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Energy expenditure and sex differences of golf playing

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Abstract

The purpose of the study was to assess the golf walking intensity and energy expenditure (EE) in a large heterogeneous group of healthy men and women of varying age and golf handicap, playing and walking one round of either 9 or 18-holes of golf on 2 hilly and 2 flat 18-hole championship courses. Forty-two males and 24 females completed an incremental cycle-ergometer exercise test to determine exercise performance markers. The heart rate (HR), duration, distance, walking speed, ascent and descent were measured via a GPS/HR monitor during the game. When playing 9 or 18-holes of golf, independent of the golf course design, the average HR was not significantly different between men vs. women or the subgroups and the intensities were light (<3 METs). The total EE of all subjects was not significant for hilly (834±344 kcal) vs. flat courses (833±295 kcal) whereas male players (926±292 kcal) expended significantly greater EE than female players (556±180 kcal). Playing golf is suggested to yield in health benefits due to the high volume of physical activity although the intensity was well below the recommended limits. Golf may have other health related benefits that may be unrelated to the lower intensity level of the activity.

Keywords: High volume, low intensity, golf course design, exercise performance

1. Introduction

Golf is a pleasurable activity for both men and women and can be enjoyed by all age groups (Kobriger et al., 2006). Approximately 60 million players worldwide enjoy playing the game on about 25,000 golf courses (Hudson, 2002). The ACSM physical activity guidelines recommend at least 30 min of moderate-intensity, defined as 3-6 metabolic equivalents of task (METs) 5 days per week (or a total of ≥150 min/week), or vigorous physical activity intensity, defined as >6 METs, for a minimum of 20 min 3 days per week (or a total of ≥75 min/week), to maintain and improve health, reduce susceptibility to disease, and to decrease mortality rate (Garber et al., 2011; Thompson et al., 2009; US Department of Health and Human Services, 1999). Accurate and acceptable recommendations for low-intensity physical activity (defined as <3 METs) are rare. Pollock et al. (1998) suggested an EE of 150 to 200 kcal per session, or 700 to 2,000 Kcal per week to reduce the risk of chronic disease, the risk of injuries, and to decrease mortality. This has been reported previously in a cohort study investigating approximately 300,000 golfers in Sweden. The results of that study revealed that the mortality was reduced by 40% and life expectancy was increased by approximately 5 years (Farahmand et al., 2009).

Golf includes long bouts of walking and the effort of the game depends on walking speed, walking distance, golf course design, if the golfers carry their equipment, or use a pull, push, or e-trolley (Parkkari et al., 2000). Referring to ACSM's guidelines for classification of physical activity intensity (Thompson et al., 2009; Ainsworth et al., 2000), recent research indicates that the intensity of playing golf varied from low- to high-intensity including only a low number of subjects (range 1-30) (Dear et al., 2010;

Hayes et al., 2008; Peterson, 2008; Sell et al., 2008; Broman et al., 2004; Stauch et al., 1999; Burkett and von Heijne-Fisher, 1998; McKay et al., 1997). Percentage of maximal heart rate (%HR_{max}) ranged from below 50% up to 85% HR_{max} determined during an incremental test (Table 1).

****Insert Table 1 about here****

However, %HR_{max} is not the best indicator of exercise performance and the use of threshold models may be a better marker (Hofmann and Tschakert, 2011; Hofmann et al., 2001). This large variation in exercise intensity described could be explained by the studies' special groupings of subjects, e.g. certain age groups, patients with different medical histories, rehabilitative activities due to different kinds of medical condition, among others (Dear et al., 2010; Dobrosielski et al., 2002; I-Min Lee et al., 2000; Unverdorben et al., 2000). Thus, playing golf may serve as a model for high-volume low-exertion physical activity.

The aim of the study was to quantify the physical effort and the EE of golf playing in 66 healthy subjects with large age variations and varying individual golf indexed handicap (HCP). Differences in physical exertion comparing male and female golf players when walking and playing on hilly vs. flat courses were analyzed with respect to ACSM's guidelines for recommended intensity and EE (Pollock et al. 1998; Thompson et al., 2009).

