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Changes of the energetic profile in masters' swimmers over a season

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Aim. **The aim of this study was to track and compare the changes of performance and energetic profile of male and female masters swimmers during a season.**

Methods. **Eleven female (age: 34.7±7.3-y) and fourteen male (age: 35.6±7.4-y) with 4.2±3.7-y and 3.9±1.6-y of experience in masters, respectively, performed an all-out 200 m freestyle to evaluate total energy expenditure (E_{tot}), aerobic (Aer), anaerobic lactic (AnL) and alactic (AnAl) contributions. The oxygen uptake (VO_2) was measured immediately after the 200 m trial and the VO_2 reached during the trial was estimated through the backward extrapolation of the O_2 recovery curve. Fingertip capillary blood samples were collected before the 200 m trial and 3, 5, and 7 minutes after its end.**

Results. **Significant differences were observed between male (TP_1:177.50±30.96s; TP_2:174.79±29.08s; TP_3:171.21±22.38s) and female (TP_1:205.18±24.47s; TP_2: 197.45±20.97s; TP_3: 193.45±18.12s) for 200 m freestyle performance at the three time periods (TPs). Male presented higher E_{tot} in all TPs (TP_1:230.40±48.40kJ; TP_2:242.49±37.91kJ; TP_3:257.94±46.32kJ) compared with that found for female swimmers (TP_1:188.51±35.13kJ; TP_2:193.18±20.98kJ; TP_3:199.77±25.94kJ). Male presented higher AnL (TP_1:33.42±6.82kJ; TP_2:30.97±8.73kJ; TP_3:30.66±8.27kJ) and AnAl (TP_1:30.61±3.48kJ; TP_2:30.61±3.48kJ; TP_3:30.60±3.48kJ) than female (TP_1:18.83±8.45kJ; TP_2:14.98±4.17kJ; TP_3:18.33±8.66kJ) and (TP_1:24.32±2.22kJ; TP_2:24.31±2.23kJ; TP_3: 24.31±2.23kJ). Aerobic metabolism is the major contributor for E_{tot} both in male (TP_1:71.63±4.99%; TP_2:74.05±5.03%; TP_3:76.14±4.46%) and female swimmers (TP_1:76.87±3.86%; TP_2:79.40±3.63%; TP_3:78.40±5.54%). Partial aerobic contribution was higher in female, while partial anaerobic contribution was greater in male.**

Conclusion. **The better performance obtained by male compared to female swimmers may be due to the different contributions of the energetic pathways. Aerobic metabolism was the major contributor to E_{tot} in a 200 m race, in both genders.**

Key words: Resistance Training - Sex - Metabolism - Swimming.

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In recent years, given the growth in sport participation by masters athletes and the interest that individuals have in healthy sport participation with the advancing of age, the enhancement of the performance of masters athletes has received increasing attention.[1] Masters athletes include ancient elite athletes,[2] "weekend athletes" who sporadically train and compete, and older competitors who have resumed training after long periods of physical inactivity.[3] The motivation beyond the participation of such athletes in competitions or of being involved in regular exercise is related with social aspects (e.g. enjoyment, travel, stress relief) and skill development factors like competition, physical fitness, health benefits, and personal challenge.[4, 5] Swimming is probably the most or, at least, one of the most popular sports for masters athletes, providing an excellent opportunity to investigate the effects of age in the metabolic/biomechanical determinants of performance,[6] avoiding physical inactivity as a potential confounding factor.[7]

Swimming performance declines with age [2, 8, 9] which may be a result of a decreased training external load [10] and physiological response to exercise.[11] The ability to produce mechanical work in swimming is determined by the ability of the muscle cells to provide energy. There are three pathways to re-synthetize ATP (aerobic, anaerobic lactic and anaerobic alactic) and, therefore, to satisfy the energy requirements of muscles.[12] Therefore, the amount of energy necessary to perform one task (E_{tot}) represents the sum of aerobic and anaerobic (lactic and alactic) contributions.[12-14] The number of works dealing with performance-oriented masters swimmers is scarce and mainly focuses the effects of age on performance. There are no longitudinal or cross-sectional studies related with aerobic and anaerobic contributions in masters swimmers. For this reason, the data reported for elite swimmers will be used as reference.

