Physiological and Performance Improvements during a Training Season in Paralympic Rowers

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¹Departamento de Biologia Estrutural e Funcional, Instituto de Biologia (IB), Universidade Estadual de Campinas (UNICAMP), Campinas, SP, Brazil, ²Laboratório de Pesquisa do Exercício (LAPEX), Faculdade Social da Bahia (FSBA), Salvador, BA, Brazil, ³Departamento de Nutrição da Universidade de Pernambuco (UPE), Petrolina, PE, Brazil, ⁴Departamento de Fisioterapia da Universidade de Pernambuco (UPE), Petrolina, PE, Brazil

ABSTRACT

Zoppi CC, Santos-Júnior CR, Guerreiro TS, Porto YC, Montenegro IHPM, Silva TFA, Schwingel PA. Physiological and Performance Improvements during a Training Season in Paralympic Rowers. JEPonline 2014;17(3):88-101. This study followed a full training process and examined variations in physical, physiological, and performance parameters in Paralympic rowers. Eight African-Brazilian male international level adaptive rowers (25 ± 5.3 yrs) were submitted to a training protocol that consisted of 4 phases. The physiological and performance improvements were assessed at the beginning and at 6, 12, 24, and 32 wks of training. Total body mass, muscular strength, power at 4 mM blood lactate, fatigue index, and a 1000-m time-trial were significantly improved after the specific training phase (24 wks), and were maintained until the end of the competitive training phase (32 wks). Sum of skinfolds at 6 sites showed significant reduction before the competition (32 wks). Three subjects achieved performance level to compete at 2008 Beijing Paralympic Games. The results demonstrate that the adaptive rowers tolerated completely the training process, which allowed them to achieve a high training level of physiological and performance improvements.

Key Words: Disabled Persons, Rowing, Training, Physical Fitness, Exercise Performance
INTRODUCTION

Although rowing is a strength and endurance sport, it also requires important training adjustments in biomechanical and physiological factors. In particular, different types of muscle fibers as well as the athlete’s physical work capacity influence performance. Power output and race performance depend on aerobic and anaerobic energy supplies (22,23), mechanical force application (1), and technical skills determine the athlete’s efficiency (14,18). In addition, rowing performance is highly correlated with anthropometric characteristics (1), mean and peak anaerobic power output (3,29) to elicit 4 mM blood lactate concentration, and maximum oxygen uptake ($ VO_2$ max) (9).

All the physiological factors that go into determining the athlete’s rowing performance cannot be developed at the same time (5,6,12,34). That is why the training process of successful rowers has to be built up with a focus on aerobic training first, which is then followed by the development of a proper relationship with strength and anaerobic training. The actual rowing training process is approximately 70% of aerobic training, 25% of aerobic-anaerobic training, and the remaining 5% is purely destined to improve anaerobic and strength capacity of which the development in muscle strength is generally carried out during non-competitive periods (5,17,34). Thus, the training process is designed to help ensure that each physiological factor is developed accordingly while avoiding undesirable effects of an imbalance in the training-recovery process (35).

Adaptive rowing is a special category of rowing race for athletes with various physical disabilities who meet the criteria set out in the Paralympic rowing classification (32). Adaptive implies that the equipment is adapted to the user to train for the sport rather than the sport being adapted to the user. In spite of the fact that adaptive rowing was added to the World Rowing Championships in 2002 and to the Summer Paralympics in 2008, there is relatively little that is known about the performance-related physiology. In agreement, Hettinga and Andrews (8) state that the physiological observations are confirmed by a limited number of comparisons (particularly for persons with spinal cord injury).

Despite the studies (28,31) that indicate an extremely high peak power output, adaptive rowers exhibit indexes of lactate threshold, strength, and body composition similar to recreational level athletes with impairments, it is apparent that some testing concepts currently applied to able-bodied individuals should not be applied to persons with disabilities (28,31). This is why the race distance of adaptive rowers has been reduced in 2006 by a half of the distance covered by rowers without disability. Whether the observed performance differences between able-bodied and disabled rowers are primarily a function of the rowers’ impairments or the inappropriate training protocols remain to be determined.

To date, it is not known if motor impairment itself limits training-induced physiological adaptations and performance enhancement. From a physiological performance perspective, the decrease in muscle mass from specific motor disabilities would be the primary reason for the decrease in physiological determinants of rowing performance. Several studies (20,26,30) describe able-bodied elite rowing-related injuries (20,26,30) that could have an even greater effect with motor disabilities and impaired training development in athletes with motor limitations (33). Yet, with the right training program that is known to elicit a high degree of stress on the muscular and cardiorespiratory systems to increase muscle strength, anaerobic power, and aerobic power, positive physiological adaptations can improve performance.

