International Journal of EXERCISE SCIENCE

Original Research

Preparation for an Half-Ironman[tm] Triathlon amongst Amateur Athletes: Finishing Rate and Physiological Adaptation

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ABSTRACT

International Journal of Exercise Science 13(6): 766-777, 2020. Long distance triathlon has gained in popularity amongst the general population. Coaches establish training programs based upon their knowledge, personal experience and on current training principles. The goal was to observe the effect of a triathlon training program for a half Ironman event in neophyte amateur athletes. A specific triathlon training program was followed from February to June 2016 by a group preparing for their first half ironman. Out of the 32 participants (19 Males and 13 Females; mean age of 39 ± 9.9 years old; body weight of 72.7 ± 13.4 kg and a height of 171.5 ± 10.2 cm), only one did not complete the event. A mean training volume of 410 ± 201 min per week led to a mean finishing time of 6 hours 28 minutes. The training program significantly increased the maximal oxygen consumption (45.9 ± 8.2 to 48.6 ± 7.5 ml/kg/min, p =0.002) and the maximal power output (293.1 ± 63.7 to 307.8 ± 58.7 W, $p < 0.001$). The absolute oxygen consumption and power output at both ventilatory thresholds also significantly increased (VT1: 2.2 ± 0.4 to 2.5 ± 0.5 L, $p = 0.001$; 157.8 ± 41.8 to 176.7 ± 41.1 W $p = 0.009$ and VT2: 2.9 ± 0.4 to 3.0 ± 0.4 L, $p = 0.017$; 229.3 ± 62.0 to 244.8± 55.2 W, $p = 0.022$). A significant diminution of waist circumference was observed (83.2 ± 10.0 to 81.8 ± 9.5 cm, $p = 0.032$) with no significant changes in body weight. Thus, a 24-week specific training program appears to be safe and efficient for amateur athletes aiming to finish their first half- Ironman event.

KEY WORDS: Ironman, maximal oxygen consumption, endurance, training periodization, sports injury

INTRODUCTION

In the past decade, participation in endurance sports such as running, cycling and triathlon is increasing amongst amateur athletes (15). As an example, in the Province of Quebec, Canada, the number of registrations with the provincial triathlon federation increased from 600 members in 2006 to 4,523 members in 2019 (23). The sport was mainly popularised in the Province of Quebec with the arrival of the Ironman[tm] (3.8 km of open water swimming, 180 km of road cycling and 42.2 km of running) and Ironman 70.3tm (1.9 km of open water swimming, 90 km of road cycling and 21.1 km of running) events in Mont-Tremblant. In those type of events, elite athletes represent a minority of all participants (5). The remainder of the athletes are amateur athletes, also known as age-groupers. In an era where sedentary behaviour is related to many chronic diseases, the increasing number of age groupers participating is encouraging as this suggests that a part of the population is getting more active (5). Nevertheless, these type of endurance events need a thoughtful preparation, and preferably, a medical clearance to minimise the potential cardiovascular risks and musculoskeletal injuries that can be associated with long distance events (17, 24, 27). Interestingly, the most represented age group is within 40-49 years old (24). It is also known that this age group often has a few other cardiovascular risk factors beside their age (14). In fact, cases at risk, such as obese or sedentary person wanting to complete a long-distance triathlon, are not uncommon and are popularised via social media. The majority of amateur athletes training for a long distance event either train on their own or hire a coach (12). Physical training/preparedness programs and periodization are often built on common knowledge, and the coach's experience and training principles (16). Thus, when coaching specific age group athletes, health outcome issues and safety are the primary objectives before performance itself, and therefore, a qualified team (Kinesiologists, physicians, and other health professionals) may be of interest in order to adapt a safe training program to their health status. According to the current literature, few studies have assessed the effect of training periodization and a best practice follow-up by health professionals with a speciality/interest in triathlon (22). Furthermore, the majority of studies on triathlon focus on the event itself and not on the training process. Thus, the main goal of this project was to observe the success rate and physiological adaptation of a 24 week training periodization in amateur athletes competing for the first time in a half-Ironman event. The secondary objective was to document musculoskeletal injuries. The importance of this study is to expand the knowledge on follow-up of age-grouper triathlon participants that represent the majority of the participants in Ironman 70.3tm events.

