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Outdoor Activity: Benefits and Risks to Recreational Runners during the COVID-19 Pandemic

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Abstract

Running has become one of the most popular recreational sports worldwide. It is an easily accessible form of exercise as there are minimal equipment and sport structure requirements. Aerodynamic simulation experiments showed a risk of droplet exposure between runners when two people run in a straight line at a close distance (slipstream). Thus, running activities require a safe physical distance of 10 meters to avoid droplet exposure, which can be a source of transmission of COVID-19 infection. However, running outdoors during the COVID-19 pandemic is still often done in pairs and even in groups without wearing a mask. Open window theory stated that changes in the immune system occur immediately after strenuous physical activity. Many immune system components showed adverse changes after prolonged strenuous activity lasting more than 90 minutes. These changes occurred in several parts of the body, such as the skin, upper respiratory tract, lungs, blood, and muscles. Most of these changes reflected physiological stress and immunosuppression. It is thought that an "open window" of the compromised immune system occurs in the 3–72-hour period after vigorous physical exercise, where viruses and bacteria can gain a foothold, increasing the risk of infection, particularly in the upper respiratory tract. Outdoor physical activity positively affects psychological, physiological, biochemical health parameters, and social relationships. However, this activity requires clear rules so that the obtained benefits can be more significant while simultaneously minimizing the risk of transmission of COVID-19 infection.

Keywords: COVID-19, outdoor physical activity, recreational runner, running behavior

Introduction

In recent years, running has become one of the most popular recreational sports worldwide. It is an easily accessible form of exercise as there are minimal equipment and sport structure requirements. According to data from different regions of the world, running is one of the top 5 adult sports and leisure-time physical activities.[1] In the Netherlands, it was found that about 12.5% of the Dutch population engage in running activities regularly.[2] Running offers various health benefits, including feelings of happiness during and after running, reduced risk of chronic disease,[3,4] and improved mental health,[5] making this type of exercise an attractive health behavior for the general population. Additionally, runners can choose to train alone or in groups, thus introducing a good social aspect to the activity.[6]

Running in an open public space seems to be very enjoyable for most runners. However, during the COVID-19 pandemic, the possible risks when running outdoors need to be taken seriously. Running is not just a sport. It can entail social interaction with a partner who is not family-related. The runner in those casual meetings may have been infected with the COVID-19 virus even though they may be asymptomatic or only have mild symptoms that allow them to continue participating in outdoor activities. However, running outdoors during the COVID-19 pandemic is still often done in pairs and even in groups without wearing a mask. When running, masks are not recommended because of the increased oxygen demand, so runners feel a shortness of breath if they wear a mask while running.[7,8] Thus, the risk of exposure to the virus in runners increases.

Previous studies have typically focused on the benefits and recommendations of physical activity,[4,9] exercise, and the immune system,[10] and droplet exposure between runners.[11] A more complete picture of the benefits and risks of running outdoors during the COVID-19 pandemic is needed to provide policymakers and recreational runners with helpful information and a good understanding of the risks and the necessary preventive measures

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for outdoor running activities. The goals of this review article were three-fold: 1) to highlight whether outdoor activities for runners provided more benefits or risks during the COVID-19 pandemic; 2) to address the harm associated with the virus outbreak that runners are exposed to when running outdoors; and 3) to recommend some practical strategies to mitigate the potential risk.

Method

The literature search was conducted using the following keywords: "COVID-19", "outdoor physical activity," "recreational runner," "running behavior," and "immune system." If multiple documents reporting participation data were found, only the most recent article was retrieved. The publication date was limited to the past ten years from the date of the search. Articles identified by the search engines were assessed by title and abstract. Full-text articles identified as appropriate based on title and abstract were retrieved and assessed for eligibility.

This review began with a brief overview of the comparison between indoor and outdoor physical activities, including why most runners prefer running outdoors rather than running indoors on a treadmill. It then explained recommendations for physical activity for adults and the response of the immune system to moderate or strenuous physical activity. A special section will be devoted to explaining the impact of exposure to viruses and bacteria due to shared outdoor activities. Finally, some recommendations for running outdoors will be given to reduce the risk of exposure to the virus to avoid the trans-mission of viral infections. Recommendations for running outdoors are explained in Table 1, consisting of risk source groups, activities, types of risks, and important recommendations.

