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# Predictive variables for half-Ironman triathlon performance

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ABSTRACT

*Objectives:* To examine the relationship between training, anthropometric characteristics, tapering, and time performance for a half-Ironman distance race.
*Design:* Cross sectional study in triathletes.
*Method:* Data were obtained for 209 participants (155 males; 54 females) competing in a half-Ironman triathlon. Participants provided information regarding triathlon experience, training, race preparation, and tapering. Participants were divided into three groups based on finish time for analysis.
*Results:* Males in the fastest group weighed less and had lower body fat percentage compared to males in the slower groups ($p \le 0.01$). Athletes in the fastest group had completed more half-Ironman races and took fewer rest days during training compared to athletes in the slower groups ($p < 0.01$). The average time spent training was $13.9 \pm 5.4$ h per week, and this did not differ between groups. The faster group of athletes set lower race time goals ($p < 0.01$) and placed greater importance on achieving goal time ($p = 0.04$). Eighty-one percent reported performing a taper with a decrease in training volume of $58.5 \pm 34.7\%$ and a decrease in training intensity of $44.9 \pm 40.8\%$. However, there were no differences in taper variables between the three groups. Age, previous best half-Ironman time, goal time, and goal importance predicted 58% of variance in finish time.
*Conclusions:* The fastest group of triathletes exhibited differences in anthropometrics, race experience, and goal-setting compared to slower athletes. There were no differences in total training hours or tapering between groups. The best predictors of race performance were age, previous best half-Ironman time, goal time, and importance of reaching this goal.


## 1. Introduction

Triathlon is a growing sport, experiencing rapid expansion worldwide. In the United States alone, approximately 40% of all triathletes participate in a half-Ironman distance race (1.9 km swim, 90 km bike and 21.1 km run) each year.[1,2] Past research has examined anthropometric characteristics, training strategies, and pre-competition taper parameters as predictors of race performance. Most of this research, however, has been done in either full Ironman or Olympic distance triathlons. Burke and Jin[3] found that full-Ironman distance finish time was related to both $VO_2$max and body fat percentage (BF%) (accounted for 52% of the variance in finish time). Others have found that predictors of finish time for full-Ironman distance include previous best finish times in triathlons and marathons,[3–5] speed of running during training,[5] and use of intervals during run and swim training.[6]

One other important determinant of race performance may be the pre-competition taper. Many endurance competitions in sport are preceded by a period of reduced training, called the taper.[7,8] A taper is designed to minimize accumulated fatigue while maximizing physiological adaptations[9] and has been linked to improvements in performance for runners, swimmers, cyclists, rowers, and triathletes.[8,10–12] Despite the apparent acceptance that pre-event taper leads to improved performance outcomes, the volume, intensity, frequency, and pattern of activity during the taper has been debated. Bosquet et al.[13] concluded that optimal performance gains followed a two-week taper consisting of a reduced training volume (by 41–60%) with no changes in frequency or intensity. Conversely, Mujika[14] reported that a 20–30% increase in training load in the final days leading up to a race may also be beneficial. Finally, Mujika and Padilla[7] reported that a progressive non-linear reduction in training volume appears to have greater performance benefits than a step-wise approach to reduction.

To date, no literature exists on the relationship between tapering and race performance for a half-Ironman triathlon. Additionally, many studies have examined selected aspects of training and preparation; however, few have considered anthropometric, physical training, mental preparation, and taper variables together in one study. The purpose of this study was three-fold. First, we wanted to determine which of the tapering, anthropometric, race experience,

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or training variables were associated with race performance. We hypothesized that hours of training, body fat percentage, years of experience, and changes in tapering volume would all be associated with race performance. We also wanted to determine which variables best predicted finishing time. We hypothesized that tapering, previous best finishing time, and training hours would be the best predictors of finishing time. Finally, we were interested in examining some descriptive characteristics of a typical half-Ironman triathlete.