METHODS

Participants

Participants recruited for this project were Canadian amateur athletes (age groupers) of 18 years old and more who had never participated in an Ironmantm or Ironman 70.3tm event. In order to take part in the project, the participants needed to be registered and show proof of their inscription for the Ironman 70.3tm Mont-Tremblant, Quebec, Canada, 2016 edition. The retained participants had to respond negatively to all questions of the Physical Activity Readiness Questionnaire (PAR-Q) (28). Exclusion criteria were: pro and/or elite athlete status; athletes with substance abuse history; participants with severe heart or pulmonary disease; cancer or any other physical limitation that limits triathlon training, and pregnant women. The project was approved by the ethics committee of *University of Quebec in Montreal* (ethic committee certificate number: 2015_e_734). Participants understood and signed the consent form prior to their participation to the project. The authors have complied with each of the ethics statements contained in this work relating to scientific discovery in exercise science(21).

Protocol

All participants were recruited to begin their preparation in January 2016. The team of kinesiologists (François Lalonde and Sarah- Maude Martin) in the study did a follow-up of participants in a 24-week training periodization in preparation for the June 27th, 2016 Ironman 70.3tm event. The second fitness assessment was done at the end of May before the taper microcycles prior to the event. On event day, the team was present for support and to collect race day data.

Fitness assessment

Pre-assessment: The consent form was reviewed with the participants as well as validation of their registration for the 2016 Ironman 70.3. Participants were questioned on their history of sports and fitness training, inventory of training equipment and garments, as well as their training schedule and availability for the reminder of the project. Prior to testing, resting heart rate (RHR) and resting blood pressure were measured in accordance with the Canadian Society of Exercise Physiology's Physical Activity Training for Health (CSEP-PATH) manual (CSEP 2013) using a Multi-Cuff Sphygmomanometer (AMG Medical Inc, Montreal, QC).

Anthropometry and body composition: Height was obtained using a stadiometer (Charder, USA), and the standing height was recorded to the nearest 0.1 cm while the participants held their breath after a complete inspiration. Weight, Body Mass Index (BMI) and body composition, which included body fat, visceral fat and lean body mass percentage, were measured with a bio impedance scale (Tanita, USA). As per protocol, the participant was instructed to remove his/her footwear and socks, any heavy accessories, additional/heavy clothing and empty his/her pockets; to step on the center of the scale (on each foot placement contour on the scale surface), with his/her hands alongside the body. The participant was told to relax, look straight ahead and not speak for the duration of the measurement. The athletic equation was selected on the bio impedance device.

Waist circumference (WC) was obtained as the participant stood erect with feet shoulder width apart and arms crossed over chest in a relaxed manner. The measure was taken directly on the skin, with just enough tension to avoid skin indentation, landmarked at the top of the iliac crests, with the tape positioned directly around the abdomen so that the inferior edge of the tape was at a level of the landmarked points, in a horizontal plane around the abdomen. Participants were instructed to breathe normally as the measure was read from the bottom of the tape at the end of a normal expiration. The measurements were recorded to the nearest 0.5cm.