2. Methods

2.1. Participants

Forty-two healthy, Caucasian males and 24 healthy, Caucasian females ranging in age between 23 and 75 years (mean ± SD for age: 53.3 ± 13.8) volunteered for this study. The anthropometric and physical characteristics of all 66 subjects and of the investigated subgroups are presented in Table 2.

****Insert Table 2 about here****

The golf players were recruited from 4 different golf clubs. They completed a health and physical activity questionnaire as part of the inclusion criteria. From the initial 121 golfers, 66 subjects met the inclusion criteria and volunteered to participate in the study. Exclusion criteria were history of heart disease and health related disorders limiting the participants' ability to perform the physical activity (Pollock et al., 1998). Moreover, the individuals were asked to avoid participation in other sports with the exception of golf. There were no restrictions regarding age, sex, or HCP. The Ethics Committee of the University of Graz approved the study and all subjects agreed and signed a written consent form before participation.

The self-reported HCP of each subject was based on the European handicap system by the European Golf Association (EGA) (European Golf Association, 2011). A sample of the equipment's weight, except e-trolleys, was measured on a medical scale (Slim Design Silver, Soehnle, Burgkunstadt, Germany) (mean ± SD: 9.4 kg ± 1.7 kg).

2.2. Experimental conditions

Two hilly and two flat 18-holes championship courses were selected. Lengths of the courses were 5,525 to 5,919 m for men and 4,871 to 5,307 m for women (360 m to 445 m above sea level). The United States Golf Association (USGA) course rating, a marker that indicates the evaluation of the playing difficulty of a course for a scratch golfer (defined as a HCP 0 player) under normal course and weather conditions (The United States Golf Association, 2011), was 69.3 to 71.1 for men and 71.0 to 73.2 for women. The USGA's slope rating describing the relative difficulty of a golf course for a bogey golfer (defined as a HCP 18 player) compared to a scratch golfer (The United States Golf Association, 2011) was 121 to 125 for men and 118 to 126 for women.

The subjects performed an incremental cycle ergometer exercise test before starting the field tests after the winter break without having played any golf. The anthropometric data (height and body mass) were measured (Table 2). After a 3 min of rest while sitting on the cycle ergometer, subjects started to exercise at 20 watts (W) and the workload was increased by 15 W (for males) and 10 W (for females) every min to voluntary exhaustion. This corresponds to the standard protocol of the Austrian Society of Cardiology (Wonisch et al., 2008). The subjects' ECG was monitored by a physician and the HR was measured via chest-belt telemetry (HR, PE 4000, Polar Electro, Kempele, Finland), blood lactate concentration was measured via fully enzymatic-amperometric method using (Biosen S-line, EKF-Diagnostic, Barleben, Germany) and respiratory gas exchange measures were determined via computerized metabolic cart ZAN 800 (ZAN, Winkling, Austria) and were assessed throughout the tests as well as during 3 min of active (20 W) and 3 min of passive recovery. The maximal oxygen uptake (VO_{2max}) and the maximal power output (P_{max}) as well as the first and the second turn point for blood lactate concentration (La) (LTP_1, LTP_2) were determined as markers of exercise performance (Hofmann and Tschakert, 2010; Hofmann et al., 1997). VO_{2max} was defined as the highest oxygen uptake during 10s means – criteria: RER > 1.1; age predicted maximum heart rate (HR_{max}) (leveling off was not expected via the applied protocol and therefore this criterion was not used). LTP_1 was defined as the first increase in La above baseline. LTP_2 was defined as the second abrupt increase in La between LTP_1 and the La at P_{max}. LTP_1 and LTP_2 were determined by means of a computer calculated linear regression break point model within defined regions of interest (ROI) (ROI for LTP_1 between La at the first work load and La at 70% P_{max}; ROI for LTP_2 was between La at LTP_1 and La at P_{max}) (Hofmann and Tschakert, 2010; Hofmann et al., 1997).

