Effect of high-intensity interval training on rowing performance in para-rowers

Efecto del entrenamiento interválico de alta intensidad sobre el rendimiento en remo en para-remeros

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Abstract

Introduction: High-intensity interval training (HIIT) is a performance-enhancing technique commonly used in training programs. Previously, HIIT has been reported to improve performance in regular rowing athletes, but there have been no studies on para-rowers.
Objective: This study aimed to examine the effects of high-intensity interval training on 2000-m rowing performance in para-rowers.
Methodology: A total of 12 participants were divided into two groups: an intervention group received a high-intensity interval training program (n = 6; 3 males, 3 females; age 36.83 ± 1.17 years; height 160.83 ± 1.83 cm; weight 55.38 ± 2.99 kg) and a control group performed a conventional rowing program (n = 6; 3 males, 3 females; age 35.67 ± 1.21 years; height 159.67 ± 1.86 cm; weight 54.67 ± 3.78 kg), performed 2 days per week for 6 weeks. The data used a paired t-test and independent sample t-test to compare the variables of 2000-m rowing performance between pre- and post- and compare between groups.
Results: In the post-test of the experimental group, it was also found that the power output and rowing time were significantly different from the pre-test ($p < 0.05$). In the control group, there were no significant differences in the pre-test and post-test.
Discussion: A key finding from this research is that appropriate HIIT training for Paralympic rowers increased power output and reduced rowing time ($p < 0.05$). In the control group, no significant difference was found in power output and rowing time for the 2000-meter distance.
Conclusions: The high-intensity interval training 2 days per week for 6 weeks can improve rowing performance in the 2000-meter in para-rowers.

Keywords

Para-rower; rowing ergometer; 2000-meter rowing; rowing stroke.

Resumen

Introducción: El entrenamiento interválico de alta intensidad (HIIT) es una técnica para mejorar el rendimiento que se utiliza habitualmente en los programas de entrenamiento. Si bien se ha informado previamente que el HIIT mejora el rendimiento en remeros convencionales, no existen estudios sobre remeros paralímpicos.
Objetivo: Este estudio tuvo como objetivo examinar los efectos del entrenamiento interválico de alta intensidad en el rendimiento en la prueba de remo de 2000 metros en remeros paralímpicos.
Metodología: Un total de 12 participantes se dividieron en dos grupos: un grupo de intervención recibió un programa de entrenamiento interválico de alta intensidad (n = 6; 3 hombres, 3 mujeres; edad 36,83 ± 1,17 años; altura 160,83 ± 1,83 cm; peso 55,38 ± 2,99 kg) y un grupo de control realizó un programa de remo convencional (n = 6; 3 hombres, 3 mujeres; edad 35,67 ± 1,21 años; altura 159,67 ± 1,86 cm; peso 54,67 ± 3,78 kg), realizado 2 días por semana durante 6 semanas. Los datos se analizaron mediante la prueba t de Student para muestras pareadas y la prueba t de Student para muestras independientes para comparar las variables del rendimiento en remo de 2000 m entre el pre y el post-intervención, así como entre los grupos. Resultados: En la prueba posterior del grupo experimental, se observó que la potencia y el tiempo de remo presentaban diferencias significativas con respecto a la prueba previa ($p < 0,05$). En el grupo de control, no se encontraron diferencias significativas entre la prueba previa y la posterior.
Discusión: Un hallazgo clave de esta investigación es que el entrenamiento HIIT adecuado para remeros paralímpicos aumentó la potencia y redujo el tiempo de remo ($p < 0,05$). En el grupo de control, no se hallaron diferencias significativas en la potencia ni en el tiempo de remo en la distancia de 2000 metros.
Conclusiones: El entrenamiento interválico de alta intensidad (HIIT) dos días por semana durante seis semanas puede mejorar el rendimiento en remo en la distancia de 2000 metros en remeros paralímpicos.

Palabras clave

Remero adaptado; ergómetro de remo; remo de 2000 metros; técnica de remo.

Introduction

Para-rowers compete over the identical 2000-m distance as able-bodied rowers. The world records for male and female PR1 rowers are around 3-minutes slower than able-bodied rowers (Severin et al. 2021). The faster times in able-bodied rowing are mainly ability to use the hole-body during rowing (Baudouin and Hawkins, 2002; Maestu et al., 2005; Van Soest & Hofmijster, (2009). Additionally, while PR1 and PR2 rowers use a set fixed seat, PR1 rowers have less sitting stability than PR2 rowers and are thus required to be strapped into their fixed seats during competition. In the PR3, athletes have good core stability and partial leg utilization, demonstrating superior body control compared to the first two types. Therefore, the PR1 rower relies mainly on the use of arms and shoulders to establish the speed of the boats. Biomechanical analysis of male and female rowers with three types of movement limitations shows that PR3 pulling efficiency is the highest, and PR1 pulling efficiency is the lowest (Cutler et al., 2017). However, athletes who can primarily move using their legs and trunk are more efficient in rowing than those who use their arms and shoulders (Calavia-Carbajal et al., 2025).