Maximal oxygen uptake and metabolic threshold testing: The first goal was to obtain the $\dot{V}O_2max$ and the metabolic threshold (ventilatory threshold 1 and ventilatory threshold 2) using an incremental test performed on an upright ergocycle (Corival 906900, LODE B.V. Medical Technology, Groningen, The Netherlands) coupled to a breath-by-breath metabolic cart system (MetaMax-3b, Cortex Biophysik GmbH, DE). Before each test, the gas analyzers were calibrated with calibration gases (25% O_2 and balance N_2; and 16% O_2, 5% CO_2 and balance N_2) and the air volume turbine with a 3L syringe. The software to display $\dot{V}O_2max$ and other parameters was provided by the manufacturer (ver. 7.2.0.52, 2001-2011, Medgraphics Corporation, St Paul, MN). A five-minute warm-up was performed prior to the incremental test on the ergocycle at a cadence of 90 rpm. The initial load was set at 25 watts (W) and after two minutes was increased to 50 W for the remainder of the warmup period. At the end of the warmup, the load was increased by 25 W and thereafter at every minute until exhaustion while maintaining a cadence of 90 RPM. The participants had to reach two out of the five following criteria in order to confirm V̇O2max: a plateau in O2 uptake despite an increased workload, a respiratory exchange ratio value >1.15, 10 on 10 for perceived exertion using the modified Borg scale (3), the predicted maximal heart rate reached using the 220-age equation (if no V̇O2 plateau was reached) or a failure to maintain the pedaling cadence for 10 seconds(1). In order to obtain the moderate and heavy intensity domain, the ventilatory threshold 1 and 2 were visually determined by two certified exercise physiologists (François Lalonde and Alain Steve Comtois) as the point at which during the incremental exercise test the ventilatory equivalent for O2 (V̇E/V̇O2) increased without any change in ventilatory equivalent for CO2 (V̇E/V̇CO2)(7). Participants were also asked to rate their perceived exertion on a modified Borg scale (range from 0 to 10) and how they perceived pain in their leg muscle (analog scale from 0 to 10) at each minute during each (2, 3).

The maximal aerobic power (MAP) output during the incremental test was considered as 100%. From those results, the training zones (on a 5-zone system) were calculated. Zone 5 was between 90-100 % of MAP; zone 4 was between 80-89.9 % of MAP; zone 3 was between 70-79.9 % of MAP; zone 2 was between 60-69.9 % of MAP and zone 1 was lower than 60 % of MAP (Table 1).

Table 1. Training zones for managing intensity

Zone	Gaz exchange ratio	Borg (/10)	% HR (bpm)	% MAS (min/km)	% MAP (watts)	Swim (pace at 100m)
1 (Easy, ≤60%)	21 % and less than VT1	0-2	-	-	-	+ 15 sec
2 (Light, 60-69.9%)	20 % less than VT1	3-4	-	-	-	+ 10 sec
3 (Moderate, 70-79.9%)	10 % less than VT1	5-6	-	-	-	+ 5 sec
4 (Intense, 80-89.9%)	Between VT1 and VT2	7-8	-	-	-	Speed at IU test
5 (Near max, 90-100%)	Between VT2 and VO2max	9-10	220-age	Half-cooper test	Incremental bike test	-5 sec
5+ (Supra max, ≥100%)	Above VO2 max or anaerobic	10 +		-	-	-5 to -15 sec

VT : Ventilatory threshold; HR : Heart rate; MAS: Maximal aerobic speed ; MAP: Maximal aerobic power

Grip strength test: The participants, from a standing position with their arm alongside the body, were instructed to apply maximal force for 2s on the hand dynamometer (Lafayette, 78010, Lafayette Instruments). Participants made at least two attempts per hand, alternating hands each time, separated by at least 60s of rest. If a difference greater than 5% was obtained, than a 3rd attempt was performed. A mean of the best two measurements was calculated and used for analysis.

Sit and reach test: Participants sat on the floor with legs stretched out straight ahead, shoes removed. The soles of the feet were placed flat against the box (Acuflex 1 flexometer, Novel

Products Inc.). Both knees were locked and pressed flat against the floor. With the palms facing downwards, and the hands-on top of each other or side by side, the participant reached forward along the measuring line as far as possible. After a little warm up stretch and practice runs, the participants were instructed to reach out and hold that position for at least two seconds while the distance was measured and recorded. The best score of two attempts was used for analysis (25).

Field testing

Swimming test: Participants performed the Ironman University™ swim test in a 25m pool. The test consisted of 6 x 100m swim as quick as possible. The amount of rest between the 100m was as needed by the participant. Each 100m time was recorded and the mean was used to set the pace per 100m for zone 4 in the training zone (Table 1). For zone 5, 5 seconds was subtracted from the test result's pace; zone 3, 5 seconds was added to the test result pace; zone 2, 10 seconds was added to the test result's pace and zone 1 (or technical swim), 15 seconds was added. These paces were used to prescribe intensity of the swimming training sessions.