On top of that, most swimming research is based on cross-sectional designs. There are some claims that only longitudinal designs (follow-up and intervention programs) can deliver deep insights about such relationships. The influence of training in performance (longitudinal designs) has already been addressed but only for younger, sub-elite and elite swimmers.[15]

The aims of this research were to assess the energetic contributions to the performance in masters swimmers over one season, and to compare the performance and energetic profiles between genders. It was hypothesized that swimming performance is influenced by energetic factors in both genders and, that there is a gender difference in such relationship between men and women.

Material and methods

A longitudinal research design was carried out, being the swimmers assessed in three different time periods (TPs) over a season: December (TP_1), March (TP_2) and June (TP_3). In each TP, the 200 m freestyle performance was assessed. Moreover, the oxygen uptake (VO_2) at the end of the 200 m and the maximal blood lactate concentration (from fingertip capillary blood samples), before the 200 m trial and, also, 3, 5, and 7 minutes after its end, were measured. Then, VO_2 was used to calculate the aerobic contribution (Aer) and the maximal blood lactate concentration (La_{peak}) was used to calculate the anaerobic lactic (AnL). The Aer, AnL and anaerobic alactic (AnAl) contributions enabled the estimation of the total energy expenditure (E_{tot}).

Subjects

Eleven female (age: 34.7±7.3-y; height: 1.63±0.05-m; body mass: 58.5±5.4-kg; Body Mass Index: 22.1±1.8 kg·m^{-2}; 4.2±3.7-y of experience in masters age-group) and fourteen male (age: 35.6±7.4-y; height: 1.76±0.06 m; body mass: 73.7±8.3 kg; Body Mass Index: 23.7±2.7 kg·m^{-2}; 3.9±1.6-y of experience in masters age-group) volunteered to serve as subjects. Twelve of the swimmers have been old athletes and the remaining ones started to swim only a few years ago.

All subjects gave their written informed consent before participation. The study was approved by the local ethics committee and is in accordance to the Declaration of Helsinki.

Procedures

Swimming performance was assessed based on time lists of the 200 m freestyle events during local, regional and national competitions. The time between the official competition and the testing day never exceeded more than two weeks.

A 200 m freestyle time trial performed in a 25 m length swimming pool was used to evaluate the performance and the swimmers' energetic adaptations. In addition, the elapsed time for 200 m was measured with a stopwatch (S141, Seiko, Tokyo, Japan) by two expert evaluators (ICC=0.98). The oxygen uptake (VO_2) was measured immediately after the end of the 200 m trial (K4b^2, Cosmed, Rome, Italy). The swimmers were instructed to breath during the last cycle before touching the wall. After finishing the trial, the swimmer leaned on the wall, while an operator fixed a portable mask on his/her face during all the recovery period. No breathing cycle was made until the portable mask was on the swimmer's face. The VO_2 (in $mL \times kg^{-1} \times min^{-1}$) reached during the trial was estimated through the backward extrapolation of the oxygen (O_2) recovery curve (mean value calculated within 6 s after the VO_2 detection, during the recovery period).[16] The first measure of VO_2 before the highest VO_2 measurement was not considered, because it corresponded to the device adaptation to the sudden change of respiratory cycles and to O_2 uptake. The device adaptation never exceeded 2 s.[16, 17]

Fingertip capillary blood samples were collected before the 200 m and at the 3rd, 5th, and 7th minutes after finishing the trial. Samples were then used to determine blood lactate concentrations (Accusport, Boherinnger Mannheim, Germany). The maximal blood lactate concentration (La_{peak}) was considered to be the highest blood lactate concentration in post-exercise condition.[14]

The total energy expenditure (E_{tot}, in kJ) was calculated for the 200 m trial, corresponding to the swimmer's maximal effort:[13]

$$E_{tot}=Aer+Anl+AnAl$$

where Aer represents the aerobic contribution (in kJ) based on the total oxygen volume, Anl is the energy derived from lactic acid production (in kJ) and AnAl stands for the energy derived from phosphocreatine (PCr) splitting in the contracting muscles (in kJ).