On the golf course, the subjects completed 9 or 18-holes of golf at the golf club of their membership between the beginning of the golf season (end of April) and the middle of May. Most of the golf rounds were played in the morning under similar weather conditions while humidity and temperature were recorded (Vaisala HM34C, Vaisala, Vantaa, Finland). Environmental conditions were not significantly different for flat vs. hilly courses. Temperature and humidity were 19°C ± 4°C and 50% ± 20% on hilly courses and 20°C ± 3°C and 47% ± 18% on flat courses, respectively. One round of golf of either 9 (n=13) or 18 (n=53) holes were played and all participants walked the entire distance. Seventy-six percent (n=50) of all participating subjects pulled, pushed (3%), or carried (4%) their golf equipment and 24% (n=16) used an e-trolley. The HR, duration, walking distance, walking speed, ascent, and descent were monitored and recorded by a "SUUNTO T6c" (T6c, SUUNTO, Vantaa, Finland) HR monitor, memory belt, and a GPS pod. HR data were stored in 10s intervals for further analysis.

The data analysis was performed by means of the "SUUNTO Training Manager" (ver. 2.0). Input data were sex, age, height, weight, and level of activity. Thereby, several metabolic and respiratory gas exchange values were automatically calculated for each subject. The measured and calculated individual data of each subject were resting HR, peak heart rate (HR_{peak}), maximal performance capability expressed in METs, maximal pulmonary ventilation, maximal respiratory rate ($B_{f\ max}$), and vital capacity (VC).

Based on the measured HR throughout the entire play, the total EE (Kcal) was calculated (SUUNTO Training Manager, ver. 2.0, Vantaa, Finland). The SUUNTO EE data were checked for plausibility by comparing it to the EE calculations based on VO_{2max} measures from the incremental cycle ergometer exercise test and the HR data from the golf course. As SUUNTO's EE data were not significantly different from cycle ergometer test results, these data were used for further analysis.

MET values of each subject were calculated from the duration, body weight, the mean total energy cost, and means (±SD) for the entire group as well as for the subgroups. The relative effort of walking during golf was obtained by calculating the $\%HR_{max}$ from the incremental test.

2.3. Statistics

Data are expressed as means ± standard deviation (SD). For the statistical analysis, standard software (SPSS ver. 18, Chicago, Illionis, USA) was used. Results were checked for normal distribution (Kolmogorov-Smirnov-test). Significant differences between hilly vs. flat golf courses and sex differences were performed by means of *t*-tests. A repeated-measures ANOVA with Bonferroni post-hoc test was performed to detect differences between subgroups. Relationship between selected variables was performed by means of Pearson´s Product Moment correlation analysis. A level of significance was set at $p < 0.05$ for all statistical tests.

3. Results

3.1. Anthropometric data

Male and female subjects were significantly different for height, body mass and body mass index (BMI), but not for age and HCP. No significant differences were found for physical characteristics of the subgroups playing on hilly or flat courses, except for BMI and HCP, which were slightly but significantly different ($p < 0.05$) (Table 2).

3.2. Incremental cycle ergometer exercise test data

Mean VO_{2max} for all subjects was of 35.6 ± 8.7 $ml \cdot kg^{-1} \cdot min^{-1}$ (range: 20.8-55.5$ml \cdot kg^{-1} \cdot min^{-1}$). Maximal ($VO_{2max}$, P_{max}) and submaximal (LTP_1, LTP_2) values for oxygen uptake and power output from the incremental exercise test were significantly different between sexes. The exercise performance was significantly related to age (P at LTP_1: $r = -0.22$, $p < 0.01$; P at LTP_2: $r = -0.46$, $p < 0.001$; P_{max}: $r = -0.49$, $p < 0.001$; VO_{2max}: $r = -0.69$, $p < 0.001$) whereby older subjects achieved lower exercise performance values. Subjects' performance characteristics were not significantly different for hilly vs. flat courses groups, except for HR at LTP_1 only, where the participants in the hilly group exhibited higher HRs compared to subjects of the flat course group. Table 3 depicts subgroup results of the incremental cycle ergometer exercise test.

