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Original Research

The Effect of a KN95 Mask on High-Intensity Interval Training Performance, Physiological Response, and Perception

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Abstract

International Journal of Exercise Science 18(3): 984-994, 2025. https://doi.org/10.70252/AIHP7164 The purpose of this study was to assess the effect of a KN95 mask on the performance, physiological response, and perception of high-intensity interval training (HIIT). Twenty college-aged participants (Male: 10, Female: 10) completed a two-visit, crossover, counterbalanced study. The HIIT workout included four 1-minute "all-out" intervals at 3.5% of body mass with 4-minute rest intervals, performed with or without a KN95 mask. Following HIIT, participants remained on the cycle ergometer for a 15-minute recovery period. For each interval, peak power and average power were recorded. Throughout the HIIT workout and recovery, heart rate, blood lactate, muscle oxygenation, perceived exertion, and perceived recovery were measured. All data were assessed using trial×time ANOVAs with post hoc pairwise comparisons. Alpha level was set to $p<0.05$. All data are presented as mean±standard deviation. No significant interactions were noted for peak power ($p=0.432$), average power ($p=0.674$), blood lactate ($p=0.533$), perceived exertion ($p=0.221$), perceived recovery ($p=0.333$), or muscle oxygenation ($p=0.991$). A significant main effect of trial was noted for heart rate during recovery, with higher heart rate during the masked trial compared to control. A KN95 mask did not affect performance, physiological response, or perception during HIIT, though it led to elevated heart rate during recovery. These results suggest KN95 masks may not impair HIIT performance but can influence short-term post-exercise heart rate recovery.

Keywords: Interval training, COVID-19, mask, tissue oxygenation, perception

Introduction

The COVID-19 pandemic necessitated widespread adoption of KN95 face masks to mitigate respiratory viral transmission to reduce infection rates. This intervention, while effective in limiting the spread of the virus,[1] introduced challenges to aspects of populated athletic activities. KN95 masks are designed to provide enhanced filtration to reduce contact with airborne pathogens; however, they may also alter breathing mechanics and thermal regulation, influencing exercise performance.[2] Throughout the COVID-19 pandemic, many athletes around the world often needed to perform high-intensity exercise during exercise training with the addition of a facial covering. While mask mandates have been largely lifted, some individuals may still choose to wear a mask when experiencing cold- and flu-like symptoms in public spaces. Furthermore, in the event of a future viral outbreak resulting in widespread masking, it is important to understand the effects of mask wearing on high-intensity exercise performance. This information may help athletes and coaches make decisions regarding mask use during exercise, as well as assist in the formulation of public health policy in response to future pandemics.

Previous research on the effect of KN95 masks on exercise performance has primarily focused on aerobic exercise.[3–5] One review article has shown that time to exhaustion during aerobic exercise may be reduced when wearing facial coverings.[3] The primary mechanism behind these changes may be psychological as ratings of dyspnea, discomfort, and exertion were increased when wearing facial coverings.[3] Another meta-analysis revealed similar effects on aerobic performance, but only for N95-like masks.[4] Furthermore, it was reported that wearing an N95-like mask results in altered levels of gas exchange and pulmonary function in addition to increasing rating of perceived exertion, dyspnea, perceived fatigue, and thermal sensation.[4] Studies investigating the effects of facial coverings during resistance training have revealed either a negative impact on exercise performance[6] or no impact on performance and association physiological response.[7] However, this difference may be due to intensity of the exercise with high intensity resistance exercise performance being negatively impacted, while moderate and low intensity did not experience a change in performance.[6] In terms of recovery from exercise, there is some research showing significantly increased heart rate values post aerobic exercise.[8] Furthermore, lactate clearance levels appear to be lower following maximal shuttle run when wearing a facial covering.[9] Taken together it appears that the use of a KN95-like mask during high-intensity exercise may impact physiological and psychological responses, while possibly decreasing exercise performance. Additionally, recovery from high-intensity exercise may be hindered when using a facial covering, which would theoretically impact a secondary exercise bout. During high intensity interval training, individuals are required to perform repeated bouts of high intensity exercise with interspersed recovery periods. If recovery from a high intensity interval bout is limited with a face covering, then performance on subsequent bouts could be impacted.