Outdoor Activity versus Indoor Activity

Physical activities, such as sports, can be done indoors and outdoors. The indoor environment consists of a closed room, such as a house, gym, or sports hall. The outdoor environment consists of open space, such as a park, field, or an environment with many trees. Engaging in exercise and moving one's body helps a person avoid having a sedentary lifestyle and improves physical health. Sports that are carried out using the correct exercise principles will have a good biological influence and adaptation on the body.[12] Exercise is the best and most affordable option to increase one's immunity and improving one's health status. The benefits of this sport can be directly felt in the immediate effects of feelings of pleasure and happiness after exercising and the long-term effects of increasing physical fitness, improving the immune system, and reducing the risk of cardiovascular disease.[13–15]

Moreover, during the COVID-19 pandemic, it is highly recommended to stay active and exercise to adequately maintain the body's immune system to prevent COVID-19 infection.[16] Exercising can be done at home with various moderate-intensity physical activities, such as walking, strength training, flexibility training, cardiopulmonary endurance training, and a combination of these sports. However, exercising at home has several drawbacks because these activities are sometimes monotonous or done without the company of friends, so it is possible to get bored easily. Consequently, some people choose to engage in more varied outdoor sports and prefer to exercise with friends or the running community they belong to. Outdoor sports are done in open spaces, such as parks, fields, or environments with many trees.

Several studies have shown that engaging in outdoor sports has good psychological, physiological (lowering heart rate and blood pressure), biochemical (noradrenaline, adrenaline, and cortisol) effects on people and enhances their social relationships.[17,18] A green environment has also been shown to reduce stress levels and mental fatigue, improve concentration, attention, cognitive function, and mood, and have positive physiological effects, such as lowering blood pressure.[19] In comparison to indoor exercise, outdoor exercise has a more significant impact in revitalizing positive feelings, reducing depression, and increasing energy.[20]

To participate in physical activity outdoors during the COVID-19 pandemic, runners must understand the principles of how COVID-19 is transmitted. A person infected with COVID-19 can transmit this virus to others 48 hours before the onset of symptoms (presymptomatic) and up to 14 days after the onset of symptoms.[7,21] A study reported that this presymptomatic transmission was 12.6%. This presymptomatic period is critical to understand because the virus can spread through droplets or contact with contaminated objects from someone who is not yet symptomatic. Asymptomatic confirmed cases are also possible sources of transmission, although the probability is very small.[22–24] However, based on a current epidemiological and virological study, it has been proven that COVID-19 is mainly transmitted through droplets from symptomatic people to other people who are in proximity.[24]

Physical Activity Recommendations

According to the World Health Organization (WHO), physical activity is defined as any movement produced by skeletal muscles that require energy expenditure.[25] Physical activity includes sports and other activities that involve bodily movement and are performed as part of play, study, work, active transportation, household chores, and active recreational activities (e.g., dancing, yoga, tai chi).[26] Physical activity can be categorized as light, moderate, and heavy. Light physical activity or

sedentary activity is a physical activity that expends <3 metabolic equivalents (METs) of energy, such as sitting in a relaxed position or lying down but not sleeping. Moderate physical activity expends 3 to 6 METs of energy; it includes walking (4.8 km/hour), brisk walking (6.4 km/hour), cycling (16–19 km/hour), climbing stairs, gardening, dancing, or carrying items with moderate weight (<20 kilograms). Heavy/strenuous physical activity requires a minimum expenditure of >6 METs of energy. Examples of strenuous physical activity include running (≥9 km/hour), cycling (≥19 km/hour), aerobic exercise, mountain climbing, swimming, carrying goods with heavy loads (>20 kilograms), and competitive sports, such as soccer, basketball, and volleyball.[25,27,28]

