Improved Blood Saturation of Golf Players After COVID-19 as Potential Marketing Management and Improved Economics of Golf Related Activities

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Abstract **– The health effects of playing golf on the athlete's body is an interesting topic. The effect of golf on increasing blood saturation has low presence in the literature. This paper demonstrates the correlation of playing golf on improving health status after COVID-19 while this positive information has a potential to be used by the marketing management of various organisations to improve economics of golf activities. We analyse the change in saturation and heart rate after playing an 18-hole course, measured by pulse oximetry (% SpO2). Then we investigate the different aspects that have the greatest health benefit in golf. By following the effect of playing golf on blood oxygen saturation and heart rate in athletes we build a linear regression model explaining the impact 14 factors have on blood oxygen saturation. An 18-hole golf course caused a 1 ± 1.49% ($p<0.001$) increase in venous blood O2 concentration and a 6 ± 8.09% ($p<0.001$) increase in resting heart rate. Golf has the positive effect on the health status of athletes after recovery or vaccination for COVID-19 disease.**

Keywords **– Marketing management, golf, blood saturation, heart rate, COVID 19, vaccination.**

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1. Introduction

The Coronavirus disease broke out in 2019, subsequently spreading worldwide and becoming a global public health threat [23]. The outbreak was declared a pandemic by the World Health Organization [33]. SARS-CoV-2 Coronavirus is responsible for the infectious respiratory disease COVID-19 [44], which has an asymptomatic or mild course in most people. In some cases, it can cause long-term physical or psychological dysfunction in patients [18]. We used to pulmonary rehabilitation to address such dysfunctions. Is used to this term refer to a multidisciplinary intervention for symptomatic patients with chronic respiratory diseases [9]. Rehabilitation reduces disability, optimizes health status [22], and helps to reduce the impact of COVID-19 on the patient's health and activity [40]. It aims to improve not only the physical but also the mental state of the patient [36], which we demonstrate in our case by the use of playing golf.

Rehabilitation with aerobic training can accelerate patients' return to normal life [37]. Golf is an ideal connection for patients who have overcome COVID 19, feel lonely and show different degrees of psychological disturbances such as anger, fear or anxiety [39]. These positive findings can be used by marketing management activities as they have potential to improve the economic performance of golf related activities while improving the health of players.

The health benefits of golf are demonstrated by an increase in SpO2, peripheral capillary oxygen saturation, measured by pulse oximetry. It provides us with an indirect, non-invasive measurement of arterial oxygenation (SaO2) based on differential absorption of light, by oxygenated and deoxygenated blood during pulsatile blood flow [17]. Normal oxygen saturation in a healthy person, who does not have a chronic disease causing inadequate blood oxygenation, ranges from 95% to 99% [41].

In the elderly, 93% is an acceptable value [24]. If the oxygenation value drops below 93%, it is necessary to be alert and check the values more frequently [1], as we also advised the 4.39% of golfers in our study who showed such values. All the aforementioned golfers with lower saturation levels were inoculated and 60% of them surpassed the COVID-19. At SpO2 values of 88%, oxygen therapy may be indicated by the attending physician [43]. Critical status occurs at values below 80%. It manifests in a few minutes [16] and at values below 60%, there is a risk of imminent critical desaturation and loss of consciousness [6].

In a number of healthy individuals, we can observe mechanisms during exercise that lead to a reduction in pulmonary gas exchange [2]. Exercise-induced arterial hypoxemia [11] implies an increase in the alveolar-arterial oxygen difference, which, combined with a minimal alveolar hyperventilation response, leads to a decrease in arterial partial pressure PO2 [8]. Women have both smaller airway diameter and lung volumes relative to body size than men. These differences affect gas exchange during exercise and thus women may have a greater alveolar-arterial PO2 difference [20]. In athletes, arterial hypoxaemia is induced by exercise, especially with rapid onset such as sprinting [3]. In sports that have a slow onset or a longer intensity as seen in our golf research, hypoxemia is less common. Therefore, we did not take measurements during the sport performance [12], but after 15 minutes, as it has been shown [21] that hypoxemia occurs during and after the immediate cessation of the sport performance [4].

