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ORIGINAL ARTICLE

In-Game Physiological Responses of Young Elite Male and Female Golf Players: A Field-Based Study

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ABSTRACT

Background. Females' golf course lengths have been reduced due to their strength characteristics, leading to shorter shot distances than men. Although the golf game requires different physical conditions for females and males, the physiological demands of both genders are unknown. **Objectives.** This study aimed to investigate the physiological responses of female and male golfers during 18 holes golf games. **Methods.** Twentynine elite golf players (females:11, males:14) with 1-10 handicaps participated in the study (age: 17.76±2.05 years and handicaps: 5.4±2.9). The players' physiological responses were assessed using BioHarness 3 Zephry wireless supported heart rate monitor. Perceived exertion rates of the players were enrolled using Borg Scale. **Results.** Female golf players had significantly higher heart rate values and energy expenditures than male golf players during 18 holes golf games ($P<0.05$). Although playing golf produced higher physiologic demands in female players, there was no difference in perceived exertion rates ($P>0.05$). **Conclusion.** Although the golf game is facilitated by changing the course length for female golf players, it has been investigated that they encountered greater physiological demands than males. However, the perceived exertion rates of females were similar to those of males during the golf course play. This study provides a comprehensive insight into the physiological demands of female and male golf players during 18 holes golf games. It can be suggested that female players should not compete in the same category as male players, despite the game being simplified by changing the course length.

KEYWORDS: ***Heart Rate, Golf Play, Energy Expenditure, Rate of Perceived Exertion.***

INTRODUCTION

Golf is a popular sport played by both males and females of all ages and abilities. The golf aims to get the ball into the hole, hitting the least number of shots possible. To achieve high performance, golfers must optimize their swing mechanics and undertake a physically demanding conditions encountered during play (1, 2). Therefore, golfers should also have a relatively high cardiovascular endurance, strength, power, balance, flexibility, and coordination (2-5).

Playing an 18-hole professional golf course requires nearly 5-7 km of walking and takes approximately 5-6 hours to complete (2)—the number of walking changes depending on the golf course design and players' ability. Since golf is played in different weather conditions, the golfers must have good cardiorespiratory endurance and fatigue tolerance to adapt to different weather conditions for scoring success (6, 7). In addition, several factors such as riding a golf cart, carrying the golf clubs, and playing with a caddy influence the game's intensity (Muray et al., 2017; Sell, Abt, and Lephart, 2008). Previous studies indicate that

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the intensity of playing golf varied from low to high intensity, referring to ACSM's guidelines for classifying physical activity intensity (Riebe et al., 2016; Luscombe et al., 2017; Zunzer et al., 2013; Vandervoot et al., 2012).

The intensity of exercise is often evaluated by monitoring the heart rate. Evaluation of heart rate using wearable technologies allows many physiological parameters to be examined during golf performance. Using wearable technologies, the average heart rate of older adults was 100.5±7.3 bpm during 18 holes of golf play and 104±14 bpm for nine holes (8, 9). In addition, on the course, the cardiovascular demands of middle-aged men were 94.8±12.3 - 104±16 bpm during 18 holes (9, 10). A study comparing the effects of age on HR determined that the peak HR of the young, middle-aged, and elderly were statistically different (194.0±5, 181.0±13, and 145.0±15 bpm, respectively) during 18 holes of golf (Broman, Johnsson, and Kaijser, 2004).

Energy expenditure is another parameter that can be assessed using wearable technologies. Dear et al. (2010) (8) found that the net and gross energy costs were 310.3±83.9 and 511.6±115.5 kcal in older adults during nine holes golf. Besides, Dobrosielski et al. (2002) (11) found that energy expenditure during nine holes of golf play was 458 kcal, which is different from the study above. In addition, Sell, Abt, and Lephart (2008) (12) found that the energy expenditure of golf differs during the walk-carry (1954 kcal), the walk-caddy (1527 kcal), or cart-riding (1303 kcal) conditions. Packard et al. (200) (9) found that energy expenditure during walking on a golf course was 1.759 for the elderly. This large variation in energy expenditure during golf play may be the result of differences in age groups, golf equipment used, course types and hole numbers played. In addition, energy expenditure calculation methods (net or gross) may also cause variations.