However, there remains a notable gap in research regarding the physiological and performance impacts of wearing a KN95 mask during high-intensity interval training (HIIT). Without sufficient research on this topic, it remains unclear how KN95 masking may influence key outcomes such as power output, heart rate recovery, muscle-oxygenation, and perceived exertion under these conditions. Addressing this gap is imperative to inform athletes about the practical implications of mask-wearing should another respiratory virus spread worldwide. Therefore, the purpose of the current study is to investigate the effect of a KN95 mask on high-intensity interval training performance, as well as physiological and psychological responses to exercise. Additionally, this study will examine the recovery from exercise with and without a KN95 mask. We hypothesize that exercise performance will be decreased when using a KN95 mask, and that the magnitude of effect will increase with subsequent bouts of exercise. Lastly, we hypothesize that the perceived effort and recovery during the high-intensity interval training will be increased when wearing a KN95 mask.

Methods

Participants

To determine the minimum number of participants, a priori power analysis was conducted with GPower (version 3.1.9.7) with a desired power level of 0.80, an alpha level of 0.05 and a moderate effect size (f=0.28) calculated from previous studies resulting in at least 20 participants.[3,4] In the current study we recruited 20 participants (10 men, 10 women) to participate in this 2-day counterbalanced crossover study. All individuals were current members of a division 3 NCAA athletics team including, soccer, volleyball, baseball, track and field, and basketball. All participants had performed HIIT as part of their regular training programs and had previously worn masks during exercise. All participants were informed of the study procedures and risks and signed an informed consent form. This study was approved by the Ursinus College Institutional Review Board. Participant descriptive data is presented in Table 1. This research was carried out fully in accordance with the ethical standards of the *International Journal of Exercise Science*.[10]

Table 1. Participant data. All data presented as mean (standard deviation).

Gender	Age (y)	Height (cm)	Body Mass (kg)	Body Fat (%)
Men (n=10)	20.47 (0.75)	176.40 (5.52)	76.78 (9.57)	17.9 (3.64)
Women (n=10)	20.61 (1.00)	165.60 (4.34)	62.34 (7.66)	24.78 (3.98)

Protocol

This study used a counterbalanced crossover design, with each subject being randomly assigned the masked or control condition on their first visit, and the opposite condition being performed on the second visit. On the first visit all participants completed body composition testing prior to completing the HIIT protocol. Throughout the HIIT protocol average power, peak power, total work, heart rate, lactate, muscle oxygenation, rating of perceived exertion, and perceived recovery status were assessed. During the masked trial, participants wore a KN95 mask fitted to the individual's face at the start of the warmup and continued to wear it until the study protocol was completed. To ensure proper mask fit, subjects were asked to forcibly exhale while researchers felt for air escaping from the sides of the mask.

Initially, participants were assessed for height and body mass using stadiometer and digital scale (seca, Chino, CA, USA), respectively. Then, participants were assessed for body composition using bioelectrical impedance spectroscopy (SFB7, Impedimed, Carlsbad, CA, USA). Participants laid supine for 3-5 minutes to allow for fluid shifts. Two single-tab electrodes were placed on the right side of the body, 5 cm apart on both the dorsal surface of the wrist and dorsal surface of the ankle, respectively. The device measured total body water and extracellular fluid based on Cole modelling with Hanai mixture theory, which was then used to calculate intracellular fluid, fat mass, fat free mass, and percent body fat.[11]

The HIIT program used in the current study was performed on an electronically braked cycle ergometer (LC7TT novo, Monark Exercise, Sweden). Prior to starting the HIIT program, a 5-minute progressive warm up was performed on the cycle ergometer. The HIIT program consisted of four 1-minute all-out intervals against a resistance set at 3% of the participant body mass with 4-minute recovery periods between sprints. After the completion of the four intervals, participants remained on the cycle ergometer for a 15-minute recovery period during which time they performed active recovery at a self-selected cadence other than assessment periods. For each interval, average power, peak power, and work completed were recorded.

