Effects of Surgical Facemasks on Perceived Exertion During Submaximal Exercise in Healthy Children

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Abstract

Background

Only a few data associated to wearability of facemask during exercise are available in children. The aim of the study was to evaluate the effect of wearing a facemask on perceived exertion (primary aim), dyspnea, physical performance, and cardiorespiratory response during a submaximal exercise test in children aged between 8 and 12 years.

Method

This study was performed in 2021 in healthy volunteer children from 8 to 12 years. They performed prospectively two one-minute sit-to-stand test (STST), with or without a surgical facemask. The perceived exertion (modified Borg scale), dyspnea (Dalhousie scale), heart rate and pulsed oxygen saturation were recorded before and after STST. The STST measured the submaximal performance.

Results

Thirty-eight healthy children were recruited (8-9 years: n=19 and 10-11 years: n=19). After the STST, the perceived exertion increased with or without a facemask (8-9 years group: +1 [0.6; 1.4] and +1.6 [1.0; 2.1]) – 10-11 years group: +1.3 [0.7; 1.8]) and +1.9 [1.3; 2.6]) and it was higher with the facemask. The difference between the two conditions in perceived exertion was not clinically relevant in any group (mBorgf: 0.56 pts and 0.68 pts, respectively). The different domains of dyspnea assessed with Dalhousie scale were not influenced by the facemask. The submaximal performance measured by the STST was not changed by the mask whatever the age group. The cardio-respiratory demand was not clinically modified.

Conclusion

The surgical facemask had no impact on dyspnoea, cardiorespiratory parameters, and exercise performance during a short submaximal exercise in healthy children.

Introduction

During the pandemic of the coronavirus disease 2019 (COVID-19), the wide use of facemask among the general community has been widely recommended to reduce the spreading of virus-loaded respiratory droplets[1, 2]. This measure was shown effective in reducing the transmission of SARS-CoV-2[3]. Indeed, respiratory droplets are easily transmitted during activities of daily living[2, 4–6] and physical activities even increase the level of transmission.

As asymptomatic cases are common in children[7, 8], their role in virus circulation and new COVID-19 case development has been questioned. Moreover, some debate quickly appeared about the need of wearing a facemask in children due to their low risk of developing the COVID-19 and the tendency to

solve spontaneously[7]. The World Health Organisation and United Nations International Children's Emergency Fund did not adjudicate on the use of masks for children during their common activities as in the classroom. Despite these uncertainties, many children wore facemasks[9].

Facemask has been associated with breathing difficulties in adults[10, 11], principally during physical activities [12]. Only a few data associated to wearability of facemask during exercise are available in children[13, 14].

The aims of the study were to evaluate the effect of wearing a facemask on perceived exertion (primary aim), dyspnea, physical performance, and cardiorespiratory response during a submaximal exercise test in children aged from 8 to 12 years. We hypothesized to observe similar findings than those found in adults.

Material And Methods

Subjects

Healthy children were consecutively recruited on written parents request from one elementary school in Brussels (Belgium) during the last week of June 2021. The only inclusion criteria were (1) to be aged between 8 and 12 years old and (2) the participation in the national physical education program at school for which an annual medical investigation is required in Belgium. Eligible children had to be free of physical activity at least one hour before the beginning of the experiments. The exclusion criteria were diagnosis of chronic lung, cardiac or neuromuscular disease, and motor disability based on parents' answer to standardized questions, or to be at risk of- or overweight (Body mass index (BMI) higher than the 85th percentile for children of the same age and sex).

The study has been approved by the local Ethics Committee from Cliniques universitaires Saint-Luc and Université Catholique de Louvain in Brussels (amended in June from B4032020000121) and written informed consent was obtained from both parents and children.

Study design

It was a prospective controlled study. Each subject performed two one-minute sit-to-stand tests (STST) separated from each other by 1 hour on the same day. One STST was performed while the children were wearing a surgical facemask whereas the other STST was performed without any facemask (control).

The order of these two STST was randomly assigned using www.randomizer.org. The children were familiarized with the STST by performing a training test at least 1 hour before, to eliminate the learning effect. The surgical facemask was a standard 3 ply disposable facemask CE-marked that complied with the European standard EN 14683:2019 Type I (Kimberly Clark, Machehen, Belgium).

STST

The STST was performed with a standard chair without arm rest[15]. Children put their hands on their hips, and they had to stand up and sit down completely as many times as possible during one minute. They could not use their arms as support. Standardized instructions were given to the children before the test. No encouragements were provided during the test. If needed, rest periods were permitted during the STST, with no interruption of the countdown timer. This exercise can be considered as submaximal effort and it reflects the activities of daily life.