World Health Organization (WHO) recommends that all adults aged 18 to 64 years should engage in regular physical activity. Every week, adults should do at least 150–300 minutes of moderate-intensity aerobic physical activity or at least 75–150 minutes of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate and vigorous activity, to reap substantial health benefits. Adults should also engage in moderate or higher intensity muscle-strengthening activities involving all major muscle groups two or more days each week for health benefits. Additional health benefits can be obtained by increasing moderate-intensity aerobic physical activity to >300 minutes or do >150 minutes of high-intensity aerobic physical activity, or an equivalent combination of moderate-intensity and vigorous-intensity activity per week.[9,25]

How Physical Activity Becomes a Protective Measure or an Open Window for URTI/COVID-19

Physical exercise has positive and negative effects on the immune response, depending on the intensity and workload of the activities performed.[29,30] Evidence from randomized controlled trials and epidemiological studies supports the theory that regular physical activity can reduce the number of sick days and suggests that the risk of upper respiratory tract infections (URTI) is reduced in people who engage in regular physical activity.[10,31]

During periods of moderate physical activity, it was found that there was no increase in immune-suppressing stress hormones and pro and anti-inflammatory cytokines that showed intense metabolic activity.[10] It is thought that although the immune system returns quickly to pre-exercise levels at the end of the workout session, each session is believed to increase immune control, thereby reducing the risk of infection in the long term.[21] During moderate-intensity aerobic exercise with a duration of <60 minutes, the antipathogenic activity of tissue macrophages occurs in parallel with an increase in circulating immunoglobulins, anti-inflammatory cytokines, neutrophils, natural killer (NK) cells, cytotoxic T cells, and immature B cells, all of which play important roles in immune system defense activity and metabolic health.[10,32]

Therefore, considering the available scientific evidence, it is reasonable to assume that training status influences the level of immunity and URTI incidence. Based on the similarities between the transmission method and the focus of URTI and COVID-19 infection, there may be a relationship between runners' training status and the incidence of COVID-19. However, it cannot be concluded that trained individuals are more protected from COVID-19 infection than untrained individuals. The COVID-19 pandemic has provided an opportunity to evaluate a patient's contaminated sports training history to provide data for further investigation of the protective effect of training status against COVID-19.

However, intensive physical activity, such as strenuous exercise, tends to be detrimental in changing some immunological indices, especially if the activity is accompanied by environmental stress or competition.[10] This can lead to an increased risk of infection, especially in athletes who participate in competitive endurance training or train excessively.[21] Open window theory stated that changes in the immune system occur immediately after strenuous physical activity. Many immune system components showed adverse changes after prolonged strenuous activity lasting more than 90 minutes. These changes occurred in several parts of the body, such as the skin, upper respiratory tract, lungs, blood, and muscles. Most of these changes reflected physiological stress and immunosuppression. It is thought that an "open window" of a compromised immune system occurs within 3 to 72 hours after vigorous-intensity physical exercise, where viruses and bacteria can gain a foothold, increasing the risk of infection, particularly in the upper respiratory tract.[10,32,33]

According to the J-curve model proposed by Nieman and Wentz (2019), the relationship between physical exercise and the risk of respiratory tract infections can be explained as follows: there is a 40–50% reduction in the risk of URTIs in someone who routinely does moderate-intensity physical exercise. Conversely, someone who does heavy-intensity physical exercise will have a 2–6-times more significant risk of URTIs.[10,33]

Based on indirect evidence and a conservative approach, the open window theory and the hypothesis that strenuous exercise sessions will acutely increase the risk of URTI/COVID-19 are still speculative. However, as previously mentioned, strenuous exercise sessions can lead to greater immunodepression. Thus, it is recommended that runners engage in short (≤90 minutes) low- or moderate-intensity training sessions. Thus, moderate-intensity exercise (and not high-intensity exercise) should be recommended as a non-pharmacological, inexpensive, and viable way to cope with URTI/COVID-19.