To further confirm the health effects of playing golf, we monitored the heart rate on a pulse oximeter [5]. It is denoted by the symbol bpm and indicates the number of heart beats made in 1 minute [7]. The heart rate value is influenced by age, weather, nutrition, fatigue, stress, or fluid consumption [14]. Its value averages 65 beats per minute in men [10] and 82 beats per minute in women [13]. An active athlete may have values significantly lower [15], averaging 40 heartbeats per minute. More beats per minute will be made by the heart of people with poor physical condition, and already with light exercise the heart rate rises rapidly [26]. Choosing the right heart rate during training has an impact on physical fitness [19], muscle mass gain, fat burning [45], but especially on strengthening the cardiovascular system. The optimal heart rate is recognized by the athlete being out of breath but not yet panting [25].

Its value ranges from 60-75% of the maximum heart rate, which averages 226 and 220 beats in women and men, respectively [27]. Anaerobic exercise exceeds this optimal value [28].

This exercise puts the body into oxygen debt [29], and it is rapidly exhausted [30]. With an anaerobic exercise, the body burns carbohydrates and thus primarily builds strength and muscles [31]. This type of exercise is not suitable for post COVID-19 conditions, but with aerobic exercise [35], the body struggles to supply oxygen to the muscles and burns fats and sugars [32]. Aerobic exercise, such as golf, primarily affects the cardiovascular system [34], speeds up metabolism [38], and helps reduce body fat [42]. Thus, the key to health is to kick-start metabolism, which is efficiently triggered at a lower heart rate [47] and prolonged exertion of more than 40 minutes in the fresh air at a slow pace [46]. In this study, we demonstrate an effective, simple way to improve oxygenation and achieve optimal heart rate in golfers following a COVID-19 pandemic such as overcoming or vaccination.

2. Methodology of Work

The health benefits of golf have been addressed in past studies. In our investigation, a sample of 114 golfers was monitored for changes in blood saturation values and heart rate before and after playing a round of golf. We analyzed the influence of different factors that may affect these values on players who had overcome the COVID 19 disease, had been vaccinated or, on the contrary, had not overcome the disease and had not been vaccinated. We collected data on individual adepts such as gender, age, occupation and sports activities. In particular, we focused on parameters associated with the COVID 19 pandemic, such as the date of overcoming the disease, its course, the vaccination, the number of doses and the date of the last vaccination dose. We investigated these aspects in relation to the change in blood oxygenation and heart rate after playing an 18-hole golf course, which lasted an average of 5 hours.

We used a certified medical device, a pulse oximeter with the integrated probe (P300 Intelli IT, OMRON Healthcare Japan), to measure SpO2. We preferentially placed the oximetry probe on the left index finger. The elbow of the left hand was placed on the table, and we recorded SpO2 at rest. Thus, we reduced the possibility of movement distorting the saturation values. To avoid temporal bias, measurements were taken in a seated position 15 minutes before and 15 minutes after playing one full round of golf. Measurements were taken 2 months apart at different outdoor temperatures of 25 ± 9.15 degrees celsius. In some cases (n=21) it was not possible to measure saturation with a pulse oximeter because the respondents had gel nails through which measurements could not be made. These female golfers were not, included in the research.

Descriptive statistics such as mean, standard deviation (± SD), and median were used to summarize demographic and clinically relevant variables. We used regression analysis to examine the association between variables that reached $p < 0.05$ in the summary model. Next, we focused on defining the influence of specific variables with statistical significance defined as a p value < 0.10.

We detected correlation on factors directly related to COVID 19 namely vaccination and SARS-CoV-2 infection itself. We compared the characteristics of golfers at rest before and after playing a round of golf, which showed a difference between heart rate and SpO2 <1% or ≥1%.

