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# Impact of surgical face masks on athletic performance in adolescent handball players

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## Abstract

**Background:** COVID-19 transmission in team sports is common, but it's uncertain if face masks impact handball players' performance.

**Aim:** This study investigated the effects of wearing surgical face masks during handball exercise for four weeks on athletic performance.

**Materials and Methods:** Thirty-four adolescent handball female players and 17 trained females as the control group were selected in this study. Players were divided into two groups: the mask group (n= 17; age: 12.63±0.67 years, BMI: 20.61±1.19 kg/m$^2$) and the unmasked group (n= 17; age: 13.45± 1.03 years, BMI: 21.08±1.46 kg/m$^2$), who underwent 4-week training with and without face masks, respectively. Performance tests were conducted before and after the training program, which include: countermovement jump (CMJ), squat jump (SJ), 10m, 20m, and 30m sprint, medicine ball throw, and Yo-Yo Intermittent Recovery Test Level 1 (Yo-YoIRT1).

**Results**: After four weeks, both mask and unmasked groups showed significant improvements in CMJ, SJ, 10m, 20m, and 30m sprint, medicine ball throw, and Yo-YoIRT1 ($P \leq 0.05$).

**Conclusion:** This study concludes that adolescent handball players can safely use face masks during physical activity without experiencing negative effects on their athletic performance.

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## 1. Introduction

COVID-19 is a highly contagious respiratory disease caused by SARS-CoV-2. Its rapid spread has led to a global pandemic, prompting governments worldwide to implement measures aimed at controlling its transmission and protecting healthcare systems [1]. Sports activities, such as team sports, pose a significant risk for transmission because players are often near each other, engage in intense physical activity, and play in enclosed spaces with inadequate ventilation [2]. Children or teenagers who contract the virus while participating in team sports can potentially spread it to more at-risk family members [3]. Furthermore, it has been noted that suspending sports activities during a pandemic can not only impact the performance of youth athletes but also affect their emotional, social, and cultural well-being [4]. Given these multifaceted challenges, maintaining the participation of children in sports activities while adhering to stringent safety protocols assumes paramount significance. One such protocol that has garnered attention is the use of face masks in public spaces, which has been lauded as an effective strategy for mitigating the transmission of contagious respiratory droplets and, consequently, the spread of diseases [5]. However, it is essential to address concerns regarding the use of face masks during exercise, particularly those related to insufficient oxygen intake and increased carbon dioxide recirculation [6]. A comprehensive review study by Das et al. (2023) suggests that face masks may have an effect on aerobic capacity, leading to decreased $PO_2$ and breathing difficulties, especially in events that require long-distance running or aerobic performance [7].

Anaerobic performance in shorter events may not be hampered, but in slightly longer events like the 1500-m race, the rebreathing of hot and humid exhaled air with reduced $O_2$ and increased $CO_2$ levels may limit performance. Schulte-Körne et al. (2021) determined that surgical face masks did not have a discernible impact on objective performance metrics in well-trained boys engaging in aerobic activities; however, there was a notable decrease in running time and an increase in perceived exertion at maximal performance levels [8].

Despite the increasing interest in the effects of face mask usage on athletic performance, especially among children and adolescents, there remains a dearth of comprehensive studies addressing this issue. However, it's worth highlighting an intriguing exception found by Ökmen et al. (2022). They explored the impact of regular educational gaming activities on aerobic capacity in children, irrespective of face mask usage, presents compelling evidence challenging the prevailing concerns surrounding face mask usage and athletic performance [6]. These findings suggest that in certain contexts, face mask usage may not impede aerobic capacity and could even have beneficial effects.

Nonetheless, it's important to acknowledge that a significant research gap persists, particularly in high-intensity team sports such as handball. The unique demands of these sports, characterized by both high-intensity physical exertion and significant physical contact, warrant further investigation. Future studies focusing on the effects of face mask usage in such contexts would provide valuable insights into optimizing safety protocols without compromising athletic performance. Nonetheless, there remains a significant research gap, especially concerning high-intensity team sports such as handball. The unique demands of these sports, characterized by not only high-intensity physical exertion but also significant physical contact, have received relatively little attention.