****Insert Table 3 about here****

3.3. Field measurements

The differences in the total ascent (159 m ± 23 m) and descent (164 m ± 26 m) between the 2 hilly and 2 flat courses were significant ($p < 0.05$). Despite these differences in overall ascent and descent, only HR_{peak} was significantly different between the golf players. Unexpectedly, the mean HR, the minimum HR (HR_{min}), and the $\%HR_{max}$ as well as the total EE were not significantly different.

3.3.1. Differences between sexes

As there were no differences found in the effort of playing hilly or flat golf courses, all sixty-six subjects were merged and divided by sex. The recorded field measurements of the minimal, maximal, and average HR, and the calculated percentages of HR_{max} showed no significant differences between male and female players, independent of the golf course type (hilly vs. flat). The average HR (Table 4) was significantly lower than HR at the LTP_1 (male: 116 ± 11 beats·min^{-1}; female 110 ± 11 beats·min^{-1}), which indicates very low-intensity exercise.

****Insert Table 4 about here****

The calculated total EE was significantly higher in males, regardless of whether they played 9 or 18-holes of golf (Figure 1(a)). Values of the male players were almost double compared to the female golfers.

****Insert Figure 1 (a) and 1 (b)****

Although playing the same courses, male players walked significantly faster, but slightly longer distances and it took more time to complete the round of golf (Table 4).

3.4. Exercise performance and physical strain in golf

A correlation analysis revealed a significant relationship between $\%HR_{max}$ and age.

****Insert Figure 2 about here****

Older subjects yielded higher $\%HR_{max}$ than younger golf players ($p < 0.05$, $r = 0.26$), (Figure 2), but there was no significant relationship between the HCP and the

%HR_{max}. Additionally, %HR_{max} was significantly related to power output at LTP_1 (r = - 0.26, $p < 0.05$), LTP_2 (r = - 0.23, $p < 0.05$), P_{max} (r = - 0.23, $p < 0.05$) and VO_{2max} (r = - 0.35, $p < 0.01$) whereas better trained golfers had a lower strain compared to the less trained golfers.

All subjects remained above LTP_1 target HR for 60 ± 72 min (28% of the total time); however, there was no significant relationship between the duration above LTP_1 and other exercise performance variables (VO_{2max}, P at LTP_1, P at LTP_2, P_{max}). Significant differences were observed between the sexes ($p < 0.05$) where men remained longer above the LTP_1 HR than women. No significant differences were found for duration above LTP_1 HR between hilly vs. flat courses.

Independent on the golf course, 16 subjects that used an e-trolley had a significantly lower HR and EE during the game; additionally, these golfers were older and achieved significantly lower exercise performance values (VO_{2max}, P at LTP_1, P at LTP_2) compared to the 50 golfers that pulled their golf equipment (data not shown).

4. Discussion

Millions of people around the world play golf (Hudson, 2002), which has been reported to reduce all-cause mortality (Farahmand et al., 2009). Quantitative studies addressing the intensity of walking and EE of golf are very sparse in the scientific literature. Previous work with a low number of subjects (Table 1) showed a diverse breadth of intensities ranging from below 50% up to 85% of HR_{max}.

Thus, the aim of the study was to assess and describe the golf walking effort and energy expenditure (EE), as these variables may contribute to health benefits, in a large heterogeneous group of healthy men and women, varying in age and golf handicap, playing and walking one round of either 9 or 18-holes of golf on 2 hilly and 2 flat 18-hole championship courses. The results of our study support the notion that playing golf may be classified as a low-intensity and high-volume exercise.