Running test: Participants performed a half-cooper test which consisted of the maximal distance covered in 6 minutes (18). The test was either done on a 400m running track or with the use of a sports watch with a global positioning system. With the test results, we converted the results into speed (km per hours) and into pace (minute per km) to determine each training zone for running. The pace set by the test was considered as 100 % of maximal speed (MS). Zone 5 was between 90-100 % of the MS; zone 4 was between 80-89.9 % of MS; zone 3 was between 70-79.9 of MS; zone 2 was between 60-69.9 % of MS and zone 1 was any pace lower than 60 % of MS (Table 1).

Training periodization and fellow-up

A twenty-four weeks training periodization inspired from Ironman University™ was used for the project (https://u.ironman.com/). There were 3 training macrocycles: preparation, competition and transition. The different phases were separated in 3 week-mesocycles that typically included 2 weeks of build up and one recovery week where both volume (in time) and intensity (in zones) were reduced. Load was increased by approximately 10% each mesocycle by increasing volume and/or intensity depending on the macrocycles goals. Microcyles (one week) consisted of a minimum of two training sessions in each of the following disciplines: swimming, cycling, running, and strength and conditioning. Each training sessions was prepared by two members of the research team (F.L.: kinesiologist, Ironman University™ coach and triathlon Canada certified coach; S.-M.M.: kinesiologist and triathlon Canada certified coach) and sent to each participant via the Training peak™ software. Training intensity was calculated with laboratory and field tests results in a system of five zones (Table 1). Participants entered their daily training and comments on the Training peak™ software via their personal training watches. The compliance to the program could therefore be calculated when compared to the prescription. Strength and conditioning followed these specific mesocycles: stability and core; endurance; hypertrophy; strength and power; and maintenance. Each training program were sent to participant (including exercise demo by picture and video) via the Physiotec™ software.

Musculoskeletal injury tracking
When a musculoskeletal injury occurred to a participant, the primary investigator (F. L.), the team's sports medicine physician (M.G.) and sports medicine physical therapist (M. R.) adjusted the training program and provided specific care to help participants to complete the regular training program. Injury type and cause was identified (overuse vs traumatic) and a description of how the injury impacted the training for participants was written.

Event day follow-up
Ironman medical chief officer (M. G.) was on duty the day of the event. Team members (F. L. and S.-M. M.) were on site to give encouragements to participants and to track their performance via Sportstats^{tm}. Data from the total race time and split time were used for data analysis.

Statistical Analysis
The descriptive statistics for all dependent variables were expressed by their means and standard deviations (Mean ± SD). An independent-samples t-test was conducted to compare the first and second assessment testing (pre training vs end of training prior to the competition).

All data were analysed with SPSS 19.0 software for Windows (IBM SPSS Statistic, USA) and all graphics were plotted with Sigma Plot version 12.0. A level of $p \leq 0.05$ was selected for statistical significance.

RESULTS

Thirty-two participants were selected (19 males and 13 females; mean age of 39 ± 9.9 years old; mean weight of 72.7 ± 13.4 kg; mean height of 171.5 ± 10.2 cm; mean BMI of 25.0 ± 2.7 kg/m^2). The majority of the participant's prior sports experience, as amateur athletes, was one to four years in the following disciplines: road running, cycling, obstacle courses, and short distance triathlon (sprint and Olympic distances). Participant characteristics are presented in Table 2.

The overall compliance with the training program was 69 % with a mean training volume of 410 ± 201 min per week. Compliance in the various disciplines were swimming at 54 %; cycling at 85 %; running at 83 % and strength training at 28 %. During the project, as indicated in Table 3, there were some musculoskeletal (MSK) injuries that were reported (the majority of them were present prior to entering the project). The main injuries were: three cases of iliotibial syndrome and one case of tendinopathy, all of which were managed with specific physical therapy (PT) exercises and light limitation on the training program; three cases of muscle sprain managed with specific PT exercises and light limitation on the training program; two cases of non specific low back pain managed with specific PT exercises and moderate limitation on the training program; one case of upper respiratory tract infection managed with one month of low intensity training and low volume; and one case of a bike fall that resulted in minor sprains and light limitation on the training program.