Relatively little is known about adaptive rowing performance, including whether the adaptive rowers can tolerate high training loads without experiencing a severe injury. Hence, the purpose of this study was to determine the physiological and performance improvements of Brazilian Paralympic rowers.
during a training season. Our hypothesis was that rowers with motor impairments would tolerate the training load of elite male rowers, but that physiological and performance changes would not be the same as seen in able-bodied rowers.

**METHODS**

**Subjects**

Eight male Afro-Brazilian and international-level Paralympic rowers took part in this study (age, 25 ± 5.3 yrs; height, 172.5 ± 6.2 cm; mean ± SD). All subjects were trained to reach their performance peak for the 2008 Summer Paralympic Games in Beijing. Four subjects had a unilateral traumatic above-the-knee amputation, 1 subject had a unilateral hip disarticulation, 1 subject had Class 5 cerebral palsy, 1 subject had Class 4 cerebral palsy, and 1 subject had a neurological impairment equivalent to a complete lesion at the L3 level.

Four of the 8 subjects were successfully admitted to the Brazilian Paralympic rowing team for the 2007 World Rowing Championships in Munich, Germany. Three subjects competed in the legs, trunk and arms mixed coxed four category (LTAMix4+), 3 subjects competed in the trunk and arms mixed double scull (TAMix2x), and 2 subjects competed in the men’s single, arms, and shoulders (ASM1x). Only the LTAMix4+ used standard boats and sliding seats. In other categories, the boats had a fixed seat.

After being fully informed about possible risks and discomforts associated with the procedures, all adaptive rowers gave their consent to participate in this study. Experimental procedures were conducted according to the principles outlined in the Declaration of Helsinki and were approved by the Ethics Committee on Human Research from the MCO at the Federal University of Bahia (UFBA), Salvador, Brazil.

**Training Schedule**

Table 1 presents the complete training schedule applied to the subjects. The training lasted 7 mths (32 wks). It was designed by the coaches of the Brazilian Paralympic rowing team with the help of publications about elite male rowers without disabilities (5,18).

The rower’s home coach was responsible for providing instruction and supervision during the training period. The complete training protocol was divided into 4 phases:

- **Incorporation** (Phase 1: 6 wks)
- **Basic** (Phase 2: 6 wks)
- **Specific** (Phase 3: 12 wks)
- **Competitive** (Phase 4: 8 wks)

The training volume was progressively increased during Phase 1 until reaching approximately 100 hrs per month, considering the sum of all activities, which was maintained throughout. Intensity was also progressively increased over the training period to prepare physiological systems and avoid injury (13,36).
Table 1. Time Course Training Activities, Intensity, and Volume Schedule.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Training description</th>
<th>Phase I* (hrs·mth⁻¹)</th>
<th>Phase II (hrs·mth⁻¹)</th>
<th>Phase III (hrs·mth⁻¹)</th>
<th>Phase IV** (hrs·mth⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long Distance</strong></td>
<td>Rowing at an intensity that maintained blood lactate between 2 and 4 mM work durations of 60 to 180 min</td>
<td>81</td>
<td>71</td>
<td>53.5</td>
<td>66</td>
</tr>
<tr>
<td><strong>Interval</strong></td>
<td>3 to 10 min long intermittent bouts that elicited blood lactate between 5 and 10 mM</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td><strong>Race Pace</strong></td>
<td>Set distances (500 to 1000 m) performed at 1000 m-competition intensity that elicited blood lactate near 10 mM</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>Over-Speed</strong></td>
<td>Intermittent rowing bouts (100 to 500 m) at near maximal intensity velocities above 1000 m race pace</td>
<td>0</td>
<td>0</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Muscular Endurance</strong></td>
<td>Strength training loads equal to 50% of 1RM and up to 70 repetitions per set</td>
<td>5</td>
<td>5</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td><strong>Training</strong></td>
<td>Strength training loads between 85% and 90% of 1RM with 5 repetitions per set</td>
<td>0</td>
<td>0</td>
<td>7.5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>Exercises used to ensure maintenance of optimal range of motion in the ankles, knees, hips, and shoulders</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Volume was progressively increased during incorporation phase, starting with 40 hrs per week and ending with 100 hrs in the last week. **Training volume was reduced by approximately 10 hrs during wks that preceded competitions. 1RM: one-repetition maximum.