Outcomes

The demographic data were collected before the test. The perceived exertion (primary outcome) and dyspnea were rated according to the modified Borg scale(mBorg)[16] and Dalhousie scale[17] before and at the end of the STST. In the condition with the surgical facemask, dyspnea and perceived exertion collected before the STST were realized after the facemask was worn for at least 5 minutes.

The mBorg ranges from zero (no perceived exertion) to ten (maximal exertion). The Dalhousie Scales assess three dyspnea constructs with a sequence of pictures depicting and rating chest tightness, throat closure, and breathing effort. It includes another pictorial scale that depicts leg exertion/fatigue. The pictorial scale was explained before the test. Both scales were validated in children[17, 18].

The cardio-respiratory parameters (heart rate (HR), pulsed oxygen saturation (SpO₂)) were recorded before (i), at the end (f) and at 1' post-effort (r). The HR and SpO₂ values were measured with a finger pulse oximeter (Onyx, NONIN, USA). The HR was expressed in absolute value and in percentage of theoretical maximal HR with the specific equation for children [$210 - (0.65 \times \text{age})$]. The cardio-respiratory demand was assessed by the change in these outcomes between the initial and the final values and between the final and rest values expressed in absolute values for SpO₂ and relative values for HR.

The number of repetitions during STST was recorded and expressed in absolute values. Only completed movements were recorded.

Statistical analyses

The sample size was calculated based on an estimated difference ($\pm$ SD) of 1 and a standard deviation of 1.1 point in the modified Borg scale between the two conditions[19] with a power of 80% and an alpha level of 0.05. In total, we aimed to recruit 38 participants to assess our hypothesis independently in children aged 8-9 years (n=19) as well as in children aged 10-11 years (n=19).

Data were analysed using SPSS 27.0 (IBM software, Armonk, NY). Normality of data was verified with the Kolmogorov-Smirnov test. Descriptive analysis was performed for all data. They were presented as mean ($\pm$ SD) or median (interquartile range) according to the normality of the distribution.

All comparisons were tested with paired Student T, Wilcoxon or Mann-Whitney tests as appropriate. A p value ≤ 0.05 was considered as statistically significant.

Results

Sixty-three children were assessed for eligibility. Two children were excluded for medical reasons, one refused to participate and the others did not bring the acceptance from the parents. Thirty-eight healthy children were recruited in this study (8-9 years: n=19 and 10-11 years: n=19). All but one in the 8-9 years group completed the two tests. This child was sick the day of the experiment. Demographic data of the children are highlighted in Table 1. All but one child had a final HR lower than 80% of the predicted value that confirms the submaximal effort.

Table 1
Demographics characteristics of the children in each of the two age groups.

Variables	8-9 years	10-11 years
Age (years)	8.5 (8-9)	10 (10-11)
Gender (M/F)	12/6	4/15
Weight (kg)	30.2 ± 6.0	39.2 ± 8.0
Height (m)	1.39 (1.17-1.46)	1.45 (1.38-1.66)
Data are expressed as n, mean ± SD, or median (min-max)		

All children had a zero score on the mBorg at rest, before the exercise, with or without the facemask. After the STST, the perceived exertion increased in the two conditions (facemask and control) in the two age groups (8-9 years group: +1 [95%CI: 0.6; 1.4]; $p<0.001$ and +1.6 [95%CI: 1.0; 2.1]; $p<0.001$) –10-11 years group: +1.3 [95%CI: 0.7; 1.8]; $p<0.001$) and +1.9 [95%CI: 1.3; 2.6]; $p<0.001$). The perceived exertion was higher with the facemask at the end of the exercise even if the mean difference between the two conditions was not clinically relevant in any group (mBorgf: 0.56 pts and 0.63 pts, respectively).

By contrast, the different domains of dyspnea assessed with Dalhousie scale were not influenced by the facemask. Only the breathing effort domain was perceived as higher with the facemask when compared to the control condition but only for the 10-11 years group. Sixty-five percent of the children increased the perception of the breathing effort with the facemask by at least one-step in the two groups. However, the domains throat closure, chest tightness, and leg exertion of the Dalhousie scale were statistically not different with or without the mask.

The cardiac demand was not changed by the mask whatever the age group. Indeed, the change in HR during effort and the recovery of HR after the test were similar between both STST (Table 2 and 3) meaning that the mask had no effect on the HR adaptation during this effort.