## 2. Methods

This was a cross-sectional study of athletes. To be included in the study, athletes had to be competing in the Ironman 70.3 Buffalo Springs Lake triathlon. All procedures for the study were approved by the ethics committee (Institutional Review Board) at Texas Tech University (protocol #503433) and all ethical procedures were followed for human participants' investigations. A research booth advertising the study was set up at the packet pick-up 1 and 2 days before the event and this was the only recruitment tool used. Study procedures were explained in detail to all potential participants, including the risks and benefits of participating in the study, and volunteer participants provided written informed consent before beginning the study. Two hundred and nine participants (155 men, 54 women; ages from 18 to 75 years) completed this study. Exclusion criteria for this study included anyone who was a professional athlete, anyone who competed in the relay portion of the race, or anyone who has a cardiac pacemaker which would interfere with body composition measurements.

Participant testing took place at packet pick-up 1 and 2 days prior to the race. For each qualified participant, height was measured, and body weight was measured to the nearest 0.1 kg using a standardized scale (Series 400KL Continental Scale Corporation, Bridgeview, IL). Body composition was measured using a Tanita Model BF-522 bioelectrical impedance analysis (BIA) instrument (Tanita Corporation of America Inc., Arlington Heights, Illinois, 60005 US). Briefly, participants removed all metal jewelry and then stood on a scale while the resistance or impedance to a very small current was measured. This is a non-invasive field measure which can be done relatively quickly so it is good for testing a large number of participants in a short time frame. Participants then provided written answers to questions about their triathlon participation history, training, race preparation methods, and tapering. This questionnaire can be found in supplemental materials. Briefly, it included questions regarding years of competing in triathlon, hours spent each week swimming, biking, and running, cross training performed, different tactics used for race preparation such as deep breathing or visualization, and changes in volume and intensity for swimming, biking, and running during a taper. Following the race, we accessed study participants' performance times which were available online.

Descriptive statistics (mean and standard deviation) were calculated for all predictor and outcome variables. Frequencies were calculated for demographic variables, race preparation, and other activities. For further analysis, study participants were divided into three groups (of equal participant number) based on their published finishing times. Group 1 represented the fastest group of participants in our sample. For males, the first group's finish times ranged from 100% to 132% (0 to 79 min) of the fastest finisher's time from our sample (mean ± SD of 120 ± 8%). Stated differently, group 1 finishers ranged from 0 to 79 min slower than the fastest male's finishing time from our study sample. For females, this group's finish times ranged from 100% to 113% of the fastest female finisher's time from our study sample (mean ± SD of 107 ± 4%) which was equal to 0 to 37 min slower than the fastest female's finishing time. Group 2 represented the second fastest group of participants in our sample. Finish times for males in this group ranged from 133% to 150% of the top finisher's time (mean ± SD of 141 ± 5%), which was equal to 82 to 124 min slower than the top male finisher's time. Finish times for females in this group ranged from 113% to 128% of the top female finisher's time (mean ± SD of 121 ± 5%), which was equal to 38 to 82 min slower than the top female finisher's time. Group 3 represented the slowest group of participants in our sample. The males in Group 3's times ranged from 151% to 208% of the top finisher's time (mean ± SD of 168 ± 14%), which was equal to 128 to 270 min slower than the top finisher's time. The females in Group 3's times ranged from 129% to 168% of the top female finisher's time (mean ± SD of 145 ± 13%), which was equal to 85 to 197 min slower than the top female finisher's time. ANOVAs were used to assess mean differences for anthropometric, training, race preparation, and taper variables for Groups 1–3. Finally, the effects of predictor variables on time performance in the race were assessed using a multiple regression model. In the first model (Model 1), anthropometric predictor variables that were significantly correlated with finishing time were entered. The second model (Model 2) included training and preparation predictor variables that were significantly correlated with finishing time.

## 3. Results

Participant characteristics for the 209 study participants can be found in Table 1S in supplemental materials. Of the 209 study participants, a total of 206 completed the race and registered a finish time. Male participants were significantly taller, weighed more, and had lower body fat percentage than female participants. There were no differences between men and women for age or BMI.