Table 2. Participants characteristics.

Characteristics	Mean ± SD
Male	19
Female	13
Age (years)	39 ± 9.9
Weight (kg)	72.7 ± 13.4
Height (cm)	171.5 ± 10.2
Body mass index (kg/m^2)	25.0 ± 2.7

Table 3. MSK injuries recorded.

Injury	N	Impact on training
Ilio-tibial syndrome	3	Light limitation on runing + PT exercices
Muscle sprain	3	Light limitation on runing + PT exercices
Back pain	2	Moderate limitation on runing + PT exercices
Tendinopathy	1	Light limitation + PT exercices
Infection	1	1 mont of low intensity and low volume training
Bike fall	1	Minors spains and light limitation

Race day results are presented in Table 4. There were 31 out of 32 participants who completed the event with a mean time of 6 hours 25 minutes and 37 seconds ± 50 minutes and 53 seconds (±52min).

Table 4. Event day results.

	N	Swim	T1	Bike	T2	run	Total time
Mean time (H:min:sec)	31	38:33:00	00:06:07	03:12:30	00:03:31	02:25:23	06:25:37
SD time (H:min:sec)		00:05:22	00:02:00	00:23:12	00:01:36	00:25:24	00:50:53
Did not finish (DNF)	1	-	-	-	-	-	-
Disqualification (DQ)	1	-	-	-	-	-	-
Finishers	30	-	-	-	-	-	-
Qualification for World championship	2	-	-	-	-	-	-

Fitness assessment and body composition are presented in Table 5 and 6, respectively. $\dot{V}O_2max$ increased significantly from 45.9 ± 8.2 to 48.6 ± 7.5 ml·kg·min ($t(28)=-3.382$, $p=0.002$) and maximal power output increased significantly from 293.1 ± 63.7 to 307.8 ± 58.7 Watts ($t(28)=-5.557$, $p<0.001$). $\dot{V}O_2$ at both ventilatory thresholds increased significantly from a $\dot{V}O_2$ of 2.2 ± 0.4 L to 2.5 ± 0.5 L and 2.9 ± 0.6 L to 3.0 ± 0.6 L ($t(28)=-3.892$, $p=0.001$; $t(28)=-2.528$, $p=0.017$). There was no significant change in the field tests (swimming [$t(21)=0.977$, $p=0.340$] and half-cooper test [$t(21)=-2.007$, $p=0.058$]), the handgrip test, but the sit and reach test decreased significantly [$t(27)=2.739$, $p=0.011$].

Table 5. Physiological adaptation of aerobic capacity and musculoskeletal tests.

Variable	January 2016	June 2016	Mean differences	t	df	p-value
VO_2 at VT1 ($L{\cdot}min^{-1}$)	2.2 ± 0.4	2.5 ± 0.5	0.24 ± 0.33	-3.892	28	0.001*
Power at VT1 (W)	157.8 ± 41.8	176.7 ± 41.1	18.97 ± 36.39	-2.807	28	0.009*
VO_2 at VT2 ($L{\cdot}min^{-1}$)	2.9 ± 0.6	3.0 ± 0.6	0.17 ± 0.36	-2.528	28	0.017*
Power at VT2 (W)	229.3 ± 62.0	244.8± 55.2	15.52 ± 34.34	-2.433	28	0.022*
VO_{2max} ($ml{\cdot}kg^{-1}{\cdot}min^{-1}$)	45.9 ± 8.2	48.6 ± 7.5	2.67 ± 4.25	-3.382	28	0.002*
Maximal power output (W)	293.1 ± 63.7	307.8 ± 58.7	14.66 ± 14.20	-5.557	28	0.000*
Half cooper (km)	1.37 ± 0.22	1.43 ± 0.22	0.05 ± 0.12	-2.007	21	0.058
Pace of the swim text 5x100m (sec)	102.5 ± 21.0	100.3 ± 17.9	-2.27 ± 10.91	0.977	21	0.340
Grip strenght (kg)	90.8 ± 27.0	92.1 ± 26.9	1.36 ± 14.75	-0.488	27	0.629
Sit and reach (cm)	26.6 ± 9.0	24.4 ± 10.5	-2.17 ± 4.20	2.739	27	0.011*

*Significant difference between evaluation

Table 6. Body composition changes.