The total oxygen volume consumed during the 200 m was estimated as:

$$VO_2=VO_2net \cdot t \cdot M$$

where VO_2net (in $mL \times kg^{-1} \times min^{-1}$) is the difference between the oxygen uptake measured during exercise and at rest, t (in min) is the total duration of the effort and M (in kg) is the mass of the subject. Aerobic contribution was then expressed in kJ assuming an energy equivalent [13] of 20.9 $kJ \times lO_2^{-1}$.

The O_2 equivalent (in mL O_2) was obtained according to:

$$O_2Eq=La_{net} \cdot 2.7 \cdot M$$

where La_{net} represents the difference between the lactate measured at the end of the 200 m trial and the lactate at rest; 2.7 is the energy equivalent (in mL $O_2 \times mmol^{-1} \times kg^{-1}$) for lactate accumulation in blood.[18] Thus, the anaerobic lactic contribution (in mL O_2) was expressed in kJ assuming [13] an energy equivalent of 20.9 $kJ \times l\ O_2^{-1}$.

Lastly, the alactic contribution (AnAl) can be calculated as:

$$AnAl=PCr \cdot (1- e^{-t/\tau}) \cdot M$$

where t is the time duration, τ is the time constant of PCr splitting at work onset (23.4 s, as proposed by Binzoni *et al.*)[19] and PCr is the phosphocreatine concentration at rest. The energy derived from the utilization of the PCr stores was estimated assuming that, in the transition from rest to exhaustion, the PCr concentration decreases by 18.5 $mM \times kg^{-1}$ muscle (wet weight) in a maximally active muscle mass (assumed to correspond to 30% of body mass).[20] AnAl can be expressed in kJ by assuming [21] a P/O_2 ratio of 6.25 and an energy equivalent of 0.468 $kJ \times mM^{-1}$.

Statistical analysis

The normality of distributions was verified using Shapiro-Wilks Tests. Parametric or non-parametric tests were selected accordingly. Mean plus one standard deviation and quartiles were computed for each TP. Data variation was assessed with ANOVA repeated measures followed by the Bonferroni post-hoc Test ($P \leq 0.05$), or Wilcoxon Signed-Rank Test ($P \leq 0.05$), to assess differences between time periods. The differences between genders were analyzed with Independent Sample t-Test, except for the aerobic contribution in TP_1, which was analyzed with the Mann-Whitney U Test ($P \leq 0.05$). Cohen's d was selected as effect size index, with $0.20 \leq d < 0.50$ representing a small effect, $0.5 \leq d < 0.80$ a moderate effect, and $d \geq 0.8$ a large one.[22]

Results

Swimming performance

The 200 m freestyle performance of males presented an insignificant improvement throughout the season (TP_1-TP_2:-1.5%; TP_2-TP_3:-2.0%; TP_1-TP_3:-3.5%). On the other hand, for females significant variations were found between TP_1-TP_2 (-3.8%), and TP_1-TP_3 (-5.7%). Comparing both genders, males always performed better than females (TP_1: P=0.02, d=0.99; TP_2: P=0.04, d=0.89; TP_3: P=0.01, d=1.13) (Figure 1).