Table 2
Results of the two STST in children aged 8-9 years

Variables	With facemask	Control	Mean difference [95%CI]	p value
Before the test				
mBorgi (pts)	0 (0-0)	0 (0-0)		>0.99
Breathing effort	1 (1-2)	1 (1-2)		>0.99
Chest tightness	1 (1-2)	1 (1-2)		>0.99
Throat closure	1 (1-2)	1 (1-2)		>0.99
HRi (bpm)	95 (70-115)	87 (73-111)	-4.4 [-11.7;2.9]	0.28
SpO2i (%)	98 (97-100)	99 (98-99)	-0.28 [-0.51;-0.05]	0.025
After the test				
mBorgf (pts)	2 (0-4)	0.5 (0-3)	-0.56 [-0.85;-0.26]	0.004
Breathing effort	1.5 (1-3)	1 (1-2)	-0.33 [-0.75;-0.08]	0.11
Chest tightness	1 (1-3)	1 (1-2)	-0.11 [0.27;-0.49]	0.53
Throat closure	1 (1-2)	1 (1-2)	-0.11 [-0.40;0.18]	0.41
Leg exertion	1 (1-3)	1 (1-2)	0.0 [-0.30; 0.30]	>0.99
Delta HRi-f (%)	30.1 ± 18.4	31.0 ± 20.2	1.3 [-14.0;16.7]	0.86
HRf (% pred)	60.1 ± 10.7	57.3 ± 6.8	-2.8 [-7.5;1.9]	0.23
SpO2f (%)	98 (97-100)	98 (96-100)	-0.11 [-0.59;0.37]	0.63
Delta HRf-r (%)	-21.0 ± 10.3	-23.0 ± 13.1	-1.9 [-10.6;6.8]	0.65
STST (n)	42.5 (30-63)	40.5 (22-63)	-3.5 [-7.88;0.88]	0.060
Data are expressed as mean ± SD, or median (min-max)				
mBorg: modified Borg scale – HR: heart rate – SpO2: pulsed oxygen saturation – i: initial – f: final – pts: points – STST: sit-to-stand test				

Table 3
Results of the two matched tests in children from the group 10-11 years

Variables	With facemask	Control	Mean difference [95%CI]	p value
Before the test				
mBorgi (pts)	0 (0-0)	0 (0-0)		>0.99
Breathing effort	1 (1-5)	1 (1-5)		>0.99
Chest tightness	1 (1-5)	1 (1-5)		>0.99
Throat closure	1 (1-3)	1 (1-3)		>0.99
HRi (bpm)	88 (76-119)	87 (69-115)	-3.0 [-8.5;2.5]	0.39
SpO2i (%)	98 (97-100)	98 (97-100)	-0.50 [-0.69;0.58]	0.52
After the test				
mBorgf (pts)	2 (0.5-6)	0.5 (0-4)	-0.63 [-1.11;-0.15]	0.021
Breathing effort	2 (1-6)	1 (1-3)	-0.79 [-1.17;-0.41]	0.001
Chest tightness	1 (1-6)	1 (1-3)	-0.47 [-0.97;0.02]	0.07
Throat closure	1 (1-3)	1 (1-3)	-0.21 [-0.47;-0.05]	0.102
Leg exertion	2 (1-5)	1 (1-3)	-0.42 [-0.88;0.04]	0.070
Delta HRi-f (bpm)	46.7 ± 19.9	54.4 ± 21.4	7.8 [-0.2;15.7]	0.055
HRf (% pred)	65.5 ± 6.6	66.9 ± 7.1	1.4 [-1.8;4.5]	0.38
SpO2f (%)	98 (97-99)	98 (94-100)	-0.37 [-0.86;0.12]	0.13
Delta HRf-r (%)	-27.4 ± 8.2	-26.0 ± 12.4	1.4 [-2.9;5.7]	0.51
STST (n)	39 (22-46)	38 (31-54)	1.2 [-1.1;3.5]	0.34
Data are expressed as mean ± SD, or median (min-max)				
mBorg: modified Borg scale – HR: heart rate – SpO2: pulsed oxygen saturation – i: initial – f: final – pts: points – STST: sit-to-stand test				

The submaximal performance measured by the STST was not different when the children wore the mask or not. However, we noted that 27% and 42% of the children from the 8-9 and 10-11 years groups clinically reduced their physical performance (Difference in STST > 2) when they wore the facemask, respectively.

Discussion

The main finding of the present study is that the surgical facemask increases the perceived exertion in children without modifying the different components of dyspnea during a submaximal effort. Moreover,

neither the cardiorespiratory parameters nor the performances were altered when wearing a facemask during an exercise of moderate intensity. In the end, the facemask did not prevent the children from performing a submaximal exercise.