Stauch et al. (1999) suggested that playing golf on a hilly course fulfills the minimum requirements of training to be above 50% HR reserve. In their study, subjects achieved between 50 to ≥ 85% of HR reserve for about 146 min. This is contrary to our findings, where subjects remain well below these levels. A low $\%HR_{max}$ may be caused by a non-regular HR behavior such as described that the regular s-shaped HR response in incremental cycle ergometer exercise test may be also linear or even inverted between LTP_1 and P_{max} (Hofmann et al. 2001; Hofmann and Tschakert, 2011). This is supported by the variability found for $\%HR_{max}$ at LTP_2 (Table 3). Therefore, the use of turn points such as the LTP or the HR turn point was recommended for exercise prescription (Hofmann and Tschakert, 2011). For comparison to reference data $\%HR_{max}$ was applied in this study accepting a rough estimate of true work load in approximately 10% of subjects.

Comparing our results of $\%HR_{max}$ to the ACSM’s guidelines, the relative intensity of walking and playing 9 or 18-holes of golf on either hilly or a flat golf course, is considered light exercise for both sexes (Thompson et al., 2009) with an increasing intensity with respect to age and low exercise performance (Figure 2). This may suggest, that older untrained subjects may accumulate greater health and fitness benefits when playing golf compared to younger and physically fitter subjects (Garber et al., 2011).

Additionally, the calculated MET values of each subgroup were compared to ACSM guidelines (Thompson et al., 2009). The results of our study remained below the reference value of 3 METs that were independent of the golf course type, whereas male subjects playing 18-holes on the flat courses had the highest values (2.9 ± 0.6 METs), and the lowest values were found in the female group playing 18-holes on the hilly courses (2.1 ± 0.4 METs) (Figure 1(a, b)). These calculated mean values below 3 METs confirmed that playing golf is a light-intensity physical activity by definition (Thompson et al., 2009). The total EE of walking and playing 18-holes on a hilly or a flat golf course was similar and was not significantly different in all subgroups suggesting analogous effects with respect to health and fitness.

4.1. Differences between sexes

Expectedly, physical characteristics of male and female subjects were significantly different for height, body mass, and BMI but not for age and HCP. Male subjects were slightly overweight, while females were of normal weight. The exercise performance was significantly different for all performance variables, but within normal age related limits (Wonisch et al., 2008). As there were no differences in the effort of playing hilly or flat golf courses, the subjects were merged and divided by sex. Although the male participants had slightly higher intensities during the game, the HR was not significantly different between male and female golfers. However, for both male and female golf players, the intensity of playing and walking one round of either 9 or 18-holes during a mean of 4 hours of golf is considered light with respect to the ACSM's guidelines (Garber et al., 2011; Thompson et al., 2009).

As expected, differences between male and female players in regard to the total EE were significant in all subgroups (Table 4). These results are in agreement with recent studies depicting differences in EE between men and women (Lin et al., 2010; Loftin et al., 2010).

The ACSM guidelines recommend that most adults engage in moderate-intensity cardiorespiratory exercise for ≥30 min per day on ≥5 days per week (≥150 min per week), or vigorous cardiorespiratory exercise for ≥20 min per day on ≥3 days per week (≥75 min per week), or a combination of moderate- to vigorous-intensity exercise to achieve a total energy expenditure of ≥500 to 1,000 MET min per week (Garber et al., 2011). Haennel and Lemire (2002) reported in their review study that about 1,000 kcal (4,200 kJ) per week was suggested to be sufficient to induce health benefits, although the minimally effective dose is still unclear. Male golf players nearly fulfilled the guidelines for healthy adults that recommend a minimal EE of 1,000 kcal per week by playing and walking 18-holes on a hilly or a flat golf course once a week (Haennel and Lemire, 2002; I-Min and Skerrett, 2001; US Department of Health and Human Services, 1999). Smith (2010) reported higher values for total caloric expenditure in a range between 1,954 kcal playing on a hilly course while carrying a bag and 1,527 kcal using a trolley. Murase et al. (1989) found average caloric values of 960 kcal following 18 holes of golf, which was comparable to our results. However, in all of these studies, estimating VO_2 demand and extrapolating EE, may have underestimated actual energy requirements (Smith, 2010). Interestingly, the current ACSM guidelines do not include recommendations for low-intensity exercise (Garber et al., 2011); however, the older version of the ACSM guidelines included recommendation for low-intensity exercise.