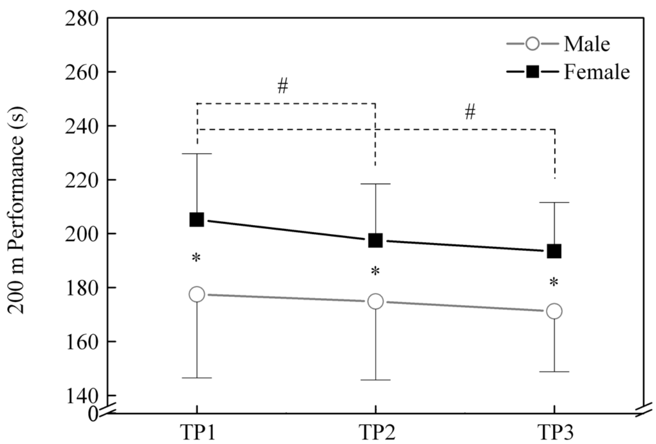

Figure 1.—Mean±SD values of the 200 m freestyle performance in the three TPs.
*Significant differences between genders (TP_1: P=0.02; TP_2: P=0.04; TP_3: P=0.01).
#Significant differences in female 200 m performance between TP_1-TP_2 (P<0.001); TP_1-TP_3 (P<0.001).

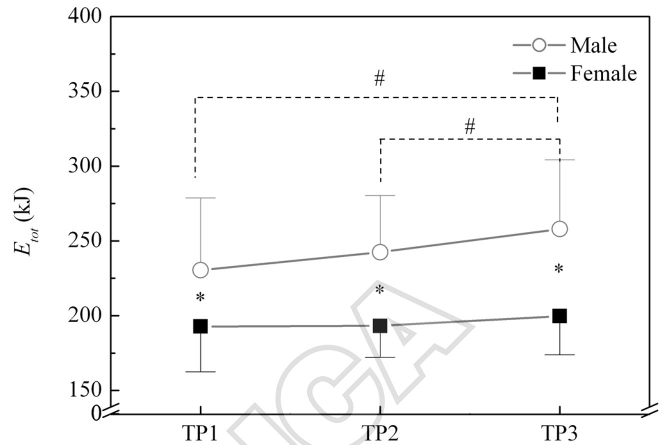

Figure 2.—Mean±SD values of the energy expenditure (E_{tot}) in the three TPs.
*Significant differences between genders (TP_1: P=0.02; TP_2: P<0.001; TP_3: P<0.001).
#Significant differences in male E_{tot} between TP_2-TP_3 (P=0.04) and TP_1-TP_3 (P<0.001).

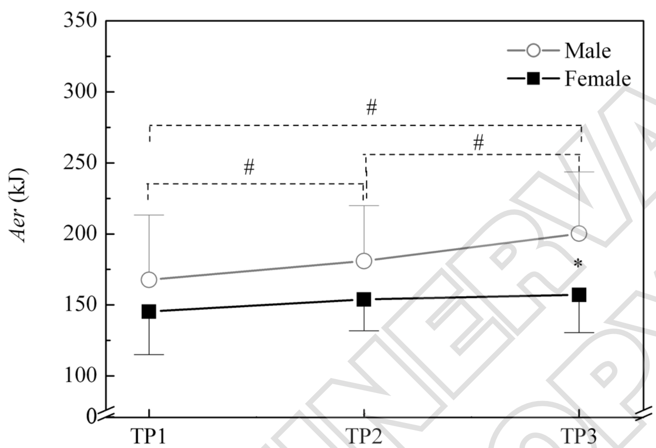

Figure 3.—Mean±SD values of the aerobic contribution (Aer) in the three TPs.
*Significant difference between genders (TP_3 p=0.01).
#Significant differences in male Aer between TP_1-TP_2 (P=0.03); TP_2-TP_3 (P=0.01); TP_1-TP_3 (P<0.001).

