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Anaerobic endurance of young untrained male and female subjects

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Summary

Study aim: To assess the anaerobic endurance of untrained male and female subjects by applying repeated maximal exercises.
Material and methods: Untrained male subjects aged 23 – 27 years (n = 17, body height 170 – 197 cm, body mass 65 – 110 kg) and female ones aged 20 – 25 years (n = 10, body height 168 – 184 cm, body mass 55 – 86 kg) performed 6 maximal cycle ergometer (CE) exercises (64 flywheel revolutions each, spaced by 15 s intermissions, the load amounting to 75 g per kg body mass) and 6 bouts of 10 push-offs on an inclined plane device (IP). Mean and maximal relative power outputs were recorded, the ratio of the two – the performance index (PI), served as a measure of anaerobic performance.
Results: Men attained significantly higher maximum power outputs than women in both tests but the respective PI values were in both genders alike. Highest power outputs amounted to 10.80 ± 0.91 and 9.45 ± 0.43 W/kg (cycle ergometer) for men and women, respectively, and to 20.06 ± 3.78 and 13.70 ± 1.88 W/kg (inclined plane) for men and women, respectively. No significant differences between genders were found for the PI values in either test but significant within-gender differences were detected between tests: mean PI values (±SD) amounted to 0.799 ± 0.052 and 0.850 ± 0.063 for men ($p<0.01$), and 0.803 ± 0.030 and 0.875 ± 0.078 for women ($p<0.05$), for CE and IP, respectively.
Conclusions: The performance index enabled comparing male and female subjects, as well as different exercise tests consisting of repeated, short, maximal exercises, with respect to anaerobic endurance.

Key words: Anaerobic endurance – Repeated exercises – Performance index

Introduction

Anaerobic endurance, i.e. the capacity to perform multiple short, maximal exercises, is a vital component of fitness especially in team games and combat sports; such exercises play an important role not only in sport training but in many circumstances of daily life as well. According to MacDougall *e*t al. [8] and Vrabas e*t al*. [22], endurance training induces adaptation to a better oxygen utilisation by muscle cells, and this significantly improves the capacity to perform multiple exercises.

Many authors reported studies on repeated maximal exercises [1-6, 9-12] consisting of 3 to 10 bouts separated by intermissions of constant or variable duration but offered no global assessment of a series of exercise bouts. The aim of this study was to assess the anaerobic endurance of untrained male and female subjects by applying the so-called performance index to repeated maximal exercises.

Material and Methods

A group of 17 untrained male subjects aged 23 – 27 years (body height 170 – 197 cm, body mass 65 – 110 kg) and 10 female ones aged 20 – 25 years (body height 168 – 184 cm, body mass 55 – 86 kg) volunteered to participate in the study. They performed two exercise tests separated by 4 – 6 days: 6 maximal cycle ergometer exercises (64 flywheel revolutions each, the load amounting to 75 g per kg body mass), and 6 bouts of 10 push-offs each on an inclined plane device. Exercise bouts in both tests were spaced by 15 s intermissions. The following equipment was used: cycle ergometer Monark 824E (Sweden), equipped with specific software [16] and a locally constructed inclined plane device. That device consisted of 33-kg truck with adjustable back rest, moving on two rails inclined at 15º vs. ground equipped with a bottom pressure plate; kinematic parameters and power output in the push-off phase were recorded on-line [20,21].

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The ability to maintain highest performance throughout all bouts was expressed by performance index (PI) [13-15,17,18] which was the ratio of the mean value of power output computed for all 6 bouts, to the maximum value recorded in those 6 bouts. Three-way ANOVA (gender×subjects×bouts) followed by *post-hoc t*-test were used in data analysis. Pearson's coefficients of correlation were used to assess the relationships between variables. The level of $p \leq 0.05$ was considered significant.