In the only study that assessed the physiological parameters of male and female adult golfers, average HR was 105±14 bpm for males and 103±12 bpm for females, and peak HR was 137±16 bpm for males and 137±14 bpm for females during 18 holes golf play (7). The measured average, peak, and the mean % HR showed no significant differences between genders, independent of the golf course type (hilly vs. flat). Still, the total energy expenditure was significantly higher in males (males: 926±292 kcal, females: 556±180 kcal).

No studies examined the cardiovascular responses of young male and female golfers during a golf game in previous literature. Therefore, this study aimed to determine and compare the heart rate, energy expenditure, and perceived exertion rates during a round of golf games in young male and female golf players. Physiologic, mechanic, and training loads and intensities of golf play have also been examined. Monitoring the physiological attributes of the golf performance with an on-course assessment will help players and trainers to enhance the fundamentals of golf success better. Comparing the cardiovascular responses of female and male players with similar handicaps also values the study.

MATERIALS AND METHODS

Experimental Approach to the Problem

There have been no studies examining the physiological demands of golf games in young golf players. This descriptive study investigated heart rate responses, energy expenditure, physiological/mechanical/training loads, and intensities using BioHarness 3 Zephry-wireless monitor. In addition, perceived exercise intensity and the difficulty level was evaluated using the Borg Scale. Comparisons across genders were also included. All players in the current study were competing at a high level for their age group (<10 handicaps).

Subjects. A total of twenty-five young elite golf players (female: 11, male: 14) with handicaps 1-10 and a minimum of three years of training experience were included in the study (age: 17.76±2.05 years, height: 173.56±8.65 m, body mass: 64.84±12.1 kg handicap: 5.4±2.9) (Table 3). Players with lower/upper extremity injuries in the last year were excluded from the study. The Declaration of Helsinki conducted the study. Subjects and parents of the subjects under the age of 18 were informed of the benefits and risks of the investigation. They signed an approved informed consent document to participate in the study. Before conducting the study, the local research ethics committee approval was obtained (18.05.2020-77).

Procedures. Height: It was measured from the top of the head, in anatomical position, with the lead on the Frankfort plane and bare feet, using the Lafayette scale with an accuracy of 0.1 cm.

Body mass was measured using Tanita bioelectrical impedance analyzer (Omron Bf 508, 0.1gr precision). During the measurements, the males wore only shorts, while the females wore shorts and busts.

Physiological Assessments: Physiological demands of the golf play were assessed using BioHarness 3 Zephry-wireless Bluetooth supported professional wearable monitor with sensitivity between 25 and 240 and a 3-dimensional accelerometer (Zephyr HxM, B. T. Heart Rate Monitor) (13, 14). The validity and reliability of this device were performed by Nazari et al. (2018) (15) (sensitivity 0.87-0.96). The proper use of the monitor was explained to the golf players before starting the study. The wearable physiological monitor device was attached to golf players as soon as they got out of bed, and the recording was initiated immediately after.

The heart rate of golf players during the 18 holes of golf in groups of two was determined using R-R wave intervals in a range of 25-240 measurements (Benedetto, 2018). Considering the lap times, resting HR, average HR, maximum HR (heart rate RR intervals, reporting frequency (hz) per R detection), and total energy expenditure (kcal) were measured (Table 1). Physiological, mechanical, and training load and intensity were also assessed (Table 1).

All data recorded on the monitor was transferred to the OmniSense software with the Bluetooth system, displayed, and monitored simultaneously (14). Data were examined in detail for each golf player and then transferred to the excel program.

Table 1. Analyzed Physiological Parameters

Parameters	Explanations
Resting heart rate	It is the heart rate of the golf players measured during resting
Average heart rate	It is the average heart rate measured during the 18-hole golf play
Maximum heart rate	It is the peak heart rate measured during the 18-hole golf play
Exercise/Training intensity	HRR= %intensity (max HR - Resting HR) + Resting HR
Energy expenditure	It is the calorie expenditure during the 18-hole golf play
Physiologic load	It is the sum over time of physiological intensity. Physiological load is the accumulation of the physiological intensity over-exercise time.
Mechanical load	It is the sum over time of mechanical intensity. Mechanical load is the accumulation of the mechanical intensity over-exercise time
Training load	It is the sum over time of training intensity. Training load is the average of physiological load and mechanical load
Physiological Intensity	It measures cardiovascular workout levels on a scale from 0 to 10. A score of 0 is a resting level, whereas a score of 10 is equivalent to the athletes working at their maximal effort. Average Physiological intensity = Physiological load / Exercise duration (min).
Mechanic Intensity	It measures musculoskeletal workout levels on a scale from 0 to 10. A score of 0 means that the athletes do not impact their musculoskeletal system, whereas a score of 10 is equivalent to a sprinting level. Average Mechanical Intensity = Mechanical load / Exercise duration (min).
Training Intensity	It measures total workout level – the average of physiological and mechanical intensities with a scale from 0 to 10. Training Intensity = (Physiological intensity + Mechanical intensity) / 2.