Specific rowing training was held both on-water and using a Concept 2 model D indoor rowing machine (Concept2 Inc., Morrisville, VT, USA) in a proportion of 3:1 sessions (on-water:ergometer). Blood lactate concentration, measured with an Accutrend® Lactate portable analyzer (Roche, Basel, Switzerland), was used to quantify and control the training intensity.

Muscular strength training exercises for the pectoral, scapular, back, and abdominal areas, and for the upper-lower extremity muscles, were conducted using free weights and Atrex® machines (Righetto Fitness Equipment, Campinas, SP, Brazil). Strength-endurance training (Phases 1, 2, and 3) consisted of the following exercises: dumbbell lying row, cambered bar lying row, weighted crunch, dumbbell fly, barbell upright row, lying T-bar row, back extension, flat barbell bench press, seated row, scapular depression and adduction combined with scapular adduction and downward rotation, and 45° leg press. Strength training (Phases 3 and 4) consisted of the following exercises: barbell upright row, flat barbell bench press, dumbbell lying row, lying T-bar row, dumbbell fly, seated row, scapular depression and adduction combined with scapular adduction and downward rotation, and 45° leg press.

**Testing Schedule**
Over the course of the training period, the athletes were evaluated five times. The first evaluation was held immediately before the beginning of the training program, which determined the control values
Before the CO evaluation, the athletes had been on vacation and resting for at least 4 wks. The other four measurements were conducted throughout the training program, at the end of each periodization phase. All procedures were carried out at the same time as the first evaluation day in the 6th, 12th, 24th, and 32nd-wks. While the anthropometric measurements and strength evaluations were conducted on Monday of each evaluation week after the athletes had rested 72 hrs, endurance and anaerobic capacities were evaluated on Wednesday, and performance evaluation were assessed on Friday.

**Anthropometric Measurements**

Total body mass (TBM) was measured on a PL-180 digital scale (Filizola, São Paulo, SP, Brazil). Fat content was estimated by the sum of the skinfolds (∑sf) of the biceps, triceps, subscapular, suprailliac, thigh, and calf using Lange® skinfold callipers (Beta Technology Inc., Santa Cruz, CA, USA) and following the International Society for the Advancement of Kinanthropometry (ISAK) Guidelines (19). The same experienced evaluator took all anthropometric measurements at the same time of day for each measurement.

**Strength Measurements**

Upper and lower body strength was measured in three strength-training exercises that elicited primarily the muscle groups used during rowing. The following exercises were measured according to American College of Sports Medicine guidelines (38): lying T-bar row, flat barbell bench press, and 45° leg press with one repetition maximum (1RM) (Righetto Fitness Equipment, Campinas, SP, Brazil). Detailed procedures are fully described elsewhere (31). A unilateral 45° leg press measurement was adopted for 7 subjects since the majority of the subjects had unilateral amputation. One subject with a complete lesion at the L3 level was excluded from this analysis.

**Endurance, Anaerobic Capacities and Performance Evaluation**

Endurance, anaerobic capacities, and performance were determined using the Concept 2 model D indoor rowing machine (Concept2 Inc., Morrisville, VT, USA). Data acquisition was made by the coupled PM3 software system (Concept2 Inc., Morrisville, VT, USA).

Endurance capacity was measured according to the onset blood lactate accumulation (OBLA) concept (7), which was defined as the power elicited to induce a 4 mM blood lactate concentration (W4mM). Athletes performed a progressive protocol of 3-min stages with a 25-Watt load-increase to induce a rise in blood lactate. At the end of each stage, a 30-µL blood sample was taken from the ear lobe. Lactate was measured using the Accutrend® Lactate portable lactimeter (Roche, Basel, Switzerland) until the blood lactate concentration increased above 4 mM. After that, W4mM was determined by linear regression.

Peak power output (Wpp), mean power output (Wmp), and the deterioration of power output (Fatigue Index [FI]) were determined during a short term maximal intensity exercise using a modified Wingate test adapted to rowing (18). The subjects first warmed-up for 5 min at a comfortable intensity prior to performing a 30-sec all-out effort. Their performance was evaluated by a 1000-m indoor rowing time-trial. Then, they performed a 1000-m rowing interval at their highest possible speed. The researchers orally encouraged the subjects during the test. Performance was determined by the time each rower covered the distance.