Exposure to Viruses and Bacteria due to Shared Outdoor Activities

An aerodynamic simulation experiment showed that there was a risk of droplet exposure between runners when two people are running in a straight line at a close distance (slipstream). It makes running activities require a safe physical distance of 10 meters to avoid droplet exposure that could potentially be a source of transmission of COVID-19 infection.[11,29] However, running outdoors during the COVID-19 pandemic is still often done in pairs and even in groups without wearing a mask. When running, wearing masks is not recommended because of the increased oxygen demand, so runners feel a shortness of breath if they must wear a mask while running.[7,8]

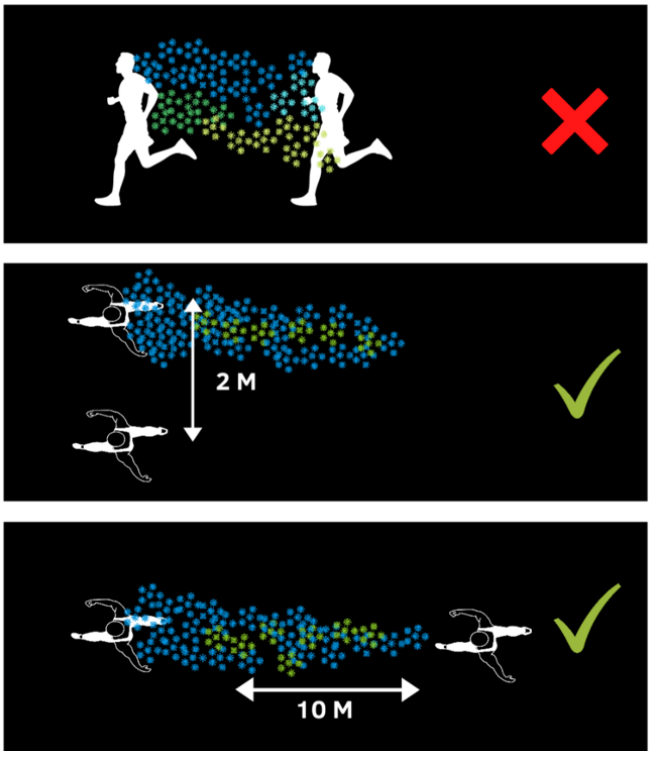

Figure 1. Droplet Spread Pattern when Running Outdoors

Blocken *et al.* (2020) showed that droplet exposure could be avoided by walking or running side-by-side and maintaining a safe distance of 2 meters;[11] however, this is virtually impossible on public roads. The most significant droplet exposure from people walking or running together occurs when two people run in a straight line at a close distance (slipstream). Droplet exposure increases as the distance between the person in front and the person behind decreases. This shows that avoiding droplet exposure can be done by one of two actions: by avoiding walking and running inline at a close distance or by maintaining sufficient physical distance to prevent exposure to droplets due to a person's walking or running speed. The equivalent physical distance for walking and running in a line (slipstream) is defined as the distance that must be maintained between the front walkers/runners and the walkers/runners behind them to avoid droplet exposure, which is equivalent to the condition when two people are

Table 1. Type of Risk and Recommendations for Running Outdoors

Risk related to	Activities	Type of Risk	Recommendation
Types of Exercises	Long runs of more than 90 minutes	Lowers the immune status (3 to 72 hours after strenuous exercise)	Prefer low-moderate intensity exercises rather than strenuous exercise[10,29]
	Hill training, interval training, or endurance training	Lowers the immune status (3 to 72 hours after strenuous exercise)	Prefer low-moderate intensity exercises rather than strenuous exercise[10,29]
Running Behavior	Running in open public spaces	Increases the risk of exposure to viruses and bacteria	Running activities require a safe physical distance of 10 meters to avoid droplet exposure that could potentially be a source of transmission of COVID-19 infection[11,29]
	Running through a crowd	Increases the risk of exposure to viruses and bacteria	Keep wearing your mask properly until you pass the crowd of people[8]
	Running with partners without wearing a mask	Increases the risk of exposure to viruses and bacteria	Avoid running inline (slipstream) at a close distance; it is preferable to run side-by-side to avoid droplet exposure from the runners in front[11]
Social Interaction	Training with a partner who is not a family member	Increases the risk of exposure to viruses and bacteria	Avoid sharing water bottles, exercise mats, towels, and other sports equipment[29]
	Warm-up and cool-down exercises	Increases the risk of exposure to viruses and bacteria	Avoid activities that involve bodily contact, such as shaking hands, warming-up or cooling-down in pairs, and team sports[29]
	Take a photo with friends by removing masks	Increases the risk of exposure to viruses and bacteria	Keep wearing masks properly if you take photos with friends[8]