High-intensity interval training (HIIT) could be performance-enhancing and is commonly used in individual and team sports training programs (Akca & Aras, 2015). High-intensity interval training involves functioning at a speed or rate of work corresponding to 90-100% of the rate at maximum oxygen consumption (VO2max), and also the work-to-rest ratio used during high-intensity interval training sessions varies from 1:1 to 2:1. Supramaximal interval training involves tasks at an intensity greater than 100% of maximum oxygen consumption, often with a work-rest ratio of 1:3 to 1:9 (Bangsbo et al., 2009). Previous high-intensity interval training studies conducted on cyclists, swimmers, and runners have reported significant improvements in maximum oxygen consumption (Smith, et al., 1999), peak-power output (Paton and Hopkins, 2005), lactate threshold (Hamilton, et al., 2006), and time-trial performance (Lindsay et al., 1996).

Many well-trained rower responses to high-intensity interval training have been published. They estimated that when rowing 2000-m at a competitive intensity that takes about 6 to 7.5 minutes (Hahn et al., 2000), 70 to 80% of total energy comes from aerobic metabolism, the remaining 20 to 30% from anaerobic metabolism (Maestu et al., 2005; Hagerman, 1984; Mickelson et al., 1982; Secher et al., 1983), and the traditional training program of total rowing distance and time are all fraction within the intensity competitions (Jensen, 1993). High-intensity interval training using an air rowing machine at an intensity of 85-95% of HRmax for 6 weeks significantly improved the strength and endurance of the core muscles of rowers compared to traditional training modalities (Nurkholis et al., 2024; Liu et al., 2024). In addition, high-intensity interval training can improve aerobic and anaerobic function and increase acute cardiovascular and metabolic responses (Faelli et al., 2022). Meanwhile, the use of proper rowing techniques and tactics can improve performance in rowers with disabilities, which is different from normal athletes. As can be seen from the study report by Severin et al., (2021) indicating that Paralympic rowers who used the appropriate seat/backrest inclination technique (seat/backrest; The 7.5° /25°, 0° /25°) rowing angles were significantly more effective than those with the traditional seat/backrest angles (seat/backrest; 0° /5°). However, great improvements were reported after the high-intensity interval training intervention compared to traditional continuous training on the effectiveness of the rowing time trial in able-bodied rowers (Driller et al., 2009; Driller et al., 2013).

From the above information, it can be seen that the important thing in rowing sports for both normal athletes and athletes with disabilities is to rely on the strength and endurance of the muscles to work continuously throughout the 2000-meter distance used in the competition. The main factors that will give athletes a chance to succeed in the competition depend on the development of physical efficiency in various aspects, including the anaerobic and aerobic energy systems that athletes have trained with the right amount of intensity and systematically (Maestu et al., 2005), including the techniques and strategies of rowing. It can be seen from Paralympic rowers who use the adjusting techniques of the seat/backrest to the appropriate angle to increase maximum force and a lower stroke rate than using the seat and backrest at a normal angle (Severin et al., 2021).

Therefore, if these things are developed together, they will help support and improve the efficiency of disability rowers. However, rowing coaches commonly utilize high-intensity interval training for able-bodied rowers. There is no information on high-intensity interval training and its effects on rowing performance in para-rowers. Therefore, this study aimed to examine the effects of high-intensity interval

training on 2000-m rowing performance in para-rowers. There is a research hypothesis that high-intensity interval training can improve 2000-m rowing performance in Para-rowers.

Method

Participants

This study was a randomized, controlled trial aimed at examining the effects of high-intensity interval training on 2000-meter rowing performance in Para-rowers. The research hypothesis was that high-intensity interval training could improve 2000-meter rowing performance in para-rowers.