Total energy expenditure

The E_{tot} value presented a negligible increase from TP_1-TP_2 (5.2%) and a significant one from TP_2-TP_3 (6.4%) and TP_1-TP_3 (12%) in males. The remaining increases were not significant in both genders. Females presented insignificant increases over the season (TP_1-TP_2: 2.5%; TP_2-TP_3: 3.4%; TP_1-TP_3: 6.0%). In all TPs, males presented a higher E_{tot} value than that calculated for females (TP_1: P=0.02, d=0.99; TP_2: P<0.001, d=1.61; TP_3: P<0.001, d=1.54) (Figure 2).

Energetic pathways

The aerobic contribution in male swimmers increased significantly from TP_1-TP_2, TP_2-TP_3 and TP_1-TP_3 (7.9%, 10.7% and 19.4%, respectively). However, female swimmers showed a smaller increase from TP_1-TP_2, TP_2-TP_3 and TP_1-TP_3 (5.9%, 2.1% and 8.1%, respectively). Comparing both groups, female swimmers presented a significantly lower aerobic contribution than males in TP_3 (P=0.01) (Figure 3). Cohen's d value presented a moderate effect in TP_1 (d=0.58) and a large one in TP_2 (d=0.85) and TP_3 (d=1.20).

The anaerobic lactic contribution (Figure 4) decreased for males, from TP_1-TP_2 (-7.3%), TP_2-TP_3 (-1.0%) and TP_1-TP_3 (-8.3%). In females, that contribution showed a decrease between TP_1-TP_2 (-20.4%), but increased from TP_2-TP_3 (22.4%) and finally decreased once again from TP_1-TP_3 (-2.7%). A higher anaerobic lactic contribution was found for males (TP_1: P<0.001, d=1.90; TP_2: P<0.001, d=2.33; TP_3: P<0.001, d=1.46).

A decrease in La_{peak} was determined for males throughout all TPs: TP_1-TP_2 (-3.9%); TP_2-TP_3 (-2.3%); TP_1-TP_3 (-6.1%) whereas La_{peak} in fe-

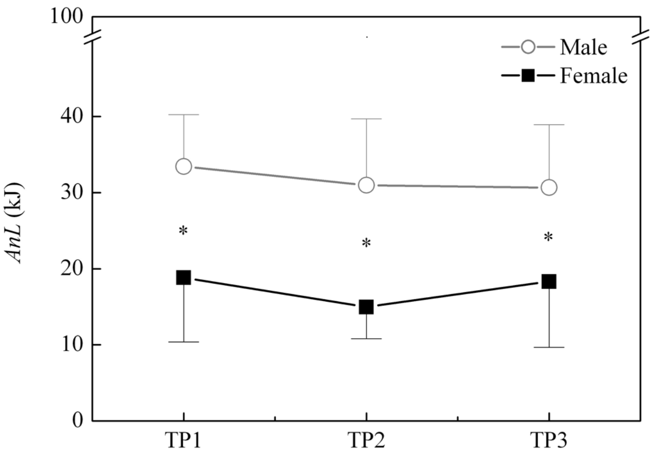

Figure 4.—Mean±SD values of the anaerobic lactic contribution (AnL) in the three TPs.
*Significant differences between genders (TP_1: P<0.001; TP_2: P<0.001; TP_3: P<0.001).

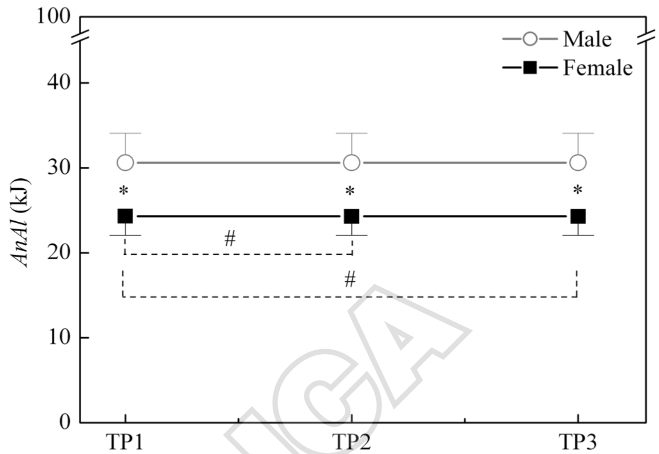

Figure 5.—Mean±SD values of the anaerobic alactic contribution (AnAl) in the three TPs.
*Significant differences between genders (TP_1: P<0.001; TP_2: P<0.001; TP_3: P<0.001).
#Significant differences in female AnAl between TP_1-TP_2 (P=0.02); TP_1-TP_3 (P<0.001).