Participants were assessed for their blood lactate using an earlobe stick at before and after each interval and during all post-exercise recovery time points. The puncture site was sterilized with alcohol prior to the stick and initial blood expressed was discarded with gauze. Expressed blood was measured via capillary action into the lactate strip and analyzer (Lactate Plus, Nova Biomedical, Waltham, MA, USA).

Throughout the high intensity interval training protocol participants were assessed for heart rate via chest strap heart rate monitor (H10, Polar Electro, Kempele, Finland). The heart rate was recorded before and after each interval and at each recovery time point. The heart rate measures were calculated as a 10-second average before each time point, except for post-interval measures which was an average of the 10 seconds immediately after each interval.

Participants were assessed for muscle oxygenation via near-infrared spectroscopy throughout the high intensity interval training protocol. Participants had NIRS oxygen sensors (Moxy Muscle Oxygen Monitor, MN, USA) attached to their right vastus lateralis to measure the amount of blood and oxygen being delivered to the muscles during exercise. These are non-invasive devices that adhere to the skin via an adhesive and allow for real-time feedback regarding the oxygen status of the muscle. The standardized placement and analysis were performed in accordance with previous research.[12,13] The muscle oxygenation was recorded before and after each interval and at each recovery time point.

Prior to each interval, participants were asked to determine their rating of recovery using the perceived recovery status scale.[14] After the completion of each interval participants were asked to determine their rating of perceived exertion ("How hard was that interval") using the cycling OMNI scale.[15–17] At the end of the entire testing trial participants provided an overall rating of perceived exertion for the session using the OMNI scale. Prior to beginning the study, all participants were provided instruction and guidance on these two surveys. The perceived recovery status scale and cycling OMNI scale are presented in Figure 1.

Statistical Analysis

One subject was unable to complete the HIIT protocol during the masked trial due to dyspnea, and his data was not included in the analysis. Average power, peak power, rating of perceived exertion, and perceived recovery data collected during the HIIT protocol were assessed using trial×sprint (2×4) repeated measures ANOVA. Heart rate, lactate, and muscle oxygenation data collected during the HIIT protocol were assessed using a trial×time (2×8) repeated measures ANOVA. All data collected during the post-exercise recovery period were assessed with trial×time (2×5) repeated measures ANOVA. For all ANOVA main effects and interactions, partial eta squared ($p\eta^2$) were calculated as an effect size and interpreted as small (0.01), medium (0.06), and large (0.14).[18] All significant interactions and main effects were assessed with post hoc Bonferroni adjusted pairwise comparisons. Alpha was set a priori to $p \leq 0.05$. All statistical procedures were conducted using JASP (Version 0.17.1).