The 206 participants were split into three groups of almost equal numbers based on their finish times. We chose to distribute groups in this way in order to avoid selecting arbitrary cutoff times or percentages for the three groups. Dividing the participants in this way allowed us to compare the top third, middle third, and bottom third of finishers to one another. Therefore, the fastest 70 finishers (53 males, 17 females) made up Group 1, the middle 69 finishers (51 males, 18 females) made up Group 2, and the slowest 67 finishers (51 males, 16 females) made up Group 3. Athletes in the fastest group (5.04 ± 0.33 h) had significantly lower times than the athletes in the middle (5.86 ± 0.22 h) and slower (6.87 ± 0.5 h) groups ($p < 0.01$). The top male participant in our study finished within 103% of the top male age group finisher (7.8 min slower than top male age group finisher). The top female participant in our study finished within 105% of the top female age group finisher (15 min slower than top female age group finisher). Table 1 presents anthropometric data for male and female participants grouped based on their finish times.

For males, there were no differences in height between participants in the faster, moderate, and slower finish time groups. Conversely, for body weight and BMI, males in Group 1 (faster time) weighed less than males in Group 3 (slower time) ($p = 0.01$). Finally, BF% of males in Group 1 was lower than males in both Groups 2 and 3. BF% of males in Group 2 was also lower than males in Group 3 ($p < 0.01$). For females, there were no significant differences in height, body weight, BMI, or body fat percentage between the 3 finish time groups.

Experience, training, tapering, and goal cognition between the three finishing groups can be found in Table 2. Total years of experience in the sport of Triathlon were not different between our three groups. Conversely, both the number of half Ironman distance races completed and the number of times completing this specific half Ironman were significant. The athletes in Group 1 completed more races than athletes in Groups 2 and 3 ($p < 0.01$). Additionally, athletes in Group 1 had completed this race more

**Table 1**
Anthropometric data for athletes grouped by finish time.

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | Group 1 Faster ($n$ = 53) | Group 2 Moderate ($n$ = 51) | Group 3 Slower ($n$ = 51) | Group 1 Faster ($n$ = 17) | Group 2 Moderate ($n$ = 18) | Group 3 Slower ($n$ = 16) |
| Height (cm) | 177.3 ± 6.3 | 177.2 ± 6.8 | 177.1 ± 7.6 | 167.1 ± 6.3 | 165.2 ± 5.2 | 162.6 ± 4.3 |
| Weight (kg) | 75.2 ± 7.5[a] | 78.0 ± 8.9 | 80.7 ± 10.3 | 59.7 ± 6.5 | 61.6 ± 10.7 | 60.1 ± 8.1 |
| BMI (kg/m$^2$) | 23.9 ± 2.0[a] | 24.8 ± 2.3 | 25.8 ± 2.9 | 21.4 ± 2.5 | 22.5 ± 3 | 22.8 ± 2.7 |
| BF (%) | 8.9 ± 4.2[a,b] | 9.5 ± 3.4[c] | 11.9 ± 4.1 | 18.0 ± 4.2 | 17.4 ± 4 | 18.9 ± 4.5 |

BMI = Body Mass Index, BF% = body fat percentage, data presented as mean ± standard deviation.
[a] Indicates a significant difference between Group 1 and Group 3 for male participants.
[b] Indicates a significant difference between Group 1 and Group 2 for male participants.
[c] Indicates a significant difference between Group 2 and Group 3 for male participants.

times than athletes in Group 3 ($p$ = 0.04). The number of training hours per week for swimming, cycling, running, and total exercise time did not differ between our 3 groups. However, athletes in Group 1 took fewer rest days than athletes in Groups 2 and 3 ($p$ < 0.01). Not surprisingly, goal finish time for Group 1 was lower than Groups 2 and 3 ($p$ < 0.01) and Group 2 was lower than Group 3 ($p$ < 0.01). The importance of reaching a time goal for athletes in Group 1 was higher than athletes in Group 3 only ($p$ = 0.04). 80.5% of our participant population reported performing some type of taper for the race. Of those participants who tapered, 39% of participants received their taper information from a coach, followed by a book (17.6%), another athlete (16.7%), the internet (15.2%), a research study (10.5%), a magazine (10%), or "other" (15.7%). There were no significant differences between Groups 1, 2, or 3 for any taper variables.