males decreased from TP_1-TP_2 (-11.6%), increased slightly from TP_2-TP_3 (3.1%) and decreased from TP_1-TP_3 (-8.1%). Comparing genders, the values of La_{peak} were higher in males (TP_1:10.02±2.08 mmol·l^{-1}; TP_2:9.63±2.66 mmol·l^{-1}; TP_3:9.41±1.88 mmol·l^{-1}) compared to that measured for females (TP_1:7.64±2.54; TP_2:6.75±1.34 mmol·l^{-1}; TP_3:6.96±1.60 mmol·l^{-1}). Cohen's d revealed large effects in all TPs (TP_1: d=1.03; TP_2: d=1.37; TP_3: d=1.40).

Finally, anaerobic alactic contribution (Figure 5) presented variations over time in the female group. Also, there were significant differences between genders (TP_1: P<0.001, d=2.15; TP_2: P<0.001, d=2.15; TP_3: P<0.001, d=2.25).

Partial contribution to total energy

Aerobic metabolism (%Aer) was the major partial contributor for E_{tot} in both genders (Table I). Anaerobic alactic (%AnAl) and anaerobic lactic (%AnL) metabolism were the second major contributors for E_{tot} in female and male, respectively. Male swimmers increased significantly %Aer from TP_1-TP_2 (P=0.03, 3.4%) and TP_1-TP_3 (P=0.01, 6.3%), whereas between TP_2-TP_3 a non-significant increase was obtained (2.8%). Female swimmers showed a non-significant increase from TP_1-TP_2 (3.3%), a decrease from TP_2-TP_3 (-1.3%) and, finally, an increase from TP_1-TP_3 (2.0%). Comparing both genders, female swimmers had a significantly higher %Aer in TP_1 (P=0.01) and TP_2 (P=0.01) than male, whereas in TP_3 non-significant differences were found between genders. Cohen's d values revealed large effects in TP_1 (d=1.17) and TP_2 (d=1.22), but small in TP_3 (d=0.45).

In male swimmers, %AnL decreased significantly (-19%) between TP_1-TP_3 (P=0.04). However, from TP_1-TP_2 and TP_2-TP_3, %AnL showed non-significant decreases (-11.2% and -8.8%, respectively). In female swimmers, a non-significant decrease from TP_1-TP_2 (-20.0%), an increase from TP_2-TP_3 (17.1%) and a decrease from TP_1-TP_3 (-6.3%) were found. Comparing genders, male reached significantly higher %AnL in TP_1 (P<0.001) and TP_2 (P<0.001) than female. Considering Cohen's d, TP_1 and TP_2 had a large effect (d=1.41, d=1.40, respectively) while TP_3 presented a moderate one (d=0.65).

Male swimmers had a significant variation in %AnAl from TP_1-TP_2 (P=0.04), TP_2-TP_3 (P=0.02) and TP_1-TP_3 (P<0.001), decreasing -5.7%, -7.0% and -12.3%, respectively. On the other hand, female swimmers showed a non-significant decrease between TP_1-TP_2 (-4.1%), TP_2-TP_3 (-2.8%), TP_1-TP_3 (-6.7%). There were no significant differences in AnAl between genders and the Cohen's d values reveled small gender effects (TP_1: d=0.18; TP_2: d=0.11; TP_3: d=0.22) in all the three TP.