We chose this predefined cutoff value to reflect the relevant difference between measurements. Analyses were performed using Gretl: GNU Regression, Econometric and Time-series library, version 3.

3. Results and Discussion - Athletes Demographics

Demographic and other relevant data were collected from athletes directly on the golf courses. These revealed that the mean age of the golfers surveyed (n=114) was 48.41 years and slight differences were noted for each gender (Figure 1).

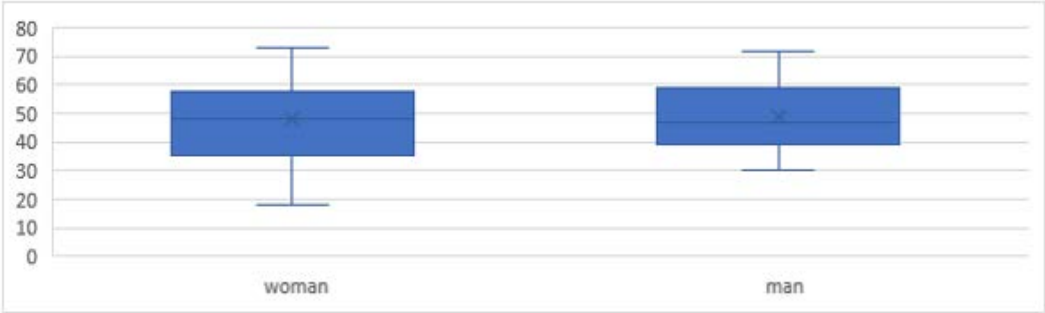

Figure 1. Age distribution of golfers by gender

Overall, 85.09% of the athletes studied were women who had overcome COVID-19 and had also been vaccinated against the disease. Table 1 shows other relevant characteristics.

Table 1. Basic characteristics of athletes

Variable	Basic determinations median ± SD, n (%)
n	114
Age (years)	48 ± 14,82
Female gender	97 (85,09)
COVID-19 Status	
Overcoming COVID- 19	81 (71,05)
Overcoming COVID- 19 (months)	7,5 ± 2,49
Course of disease (0-asymptomatic course, 5-hospital admission on artificial lung ventilation)	1 ± 1,21
COVID- 19 vaccination status	
Vaccinated against COVID- 19	91 (79,82)
Number of doses of vaccination against COVID- 19	3 ± 1,33
Last dose of COVID- 19 vaccination administered (months)	9 ± 5,08
Golfers who have not overcome COVID- 19 and have not even been vaccinated for it	5 (4,38)
Sports activity (per week)	
Golf	2 ± 1,92
Other sports activity	2 ± 1,74
Sedentary work	79 (69,29)

To elucidate the beneficial effect of playing golf on players' health, we examined the effect of individual factors on blood saturation using linear regression (Table 2).

Table 2. Regression analysis of the influence of the investigated factors on blood oxygenation

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Const	74,285	10,708	6,937	<0,0001	***
Gender	-0,077	0,391	-0,196	0,845	
Age	0,004	0,009	0,367	0,716	
COVID- 19 date	0,108	0,062	1,745	0,087	*
The course of the COVID- 19	0,401	0,192	2,091	0,041	**
Vaccination	-4,755	2,006	-2,371	0,021	**
Vaccination doses	-1,187	0,429	-2,768	0,008	***
The last batch	-0,188	0,105	-1,792	0,079	*
Golf weekly	0,034	0,098	0,345	0,732	
Sport weekly	0,045	0,081	0,552	0,583	
Occupation	-0,965	0,384	-2,512	0,015	**
Saturation before	0,319	0,094	3,399	0,001	***
The pulse before	0,018	0,017	1,103	0,275	
The pulse after	-0,006	0,017	-0,361	0,719	
Outdoor temperature	0,025	0,019	1,271	0,211	
Mean dependent var	97,456	S.D. dependent can		1,165	
Sum squared resid	50,854	S.E. of regression		0,979	
R-squared	0,441	Adjusted R-squared		0,293	
F(14, 53)	2,979	P-value(F)		0,002	