Understanding how the usage of a face mask influences athletic performance, particularly in such demanding situations, is pivotal for enhancing awareness and devising performance planning strategies for adolescent athletes. This emphasizes the importance of investigating the effects of face mask usage in high-intensity team sports and how it impacts athletic performance. This research contributes to raising awareness and providing evidence-based guidance for safely planning physical activities during pandemics or similar disease outbreaks.

To the best of the researchers' knowledge, no study has yet explored the prolonged effects of wearing face masks on the athletic performance of handball players during a pandemic, making it imperative to investigate. Therefore, the primary objective of this study is to examine the long-term (4-week) effect of wearing surgical face masks during handball exercises on the performance of adolescents. This study seeks to address this research gap by focusing on the long-term effects of wearing face masks on athletic performance in the context of handball exercises. This investigation is poised to provide essential insights into the underexplored realm of face mask usage in sports and its potential implications for the well-being and performance of young athletes.

## 2. Materials and Methods

### *2.1. Participation*

Thirty-four female adolescent handball players participated in the exercise groups, and 17 trained female adolescents were in the control group (n= 17; age: 12.78 ± 1.6 years, BMI: 21.6 ± 1.58 kg/$m^2$). All athletes in the exercise groups had a history of 2-3 years of regular handball training. Adolescent handball players were randomly assigned to the mask group (n= 17; age: 12.63 ± 0.67 years, BMI: 20.61 ± 1.19 kg/$m^2$) and the unmasked group (n= 17; age: 13.45 ± 1.03 years, BMI: 21.08 ± 1.46 kg/$m^2$) using a random number table.

All participants were healthy and were not using any medications. Throughout the study, participants were prohibited from engaging in any other training programs that could potentially introduce bias into the results. Individuals with metabolic, renal, pulmonary, or cardiovascular conditions were excluded from the study. Participants voluntarily took part in this study, and informed written consent was obtained from the parents or legal guardians of all participants. The study protocol was approved by the ethics committee of the Medical Sciences Faculty of Islamic Azad University, Shahrekord Branch (ethics code IR.IAU.SHK.REC.1401.026).

### *2.2. Instrument*

The study involved measuring height and weight using a stadiometer and scale. The photocell system, MICROGATE (Witty Sem, Microgate, Bolzano, Italy), was utilized for measuring 10m, 20m, and 30m sprints. Additionally, the medicine ball (Tigar, Pirot, Serbia) was used for evaluating throwing performance. Surgical face masks equipped with ear loops from IAP Services Ltd. in Hong Kong were utilized.

### *2.3. Procedure*

These performance tests were selected based on previous research as standard criteria for evaluating the physical performance of handball players [9]. One week prior to the start of the exercise program, all participants underwent a familiarization session with the sports exercises and research program. Baseline measurements were taken following a 15-min standard warm-up. The performance tests commenced at 9 a.m. and continued until 1 p.m. All tests were conducted under similar conditions before and after the 4-week period in both groups, without the use of masks. Participants were instructed to avoid strenuous physical activities and consume caffeine or alcohol 24 hours prior to the study. They were also advised to maintain a standardized diet throughout the study period. Participants performed a CMJ and SJ test three times each, with a 5-min rest between each trail. The best performance was recorded in centimeters. The throw test was performed from a lying position using a 1-kg medicine ball with a diameter of 21.5 cm. The distance between the zero point of the throw and the first contact with the ground was measured. The medicine ball throw test was performed three times, and the best result was recorded for statistical analysis. The Yo-Yo Intermittent Recovery Test Level 1 was conducted following relevant protocols [10], with the total distance covered during the test being determined as the testing score.

The training program lasted for four weeks, starting one week after pre-test examinations and continuing for four weeks. Post-assessment tests were conducted forty-eight hours after the final session. The program consisted of four sessions per week, each lasting approximately 90 min, and included a combination of handball and high-intensity interval training (Table 1).