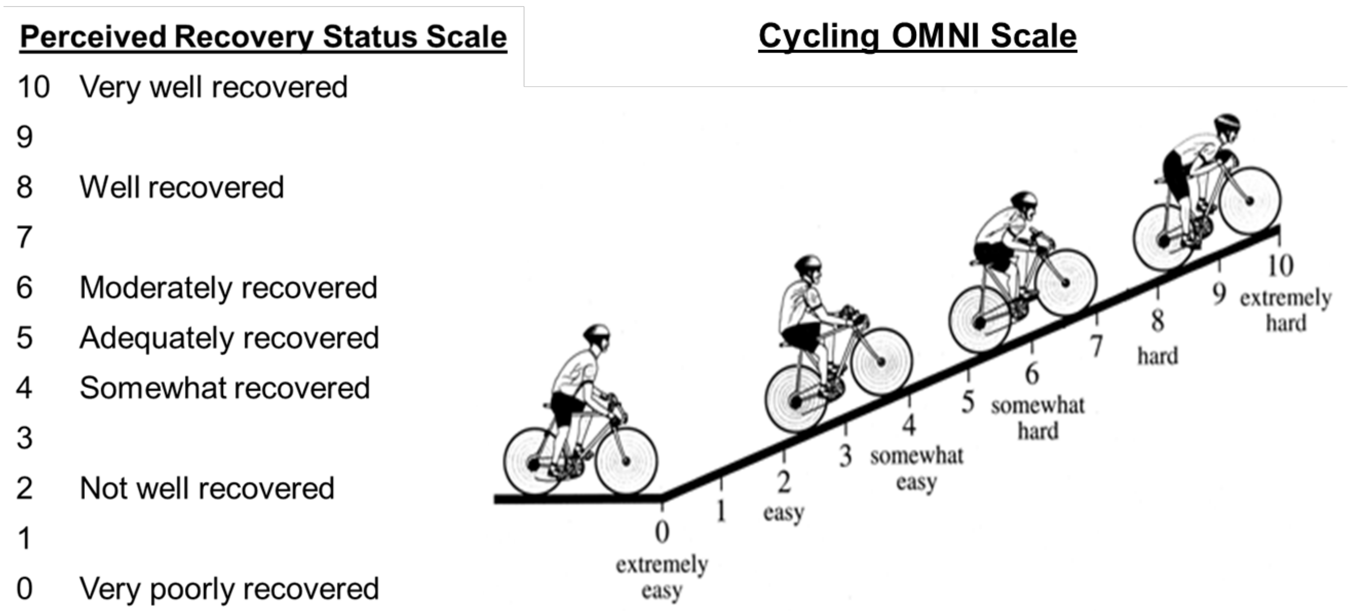

Figure 1. Perceived Recovery Status Scale and Cycling OMNI Scale

Results

Average and peak power during the high intensity interval exercise are presented in Table 2. No significant trial×sprint interactions or main effects of trial were noted for average power ($F_{1,3}$=0.514, p=0.674, $p\eta^2$=0.028 and $F_{1,3}$=1.256, p=0.277, $p\eta^2$=0.065, respectively). Further, no significant trial×sprint interactions or main effects of trial were noted for peak power (F=0.931, p=0.432, $p\eta^2$=0.049 and F=0.292, p=0.595, $p\eta^2$=0.0016, respectively). However, a large significant main effect of sprint was noted for both average power ($F_{1,3}$=20.677, p<0.001, $p\eta^2$=0.535) and peak power ($F_{1,3}$=3.750, p=0.041, $p\eta^2$=0.172). For average power, there was a significant decline from sprint 1 to sprint 2 (p=0.018), sprint 3 (p<0.001), and sprint 4 (p<0.001) regardless of trial. Furthermore, there was a significant decrease in average power from sprint 2 to sprint 3 (p=0.019) and sprint 4 (p=0.001) regardless of trial. For peak power, there was a significant decline from sprint 1 to sprint 3 (p=0.013) regardless of trial.

Perceived exertion and perceived recovery data during the high intensity interval exercise are presented in Table 2. For rating of perceived exertion, there was no significant trial×sprint interaction ($F_{1,3}$=1.514, p=0.236 $p\eta^2$=0.078) or main effect of trial ($F_{1,3}$=0.141, p=0.711, $p\eta^2$=0.008); however, there was a large significant main effect of sprint ($F_{1,3}$=62.254, p<0.001, $p\eta^2$=0.776).

Post hoc tests revealed that all four sprints were significantly different from each other ($p<0.001$) with significant increases from sprint to sprint regardless of trial. Similarly, perceived recovery had no significant trial×sprint interaction ($F_{1,3}=2.416$, $p=0.098$, $p\eta^2=0.118$) or main effect of trial ($F_{1,3}=0.511$, $p=0.484$, $p\eta^2=0.028$), but a large significant main effect of sprint was observed ($F_{1,3}=134.418$, $p<0.001$, $p\eta^2=0.882$). Post hoc tests revealed that perceived recovery significantly decreased with each subsequent sprint ($p<0.001$) regardless of trial.