standing still at a distance of 2 meters. If there is no strong wind, for fast walking at a speed of 4 km/hour, the safe distance is about 5 meters behind the person in front; for running at a speed of 14.4 km/hour, the safe distance is about 10 meters, which may become a problem if there are many people nearby.[11,29] It is possible to run easily with a mask while doing low-intensity exercise/running. However, with moderate/high-intensity exercise/running, it may become difficult to run with a mask, triggering shortness of breath.[8]

In another study,[34] the probability of collision between a runner and micrometric respiratory droplets suspended in the air and rest (from the environment) was discussed within a raindrop collisional model framework. It was shown that, as expected from this theory, the probability of collision does not increase indefinitely with the approaching velocity of the runner; instead, there is a maximum peak or threshold velocity after the efficiency of the collision decreases.[34] However, this theory is only limited to doubting the collision speed between the droplets released by the front runner to the runner behind them; it has not well explained the recommendations for two runners who run together to avoid possible droplet exposure between them.

Furthermore, running outdoors can create risks related to the type of exercise, running behavior, and social interaction performed by runners (Table 1).

Strengths and Limitations

A strength of this review is that the study topic is actual, and it will probably remain important in the future. This is significant because running has become one of the most popular recreational sports worldwide. However, running outdoors during the COVID-19 pandemic is still often done in pairs and even in groups without wearing a mask.

This review has several limitations. This paper only analyzed various theories to produce a conclusion. The real-world condition of the population should be investigated by researching running behavior and COVID-19 infections in recreational runners during the COVID-19 pandemic. Another limitation is that research on running behavior during the COVID-19 pandemic is still very limited, so the analysis of existing theories is still not optimal.

It is important to note that this review is an initial step towards understanding the risks of running outdoors during the COVID-19 pandemic. Further research in the runner population is needed to explore changes in run-ning behavior due to the COVID-19 pandemic, assess the impact of COVID-19 infections on runners, and identify whether there is an association between running habits/running behavior and COVID-19.

Conclusion

Outdoor physical activity positively affects people's psychological, physiological, biochemical health parameters, and social relationships. However, this activity requires clear rules so that the obtained benefits can be more significant and the risk of transmission of COVID-19 infection can be minimized. Moderate-intensity physical activity with an exercise duration of <60 minutes can increase the body's immunity to infection. Heavy-intensity physical activity that lasts >90 minutes tends to decrease the immune response, especially 3 to 72 hours after strenuous activity.

Running behavior can be a potential risk of COVID-19 transmission for recreational runners. This requires a commitment to general health protocols and paying special attention to the risk of droplet exposure among runners. Running during the COVID-19 pandemic is ideally done alone in a quiet place to avoid the potential for exposure to the virus. However, if running activities must be carried out in groups, then the position between the two runners must be side-by-side instead of inline, and runners should maintain a safe distance of 2 meters. Furthermore, if the running positions are parallel (in a line), a safe physical distance of 10 meters is required between the two runners in front and behind.

Abbreviations

COVID-19: coronavirus disease 2019; WHO: World Health Organization; METs: metabolic equivalents; APCs: antigen-presenting cells; NK: natural killer; URTI: upper respiratory tract infection.

Ethics Approval and Consent to Participate

Not applicable.

Competing Interest

The authors declare that there are no significant competing financial, professional, or personal interests that might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

Not applicable.

Authors' Contribution

AM and DHR conceptualized, designed, and prepared the manuscript. Furthermore, both authors contributed to reviewing the manuscript and also read and approved the submitted version.

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