**Table 1.** Description of the training schedule over the 8-week training period in masked and unmasked groups

| Training period | Training day | Training program | Number series x time running | Interval running (Intensity running) | Interval recovery | Recovery between series |
|---|---|---|---|---|---|---|
| **1 week** | Monday | Handball training | | | | |
| | Wednesday | HIIT | 2 x 6 min | 15 s (90% of MAS) | 15 s | 3 min |
| | Thursday | Handball training | | | | |
| | Friday | HIIT | 2 x 6 min | 15 s (90% of MAS) | 15 s | 3 min |
| **2 weeks** | Monday | Handball training | | | | |
| | Wednesday | HIIT | 2x 6 min 30 s | 15 s (90% of MAS) | 15 s | 3 min |
| | Thursday | Handball training | | | | |
| | Friday | HIIT | 2x 6 min 30 s | 15 s (90% of MAS) | 15 s | 3 min |
| **3 weeks** | Monday | Handball training | | | | |
| | Wednesday | HIIT | 2x 7 min | 15 s (92% of MAS) | 15 s | 3 min |
| | Thursday | Handball training | | | | |
| | Friday | HIIT | 2x 7 min | 15 s (92% of MAS) | 15 s | 3 min |
| **4 weeks** | Monday | Handball training | | | | |
| | Wednesday | HIIT | 2x 7 min 30 s | 15 s (92% of MAS) | 15 s | 3 min |
| | Thursday | Handball training | | | | |
| | Friday | HIIT | 2x 7 min 30 s | 15 s (92% of MAS) | 15 s | 3 min |

**Note**: MAS – maximal aerobic speed

The masked and unmasked athletes followed a similar training program.

Handball exercises included 15 min of general movements, a 15-min warm-up period, and a 30-min primary exercise session. High-intensity interval training included exercises like jumping, throwing, catching, passing, change of direction, and individual positions. The high-intensity interval training was based on two sessions of running at the final speed of the Yo-Yo test, with 15-sec alternate running at the end of the test and 15 sec of active recovery [10]. The RPE (Rating of Perceived Exertion) and HR (Hart Rate) of participants were monitored during training sessions. No difference in heart rates existed between the two training groups during the training period. All exercises were performed on a short course, with players placed on different courses based on their maximum aerobic speed. The research was conducted in typical environmental settings, maintaining a temperature range of 20 to 25°C and a relative humidity between 40% and 60%.

Throughout the study, the surgical face masks were determined to be comfortable and facilitate easy breathing during physical activity. The control group had no training or lifestyle changes during the same period, and dietary intake was not controlled during the training period.

### *2.4. Statistic*

Descriptive statistics are presented as the mean± standard deviation. The normality of the data was assessed using the Shapiro-Wilk test. An analysis of variance (ANCOVA) was used to compare differences between groups, with baseline values as covariates. The reliability coefficients for the tests fell within the range of 0.75 to 0.99, which were quantified as intraclass correlation coefficients (ICC). Statistical analyses were performed using SPSS software (version 20.0; IBM SPSS, Inc., Chicago, IL, USA). A p-value less than 0.05 was considered statistically significant.

## 3. Results

All the data was normally distributed. There was no statistically significant difference ($P$> 0.05) in heart rates observed during training sessions between the two groups: the masked group had an average heart rate of 172.05±5.02 bpm, while the unmasked group had an average heart rate of 174.15±4.07 bpm. The mean HRmax during the training program was 87.3±9.194 bpm in the masked group and 82.3±9.195 bpm in the unmasked group, with no significant difference ($P$> 0.05) observed between the two groups.

The results of the performance tests for both masked and unmasked groups are presented in Table 2. Preliminary data analysis revealed the absence of any significant differences between the groups in CMJ ($P$= 0.72), SJ ($P$= 0.71), 10m sprint ($P$= 0.16), 20m sprint ($P$= 0.52), 30m sprint ($P$= 0.60), throwing a medicine ball ($P$= 0.37), and Yo-YoIRT1 ($P$= 0.24). In both the masked and unmasked groups, improvements were observed in the CMJ (4.83% and 3.16%, $P$≤ 0.05), and a significant effect for time was present ($P$= 0.006); however, no significant effects were detected for group or group-time interactions ($P$> 0.05). Upon investigating the impact of the 4-week training program on SJ, it was observed that both groups exhibited improvements (masked group 4.54% vs. unmasked group 4.41%), yet neither the group nor the group-time interactions yielded significant effects ($P$> 0.05).