The perceived exertion and the cardio-respiratory parameters were not modified by a facemask at rest. These findings are in agreement with the results of Li et al. who previously observed that the discomfort associated with the use of a surgical facemask was not impacted during rest periods[20]. Moreover, findings from a recent study with a similar design but conducted in adults highlighted that the surgical facemask had no immediate effect on HR, SpO₂ or dyspnea[21].

To our knowledge, this is the first study performed in children that evaluated the effect of a facemask during an exercise that reflects the physical level of daily life activities. This study showed that the facemask increased the perceived exertion during the STST in children even if this difference is not clinically relevant. Indeed, the mean difference is lower than the minimal clinically important difference determined with the modified Borg scale (1 point). This was also demonstrated in other studies conducted in adults during an exercise of mild to moderate intensity(9, 16, 18, 19). This feeling was demonstrated to progressively increase proportionally to the exercise intensity in adults[22]. This higher perceived exertion at elevated exercise intensity is probably related to the increase in inspiratory and expiratory resistances that were previously highlighted[22, 23]. Similarly, there was a significant reduction in running time with facemasks in trained children, at the maximum performance level[24].

The different domains of dyspnea assessed by the Dalhousie scale were low and, contrarily to the perceived exertion, not modified by the facemask in children. At rest, the different domains of the scale hovered around 1 point which was similar to the resting values found in the validation study of the Dalhousie scale in children of similar age[17]. The values of dyspnea (2.2) and perceived leg exertion (2.6) that we observed at the end of the STST corresponds to values associated with peak work capacities lower than 60%[17] confirming the submaximal intensity of this test. A significant increase in breathing effort due to the surgical facemask was only noted in older children, although this difference seems clinically not relevant for the authors (<1 interval on the scale). Two hypotheses are that the older children are closer to the adult physiology and mainly the girls that dominated in this age group and, that they performed this exercise at a higher intensity than the younger ones as suggested by the greater percentage of maximal HR obtained in older children compared to the younger ones. However, a clinical change in this perception concerned more than 50% of the investigated children whatever the age of the children. The cardiac demands of the two groups were in the same range than the ones from previous studies (change in HR between 50 and 60%[15, 25]).

The median number of STST repetitions was around 40 repetitions. This is close to values found by other studies in children[15, 25] As expected, owing to the inverse relationship between height and the number of repetitions, the younger children performed more repetitions than the older ones. Indeed, the smaller children have a shorter displacement to perform than the older ones due to the chair height. That

also generates a smaller effort as highlighted by the difference in HR change between the two age groups.

The main limitations of this study are the selected intensity of the exercise and the environmental conditions. To extrapolate our results to an exercise with a maximal intensity level or in different environmental conditions is hazardous. The physical performance could be differently influenced depending on the intensity of the exercise or its duration, or the ambient air temperature and humidity[26, 27]. This is due to the humidity level from the exhaled air that increase either with exercise intensity and duration or with the climate, and that changes the resistance[27]. In Belgium, the climate is temperate and maritime. Moreover, the study was performed in June and the environmental conditions change during the year. Our results have also to be extrapolated with caution to other facemasks as the cloth facemask[21]. The powers of filtration or absolute humidity inside these facemask[20], and then the related resistances can differ. The intensity of the exercise was lower than a maximal effort as highlighted by the mean heart rate around 60% at the end of the test.

In conclusion, this study highlights that a surgical facemask had no impact on dyspnoea, cardiorespiratory parameters, and exercise performance during a short submaximal exercise test in healthy children. Even if the perceived exertion was slightly increased with a facemask, this is not clinically relevant. Based on this, it seems reasonable to reassure the parents about the negative perception about wearing a facemask during submaximal effort.

Declarations

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Statements and Declarations

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Competing Interests

All authors declare they have neither financial nor non-financial interests.

Availability of data material

On request

Code availability

Not applicable

Authors contribution

Gregory Reyckler: Conceptualization; Methodology, Formal analysis; Investigation; Writing - Original Draft; Supervision

Marie Standaert: Investigation; Writing - Review & Editing

Nicolas Audag: Methodology; Writing - Review & Editing

Annie Robert: Methodology; Analysis; Writing - Review & Editing

Gilles Caty: Methodology; Writing - Review & Editing

William Poncin: Methodology; Analysis; Writing - Review & Editing

Ethics approval

The study has been approved by the local Ethics Committee from Cliniques universitaires Saint-Luc and Université Catholique de Louvain in Brussels (amended in June from B4032020000121)

Consent to participate

A written informed consent was obtained from both parents and children.

Consent to publication

Not applicable

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