We used multiple regression to test a model predicting race finish times for the whole study population in order to have the most statistical power. The most parsimonious model included four predictor variables; age, previous best half Ironman finish time, goal finish time, and importance of reaching goal as predictors. The model explained 51% of the variance in race time with importance of reaching goal ($\beta$ = −0.311) and goal finish time ($\beta$ = 0.302) having the largest impact on race time. Therefore, finish time in minutes for a half-Ironman race may be partially predicted by the equation ($r^2$ = 0.51, standard error of the estimate 0.584) = 0.013 × (age on race day) + 0.374 × (previous best half-Ironman time) + 0.347 × (goal finish time) − 0.005 × (importance of reaching goal time). Table 2S in the supplemental materials displays the unstandardized regression coefficients, the standardized regression coefficients, $R^2$ and adjusted $R^2$ after entry of all independent variables entered for Model 1. Contrary to our hypothesis, anthropometrics, training volume, and taper characteristics did not significantly improve $R^2$ when entered into the model (Model 2). Since we had divided the participants into 3 groups based on finishing time, we also performed a multiple regression analysis on each group separately. Not surprisingly, due to smaller sample sizes for each Group, we found that the model accounted for a smaller portion of variance for each of the group's finish times. For each of Groups 2 and 3, only one variable was significant in the model; previous best half-Ironman time was significant for Group 2 and goal finish time was significant for Group 3. Nothing was significant for Group 1.

**Table 2**
Mean and standard deviation for race experience and preparation variables by finish time group.

| | Group 1 ($N$ = 69) | Group 2 ($N$ = 69) | Group 3 ($N$ = 66) | Total ($N$ = 204[d]) |
|---|---|---|---|---|
| *Race experience* | | | | |
| Years competing in triathlon (years) | 8.3 ± 7.4 | 6.6 ± 7.0 | 7.0 ± 6.9 | 7.3 ± 7.1 |
| Number of half Ironmans completed | 9.7 ± 12.1 [a] | 4.6 ± 4.5 | 5.0 ± 5.8 | 6.5 ± 8.5 |
| Number of times competed at this race | 1.3 ± 2.3 [b] | 0.6 ± 1.0 | 0.9 ± 1.5 | 0.9 ± 1.7 |
| *Training* | | | | |
| Number of training hours/week (total) (h) | 14.3 ± 4.8 | 13.9 ± 6.4 | 15.5 ± 5.1 | 13.9 ± 5.4 |
| Number of training hours/week (swim) (h) | 3.1 ± 1.2 | 3.1 ± 1.3 | 2.8 ± 1.5 | 3.0 ± 1.3 |
| Number of training hours/week (bike) (h) | 7.6 ± 2.9 | 6.8 ± 3.0 | 6.6 ± 2.8 | 7.0 ± 2.9 |
| Number of training hours/week (run) (h) | 4.5 ± 1.8 | 4.6 ± 4.0 | 4.4 ± 1.9 | 4.5 ± 2.8 |
| Number of rest days per week (days) | 0.8 ± 0.5[a] | 1.1 ± 0.7 | 1.2 ± 0.7 | 1.0 ± 0.7 |
| *Goal cognition* | | | | |
| Goal finish time (h) | 5.2 ± 0.7[a] | 5.7 ± 0.8[c] | 6.3 ± 0.7 | 5.7 ± 0.9 |
| Importance of reaching goal, 0–100 | 66.3 ± 29.3[b] | 61.0 ± 29.8 | 53.6 ± 28.3 | 60.5 ± 29.5 |
| *Tapering* | | | | |
| Number of days tapered for race (days) | 7.4 ± 4.1 | 7.7 ± 4.2 | 7.9 ± 4.5 | 7.6 ± 4.3 |
| Number of rest days during taper (days) | 2.3 ± 1.8 | 2.3 ± 1.1 | 2.8 ± 1.8 | 2.7 ± 3.9 |
| Change in total volume during taper (%) | 59.6 ± 35.7 | 64.3 ± 42.6 | 54.5 ± 26.4 | 58.5 ± 34.7 |
| Change in swim volume during taper (%) | 41.1 ± 24.7 | 42.8 ± 26.0 | 41.4 ± 28.8 | 41.6 ± 26.3 |
| Change in bike volume during taper (%) | 51.9 ± 22.4 | 48.1 ± 18.8 | 49.0 ± 23.9 | 49.5 ± 21.9 |
| Change in run volume during taper (%) | 47.9 ± 19.3 | 46.8 ± 17.3 | 48.8 ± 24.2 | 47.7 ± 20.6 |
| Change in total intensity during taper (%) | 48.7 ± 48.7 | 53.0 ± 32.4 | 34.4 ± 36.8 | 44.9 ± 40.8 |
| Change in swim intensity during taper (%) | 35.2 ± 35.4 | 31.0 ± 30.2 | 31.1 ± 36.3 | 32.5 ± 33.9 |
| Change in bike intensity during taper (%) | 42.8 ± 33.3 | 40.6 ± 26.7 | 33.8 ± 34.6 | 38.8 ± 31.8 |
| Change in run intensity during taper (%) | 40.8 ± 33.3 | 40.0 ± 26.5 | 33.6 ± 34.0 | 38.0 ± 31.6 |