**Statistical Analyses**

The data were analyzed using INSTAT (GraphPad Software Inc., San Diego, CA, USA, Release 3.06) and PRISM (GraphPad Inc., San Diego, CA, USA, Release 5.01) software. Initially, descriptive statistics were applied to the Kolmogorov-Smirnov test and to Bartlett’s criteria. Continuous variables
are presented as means and standard errors of means. A one-way repeated measures analysis of variance (ANOVA) was performed to compare different phases. When significant differences were found, a Tukey's post-hoc test was applied. Furthermore, in line with trends in analysis of small sample sizes, statistical treatment included identifying effect sizes (Cohen's d) within confidence intervals set at 95% (95%CI). All statistical methods were two-tailed, P values were calculated and significance level was set to $P \leq 0.05$.

RESULTS

The adaptive rowers tolerated a high training load with no severe injury detected throughout the training process. Repeated ANOVA measurements indicated that differences were present in TBM ($F(4,35) = 27.98$, $P<0.0001$) and $\Sigma_{sf}$ ($F(4,35) = 3.244$, $P = 0.0263$). Despite an initial increase tendency, the prescribed training significantly reduced TBM at the end of Phase 3, which was maintained during the competitive phase (Figure 1); whereas, the $\Sigma_{sf}$ profile no showed alterations until the end of Phase 4 ($F(4,35) = 3.244$, $P = 0.0263$). Furthermore, the Cohen's effect sizes for TBM ($d = -1.03$, 95%CI: -1.84 – -0.22) and $\Sigma_{sf}$ ($d = -0.63$, 95%CI: -1.41 – 0.15) were considered medium negative based on confidence intervals.

![Figure 1. Changes during 32-wk Training Season in Total Body Mass (TBM) and Six Skinfold Thickness Sum ($\Sigma_{sf}$). Results are presented as mean ± SEM in vertical bars (n = 8). *$P \leq 0.05$ compared to Phase 2. **$P \leq 0.01$ compared to CO, Phases 1 and 2. ***$P \leq 0.05$ compared to CO and Phase 1.](image)

Upper and lower body strength increased during the different training phases (Figure 2). Maximal strength values were significantly higher than the control values for the three exercises evaluated after the specific phase of training (Phase 3). Lower body strength, measured by 45° leg press exercise, showed a significant improvement ($F(4,35) = 51.92$, $P<0.0001$) with large effect sizes ($d = 2.70$, 95%CI:1.72–3.67). Lying T-bar row 1RM was enhanced along all phases of training ($F(4,35) = 1211.0$, $P<0.0001$) presenting very large effect sizes ($d = 15.21$, 95%CI:11.79–18.63). The flat barbell bench press 1RM also showed very large effect sizes ($d = 12.01$, 95%CI:9.27–14.75), and increased to nearly 160% above the CO values ($F(4,35) = 838.4$, $P<0.0001$).
Although the means of the power output during maximal intensity exercise remained unchanged (Figure 3), they presented higher values in the first evaluation \((F(4,35) = 26.66, P<0.0001)\) with large negative effect sizes \((d = -3.93, 95\%CI: -5.09 – -2.77)\). The \(W_{mp}\) also presented negative effect sizes \((d = -1.12, 95\%CI: -1.93 – -0.31)\) with similar results among the means of Phases 3 and 4 when compared to CO \((F(4,35) = 94.45, P<0.0001)\).

\(W_{4mM}\) showed a progressive increase throughout the training process \((F(4,35)=94.45, P<0.0001)\). After Phase 4, \(W_{4mM}\) reached significantly higher values than in all previous training phases. It ended the competitive phase with more than twofold peak values compared to baseline levels \((d = 5.30, 95\%CI:3.90–6.70)\). FI revealed a remarkable 68% decrease after the training protocol, which was maintained during the competitive phase. The repeated ANOVA measurements indicated that the effect was significant \((F(4,35) = 400.5, P<0.0001)\), and Cohen’s \(d\) showed a very high negative effect \((d = -6.46, 95\%CI: -8.07 – -4.85)\).
Figure 3. Changes during 32-wk Training Season in Power Output during Maximal Intensity Exercise (Wpp), Mean Power Output (Wmp), Power at 4 mM Blood Lactate (W4mM), and Fatigue Index (FI). Results are presented as mean ± SEM in vertical bars (n = 8). *P<0.01 compared to CO. **P<0.01 compared to the previous phases of training. ***P<0.01 compared to CO and Phase 1. ****P<0.01 compared to CO, Phases 1 and 2.