TABLE I.—*Partial contribution of aerobic (%Aer), anaerobic lactic (%AnL) and anaerobic alactic (%AnAl) energy sources to total metabolic power output for both genders in the 200 m freestyle race over a full season.*

	Female			Male		
	TP_1	TP_2	TP_3	TP_1	TP_2	TP_3
%Aer	76.87±3.86*	79.40±3.63*	78.40±5.54	71.63±4.99*#	74.05±5.03*#	76.14±4.46#
%AnL	9.94±3.41*	7.95±2.76*	9.31±4.71	14.76±3.44*#	13.11±4.41*	11.96±3.32#
%AnAl	13.19±2.02	12.65±1.14	12.30±1.48	13.61±2.54#	12.84±2.13#	11.94±1.82#

* Significant difference between male and female masters swimmers %Aer TP_1 (P=0.01) and %Aer TP_2 (P=0.01); %AnL TP_1 (P<0.001) and %AnL TP_2 (P<0.001); # significant difference in male %Aer between TP_1-TP_2 (P=0.03), TP_1-TP_3 (P=0.01); %AnL between TP_1-TP_3 ((P=0.04); %AnAl between TP_1-TP_2 (P=0.04); TP_2-TP_3 (P=0.02); TP_1-TP_3 (P<0.001).

Discussion

The aim of this study was to compare the changes of performance and energetic profile of male and female masters swimmers over a season. Female improved their performance throughout the season and presented lower Aer, AnL and AnAl contributions than male. The major contributor for E_{tot} in both genders was %Aer, followed by %AnL for male and %AnAl for female.

Swimming performance

Male and female masters swimmers improved their performance over the season, but only females presented a significant variation. The power and capacity of the immediate (ATP-PCr), short-term (anaerobic glycolysis), and long-term (oxidative phosphorylation) systems of energy production are the major factors in determining swimming performance.[23] Over the season, we found a decrease in the anaerobic contributors in women, although only AnAl showed meaningful decreases. The AnL decreased by 20.4% from TP_1-TP_2 and, otherwise, Aer increased 5.9%. In male swimmers, in the same timeframe, the magnitude of AnL decrease was not as sharp as the one found in female (-7.3%). Moreover, the Aer improvement in males was similar to that seen in women (7.9%). Not surprisingly, men had better performances than women. This can be explained by the different contribution of the energetic pathways for the overall energy expenditure, which is notably the highest deliver from the anaerobic pathway (AnL and AnAl) by male compared to female.

Total energy expenditure

The increase in E_{tot} observed for both genders may be related with the increase in speed.[24] The improvement of swimming performance observed in the female swimmers may be one of the reasons for the slight increase verified in this cohort group. Comparing these results with those in the literature reported for younger and elite swimmers,[25, 26] both male and female masters presented lower E_{tot} values. This difference may rely on the sample characteristics (masters vs. elite) and age group (masters vs. young swimmers).

Energetic pathways

The higher aerobic workout in the masters training is one of the characteristics of this cohort. Comparing both genders, female swimmers present a significant aerobic contribution but lower than that found in their male counterparts. Two major reasons can be put forward:[27] lower blood hemoglobin concentration and smaller size of the heart in relation to total muscle mass in females, compared to men resulting in a less oxygen-carrying capacity.

The lack of improvement in AnL and AnAl for both genders can be attributed to the lower anaerobic training load (TP_1: 7.19%; TP_2: 9.65%; TP_3: 8.64%) throughout the season. Indeed, this is a characteristic reported for training sessions of masters athletes and periodization programs[11]. Furthermore, the decrease in anaerobic performance may also be attributed to changes in morphological factors (decreased muscle mass and type II muscle fiber atrophy), muscle contractile property (decreased rate of force development) and biomechanical aspects (changes in enzyme activity and decreased lactate production) arising from ageing.[28] The AnL is also gender dependent. The major mechanism explaining this gender difference in anaerobic performance appears to be related to the greater rates of type II fiber atrophy [29] and to the lower peak blood lactate following anaerobic performance [28] exhibited by women. The type II fiber uses anaerobic metabolic processes to generate ATP, enabling short contraction time and the ability to produce high tension.[28] Therefore, it is expected that female swimmers muscles lose their ability for power strength as a result of the preferential fibers atrophy [29] and lower anaerobic contribution.