Data presented as mean ± standard deviation.
[a] Indicates a significant difference between Group 1 and both Group 2 and Group 3.
[b] Indicates a significant difference between Group 1 and Group 3.
[c] Indicates a significant difference between Group 2 and Group 3.
[d] Denotes total number of participants who answered all questionnaire items for this section.

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**Table 3**
Participant responses for dietary supplement use, training, intensity measures, and pre-race strategy.

| Measure | Participant response ($n$) | Participant response (%) |
|---|---|---|
| *Dietary supplement use* | | |
| Regular vitamin or mineral | 130 | 61.9 |
| Supplement use (other than vitamins or minerals) | 92 | 43.8 |
| *Additional training activities* | | |
| Strength training | 117 | 55.7 |
| Yoga | 39 | 18.6 |
| Pilates | 10 | 4.8 |
| Plyometrics | 21 | 10.0 |
| Other cardio | 13 | 6.2 |
| Other | 34 | 16.2 |
| *Method used to measure intensity* | | |
| Heart rate | 132 | 62.9 |
| Perceived exertion | 127 | 60.5 |
| Pace | 131 | 62.4 |
| Power | 51 | 24.3 |
| Other | 10 | 4.8 |
| *Type of pre-race strategy used* | | |
| Visualization | 118 | 56.2 |
| Positive self-talk | 116 | 55.2 |
| Relaxation | 100 | 47.6 |
| Pre-competition routine | 70 | 33.3 |
| Other | 22 | 10.5 |

$n$ = number of participants, % = percent of participants.

In order to learn more about the training habits of a half Ironman triathlete, the prevalence of supplement use, and types of pre-race strategies used, we performed frequencies for a number of variables (Table 3). 62% of our participants reported regular vitamin/mineral supplement use and 44% take at least one other supplement. Nearly 75% of our participants reported doing at least one type of additional training and strength training was the most prevalent (56%). Finally, our participants primarily used heart rate (62.9%), pace (62.4%), and perceived exertion (60.5%) to measure training intensity.

## 4. Discussion

The aim of this study was to investigate the relationship of various anthropometric characteristics, tapering practices, prior race experience, and training approaches to race finish time in a sample of half-Ironman distance triathletes. When split up into three groups based on finishing times, our fastest group of triathletes had a lower body weight and BF% compared to our slowest group of triathletes. Further, athletes in the fastest finishing group had completed more half-Ironman distance races. Surprisingly, there were no differences in total training hours or in tapering between our groups. Finally, the best predictors of race performance were age, previous best half-Ironman time, goal finish time, and importance of reaching this goal.

To verify that our athletes were similar to those studied in other triathlon races and represented a "typical" recreational, non-professional triathlete, we compared the race results and anthropometric results from our participants with those of previous studies. Our finishing times were similar to those previously reported for a half-Ironman study.[15] Further, our anthropometric data (height, weight, BMI, and body fat percentage) for our participants was similar to recreational triathletes competing at the full Ironman distance for both men[16,17] and women.[17]

Since we expected to find anthropometric differences between our male and female participants, we analyzed these variables by sex. Males in the fastest finishing group had lower body weight, BMI and BF% than males in the slowest group. This finding is partially in line with Knechtle et al.,[4] who found that BMI was significantly related to race time for Ironman athletes. Burke and Jin[3] also reported that skinfold thickness was related to finish time in Ironman athletes. We did not find any significant differences in anthropometric variables for females in the three finish time groups. However, the lack of differences in females in our study should be taken with caution. We had relatively small sample sizes in each group ($n$ = 17, 18, and 16 for Groups 1, 2, and 3, respectively). It is possible that with a larger number of female participants, similar to those of the males, differences may have been found.