Table 2. Performance and perception data during high intensity interval exercise. All data presented as mean (standard deviation).

Variable	Trial	Sprint 1	Sprint 2	Sprint 3	Sprint 4
Average Power (W)	CON	266.84 (59.97)	255.39 (50.06)	240.90 (50.52)	235.90 (52.88)
	MASK	266.62 (56.68)	249.51 (51.73)	235.59 (52.73)	232.39 (52.73)
Peak Power (W)	CON	328.84 (100.83)	315.58 (80.84)	297.21 (65.07)	314.74 (87.94)
	MASK	327.84 (80.33)	311.21 (70.20)	303.68 (69.57)	300.74 (68.44)
Rating of Perceived Exertion (AU)	CON	7.16 (0.96)	8.11 (1.05)	9.00 (0.82)	9.68 (0.48)
	MASK	7.37 (1.42)	8.42 (1.12)	9.00 (1.05)	9.37 (0.83)
Perceived Recovery Status (AU)	CON	9.21 (0.86)	6.79 (1.27)	5.31 (1.42)	4.32 (1.64)
	MASK	9.16 (1.34)	5.95 (1.55)	5.32 (1.57)	4.47 (1.61)

Table 3. Heart rate, lactate, and muscle oxygenation data during high intensity interval exercise. All data presented as mean (standard deviation).

Variable	Trial	Pre-Sprint 1	Post-Sprint 1	Pre-Sprint 2	Post-Sprint 2	Pre-Sprint 3	Post-Sprint 3	Pre-Sprint 4	Post-Sprint 4
Heart Rate (bpm)	CON	93.25 (15.06)	178.2 (10.32)	129.55 (13.05)	183.65 (10.61)	142.75 (10.89)	185.65 (8.35)	145.8 (13.24)	186.3 (8.88)
	MASK	91.40 (14.17)	178.95 (10.10)	132.45 (12.92)	183.90 (8.23)	144.55 (11.24)	185.85 (7.96)	146.85 (12.23)	186.65 (8.19)
Lactate (mmol/L)	CON	1.69 (0.51)	7.13 (1.73)	10.70 (2.50)	13.64 (2.86)	14.12 (2.13)	15.22 (1.89)	15.19 (2.29)	15.94 (2.41)
	MASK	1.66 (0.45)	7.88 (1.95)	11.00 (2.25)	13.48 (3.18)	14.03 (3.03)	15.02 (3.40)	14.36 (2.99)	15.86 (3.13)
Muscle Oxygenation (%)	CON	58.13 (12.53)	33.39 (13.34)	62.32 (16.05)	25.38 (10.70)	62.29 (16.53)	28.05 (14.03)	64.06 (17.04)	26.15 (9.52)
	MASK	58.14 (13.32)	33.66 (14.64)	60.91 (17.11)	25.49 (11.23)	59.97 (17.31)	27.69 (15.19)	63.06 (17.69)	29.01 (15.45)

Heart rate, lactate, and muscle oxygenation data during high intensity interval exercise are presented in Table 3. There were no significant trial×time interactions or main effects of trial for heart rate, lactate or muscle oxygenation during exercise. However, there was a large significant main effect of time for heart rate ($F_{1,7}$=470.688, $p<0.001$, $p\eta^2$=0.963), lactate ($F_{1,7}$=242.378, $p<0.001$, $p\eta^2$=0.934), and muscle oxygenation ($F_{1,7}$=48.224, $p<0.001$, $p\eta^2$=0.728). Regardless of trial, heart rate significantly increased ($p<0.001$) from pre- to post-sprint for each individual sprint, and significantly decreased from post- to pre-sprint during each inter-sprint recovery period regardless of trial. Lactate significantly increased from pre-sprint 1 to post-sprint 1, then significantly increased again to pre-sprint 2, and again to post-sprint 2, which remained significantly elevated throughout the remainder of the high intensity interval exercise. Muscle oxygenation significantly decreased from pre- to post-sprint for each sprint, then significantly increased from post- to pre-sprint during the inter-sprint recovery period regardless of trial.