**Table 2.** Pretest and posttest results for physical performance in young female handball players

| | **Pretest** (**Mean ± SD**) | **Posttest** (**Mean ± SD**) | **F values, p-values, η2p** |
|---|---|---|---|
| CMJ (cm) | | | Group: F = 0.16, *P*= 0.85, $\eta^2_p$= 0.01 |
| Masked group | 236±11.5 | 248±9.8 | Time: F = 5.98, ***P*= 0.006**, $\eta^2_p$= 0.27 |
| Unmasked group | 238±13.03 | 246±11.2 | |
| Control group | 235 ±12.28 | 233 ±11.9 | |
| SJ (cm) | | | Group: F = 0.43, *P*= 0.64, $\eta^2_p$= 0.027 |
| Masked group | 23٠±3.70 | 241±10.6 | Time: F = 5.37, ***P*= 0.01**, $\eta^2_P$= 0.25 |
| Unmasked group | 232±12.9 | 242±13.02 | |
| Control group | 227±11.57 | 228±11.21 | |
| Sprint 0–10(m) | | | Group: F = 0.98, *P*= 0.38, $\eta^2_p$ = 0.06 |
| Masked group | 2.50±0.26 | 2.35±0.23 | Time: F = 2.92, *P*= 0.069, $\eta^2_p$= 0.15 |
| Unmasked group | 2.34±0.25 | 2.19±0.21 | |
| Control group | 2.44±0.27 | 2.45±0.29 | |
| Sprint 0–20 (m) | | | Group: F = 0.20, *P*= 0.81, $\eta^2_p$ = 0.013 |
| Masked group | 4.45±0.40 | 4.35±0.33 | Time: F = 1.26, *P*= 0.29, $\eta^2_p$ = 0.075 |
| Unmasked group | 4.27±0.42 | 4.20±0.29 | |
| Control group | 4.42±0.41 | 4.44±0.40 | |
| Sprint 0–30 (m) | | | Group: F = 0.13, *P*= 0.87, $\eta^2_p$ = 0.009 |
| Masked group | 5.55±0.34 | 5.63±0.31 | Time: F = 1.09, *P*= 0.34, $\eta^2_p$= 0.066 |
| Unmasked group | 5.41±0.35 | 5.46±0.29 | |
| Control group | 5.60±0.35 | 5.6±0.33 | |
| TB (m) | | | Group: F = 0.38, *P*= 0.68, $\eta^2_p$=0.024 |
| Masked group | 5.27±0.46 | 5.42±0.32 | Time: F = 0.90, *P*= 0.41, $\eta^2_p$= 0.055 |
| Unmasked group | 5.48±0.40 | 5.56±0.36 | |
| Control group | 5.34±0.43 | 5.33±0.45 | |
| Yo-YoIRT1 (m) | | | Group: F = 1.43, *P*= 0.25, $\eta^2_p$= 0.085 |
| Masked group | 444.18±19.67 | 470.90±24.16 | Time: F = 2.72, *P*= 0.082, $\eta^2_p$ = 0.14 |
| Unmasked group | 458.18±33.55 | 486.45±37.39 | |
| Control group | 463.66±29.47 | 458.1±24.05 | |

**Note**: CMJ-Counter movement jump; SJ-Squat jump; TB-Throwing medicine ball; Yo-YoIRT1 (m) - Yo-Yo Intermittent recovery test level 1 (total distance running (m)); # variable with opposite metric orientation; ES – effect size; % changes – Pretest and posttest changes; F – statistics; p – significant difference of *P*≤ 0.05; ŋ 2 p Partial Eta Squared; * significant pre-posttest changes at *P*≤ 0.05 (the simple main effect of time) ; + groups significantly different at *P*≤ 0.05 (the simple main effect of group);† significant main effect of interaction at *P*≤ 0.05

In the present study, both masked and unmasked groups displayed improvements in 10m sprint (4.57% and 6.80%, *P*≤ 0.05), 20m sprint (4.04% and 3.44%, *P*≤ 0.05), and 30m sprint (2.52% and 3.19%, *P*≤ 0.05). Nevertheless, no significant effects were attributed to time, group, or their interactions ($P \geq 0.05$).

The results indicated a substantial increase in medicine ball throw in both groups following the 4-week training regimen (masked group 3.98% vs. unmasked 2.58%). However, neither the group nor the group-time interactions exerted a significant influence ($P \geq 0.05$). The 4-week training program led to a significant enhancement in Yo-YoIRT1 for both groups (masked group 6.01% vs. unmasked group 6.17%, $P \leq 0.05$). Nevertheless, no significant effects were observed in time, group, or their interaction ($P \geq 0.05$).