Temperature and Humidity Measurement: To evaluate the weather condition, a MultiFun temperature meter with accuracy between -20 and 80 ºC was used. Golf games were played at a temperature of 18-24 ºC.

Rating of Perceived Exertion (RPE): The Borg Scale (10 points) was used to measure exercise intensity perception and difficulty level in the study. The Borg scale is based on the participant's expression of fatigue felt during exercise in a range between 0-10: nothing at all (0), very, very weak (just noticeable) (0,5), very weak (1), weak (light) (2), moderate (3), somewhat strong (4), strong (heavy) (5), very strong (7), very, very strong (almost max) (10) (16-19). The Borg scale was questioned after each hole, and the average value of 18 holes was used in the analysis.

Data Collection. The players were asked to take 5 lap times on the heart rate monitor in the following order to separate the warm-up data from 18-hole golf play data (Table 2). Four stages of the warm-up protocol have been carried out to train all the domains of the golf game (Table 2). The average duration of the warm-up was 91.00±24.11 minutes. The golf game was played on an 18-holes golf course with a total length of 6314 meters in 18-24°C weather. Golfers were divided into groups with two people according to gender, and games started from the first hole in the course at 10 minutes. The stroke play game format was played in which the sum of the strokes made by the players in each hole was recorded. The average duration of the 18 holes game was 245.36 ± 29.42 minutes.

Statistical Analysis. All statistical analyses were performed using the IBM SPSS 24 Statistics software (SPSS, SPSS Inc, Chicago, IL, USA). Data are reported as mean ± SD. The normality of the distribution of all data was assessed using the Shapiro-Wilk test. Variables were not normally distributed.

Therefore, nonparametric statistics (Mann-Whitney U Test) were used to compare heart rate, energy expenditure, rate of perceived exertion, and physiologic/mechanic/training loads and intensities between male and female golf players. The statistical significance was set at a P < 0.05 level.

RESULTS

Comparing the male and female golfers, there was a statistically significant difference in age, body weight, and height (P<0.05), whereas there was no significant difference in BMI and handicaps of the players (P> 0.05) (Table 3). During the 18 holes golf play, HR values (average and peak) of the female golf players were found to be higher than the male golf players (P<0.05) (Table 4). The energy expenditure during 18 holes was significantly higher in females than males (P<0.05). Although playing golf produced higher physiologic and training load and intensity in female golf players (P<0.05), there was no difference between genders in both mechanical load and intensity (P>0.05) (Table 5).

Table 2. Experimental Protocol

Lap Times	Periods
1st Lap	Resting (This tap was taken immediately after the players get out of bed)
2nd Lap	Beginning of the warm-up (This tap was taken when players start to warm up on the driving range)
	General warm-up: Players start to warm up with jogging and then continue with dynamic movements on the driving range (20-30 minutes).
	Driving range warm-up-without balls: Players executed an average of 40-50 reps of golf swing practice with a golf club without hitting the ball (5 minutes).
	Driving range warm-up-hitting balls: Players hit an average of 100 golf shots using all the clubs in their golf bags (30-40 minutes).
	Short game warm-up: Players executed their self-specific short game warm-ups with their golf clubs and balls on the chipping and putting green (20 minutes).
3rd Lap	End of the warm-up (This tap was taken when the warm-up was finished)
4th Lap	Beginning of the golf game (This tap was taken shortly before they started to play 18-hole golf)
	Eighteen holes golf game
5 th Lap	End of the golf game (This tap was taken after they played the 18-holes golf course)

