skin temperature after 1 min, returning to baseline levels after 5 min [32]. However, caution should be taken, especially in warm conditions.

According to cardiovascular values, participants with surgical masks presented significantly higher maximal and mean heart rate. It could be addressed to the decrease in O_2 inhalation and increased CO_2 inhalation would increase aortic and left ventricular pressure, leading to an upsurge of cardiac overload and coronary demand [24]. This response was also measured in steady state healthy subjects with surgical masks, showing increased systolic blood pressure and cardiovascular response [10], and an even greater heart rate when wearing FFP2 masks. Furthermore, regarding the autonomic modulation, we found significant lower RMSSD and HF values and higher LF values when using a mask. These HRV results are related to a higher sympathetic modulation [27]. It may be explained by the stress response caused by the higher contextual physiological demands due to mask use, since the impaired thermoregulation, discomfort, and increased hypoxia state due to CO_2 rehinalation may lead to a dysregulation of normal autonomic modulation [7]. Not only objective stress response was monitored; the modified context by using masks also affected subjective stress perception as the significantly higher subjective stress perception using masks showed. In this line, other authors also found how the autonomic nervous system responds increasing its sympathetic branch in other stressful contexts as clinical stays, clinical simulations, clinical practices, final degree dissertations and objective structured clinical examination, [28–31] even not using masks. Future research should focus on the effect of the added stress of using the mask in this type of highly stressful contexts.

4.1. *Practical applications*

The present study highlights the psychophysiological modifications of physical education students with and without using masks. This information could help physical education teachers to implement the pertinent curricular, educational, and physical adaptations. The lower oxygen saturation and its possible decrease during physical activity require teachers to adapt the class in terms of intensity and volume. Finally, the increased sympathetic modulation will negatively condition the teaching–learning process as previous authors reported, [28–30] therefore teachers need to implement pedagogical techniques to address this problem, trying to maintain a correct sympathetic-parasympathetic modulation.

4.2. *Limitations of the study*

The first limitation was the low sample size, but the restrictions, and COVID-19 health protocols precluded to recruit a larger sample. It would be optimal to analyze cerebral tissue oxygen saturation for a better comprehension of the impact of surgical masks in cognitive physiology, as well as the measurement of stress related hormones such as cortisol or alpha amylase. However, technological and financial lack limited its applications.

4.3. Future line of research

The study of surgical mask use in professors, as well as the long time use of surgical mask in students and professors are proposed as future research lines. Also, the analysis of different academic levels (pre-school, school, and high school) as well as to analyze the effect of mask use in different physical manifestation as endurance, strength, or velocity activities.

5. Conclusions

The use of surgical masks in physical education students produced a significant increase on subjective stress perception, sympathetic modulation, cardiovascular response, face, and temple temperature while decreased blood oxygen saturation.

CRediT authorship contribution statement

José F Tornero-Aguilera: . **Alejandro Rubio-Zarapuz:** Data curation. **Vicente J Clemente-Suárez:** .

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