Women have less lean muscle in relation to total body weight and lower total stores of ATP, PCr and glycogen than men.[30] Moreover, older women present type I and type II fibers with smaller areas than older men.[10]

Partial contribution to total energy

The %Aer was the major partial contributor for E_{tot} in both genders whereas the %AnAl and %AnL were the second one for females and males, respectively. Each system is best suited to provide a higher contribution to ATP re-synthesis according to the race characteristics. The role of aerobic energy system during high intensity exercise was reported by Gastin [12] and the data of the present study are in agreement with previous studies as well.[21, 24-26] The increase of %Aer verified in both genders is probably due to the higher percentage of workout focused on the aerobic capacity. The aerobic contribution expressed as a percentage of total work accomplishment is greater in female compared with male; otherwise %AnL and %AnAl are higher in male. Comparing both genders, the greater aerobic contribution, obtained in women compared to men may be assigned to the lower swimming speed achieved.[31] For shorter distances, the anaerobic performance of elite male masters swimmers in 50 m and 100 m is 10% better than female masters. This can be explained by gender differences in muscle mass, lower La_{peak} and greater rates of type II fiber atrophy.[8]

Available literature reports that the major contributor to E_{tot} is also %Aer even though no study recruited masters swimmers as subjects. An effort of about 75 seconds derives energy from both aerobic and anaerobic energy sources and, from this moment, aerobic metabolism increases while the anaerobic contribution decreases,[12] which is what occurs in the 200 m trial. Masters swimmers have a higher prevalence of aerobic workout during their training whereas younger swimmers train for endurance, strength, speed, and power.[10] The %AnL values were lower than those obtained by Capelli *et al.*,[21] and Pendergast *et al.*[24] With increasing age, anaerobic capacity decreases [7, 8, 28] and the human skeletal muscle undergoes both structural and functional changes, the most striking of which are the reduction in muscle volume and muscle strength.[32] The area of muscle mass of old individuals was found to be significantly smaller and the total number of fibers significantly fewer than those of young individuals. The number of fibers seems to have the greatest influence on the muscle area. For all age groups, average type II fiber size is diminished with age while the size of type I fibers is much less affected, marking short contraction time and the ability to produce high tension, as already mentioned.

The %AnAl values are similar to those obtained by Capelli *et al.* [21] and Sousa *et al.* [26] being, however, lower than those of Pendergast *et al.* [24] and Figueiredo *et al.*[25] These differences may be attributed to the method of estimation of AnAl. Capelli *et al.* [21] considered that PCr concentration decreases, in transition from rest to exhaustion, by 18.5 mM×kg^{-1} muscle (wet weight) in a maximally active muscle mass equal to 30% of the overall body mass (similar to our study), but Figueiredo *et al.* [25] found that this value was 27.75 mM×kg^{-1} and assumed that the maximally active muscle mass corresponds to 50% of body mass. This last assumption does not seem to be appropriate for masters swimmers since, with ageing, there is a decrease in skeletal muscle mass [33] whereby it is unlikely that 50% of the total mass corresponds to muscle mass. Thus, assuming the value of 30% of active muscle mass seems to be more appropriate for this age group.

Conclusions

The better performance obtained by male compared with female swimmers may be due to the different contributions of energetic pathways. Male swimmers present higher Aer, AnL and AnAl contributions than female. Aerobic metabolism was the major contributor to E_{tot} in a 200 m race, in both genders. Partial aerobic contribution was higher in female, while partial anaerobic contribution was greater in male.

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