Variable	January 2016	June 2016	Mean differences	t	df	p-value
Weights (kg)	72.7 ± 13.4	72.3 ± 12.0	-0.36 ± 3.16	0.599	27	0.544
Waist circumference (cm)	83.2 ± 10.0	81.8 ± 9.5	-1.44 ± 3.43	2.263	28	0.032*
Body fat (%)	23.4 ± 7.5	23.6 ± 7.0	0.23 ± 3.11	-0.389	27	0.700
Visceral fat (%)	7.2 ± 3.0	6.7 ± 2.7	0.50 ± 1.17	2.260	27	0.032*
Lean body mass (%)	35.5 ± 5.0	35.2 ± 4.6	-0.32 ± 2.00	0.864	27	0.395
BMI (kg/m^2)	25.0 ± 2.7	24.7 ± 2.4	-0.31 ± 0.84	1.967	27	0.060

*Significant difference between evaluation

DISCUSSION

The goal of this project was to observe the physiological adaptation of an exercise training periodization of 24 weeks on different parameters amongst amateur triathletes. The success rate for completion of their first-time half-Ironman was very high. The only triathlete that did not complete the event dropped out of the race after the 90 km bike ride due to heat stroke. Indeed, it was a particularly hot day in Mont-Tremblant (LONG 46.1185 and LAT 74.5962) on June 26 2016 and the medical staff had many cases of heat stroke that is consistent with Yang and colleague's findings (27). There was one disqualification within the group of participants, but the participant managed to finish the event (the reason for disqualification is unknown). Consequently, reviewing race rules with athletes is important to maximize the athlete's experience. Two of the participants earned a qualification in their age group to participate in the World Championship the following year. It is important to note that although they were new to the half-ironman distance, both had an athletic competitive background at a young age compared to the other participants who had just recently chosen a more active lifestyle.

The training loads and progression were very conservative (10 % build per mesocycle) with only two scheduled training sessions per week for each discipline that represented a training volume of 6.5 to 11.50 hours per week during that period. The global compliance to the program was satisfying, where participants did 69 % of the prescribed training similar to other study (8). Factors that affected the compliance was MSK injuries, illness and sometimes family or work constraint. Swimming was the discipline with the lowest compliance (54 % vs 85 % for cycling and 83 % for running). Swimming is often seen as a burden for many age-groupers without a swimming background and our data reflect that state of mind. In our study, the average compliance for swimming was also lowered by a participant who had a shoulder limitation prior to entering the study. Other reasons that may be evoked for less participation in swimming were: limited pool availability, fear of water, finding it difficult to learn how to swim and finally, since the swimming portion of an Ironman 70.3 event is 2.7 % of the overall event in terms of distance, many athletes don't see the cost-benefit of investing more time in that specific discipline. In fact, the age-grouper's main goal is just completing the event while being healthy rather than aiming for a podium. With that objective in mind, they mainly want to finish the swim efficiently and keep their energy for the rest of the event. The lowest compliance, however, was for the strength and conditioning (SnC) part of the training program (28%). Because age-group athletes have a restricted training schedule due to many factors that include family and/or work obligations, the SnC is often the first training modality to be skipped. Nonetheless, it is important to indicate that the global effect of strength training has an effect on health (and endurance performance for that matter) and should then not be neglected (13). Other reasons why participants did not comply with SnC are: fear of gaining muscle mass (perceived as being associated with lower speed), accumulation of general fatigue, and lack of experience on weightlifting techniques and SnC intensity management. Typically, the reason why endurance athletes engage in serious SnC exercises is when they fear MSK injuries (24). In our project, each MSK injury was assessed by an immediate physiotherapy evaluation. As well, following the PT evaluation, the training plan (volume/intensity) was immediately adjusted according to the type of injury . Specific stabilization/activation and mobility exercises would replace some of the SnC to avoid overstress on the injured structures and rebalance the athlete weaknesses and strengths. Typically, as reported with the occurrence of injuries, when the load applied either acutely or chronically exceeds the tissue's capacity to maintain integrity or its ability to repair between episodes, such as a high volume or a high intensity training session, the risk of MSK injury may increase . Thus, the training plan respected those principles, and perhaps contributed to the low number of MSK injuries in the present cohort, except for one athlete that did not comply with the advice provided and combined a lot of mountaineering activities, such as climbing and backcountry skiing into the program and suffered from a recurrent plantar fasciitis (6)**.** In fact, that specific athlete could not follow through with the running program from the time of the injury until the day of the event, so the athlete was able to complete the event, but was not able to run the entire half marathon.