$$y_i = 74{,}285 - 0{,}077x_1 + 0{,}004x_2 + 0{,}108x_3 + 0{,}401x_4 - 4{,}755x_5 - 1{,}187x_6 - 0{,}188x_7 + 0{,}034x_8 + 0{,}045x_9 - 0{,}965x_{10} + 0{,}319x_{11} + 0{,}018x_{12} - 0{,}006x_{13} + 0{,}025x_{14}$$

We make an assumption where a given round of golf is played by a woman aged 46 years old who has not overcome COVID-19, is vaccinated with 3 doses 9 months ago. She has a sedentary job, plays golf once a week, and does other sports activity in addition. Before playing, the saturation value is at 90% at an outdoor temperature of 25 °C. Subsequent to the game, an assumption of improvement in health would confirm a saturation of 95%. In this way, we explain that playing golf helped to oxygenate the blood by 5%.

Making a prognosis: we analyze a man aged 70 years old who had overcome COVID 12 months ago and was vaccinated with 2 doses 6 months ago. He does not have a sedentary job, plays golf 7 times a week and does other sports activities every day. His saturation at an outside temperature of 25 degrees celsius before playing would be 90%. After playing an 18 hole course, the saturation value would increase by 7% to 97%.

The regression coefficient is statistically significant, therefore playing golf positively affects blood saturation of most golfers regardless of age and the gender. By the regression model with given independent variables, we can explain 50.85% of the variability of the effect on blood oxygenation. Golf brings bigger health effect on people with the sedentary occupation and better health. More frequent movement on or off the golf course in varying exertion does not contribute significantly more to blood oxygenation. By regression analysis, we found a significant effect of golf on blood oxygenation as a function of factors of COVID-19 recovery and the vaccination. Single doses of the vaccination against this infection have the most significant effect.

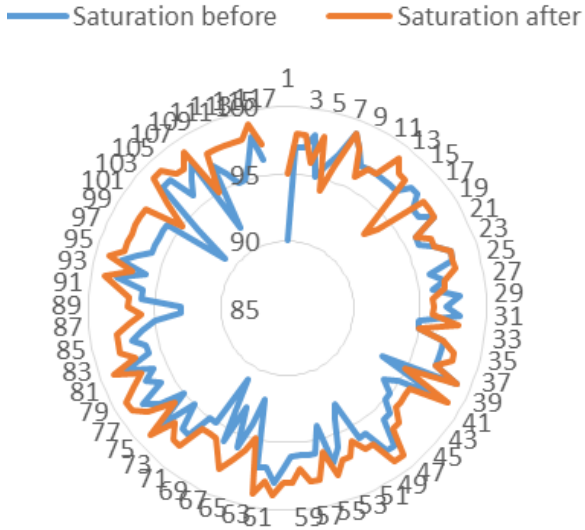

Figure 2. Difference in blood saturation before and after playing golf

Figure 2 shows that for the vast majority, 79.98% of golfers, playing golf helps to oxygenate the blood by an average of 1.18%. The average value before playing golf of 96.16% increases to a value of 97.33% after playing an 18 hole course. In some groups of golfers we see a more significant increase in blood saturation and this is for example in the group of athletes who have not overcome COVID-19 and have not been vaccinated either. All the results for each group can be seen in Table 3

Table 2. Difference of SpO2 in the different groups of survival and vaccination against COVID-19