As expected, athletes in the fastest finishing group had more half-Ironman race experience and had completed this specific race more times. Houston et al.,[6] reported a similar finding for an Olympic distance triathlon. We also found that previous race finish time significantly predicted finish time in the current race, accounting for 37% of variance in race time. Knechtle et al.,[4] also reported that personal best times in both running and triathlon were significantly related to finish time in an Ironman distance race. Similarly, Rust et al.[18] also showed that personal best times in an Olympic distance triathlon and marathon were associated with Ironman race time.

Contrary to our hypothesis, there were no significant differences in number of training hours for athletes in the fastest group compared to athletes in the slower groups. It is important to note that the faster group of athletes may also train at faster paces, so these athletes may have a higher absolute volume of training (i.e. in miles or kilometers covered). However, this is purely speculation. In fact, a study on Ironman triathletes actually found that speed in training was not associated with race performance in either men or women.[17] Conversely, earlier work by Morton et al.[19] and Millet et al.[20] showed that performance in simulated race conditions or performance could be reliably predicted from training volume and intensity. A more comprehensive study on training volume may be able to show if differences in training distances covered do in fact exist. We did find that athletes in the fastest group took fewer rest days during their training cycles. This indicates that athletes in the fastest group perhaps train with more consistency. It is also possible that these athletes are able to recover more quickly from training sessions and therefore do not need to rest as frequently.

Not surprisingly, goal finish time discriminated well between each of the fastest, moderate and slower finish time groups. Furthermore, athletes who placed higher importance on achieving this goal were more likely to be in the fastest finishing group. These findings are in agreement with an earlier study by Stoeber et al.[21] that showed athletes who had set faster personal time goals for an Olympic distance race achieved lower race times than those who set slower personal time goals. Bar-Eli et al.[22] demonstrated the importance of appropriate goals in their seminal study on goal setting in muscular endurance activities. These researchers found that when students set specific and difficult, yet attainable, goals for number of sit-ups to complete, they were more likely to reach their target.

Interestingly, in our study, athletes in the slowest finishing group appeared to have to set the most appropriate time goals. This group was shown to have the highest correlation between goal finish time and actual finish time ($r$ = 0.45, $p$ < 0.01), whereas athletes' goal times in the moderate and fastest groups were not correlated with actual finish time ($r$ = 0.22 and $r$ = 0.06, respectively). This is an unexpected finding but may reflect the appropriateness of goal difficulty that athletes chose. Athletes who achieved a faster finishing time appeared to have set more ambitious time goals and fell further short of their goal compared to athletes in slower groups.

Our findings regarding athletes' use of a taper phase prior to this race were unexpected. Most existing literature suggests at least a 1–3% gain in performance following a taper.[13] Houmard et al.[10]

found that distance runners experienced a 3% performance gain following a seven day taper where run volume was reduced by 85% (no change in intensity). Approximately 80% of our participants reported performing a taper prior to this race. Surprisingly, we found no differences for the percentage volume and intensity changes or rest days for athletes between the three finish time groups. What was more surprising was the large percentage decreases in both training volume (58.5%) and intensity (44.9%) in the days leading up to the race. Although the decrease in training intensity was less than that of volume, research seems to support a decrease in training volume with little to no change in intensity or frequency for the best results.[13] It is possible that by decreasing their intensity during the taper, athletes experienced a de-training effect,[14] thereby limiting the potential gains from a taper. These findings perhaps reflect on the average triathlete's level of understanding (or lack thereof) of optimal tapering protocols. This also highlights the need to disseminate accurate information to coaches and athletes wanting to improve performance and obtain maximum benefit from training.