The ACSM guidelines do not distinguish between the males and females for low-intensity exercise (Pollock et al., 1998). Based on the results of our study, women would have to play at least 2 times per week to achieve the same EE compared to their male counterparts. As female subjects were smaller and had less body mass, compared to the male players (Table 2), a lower absolute EE was determined in females which may be comparable to the male with respect to the health and fitness effects in relative terms. Several studies found significantly lower daily EE in women compared to men (Tooze et al., 2007; Manini et al., 2006; Morio et al., 1997). It is important to mention that the guidelines for low-intensity physical activity (Pollock et al., 1998) only refer to the same absolute sum of EE for both male and female subjects. As EE is known to be significantly different between the sexes (Lin et al., 2010; Loftin et al., 2010) specific recommendations for females should be included.

4.2. Health aspects

The benefits of leisure-time physical activities with respect to reduction in cardiovascular disease are well documented (Sattelmair et al., 2011; Mensink et al., 1999). Activities, similar to playing golf contain components of potential health benefits that engage large muscle groups. A recently published controlled trial revealed that playing golf regularly increases aerobic performance and strengthens trunk muscles (Parkkari et al., 2000). Thus, it can be expected that regular walking on a golf course may reduce cardiovascular risk factors. This contributes to the reduced total mortality that has been observed in a large cohort study (N >300,000) with golf players in Sweden (Farahmand et al., 2009). The lowest mortality occurred among those players with the lowest HCP and the authors suggested that the intensity level of the game may contributed to this reduction. However, the HCP in our study was not significantly related to any performance variables or the physical characteristics of the subjects. Moreover, the $\%HR_{max}$ was significantly related to both, age and performance, demonstrating that individual performance is more important than the HCP in any health related benefit from playing golf.

Although the mortality has been shown to be significantly reduced by 40% in regularly practicing golfers, the overall life style of golfers may have substantial influence and the effects described may not be related solely to golf playing (Farahmand et al., 2009). Part of the effects may be attributed to playing golf regularly although the intensity of exercise is low. Therefore, the question arises whether the impact of high volume and low-intensity exercise such as golf is sufficient to substantially reduce cardiovascular risk factors and improve health and physical fitness.

Conclusion

The purpose of the study was to assess and describe the golf walking effort and energy expenditure in a large heterogeneous group (n=66) of healthy golfers including; younger and older adults of both sexes, varying in HCP and in exercise performance. Within this diverse group, the overall intensity of playing one round of either 9 or 18-holes of golf was found to be light for both sexes, independent of hilly or flat golf courses, as well as age and body mass; however, relative intensity was related to exercise performance and age. Calculated EE showed that the male golfers were approaching the minimum recommended level for low physical activity intensity to gain health benefits with only one 18-hole round of golf per week, whereas the female players needed to play at least two 18-hole rounds of golf per week to fulfill these recommendations. Specific recommendations for low-intensity exercise for female subjects are still lacking and future guidelines should be adapted. Although health benefits have been described in golfers randomized controlled trials are warranted to confirm the effects of low-intensity and high volume exercise model.

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Table 1. Different studies showing number of subjects, sex, mean age, mean handicap (HCP), number of played holes, mean absolute heart rate, and the percentage of the peak heart rate (%HR_{max}). Modified Table II according to Smith (2010).