Performance, which was evaluated by 1000-m time trials, showed significant differences between the training phases \( F(4,35) = 669.7, \ P<0.0001 \). Post hoc analyses revealed a reduction in the execution test time soon after Phase 1 that reached a significant ~50% fall after Phase 3, which was maintained until the end of Phase 4 (Figure 4). In addition, the effect sizes observed were considered extremely negative (d = -13.64 (95%CI: -16.73 – -10.55).

Figure 4. Changes during 32-wk Training Season in 1000-m Time Trial. Results are presented as mean ± SEM in vertical bars (n = 8). *P<0.01 compared to CO. **P<0.01 compared to CO, Phases 1 and 2.
DISCUSSION
The results indicate that the training protocol resulted in an improvement in the athletes’ body composition, power elicited at 4 mM blood lactate, lactate concentration, and muscular strength. The most pronounced improvements were achieved, as expected, at more specific and intense phases of training, reaching peak performance during the competitive phase. According to the results, the proposed training showed very large effect sizes among upper and lower body strength, peak and mean power output at maximum intensity exercise, and the deterioration of power output, resulting in a remarkable increase in rowing performance (evaluated here based on race time). In addition, 3 subjects in the present study achieved the necessary performance level to take part in the Brazilian Paralympic rowing team at the 2008 Beijing Summer Paralympic Games. One subject won a bronze medal (TAMix2x) and the others finished the competition in 9th (ASM1x) and 7th places (LTAMix4+ won rowing adaptive B-finals).

In a previous study by Porto et al. (28), it was reported that rowers with motor impairments showed low levels of performance-related parameters. Given the observations in the present study and the relatively little scientific data concerning this specific population, there are two major questions. First, is it likely that the results might be a function of the lower muscle mass (i.e., from the loss of one limb, paraplegia or decreased sensory function of the lower extremities by cerebral palsy) that limits physiological function? Second, is it the results of an inadequate training protocol with these athletes? Both possibilities seem reasonable, and one does not necessarily exclude the other.

Based on a previous study by Fiskerstrand and Seiler (5), who showed an increase in performance and medals when changes in training were adopted for elite Norwegian able-bodied rowers, the present study was concerned whether the elite adaptive rowers could tolerate the imposed training loads during a complete season without severe injuries. There is evidence of rowing injuries (particularly, lower back pain) due to the repetitive and excessive hyperflexion and twisting during training (30). Other studies (20,26) pointed to trunk and leg strength asymmetry-induced rowing injuries. Leg and trunk asymmetries were found in the present sample as well (data not shown). However, none of the subjects experienced a severe injury throughout this period. This outcome is likely due to the interdisciplinary team of physicians, medical doctors, and physiotherapists who provided care when it was needed. Also, the absence of injuries during this study may have been related to the short period of training. A longer follow-up study is needed to address this issue in elite adaptive rowers.

The present study provides evidence that most performance-related parameters were improved by the training protocol proposed by the coaches of the Brazilian Paralympic rowing team. The rowers’ performance peak occurred following Phase 3 (Specific), which was then maintained during Phase 4 (Competitive). This finding indicates that at least, in part, the prior low performance that was observed by Porto et al. (28) was due to inadequate training.

The training protocol was designed to comply with the periodization principles of progressive and adequate training load enhancement (12,36). Thus, the present training protocol started with an Incorporation phase (Phase 1) to acclimate the athletes from rest to a new training program. Phase 1 took 6 wks during which the total volume was progressively increased until it reached the volume that was maintained thereafter. Phases 1 and 2 were composed of a long-lasting very low-intensity effort (17).

During this period, 70 to 80% of the training was dedicated to extensive aerobic training at intensities that elicited blood lactate concentrations of 2 mM, coupled with a 10 to 20% volume of 10-min bouts of extensive interval training with intensities that raised blood lactate to a maximum of 5 mM. The
remaining activities were dedicated to developing strength-endurance and flexibility. At the end of this first extensive training period, as expected, no significant changes were detected on the studied parameters. However, this period played a pivotal role in creating a solid base of physiological adaptations that allowed for later high intensity loads that helped to avoid injuries (17,36).

Phase 3 was characterized by an increase in training intensity, as suggested by Steinacker (34). During this phase, the long distance training was conducted at intensities that elicited ~4 mM blood lactate concentration. Also, the total volume of the activity was reduced with a concomitant increase in specific high intensity and speed activities. Interval, race pace, over-speed, and strength training represented 40% of the training activities, which were previously supported by the findings of Hagerman (6) and Peterson and colleagues (27).