The participants were 12 Thai national rowing athletes (classification status: PR1 = 2 male, 2 females; PR2 = 2 male, 2 females; PR3 = 2 male, 2 female). They were screened with pre-exercise health and physical activity readiness questionnaires (PAR-Q). All subjects showed they were healthy, well-trained, and free from musculoskeletal injuries before participating in the study. If the participants had an accident and sustained a musculoskeletal injury during training, they would be excluded from the study. The participants were divided into two groups: an experimental group received an intervention with a high-intensity interval training program (n = 6; 3 male, 3 female, age 36.83 ± 1.17 yrs, height 160.83 ± 1.83 cm, weight 55.38 ± 2.99 kg, body mass index 21.85 ± 1.86 kg/m2), was performed 2 days per week for 6 weeks and a control group performed a conventional rowing program (n = 6; 3 male, 3 female, age 35.67 ± 1.21 yrs, height 159.67 ± 1.86 cm, weight 54.67 ± 3.78 kg, body mass index 22.28 ± 1.42 kg/m2) as shown in Table 1. The sample size used in this study was conducted according to the previous literature review by Driller et al. (2009) using the G*Power V 3.1.9.4 program with a power value = 0.8 and an effect size d = 7.69 at an alpha level = 0.05. The calculated sample size is not less than 3 people per group. To prevent missing the samples. The sample size was increased by another 20%. The total sample size was 12 persons, divided into 6 persons per group. This study was ethically approved by the Human Research Ethics Committee. Suranaree University of Technology (EC-64-0063), in which all participants voluntarily provided written informed consent before participating in this research study.

Table 1. The para-rowers characteristics (mean ± SD)

Characteristics	Experimental group (n=6)	Control group group (n=6)
Age (yrs)	36.83 ± 1.17	35.67 ± 1.21
Height (cm)	160.83 ± 1.83	159.67 ± 1.86
Weight (kg)	55.38 ± 2.99	54.67 ± 3.78
BMI (kg/m^2)	21.85 ± 1.86	22.28 ± 1.42

Procedure

Before participating in this research study. The participants used a similar traditional rowing ergometer session in the training program. The participants completed a baseline of physical characteristics and testing and were assigned to 6-weeks of high-intensity interval training on a rowing ergometer. Following a 6-weeks training period, participants were then retested. The testing consisted of a 2000-m performance trial on a rowing ergometer. The participants were instructed to arrive at the test period in a resting state and avoid strenuous exercise 48 hours before the test period. Each participant was tested at the same time of day throughout the study and always perform a performance test with the same rowing ergometer.

Instrument

Physical characteristics: —The height (cm) of the participants was measured using a portable wall-mounting height scale with a measuring slide and a heel plate (Seca 214, Hamburg, Germany) with participants sitting in a wheelchair, using crutches, or standing upright with the arms hanging freely, heels together without shoes. Their height was measured to the nearest 0.01 cm. Weight was measured to the nearest 0.02 kg on a digital platform scale (Yamato DP-6900K-60, Akashi, Japan) in a rowing uniform suit without wheelchair, crutches, prosthesis, and shoes. Body mass index (BMI) was calculated by dividing weight (kg) by squared height (m2).

Rowing performance: —The rowing performance test was conducted with air-braked rowing ergometers (Concept II, Model-D PM5, Vermont, USA). It is believed that using the rowing ergometer simulates the metabolic and biochemical demand for on-water rowing and can be used to assess the efficiency of rowing performance (Maestu & Jurimae, 2001; Driller et al., 2009). Participants were familiar with the 2000-m time trial testing equipment and process before participating in the study. All participants participate 10-minute rowing warmed-up on a rowing ergometer before the test was simulated before each 2000-m time trial. Power output, stroke rate, and 500-m split times are continuously updated on the computer screens of the rowing ergometer during the 2000-m time trial, and average values are displayed for each measurement when the 2000-m time trial is complete. The time to complete the 2000-m time trial is recorded as a criterion variable.

High-intensity interval training intervention: —The high-intensity interval training of this study was developed based on Tabata protocol. According to Tabata et al. (1996) showed that 4-min of cardiovascular training improved physical performance. It lasted 6 weeks and is performed twice a week (Tuesday, and Friday) in the evening from 17:00-18:00 pm. Overall, 12 training sessions were carried out. Each session lasted 60 min and consisted of a 10-minute warm-up, a 40-minute HIIT training primary portion (by rowing ergometers of 20-second at maximum effort with 10-second rest for 8 rounds per set for a total of 8 sets), and a 10-minute final stretching portion.

Data analysis

Statistical was using SPSS Version 22.0. The data used a paired t-test to compare the variables of 2000-m rowing performance between pre- and post-, and an independent sample t-test between groups was computed for each of the 2000-m rowing performance variables, including rowing time, rowing stroke rate, and peak rowing power. Statistical significance was accepted at $p < 0.05$.