Study (year)	# Subjects	HCP	Sex	Age (years)	# Holes	Absolute HR (beats·min^{-1})	%HR_{max}
Hayes et al. (2008)	7	12.5	M	50.0	18	95	54.8 [a]
Peterson (2008)	13	≤ 7	M	24.1	18	111	58.4 [a]
McKay et al. (1997)	15	3.8±0.5	M	22.5	18 (prc.)	100	52.1 [a]
	15	3.8±0.5	M	22.5	18 (cp.)	117	61.0 [a]
Stauch et al. (1999)	30	29±7	M/F	53.5	18	113	66.1 [a]
Burkett et al. (1998)	10	5-20	M	24.0	18	120	62.9 [a]
Sell et al. (2008)	1	N/A	M	43.0	18	120	67.4 [a]
Unverdorben et al.	20[b]	N/A	M	65.3	18	105	63.0
(2000)	8[c]	N/A	M	62.0	18	101	49.0
Dear et al. (2010)	18	N/A	M	71.2	9	104	48.5

[a] Predicted HR_{max} = 206.9-(0.67·age); [b] subjects with cardiovascular disease; [c] healthy controls; prc. = practice; cp. = competition; F = female; M = male, N/A = indicates not specified

Table 2. Anthropometric and physical characteristics of the subjects including subgroups. Values are mean ± SD.

GC	**Variables**	**Overall Mixed** (n=34)		**Total Male** (n=21)	**Total Female** (n=13)		**18-holes Overall Mixed** (n=28)	**18-holes Male** (n=19)	**18-holes Female** (n=9)	
Hilly	Age (years)	56.2 ± 13.9		53.9 ± 15.2	59.9 ± 11.0		55.1 ± 14.9	52.6 ± 16.0	60.3 ± 11.2	
	Height (cm)	172.7 ± 8.5		176.3 ± 6.0	166.9 ± 8.8	*	173.8 ± 8.4	177.5 ± 5.2	166.0 ± 8.7	*
	Weight (kg)	80.1 ± 14.8		85.5 ± 14.8	71.4 ± 10.1	*	80.8 ± 15.7	84.9 ± 16.0	71.9 ± 11.5	*
	BMI (kg·m^{-2})	26.83 ± 4.27	§	27.51 ± 4.47	25.72 ± 3.81		26.69 ± 4.45	26.92 ± 4.66	26.19 ± 4.18	
	HCP	26.4 ± 12.5	§	23.6 ± 11.8	30.8 ± 12.7		24.3 ± 10.4	22.6 ± 9.9	27.9 ± 11.0	
		Overall Mixed (n=32)		Total Male (n=21)	Total Female (n=11)		18-holes Overall Mixed (n=25)	18-holes Male (n=19)	18-holes Female (n=6)	
Flat	Age (years)	51.0 ± 12.0		48.6 ± 12.9	55.6 ± 8.7		47.8 ± 12.7	46.1 ± 12.8	53.3 ± 11.6	
	Height (cm)	173.9 ± 8.8		179.1 ± 5.2	163.9 ± 4.5	*	175.8 ± 7.4	178.7 ± 5.4	166.5 ± 4.4	*
	Weight (kg)	74.6 ± 13.6		82.5 ± 8.8	59.5 ± 6.0	*	77.3 ± 12.5	82.3 ± 9.3	61.6 ± 6.8	*
	BMI (kg·m^{-2})	24.50 ± 2.91	§	25.74 ± 2.65	22.12 ± 1.66	*	24.90 ± 2.94	25.76 ± 2.70	22.18 ± 1.93	*
	HCP	20.4 ± 9.0	§	21.3 ± 9.8	18.7 ± 7.3		22.2 ± 9.1	22.5 ± 9.7	21.1 ± 7.4	

*, significant difference between sexes $p < 0.05$; §, significant difference between hilly vs. flat courses $p < 0.05$

Table 3. Results of the incremental cycle ergometer exercise test. Subgroups of sexes as well as the subjects playing on hilly or flat golf courses are presented at three stages (LTP_1, LTP_2, and maximal power output). Values are mean ± SD.