Variable	**Basic determinations median ± SD, n (%)**
Blood oxygenation SpO2 before playing a round of golf	96 ± 1,71
Blood oxygenation SpO2 after 18 holes of golf	98 ± 1,26
SpO2 difference before and after golf of the whole sample of adepts	1 ± 1,49
Difference in SpO2 before and after golf of golfers who did not overcome covid	1 ± 1,79
Difference in SpO2 before and after golf of golfers who overcame covid	1 ± 1,36
Difference in SpO2 before and after golf in golfers who were not vaccinated	1 ± 1,07
Difference in SpO2 before and after golf of golfers who were vaccinated	1 ± 1,59
Difference in SpO2 before and after golf in golfers who did not overcome covid and were not vaccinated	1 ± 0,71
Difference in SpO2 before and after golf of golfers who overcame covid and were vaccinated	1 ± 1,43
Unchanged saturation after golf activity	14 (12,28)
Deterioration of saturation after golf activity	9 (7,89)
Heart rate before playing a round of golf	82 ± 11,77
Heart rate after playing a round of 18 holes of golf	89,5 ± 11,19
Heart rate difference before and after golf	6 ± 8,09

The older the athlete is, the more golf helps to improve his, her health (Figure 3). The greatest number of golfers who showed improvement were in the 25-40 age range.

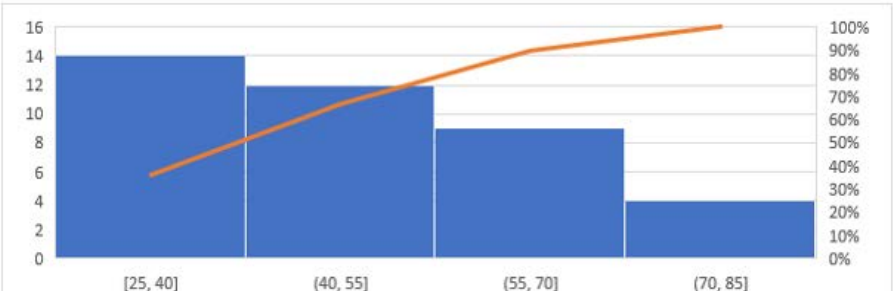

Figure 3. Difference in blood saturation at different ages when playing golf

Golf most significantly helped those with sedentary jobs who were vaccinated with three doses and overcame COVID-19 disease in the observational study (Figure 4).

Figure 4. Factors most significantly affecting the health status of golfers with the highest saturation

Golf saturation has not only increased, but has managed to reduce its value. Therefore, we looked for the factors (Figure 5) that have the highest correlation to the athlete's health status. We found that factors such as age were highly correlated to saturation prior to the sport performance. Overcoming the disease and the intensity of the sports load expressed in heart rate has an influence on the value after playing a round of golf.