Table 3. Physical Characteristics and Handicaps of the Golf Players

	Total (n=25), Mean ± SD	Female (n=11), Mean ± SD	Male (n=14), Mean ± SD	P
Age (year)	17.76 ± 2.05	16.64 ± 2.29	18.64 ± 2.37	0.044*
Height (cm)	173.56 ± 8.65	166.27 ± 5.37	179.29 ± 5.98	0.000*
Body Mass (kg)	64.84 ± 12.14	56.68 ± 5.66	71.28 ± 12.09	0.003*
BMI (kg/m2)	21.4 ± 3.04	20.48 ± 1.82	22.18 ± 3.63	0.298
Handicap	5.91 ± 2.94	6.90 ± 2.94	5.14 ± 2.79	0.149

BMI: Body Mass Index: * P<0.005

Table 4. Physiological responses of the golf players

	Total (n=25), Mean ± SD	Female (n=11), Mean ± SD	Male (n=14), Mean ± SD	P
$HR_{resting}$ (bpm)	67.48 ± 6.97	69.36 ± 8.30	66.00 ± 5.60	0.222
$HR_{average}$ (bpm)	119.56 ± 11.87	127.64 ± 9.28	113.21 ± 9.77	0.002*
$HR_{maximum}$ (bpm)	165.04 ± 15.00	175.36 ± 13.44	156.93 ± 10.73	0.002*
% $HRR_{maximum}$	72.35 ± 10.76	78.95 ± 10.08	67.16 ± 8.34	0.006*
% $HRR_{average}$	38.60 ± 8.64	43.39 ± 7.91	34.84 ± 7.41	0.015*
EE (kcal)	1609.08 ± 527.93	1823.73 ± 304.84	1440.43 ± 611.11	0.033*
$RPE_{average}$	3.59 ± 1.07	3.44 ± 1.14	3.71 ± 1.04	0.647

HRR: heart rate; EE: energy expenditure; RPE: Rate of Perceived Exertion; *P<0.05

Table 5. Physiologic, mechanic, and training loads and intensities of the golf game

	Total (n=25), Mean ± SD	Female (n=11), Mean ± SD	Male (n=14), Mean ± SD	P
Physiologic load	807.61 ± 437.43	1027.92 ± 481.54	634.50 ± 318.64	0,018*
Mechanic load	215.04 ± 32.71	212.46 ± 33.80	217.07 ± 32.95	0,809
Training load	538.48 ± 202.30	672.91 ± 175.70	432.86 ± 156.53	0,004*
Physiologic Intensity	2.77 ± 1.07	3.38 ± 0.90	2.29 ± 0.96	0,021*
Mechanic Intensity	1.32 ± 0.17	1.29 ± 0.19	1.34 ± 0.16	0.344
Training Intensity	2.03 ± 0.56	2.35 ± 0.52	1.79 ± 0.48	0.015*

***P<0.05**

DISCUSSION

It is the first study to investigate the physiological responses of young elite golf players during eighteen holes golf games. In the present study, heart rate, energy expenditure, and rate of perceived exertion values of male and female young golfers with an average handicap of 5.9 were evaluated during 18-hole golf play. The maximum and mean heart rate values and energy expenditure of the female were higher than that of the male. In addition, it has been found that female golfers' physiologic and training loads and intensities were higher than males during eighteen-hole golf play. Although female golf players play on a shorter course than males, it has been investigated that they encounter greater physiological demands during the golf game than males. These findings suggest that female players should not be competed in the same category as male players, although the game is facilitated by changing the course length. However, despite the physiological differences between the sexes, it has been examined that the perceived difficulty of females and males was similar during the golf course play. It shows that the players may tolerate different training intensities through the long training backgrounds. In addition, hormonal differences in females affecting the central nervous system may cause a decrease in the rate of perceived exertion by changing the cognitive function and pain threshold.

In the study of Wells et al. (2009) (20), in which they evaluated the physiological relations of golf performance, BMI values were found to be 23.4±2,2 kg/m² in young men and 21.4±3,3 kg/m² in young women. Similarly, in Son et al. (2016) (21), BMI values were determined as 25.1±4,9 kg/m² in young men and 22.7±3,0 kg/m² in young women. In the present study, it was determined that the body mass indexes of young male (22,18 kg / m²) and female (20,48 kg / m²) golfers were relatively similar to the values of young golfers in the studies mentioned above and were within healthy/normal range values (18.5-24,9 kg / m²) (Riebe et al., 2016) (22). In this study, the resting heart rate of golfers with at least 3 years of golf experience was between the normal values of sedentary individuals (60-80 bpm) and no difference between the sexes (women: 69.36±8.30 bpm, men: 66.00±5.60). The resting heart rate of the male athletes in the present study was similar to young, middle-aged, and old male golfers in the study of Broman et al. (2004) (23). Although the golf players' ages in the studies differed, the fact that they had similar training ages may have caused the resting heart rate to be similar to each other.