Variables	Men (n=42)	Women (n=24)	Total Hilly (n=34)	Total Flat (n=32)
At LTP₁				
P (W)	83 ± 17	62 ± 17 *	76 ± 20	74 ± 20
HR (beats·min^{-1})	112 ± 11	116 ± 12	116 ± 11	110 ± 11 *
Blood lactate (mmol·l^{-1})	1.23 ± 0.23	1.28 ± 0.37	1.29 ± 0.30	1.21 ± 0.28
At LTP₂				
P (W)	154 ± 30	102 ± 26 *	135 ± 38	135 ± 39
HR (beats·min^{-1})	142 ± 15	143 ± 12	144 ± 12	141 ± 15
Blood lactate (mmol·l^{-1})	3.55 ± 0.53	3.28 ± 0.67	3.46 ± 0.63	3.43 ± 0.56
At Maximum				
VO_{2max} (ml·kg^{-1}·min^{-1})	37.69 ± 9.06	32.80 ± 5.72 *	34.72 ± 9.93	37.17 ± 7.06
P (W)	217 ± 42	144 ± 31 *	189 ± 51	192 ± 55
HR (beats·min^{-1})	170 ± 14	167 ± 13	170 ± 13	167 ± 15
Blood lactate (mmol·l^{-1})	8.77 ± 1.97	8.39 ± 1.56	8.49 ± 1.82	8.78 ± 1.86

P = power; HR = heart rate; Blood lactate concentration; VO_{2max} = maximal oxygen uptake;

*, significant difference $p < 0.05$.

Table 4. Results of the field measurements of men and women golfers who performed either an 18-hole or a 9-hole round of golf on hilly or flat golf courses. Values are mean ± SD.

Variables	Total Men (n=42)	Total Women (n=24)		18-h.Men (n=38)	18-h. Women (n=15)		9-h. Men (n=4)	9-h. Women (n=9)	
Average HR (beats·min^{-1})	104 ± 14	102 ± 13		105 ± 14	103 ± 12		101 ± 12	99 ± 13	
HR_{min} (beats·min^{-1})	73 ± 14	73 ± 13		73 ± 15	73 ± 13		74 ± 8	74 ± 13	
HR_{peak} (beats·min^{-1})	136 ± 17	135 ± 17		137 ± 16	137 ± 14		140 ± 11	131 ± 22	
%HR_{max} (%)	60.8 ± 8.2	60.4 ± 7.7		60.9 ± 8.6	61.6 ± 7.7		59.2 ± 3.1	59.2 ± 8.9	
EE (kcal)	865 ± 313	450 ± 202	*	926 ± 292	556 ± 180	*	520 ± 133	273 ± 66	*
Duration (h:min)	03:42 ± 00:43	03:11 ± 00:55	*	03:57 ± 00:22	03:51 ± 00:20		02:08 ± 00:04	02:04 ± 00:06	
Walking distance (km)	9.78 ± 2.09	8.15 ± 2.42	*	10.54 ± 0.94	9.89 ± 0.81	*	5.32 ± 0.48	5.25 ± 0.76	
Average speed (km·h^{-1})	2.64 ± 0.27	2.53 ± 0.28		2.69 ± 0.26	2.56 ± 0.26		2.43 ± 0.10	2.50 ± 0.33	
Total ascent (m)	111 ± 84	105 ± 76		118 ± 86	130 ± 79		80 ± 57	62 ± 50	
Total descent (m)	110 ± 86	105 ± 79		118 ± 88	130 ± 83		72 ± 52	63 ± 50	

18-h = 18-holes; 9-h = 9-holes; HR = heart rate; %HR_{max} = percentage of the HR_{max}; EE = total energy expenditure; Average speed = average walking speed. *, significant difference $p < 0.05$.

Figure legend:

Figure 1. Calculated MET values referring to the subgroups in Table 3 and 4 were independent of sex (**a**) playing 9, 18-holes of golf and independent of playing on hilly vs. flat golf courses (**b**). Mean intensity (±SD) was lower than 3 MET as defined by ACSM guidelines (9, 34).

Figure 2. Relationship between age and mean heart rate during golf play related to maximal heart rate from the incremental exercise test (%HR_{max}).