Table 4. Perceived recovery status, heart rate, lactate, and muscle oxygenation data during post-exercise recovery. All data presented as mean (standard deviation).

Variable	Trial	0-Min Recovery	2-Min Recovery	5-Min Recovery	10-Min Recovery	15-Min Recovery
Perceived Recovery Status (AU)	CON	1.11 (0.81)	4.53 (1.78)	5.84 (2.17)	7.05 (1.99)	7.63 (2.03)
	MASK	0.79 (0.86)	4.74 (1.56)	6.00 (1.73)	6.95 (1.75)	7.90 (1.29)
Heart Rate (bpm)	CON	186.74 (8.90)	149.58 (13.12)	132.74 (12.66)	128.37 (12.53)	124.53 (14.74)
	MASK	187.16 (8.09)	152.37 (11.75)	137.21 (12.70)	133.84 (11.34)	130.79 (13.94)
Lactate (mmol/L)	CON	15.94 (2.48)	15.91 (2.27)	14.96 (2.21)	13.64 (2.30)	11.73 (2.13)
	MASK	15.77 (3.20)	15.39 (2.90)	14.72 (2.71)	13.13 (3.23)	11.22 (3.22)
Muscle Oxygenation (%)	CON	27.15 (8.64)	59.58 (18.72)	64.01 (16.06)	63.69 (16.63)	63.34 (18.97)
	MASK	29.94 (15.29)	58.61 (20.00)	64.68 (14.45)	63.43 (16.91)	59.77 (20.81)

All post-exercise recovery data are presented in Table 4. No significant trial×time interactions or main effects of trial were noted for any post-exercise recovery data, other than a large main effect of trial for heart rate ($F_{1,4}$=4.249, p=0.050, $p\eta^2$=0.191). However, large significant main effects of time were noted for perceived recovery status ($F_{1,4}$=150.328, $p<0.001$, $p\eta^2$=0.893), heart rate ($F_{1,4}$=357.812, $p<0.001$, $p\eta^2$=0.952), lactate ($F_{1,4}$=68.668, $p<0.001$, $p\eta^2$=0.535), and muscle oxygenation ($F_{1,4}$=49.989, $p<0.001$, $p\eta^2$=0.735). For recovery status, regardless of trial there were significant increases from IP to 2MIN ($p<0.001$), 2MIN to 5MIN ($p<0.001$), and 5MIN to 10MIN (p=0.008); but no difference between 10MIN and 15MIN (p=0.159). For heart rate during recovery, regardless of trial there were significant decreases in heart rate from IP to 2MIN ($p<0.001$) and 2MIN to 5MIN ($p<0.001$). Post hoc tests revealed that lactate levels during recovery, regardless of trial, significantly decreased from 5MIN to 10MIN ($p<0.001$) and 10MIN to 15MIN ($p<0.001$), but no other differences noted prior to 5MIN. For muscle oxygenation, post hoc tests revealed the only difference during recovery was from IP to 2MIN ($p<0.001$) regardless of trial.

Discussion

The purpose of this study was to investigate the effects of wearing a KN95 mask on performance, physiological responses, and perceived exertion during high intensity interval training. We hypothesized a negative effect of wearing a KN95 mask on exercise performance; however, the results showed that wearing a KN95 mask did not significantly affect peak power or average power during the high-intensity interval training protocol. In terms of physiological response to exercise, blood lactate, heart rate, and muscle oxygenation during exercise were unaffected by a KN95 mask. However, heart rate during recovery was significantly higher in the masked condition. As for psychological response, the KN95 mask did not change the perceived levels of exertion or recovery during the high-intensity interval training or recovery. These findings suggest that while the KN95 mask does not impair performance or perception during exercise, it may influence cardiovascular recovery post exercise.