Results

The results of tests, i.e. maximum power outputs in repeated bouts of cycle ergometer and inclined plane exercises are shown in Fig. 1. Highest values were attained in the first bout of exercise and amounted to 10.80 ± 0.91 and 9.45 ± 0.43 W/kg (cycle ergometer) for men and women, respectively, and to 20.06 ± 3.78 and 13.70 ± 1.88 W/kg (inclined plane) for men and women, respectively. In both cases the courses of changes were non-linear and women attained markedly lower relative results than men – by about 10 and 30% (on average) for cycle ergometer and inclined plane exertions, respectively. Analysis of variance revealed significant between-subject, within-gender differences in both tests ($F_{25,124}$ = 4.12 and 15.53, respectively, and significant interaction gender × bouts ($F_{5,124}$ = 3.40 and 5.36, respectively). When individual values were presented as relative to those attained in the first bout, ANOVA revealed no significant between-gender differences.

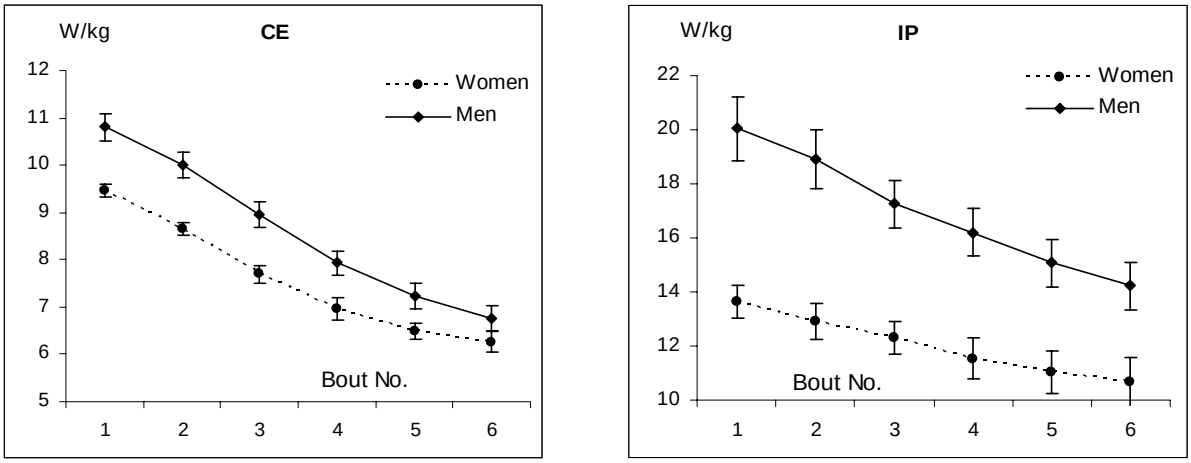

Fig. 1. Mean values (±SE) of maximum power output attained by untrained male (n = 17) and female (n = 10) subjects aged 23 – 27 years in 6 bouts of cycle ergometer (CE) or inclined plane (IP) exertion spaced by 15-s breaks

No significant between-gender differences were found for PI values in either test but significant within-gender differences were detected between tests: mean PI values (±SD) amounted to 0.799 ± 0.052 and 0.850 ± 0.063 for men ($p<0.01$), and 0.803 ± 0.030 and 0.875 ± 0.078 for women ($p<0.05$), for the cycle ergometer and inclined plane tests, respectively. Individual values of the performance index related to those of maximum power output in both tests are presented in Fig. 2.