The decrease in TBM is in agreement with Morris and Payne (25), which demonstrated that after a preparation phase, able-bodied lightweight rowers had lower TBM and body fat mass even though the present study found only a significant reduction in \( \Sigma_{sf} \) at the end of Phase 4 in the disabled rowers. However, this finding is not in agreement with the results presented by Mikulic (24) who reported minimal variation in the body composition of four world-class rowers. The total body mass and fat mass from these heavyweight male rowers remained stable over the annual training cycle. In the present study, the reason for a significant fall in TBM and body fat content after Phases 3 (Specific) and 4 (Competitive) training might be a higher energy expenditure elicited during this period when total training volume was maintained and intensity was increased.

No standardized methods exist for body composition measurement in this specific population (impaired lean body mass assessment). Thus, it is not possible to state precisely the causes of the observed decrease in TBM without a parallel decrease in \( \Sigma_{sf} \). One possible reason may be the decrease in lean body mass, which would not be desired outcome. Most of the other parameters determined by muscle mass showed an improvement. Perhaps, the decrease in TBM followed by \( \Sigma_{sf} \) might have increased the athletes’ relative power and, therefore, their rowing performance (17).

The absence of power output during short-term maximal intensity exercise enhancement was expected and also desired since the athletes already had high levels of \( W_{pp} \) and \( W_{mp} \) similar to that observed in competitive able-bodied rowers (24,29). On the other hand, the findings in the baseline evaluation deserve attention and illustrate the need to improve muscle strength, \( W_{4mM} \), and power decline (FI) in these adaptive rowers. Therefore, this was emphasized during the training process in which special attention was given to decrease the FI index. Also, power endurance and muscular endurance were the main objectives for Phase 1 (Specific) of the training program.

A number of studies (4,14,16,29) indicate that a high intensity training-induced increase in \( W_{4mM} \) and decreased FI. Improved \( W_{4mM} \) might be related to a higher degree of high intensity training-induced mitochondrial oxidative enzyme enhancement (15,29) and the FI decrease is probably caused by a higher concentration of \( H^+/\)lactate transporter (10,11). In addition, an increase in strength was also expected since the training protocol has been shown to increase 1RM levels (27). This finding was expected since the present study followed the specific protocol described by Bell et al. (2) who reported an increase in muscle strength during rowing training even though the primary objective was to develop aerobic capacity. Concerning the higher percent of increase in lower body strength, it is possible that the unilateral amputation of most of the rowers allowed for compensation for this deficiency.

Taken together, the sum of all the above-mentioned improvements might have been responsible for the huge performance increase with ~50% decrease in time to complete the 1000-m time-trial. While
it was not the purpose of the present study, given that several studies (1,3,9,23,29,39) reported a strong relationship between body composition, peak power output, strength, power elicited at 4 mM blood lactate, and performance in able-bodied rowers, significant moderate linear correlations were obtained between body composition with muscle strength, time to perform 1000-m race, and anaerobic capacity among the rowers with motor impairments (data not shown). Furthermore, in a recent review, none of the cited longitudinal studies detected a similar level of variation in able-bodied rowers (17), which was probably due to a higher initial training status of the athletes.

The final Phase 4 training was designed to maintain the acquired adaptation and performance level during competitions. Training loads were assigned according to previously described protocol (17) that was composed of nearly 70% aerobic training and ~25% aerobic-anaerobic and strength training. In agreement with our findings, it was shown that a similar 9-mth training protocol sustained W4mM and maximal power in female rowers (37). In addition, Bell et al. (2) showed that strength gains acquired during the preparation phase could be maintained for 6 wks despite the use of a concurrent training protocol.

CONCLUSIONS

The present findings demonstrated that a 32-wk training program improves body composition, muscular strength, anaerobic capacity, and exercise-performance of male adaptive rowers with physical disabilities. These results indicate that the periodized rowing training analyzed may represent an adequate short-term intervention to be applied by the coaches to male adaptive rowers. In addition, increases in the specific and competitive periods could likely elicit greater improvements in performance without severe injury. The evidences reported in this article can be a useful tool to Paralympic coaches for training control and performance diagnosis on Paralympic rowers with motor disabilities. On the other hand, caution must be taken considering the small sample, and further studies with higher homogeneous samples and longer periods of training are needed to ensure these preliminary data.

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