Aligning with previous research examining the performance effects of mask-wearing, the current study observed no significant decrease in peak or average power during HIIT. Consistent with this finding, Glänzel et al[3] employed an ergometer-based methodology comparable to the present study and reported no significant impairment in maximal power output due to mask usage. Additionally, Epstein et al[5] observed that mask wearing, specifically an N95 respirator, did not significantly impact time to exhaustion during exercise. Taken together, these results suggest that short-duration, high-intensity intervals are not adversely affected by general mask usage in terms of measurable performance outcomes. However, it is important to note that one subject was unable to complete the HIIT protocol with the mask but was able to complete the workout completely without the mask, thus the effect of masks may be specific to the individual.

Similar to the performance results, there were no significant changes in physiological response while wearing a mask during exercise. The present study observed no significant alterations in blood lactate or skeletal muscle oxygenation during HIIT when wearing a KN95 mask. This aligns with Hopkins et al[2], who reported minimal to undetectable differences in whole body VO2, blood gases, and other physiological measures during exercise across numerous mask types. Similarly, Epstein et al[5] found no physiological changes in heart rate, respiratory rate, oxygen saturation, or systolic blood pressure during incremental ergometer exercise with surgical masks. Despite methodological differences, the consistency in findings across varying exercise modalities supports the conclusion that general masking does not substantially impact acute physiological responses. It is important to note that the present study uniquely identified that heart rates remained elevated during recovery periods following HIIT with a KN95 mask, potentially indicating slightly increased respiratory workload in recovery.

In contrast to the similarity of findings in physiological and performance metrics, there were discrepancies in the psychological response to exercise. The present study found that, in general, there were no differences in perceived exertion or perceived recovery status between masked and unmasked conditions during HIIT. This contrasts somewhat with prior literature, which frequently identifies mask induced perception impacts. Glänzel et al[3] conducted a comprehensive meta-analysis that demonstrated that wearing a mask significantly increases discomfort, dyspnea, and perceived exertion across various exercise modalities. Epstein et al[5] similarly reported increased subjective discomfort when using N95 respirators which the authors attributed to elevated CO_2 rebreathing and thermal stress. The discrepancy observed may be attributed to the intermittent nature of the HIIT protocol, which provides regular recovery periods which may reduce cumulative perceptual strain. Another potential factor may be the intensity of the exercise, which was considered an "all-out" effort and as such the RPE was already quite high during the unmasked trial. Additionally, the discrepancy in perceptual findings may be due how perception was assessed. The current study assessed perceived exertion; however, other studies have assessed comfort[19] or dyspnea.[20,21] Furthermore, the current study used an OMNI Likert scale from 1-10; however, other studies have used modified Borg CR10 scale,[22] Borg 6-20 scale,[23,24] or visual analog scale.[20] Lastly, the current study utilized an environmentally controlled environment, whereas many studies have investigated the perceptual response to masks in hot, humid environments.[23,24] Many factors influence an individual's perception of exertion[25,26] and wearing a mask may influence some more than others.

Despite the contributions there are several limitations that may warrant consideration. Although balanced in gender, the population size was relatively small and limited to Division III NCAA athletes, reducing generalizability. Second, the study focused on acute responses, leaving the long-term effects of repeated sessions with masking unexplored. Future research should investigate larger, more diverse populations to assess the cumulative effects or adaptations of masked exercise on performance metrics.

In conclusion, wearing a KN95 mask during HIIT does not appear to impact exercise performance or perception but may influence post exercise recovery. These findings indicate that athletes can confidently perform HIIT while wearing masks, provided that heart rate recovery is monitored appropriately. This is particularly relevant in settings where mask wearing is required for public health, ensuring safety is maintained during exercise should another pandemic ever unfold.

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