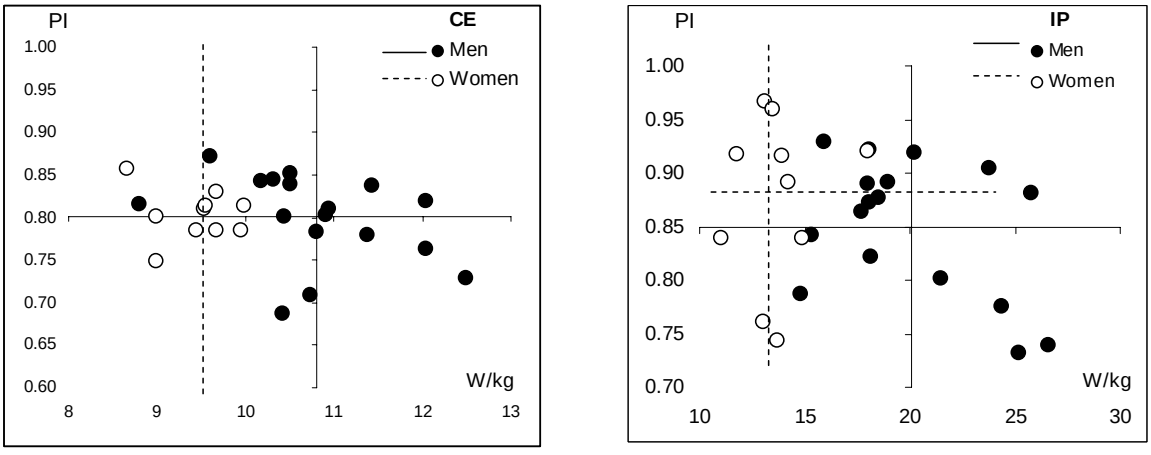

Fig. 2. Relationships between maximum power outputs and performance index values in cycle ergometer (CE) or inclined plane (IP) exertions spaced by 15-s breaks

No significant correlations were found between PI values and maximum power outputs in either test or between PI values from both tests. Maximum power output values recorded in both tests were significantly correlated in men ($r = 0.512$; $p<0.05$) but not in women ($r = 0.390$).

The between-subject variability in power outputs was markedly lower in cycle ergometer test than in the inclined plane one, the coefficients of variability amounting to 18 and 42%, respectively (men and women combined); this showed also in the performance index, the coefficients of variability amounting to 5.5 and 8%, respectively.

Discussion

Female subjects attained significantly lower values than men in relative power outputs in both tests – on cycle ergometer and on inclined plane device. This may have been due to relatively lower muscle mass in women. Yet, when the results were additionally related to those attained in the first exercise bout, no significant difference between men and women was found. This means that the fatigue-induced decreases in power output in consecutive bouts of exercise were proportionally constant in men and women in both kinds of exercise. Still, the anaerobic endurance reflected by the performance index was in women significantly lower than in men.

The cycle ergometer test induced a more pronounced response than did the inclined plane test because of a high muscle tension of upper body. The inclined plane test, in turn, induced a more pronounced variability between subjects than the other test which could have been due to the specific technique, different from the natural movement structures and, thus, to individual differences in its performance. Moreover, that specific movement structure consisting of relatively long resting phases between consecutive push-offs, combined with the engagement of smaller muscle groups and, thus, lower muscle fatigue compared with cycle ergometer test, might have brought about higher PI values than in the cycle ergometer test. Due to those resting phases and smaller muscle mass engaged in the inclined plane test, the intensity of that exertion could have been lower than on cycle ergometer.

As reported by Balsom *et al*. [2] and Linnosier *et al*. [7], muscle fatigue developing in short, multiple exercises of high intensity is due to insufficient resynthesis of phosphagens in muscle fibres. The rate of phosphagen resynthesis would thus condition the anaerobic endurance. The fact that both men and women attained similar PI values in each test is indicative of their anaerobic endurance levels being also alike.

The performance index was shown previously to be independent of either the courses of changes in consecutive exercise bouts or of the number of bouts [15,19], as well as on the maximum values of the measured variables [13-15,17-19]. The fact that PI values showed no correlation with maximum performance values enabled the use of the relationship between them as a tool in detecting the "best" and "worst" performing subjects (cf. Fig. 2).

Summing up, the performance index used in this study enabled comparing male and female subjects, as well as different exercise tests consisting of repeated, short, maximal exercises, with respect to anaerobic endurance.

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