In considering the multitude of characteristics and training behaviors associated with triathlon performance, we took a multivariate approach to predicting race times in this study. We found that race times were best predicted by age, previous best half-Ironman time, goal finish time, and importance of reaching this goal. Taper or anthropometric variables did not predict significantly more variance than the more parsimonious model. Interestingly, Knechtle et al.[4] report a similar pattern of predictors for race finish time. When previous best race time and run speed during training were entered into their regression model, anthropometric variables were not predictive of finishing time. Similarly, Rust et al.[18] also found that personal best time in an Olympic distance triathlon and marathon were the best predictors for Ironman race time. These findings are most interesting and suggest that characteristics beyond physiological attributes are important in determining athletes' performance.

Despite the fact that the half-Ironman triathlon has grown in popularity, very little research has been conducted on athletes in this race distance. Based on all of the data collected in our study, we can make the following summaries regarding a "typical" half-Ironman triathlete. The average half-Ironman triathlete falls within the normal category for BMI and body fat percentage. They have been competing in triathlons for an average of 7.3 years and have completed an average of 6.5 previous half-Ironman races. More than half also perform strength training, which has been reported previously in triathletes competing in all triathlon distance races,[23] and nearly two-thirds use heart rate, pace, and/or perceived exertion as a method to measure intensity. They spend approximately 14 total hours each week training (3 h swimming, 7 h cycling, and 4.5 h running). This was somewhat surprising since previous studies have shown that Ironman triathletes report training approximately 14 h per week.[16,17] Over 60% regularly take vitamins or minerals, and 44% take some other type of dietary supplement. This is slightly more than has been reported for triathletes competing at all distances of triathlon. In that study, 54.6% of men and 52.6% of women used dietary supplements and just under 40% took daily multivitamin/minerals pills for both men and women.[23] Finally, the majority of athletes taper for a half-Ironman race. The average length of the taper was 7.6 days and the average number of rest days during the taper was 2.7. Total changes in training volume during the taper were almost 60% while intensity decreases were only 45%. Finally, the majority of taper information for the triathletes came from a coach.

Certain limitations of this study may have impacted our findings. It is possible that those who chose to volunteer in the study were more experienced, informed, or interested in the topic of the research study. The sample may therefore be biased which potentially limits generalizability of our findings. Second, we acknowledge that during a race of this length, there are opportunities for unforeseen obstacles to interfere with a competitor's race time. We were unable to account for bike mechanical breakdowns, illness, or injury. Third, we asked participants to report their volume of activity in swimming, cycling, and running. It has been noted that self-report of physical activity tends to be somewhat unreliable.[24] However, given the characteristics of our sample, we believe that self-report for training volume would be a more valid method of obtaining this data compared to other populations. Although we had over 200 participants in our research study, we had a disproportionate number of male vs. female participants. We had fairly small sample sizes for the female participants which could have contributed to non-significant anthropometric differences between groups. A final limitation is the accuracy of the body composition technique used in this study. Although BIA is considered one of the better field measures for estimating body fat percentage, it is not as accurate as some laboratory methods. Further, we were unable to control the hydration status of the athletes since we performed recruitment and testing at the same time. Not controlling for hydration status could have affected the accuracy of body composition measurements.[25]

## 5. Conclusion

In summary, athletes' previous best half-Ironman race time, age, goal importance, and goal finish time are important predictors of performance in a half-Ironman triathlon. Anthropometric variables, tapering, and training volume have less impact on race performance than expected. Additionally, tapering and training characteristics in general did not differ between our fastest and slowest finishers. Our study was successful in determining a holistic profile for the average half-Ironman competitor including physical characteristics, training methods, taper, and race preparation. Future research should be aimed toward obtaining broader samples of participants as well as experimental designs in which certain taper and race preparation variables are manipulated in order to determine their impact on performance.

## Practical implications

- Tapering (assessed as changes in volume and/or intensity) is not a predictor of half-Ironman performance time.
- Goal importance and goal finish time are strong predictors of performance for a half-Ironman triathlon.
- Faster male triathletes weighed less and had a lower body fat percentage.
- For female athletes, body weight and body fat percentage did not differ between the fastest and slowest female athletes.

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jsams.2013.04.014.

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