## 4. Discussion

The main goal of this research was to investigate the long-term effects (4 weeks) of wearing a surgical face mask during exercise on the performance of adolescent handball players. The results indicated that there was no significant difference in the Yo-Yo test scores between the masked and unmasked groups ($P \geq 0.05$). These findings align with Shaw et al. (2021) who reported no impact of face mask usage on athletes' Yo-Yo test results. Wearing a face mask may increase dead space volume, leading to a higher exhaled carbon dioxide fraction and partial pressure of carbon dioxide in the blood, potentially affecting ventilation and respiratory function [11].

However, it does not appear to significantly impact respiratory muscle fatigue, perceived exertion, or sports performance [12]. Despite previous studies demonstrating that surgical face masks can double air resistance [13], two other studies found no significant impact on maximum aerobic power during cycling [11, 14]. Furthermore, time to exhaustion in cycling did not significantly differ between non-athletes wearing surgical masks and those without face masks (with a higher exhaled carbon dioxide fraction in the mask group) [14].

In contrast to the results of our study, Fikenzer et al. (2020) reported that surgical face masks could reduce aerobic capacity. They attributed this reduction to a decrease in arterial oxygen saturation and arterial carbon dioxide tension differences. The initial impact of using a face mask during exercise comes from reduced lung function, leading to reliance on accessory muscles and increased fatigue. Medical masks, similar to surgical face masks, negatively impact cardiorespiratory fitness and may disrupt physical and occupational activities [15].

The conflicting results from previous studies suggest that there is no clear consensus on the effect of a face mask on aerobic capacity. It is possible to speculate that continuous use of face masks during exercise may lead to adaptation, reducing their limiting effects on performance over time. Very few studies have focused on the impact of wearing face masks during exercise on children and adolescents. In one of these studies, it was reported that using face masks during maximum treadmill exercise did not have a significant effect on heart rate and arterial oxygen saturation in children aged 7 to 14 years [16].

The results of our study demonstrated no significant difference in other performance tests like jumping, sprinting, and ball-throwing. In contrast, Tornero et al. (2021) indicated that wearing surgical face masks negatively affected running performance, resulting in a 12.51% increase in time for the 50m test and a 19.09% increase for the 400mr test, accompanied by higher levels of blood glucose and lactate after the exercise tests. These researchers suggest that the higher blood lactate levels observed in athletes wearing face masks may result from increased activation of anaerobic lactic metabolism [17].

Some researchers argue that the primary challenge with face masks during sports activities is the discomfort they cause, which reduces athletes' willingness to continue wearing them. Nevertheless, the face mask itself does not seem to have a physiologically limiting effect on the body [18]. Several studies have also indicated that face masks do not affect athletes' speed [19]. The type of face masks used could be another factor contributing to the disparities between our results and some previous studies. For example, N95 masks have been reported to potentially have negative effects on exercise performance by increasing heart rate, respiratory rate, and carbon dioxide levels [20]. However, in other studies, no negative impact on aerobic performance was observed when using surgical or cloth face masks [18].

A limitation of our study is its small sample size, which restricts the generalizability of the results to larger populations. Furthermore, our study did not include an examination of face mask utilization under authentic handball circumstances. Handball assessments were solely conducted by a solitary examiner and one player due to COVID-19 restrictions implemented throughout the investigation. It is recommended that future research utilize larger and more diverse samples to contribute to a more comprehensive and complete understanding of the effects of face mask usage on athlete performance.

## 5. Conclusion

The athletic performance of the groups applying masks and those without masks both significantly increased. Based on this study, using surgical facial masks during physical activity can be done safely by teenage handball players without having a negative impact on their athletic performance. The findings support the use of face masks during team sports as a preventive measure, especially during pandemics or similar disease outbreaks. The study highlights the challenge of continuing to play sports while there is a pandemic. It emphasizes the importance of adhering to safety procedures, such as using face masks, in order to reduce the dangers of COVID-19 transmission in team sports conditions. The security of young athletes and their family members is greatly improved by these precautions.

## Conflict of interest

The authors declared no conflicts of interest.

## Authors' contributions

All authors contributed to the original idea, study design.

## Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

## Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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