Results

From the comparative data of rowing efficiency in the distance of 2000-meters pre-test and post-test in the experimental group, it was found that the stroke rate within the experimental group was not different. However, when compared between groups, it was found that the experimental group had a stroke rate post-test (23.83 ± 0.41 time/min, $p = 0.046$), which was significantly different from the control group, $p < 0.05$. In the experimental group post-test, it was also found that the power output (113.50 ± 33.41 watts, $p = 0.001$) and rowing time (9.52 ± 1.25 min, $p = 0.002$) were significantly different from the pre-test (103.00 ± 35.12 watts, 10.09 ± 1.21 time), $p < 0.05$. In the control group, there were no significant differences in the pre-test and post-test for stroke rate, power output, and rowing time, as shown in Table 2.

Table 2. Comparison of 2000-meter rowing performance

Variable	Experimental group (n = 6)		Control group (n = 6)	
	Pre-test	Post-test	Pre-test	Post-test
Stroke rate (times/min)	24.33 ± 1.03	23.83 ± 0.41†	23.50 ± 2.35	23.33 ± 0.52
Power output (watt)	103.00 ± 35.12	113.50 ± 33.41*	102.00 ± 34.44	111.33 ± 29.43
Rowing time (min)	10.09 ± 1.12	9.52 ± 1.25*	10.10 ± 1.12	10.21 ± 0.90

Significant difference: within the group, *p <0.05, between the groups, †p <0.05.

Discussion

The results of the 2000-m rowing performance study using high-intensity interval training in para-rowers are shown in Table 2, this study aimed to examine the effect of high-intensity interval training on 2000-meter rowing performance. Although no difference in paddling rate was found within groups after training, a comparison between groups showed that the experimental group, which received high-intensity interval training twice a week for six weeks, had a significantly better paddling rate compared to the control group that received traditional training. Furthermore, the experimental group also showed significant improvements in propulsion and paddling time after training. However, the present study shows that high-intensity interval training significantly improves rowing performance in well-

trained para-rowers. The key findings from this investigation are that an appropriately high-intensity interval training intervention for Para-rowers significantly increased power output from 103.00 - 113.50 watts (an increase of ~10.5 watts) and improved rowing time from 10.09 - 9.52 min (a decrease of ~17 seconds) compared to the control group. The power output from 102.00 - 111.33 watts increased by ~9.33 watts and rowing time from 10.10 - 10.21 min increased by ~10 seconds per 2000-m rowing, with no significant differences.

Data collection in this study was conducted before the competition. All athletes were under close supervision, and the training modalities and duration used in this study were approved by the coach and team leader. An important application is the application of the developed high-intensity interval training modality on a rowing simulator in addition to conventional training, 2 days per week for 6 weeks. This application has been shown to improve performance in para-rowers. However, this study was conducted in male and female rowing athletes with disabilities of the following types: PR1 (limited arm and shoulder movement), PR2 (increased torso movement), and PR3 (increased leg movement). The sample size may be small, as this is a specific group of athletes. Previous literature reviews have outlined standard practice but highlighted the limitations of the current study. Therefore, further studies using larger sample sizes and separating men and women are needed to investigate these specific outcomes in the future.

The improvements in power output and rowing time that occurred in the high-intensity interval training group are consistent with previous research indicating that increased power output resulting from training patterns with 85–95% intensity efficiently develops strength, muscular endurance, and maximal oxygen consumption, resulting in reduced improvements in rowing time (Faelli et al., 2022; Nurkholis et al., 2024; Liu et al., 2024). Meanwhile, para-rowers who received high-intensity interval training also had a statistically significant improvement in stroke rate of ~0.5 times/min, or ~227 strokes per 2000-m, compared to a control group using a traditional training modality, which reduced it by only 0.17 times/min, or ~229 strokes per 2000-m. However, the improvements in power output, rowing time and stroke rate after 6 weeks of training are proven indications that the induced muscle work in strength and endurance is a result of the appropriate training intensity level, thus inducing physiological adaptations such as muscle fiber composition and neurological function, as well as technical and competition experience (González & Sedlacek, 2022; Akca, 2014; Cataldo et al., 2015), which are important for improving rowing performance.

Conclusions

Current research studies on athletes with disabilities are still limited. Previous studies on high-intensity interval training have shown the effectiveness of training on muscle function in terms of strength, power, and endurance, as well as blood lactate concentration and maximal oxygen consumption, indicating statistically significant improvements with high-intensity interval training in well-trained normal athletes. This study was conducted on the Thai national rowing team with disabilities. The results showed a significant improvement of ~17 seconds in the 2000-meter rowing time, taking ~9.52 minutes after high-intensity interval training 2 days per week for 6 weeks. However, these results are preliminary data for those interested in studying athletes with disabilities.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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