It is a popular belief that engaging in a long-distance triathlon training will automatically result in a weight loss. However, in this study, no change was observed in total weight or lean and fat body mass in our subjects as a result of the triathlon training period. Nonetheless, taking a closer look at body composition, no change was observed in both lean and fat body mass. Rapid weight loss associated with overtraining often leads to a loss of lean body mass (19, 26). Therefore, the fact that our participants kept their lean body mass for the duration of the project is a positive finding. The interesting and particularly important part is that our data shows a reduction in WC that is typically associated with a loss of visceral fat (4). It is well established that WC and visceral fat are also associated with risk of cardiovascular disease (11). The present study demonstrates that participants can decrease this risk factor with a triathlon training regimen. Kandel and colleagues (9) reported that the somatotype of an athlete could be a strong predictor of performance in an Ironman event. We did not assess somatotype of the participants, but the hypothesis was that a lower WC may also have contributed to changing one's somatotype and therefore an increased performance (example: being less endomorph with a lower WC). Even if there was no significant weight loss, the participants increased their metabolic profile as reflected by a better WC and lower visceral fat accumulation. One hypothesis to explain the absence of significant weight loss is that amateur triathletes often tend to eat a little more and treat themselves with food after hard training sessions. Since nutritional assessment was not part of this project, it could be interesting for future projects to test that hypothesis. Nonetheless, it is important to track food in accordance with each macrocycle of the training program as a means of optimising the training program and the health benefits related to long distance training (10).

The major health related improvement associated with the training program was a significant increase in $\dot{V}O_2max$ (mean differences of 2.67 ± 4.25 ml·kg·min). As $\dot{V}O_{2max}$ is a strong predictor of general health, the data presented herein demonstrates that age-group athletes are capable of improving their cardiovascular fitness with this type of program. In a training perspective, it is also well established that one of the elements that may predict better performance in long distance events is a better power output at the ventilatory threshold (20). The data of the present study supports this notion with an increase in power output at both ventilatory threshold 1 (mean differences of 18.97 ± 36.39 W) and 2 (mean differences of 15.52 ± 34.34 W). Participants can produce more power and spare energy during a long duration effort such as is needed in long distance triathlon. Our results are therefore in accordance with Munoz et al. who reported that the larger the amount of time of training spent below the 1st ventilatory threshold (in zone 1), the better performance will be when athletes maintain an effort above the 1st ventilatory threshold (in zone 2)(20). Finally, there were no significant changes in grip strength and sit and reach results. Beside the SnC section of the periodization, there was no primary goal to increase those fitness variables. Nevertheless, we are comforted by the fact that flexibility and strength were not lost in the process.

This project is one of the first to measure favourable physiological adaptations of amateur triathletes preparing for their first Ironman70.3^{tm} event, i.e., an increase in $\dot{V}O_2max$ and rightward shifts of ventilatory threshold 1 and 2. As well, it is important for coaches to consider the health status and training experience of age-group athletes before engaging into the journey of long-distance triathlon. As this study demonstrates, it is important for coaches to work with a multidisciplinary team that is specialized and knowledgeable in long distance triathlons in order to enhance the chance of success and the safety of the training plan. In that regard, it is important to adapt the training plan quickly in accordance with athlete responses or injuries concurred by the athletes during the training period (ex. in a case of a MSK injury). Amateur athletes and coaches that consider completing a first half-ironman race may consider the results obtained in the current study to complete their journey.

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