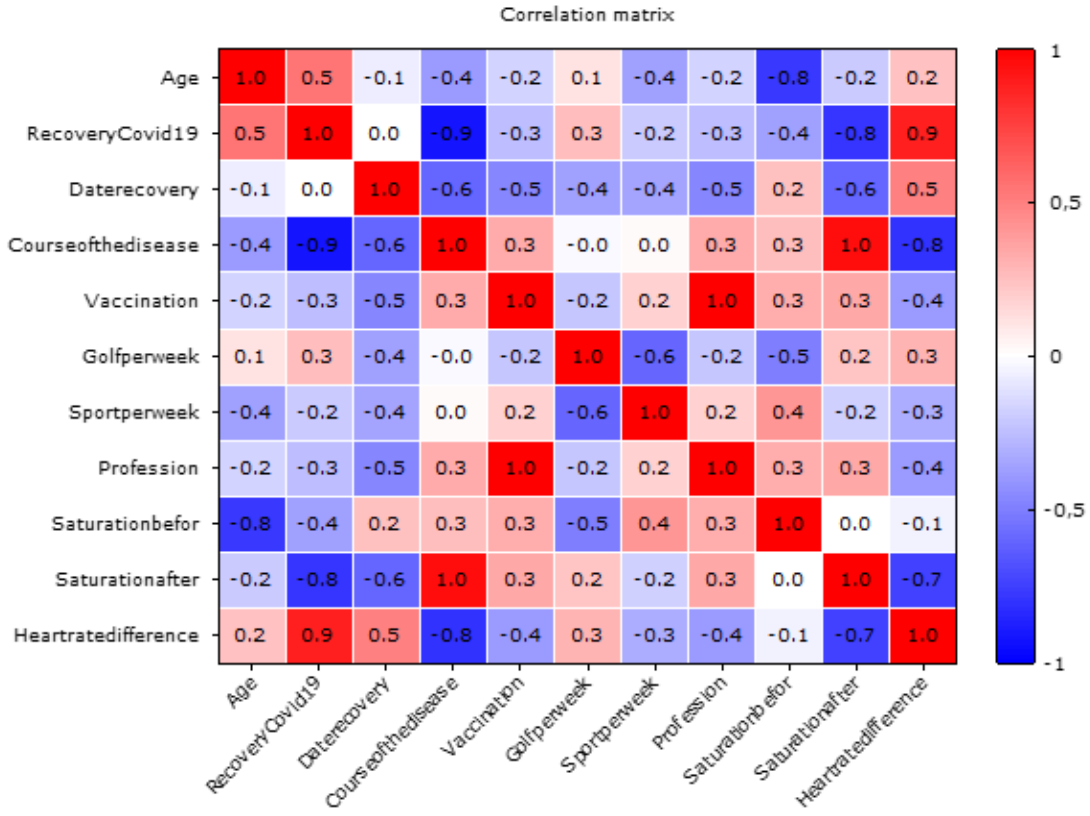

Figure 5. Correlation of individual factors in athletes for whom golf reduces blood saturation

4. Conclusion

We included 114 golfers aged 48 ± 14.82 years, 85.09% of whom were female. By basic statistical tests, we found higher blood saturation in males. On average, there was a 1 ± 1.49% improvement in saturation; the athletes played golf 2 ± 1.92 per week and performed another sport activity 2 ± 1.74 per week. The COVID-19 disease was overcome by 71.09% of people before a mean of 7.5 ± 2.49 months with a mild course. Vaccination coverage of 79.82% was 3 ± 1.33 doses 9 ± 5.08 months ago. The more distant the overcoming of the COVID-19, with a worse course, the more beneficial golf is to health. At higher vaccination rates, golf has less effect on improving overall health status.

Regression analysis revealed statistical significance ($p<0.001$) of playing golf on the positive increase in blood saturation in the majority of golfers, regardless of age and the gender. To people with sedentary occupations and in better health, golf brings a greater health effect. More frequent movement on or off the golf course in varying exertion does not contribute significantly to better blood oxygenation. By regression analysis, we found a significant effect of golf on blood oxygenation as a function of the factors of overcoming COVID-19 disease and its vaccination. Single doses of vaccination against this infection have the most significant effect.

Overall, 79.98% of golfers had SpO2 ≥ 1%, with the sedentary occupation, who were vaccinated with three doses and overcame COVID-19 disease. n=9*;* 7.89% of athletes had SpO2 values ≤ 1% and were correlated with age and general health status. Overcoming the disease and the intensity of the sporting load, expressed in heart rate values, had an effect on the increase in saturation during golf. Aerobic exercise such as golf has an effect on the cardiovascular system, speeding up metabolism and helping to reduce body fat by getting the body to an optimal heart rate. We measured this increase 15 minutes after playing golf with a value of 89.5 ± 11.19 beats per minute.

The effects of playing golf on improving health-related quality of life were statistically significant. It was concluded that playing an 18-hole golf course is effective in improving cardiorespiratory fitness in patients recovering from respiratory COVID-19 infection. However, health-related quality of life was not influenced by all aspects, but mainly by general health status, occupation, the way of overcoming SARS-CoV-2 disease, and the number of vaccine doses administered.

The positive effects of playing golf in relationship to COVID-19 should be foremost used by players and have potential in the field of marketing management to increase interest in golf and subsequently improve economics of related manufacturing and services.

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