In the literature, there is only one study comparing the physiological characteristics of golf games between the sexes. In the study of Zunzer et al. (2013) (7) comparing cardiovascular demands of female and male golfers during the golf game, it was determined that there was no difference between the sexes on mean heart rate (women:103±12 bpm and men:105±14 bpm) and maximum heart rate (women:137±14 bpm and men:137±16 bpm). In our study, the mean heart rates (women: 127.64±9.28 bpm and males: 113.21±9.77 bpm) and maximum heart rates (female:175.36±13.44 bpm and Men:156.93±10.73 bpm) of female golfers were higher than male golfers. The difference in heart rate responses of male and female golf players may have resulted from a gender-specific physiological response (Kenney, Wilmore, and Costill, 2015) (24). The variability of cross-gender differences in studies may also be due to the variable course length differences between female and male golfers. The fact that the mean and maximum heart rates measured in the study mentioned above were lower than ours may be due to the different ages and handicaps of the golf players between studies. This difference between age and game levels may have also caused a difference in the amount of energy consumed in both studies.

Studies on male golf players have reported that the mean heart rates measured during the golf game vary between 94 to 104 bpm, and the %HRmax varies between 48.5 to 59% (8-10). In the present study, while the mean heart rate of golf players of both sexes during the golf game was higher than in the studies mentioned above, the %HR max values were relatively similar compared to the studies mentioned. Whereas the heart rate values in our study were higher, it was observed that the athletes trained at lower loading rates because they were younger. Young female and male golf players completed the 18 holes golf game with moderate exercise intensity. These results were also confirmed by a moderate to the somewhat strong rate of perceived exertion declared by the players after the golf game.

The amount of energy consumed during the golf game also indicates the intensity of the exercise. In this context, the higher energy expenditure of female golf players that have been found in our study shows that female players' physiological demands during the game were greater than males. Despite similar mechanical load and intensity values of both sexes, female golf players had higher physiologic and training loads and intensities and higher HR% values during a golf game. Although golf game leads to higher exercise intensity in females, their self-reported difficulty rates were similar to males'. It is thought that female golf players could tolerate higher exercise intensities due to their high level of play and long training backgrounds. In addition, estrogen hormone in females exerts various effects on the nervous system (25). This hormonal difference between genders may cause a decrease in the rate of perceived exertion of females by changing the cognitive function and pain threshold or by its protective effects on cardiac and skeletal muscles (26).

Evaluating the energy expenditures, it has been reported that male golf players expenditure 458-511.6 kcal during 9 holes (8, 11) and 1303-1954 kcal during 18 holes of golf game (12). Our study's energy expenditures were closer to the upper limit obtained in other studies. In the present study, players carried their golf bags during the course game. It may result in higher energy expenditure, as using a caddy or golf cart alters the energy expenditure (12). The dissimilarity in the design, height, etc., in the golf courses, played and the differences in the air to conclude, despite the similar body mass index, handicap, and resting heart rates of female and male golf players', physiological demands during the golf game differ. The higher average and maximum HR and consequently higher physiologic and training load and intensity values in female players caused the exercise intensity they were exposed to during golf games to be higher. These results suggest that the intensity of endurance training programs for male and female golfers should differ. Although the female players had higher %HR values, they reported similar RPE values to males, suggesting they are well trained. In this study, young golf players had a low to medium exercise intensity during the 18 holes golf game. Nevertheless, it should be considered that the psychological stress during the tournament, the athlete's experience, the game speed, and the different weather conditions can change the physiological demand and, thereby, golf game performance.

APPLICABLE REMARKS

- This study provides a comprehensive insight into the physiological demands of female and male golf players during 18 holes golf games.
- It can be suggested that the female players should not compete in the same category as male players, despite the game being simplified by changing the course length.
- In addition to that, endurance training programs should be different due to the different cardiovascular requisites of golf games in females and males.

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